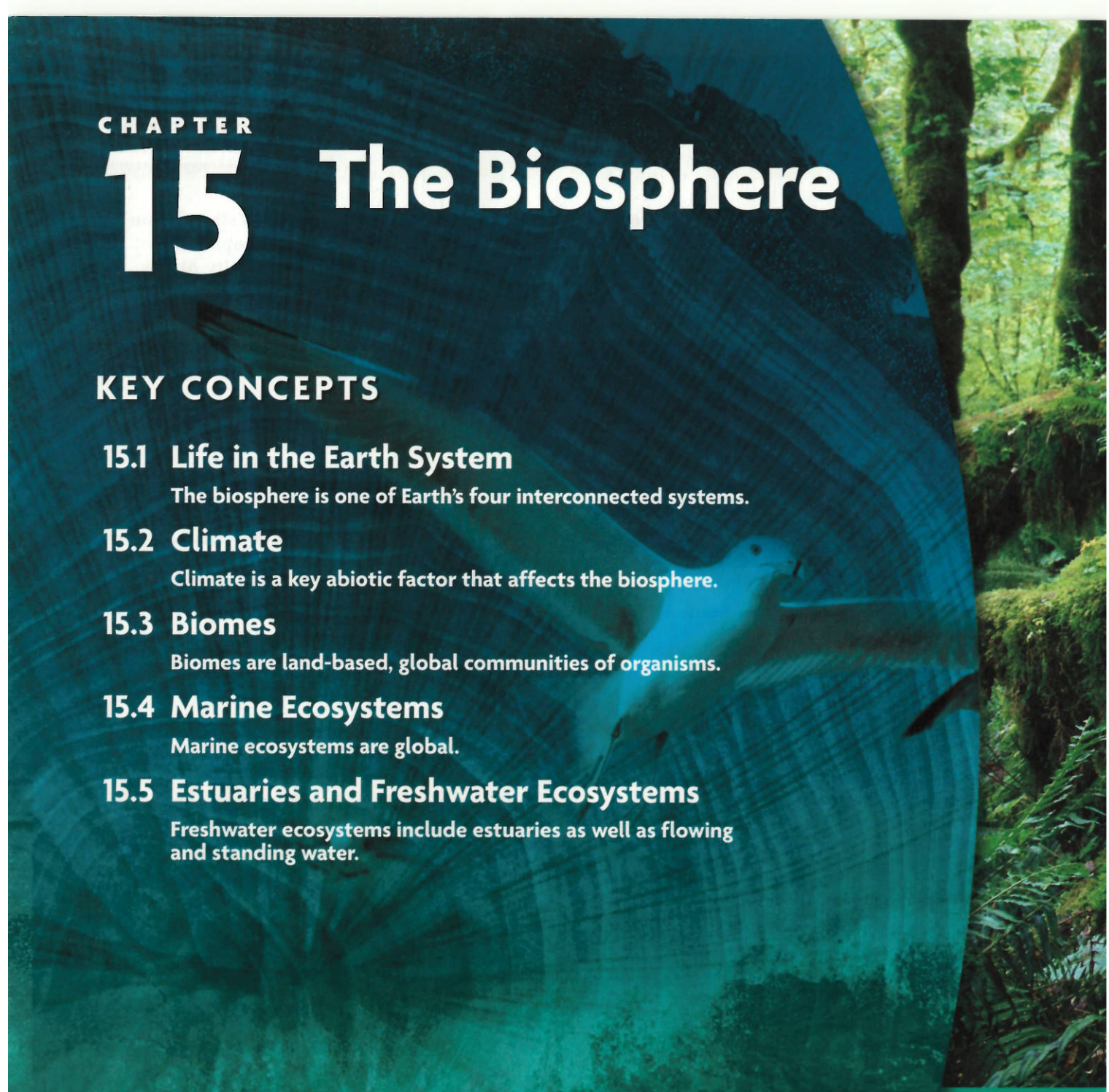
CHAPTER

15 The Biosphere



KEY CONCEPTS

15.1 Life in the Earth System

The biosphere is one of Earth's four interconnected systems.

15.2 Climate

Climate is a key abiotic factor that affects the biosphere.

15.3 Biomes

Biomes are land-based, global communities of organisms.

15.4 Marine Ecosystems

Marine ecosystems are global.

15.5 Estuaries and Freshwater Ecosystems

Freshwater ecosystems include estuaries as well as flowing and standing water.

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STANDARDS-BASED ASSESSMENT

Test Practice
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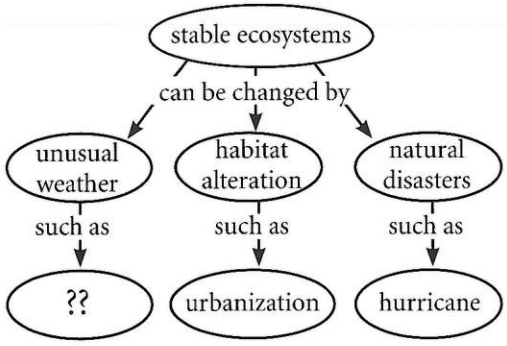
1. Archaeologists find that the disappearance of a large mammal occurred shortly after the arrival of hominids in a certain region. What most likely occurred between these two species?

A dispersion
B predation
C commensalism
D parasitism

2. Officials attempt to control the spread of an exotic wildflower species by introducing its natural predator, a beetle. Unexpectedly, the beetle population grows exponentially and begins to eat local crops. What best accounts for this unexpected population explosion?

A Adaptive radiation allowed the beetle population to evolve faster.
B The beetle population has few predators in the new habitat.
C The wildflower and the local crops are genetically similar kinds of plants.
D The beetle has different nutritional requirements in the new habitat.

3.



Which of these best completes this concept map?

A acid rain
B pollution
C an earthquake
D extended drought

THINK THROUGH THE QUESTION

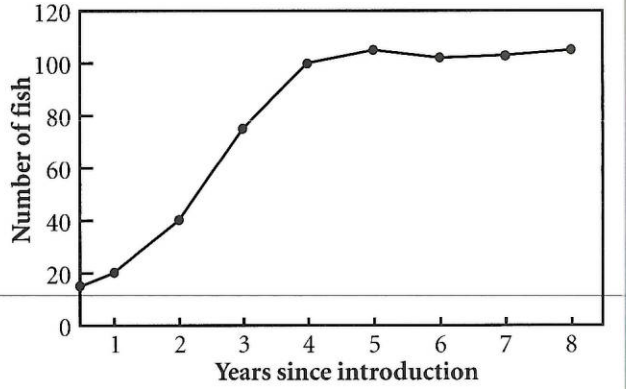
Keep in mind that unusual weather is a natural part of ecosystem function.

4. A population of rodents becomes stranded on a remote island. Eventually, the population reaches the island's carrying capacity. At this point, the birth and death rates are

A relatively equal.
B crashing.
C density independent.
D density dependent.

5.

Fish Population in Birch Park Pond



A fish species is introduced to a park pond. Which statement best describes the population growth of these fish shown in the graph?

A The population stopped growing because the fish stopped reproducing.
B The population stopped growing because this species of fish lives less than one year.
C The population grew until disease caused the population to level off.
D The population grew until it reached the pond's carrying capacity.

6. In many parts of the United States, native plants that once grew on the forest floor have been replaced by garlic mustard, an invasive species that thrives in cool forest understories. This situation is an example of

A parasitism between species.
B primary succession between species.
C predation between species.
D competition between species.

What species would you expect to find in a rain forest?

Connecting CONCEPTS

Not all rain forests are teeming with monkeys and macaws. The temperate rain forest of the Pacific Northwest is inhabited by an entirely different community of plants and animals than is found in tropical rain forests. Location, climatic conditions, and other abiotic factors determine what species you will find in a particular area.

Plant Evolution Ferns, which are abundant in the temperate rain forest, first appeared during the early Carboniferous period (360 to 320 million years ago). These plants diversified before the evolution of flowering plants. Instead of reproducing through pollen, ferns reproduce through spores. The early evolution of ferns makes them among the oldest plants still in existence today.

15.1 Life in the Earth System

KEY CONCEPT The biosphere is one of Earth's four interconnected systems.

MAIN IDEAS

- The biosphere is the portion of Earth that is inhabited by life.
- Biotic and abiotic factors interact in the biosphere.

VOCABULARY

biosphere, p. 456
biota, p. 456
hydrosphere, p. 456
atmosphere, p. 456
geosphere, p. 456

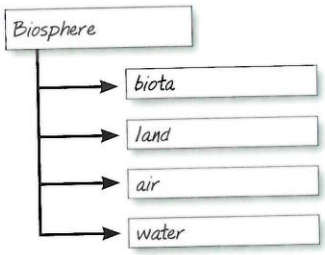
Review
biotic, abiotic

REVIEW AT CLASSZONE.COM

Connect You've probably seen many photos of tropical rain forests, complete with monkeys and brightly colored frogs. But did you know that there are also temperate rain forests? They get just as much rain but have cooler temperatures and different types of plants and animals. These are just two of the biomes found within the biosphere.

TAKING NOTES

Use a diagram to take notes on the biosphere.



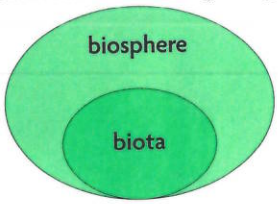
MAIN IDEA

The biosphere is the portion of Earth that is inhabited by life.

The **biosphere** is the part of Earth where life exists. All of Earth's ecosystems, taken together, form the biosphere. If you could remove all the nonliving parts of the biosphere—all the water, air, rocks, and so on—you would be left with the biota. The **biota** is the collection of living things that live in the biosphere.

VISUAL VOCAB

The **biosphere** includes living organisms and the land, air, and water on Earth where living things reside.



The collection of living things in the biosphere may also be called the **biota.**

The biosphere is one of Earth's four major interconnected systems. The other three Earth systems are

- the **hydrosphere,** all of Earth's water, ice, and water vapor
- the **atmosphere,** the air blanketing Earth's solid and liquid surface
- the **geosphere,** the features of Earth's surface—such as the continents, rocks, and the sea floor—and everything below Earth's surface

You need to look at how all four Earth systems interact to really understand how an ecosystem works. For example, a plant growing in a swamp depends on the soil in which it grows just as much as on the water in the swamp. It uses carbon dioxide from the atmosphere to make sugars, and it gives off excess oxygen, slightly changing the air around it. One plant growing in one swamp has a small effect on the Earth system as a whole. But all living things together throughout the planet's history have had a vast effect.

Connect **Is the air in your classroom part of the biosphere or the biota? Explain.**

MAIN IDEA

Biotic and abiotic factors interact in the biosphere.

Just as one ecosystem is connected to another, all four Earth systems are also connected. A change in one sphere can affect the others. If plants are removed from a riverbank, for example, rain may flow more easily from the land to the water. This increased flow would likely carry more sediment and therefore make the river water murkier, as shown in **FIGURE 15.1**. The murky water might block sunlight, affecting the growth of aquatic plants. This change might in turn prevent these plants from taking up carbon dioxide and releasing oxygen.

FIGURE 15.1 Deforestation, or the removal of forests, along the Mahajamba Bay in Madagascar has led to erosion along the waterway, clogging the water with silt and soil.

James Lovelock, an atmospheric scientist from the United Kingdom, proposed the Gaia hypothesis to explain how biotic and abiotic factors interact in the biosphere. This hypothesis considers Earth itself a kind of living organism. Its atmosphere, geosphere, and hydrosphere are cooperating systems that yield a biosphere full of life. He called this living planet Gaia after the Greek goddess of Earth. In the early 1970s, Lynn Margulis, a microbiologist from the United States, added to the hypothesis, specifically noting the ties between the biosphere and other Earth systems. For example, when carbon dioxide levels increase in the atmosphere, plants grow more quickly. As their growth continues, they remove more and more carbon dioxide from the atmosphere. The atmospheric carbon dioxide level drops, and plant growth slows. This give-and-take, known as a feedback loop, helps maintain a fairly constant level of carbon dioxide in the atmosphere.

Sometimes, people mistakenly believe that the Gaia hypothesis suggests that Earth is a thinking being that regulates the geosphere, the atmosphere, and the hydrosphere. This is obviously not the case. Rather, the Gaia hypothesis recognizes the extensive connections and feedback loops between the living and nonliving parts of the planet. Many scientists are now devoting their careers to organizing new fields of study, such as geobiology and geomicrobiology, to examine these intriguing relationships.

Summarize **Explain the Gaia hypothesis in your own words.**

15.1 ASSESSMENT

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REVIEWING MAIN IDEAS

1. What is the relationship between the **biota** and the **biosphere**?
2. How does the Gaia hypothesis explain the interaction between biotic and abiotic factors in the biosphere?

CRITICAL THINKING

3. **Apply** A frog jumps into a pond and it's skin absorbs water. What spheres has the water moved through?
4. **Predict** How might a rise in global temperatures affect the biosphere?

Connecting CONCEPTS

5. **Predator-Prey** Explain how feedback loops, such as those described in the Gaia hypothesis, might apply to predator-prey relationships.

15.2 Climate

KEY CONCEPT Climate is a key abiotic factor that affects the biosphere.

MAIN IDEAS

- Climate is the prevailing weather of a region.
- Earth has three main climate zones.

VOCABULARY

climate, p. 458

microclimate, p. 458

Review
biosphere

REVIEW AT CLASSZONE.COM

Connect Although you might sometimes check the local weather report to see if you'll need an umbrella, you are already familiar with the general climate where you live. If you live in the Midwest, you know that winter means cold temperatures, while if you live in the Southwest, winter temperatures are much milder. The long-term weather patterns of an area help determine which plants and animals you will find living there.

MAIN IDEA

Climate is the prevailing weather of a region.

The weather of an area may change from day to day, and even from hour to hour. In contrast, the **climate** is the long-term pattern of weather conditions in a region. Climate includes factors such as average temperature and precipitation and relative humidity. It also includes the seasonal variations an area experiences, such as rainy or dry seasons, cold winters, or hot summers.

The key factors that shape an area's climate include temperature, sunlight, water, and wind. Among these abiotic factors, temperature and moisture play a large role in the shaping of ecosystems. Descriptions of a specific region's climate take these abiotic factors into consideration. For example, a specific region such as a desert may be described as hot and dry, while a rain forest may be described as warm and moist.

Even within a specific region, climate conditions may vary dramatically. A **microclimate** is the climate of a small specific place within a larger area. A microclimate may be as small as a hole in a decaying log where mushrooms grow, as pictured in **FIGURE 15.2**, or as large as a city neighborhood. San Francisco, for example, is characterized by frequent fog and cool temperatures. However, not far beyond the city limits, and even within other sections of the city itself, the weather may be quite different.

Microclimates can be very important to living things. The same grassy meadow, for example, may be home to both frogs and grasshoppers. The frogs may tend toward areas that are moist, often at the base of the grasses, while the grasshoppers may prefer drier sites and cling to the tops of the grass blades. Each of these locations is a microclimate.

FIGURE 15.2 The cavity in this log provides a humid microclimate that supports the growth of mushrooms.

Analyze **Where in a forest might you find different microclimates?**

MAIN IDEA

Earth has three main climate zones.

Scientists use average temperature and precipitation levels to categorize a region's climate. Using this system, Earth can be divided into three main climate zones, as shown in **FIGURE 15.3.** These three zones are the polar, tropical, and temperate climates. The polar climate is found at the far northern and southern regions of Earth. The tropical zone surrounds the equator. The temperate zone is the wide area in between the polar and tropical zones.

Influence of Sunlight

What determines an area's climate? The answer begins with the Sun. The Sun's rays are most intense, and therefore hottest, on the portion of the planet that sunlight strikes most directly. Earth's surface is heated unevenly due to its curved shape. The area of Earth that receives the most direct radiation from the Sun all year is the region at and around the equator, where the tropical climate zone is found. Near the north and south poles, or polar climate zones, the Sun's rays strike Earth's surface at a lower angle, diffusing their heat over a larger area.

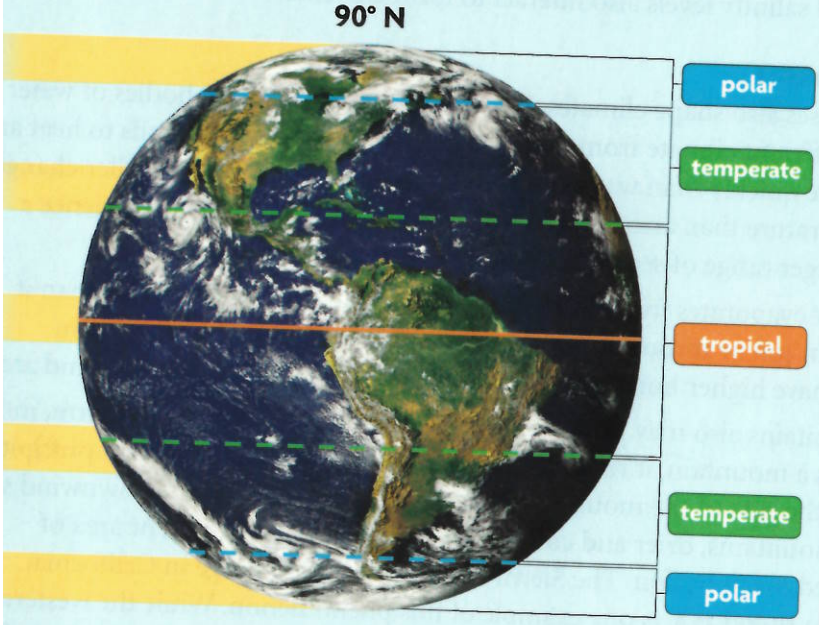
Earth's tilt on its axis also plays a role in seasonal change. As Earth orbits the Sun, different regions of the planet receive higher or lower amounts of sunlight. When the North Pole is at its maximum tilt away from the Sun, it is winter in the Northern Hemisphere and summer in the Southern Hemisphere. When the North Pole reaches its maximum tilt toward the Sun, the opposite is true.

Connecting CONCEPTS

Seasons At the March and September equinoxes, both hemispheres receive equal amounts of sunlight. At the June solstice, the Northern Hemisphere enters summer and the Southern Hemisphere enters winter. The opposite is true at the December solstice.

FIGURE 15.3 Climate Zones

The uneven heating of Earth by the Sun results in three different climate zones.



POLAR CLIMATE

The polar climate zone is located in far northern and far southern reaches of the planet, where the temperature is typically cold and often below freezing.

TROPICAL CLIMATE

The tropical climate zone, which surrounds the equator, runs from the tropic of Cancer to the tropic of Capricorn and is characterized by warm, moist conditions.

TEMPERATE CLIMATE

The temperate climate zone is located in the broad area lying between the polar and tropical climate zones. This zone experiences summer and winter seasons of about equal length.

pply What is the relationship between sunlight and climate zone?

QUICK LAB OBSERVING

Microclimates

Determine the temperature of inside and outside areas of your school to identify different microclimates.

PROBLEM Where are different microclimates in and around your school grounds?

PROCEDURE

1. Identify one place inside and one place outside your school where microclimates may exist.
2. Place a thermometer at each location. Wait at least five minutes before recording the temperature.

MATERIALS

- thermometer
- stopwatch

ANALYZE AND CONCLUDE

Compare the temperatures you collected with those recorded by your classmates at different locations.

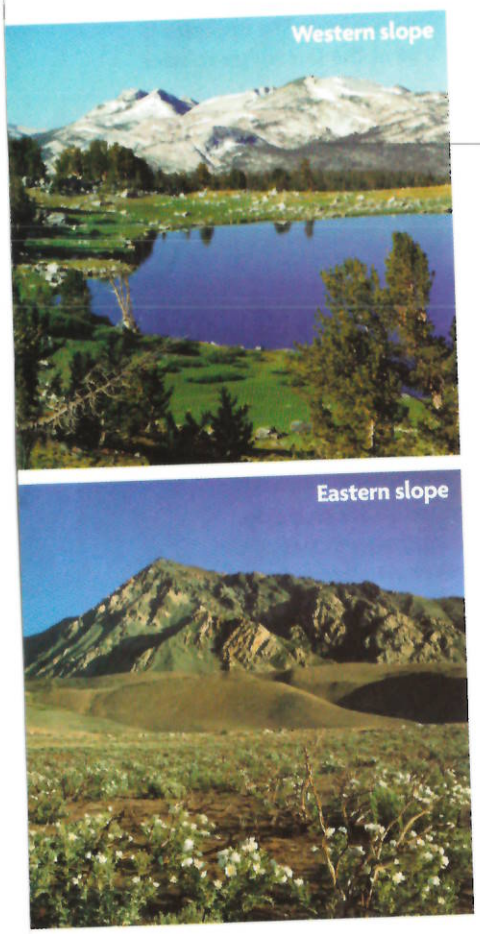


FIGURE 15.4 The western slope of the Sierra Nevada, which faces the prevailing winds, receives precipitation throughout the year. Due to the rain shadow, the eastern slope of the Sierras is much drier.

Air and Water Movement

When the Sun heats Earth, it warms not only the land and the rocks but also the water and the air. This heating causes movements in both water and air. Warm air and warm water are less dense than cooler air and water, and therefore they rise. Since the tropics near the equator are especially warm, the warm air here rises and the cooler air from areas to the north or south moves in to take its place. As the warm air rises, it cools. Since cold air holds less moisture than warm air does, a large amount of precipitation drops as rain. This large amount of precipitation, along with warm temperatures, defines the tropical rain forest regions found near the equator. The movement of air also leads to movement in water, forming currents. The rotation of Earth, water temperatures, and salinity levels also interact to form currents.

Landmasses

Landmasses also shape climates. For example, areas closer to bodies of water have a different climate from areas farther away because land tends to heat an cool more quickly than water. Thus, coastal areas tend to have smaller change in temperature than areas farther inland. Farther inland, areas experience a much larger range of seasonal high and low temperatures.

Water evaporates from open bodies such as lakes or oceans faster than it does from soil or through plant transpiration. As a result, coastal sites in general have higher humidity and receive more precipitation than inland area

Mountains also may have a large effect on an area's climate. As warm, moi air nears a mountain, it rises and cools. This cooling of air results in precipita tion on the side of the mountain range facing the wind. On the downwind si of the mountains, drier and cooler air produces a rain shadow, or area of decreased precipitation. The Sierra Nevada mountain range in California, shown in **FIGURE 15.4**, is one example of this phenomenon. While the western slope receives a large amount of precipitation, the Great Basin to the east of the mountains is dry.

DATA ANALYSIS

CONSTRUCTING COMBINATION GRAPHS

Climatograms are combination graphs that represent weather data for a specific location or biome over a period of time. Refer to the Data Analysis Feature on page 442 to recall what a combination graph looks like.

1. **Graph Data** Plot the average precipitation as a bar graph, and plot the average temperature as a line graph.
2. **Analyze** How would you describe the temperature change throughout the year in this location?
3. **Identify** During which month is the precipitation level lowest for this location?
4. **Analyze** Is there a relationship between temperature and precipitation in Albuquerque, New Mexico? If so, explain how they are related.
5. **Explain** What is the benefit of using a combination graph to illustrate an area's climate?

TABLE 1. AVERAGE CLIMATE IN ALBUQUERQUE, NM

Month	Precipitation (mm)	Temperature (°C)
January	12.4	2.1
February	11.2	5.2
March	15.5	8.9
April	12.7	13.1
May	15.2	18.2
June	16.5	23.8
July	32.3	25.8
August	43.9	24.5
September	27.2	20.6
October	25.4	14.1
November	15.7	6.9
December	12.4	2.3

Source: National Oceanic and Atmospheric Administration

Adaptations to Climate

Many organisms have adaptations that allow them to survive in a specific climate. The water-holding frog shown in **FIGURE 15.5** is a dramatic example. It lives in the dry grasslands and deserts of inland Australia, where the rainy season comes only once a year. Dry periods can last 10 months or more. The frog survives the dry season by burrowing underground, where water evaporates more slowly. Moisture loss is further reduced by a cocoonlike structure formed from the frog's shed skin. When rains soak the ground, the frogs crawl out of their burrows to mate, and the females lay eggs in water puddles that form in depressions along the ground. Within a matter of weeks, the eggs hatch into tadpoles, and the tadpoles change into frogs. This frog must move through its life cycle very quickly because the water evaporates quickly once the rains end. If the tadpoles are not ready to leave the ponds, they will die.

Connect **Describe the climate where you live.**

FIGURE 15.5 Water-holding frogs crawl out of their burrows to mate during the rainy season.

15.2 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. What is the difference between **climate** and weather?
2. What are the three different climate zones, and where are they located?

CRITICAL THINKING

3. **Connect** Where might there be **microclimates** in your area?
4. **Infer** Would areas along the shores of the Great Lakes have warmer summers and colder winters than other inland areas? Explain.

Connecting CONCEPTS

5. **Niches** Would you expect an area with several microclimates to have more or fewer ecological niches? Explain your answer.

15.3 Biomes

KEY CONCEPT Biomes are land-based, global communities of organisms.

MAIN IDEAS

- Earth has six major biomes.
- Polar ice caps and mountains are not considered biomes.

VOCABULARY

canopy, p. 464
grassland, p. 464
desert, p. 464
deciduous, p. 465
coniferous, p. 465
taiga, p. 465
tundra, p. 466
chaparral, p. 466

Review
biome

REVIEW AT CLASSZONE.COM

Connect You wouldn't find a cactus in a tropical rain forest or a penguin in a desert. Individual plant and animal species have adaptations that let them thrive only in certain biomes. In this section, you will learn about the major biomes of the world and the characteristics of each.

MAIN IDEA

Earth has six major biomes.

The global distribution of biomes is shown in **FIGURE 15.6.** Characteristics of each biome are given in **FIGURE 15.7.** As you will see, these broad biome types can be divided into even more specific zones. For example, the grassland biome can be further separated into zones of temperate and tropical grassland.

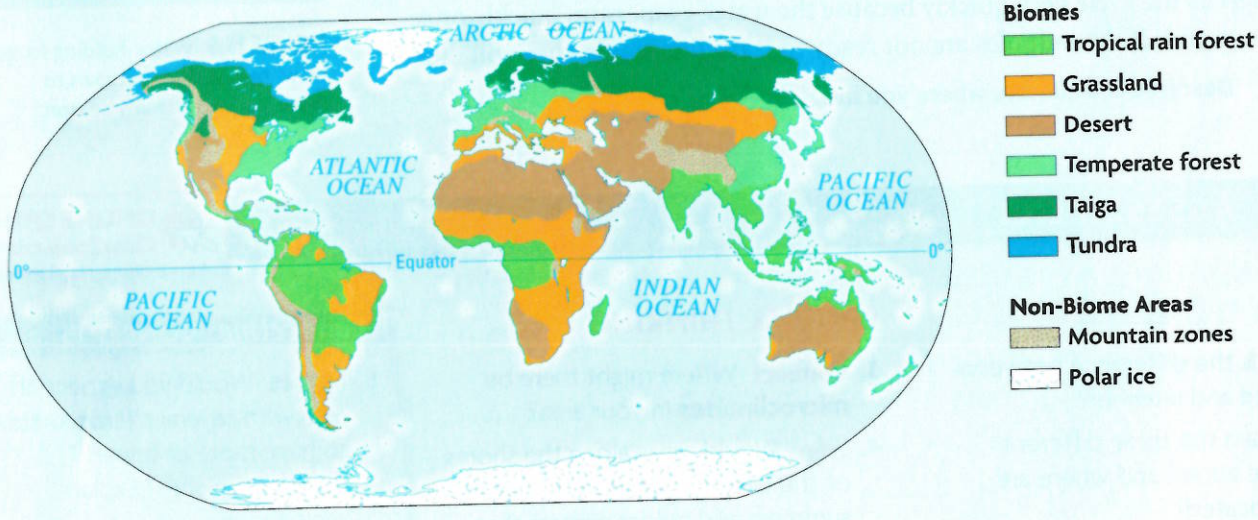
A variety of different ecosystems are found within a biome. However, because a biome is characterized by a certain set of abiotic factors, ecosystems located across the globe in the same biome—the tropical rain forest of Brazil or Madagascar, for example—tend to have similar plant and animal species.

Connecting CONCEPTS

Levels of Organization Recall from **Chapter 13** that a biome is a major community of organisms, usually characterized by the climate conditions and plant communities that live there.

FIGURE 15.6 World Biomes

A biome is defined by its climate and by the plant communities that live there.



Identify **Which biomes are found in North America?**

FIGURE 15.7 Biomes

TROPICAL

Tropical rain forest

- Warm temperatures and abundant rainfall occur all year.
- Vegetation includes lush thick forests.
- Animals that live within the thick cover of the uppermost branches of rain forest trees use loud vocalizations to defend their territory and attract mates.


GRASSLAND

Tropical grassland

- Temperatures are warm throughout the year, with definite dry and rainy seasons.
- Vegetation includes tall grasses with scattered trees and shrubs.
- Hoofed animals, such as gazelles and other herbivores, dominate this biome.


Temperate grassland

- This biome is dry and warm during the summer; most precipitation falls as snow during the winter.
- Vegetation includes short or tall grasses, depending on the amount of precipitation.
- Many animals live below ground to survive the dry and windy conditions in this biome.


DESERT

Desert

- This biome has a very dry climate.
- Plants, such as cacti, store water or have deep root systems.
- Many animals are nocturnal; they limit their activities during the day.


TEMPERATE

Temperate deciduous forest

- Temperatures are hot in the summer and cold in the winter; precipitation is spaced evenly over the year.
- Broadleaf forest dominates this biome, and deciduous trees lose their leaves in the winter.


Temperate rain forest

- This biome has one long wet season and a relatively dry summer.
- Evergreen conifers, which retain their leaves (needles) year-round, dominate this biome.
- While some species remain active in the winter, others migrate to warmer climates or hibernate.


TAIGA

Taiga

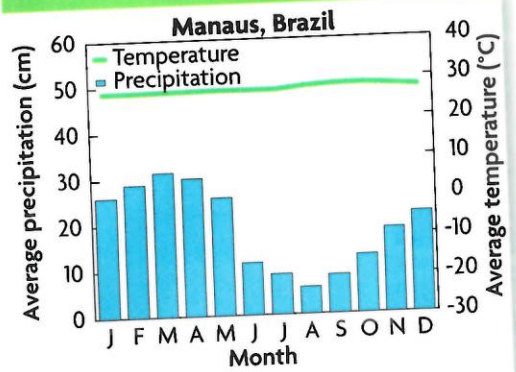
- This biome has long, cold winters and short, warm, humid summers.
- Coniferous trees dominate this biome.
- Mammals have heavy fur coats to withstand the cold winters.


TUNDRA

Tundra

- Subzero temperatures are the norm during the long winter, and there is little precipitation.
- The ground is permanently frozen; only mosses and other low-lying plants survive.
- Animal diversity is low.


TROPICAL RAIN FOREST



Source: World Meteorological Organization

Tropical Rain Forest Biome

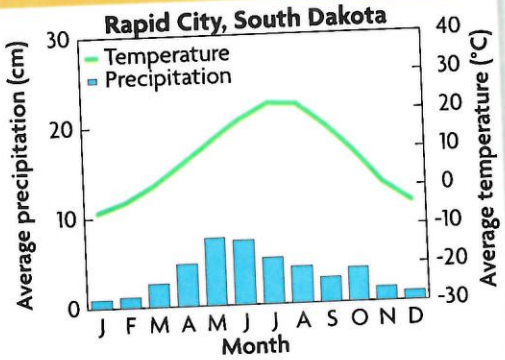
A tropical rain forest has warm temperatures and abundant precipitation throughout most, if not all, of the year. This climate typically produces lush, thick forests that can completely shade the forest floor. The limiting factor for plants that live on the forest floor is sunlight. In fact, as little as 1 percent of the sunlight that strikes the uppermost branches of the trees, called the **canopy,** may make it through to the ground. The soil is very thin and low in nutrients. Most organisms that live in this biome inhabit branches of the upper canopy. Some plants, called epiphytes, grow above the ground on the branches of trees. A few of these, such as some figs, sprout and develop on branches and then send down long lengths of roots that grow into the ground below.

Grassland Biomes

Grassland biomes occur in a variety of climates. A **grassland** is an area where the primary plant life is grass. Tropical grasslands are found in the tropical climate zones of South America, Africa, and Australia. Temperate grasslands are found in the temperate climate zones of South Africa, eastern Europe, and central North America.

Tropical grasslands, also called savannas, are covered with grass plants that may stand 1–2 meters (3–7 ft) in height. Some grasslands have scattered trees or shrubs, but the trees are never as thick and lush as in the tropical rain forests. The limiting factor in the savanna is rainfall. For five months or more each year, precipitation averages at most 10 centimeters (4 in.) a month; often there is much less. During the rainy season, however, water can replenish lakes, rivers, streams, and wetlands and form temporary ponds. This biome is home to plants and animals that have adapted to the extreme shifts in moisture.

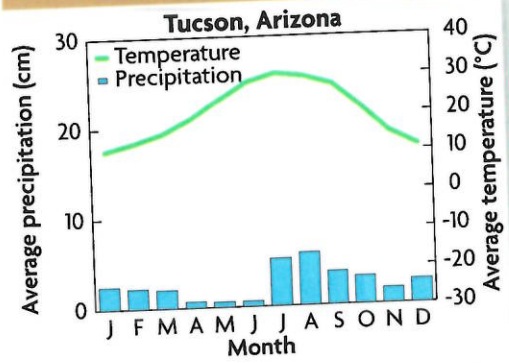
TEMPERATE GRASSLAND



Source: National Oceanic Atmospheric Administration

Temperate grasslands receive 50–90 centimeters (20–35 in.) of annual precipitation, most occurring as rain in the late spring and early summer. Summers may be warm or quite hot, depending on the latitude of the grassland. Under such arid conditions, fast-spreading fires are common. Some plants in temperate grasslands have adapted to fire by producing fire-resistant seeds that require the fire's heat to start germination.

DESERT



Source: National Oceanic Atmospheric Administration

Desert Biome

Desert biomes receive less than 25 centimeters (10 in.) of precipitation annually, and are always characterized by a very dry, or arid, climate. There are four different types of deserts: hot, semiarid, coastal, and cold.

In hot deserts, such as the Sonoran Desert in Arizona, the daily summer temperature may easily top 38°C (100°F). At night, however, the temperature can drop by 10 degrees Celsius or more. During the winter, the temperature may be as low as 0°C (32°F). The precipitation falls as rain in hot deserts.

Semiarid deserts, like hot deserts, have long and dry summers and low amounts of rain in the winter. In comparison with hot deserts, however, temperatures are cooler and rarely exceed 38°C. Coastal deserts are characterized by cool winters followed by relatively long, warm summers. Temperatures range from a maximum of 35°C (95°F) in the summer to –4°C (25°F) in the winter. In cold deserts, such as the Great Basin of the western United States, precipitation falls evenly throughout the year and often occurs as snow in the winter. Summer temperatures range between 10°C (50°F) at night to 24°C (75°F) during the day, and winter temperatures can drop below freezing.

Plants use a variety of strategies to survive a desert's heat and lack of moisture. The reduced surface area of a cactus's spines helps it to retain more water by avoiding moisture loss from transpiration. Many desert plants have the ability to conserve or store water over a long period of time. Some desert plants, such as mesquite, have extremely long root systems that absorb water by reaching down to the water table. Desert plants also have heat- and drought-resistant seeds.

Contrast **How do rainfall amounts differ in deserts and in tropical rain forests?**

Temperate Forest Biomes

A key feature of temperate biomes is their distinguishable seasons. The growing season occurs during the warmer temperatures from mid-spring to mid-fall and depends upon the availability of water.

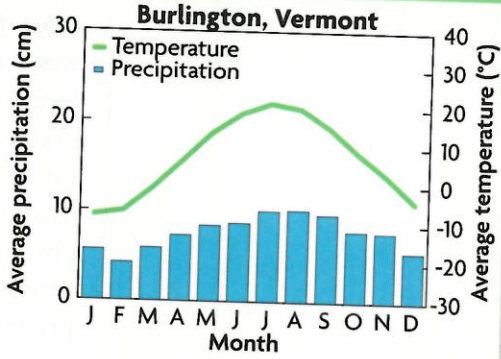
The **temperate deciduous forest** typically receives about 75–150 centimeters (30–59 in.) of precipitation spread over the entire year as rain or snow. This biome is characterized by hot summers and cold winters. **Deciduous** trees have adapted to winter temperatures by dropping their leaves and going dormant during the cold season. Trees, such as oaks, beeches, and maples, along with shrubs, lichens, and mosses, make up the main vegetation.

The **temperate rain forest** does not receive precipitation evenly spaced across the year. Instead, it has one long wet season and a relatively dry summer, during which fog and low-lying clouds provide the needed moisture. Precipitation in the temperate rain forest averages over 250 centimeters (98 in.) per year. Evergreen conifers, such as spruces, Douglas firs, and redwoods, dominate this biome. **Coniferous** trees retain their needles all year. Mosses, lichens, and ferns are plant species found on the forest floor.

Taiga Biome

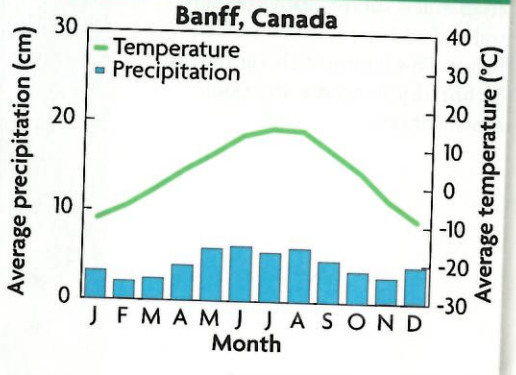
The **taiga** (TY-guh), also known as the boreal forest, is located in cooler climates. Winters are long and cold, often lasting six months or more. The average winter temperature is below freezing. Summers are short, typically with only two to three months of frost-free days. However, they may be quite humid and warm, sometimes reaching 21°C (70°F). Precipitation in the taiga is 30–85 centimeters (12–33 in.) per year, which is similar to that in the arid temperate grasslands. Coniferous forest is dominant in the taiga.

TEMPERATE FOREST

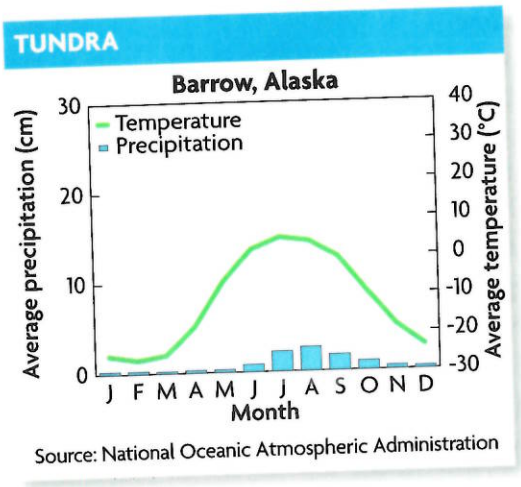


Source: National Oceanic Atmospheric Administration

TAIGA



Source: Environment Canada



Tundra Biome

Often described as bleak, the **tundra** is located beyond the taiga in far northern latitudes. Winter lasts as long as 10 months a year. The average winter temperature is below freezing. The ground below the surface is always frozen. This frozen ground is known as permafrost. Summers last just 6 to 10 weeks. Precipitation is meager, averaging less than 13 centimeters (5 in.) annually.

In addition to limited precipitation, permafrost captures and holds moisture, making very little available to plants. Therefore, the tundra is quite barren. Only mosses, other tiny, low-lying plants, and a few scattered shrubs are able to survive. Trees and most flowering plants do not grow here.

Minor Biomes

In addition to the six major biomes, there are also some other biomes that occur globally, but on a smaller scale. One example is chaparral, shown in **FIGURE 15.8.** **Chaparral** (SHAP-uh-RAL), also called Mediterranean shrubland, is characterized by its hot, dry summers and cool, moist winters. Over the year, temperatures in the chaparral range from 10°C (50°F) to 40°C (104°F). Annual precipitation ranges from 38–102 centimeters (15–40 in.), and occurs mostly during the winter as rain. The dominant plants in the chaparral are small-leaved evergreen shrubs. This biome is found in small areas across the globe, including the central and southern coast of California in the western United States, the coast of Chile in South America, the Mediterranean Sea coast in Europe, the southern and western coasts of Australia, and the south-western tip of South Africa. Because of the fairly hot climate, the plants in this biome exhibit some of the same adaptations to heat as those found in the desert biome. Many plants have shallow root systems that let them take in as much water as possible when it rains. The leaves of shrubs have thick cuticles that help in water retention. Many plant species, such as sage and rosemary, give off a strong smell. These aromatic oils are also highly flammable, and promote fire. As in temperate grasslands, chaparral plants have adapted to the presence of fire, and some plants need fire in order for their seeds to germinate.

Connect **What biome includes the area where you live?**

FIGURE 15.8 In the United States, chaparral is found along the central and southern coasts of California. This biome is characterized by hot, dry summers and cool, moist winters.

MAIN IDEA

Polar ice caps and mountains are not considered biomes.

Polar ice caps are ice-covered areas that have no soil and do not have a specific plant community. In mountains, the climate and the animal and plant communities change depending on elevation. Because of these characteristics, polar caps and mountains are not categorized as biomes.

Polar ice caps occur around the poles at the top and bottom of Earth. In the Northern Hemisphere, the polar ice cap includes parts of Greenland and permanently frozen portions of the Arctic Ocean and surrounding islands. In the Southern Hemisphere, the polar ice cap includes the glacier-covered continent of Antarctica. At the ice caps, ice and snow cover the surface all year. Very few plants or fungi are able to survive the harsh conditions found in the polar regions. Some species found in Antarctica include mosses and lichens. Most animals in this region depend on the sea for their food. Animals such as polar bears, shown in **FIGURE 15.9**, have layers of fat that keep them warm in the cold polar conditions. Different animals are found in the northern and southern polar regions. For example, polar bears are found only in the north, while penguins are found only in the south.

FIGURE 15.9 A polar bear's thick layer of fat, or blubber, keeps it well insulated from the cold as it rests on an ice floe or swims in Arctic waters to catch food.

Mountains are often rich with life. Different communities of species have adapted to the variety of ecosystems found at different mountain elevations. As you move up a mountain, the different communities that you see are similar to the biomes found in different latitudes across the globe. For example, you may begin a hike in a grassland at the base of the mountain, continue upward through a coniferous forest, and finally reach a desolate tundralike zone at the mountain's top. While the life zones found on mountains are similar across biomes, their species of plants and animals differ as a result of the different abiotic factors that shape each biome.

Summarize **Explain why neither polar ice caps nor mountains are considered**

15.3 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. List and describe the six major biome types.
2. What are some characteristics of mountains and polar ice caps?

CRITICAL THINKING

3. **Predict** How might stopping fires change a temperate **grassland**?
4. **Infer** Polar bears have white fur but black skin underneath. Consider the climate in which the bears live. What might be the adaptive advantage of the bears' black skin?

Connecting CONCEPTS

5. **Animal Behavior** Male birds that migrate the earliest to their summer nesting sites can usually secure the best territories. What limiting factor keeps birds from arriving too early in the **taiga**?

15.4 Marine Ecosystems

KEY CONCEPT Marine ecosystems are global.

MAIN IDEAS

- The ocean can be divided into zones.
- Coastal waters contain unique habitats.

VOCABULARY

intertidal zone, p. 468
neritic zone, p. 468
bathyal zone, p. 469
abyssal zone, p. 469
plankton, p. 469
zooplankton, p. 469
phytoplankton, p. 469
coral reef, p. 470
kelp forest, p. 470

REVIEW AT CLASSZONE.COM

Connect If you've ever been to the ocean, you are already familiar with some ocean zones. If you walked on the beach at the edge of the surf, you were in the intertidal zone. If you went into the water, you were swimming in the neritic zone. In this section, you will learn about these and other zones that divide the ocean. You will also read about the unique habitats found along the ocean's coasts.

MAIN IDEA

The ocean can be divided into zones.

The oceans are a global expanse of water containing a large variety of living things that dwell from coastline shallows to the great depths of the deep-sea vents.

FIGURE 15.10 Organisms that live in tidal pools, such as this one off the Washington coast, are adapted to habitats with constantly changing salt and moisture levels.

Ocean Zones

Scientists use several systems to divide the ocean into different zones. The simplest division of the ocean separates the water of the open sea, or pelagic zone, from the ocean floor, which is called the benthic zone.

The presence of light is also used to differentiate between areas of the ocean. The photic zone is the portion of the ocean that receives plentiful sunlight. In contrast, the aphotic zone refers to the depths of the ocean where sunlight does not reach.

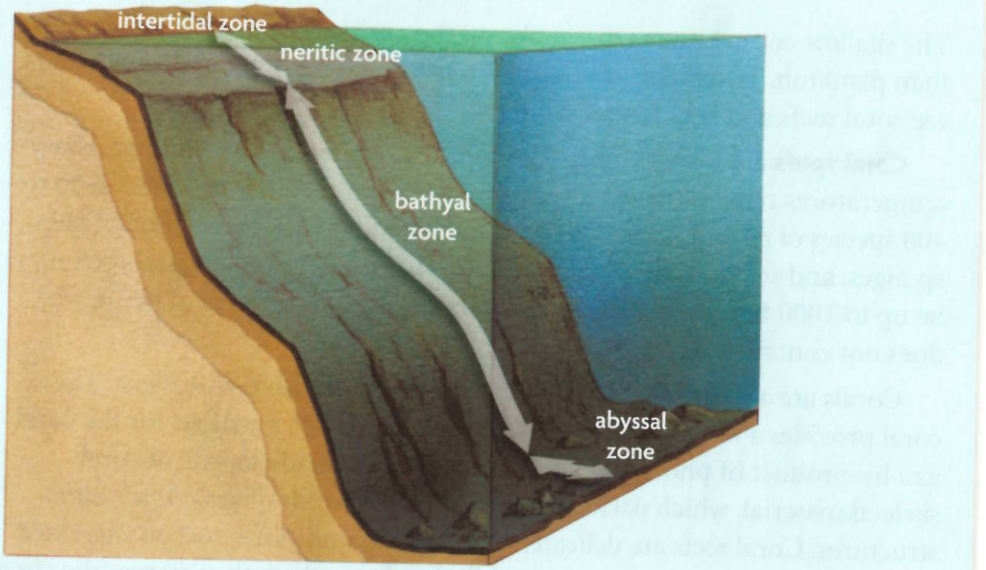
In a third system, as shown in **FIGURE 15.11**, the ocean is separated into zones using distance from the shoreline and water depth as dividing factors.

The **intertidal zone** is the strip of land between the high and low tide lines. If you have ever walked on the beach, you have been in the intertidal zone. Organisms in this zone, such as those that inhabit tidal pools, must tolerate a variety of conditions that result from changing water levels. Organisms must contend with changes in temperature, amount of moisture, and salinity. The sea anemone, for example, opens up when underwater during high tide. It avoids drying out during low tide by closing up.

The **neritic zone** (nuh-RIHT-ihk) extends from the intertidal zone out to the edge of the continental shelf. The depth of the neritic zone may range from a few centimeters at low tide to more than 200 meters deep.

FIGURE 15.11 Ocean Zones

The ocean is divided into four major zones.



The **bathyal zone** (BATH-ee-uhl) extends from the edge of the neritic zone to the base of the continental shelf. The bathyal zone lies between the depths of 200 and 2000 meters. This zone is characterized by water that is turbid, or murky, due to the accumulation of silt. Fish that have adapted to living in areas of high pressure live in the bathyal zone. Burrowing animals thrive in this zone.

The **abyssal zone** (uh-BIHS-uhl) lies below 2000 meters and is in complete darkness. While deep-sea vents support a large number of organisms, the total number of species found in this zone is much smaller than the number found in the neritic zone. Since there is no light, photosynthetic organisms do not exist. Chemosynthetic organisms are the base of the food webs at the deep-sea vents. Many organisms that live in the abyssal zone make their own light, much as a firefly produces its glow. This light is often used to attract mates and prey.

VOCABULARY

In the word *bathyal*, the prefix *bathy-* comes from a Greek word meaning "deep." In the word *abyssal*, the word part *abyss* comes from a Greek word meaning "bottomless."

Life in the Neritic Zone

Although the neritic zone represents less than one-tenth of the total ocean area, it contains 40 times more biomass than the rest of the ocean. Much of the biomass consists of organisms called plankton. **Plankton** are tiny free-floating organisms that live in the water. These organisms include both animals and protists. **Zooplankton** is another term for animal plankton. **Phytoplankton** are photosynthetic plankton, which include microscopic protists such as algae.

Marine phytoplankton, especially blue-green algae and other types of algae, are critical to life on the planet. These organisms carry out the bulk of photosynthesis on Earth, and therefore provide most of the oxygen. According to many estimates, 70 percent or more of the oxygen in every breath you take can be traced back to marine phytoplankton. In addition to their role in oxygen production, phytoplankton also form the base of the oceanic food web.

Hypothesize **What other adaptations might organisms have in the abyssal zone?**

Connecting CONCEPTS

Invertebrates Some invertebrates, such as sea stars and lobsters, are plankton during their larval stage. You will learn more about the life stages of invertebrates in **Chapter 23.**

MAIN IDEA

Coastal waters contain unique habitats.

FIGURE 15.12 Ecologists are working to rebuild coral reef ecosystems by building artificial reefs, such as this network of cables, onto which corals can adhere.

NSTA SCILINKS
scilinks.org
To learn more about coral reefs, visit scilinks.org.
Keycode: MLB015

The shallow coastal waters that make up the neritic zone contain much more than plankton. Two highly diverse habitats found within these coastal waters are coral reefs and kelp forests.

Coral reefs are found within the tropical climate zone. In this area, water temperatures remain warm all year. A single coral reef may be home to 50 to 400 species of corals, along with hundreds of other species, including fishes, sponges, and sea urchins. Studies indicate that the biomass in coral reefs may be up to 1000 times greater than the biomass in a similar area of ocean that does not contain a reef.

Corals are animals that have a mutualistic relationship with algae. The coral provides a home for the algae, and algae provide nutrients for the coral as a by-product of photosynthesis. Coral reefs are made mostly of coral skeletal material, which packs together over thousands of years into solid structures. Coral reefs are delicate. A change in conditions, such as increased water temperature or pollution, can kill the algae, which then starves the coral. With global ocean temperatures on the rise, coral reefs are in decline around the world.

Ecologists are trying to reintroduce these diverse communities in some areas by making artificial reefs, shown in **FIGURE 15.12**, where organisms can find shelter. In addition, some shipwrecks and sunken oil rigs have become artificial reefs that can support fishes and other species associated with coral reefs.

In contrast to coral reefs, **kelp forests** exist in cold, nutrient-rich waters, such as those found in California's Monterey Bay. These forests are composed of large communities of kelp, a seaweed. Kelp grows from the ocean floor up to the water's surface, sometimes extending up to a height of over 30 meters (about 100 ft). Kelp forests are areas of high productivity that provide habitat and food sources to many marine species ranging from tiny invertebrates to large mammals, such as sea lions.

Compare **What are the similarities between coral reefs and kelp forests?**

15.4 ASSESSMENT

ONLINE QUIZ
ClassZone.com

REVIEWING MAIN IDEAS

1. What criteria do scientists use to divide the ocean into different zones?
2. What conditions account for the development of highly diverse habitats in coastal waters?

CRITICAL THINKING

3. **Connect** A red tide occurs when a bloom of **plankton** causes a reddish discoloration of coastal ocean waters. What might cause such an increase in plankton populations?
4. **Predict** What might organisms that inhabit the **abyssal zone** eat?

Connecting CONCEPTS

5. **Food Webs** How might the disappearance of coastal habitats affect an oceanic food web?

15.5 Estuaries and Freshwater Ecosystems

KEY CONCEPT Freshwater ecosystems include estuaries as well as flowing and standing water.

MAIN IDEAS

- Estuaries are dynamic environments where rivers flow into the ocean.
- Freshwater ecosystems include moving and standing water.
- Ponds and lakes share common features.

VOCABULARY

estuary, p. 471
watershed, p. 473
littoral zone, p. 474
limnetic zone, p. 474
benthic zone, p. 474

Review
ecosystem

REVIEW AT CLASSZONE.COM

Connect You rely on aquatic ecosystems more than you might realize. Many of the fish and shellfish that you might eat depend, at least for a part of their lives, on estuaries. But more importantly for you, freshwater ecosystems provide the water that you need to survive.

MAIN IDEA

Estuaries are dynamic environments where rivers flow into the ocean.

An **estuary** is a partially enclosed body of water formed where a river flows into an ocean. The San Francisco and Chesapeake bays are estuaries. So are the Louisiana bayous, Florida Bay in the Everglades, and many other harbors, sounds, and inlets around the world.

The distinctive feature of an estuary is the mixture of fresh water from a river with salt water from the ocean. The river carries high levels of nutrients from inland areas. The tidal movements of water in the ocean also bring in large volumes of organic matter and a variety of marine species from the ocean. Large numbers of species thrive in this rich mixture of fresh water and salt water.

Estuaries are highly productive ecosystems, on a level comparable to tropical rain forests and coral reefs. Photosynthetic organisms thrive in estuaries throughout the year, providing the basis for the aquatic food web. Estuaries also have thriving detritivore communities that decompose the enormous amounts of dead plant and animal matter that build up in the estuary's waters. These decomposers return vital nutrients back to the ecosystem. Estuaries also provide the necessary habitat for a number of endangered and threatened species. For example, the brown pelican, the Morro Bay kangaroo rat, and a plant called the Morro manzanita are all threatened or endangered species that depend on the Morro Bay estuary in California, shown in **FIGURE 15.13.**

FIGURE 15.13 An estuary occurs where a river flows into the ocean. Estuaries are high in biodiversity and provide habitat for a number of different species.

FIGURE 15.14 The Tejo Estuary in Portugal is an important stopover point for migratory birds such as these greater flamingos.

Connecting CONCEPTS

Keystone Species Recall from **Chapter 13** that a keystone species is a species that has a large effect on its ecosystem. Migratory birds in the Delaware Bay depend on horseshoe crab eggs as a main food source. This dependence illustrates the importance of the horseshoe crab in its estuarine ecosystem.

Estuary Characteristics

The large number of phytoplankton and zooplankton in an estuary support a variety of species. Populations of fish and crustaceans depend on plankton as their primary food source. In turn, birds and other secondary consumers eat fish and crustaceans. Humans also rely on estuaries as a food source. In fact, 75 percent of the fish we eat depend on estuary ecosystems, making estuaries an important resource for the commercial fishing industry.

Estuaries provide a protected refuge for many species. Reefs and barrier islands along an estuary's boundary with the ocean protect estuary species from storms and the ocean's strong currents and waves. In an estuary's calm waters, many aquatic species lay eggs, and their young mature there before venturing into the ocean. The use of estuaries as spawning grounds explains why these areas are often called nurseries of the sea. Estuaries are also a key part of the migration paths of many bird species, as shown in **FIGURE 15.14.** Birds rely on estuaries as a refuge from the cold weather that occurs in the northern parts of their range during certain parts of the year.

Changing conditions in estuaries present challenges for species that live there. For example, in order to withstand changing salinities, some organisms have glands that remove the excess salt that builds up in their bodies. This adaptation helps organisms cope with an estuary's changing salinity level. Salt levels may lower with the tide and during periods of drought or heavy rainfall

Threats to Estuary Ecosystems

Estuaries are made up of a variety of ecosystems, including salt marshes, mud flats, open water, mangrove forests, and tidal pools. When estuaries are lost to land development and other human activities, these ecosystems and the organisms that live within them are also lost.

The removal of estuaries also makes coastal areas more vulnerable to flood damage from catastrophic storms such as hurricanes. Estuaries act as a buffer between the ocean and coastal land. In some coastal areas of the United States, over 80 percent of the original estuary habitat has been lost to land development.

Analyze What characteristics make an estuary such a productive ecosystem?

MAIN IDEA

Freshwater ecosystems include moving and standing water.

Rivers and streams are the flowing bodies of fresh water that serve as paths through many different ecosystems. Rivers and streams, along with lakes and ponds, originate from watersheds. A **watershed** is a region of land that drains into a river, a river system, or another body of water.

Freshwater Ecosystems

If you have ever paddled down a river in a canoe, you have probably witnessed the change in shoreline ecosystems, perhaps with a forest along one stretch and sand dunes along another. Along its course, a river may vary in many ways. For example, the speed of its flow is greater in narrow areas than in wide ones. The river bottom may be alternately sandy, gravel-covered, or rock-strewn. The water level may differ across seasons. In some areas, spring brings about the melting of snow and causes river water levels to rise. Humans also affect water levels by damming rivers or by draining water for irrigation or drinking water.

Unlike rivers and streams, wetlands have very little water flowing through them. A wetland is an area of land that is saturated by ground or surface water for at least part of the year. Bogs, marshes, and swamps are different types of wetlands that are identified by their plant communities. Common wetland plants include cattails, duckweed, and sedges.

Like estuaries, wetlands are among the most productive ecosystems on Earth. They provide a home for a large number of species, some of which are only found in wetlands. Wetlands also help maintain a clean water supply. A wetland filters dirty water and renews underground stores of water.

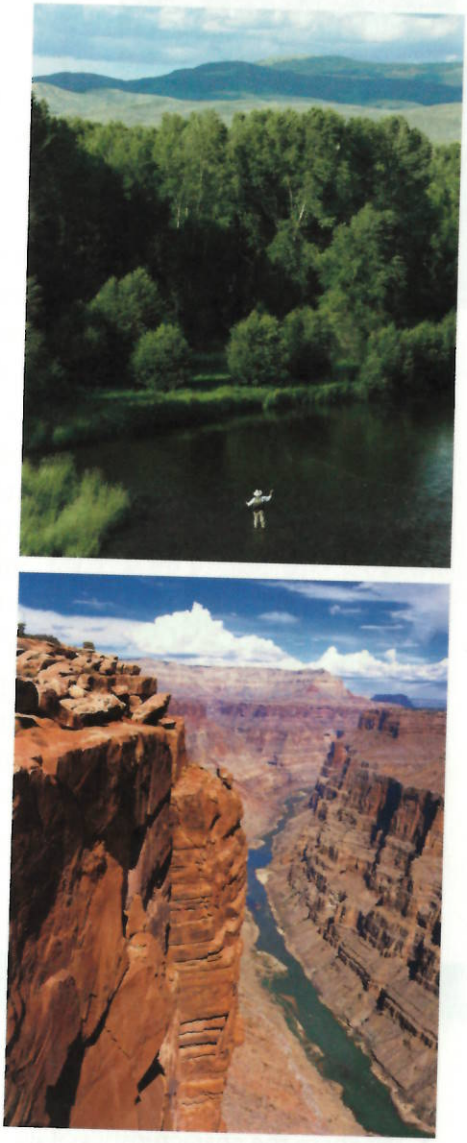


FIGURE 15.15 As the Colorado River travels southward from Colorado to Mexico, it flows through different ecosystems, including forests and deserts.

Adaptations of Freshwater Organisms

The particular variety of freshwater organisms found in a body of water depends on a number of factors. These factors include water temperature, oxygen levels, pH, and the water flow rate. Each type of freshwater ecosystem is home to species with adaptations suited to its conditions. In fast-moving rivers, for example, trout are adapted to swim against the current. They have streamlined bodies that can slice through the water easily. Some aquatic insects, such as the stonefly, have hooks on their bodies. The stonefly uses the hooks to attach itself to a solid surface in fast-running water to avoid being swept away. Similarly, tadpoles that live in fast-running water often have sucker mouths that they use to attach to a surface while feeding. These tadpoles also have streamlined bodies with long tails and low fins that help them to move in the fast water. Tadpoles that live in pools or in slower moving water often lack sucker mouths and have more rounded bodies and higher fins.

redict **What effect would the construction of a dam have on a river ecosystem?**

MAIN IDEA

Ponds and lakes share common features.

Animated BIOLOGY
Watch how the water and nutrients in a lake turn over at ClassZone.com.

FIGURE 15.16 In the spring and fall, the water in a lake turns over, bringing nutrients from the bottom of the lake to the top.

Although they are much smaller in size than oceans, freshwater ponds and lakes are also divided into zones. Scientists use the terms *littoral, limnetic,* and *benthic* to identify and separate these zones.

- The freshwater **littoral zone** is similar to the oceanic intertidal zone, and it is located between the high and low water marks along the shoreline. The waters of the littoral zone are well-lit, warm, and shallow. A diverse set of organisms, including water lilies, dragonflies, and snails, live in this zone.
- The **limnetic zone** (also called the pelagic zone) refers to the open water located farther out from shore. This zone is characterized by an abundance of plankton communities, which support populations of fish.
- The **benthic zone** is the lake or pond bottom, where less sunlight reaches. Decomposers, such as bacteria, live in the mud and sand of the benthic zone.

During the summer and the winter, the water temperature within a lake is stratified, which means that different layers of the lake have different temperatures. In the summer, water is warmer near the surface and colder at the bottom of the lake. These warm and cold regions are separated by a thin zone called the thermocline.

All of the water within a lake "turns over" periodically. This happens because water is most dense at 4°C (39°F). When water reaches this temperature, it will sink beneath water that is either warmer or cooler. In autumn, colder air temperatures cool the surface layer of water to 4°C, causing it to sink and mix with the water underneath. During the winter, the surface layer of water cools to less than 4°C. In the spring, when the surface water warms to 4°C, it sinks and mixes with the layers of water below. In both autumn and spring, the underlying water flows upward and switches places with the surface water. This upwelling brings nutrients such as bits of decaying plants and animals from the benthic zone to the surface, where they are eaten by surface-dwelling organisms.

Analyze **What is the significance of lake turnover to the lake ecosystem?**

15.5 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. What are the characteristics of an **estuary** ecosystem?
2. What abiotic factors might affect a river ecosystem?
3. How is a lake different from the ocean? How is it the same?

CRITICAL THINKING

4. **Compare and Contrast** How are coastal wetlands different from and similar to estuaries?
5. **Predict** If an oil spill wipes out most of the producers in an estuary, how might the food web in the surrounding area be affected?

Connecting CONCEPTS

6. **Adaptation** Many fish species and other aquatic animals have colorations that closely resemble the rocks or silt found on the bottom of their aquatic habitat. What types c ecological advantages might such an adaptation give an aquatic species?

Winter Water Chemistry

Seasonal changes in temperature cause changes in lake ecosystems and the organisms that live there. Chemical cycles can vary from winter to summer, and the presence of ice on the surface of a lake also can alter oxygen levels. In this lab, you will design an experiment that models the conditions of lake water in the summer and in the winter. You will collect data from both models to determine how a layer of surface ice can affect lake water chemistry.

MATERIALS

- 2 plastic bowls
- sample water and sediment
- 500 mL beaker
- Elodea leaves
- wax paper
- plastic food wrap
- large rubber band
- warm water bath
- cold water bath
- 2 thermometers
- dissolved oxygen kits
- pH strips

PROCESS SKILLS

- **Designing Experiments**
- **Collecting Data**
- **Analyzing Data**

PROBLEM How does a layer of winter ice affect the chemistry of lake water?

DESIGN YOUR EXPERIMENT

1. Using the materials listed, design an experiment to determine differences between lake water chemistry in winter conditions and in summer conditions. Keep in mind that dissolved oxygen and pH are two variables that are influenced by lake surface ice.
2. Write a procedure to explain how you will set up your experiment, and which variable you will test. Identify a control group and experimental group, the data you will collect, and how often you will collect it.
3. Have your experimental design approved by your teacher.
4. Design a table to organize your results.
5. Conduct your experiment.

ANALYZE AND CONCLUDE

1. **Graph Data** Determine the best way to present how the variable in the experimental group changed over time. Determine whether you should draw a line graph or a bar graph, and then construct that type of graph.
2. **Analyze Data** How did the variable in each experimental group change over time? Why did these changes occur? What differences occurred between the two set-ups? What accounts for these differences?
3. **Experimental Design** What discrepancies exist between your simulation of summer and winter water conditions and real conditions? How might these discrepancies affect your results?
4. **Communicate** Discuss your results with other groups. Are the trends in their results similar to yours? If not, compare your experimental designs. Can any differences in experimental design or procedure account for differences in results? As a class, discuss what factors in this experiment are most important to obtaining accurate results.
5. **Apply** Review your data. How would the changes in the chemistry of the water affect aquatic organisms?

EXTEND YOUR INVESTIGATION

Design an experiment in which you would track the changes in these variables in a real lake over a year. Include information on how you would measure the effects of the changes on the organisms living in the lake. What other variables, besides dissolved oxygen and pH, would you want to track as part of this experiment?

Use these inquiry-based labs and online activities to deepen your understanding about the biosphere.

INVESTIGATION

Modeling Biomes

You have already learned about the characteristics of Earth's different biomes, including temperature ranges and how much water and light they receive. In this lab, you will model several biomes.

SKILL Modeling

PROBLEM What types of plants grow in certain biomes?

MATERIALS

- cardboard container
- scissors
- stapler
- plastic or aluminum tray
- sandy soil
- potting soil
- 30 wheatgrass seeds
- 10 lima bean seeds
- 5 sunflower seeds
- permanent marker
- masking tape
- water
- light source
- refrigerator
- metric ruler

PROCEDURE

1. Choose two of the following biomes to model: desert, grassland, or tropical rain forest.
2. Choose which soil you will use in each biome and which seeds you will plant in each. Decide how much light and water each biome will receive each day. Determine how you will measure which type of plant grows in each biome.
3. Determine what type of data you need to collect and how often you need to collect it; construct a data table to record the data you collect.

ANALYZE AND CONCLUDE

1. **Analyze** How did seed growth differ between the biomes? Which seeds were the most and least successful? Under which conditions did these situations occur?
2. **Experimental Design** What other variables could you control to make your model biomes as realistic as possible?
3. **Synthesize** How would you model an aquatic biome such as a wetland or a lake?

INVESTIGATION

Heating and Cooling Rates of Water and Soil

Water and soil have many different qualities. One quality is the rate at which each substance heats up and cools down. In this lab, you will compare the heating and cooling rates of water and soil.

SKILL Comparing

MATERIALS

- marker
- 2 clear plastic cups
- ruler
- soil
- water at room temperature
- 2 thermometers
- lamp

PROBLEM What are the heating and cooling rates of water and soil?

PROCEDURE

1. Mark a line 3 centimeters from the bottom of each cup. Fill one cup to the line with water and the other with soil.
2. Design a table in which to record your data.
3. Place a thermometer into the contents of each cup. Allow the thermometer to sit in each cup for 3 minutes, then take an initial temperature reading. Record your data in your data table.
4. Put the cups side by side under a lamp. Do not allow the lamp bulb to touch the water. Keep all electrical cords away from the water. After 15 minutes, record the temperature in each cup.
5. Turn off the lamp and move the cups away from the lamp to simulate shade. After 15 minutes, record the temperature in each cup.

ANALYZE AND CONCLUDE

1. **Analyze Data** Which substance had the faster rate of heating? Which had the faster rate of cooling?
2. **Apply** How do the heating and cooling rates of water and soil affect aquatic and land ecosystems?
3. **Connect** How do the differences in heating and cooling rates affect climates of coastal cities?

Online BIOLOGY
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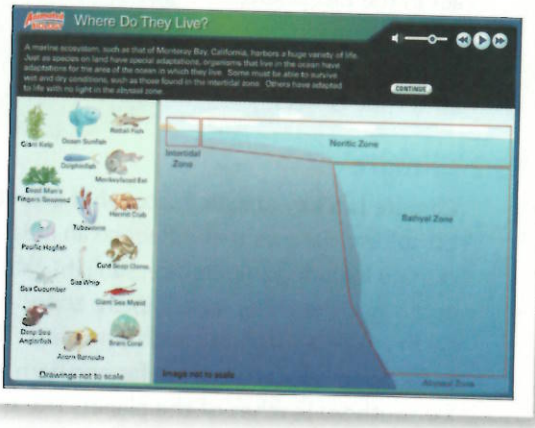
ANIMATED BIOLOGY

Where Do They Live?

Species have adapted to life in specific ocean zones. Use their adaptations as well as other clues to place organisms in the appropriate ocean environments.



WEBQUEST

In this chapter you read overviews of the major ecosystems on Earth. Use this WebQuest to focus on one ecosystem and dig further. Explore the organisms, geology, soils, climate, and other characteristics specific to that environment. Then compare that ecosystem with your observations of the one in which you live.

DATA ANALYSIS ONLINE

Amphibians are found all over the world, but they are not evenly distributed. Some areas have many more types of amphibians than others. Graph the number of known amphibian species by region and analyze the distribution.

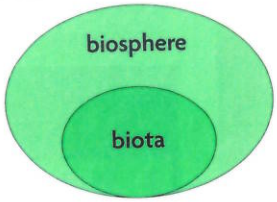
CHAPTER 15

Interactive Review @ CLASSZONE.COM

KEY CONCEPTS | Vocabulary Games | Concept Maps | Animated Biology | Online Quiz

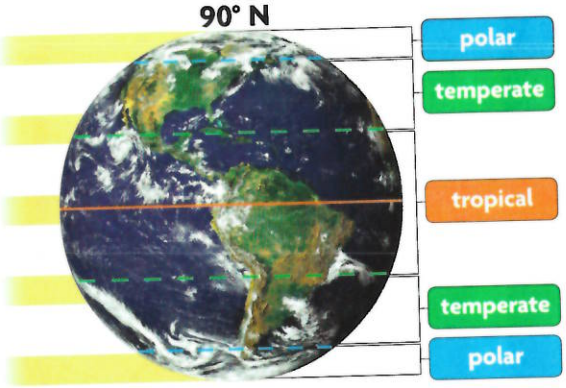
15.1 Life in the Earth System

The biosphere is one of Earth's four interconnected systems. The biosphere includes living organisms, called the biota, and the land, air, and water on Earth where the biota live. Biotic and abiotic factors interact in the biosphere, and a change in one Earth system can affect the others.



15.2 Climate

Climate is a key abiotic factor that affects the biosphere. Factors that influence an area's climate include temperature, sunlight, water, and wind. The three main climate zones on Earth are polar, tropical, and temperate. The polar zone is located at the far northern and far southern reaches of the planet. The tropical zone surrounds the equator. The temperate zone is located in the broad area between the polar and tropical zones.

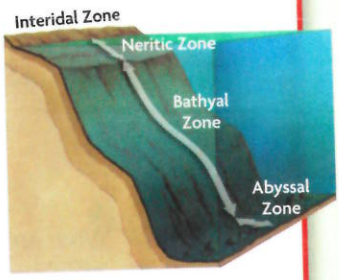


15.3 Biomes

Biomes are land-based, global communities of organisms. Earth has six major biomes. These biomes include tropical rain forest, grassland, desert, temperate forest, taiga, and tundra. Polar ice caps and mountains are not considered biomes.

15.4 Marine Ecosystems

Marine ecosystems are global. Scientists use different criteria to separate the ocean into different zones. One system separates the ocean into zones using distance from the shoreline and water depth as dividing factors. The neritic zone contains 40 times more biomass than the open ocean. Coral reefs are found in the warm, shallow waters of the tropical climate zone. Kelp forests thrive in cold, nutrient-rich waters.

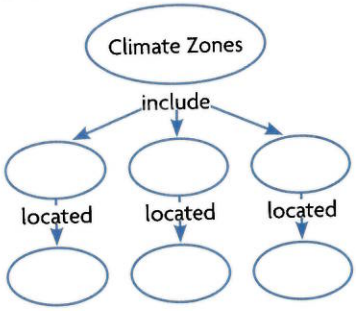


15.5 Estuaries and Freshwater Ecosystems

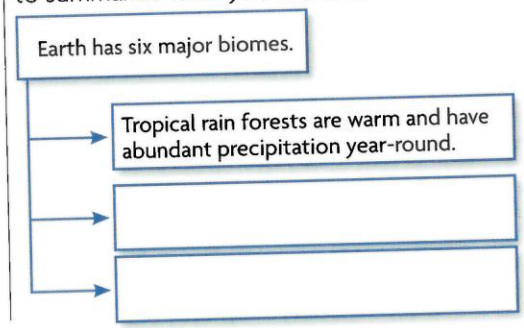
Freshwater ecosystems include estuaries as well as flowing and standing water. An estuary is a partially enclosed body of water that exists where a river flows into an ocean. A variety of organisms are adapted to the constant change in salinity found in an estuarine ecosystem. Freshwater ecosystems include rivers and streams, wetlands, and lakes and ponds.

Synthesize Your Notes

Concept Map Use a concept map to summarize what you know about climate zones.



Supporting Main Ideas Use a diagram like the one below to summarize what you know about biomes.



Chapter Assessment

Chapter Vocabulary

15.1 biosphere, p. 456
biota, p. 456
hydrosphere, p. 456
atmosphere, p. 456
geosphere, p. 456

15.2 climate, p. 458
microclimate, p. 458

15.3 canopy, p. 464
grassland, p. 464
desert, p. 464
deciduous, p. 465
coniferous, p. 465
taiga, p. 465
tundra, p. 466
chaparral, p. 466

15.4 intertidal zone, p. 468
neritic zone p. 468
bathyal zone, p. 469
abyssal zone, p. 469
plankton, p. 469
zooplankton, p. 469
phytoplankton, p. 469
coral reef, p. 470
kelp forest, p. 470

15.5 estuary, p. 471
watershed, p. 473
littoral zone, p. 474
limnetic zone, p. 474
benthic zone, p. 474

Reviewing Vocabulary

Compare and Contrast

Describe one similarity and one difference between the two terms in each of the following pairs.

1. biosphere, biota
2. zooplankton, phytoplankton
3. hydrosphere, atmosphere
4. climate, microclimate
5. taiga, tundra
6. neritic, intertidal
7. kelp forest, coral reef

Greek and Latin Word Origins

8. The term *plankton* comes from the Greek word *planktos,* which means "wandering." Explain how this meaning relates to plankton.

9. The term *climate* comes from the Greek word *klima,* which means "surface of the earth." Explain how this meaning relates to the definition of *climate.*

10. The term *estuary* comes from the Latin word *æstus,* which means "tide" or "surges." Using this meaning, explain how it relates to what an estuary is.

11. The term *littoral* comes from the Latin word *litoralis,* meaning "shore." Explain how this meaning relates to the definition of *littoral zone.*

12. The term *deciduous* comes from the Latin word *decidere,* which means "to fall off." How is this meaning related to the definition of *deciduous?*

Reviewing MAIN IDEAS

13. Explain the difference between the terms *biota, biosphere,* and *biome.*

14. After a forest fire wipes out plants growing on a hill, rainwater washes soil down into a stream, and the stream fills with silt. In this example, what are the interactions between biotic and abiotic factors?

15. If the temperature in an area drops five degrees between one day and the next, has the climate of the area changed? Explain.

16. What is the connection between sunlight, the curved shape of Earth, and Earth's three main climate zones?

17. Earth has six major biomes—tropical rain forest, grassland, desert, temperate forest, taiga, and tundra. Why are two different deserts, each on a separate continent, considered to be the same biome?

18. Why are polar caps and mountains not considered biomes?

19. Briefly compare the four ocean zones—intertidal, neritic, bathyal, and abyssal—based on their distance from the shoreline and their water depth.

20. Where, in terms of water depth, would you expect to find a coral reef? a kelp forest?

21. Estuaries occur where rivers flow into the ocean. What conditions in estuaries make them suitable as nurseries for organisms that live out in the open ocean as adults?

22. The ecosystem of a river upstream in the mountains and downstream in a valley can be very different. Describe the adaptations of an upstream organism and an organism that lives downstream in the same river.

Critical Thinking

23. Apply A deer drinks water from a stream, and then later it breathes out some of the water as vapor into the air. Through which three Earth spheres has this water moved?

24. Infer How would Earth's three main climate zones be different if Earth's axis were not tilted in relation to the Sun? (**Hint:** The tropical climate zone would likely be the most similar to how it is now.)

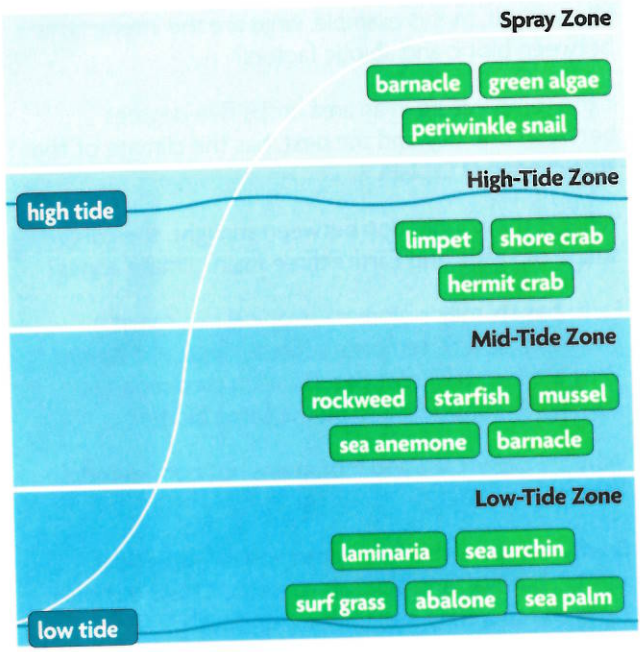
25. Infer Do you think it is possible for a biome to change from one type into another? Explain a situation in which this might happen.

26. Connect Why does the health of an entire coral reef ecosystem depend on algae?

27. Analyze Describe two reasons why it is critical to protect estuary ecosystems.

Interpreting Visuals

Use the diagram of a rocky intertidal zone to answer the next three questions.



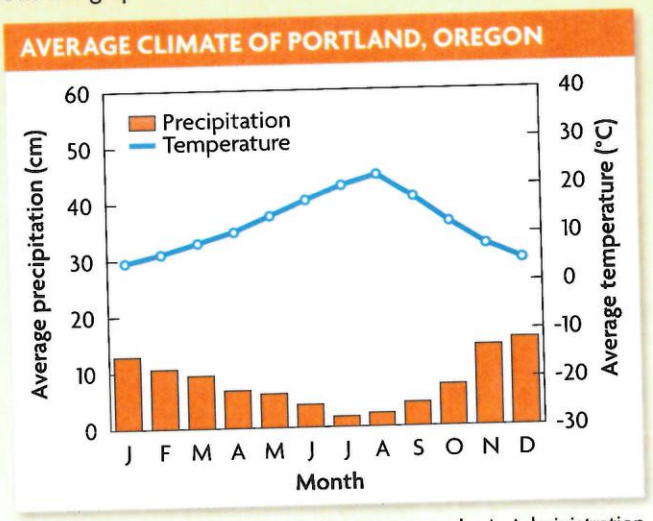
28. Predict How do you think the organisms above the high-tide mark are able to obtain the water they need to survive?

29. Compare What adaptations are necessary for a species to survive in the spray zone compared with a species in the low-tide zone?

30. Hypothesize Why do you think there aren't any fish shown in the diagram? Why wouldn't fish be a major part of the rocky intertidal zone?

Analyzing Data

Below is a climatogram for the city of Portland, Oregon. Use the graph to answer the next four questions.



Source: National Oceanic Atmospheric Administration

31. Analyze Which month receives the highest amount of rain? the highest temperature?

32. Summarize Describe in one or two sentences the climate of Portland throughout the year.

33. Analyze A family is planning to vacation in Portland. Many of their planned activities occur outdoors. If they wish to avoid rain, in which month should they travel?

34. Connect Based on the data in the graph, which biome is Portland a part of? Explain your choice.

Connecting CONCEPTS

35. Write a Policy The majority of the wetlands in the United States have been drained and used for development. A company has submitted a proposal to purchase an area of 100 acres of wetland that it plans to develop. If you were an official in the area, how would you respond to this proposal? What would you say to a local environmental group that opposes the proposal? What might be a possible compromise? Use information from the chapter to convince your fellow elected officials to take your position.

36. Synthesize Reread the information about the temperate rain forest at the beginning of the chapter. Using your knowledge of climate, biomes, and evolution, explain why different species are found in temperate and tropical rain forests.