Section 4

Biomes and Aquatic Ecosystems

Reading Preview

Key Concepts

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

Key Terms

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

Target Reading Skill

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

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

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Ecosystems and Biomes

Video Preview
▶ Video Field Trip
Video Assessment

Lab zone **Discover Activity**

How Much Rain Is That?

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

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

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

Think It Over

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

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

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

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

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

Rain Forest Biomes

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

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

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

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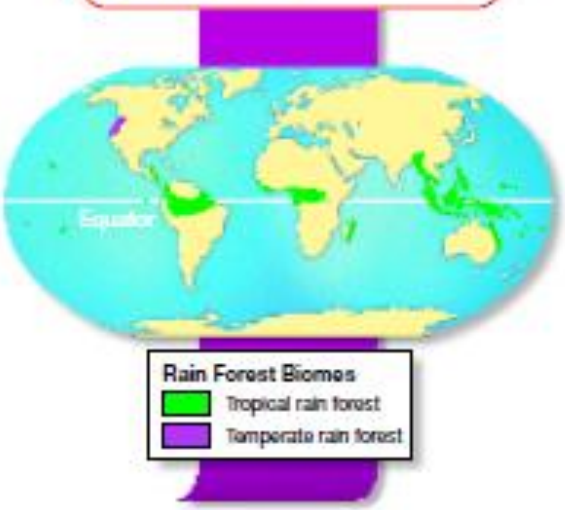
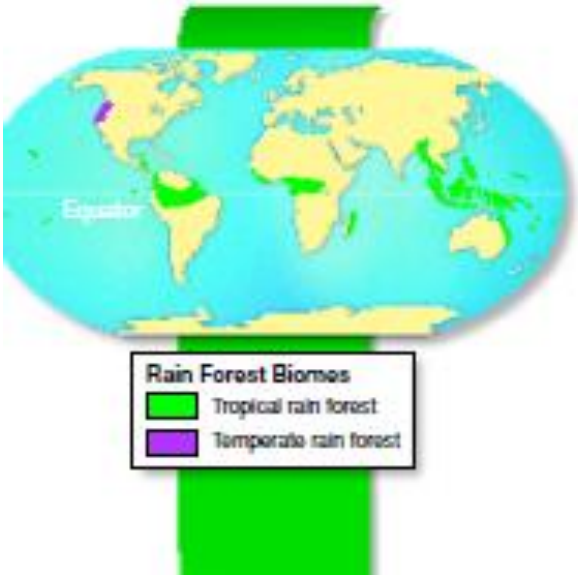


FIGURE 13 Temperate Rain Forest
Temperate rain forests receive a great deal of rain and have moderate temperatures. Mule deer are commonly found in the Olympic Rain Forest in Washington State. **Interpreting Maps** *Where is one temperate rain forest located?*

◀ Pileated woodpecker

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



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

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

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

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

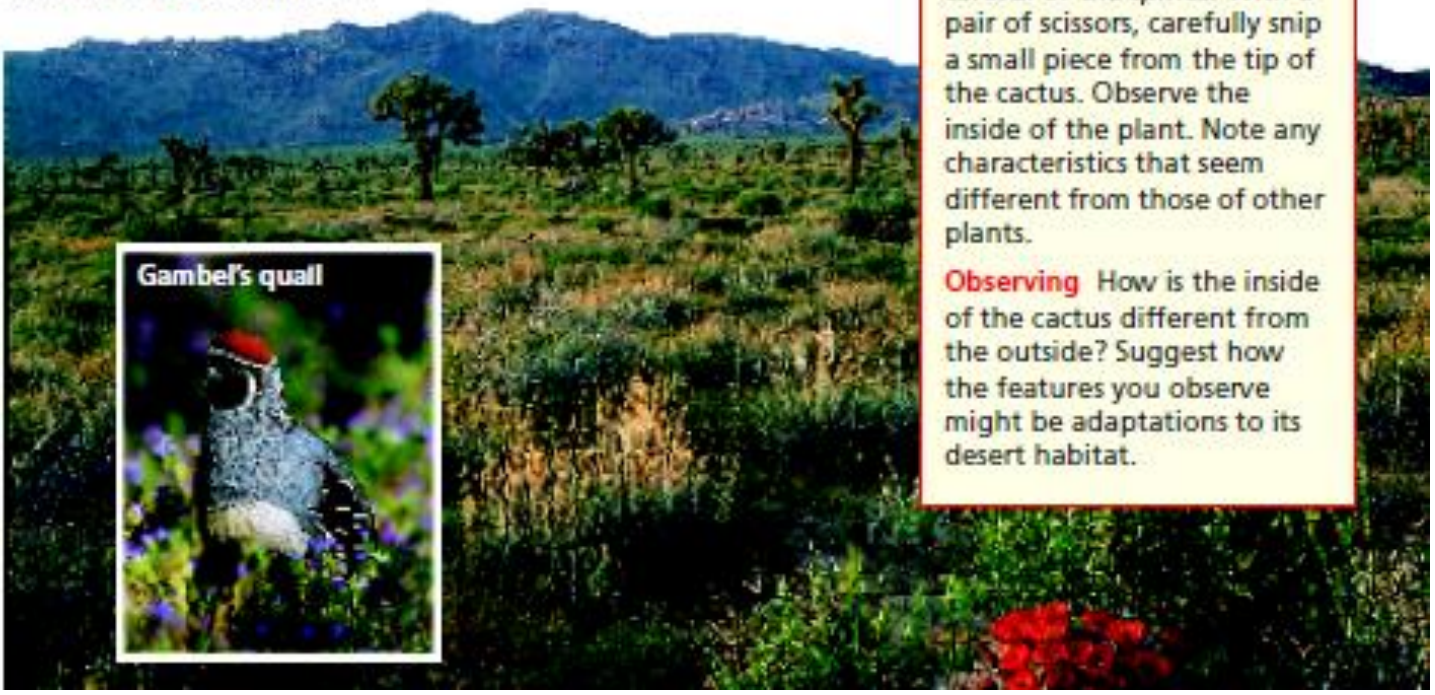
Desert Biomes

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

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

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

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



Lab zone Try This Activity

Desert Survival

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

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

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

Grassland Biomes

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

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

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

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

Deciduous Forest Biomes

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

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

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

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

Reading Checkpoint What are deciduous trees?

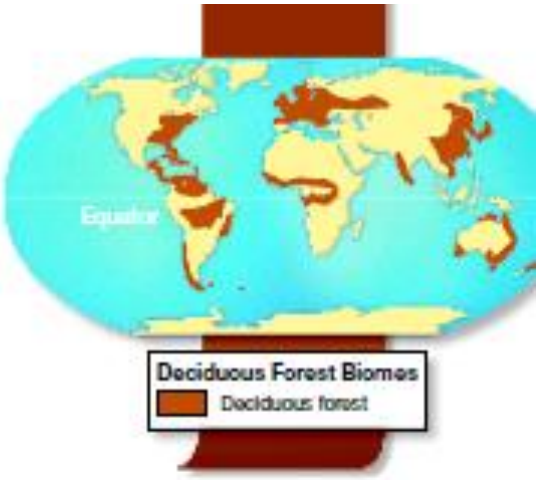


FIGURE 17
Deciduous Forest
This forest is a beautiful example of a deciduous forest in autumn. Most of the trees in a deciduous forest have leaves that change color and drop each autumn.
Comparing and Contrasting *How do deciduous forests differ from rain forests?*

▼ Southern flying squirrel

▼ Red fox

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

Boreal Forest Biomes

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

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

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

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

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

Lab zone **Skills Activity**

Inferring

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

Tundra Biomes

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

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

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

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

Reading Checkpoint **What is permafrost?**

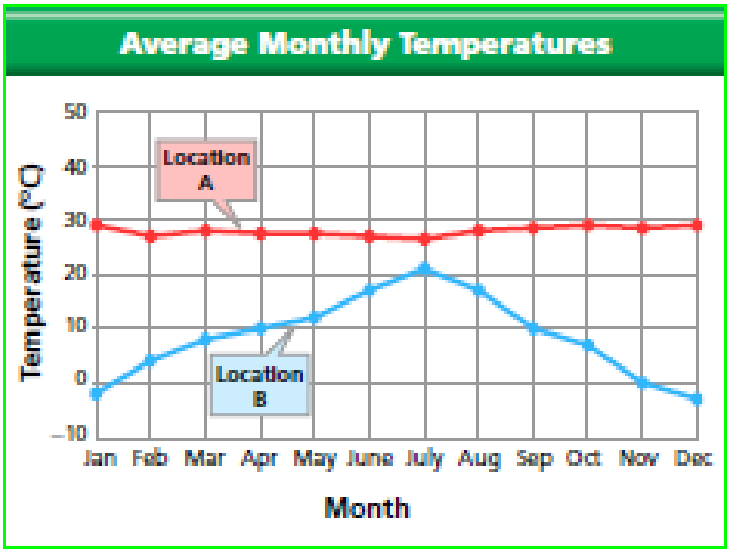
FIGURE 19
Tundra
Although it is frozen and seemingly barren in winter, the tundra in Alaska explodes with color in autumn.
Relating Cause and Effect *Why are there no tall trees on the tundra?*

Musk ox ▲

Math Analyzing Data

Biome Climates

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



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

Mountains and Ice

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

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

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

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

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

Freshwater Ecosystems

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

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

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

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

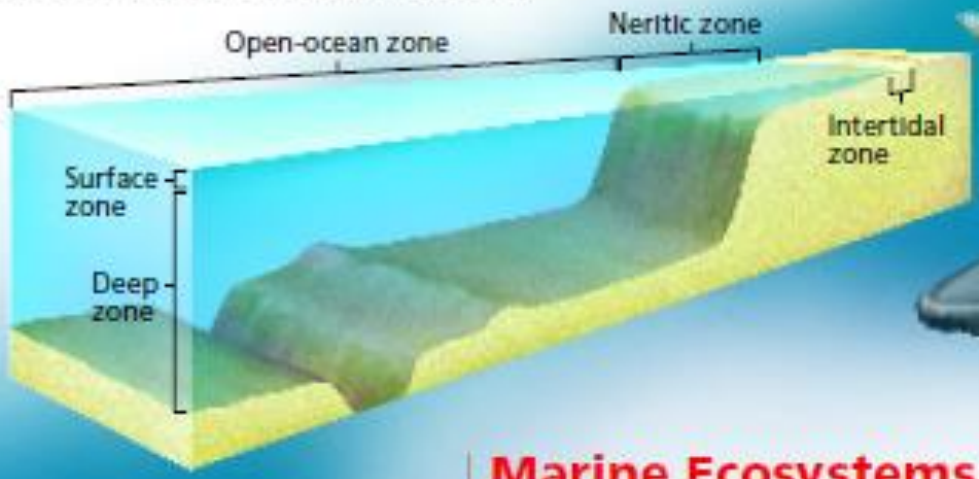
Many animals are adapted for life in the still water. Along the shore of the pond, you observe dragonflies, turtles, snails, and frogs. Sunfish live in the open water, feeding on insects and algae from the surface. Scavengers such as catfish live near the pond bottom. Bacteria and other decomposers also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

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

FIGURE 22

Marine Ecosystems

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



Marine Ecosystems

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

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

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

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

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

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

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Section 4 Assessment

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

Reviewing Key Concepts

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

Writing in Science

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