Section 4–3

1 FOCUS

Objectives

4.3.1 Explain what microclimates are.
4.3.2 Identify the characteristics of major land biomes.

Guide for Reading

Vocabulary Preview

Have students recall the definition of climate they learned earlier. Write microclimate on the board, and draw a box around the prefix micro-. Ask a volunteer to find the meaning of the prefix in a dictionary. Micro- means “small”; thus the term microclimate literally means “small climate”—a climate that exists over a small area.

Reading Strategy

Encourage students to create a table for recording the characteristics of each biome. Suggest that they include the following columns: Name of Biome, Temperature, Precipitation, Soil Type, Dominant Plants, Dominant Animals, and a final column labeled Other Characteristics in which to record any information that does not fit in the previous columns.

2 INSTRUCT

Biomes and Climate

Use Community Resources

Take students on a tour of the school grounds or immediate neighborhood to look for microclimates. Examples might include a south-facing embankment along a roadway; the sunny south side and shaded north side of a building; and the shaded, damp environment beneath a group of trees. Encourage students to check each microclimate periodically and note any changes—for example, spring flowers blooming along a building’s south side.

4–3 Biomes

Ecologists group Earth’s diverse environments into biomes. A biome is a complex of terrestrial communities that covers a large area and is characterized by certain soil and climate conditions and particular assemblages of plants and animals. Can all kinds of organisms live in every biome? No. Species vary in their adaptations to different conditions. An adaptation is an inherited characteristic that increases an organism’s ability to survive and reproduce.

The leaves of the saguaro cactus, for example, are reduced to spines to minimize water loss, and its stems store water during dry spells. Its shallow, wide-spreading roots absorb water rapidly. Desert rodents, such as kangaroo rats, have adaptations in their kidneys that help conserve water, and they extract water from food. Many rain forest plants, such as certain anthuriums, have long, thin leaves whose pointed tips help shed excess water. Some rain forest animals, such as certain tree frogs, spend their life in trees—their tadpoles grow in water pockets in leaf bases of plants such as bromeliads.

These sorts of variations in plants and animals help different species survive under different conditions in different biomes. Plants and animals also exhibit variations in tolerance, or ability to survive and reproduce under conditions that differ from their optimal conditions. Plants and animals of the Arizona desert, for example, can tolerate temperatures that range from blisteringly hot to below freezing. Some rain forest plants and animals, by comparison, die quickly if the temperature drops too little or too little of any environmental factor can make it difficult for an organism to survive. A saguaro would rot and die in a rain forest as surely as an anthurium or rain forest tree frog would shrivel and die in the desert!

Biomes and Climate

Because each species is adapted to certain conditions, the climate of a region is an important factor in determining which organisms can survive there. Even within a biome, precise conditions of temperature and precipitation can vary over small distances. The climate in a small area that differs from the climate around it is called a microclimate. For example, certain streets in San Francisco are often blanketed in fog while the sun shines brightly just a few blocks away. Two main components of climate—temperature and precipitation—can be summarized in a graph called a climate diagram, as shown in Figure 4–10.

SECTION RESOURCES

Print:

- Teaching Resources, Lesson Plan 4–3, Adapted Section Summary 4–3, Adapted Worksheets 4–3, Section Summary 4–3, Worksheets 4–3, Section Review 4–3
- Reading and Study Workbook A, Section 4–3
- Adapted Reading and Study Workbook B, Section 4–3

Technology:

- iText, Section 4–3
- Transparencies Plus, Section 4–3

- Issues and Decision Making, Issues and Decisions 46
- Investigations in Forensics, Investigation 2
The Major Biomes

Ecologists recognize at least ten different biomes. The world’s major biomes include tropical rain forest, tropical dry forest, tropical savanna, desert, temperate grassland, temperate woodland and shrubland, temperate forest, northwestern coniferous forest, boreal forest, and tundra. Each of these biomes is defined by a unique set of abiotic factors—particularly climate—and a characteristic assemblage of plants and animals. The distribution of major biomes is shown in Figure 4–11, and some of their most important characteristics are summarized over the next five pages.

There is often ecological variation within a biome. Sometimes, this variation is due to changes in microclimate caused by differences in exposure or elevation above sea level. Other times, variation may be related to geological factors such as local soil conditions or the presence of rock outcroppings. Note also that although boundaries between biomes on this map appear to be sharp, there are often transitional areas in which one biome’s plants and animals become less common, whereas organisms of the adjacent biome become more common. These variations in distribution often can be related to the ranges of tolerances of plants and animals for different environmental factors. As you look at Figure 4–11 and the following pages, see if you can relate the characteristics and locations of biomes to the patterns of global winds and ocean currents in Figure 4–3.

Build Science Skills

Interpreting Tables and Graphs
To ensure that students understand the format of a climate diagram, ask questions about Figure 4–10, such as the following: In which month does New Orleans have the least precipitation? (October) The most precipitation? (July) What general trend do you see in the average monthly temperatures throughout the year? (Temperatures are lowest in winter, rise through the spring, are highest in summer, and decline through the fall and early winter.)

The Major Biomes

Use Visuals

Figure 4–11 Direct students’ attention to the map and ask: Which biomes are found in the United States, not including Alaska and Hawaii? (Temperate grassland, desert, temperate woodland and shrubland, northwestern coniferous forest and temperate forest) Which biomes are found in Alaska? (Temperate forest, boreal forest, and tundra)

Build Science Skills

Inferring Direct students to look back at Figure 4–2 on page 88 and compare it with Figure 4–11 on this page. Ask: Why do you think scientists classify land biomes into 10 categories when there are only three major climate zones on Earth? (Conditions vary somewhat within each climate zone, so several biomes may occur in some climate zones.)

Go Online

For: Earth’s Biomes activity
Visit: PHSchool.com
Web Code: ctp-2043

SUPPORT FOR ENGLISH LANGUAGE LEARNERS

Comprehension: Prior Knowledge

Beginning Have the students locate their native country on the biome map in Figure 4–11. Ask the students to use the key to identify the biome of their native country and the biome of their current home in the United States. Point out the names of the biomes in the figure’s key, and read the names out loud to model correct pronunciation.

Intermediate Pair ESL students with English proficient students to prepare two lists. One list should contain words or phrases that describe the biome, climate, and common organisms of their native country. The other list should contain words or phrases that describe the biome, climate, and common organisms of their current home in the United States. Have the students add examples to their list by using pictures from newspapers and magazines.

Answer to . . .

Figure 4–10 During the month of July in New Orleans, the average temperature is 25°C and the average precipitation is 200 mm.
Tropical Rain Forest

Tropical rain forests are home to more species than all other biomes combined. The leafy tops of tall trees—extending from 50 to 80 meters above the forest floor—form a dense covering called a canopy. In the shade below the canopy, a second layer of shorter trees and vines forms an understory. Organic matter that falls to the forest floor quickly decomposes, and the nutrients are recycled.

- **Abiotic factors**: hot and wet year-round; thin, nutrient-poor soils
- **Dominant plants**: broad-leaved evergreen trees; ferns; large woody vines and climbing plants; orchids and bromeliads
- **Dominant wildlife**: herbivores such as sloths, tapirs, and capybaras; predators such as jaguars, anteaters; monkeys; birds such as toucans, parrots, and parakeets; insects such as butterflies, ants, and beetles; piranhas and other freshwater fishes; reptiles such as caimans, boa constrictors, and anacondas
- **Geographic distribution**: parts of South and Central America, South-east Asia, parts of Africa, southern India, and northeastern Australia

Tropical Dry Forest

Tropical dry forests grow in places where rainfall is highly seasonal rather than year-round. During the dry season, nearly all the trees drop their leaves to conserve water. A tree that sheds its leaves during a particular season each year is called deciduous.

- **Abiotic factors**: generally warm year-round, alternating wet and dry seasons; rich soils subject to erosion
- **Dominant plants**: tall, deciduous trees that form a dense canopy during the wet season; drought-tolerant orchids and bromeliads; aloes and other succulents
- **Dominant wildlife**: tigers; monkeys; herbivores such as elephants, Indian rhinoceroses, hog deer; birds such as great pied hornbills, pied harriers, and spotted pelicans; insects such as termites, reptiles such as snakes and monitor lizards
- **Geographic distribution**: parts of Africa, South and Central America, Mexico, India, Australia, and tropical islands

**What’s soil got to do with it?**

Soil is a mixture of rock, mineral ions, and organic matter. Each land biome tends to have a characteristic soil type. The top layer of soil in tropical rain forest biomes is acidic, with light-colored humus. The subsoil consists of iron and aluminum compounds mixed with clay. The soil in desert biomes is dry, brown to reddish brown with variable accumulations of clay, calcium carbonate, and soluble salts. A humus-mineral mixture exists in a thin layer of topsoil.
Tropical Savanna

Receiving more seasonal rainfall than deserts but less than tropical dry forests, tropical savannas, or grasslands, are characterized by a cover of grasses. Savannas are spotted with isolated trees and small groves of trees and shrubs. Compact soils, fairly frequent fires, and the action of large animals such as rhinoceroses prevent some savanna areas from turning into dry forest.

**Abiotic factors:** warm temperatures; seasonal rainfall; compact soil; frequent fires set by lightning

**Dominant plants:** tall, perennial grasses; sometimes drought-tolerant and fire-resistant trees or shrubs

**Dominant wildlife:** predators such as lions, leopards, cheetahs, hyenas, and jackals; antelopes; herbivores such as elephants, giraffes, antelopes, zebras; baboons; birds such as eagles, ostriches, weaver birds, and storks; insects such as termites

**Geographic distribution:** large parts of eastern Africa, southern Brazil, and northern Australia

Build Science Skills

**Communicating** Divide the class into 10 groups, and assign a different biome to each group. Tell students that each group is to serve as the “class experts” on its assigned biome. Let each group’s members divide responsibilities among themselves however they wish. For example, one student could handle abiotic factors, another student the dominant plants, and a third student the dominant animals. Encourage groups to do research to gain additional information about the biomes. Provide an opportunity for each group to present its biome to the class, share additional information they have gathered, and answer other students’ questions.

**Address Misconceptions**

Most students—in fact, most people in general—think that all deserts are hot as well as dry. Emphasize that it is the amount of precipitation, not the temperature range, that distinguishes the desert from other biomes. Encourage students to find out about cold deserts, including the high-altitude deserts of Mongolia and China and the Great Basin in the western United States.

Desert

All deserts are dry—in fact, a desert biome is defined as having annual precipitation of less than 25 centimeters. Beyond that, deserts vary greatly, depending on elevation and latitude. Many undergo extreme temperature changes during the course of a day, alternating between hot and cold. The organisms in this biome can tolerate the extreme conditions.

**Abiotic factors:** low precipitation; variable temperatures; soils rich in minerals but poor in organic material

**Dominant plants:** cacti and other succulents; creosote bush and other plants with short growth cycles

**Dominant wildlife:** predators such as mountain lions, gray foxes, and bobcats; herbivores such as mule deer, pronghorn antelopes, desert bighorn sheep, and kangaroo rats; bats; birds such as owls, hawks, and roadrunners; insects such as ants, beetles, butterflies, flies, and wasps; reptiles such as tortoises, rattlesnakes, and lizards

**Geographic distribution:** Africa, Asia, the Middle East, United States, Mexico, South America, and Australia

FACTS AND FIGURES

**Convergent evolution** Plants and animals that appear to be quite similar often are found in similar environments but in widely separated parts of the world. For example, a member of the cactus family that grows in deserts of southwestern United States is similar in appearance to a member of the spurge family that grows in the deserts of southwestern Africa. It would seem that these plants have evolved from a common ancestor, but this is not the case. The two species evolved from plants that are not related. This phenomenon of similar yet unrelated species occurring in different parts of the world is known as convergent evolution.
4-3 (continued)

Build Science Skills
Comparing and Contrasting
Have students refer back to the biome map in Figure 4–11 on page 99. Ask: Which biome makes up the largest portion of the continental United States? (Temperate grassland)
Then, direct students to review the climate diagrams and text descriptions of the temperate grassland biome on this page and the tropical savanna biome on page 101. Ask: What is the major similarity between these two biomes? (The dominant plants are grasses.) What are the major differences in the two biomes’ climate? (The savanna gets more rainfall and has a greater range between the highest and lowest amounts. Savanna temperatures are higher but less variable than temperate grassland temperatures.)

Make Connections
Earth Science Ask students: What is the difference in the soils of temperate grassland and temperate woodland and shrubland? (Temperate grassland has fertile soils, whereas temperate woodland and shrubland has nutrient-poor soils.) Have students compare the climate diagrams for the two biomes. Explain that soil is a combination of mineral and organic matter, and climate is perhaps the most influential factor in soil formation. Temperature and precipitation determine the kind of weathering, which determines the characteristics of the minerals that make up the soil. In addition, climate also is the main factor in the growth of vegetation and the abundance of microorganisms in the soil, both of which affect the soil’s characteristics. Point out that just as the soils help determine the kind of vegetation found in a biome, the vegetation in turn contributes to how rich the soils are, since it’s primarily the vegetation of an area that contributes the organic material in a rich soil.

Temperate Grassland
Characterized by a rich mix of grasses and underlaid by some of the world’s most fertile soils, temperate grasslands—such as plains and prairies—once covered vast areas of the midwestern and central United States. Since the development of the steel plow, however, most have been converted to agricultural fields. Periodic fires and heavy grazing by large herbivores maintain the characteristic plant community.

- **Abiotic factors:** warm to hot summers, cold winters; moderate, seasonal precipitation; fertile soils; occasional fires
- **Dominant plants:** lush, perennial grasses and herbs; most are resistant to drought, fire, and cold
- **Dominant wildlife:** predators such as coyotes and badgers—historically included wolves and grizzly bears; herbivores such as mule deer, pronghorn antelopes, rabbits, prairie dogs, and introduced cattle—historically included bison; birds such as hawks, owls, bobwhites, prairie chickens, mountain plovers; reptiles such as snakes; insects such as ants and grasshoppers
- **Geographic distribution:** central Asia, North America, Australia, central Europe, and upland plateaus of South America

Temperate Woodland and Shrubland
This biome is characterized by a semiarid climate and a mix of shrub communities and open woodlands. In the open woodlands, large areas of grasses and wildflowers such as poppies are interspersed with oak trees. Communities that are dominated by shrubs are also known as chaparral. The growth of dense, low plants that contain flammable oils makes fires a constant threat.

- **Abiotic factors:** hot, dry summers; cool, moist winters; thin, nutrient-poor soils; periodic fires
- **Dominant plants:** woody evergreen shrubs with small, leathery leaves; fragrant, oily herbs that grow during winter and die in summer
- **Dominant wildlife:** predators such as coyotes, foxes, bobcats, and mountain lions; herbivores such as blacktailed deer, rabbits, and squirrels; birds such as hawks, California quails, warblers and other songbirds; reptiles such as lizards and snakes; butterflies
- **Geographic distribution:** western coasts of North and South America, areas around the Mediterranean Sea, South Africa, and Australia

More on soil
The topsoil of temperate grassland biomes tends to be dark, alkaline, and rich in humus. This topsoil layer extends downward for more than a meter. Because topsoil formed on grasslands is often very fertile, most of the world’s crops are grown on grassland soils. The subsoil consists of clay and calcium compounds. Soil in the boreal forest biomes is often quite acidic.
Point out that the temperate forest biome in northeastern regions of North America and Asia is noted for its striking colored fall foliage. If students do not live in an area that experiences this seasonal change, urge them to collect photographs of fall foliage. Also suggest that they obtain booklets and other tourist guides that describe the best times and locations for foliage viewing at different latitudes within the biome.

**Build Science Skills**

**Applying Concepts** Point out that the temperate forest biome in northeastern regions of North America and Asia is noted for its striking colored fall foliage. If students do not live in an area that experiences this seasonal change, urge them to collect photographs of fall foliage. Also suggest that they obtain booklets and other tourist guides that describe the best times and locations for foliage viewing at different latitudes within the biome.

**Build Science Skills**

**Classifying** Collect photographs of various types of animals that are characteristic of each major land biome. Number the photographs, and display them in random order. Working individually or in pairs, students should try to determine the biome(s) in which each animal might live. In a follow-up class discussion, let students compare their choices and explain their reasoning.

**Temperate Forest**

Temperate forests contain a mixture of deciduous and coniferous (koh-NIF-ur-us) trees. Coniferous trees, or conifers, produce seed-bearing cones, and most have leaves shaped like needles. These forests have cold winters that halt plant growth for several months. In autumn, the deciduous trees shed their leaves. In the spring, small plants burst out of the ground and flower. Soils of temperate forests are often rich in humus (HYOO-mus), a material formed from decaying leaves and other organic matter that makes soil fertile.

- **Abiotic factors:** cold to moderate winters; warm summers; year-round precipitation; fertile soils
- **Dominant plants:** broadleaf deciduous trees; some conifers; flowering shrubs; herbs; a ground layer of mosses and ferns
- **Dominant wildlife:** Deer; black bears; bobcats; nut and acorn feeders such as squirrels; omnivores such as raccoons and skunks; numerous songbirds; turkeys
- **Geographic distribution:** eastern United States; southeastern Canada; most of Europe; and parts of Japan, China, and Australia

**Northwestern Coniferous Forest**

Mild, moist air from the Pacific Ocean provides abundant rainfall to this biome. The forest is made up of a variety of conifers, ranging from giant redwoods along the coast of northern California to spruce, fir, and hemlock farther north. Moss often covers tree trunks and the forest floor. Flowering trees and shrubs such as dogwood and rhododendron are also abundant. Because of its lush vegetation, the northwestern coniferous forest is sometimes called a “temperate rain forest.”

- **Abiotic factors:** mild temperatures; abundant precipitation during fall, winter, and spring; relatively cool, dry summer; rocky, acidic soils
- **Dominant plants:** Douglas fir, Sitka spruce, western hemlock, redwood
- **Dominant wildlife:** bears; large herbivores such as elk and deer; beavers; predators such as owls, bobcats, and members of the weasel family
- **Geographic distribution:** Pacific coast of northwestern United States and Canada, from northern California to Alaska

**FACTS AND FIGURES**

**Layers of plant growth**

In a temperate forest, there may be up to five layers of plant growth. The tallest trees make up the canopy layer; often this layer consists of only one or two dominant species. Under the canopy is a layer of shorter trees called the understory. Below the understory is a shrub layer made up of short, branching, woody plants. An herb layer consisting of grasses, ferns, and annual wildflowers grows close to the ground. Finally, there is the ground layer, which consists of mosses, fungi, and leaf litter.
4–3 (continued)

Build Science Skills

Drawing Conclusions Focus students’ attention on the climate diagram for the tundra biome. Ask: In terms of precipitation throughout the year, which other biome does the tundra most resemble? (The desert biome) Have students look back at the biome map on page 99. Ask: Why does the tundra biome have the lowest temperatures of all the biomes? (The tundra is the farthest north of all biomes, so it receives the sun’s rays at the lowest angles and for the shortest periods of time.)

Other Land Areas

Make Connections

Earth Science Display a large world map that shows Earth’s major mountain ranges. Have students locate the color-coded mountain areas on the biome map in Figure 4–11, page 99, and then find those areas on the large map and list the names of the mountain ranges. Separate groups could investigate each range’s characteristics—the heights of its tallest peaks, the temperature ranges and dominant organisms at various elevations, and other data. Encourage students to also search out interesting facts about the ranges, such as the 1998 discovery of mummified children on high Andean peaks or tales of the elusive Yeti (“abominable snowman”) high in the Himalayas. Let groups share their findings in oral reports, illustrated displays, or three-dimensional models.

Tundra

The tundra is characterized by permafrost, a layer of permanently frozen subsoil. During the short, cool summer, the ground thaws to a depth of a few centimeters and becomes soggy and wet. In winter, the topsoil freezes again. This cycle of thawing and freezing, which rips and crushes plant roots, is one reason that tundra plants are small and stunted. Cold temperatures, high winds, the short growing season, and humus-poor soils also limit plant height.

Abiotic factors: strong winds; low precipitation; short and soggy summers; long, cold, and dark winters; poorly developed soils; permafrost

Dominant plants: ground-hugging plants such as mosses, lichens, sedges, and short grasses

Dominant wildlife: a few resident birds and mammals that can withstand the harsh conditions; migratory waterfowl, shore birds, musk ox, Arctic foxes, and caribou; lemmings and other small rodents

Geographic distribution: northern North America, Asia, and Europe

Oases in the tundra

As an example of the tundra’s extreme dryness: In the Arctic regions north of mainland Canada, less than 15 cm of precipitation falls annually—about the same amount as falls in the desert regions of Arizona. Such dryness, coupled with intense cold, makes the tundra a barren place. Yet, like the oases in deserts, there are areas where living things can survive and even thrive. Some of these areas are sheltered valleys that are protected from bitterly cold winds. Other areas are meadows with an abundant water supply that can support large numbers of animals.
Other Land Areas
Some areas of land on Earth do not fall neatly into the major biome categories described on the previous pages. These areas include mountain ranges and polar ice caps.

Mountain Ranges Mountain ranges can be found on all continents. On mountains like the one in Figure 4–12, the alpine and biotic conditions vary with elevation. As you move up from base to summit, temperatures become colder and precipitation increases. Therefore, the types of plants and animals also change. If you were to climb the Rocky Mountains in Colorado, for example, you would begin in a grassland. Then, you would pass through an open woodland of pines. Next, you would hike through a forest of spruce and other conifers. Near the summit, you would reach open areas of wildflowers and stunted vegetation resembling tundra. In the Canadian Rockies, ice fields occur at the peaks of some ranges.

Polar Ice Caps The icy polar regions that border the tundra are cold year-round. Outside of the ice and snow, plants and algae are few but do include mosses and lichens. In the north polar region, the Arctic Ocean is covered with sea ice, and a thick ice cap covers most of Greenland. Polar bears, seals, insects, and mites are the dominant animals. In the south polar region, the continent of Antarctica is covered by a layer of ice that is nearly 5 kilometers thick in some places. There, the dominant wildlife includes penguins and marine mammals.

4–3 Section Assessment
1. **Key Concept** List the major biomes, and give one characteristic feature of each.
2. How are biomes classified?
3. What are the two types of tropical forests? How do they differ?
4. How might a mountain range affect the types of plants and animals found in an area?
5. **Critical Thinking** Inferring What characteristics would you expect tundra animals to have?

6. **Critical Thinking** Comparing and Contrasting Choose two very different biomes. From each biome, select a plant and an animal that are dominant. Compare how these plants’ adaptations are suited to their biomes. Compare how these animals’ adaptations are suited to their biomes.

3 ASSESS
Evaluate Understanding
Briefly describe characteristics of various biomes, and call on students at random to identify each one. For example, if you say, “High temperatures that do not vary much throughout the year,” students should identify the biome as a tropical rain forest or a tropical savanna. Base your descriptions on the information presented on pages 100–104 of the student text.

Reteach
Make overhead transparencies of the climate diagrams for each of the land biomes. Project the diagrams in any order. For each diagram, call on one student to summarize the diagram’s information about temperature and precipitation (for example, “High temperatures and heavy rainfall year-round”), and call on a second student to identify the biome.

Focus on the Big Idea
This activity can be completed individually or in small groups. Provide students with a variety of materials to choose from, including basic art supplies, modeling clay, pasta shapes, pipe cleaners, fabric, and construction paper. You might also encourage students to bring materials from home, or you might coordinate this activity with an art class at your school. Encourage students to be creative but accurate in depicting the biomes.

4–3 Section Assessment
1. Students should list the major biomes along with one characteristic of each.
2. By their climate, which is determined by precipitation and temperature, and by the community of organisms that live there
3. Tropical rain forests have higher temperatures and more rainfall annually than do tropical dry forests.
4. Animals and plants found in mountain ranges must be adapted to the generally cooler, wetter conditions that are found there.
5. Sample answer: Tundra animals need to be well insulated with thick coats of fur/hair or layers of feathers.
6. Answers may vary. Students might select any plants and animals mentioned in the profiles of the 10 biomes. In their comparisons, they should discuss specific adaptations of the organisms.

Figure 4–12 Boreal forest