Chapter 3

Communities and Biomes

What You'll Learn

- You will identify factors that limit the existence of species to certain areas.
- You will describe how and why different communities form.
- You will compare and contrast biomes of Earth.

Why It's Important

Life on Earth is found in communities made up of different species. To understand life on Earth, it is important to know about the variations, tolerances, and adaptations of plants and animals in these communities.

Understanding the Photo

Marsh grasses, birds, a supply of water rich in food resources, and a clear blue sky. This community in the Chesapeake Bay is a small example of the elements that make up larger ecosystems, called biomes, that make up the living world. Not every biome has these particular organisms or conditions. Organisms that make up communities in other biomes will reflect the climate and latitude of that part of the world.

Breck P. Kent/Earth Scenes

Biology Online

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- study the entire chapter online
- access Web Links for more information and activities on communities and biomes
- review content with the Interactive Tutor and self-check quizzes

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Section 3.1

Communities

SECTION PREVIEW

Objectives

Identify some common limiting factors.

Explain how limiting factors and ranges of tolerance affect distribution of organisms.

Sequence the stages of ecological succession.

Describe the conditions under which primary and secondary succession take place.

Review Vocabulary

community: a collection of interacting populations that inhabit a common environment (p. 39)

New Vocabulary

limiting factor
tolerance
succession
primary succession
climax community
secondary succession

Wonder Weeds

Using Prior Knowledge In most parts of the world, with regular rainfall, living organisms such as grasses and weeds stay alive and produce more of themselves. But, if no rain falls and it is very warm, the grasses turn brown. Soil cracks open. It seems that everything dies except the weeds.

Observe and Infer *Look at your neighborhood. List the types of changes that occur there in a year. Include changes that you have observed in plants, temperatures, or rainfall. Use this information to explain how your neighborhood is an ecological community.*

Dandelions in a lawn

Life in a Community

Look closely at a square meter of healthy, green lawn and you will discover that, hidden in the grass population, there are also populations of weeds, beetles and other insects, earthworms, and grubs. There may also be twigs, seeds, and maybe a bird feather, along with soil and moisture. Not so visible are the populations of bacteria and fungi that outnumber all the other organisms. This community is alive, and each population or factor in it contributes something important to the life of the lawn.

How do plants and animals survive where they live? What is there about a climate where green lawns live and die that is different from a climate where polar bears thrive? Various combinations of abiotic and biotic factors interact in different places around the world. The result is that conditions in one part of the world are suitable for supporting certain forms of life, but not others.

Limiting factors

Factors that affect an organism's ability to survive in its environment, such as the availability of water and food, predators, and temperature, are called limiting factors. A **limiting factor** is any biotic or abiotic factor that restricts the existence, numbers, reproduction, or distribution of organisms. The timberline in ***Figure 3.1*** on the next page shows that limiting factors affect the plant life of an ecosystem. High elevations, low temperatures, strong winds, and soil that is too thin to support the growth of anything more than small, shallow-rooted plants, mosses, ferns, and lichens are all limiting factors. Other common limiting factors are listed in ***Table 3.1.***

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Figure 3.1
The timberline is the upper limit of tree growth on this mountainside. **Analyze** ***How do the limiting factors in Table 3.1 affect your community?***

Table 3.1 Common Limiting Factors

Sunlight
Climate
Temperature
Water
Nutrients/Food
Fire
Soil chemistry
Space
Other organisms

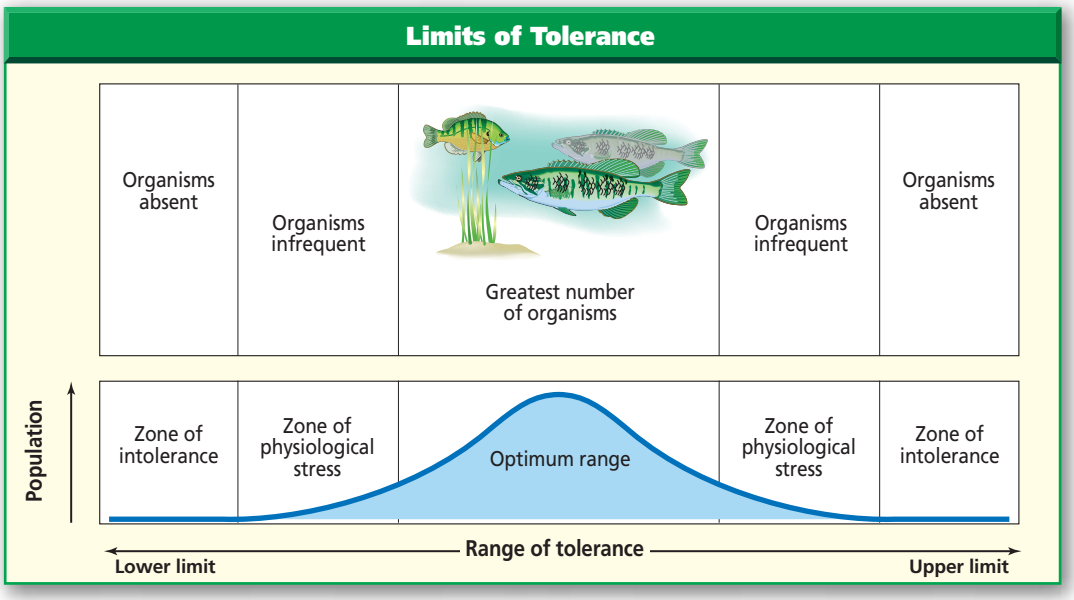
Factors that limit one population in a community may also have an indirect effect on another population. For example, a lack of water could restrict the growth of grass in a grassland, reducing the number of seeds produced. The population of mice dependent on the seeds for food will also be reduced. What about hawks that feed on mice? Their numbers also may be reduced as a result of a decrease in their food supply.

Reading Check **Describe** why a limiting factor is important.

Ranges of tolerance

Corn plants need two to three months of warm, sunny weather and a regular supply of water to produce a good yield. Corn grown in the shade or during a long dry period may survive, but probably won't produce a marketable crop. The ability of an organism to withstand fluctuations in biotic and abiotic environmental factors is known as **tolerance.** ***Figure 3.2*** illustrates that a population will survive according to its tolerance for environmental extremes.

Figure 3.2
The limits of an organism's tolerance are reached when the organism receives too much or too little of some environmental factor. Populations respond by becoming smaller as conditions move toward either extreme of the availability of resources.



Jeff Lepore/Photo Researchers

Succession: Changes over Time

If grass were no longer cut on a lawn, what would it look like in one year? Five years? In 90 years? From experience, ecologists can predict the changes that will take place.

1. The grass gets taller; weeds start to grow. The area resembles a meadow.
2. Later, bushes grow, trees appear and different animals enter the area to live.
3. The bushes and trees change the environment; less light reaches the ground. The grass slowly disappears.
4. Thirty years later, the area is a forest.

Ecologists refer to the orderly, natural changes and species replacements that take place in the communities of an ecosystem as **succession** (suk SE shun).

Succession occurs in stages. At each stage, different species of plants and animals may be present. The conditions at each stage are suitable for some organisms but not for others. As succession progresses, new organisms move in. Others may die out or move out. Succession often is difficult to observe because it can take decades or even centuries for one community to succeed another. There are two types of succession—primary and secondary.

Primary succession

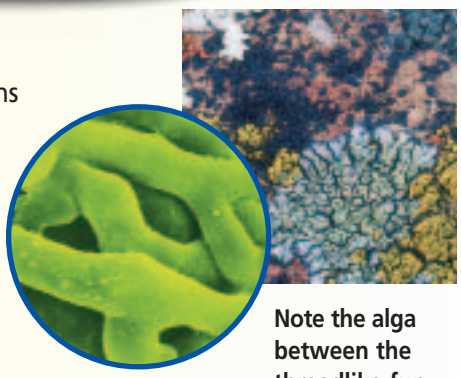
The colonization of barren land by communities of organisms is called **primary succession.** Primary succession takes place on land where there are no living organisms. For example, lava flowing from a volcano destroys everything in its path. When it cools, new, but barren, land has formed. The first species to take hold in an area like this are called pioneer species. An example of a pioneer species is a lichen, which is a combination of small organisms. Examine lichens in the *MiniLab* on this page.

Pioneer species eventually die. Decaying lichens, along with bits of sediment in cracks and crevices of rock, make up the first stage of soil development. In time, new soil makes it possible for small weedy plants, small ferns, fungi, and insects to become established. As these organisms die, more soil builds. Seeds, carried by water, wind or animals, move into these expanding patches of soil and begin to grow.

MiniLab 3.1

Observe

Looking at Lichens Lichens are known for being a pioneer species when it comes to primary succession. They colonize rocky areas and start the process of soil formation. How can lichens grow on a rock?



Color-enhanced SEM Magnification: 342×

Note the alga between the threadlike fungus in the close-up at left.

Procedure

1. Examine the lichen samples provided by your teacher. Note their color, shape, and texture.
2. Use a microscope to examine a prepared slide of a stained section of a lichen. Use low-power magnification and then change to high power as needed.
3. Observe the dark bodies that are cells containing chloroplasts. Notice that lichens are composed of an alga and a fungus. Diagram what you see. **CAUTION:** ***Use safe practices. Wash hands with soap at the end of the lab.***

Analysis

1. **Observe** Describe the general appearance of a whole lichen and of the lichen under a microscope.
2. **Interpret Interactions** Interpret the relationship between organisms in a lichen as mutualism.
3. **Make Inferences** How does mutualism explain why lichens are able to survive on rocks?

Problem-Solving Lab 3.1

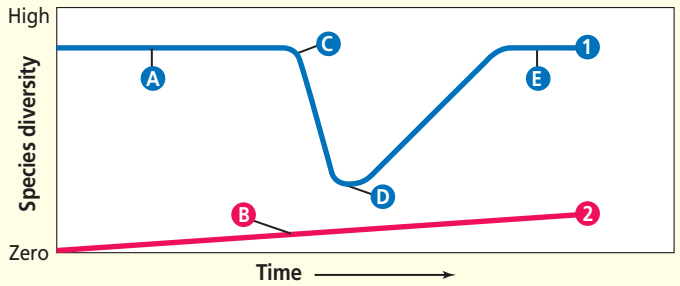
Interpret Scientific Illustrations

How do you distinguish between primary and secondary succession? Succession is the series of gradual changes that occur in an ecosystem. Ecologists recognize two types of succession—primary and secondary. The events occurring during these two processes can be represented by a graph.

Solve the Problem

Examine the graph. The two lines marked 1 and 2 represent primary and secondary succession. Note, however, that neither line is identified as such for you.

Primary and Secondary Succession



Thinking Critically

1. **Analyze Trends from Data** Which line, 1 or 2, represents primary succession? Secondary succession? Explain.
2. **Make Inferences from Data** Which label, C or D, might best represent a climax community? Pioneer organisms? Explain.
3. **Predict Trends from Data** What does the sudden drop at point C represent? What happens between D and E?

After some time, primary succession slows down and the community becomes fairly stable, or reaches equilibrium. A stable, mature community that undergoes little or no change in species is a **climax community.** A climax community may last for hundreds of years.

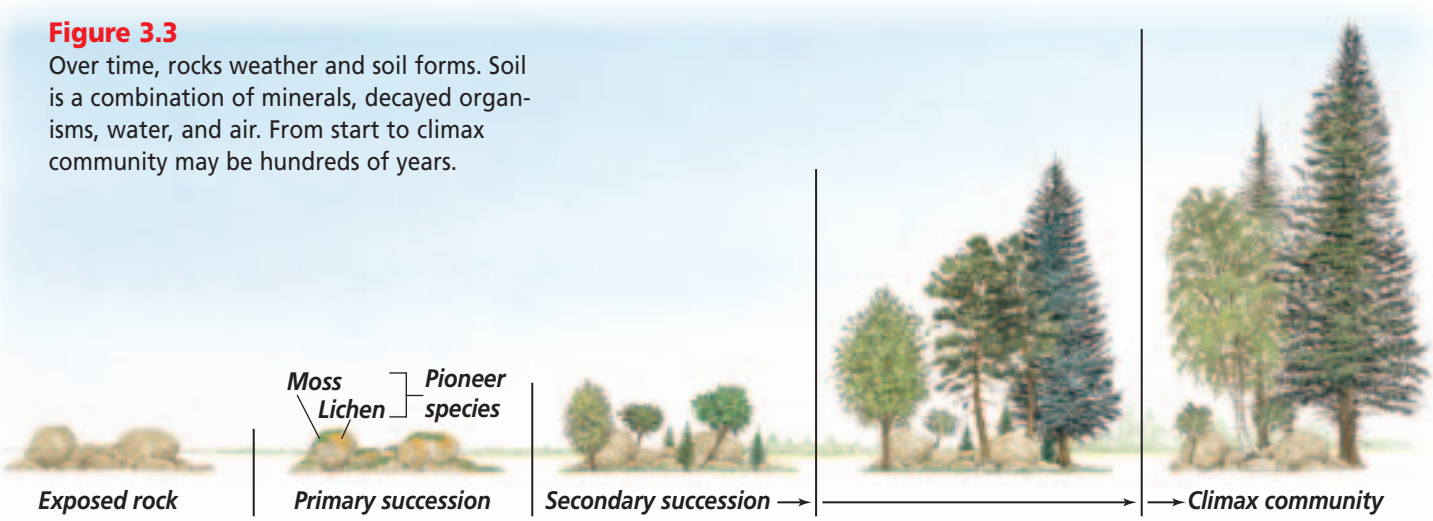
Stability or equilibrium does not mean that change stops. Change is dynamic as the numbers of species may rise and fall in an area. Over time, however, the changes are balanced, so long as nothing drastic—such as fire—happens to the area. Succession from bare rock to a climax community is illustrated in ***Figure 3.3.*** Observe the characteristics of succession in the *BioLab* at the end of this chapter.

Secondary succession

What happens when a natural disaster such as a forest fire destroys a community? What happens when a field isn't replanted or when a building is demolished in a city and nothing is built on the site? Then secondary succession begins. **Secondary succession** is the sequence of changes that takes place after an existing community is severely disrupted in some way.

During secondary succession, as in primary succession, the community of organisms inhabiting an area gradually changes.

Figure 3.3
Over time, rocks weather and soil forms. Soil is a combination of minerals, decayed organisms, water, and air. From start to climax community may be hundreds of years.



Secondary succession, however, occurs in areas that previously contained life, and on land that still contains soil. Therefore, the species involved in secondary succession are different from those in primary succession. Because soil already exists, secondary succession may take less time than primary succession to reach a climax community. Learn more about the differences between primary and secondary succession in the *Problem-Solving Lab*.

Reading Check **Compare** primary and secondary succession.

An example of secondary succession

In 1988, forest fires burned from June to September in Yellowstone National Park. Hundreds of thousands of hectares of trees, shrubs, and grasses were burned. The fire has given biologists an opportunity to study secondary succession in a community. Ecologically, the fire represented change, not total destruction. Annual wildflowers, like those in ***Figure 3.4***, were among the first plants to grow back. Previously, the shade of the trees was a limiting factor for wildflower growth. Within three years of the fire, perennial wildflowers, grasses, ferns, and thousands of lodgepole-pine seedlings began to replace the annuals. Once the pine seedlings grow above the shade cast by the grasses and perennials, the trees will grow more quickly.

Figure 3.4
The spring after Yellowstone National Park's forest fire of 1988, wildflowers were already blooming in places where the fire had been most hot.

Section Assessment

Understanding Main Ideas

1. Explain how temperature is a limiting factor for a cactus in the desert.
2. Plan an investigation by writing two questions that would test temperature as a limiting factor for an organism in an ecosystem.
3. Give an example of secondary succession. Include plants and animals in your example.
4. A field has been left uncut for a year. Describe what it looks like at the end of one year and predict how it will be in five years. In ten years.
5. Compare primary succession and climax community. In your discussion, identify how long-term survival of species is dependent on resources that may be limited.

Thinking Critically

6. Explain how the growth of one population can bring about the disappearance of another population during the process of succession.

Skill Review

7. **Make and Use Graphs** Using the following data, graph the limits of tolerance for temperature for carp. Carp is a large freshwater fish found in many places throughout the world. In the following data, the first number in each pair is temperature in degrees Celsius; the second number is the number of carp surviving at that temperature: 0, 0; 10, 5; 20, 25; 30, 34; 40, 27; 50, 2; 60, 0. For more help, refer to *Make and Use Graphs* in the **Skill Handbook.**

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Richard Thom/Visuals Unlimited

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Section 3.2

Biomes

SECTION PREVIEW

Objectives

Compare and contrast the photic and aphotic zones of marine biomes.

Identify the major limiting factors affecting distribution of terrestrial biomes.

Distinguish among biomes.

Review Vocabulary

biosphere: the portion of Earth that supports life (p. 36)

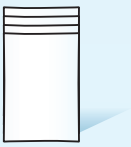
New Vocabulary

biome
photic zone
aphotic zone
estuary
intertidal zone
plankton
tundra
taiga
desert
grassland
temperate/deciduous forest
tropical rain forest

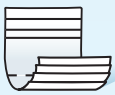
FOLDABLES Study Organizer

Biomes Make the following Foldable to help you understand the nature of terrestrial biomes.

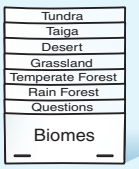
STEP 1 **Collect** 4 sheets of paper and layer them about 1.5 cm apart vertically. Keep the edges level.



STEP 2 **Fold** up the bottom edges of the paper to form 8 equal tabs.



STEP 3 **Fold** the papers and crease well to hold the tabs in place. Staple along the fold. **Label** each tab as shown.



Identify and Describe Before you read Section 3.2, label each tab with the name of a terrestrial biome. Label the final tab "Questions" and list questions you would like to have answered. As you read, describe the biomes on your Foldable and answer your questions.

What is a biome?

Ecosystems that reach similar climax communities can be grouped into a broader category called a biome. A **biome** is a large group of ecosystems that share the same type of climax community. There are terrestrial biomes and aquatic biomes, each with organisms adapted to the conditions characteristic of the biome. Biomes located on land are called terrestrial biomes. Organisms such as the cardon cactus shown here, populate terrestrial desert biomes. Oceans, lakes, streams, ponds, or other bodies of water are aquatic biomes.

Aquatic Biomes

As a human who lives on land, you may think of Earth as a terrestrial planet. But one look at a globe, a world map, or a photograph of Earth taken from space tells you there is an aquatic world, too. Approximately 75 percent of Earth's surface is covered with water. Most of that water is salty. Oceans, seas, and even some inland lakes contain salt water. Freshwater is confined to rivers, streams, ponds, and most lakes. Saltwater and freshwater environments have important differences. As a result, aquatic biomes are separated into marine biomes and freshwater biomes.

Cardon cactus

Tom Bean/DRK Photo

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Figure 3.5
Because estuaries provide an abundant supply of food and shelter, many fishes, clams, and commercially important shrimp live there while young. Many then move out of the estuary and into the ocean as they reach adulthood.
Analyze ***How does the movement of these organisms show an interaction with their environment?***

Marine biomes

Different parts of the ocean differ in abiotic factors (salinity, depth, availability of light, and temperature) and biotic factors found there. The oceans contain a large amount of biomass, or living material. Most of this biomass is made up of extremely small, often microscopic, organisms that humans usually don't see but that large marine animals, such as baleen whales, depend upon.

One of the ways ecologists study marine biomes is to make separate observations in shallow, sunlit zones (photic zones) and deeper, unlighted zones (aphotic zones). The portion of the marine biome that is shallow enough for sunlight to penetrate is called the **photic zone.** Shallow marine environments exist along the coastlines of most landmasses on Earth. These coastal ecosystems include bays, rocky shores, sandy beaches, mudflats, and estuaries. Coral reefs also are located in shallow water in warmer parts of the ocean. All are part of the photic zone. Deeper water that never receives sunlight makes up the **aphotic zone.** The aphotic zone includes the deepest, least explored areas of the ocean.

Estuaries—Mixed waters

If you were to follow the course of a river, you would, in most cases, reach a sea or ocean. Wherever rivers join oceans, freshwater mixes with salt water. In many such places, an estuary forms. An **estuary** (ES chuh wer ee) is a coastal body of water, partially surrounded by land, in which freshwater and salt water mix.

The salinity, or amount of salt, in an estuary ranges between that of seawater and that of freshwater, and depends on how much freshwater the river brings into the estuary. Salinity in the estuary also changes with the tide and so a wide range of organisms can live in estuaries. Estuaries, as illustrated in ***Figure 3.5,*** may contain salt marsh ecosystems, which are dominated by salt-tolerant smooth cordgrass, salt marsh hay, or eelgrasses. These grasses can grow so thick that their stems and roots form a tangled mat that traps food material and provides a "nursery" habitat for small developing snails, crabs, and shrimp. These organisms feed on decaying, suspended materials. In turn, these small organisms attract a wide range of predators, including birds.

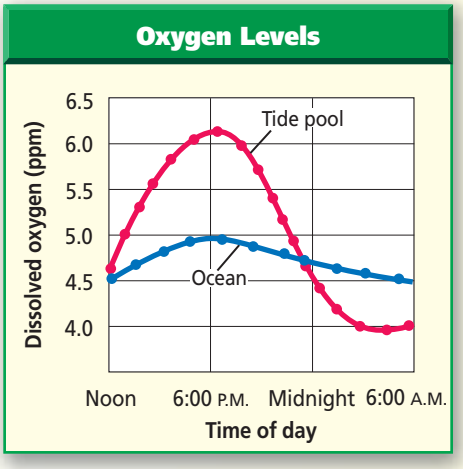
Physical Science Connection

Salinity and density of a solution Water that contains dissolved salts is denser than pure water. As the concentration of dissolved salts increases, the density of the solution increases. Because seawater is denser than freshwater, seawater tends to enter an estuary along the bottom.

Problem-Solving Lab 3.2

Analyze Information

How does oxygen vary in a tide pool?
Tide pools are depressions along rocky coasts that are covered by ocean water during high tide. During low tide, these tide pools become temporarily cut off from ocean water.



Solve the Problem

The graph shows results from tests of water samples taken in a tide pool and in the surrounding ocean. A scientist measured oxygen levels in ppm (parts per million). Both the ocean and tide pool have the same producer present, a green algae called *Cladophora.*

Thinking Critically

1. **Analyze Trends from Data** What can you tell about how the experiment was done using only the *x*- and *y*-axis information?
2. **Conclude** What is the importance of the green algae?
3. **Make Inferences from Data** What specific information was learned as a result of the experiment?

With the help of bacteria, decay of dead organisms proceeds quickly in an estuary and nutrients are released. Nutrients are recycled through the food web and as a result, microorganisms help maintain equilibrium.

The effects of tides

Daily, the gravitational pull of the sun and moon causes the rise and fall of ocean tides. The portion of the shoreline that lies between the high and low tide lines is called the **intertidal zone.** The size of this zone depends upon the slope of the land and the difference between the high and low tides. Intertidal ecosystems have high levels of sunlight, nutrients, and oxygen.

Tide pools, pools of water left when the water is at low tide, can isolate the organisms that live in the intertidal zone until the next high tide. Therefore, these areas can vary in nutrient and oxygen levels from one time of day to another. Compare and contrast oxygen content between tide pools and the ocean in the *Problem-Solving Lab* on this page.

Intertidal zones differ in rockiness and wave action. ***Figure 3.6*** shows a rocky intertidal zone. If the shore is rocky, waves constantly threaten to wash organisms into deeper water. Many intertidal animals, such as snails and sea stars, have adaptations that act by suction to hold onto wave-beaten rocks. Other animals, such as barnacles, secrete a strong glue that helps them remain anchored. If the shore is sandy, wave action keeps the bottom in constant motion.

Figure 3.6
Waves crashing against a rocky shore are a limiting factor for organisms in the intertidal zone.

Norbert Wu/Peter Arnold, Inc.

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Clams, worms, snails, crabs, and other organisms that live along sandy shores survive by burrowing into the sand.

In the light

As you move into deeper water, the ocean bottom is less affected by waves or tides. Thousands of organisms live in this shallow-water region. Nutrients washed from the land by rainfall and runoff contribute to the abundant life and high productivity of this region of the photic zone.

The photic zone of the marine biome also includes the vast expanse of open ocean that covers most of Earth's surface. Most of the organisms that live in the marine biome are plankton. **Plankton** are small organisms that drift and float in the waters of the photic zone. They include autotrophs, diatoms, eggs, and the juvenile stages of many marine animals. Plankton are important because they form the base of all aquatic food chains. Not all organisms that eat plankton are small. Baleen whales and whale sharks, some of the largest organisms that have ever lived, consume vast amounts of plankton. Examine plankton in the *MiniLab* shown here.

In the dark

Imagine a darkness blacker than night and pressure so intense it exerts hundreds of pounds of weight on every square centimeter of your body's surface. These are the conditions deep in the ocean where light does not penetrate. Much of the ocean is more than a kilometer deep. The animals living there are far below the photic zone where plankton abound. Many of them still depend on plankton for food, either directly, or indirectly, by eating organisms that feed on plankton.

MiniLab 3.2

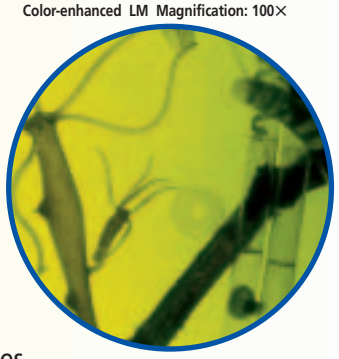
Compare and Contrast

Marine Plankton Plankton is the term used to define the floating protists, animal eggs and larvae present in an aquatic environment.

Procedure

1. Use a dropper to obtain a small sample of marine plankton.
2. Prepare a wet mount of the material. **CAUTION:** ***Handle microscope slides and coverslips carefully.***
3. Observe under low-power magnification of the microscope.
4. Look for a variety of organisms and diagram several different types. **CAUTION:** ***Wash hands with soap at the end of the lab.***

Color-enhanced LM Magnification: 100×



Marine plankton

Analysis

1. **Observe** Describe and draw two specific planktonic organisms. Identify some common characteristics.
2. **Distinguish** Are both autotrophs and heterotrophs present? How can you distinguish them?
3. **Explain Interactions in a Food Chain** Why are plankton important in food chains?

Freshwater biomes

Have you ever gone swimming or boating in a lake or pond? If so, you may have noticed different kinds of plants, such as cattails, growing around the shoreline and into the water. The shallow water in which these plants grow serves as home for tadpoles, aquatic insects, turtles that bask on rocks and fallen tree trunks, and worms and crayfishes that burrow into the muddy bottom. Insect larvae, whirligig beetles, dragonflies, and fishes such as minnows, bluegill, and carp also live here and are each part of the local food chain.

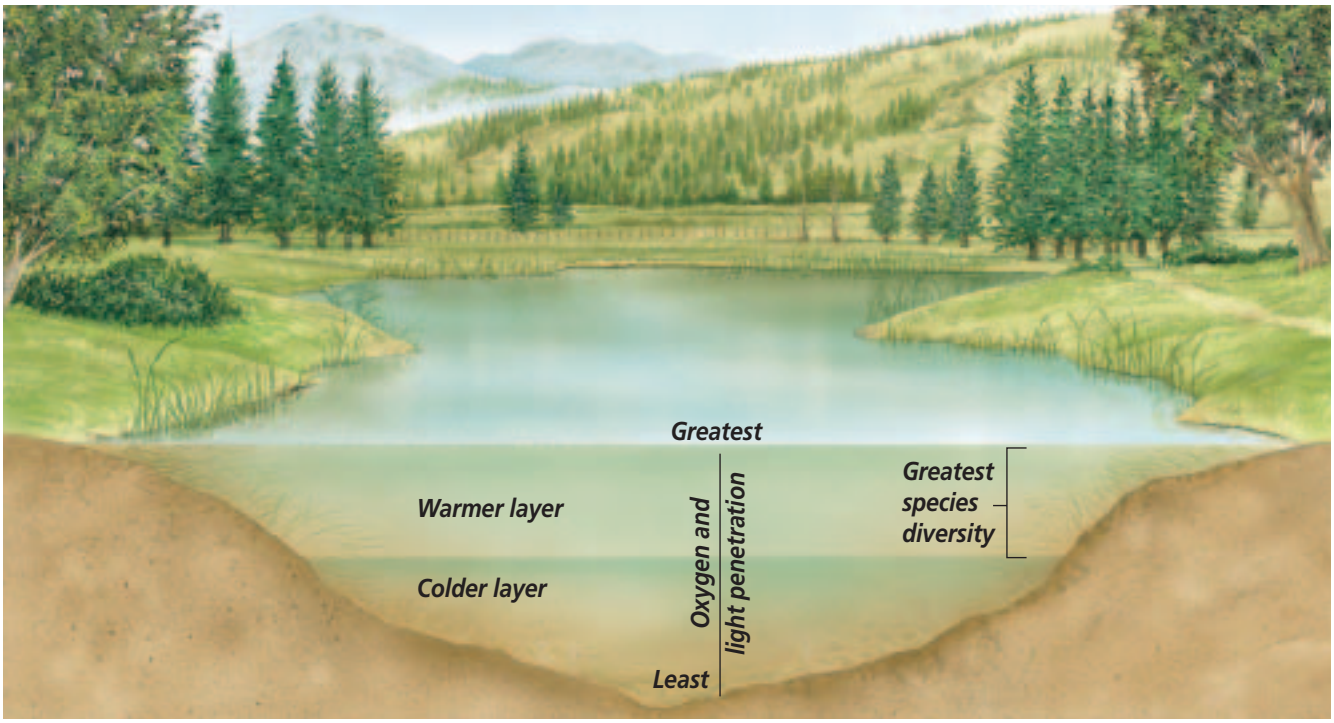


Figure 3.7
The shallow waters in this lake are exposed to sunlight. They are warmer and contain more oxygen, which can make these areas more productive than deeper, colder, more oxygen-poor layers.

Although the spring and summer sun heats the surface of a lake like the one in ***Figure 3.7***, the water a few feet below the surface remains cold. Cold water is more dense than warm water. If you were to dive all the way to the bottom of the lake, you would discover layers of increasingly colder water as you descended. These temperature variations within a lake are an abiotic factor that limits the kinds of organisms that can survive in deep lakes.

Another abiotic factor that limits life in deep lakes is light. Not enough sunlight penetrates to the bottom to support photosynthesis, so few aquatic plants or algae grow. As a result, population density is lower in deeper waters. As dead organisms drift to the bottom, bacteria break them down and recycle the nutrients. Decay takes place more slowly at the bottom of a deep lake.

Other aquatic biomes

Other places where land and water meet are called wetlands, but there are several different kinds of wetlands. Swamps have trees. Marshes do not, but both usually have water flowing through them. Marshes are found inland and in coastal regions. Both are highly productive and are the source of food for many migratory birds and other animals. Other wetland areas, called bogs, get their water supply from rain. Water does not flow through bogs.

Terrestrial Biomes

If you are setting off on an expedition beginning at the north pole and traveling south to the equator, what kinds of environmental changes do you expect to experience and why? The weather gets warmer, and you see a change in the sizes, numbers, and kinds of plants that cover the ground. At the polar cap, temperatures are always freezing and no plants exist. A little farther south, where temperatures sometimes rise above freezing but the soil never thaws completely, you would be attacked by hordes of mosquitoes and black flies. You'd see soggy ground with lichens and low-growing cushion plants.

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As you continue on your journey, temperatures rise a little and you enter forests of coniferous trees. Then there are deciduous forests, with moderate rainfall and temperatures. Farther on are grasslands and deserts, with high summertime temperatures and very little rain. Finally, as you approach the equator, you find yourself surrounded by the lush growth of a tropical forest, where it rains almost every day.

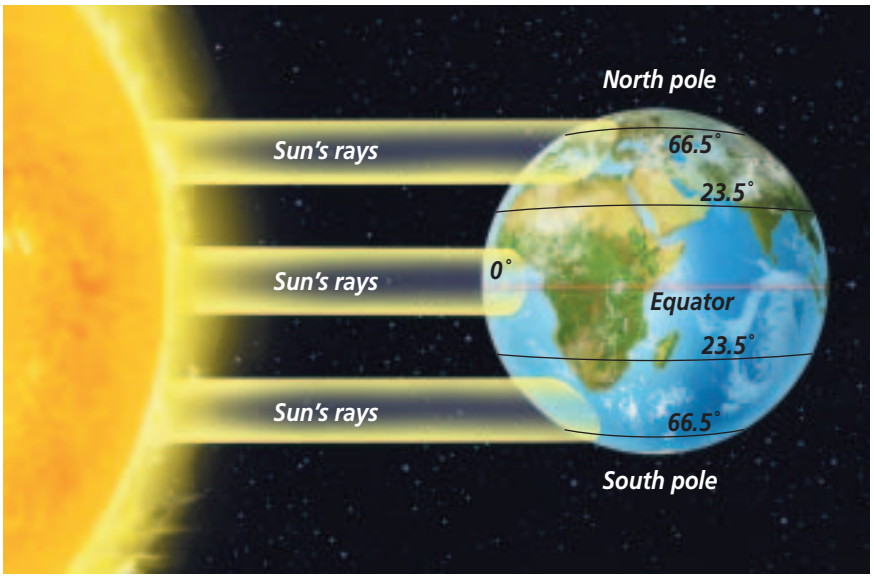

Figure 3.8
Because of Earth's curved surface, the sun's rays strike the equator more directly than areas toward the north or south poles.

Latitude and climate

What caused the changes that you experienced as you moved south from the north pole to the equator? As you traveled, you were changing latitude. Latitude describes your position in degrees north and south of the equator. Look at ***Figure 3.8.*** At different latitudes, the sun strikes Earth differently. As a result, the climate—wind, cloud cover, temperature, humidity and precipitation in that area—are different. Latitude and climate are abiotic factors that affect what plants and animals will survive in a given area. The graph in ***Figure 3.9*** shows how two abiotic factors—temperature and precipitation—influence the kind of climax community that develops. Small differences in temperature or precipitation can create different biomes. Look at the distribution of the six most common terrestrial biomes on pages 1062 and 1063 in the *Focus On*.

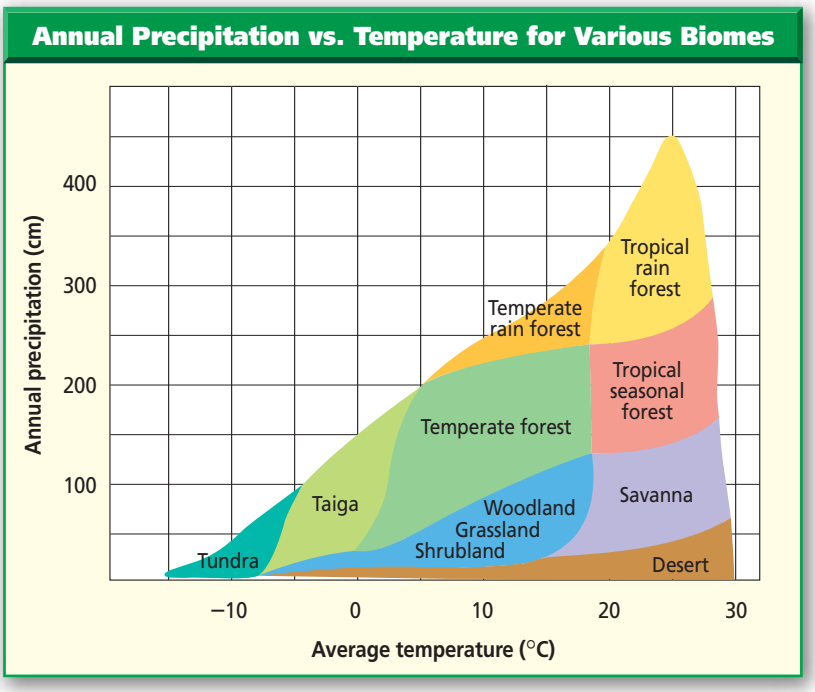

Figure 3.9
If you know the average annual temperature and rate of precipitation of a particular area, you should be able to determine the climax community that will develop. **Interpret Scientific Illustrations** ***In what biome does annual rainfall exceed 400 cm?***

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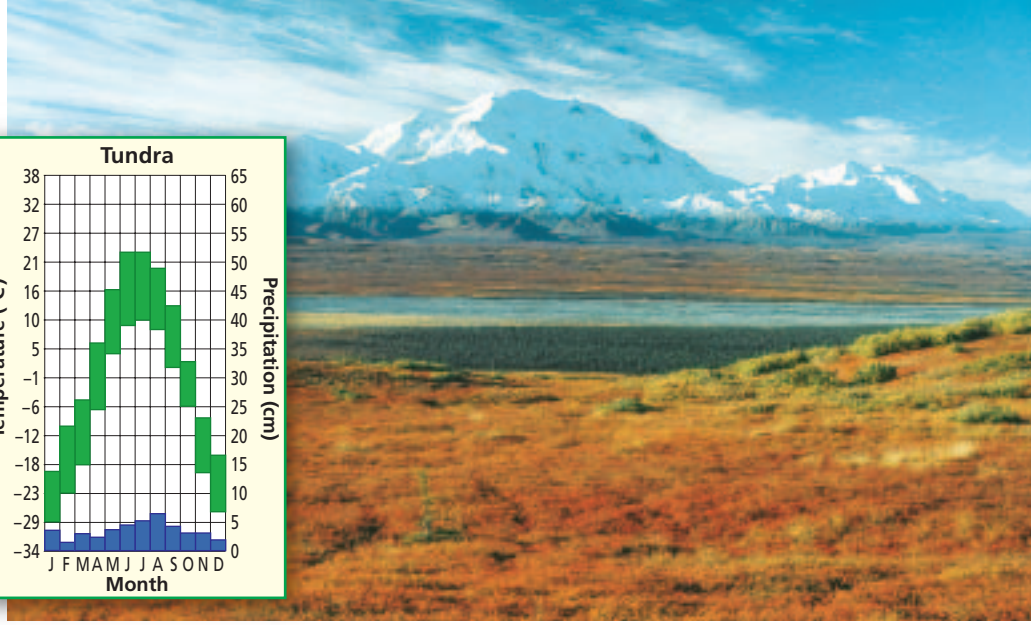


Figure 3.10
Grasses, grasslike sedges, small annuals, and reindeer moss, a type of lichen on which reindeer feed, are the most numerous producers of the tundra. The growing season may last fewer than 60 days.

Life on the tundra

As you begin traveling south from the north pole, you reach the first of two biomes that circle the north pole. This first area is the **tundra** (TUN druh), a treeless land with long summer days and short periods of winter sunlight.

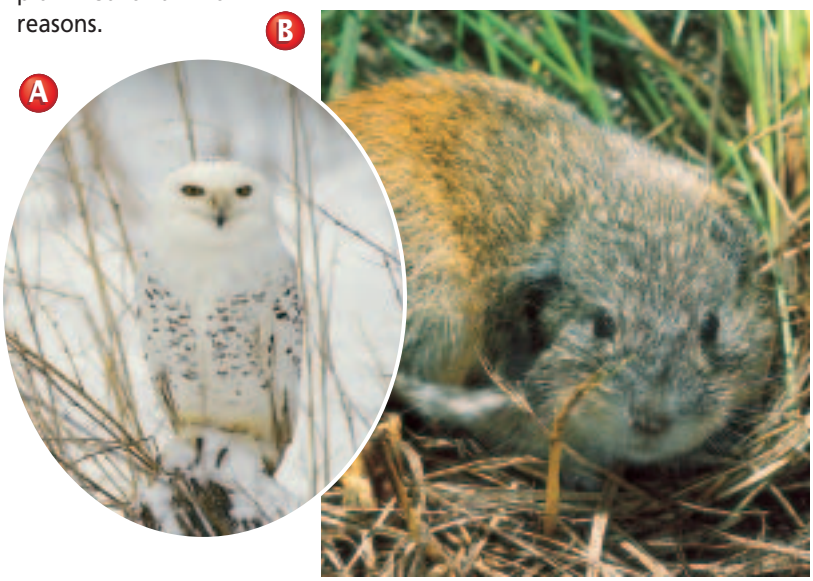
Because of its latitude, temperatures in the tundra never rise above freezing for long, and only the topmost layer of soil thaws during the summer. Underneath this top layer is a layer of permanently frozen ground called permafrost.

In most areas of the tundra, the topsoil is so thin that it can support only shallow-rooted grasses and other small plants. The soil is lacking in nutrients. The process of decay is slow due to the cold temperatures and, as a result, nutrients are not recycled quickly. Lack of nutrients limits the types of organisms the tundra can support.

Summer days on the tundra may be long, but the growing season is short. Because all food chains depend on the producers of the community, the short growing season limits the type of plants found in this biome shown in ***Figure 3.10***, to grasses, dwarf shrubs, and cushion plants. These organisms live a long time and are resistant to drought and cold.

Hordes of mosquitoes and blackflies are some of the most common tundra insects during the short summer. The tundra also is home to a variety of small mammals, including ratlike lemmings, weasels, arctic foxes, snowshoe hares, and even birds such as snowy owls and hawks. Musk oxen, caribou, and reindeer are among the few large animals that migrate into the area and graze during the summer months. ***Figure 3.11*** shows two common tundra animals.

Figure 3.11
Snowy owls **(A)** are predators of the lemming **(B)** in the tundra. Populations of lemmings rise to exceedingly high numbers periodically and then plummet for unknown reasons.



Reading Check **Explain** why the tundra is treeless.

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Life on the taiga

Just south of the tundra lies another biome that circles the north pole. The **taiga** (TI guh) also is called the boreal or northern coniferous forest. The taiga, shown in ***Figure 3.12,*** forms an almost continuous belt of coniferous trees worldwide. Common trees are larch, fir, hemlock, and spruce trees.

How can you tell when you leave the tundra and enter the taiga? The line between these two biomes can be indistinct, and one can blend into the other. For example, if the soil in the taiga is waterlogged, a peat swamp habitat develops that looks much like tundra. Because of their latitude, taiga communities usually are somewhat warmer and wetter than tundra. However, the prevailing climatic conditions are still harsh, with long, severe winters and short, mild summers.

In the taiga, which stretches across much of Canada, Northern Europe, and Asia, permafrost is usually absent. The topsoil, which develops slowly from decaying coniferous needles, is acidic and poor in minerals. When fire or logging disrupt the taiga community, the first trees to recolonize the land may be birch, aspen, or other deciduous species because the new soil conditions are within their ranges of tolerance. The abundance of trees in the taiga provides more food and shelter for animals than the tundra. More large species of animals are found in the taiga as compared with the tundra. ***Figure 3.13*** shows some animals of the taiga. Others include weasels, red squirrels, voles, elk, red deer, and moose, along with a variety of migratory birds.

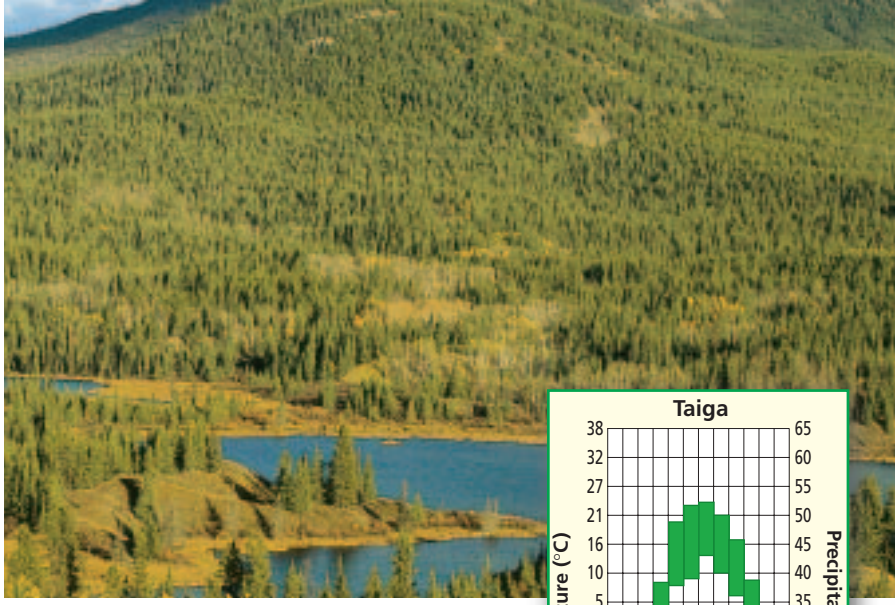

Figure 3.12
The dominant climax plants of the taiga in North America are primarily fir and spruce trees. **Evaluate Data** ***What is the range of temperature in the taiga?***

Figure 3.13
Taiga animals are adapted for cold temperatures.

A The lynx is a predator that depends on the snowshoe hare as a primary source of food.

B During the winter, the snowshoe hare grows a thick, white coat with extra hair on its feet.

C Caribou are large, herbivorous, migrating mammals. Herds of them spend spring and summer on the tundra and the rest of the year in the taiga.

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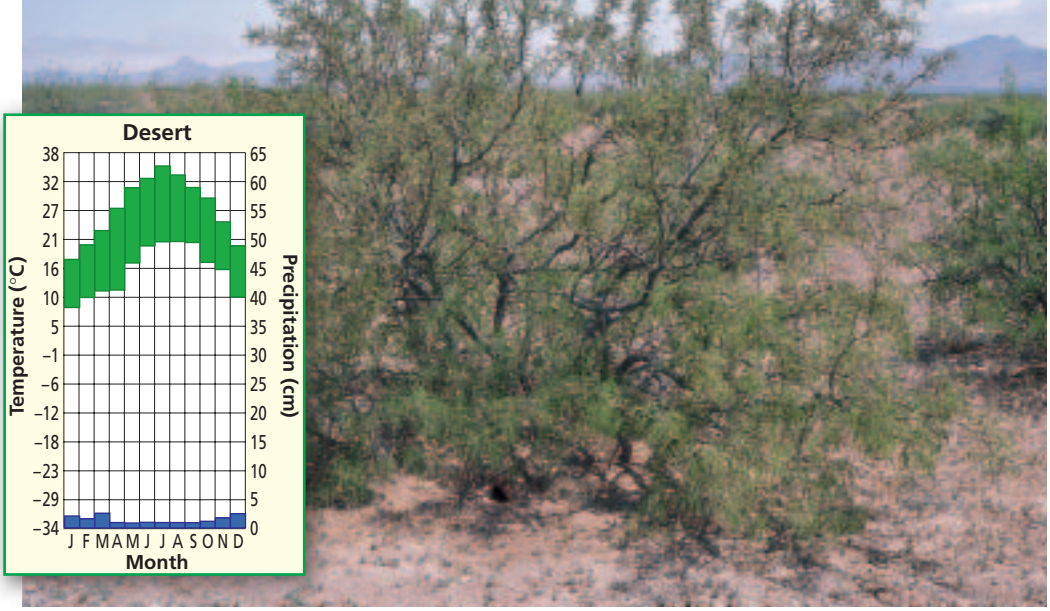

Figure 3.14
Creosote bushes cover many square kilometers of desert in the southwestern United States. These plants are adapted with small leaves containing a substance that deters herbivores from feeding on them.

Life in the desert

The driest biome is the desert biome. A **desert** is an arid region with sparse to almost nonexistent plant life. Deserts usually get less than 25 cm of precipitation annually. One desert, the Atacama Desert in Chile, is the world's driest place. This desert receives an annual rainfall of less than 0.004 inches because it is in the rain shadow of the Andes.

With rainfall as the major limiting factor, vegetation in deserts varies greatly. Areas that receive more rainfall produce a shrub community that may include drought-resistant trees such as mesquite. Less rainfall results in scattered plant life and produces an environment with large areas of bare ground. The driest deserts are drifting sand dunes. Plants such as the creosote (KREE uh soht) bush shown in ***Figure 3.14*** have various adaptations for living in arid areas. Many desert plants are annuals that germinate from seed and grow to maturity quickly after sporadic rainfall. Cacti have leaves reduced to spines, photosynthetic stems, and thick waxy coatings—all adaptations that conserve water. The leaves of some desert plants curl up, or even drop off altogether, thus reducing water loss during extremely dry spells. Spines, thorns, or poisons also are adaptations thought to discourage herbivores.

Many desert mammals are small herbivores that remain under cover during the heat of the day, emerging at night to forage on plants. The kangaroo rat is a desert herbivore that does not have to drink water. These rodents obtain the water they need from the water content in their food. Coyotes, hawks, owls, and roadrunners are carnivores that feed on the snakes, lizards, and small mammals of the desert. Scorpions are an example of a desert carnivore that uses venom to capture prey. Two of the many reptiles that make the desert their home are shown in ***Figure 3.15***.

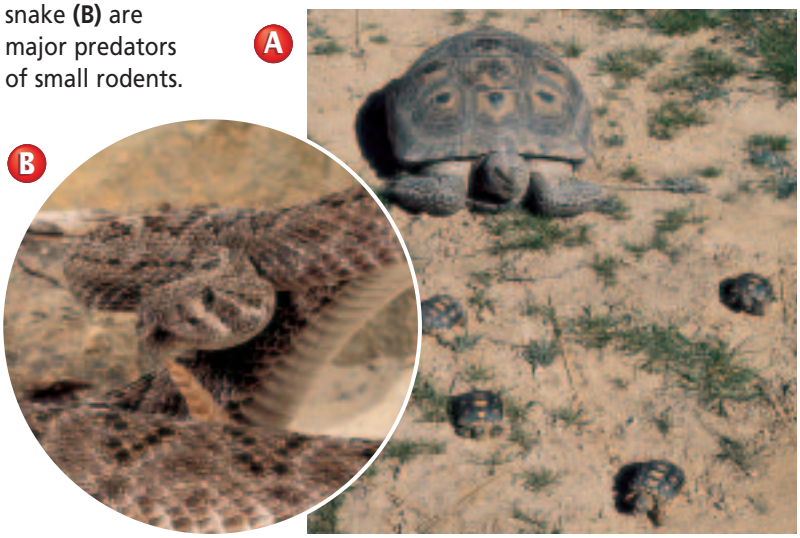

Figure 3.15
Desert tortoises **(A)** feed on insects and plants. Venomous snakes such as the diamondback rattlesnake **(B)** are major predators of small rodents.

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Life in the grassland

If an area receives between 25 and 75 cm of precipitation annually, a grassland usually forms. **Grasslands** are large communities covered with rich soil, grasses, and similar plants. Grasslands, such as the ones shown in ***Figure 3.16,*** occur principally in climates that experience a dry season, where insufficient water exists to support forests.

Grasslands contain few trees per hectare, though larger numbers of trees usually are found near streams and other water sources. This biome has a higher biological diversity than deserts, often having more than 50 species per hectare.

The soils of grasslands have considerable humus content because many grasses die off each winter, leaving byproducts to decay and build up in the soil. Grass roots survive through the winter, enlarging every year to form a continuous underground mat called sod.

Some grasslands are ideal for growing cereal grains such as oats, rye, and wheat. Each of these is a different species of grass; therefore, grasslands are known as the breadbaskets of the world. Many other plant species live in this environment, including drought-resistant and late-summer flowering species of wildflowers, such as blazing stars and sunflowers.

At certain times of the year, many grasslands are populated by herds of grazing animals. Bison, a species of mammal shown in ***Figure 3.16A,*** once ranged over the American prairie, but are now found only in small pockets of rangeland. Other important prairie animals include jack rabbits, deer, elk, and prairie dogs. Prairie dogs are seed-eating rodents that build underground "towns" that are known to stretch mile after mile under the grassland. Foxes and ferrets prey on prairie dogs. Many species of insects, birds, and reptiles, also make their homes in grasslands.

The term *prairie* is used in Australia, Canada, and the United States. Similar communities are called *steppes* in Russia, *savannas* in Africa, and *pampas* in Argentina. Grasslands in the United States can be found in the central and southwestern states.

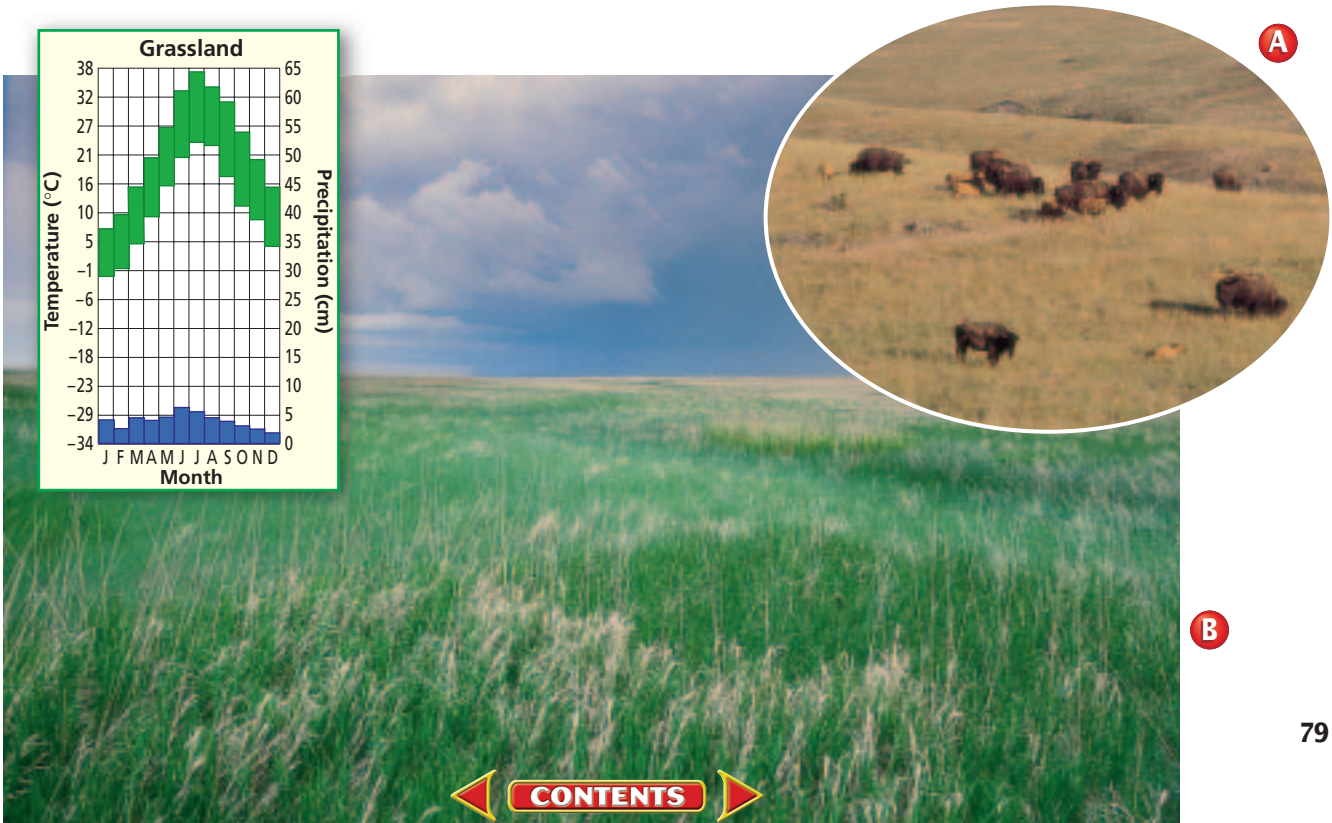

Figure 3.16
The prairies of America support bison as well as many species of large mammals, birds, and insects **(A).** Summers are hot, winters are cold, and rainfall is often uncertain in a temperate grassland **(B).**

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Figure 3.17
There are many types of temperate forests, each characterized by two or three dominant species of trees. Typical trees of the temperate forest include birch, hickory, oak, beech, and maple.

(t)Barbara Cushman Rowell/DRK Photo

Life in the temperate forest

When precipitation ranges from about 70 to 150 cm annually in the temperate zone, temperate deciduous forests, like the one in ***Figure 3.17***, develop. **Temperate** or **deciduous forests** are dominated by broad-leaved hardwood trees that lose their foliage annually. Examples of these trees include maple, oak, birch, elm, and ash.

European settlers cleared vast tracts of temperate forest for farmland and lumber. Since then, secondary succession has restored much of the original forest, especially in the eastern United States.

The soil of temperate forests usually consists of a top layer that is rich in humus and a deeper layer of clay. If mineral nutrients released by the decay of the humus are not immediately absorbed by the roots of the living trees, they may be washed into the clay and lost from the food web for many years.

The animals that live in the temperate deciduous forest, as shown in ***Figure 3.18***, include squirrels, mice, rabbits, deer, and bears. Many birds, such as bluejays, live in the forest all year long, whereas other birds migrate seasonally.

Figure 3.18
Black bears are residents of temperate forests in the United States. Other abundant animals in temperate forests are squirrels and salamanders.

(bl)Jeff Lepore/Photo Researchers , (bc)M.H. Sharp/Photo Researchers, (br)Joe McDonald/Visuals Unlimited

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Life in rain forests

Rain forests are home to more species of organisms than any other biome on Earth. There are two types of rain forests in the world—the temperate rain forest and the more widely known tropical rain forest shown in ***Figure 3.19***. Both are identified by extensive amounts of moisture supplied by rainfall or by coastal clouds and fog. Temperate rain forests are found on the Olympic Peninsula in Washington state and in other places throughout the world, such as South America, New Zealand, and Australia. The huge number of species in rain forests has made their protection an important objective.

As their name implies, **tropical rain forests** have warm temperatures, wet weather, and lush plant growth. These forests are warm because they are near the equator. The average temperature is about 25°C. They are moist because wind patterns drop a lot of precipitation on them. Rain forests receive at least 200 cm of rain annually; some rain forests receive 600 cm.

Why do tropical rain forests contain so many species? The following hypotheses have been proposed by ecologists:

1. Due to their location near the equator, tropical rain forests were not covered with ice during the last ice age. Thus, the communities of species had more time to evolve and greater biodiversity exists.
2. Unlike the temperate forests—where deciduous trees drop their leaves in autumn—the warm weather near the equator gives tropical rain forest plants year-round growing conditions. This creates a greater food supply in tropical rain forests, which can support larger numbers of organisms.
3. Tropical rain forests provide a multitude of habitats and niches for diverse organisms.

One reason for the large number of niches in rain forests is vertical layering. How are these layers, or stories, arranged? Find out by studying ***Figure 3.20*** on the next page. From top to bottom, the three major stories are the *canopy*, *understory*, and *ground* layers. The layers often blend together, but their differences allow many organisms to find a niche.

Most of the nutrients in a tropical rain forest are tied up in the living material. There are very few nutrients held in the soil and most are quickly recycled through complex food webs. The hot humid climate enables ants, termites, fungi, bacteria, and other decomposers to break down dead plants and animals rapidly. Plants must quickly absorb these nutrients before they are carried away from the soil by rain.

Tropical rain forest habitats support a wide variety of plants and animals. This makes them the most species-rich places on Earth.

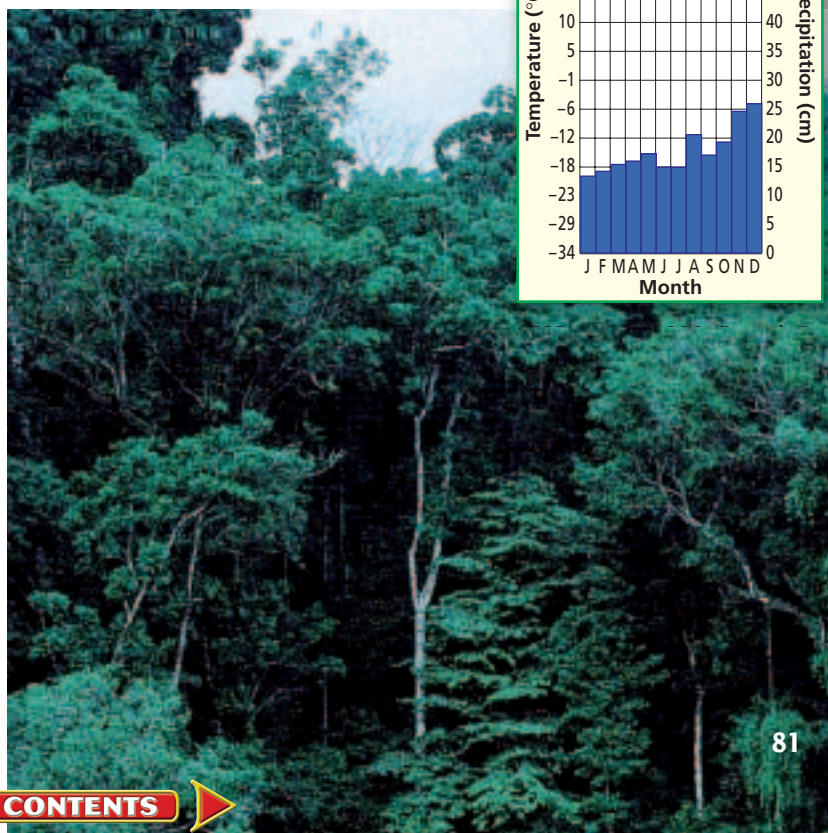

Figure 3.19
Warm temperatures, high humidity, and abundant rainfall allow the growth and great species diversity found in rain forests.

Gregory G. Dimijian/Photo Researchers

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INSIDE STORY

A Tropical Rain Forest

Figure 3.20

In the layers of a tropical rain forest are niches for thousands of species of plants and animals. Ecologists generally consider rain forests to have a storied structure. The illustration shows organisms in a Central American tropical rain forest. **Critical Thinking** ***Research plants and animals in the tropical rain forest. Analyze relationships among organisms. Analyze the interactions that might occur between organisms in the different stories.***

A Canopy The canopy layer, 25–45 meters high, is a living roof. The tree tops are exposed to rain, sunlight, and strong winds. A few giant trees called emergents poke through the canopy. Monkeys frequently pass through. Birds, such as scarlet macaws, live on the fruits and nuts of the trees.

B Understory In the understory, the air is still, humid, and dark. Vines grow from the soil to the canopy. Leaf cutter ants harvest leaves and bring them to the ground. Plants include ferns, broad-leaved shrubs, and dwarf palms. Insects are common in the understory. The limbs of the trees are hung with a thick layer of epiphytes, plants that get most of their moisture from the air. Birds and bats prey upon the insects. Tree frogs are common understory amphibians. Reptiles include chameleons and snakes.

C Ground The ground layer is a moist forest floor. Leaves and other organic materials decay quickly. Roots spread throughout the top 18 inches of soil. There is great competition for nutrients. Mammals living on the ground include rodents and cats, such as the jaguar. Ants, termites, earthworms, bacteria, and fungi live in the soil and quickly decompose organic materials.

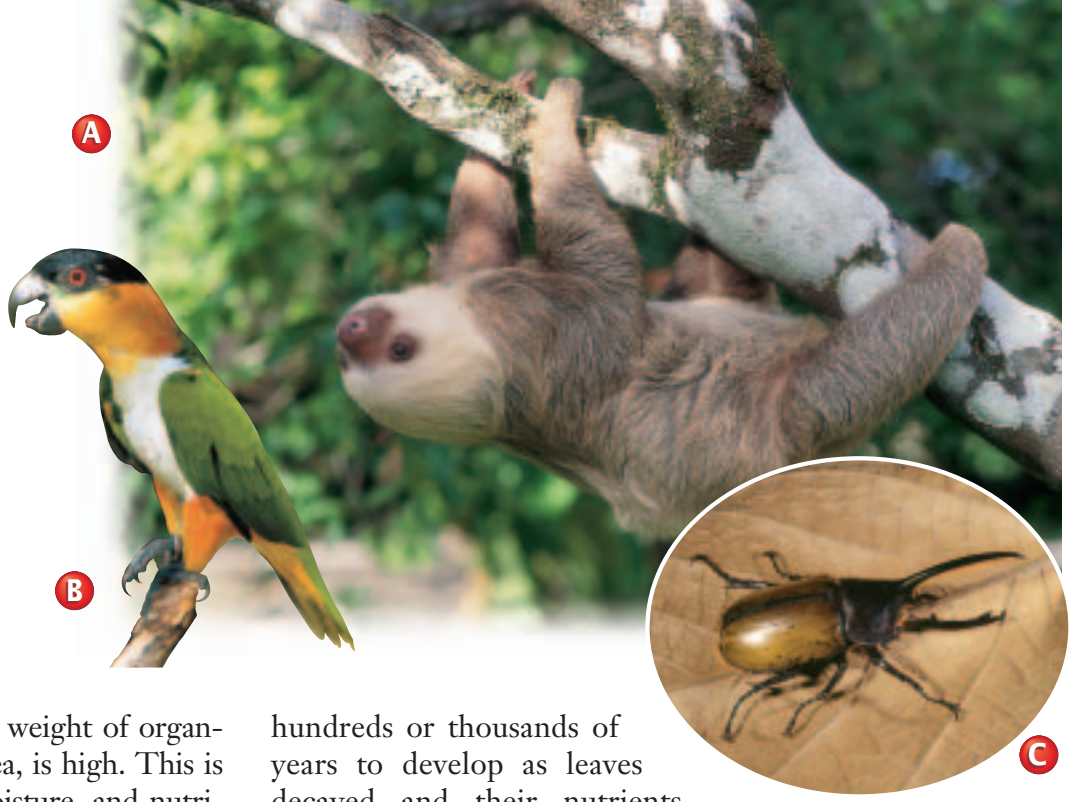

Figure 3.21
Tropical rain forests are rich ecosystems. Sloths **(A)** and other mammals, as well as a multitude of bird species like this black-headed caique **(B),** live in the rain forest canopy. Insects, such as this Hercules beetle **(C),** are numerous in the understory.

Biomass, the total weight of organisms living in the area, is high. This is because sunlight, moisture, and nutrients are available in abundance for plants to convert light energy to chemical energy. This energy is used by the plants and passed to consumers, such as those pictured in ***Figure 3.21.***

Some rain forest plants are important sources of medicinal products and hardwood trees and have provided a source of income for people. Agricultural land is not common in rain forests. The soil there does not convert to cropland easily. In temperate deciduous forests, topsoil has taken hundreds or thousands of years to develop as leaves decayed and their nutrients became part of the soil. In contrast, soils in rain forests do not have substantial amounts of organic matter because leaf matter, which contains nutrients, disappears so quickly. Without organic matter, once rain forest soil is exposed and farmed, it becomes hard, almost brick-like, and nutrient-poor in a matter of a few years. Research is underway to find out how people can manage these lands so that they will be able to obtain the food and products they need.

Section Assessment

Understanding Main Ideas

1. Explain how organisms in the photic and aphotic zones are interdependent.
2. Describe the role of bacteria in maintaining healthy ecosystems. Give examples of where bacteria act in ecosystems.
3. Explain the interactions that take place in a tropical rain forest by describing two or more food chains that you would find there. Then show how these food chains might be part of a larger food web.
4. Describe three variations you would observe as you travel south from a taiga into a temperate forest.
5. Compare the biodiversity of the temperate forest biome with the tropical forest biome.

Thinking Critically

6. In reading before a family trip, George found that the area they were traveling to was cold in winter, hot in summer, and most of the land was planted in fields of wheat. Infer which biome George's family would visit. Explain your choice.

Skill Review

7. **Get the Big Picture** Make a table to show the climate, plant types, plant adaptations, animal types, and animal adaptations for the terrestrial biomes. For more help, refer to *Get the Big Picture* in the **Skill Handbook.**

bdol.glencoe.com/self_check_quiz

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INVESTIGATE

BioLab

Succession in a Jar

FIELD Investigation

Before You Begin

Succession describes the changes that take place in ecosystems over a period of time. Succession is a process that is going on all the time. It can be observed in a micro-ecosystem, such as in a jar of pond water. The type and number of organisms in the container will change over time.

PREPARATION

Problem

Can you observe succession in a pond water ecosystem?

Objectives

In this BioLab, you will:

- **Observe** changes in three pond water environments.
- **Count** the number of each type of organism seen.
- **Determine** if the changes observed illustrate succession.

Materials

small glass jars (3)
labels
sterilized spring water
pond water containing plant material
glass slides and cover glasses
droppers
plastic wrap
cooked white rice
teaspoon, plastic
microscope

Safety Precautions

CAUTION: ***Use safe practices. Always wear goggles during this lab.***

Skill Handbook

If you need help with this lab, refer to the **Skill Handbook.**

Bob Daemmrich

PROCEDURE

1. Examine the pond water sample provided.
2. Label the jars *A*, *B*, and *C*. Add your name and the date. Fill the jars with equal amounts of sterilized spring water.
3. Add the following to the appropriate jar:
   to **Jar *A*:** Nothing else
   to **Jar *B*:** 3 grains of cooked white rice
   to **Jar *C*:** 3 grains of cooked white rice, one teaspoon of pond sediment, and a small amount of any plant material present in the pond water
4. Gently swirl the contents of each jar. Record the cloudiness of each jar in your data table. Score cloudiness on a scale of 1 to 10—1 meaning very clear; 10 meaning very cloudy.

5. Label glass slides *A*, *B*, or *C*. Using a different, clean dropper for each jar, prepare a wet mount of the liquid from each jar. **CAUTION:** ***Handle glass slides, coverslips, and glassware carefully.***
6. Observe each sample under low power. Identify autotrophic and heterotrophic organisms by name, and either describe their appearance or make a sketch of each one.
7. Record the number of each type of organism.
8. Complete the data table for your first observations.
9. Cover each jar and place them in a lighted area.
10. Observe the jars every three days for several weeks. Repeat steps 4–9 each time an observation is made and collect data precisely.
11. **CLEANUP AND DISPOSAL** Determine ahead of time wise choices for disposing of these materials at the end of the investigation. **CAUTION:** ***Wash hands with soap at the end of the lab.***

Data Table

Date	Jar	Cloudiness	Name, Description, or Diagram of Organism Seen	Autotroph or Heterotroph?	Number Seen Per Low-Power Field
	A				
	B				
	C				
	A				
	B				

ANALYZE AND CONCLUDE

1. **Apply Concepts** Which jar was a control? Explain.
2. **Observe and Infer** What is the role of the cooked rice?
3. **Recognize Cause and Effect** Why was there little, if any, cloudiness in jar *A*?
4. **Analyze Information** Describe the changes over time in the number and type of heterotrophs. Was this succession? Was it primary or secondary succession? Explain.
5. **Observe and Infer** Why would you say you had NOT observed a climax ecosystem during this experiment?
6. **ERROR ANALYSIS** Describe variables that could have affected the outcome and how these could be controlled.

Apply Your Skill

Field Investigation Plan and implement a field investigation that tests the effect of temperature on the rate at which succession occurs in pond water. Demonstrate safe practices during the field investigation.

Web Links To find out more more about succession, visit bdol.glencoe.com/succession

connection to literature

Our National Parks

by John Muir

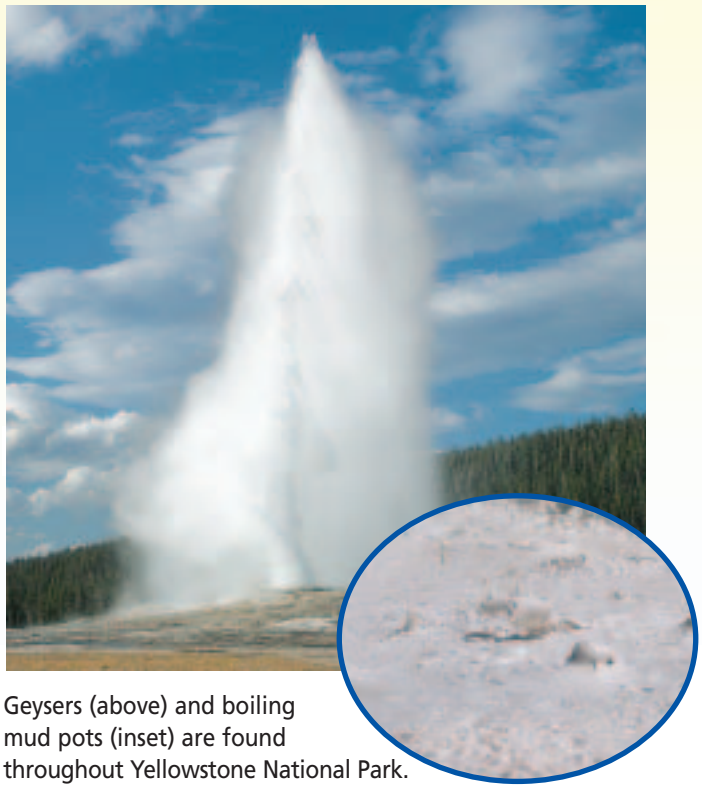
"Many of these pots and caldrons have been boiling thousands of years. Pots of sulphurous mush, stringy and lumpy, and pots of broth as black as ink, are tossed and stirred with constant care, and thin transparent essences, too pure and fine to be called water, are kept simmering gently in beautiful sinter cups and bowls that grow ever more beautiful the longer they are used."

—John Muir

The first, and largest, national park in the world was commissioned by an act of the United States Congress in 1872 as Yellowstone National Park. Because of the writing and influence of a man named John Muir, Congress also created the National Parks System, which includes Yellowstone, to preserve the lands that we enjoy today. In recognition of his contributions, Muir is often called "The Father of our National Park System."

Although it includes waterfalls, a high-elevation lake with one hundred and ten miles of shoreline, and one of the world's largest volcanic craters, Yellowstone National Park is probably most famous for its hot springs and geysers. In fact, more boiling caldrons and spouting plumes of hot water and mud are found in Yellowstone than in all of the rest of the world.

Muir's dream As a young man Muir had a vision of a "wildlands set aside by the government." The purpose of these lands would be simply to preserve the scenery and to educate people about the natural wonders of the land. As an adult, he was an avid explorer and prolific writer whose goals were to educate the public about the value of nature and the destructive effects man had on the natural environment.



Geysers (above) and boiling mud pots (inset) are found throughout Yellowstone National Park.

Muir felt that the beauty of nature was as essential to the well-being of man as was food.

Muir the author In his book, *Our National Parks*, Muir provided his readers with the description of the boiling basins and geysers at Yellowstone that you read above. Over his lifetime, Muir wrote ten books and three hundred articles bringing the idea of wilderness to people. His writings so clearly depicted nature that Muir has been called the United States' most famous and influential naturalist and conservationist.

Writing About Biology

Research Contributions of Scientists In an essay, describe the contributions that Muir made toward expanding people's appreciation of nature.

To find out more about John Muir, Yellowstone National Park, and national parks worldwide, visit bdol.glencoe.com/literature

CONTENTS

Chapter 3 Assessment

Study Guide

Section 3.1

Communities

Key Concepts

- Communities, populations, and individual organisms interact in areas where biotic or abiotic factors fall within their range of tolerance. Abiotic or biotic factors that define whether or not an organism can survive are limiting factors.
- The sequential development of living communities from bare rock is an example of primary succession. Secondary succession occurs when communities are disrupted. Left undisturbed, both primary succession and secondary succession will eventually result in a climax community which can last for hundreds of years.

Vocabulary

climax community (p. 68)
limiting factor (p. 65)
primary succession (p. 67)
secondary succession (p. 68)
succession (p. 67)
tolerance (p. 66)

Section 3.2

Biomes

Key Concepts

- Biomes are large areas that have characteristic climax communities. Aquatic biomes may be marine or freshwater. Estuaries occur at the boundaries of marine and freshwater biomes. Approximately three-quarters of Earth's surface is covered by aquatic biomes, and the vast majority of these are marine communities.
- Terrestrial biomes include tundra, taiga, desert, grassland, deciduous forest, and temperate and tropical rain forests. Latitude influences the angle at which the sun reaches Earth and is a strong factor in determining what a particular biome is like. Two climatic factors, temperature and precipitation, are major limiting factors for the formation of terrestrial biomes.

Vocabulary

aphotic zone (p. 71)
biome (p. 70)
desert (p. 78)
estuary (p. 71)
grassland (p. 79)
intertidal zone (p. 72)
photic zone (p. 71)
plankton (p. 73)
taiga (p. 77)
temperate/deciduous forest (p. 80)
tropical rain forest (p. 81)
tundra (p. 76)

FOLDABLES Study Organizer

To help you review biomes, use the Organizational Study Fold on page 70.

bdol.glencoe.com/vocabulary_puzzlemaker

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Chapter 3 Assessment

Vocabulary Review

Review the Chapter 3 vocabulary words listed in the Study Guide on page 87. Distinguish between the vocabulary words in each pair.

1. photic zone—aphotic zone
2. primary succession—secondary succession
3. taiga—tundra
4. biome—climax community
5. estuary—intertidal zone

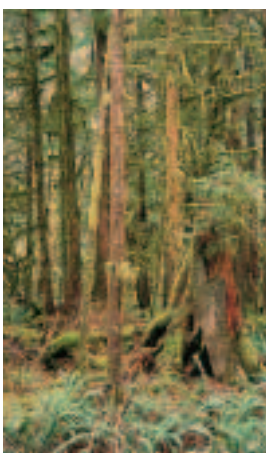
Understanding Key Concepts

6. The removal of which of the following would have the biggest impact on a marine ecosystem?
   A. fishes **C.** shrimp
   B. whales **D.** plankton

7. An undersea volcano erupts, creating a new island in the Gulf of Mexico. Life slowly starts to appear on the island. What would probably be the first species to take hold and survive?
   A. ferns **C.** lichens
   B. finches **D.** grasses

8. The changes in communities that take place on the new island described in question 7 would best be described as _____.
   A. intertidal succession
   B. primary succession
   C. secondary succession
   D. tropical succession

9. The photograph shows a forest in Washington state. The annual rainfall is 300 cm and the average temperature is 15°C. What type of forest is shown?
   A. tropical rain forest
   B. coniferous forest
   C. temperate rain forest
   D. temperate forest



Simon Fraser/Science Photo Library/Photo Researchers

Constructed Response

10. **Open Ended** Select a biome and evaluate the effect of flood on that environment. Use ecological terms in your discussion.

11. **Open Ended** A population of catfish survives in a pond, but does not reproduce there. Discuss what might be happening here in terms of tolerance.

Study the map below to answer question 12.

12. **Open Ended** Describe two limiting factors responsible for the desert biome on the map. How do they affect the biome? What would happen to the biome if one of these factors were to change?

Thinking Critically

13. **REAL WORLD BIOCHALLENGE** Each year, fires occur naturally or are set in forests throughout the United States. Fire ecology is the science that researches the effects of fires on the environment and deals with the management of fire in maintaining healthy forests. Visit bdol.glencoe.com to research various hypotheses about fire management. In class, analyze the strengths and weaknesses of these hypotheses.

14. **Explain** Explain why you travel through several biomes when climbing a tall mountain even though it is located near the equator. Compare the variations in plants from biome to biome.

bdol.glencoe.com/chapter_test

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15. Writing About Biology Beech trees and maple trees dominate a forest that has stayed the same for 100 years. What is the ecological term for this stable community? Explain your choice.

16. Explain Explain why the shallow parts of a lake have more sunlight, produce more oxygen, and have greater species diversity than the deepest part of the lake.

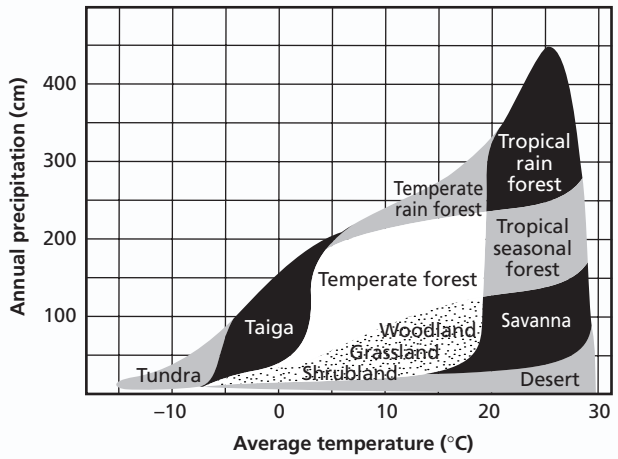
Standardized Test Practice

All questions aligned and verified by The Princeton Review

Part 1 Multiple Choice

Use the table below to answer questions 17 and 18.

Annual Precipitation Versus Temperature



17. According to the graph, which biome would be expected when rainfall ranges between 150 cm/year and 200 cm/year?
- **A.** tropical rain forest
- **B.** grassland
- **C.** tropical seasonal forest
- **D.** savanna

18. Which biome extends across the largest temperature variation?
- **A.** temperate forest
- **B.** taiga
- **C.** grassland
- **D.** desert

Productivity is the amount of biomass generated by producers per unit area in a given period. Use the information below to answer questions 19 and 20 about biome productivity.

Biome Productivity

Biome	Percent of Earth's Surface	Estimated Productivity (grams per meter^2 per year)
Open ocean	65.0	125
Desert	3.5	90
Tropical rain forest	3.3	2000
Taiga	2.4	800
Tundra	1.6	140
Temperate/ deciduous forest	1.3	1250
Swamp/marsh	0.4	2000
Lake/stream	0.4	250
Estuary	0.3	1500

19. Which biomes have the least productivity per square meter per year?
- **A.** desert and tundra
- **B.** open ocean and tundra
- **C.** lake/stream and desert
- **D.** desert and open ocean

20. Which biome occupies the smallest percent of Earth's surface?
- **A.** temperate deciduous forest
- **B.** estuary
- **C.** tundra
- **D.** tropical rain forest

Part 2 Constructed Response/Grid In

Record your answers on your answer document.

21. Open Ended Describe how secondary succession in a forest differs from primary succession after a volcano.

22. Open Ended Explain how a swamp or marsh differs from other aquatic biomes.