Chapter 1

Biomes and ecosystems are divisions of the biosphere.

This famous photograph of Earth was taken in 1972 during the *Apollo 17* space mission to the moon. Never before had humans been able to obtain such a clear picture of a completely illuminated face of Earth. Since *Apollo 17* was the last voyage of humans to the moon, no person has been able to take such a photograph again. Today, similar images of Earth are created from data received from satellites. Known as the Blue Marble photograph, this image is thought to have greatly influenced the environmental movement and deeply affected how people view their relationship to the biosphere.

The **biosphere** is the thin layer of air, land, and water on or near Earth's surface in which all living things on Earth exist. Scientists have estimated that the total number of different living species on Earth may range from 3 million to 100 million, but the current estimate is about 13 million. If an apple represented Earth, the biosphere would be the thickness of the apple's peel.

What You Will Learn

In this chapter, you will

- **describe** the factors that influence the characteristics and distribution of biomes on Earth
- **identify** biotic and abiotic characteristics of biomes and ecosystems
- **explain** the interaction of biotic and abiotic components in biomes and ecosystems
- **relate** plant and animal adaptations to environmental conditions in biomes and ecosystems
- **understand** the biotic interactions among populations and communities in ecosystems

Why It Is Important

The interaction of biotic and abiotic components in the environment determines the distribution of life on Earth and the health of ecosystems. Biotic interactions between organisms influence the survival rates of populations. Understanding these relationships gives us a better understanding of the impact of human activities and natural events on ecosystems.

Skills You Will Use

In this chapter, you will

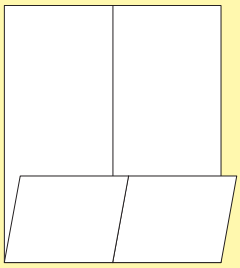
- **construct** a climatograph
- **graph** predator-prey relationships

FOLDABLES™
Reading & Study Skills

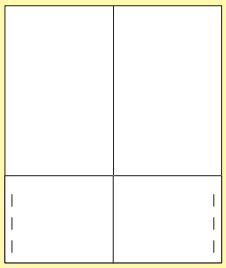
Make the following Foldable and use it to take notes on what you learn in Chapter 1.

STEP 1 Using an 28 cm by 43 cm piece of paper, **make** a hotdog fold. **Crease** the edge.

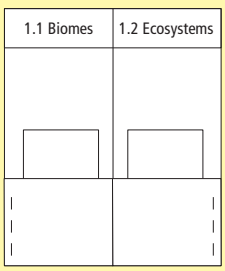
STEP 2 **Open** the paper and **fold** the short side of the paper upward to create a 10 cm tab. **Crease** this edge.



STEP 3 **Staple** or glue the outer edges of the 10 cm tab to create a pocket.



STEP 4 **Fold** the top edge of the paper down by 5 cm, **crease**, and **unfold** to create a heading space for the two-column chart. **Label as shown**.



Organize As you read this chapter, use your Foldable to store work and notes. In the columns, list biotic and abiotic components found in biomes and ecosystems. Use index cards or quarter sheets of notebook paper to record information, define terms, describe specific biomes, and explain different relationships and interactions found within ecosystems.

1.1 Biomes

Biomes are the largest divisions of the biosphere. The large regions within biomes have similar biotic and abiotic components. The interaction of these components determines the characteristics of biomes. Temperature and precipitation are the main abiotic factors that influence the distribution of biomes and the organisms within them. Organisms have adaptations for survival in the specific environmental conditions of their biome.

Words to Know

abiotic
adaptation
biome
biotic
climate
climatograph

If you were to walk in the forest shown in Figure 1.1, you might think you were walking in a rainforest on Vancouver Island. The winters here are warm and have large amounts of rainfall. This forest has many tall evergreen trees under which a variety of ferns and mosses grow in the shade.

If you were on this bridge, you would actually be walking in a rainforest on New Zealand's South Island. If you were walking on the bridge in Figure 1.2 on the next page, you would be walking in a rainforest on Vancouver Island.

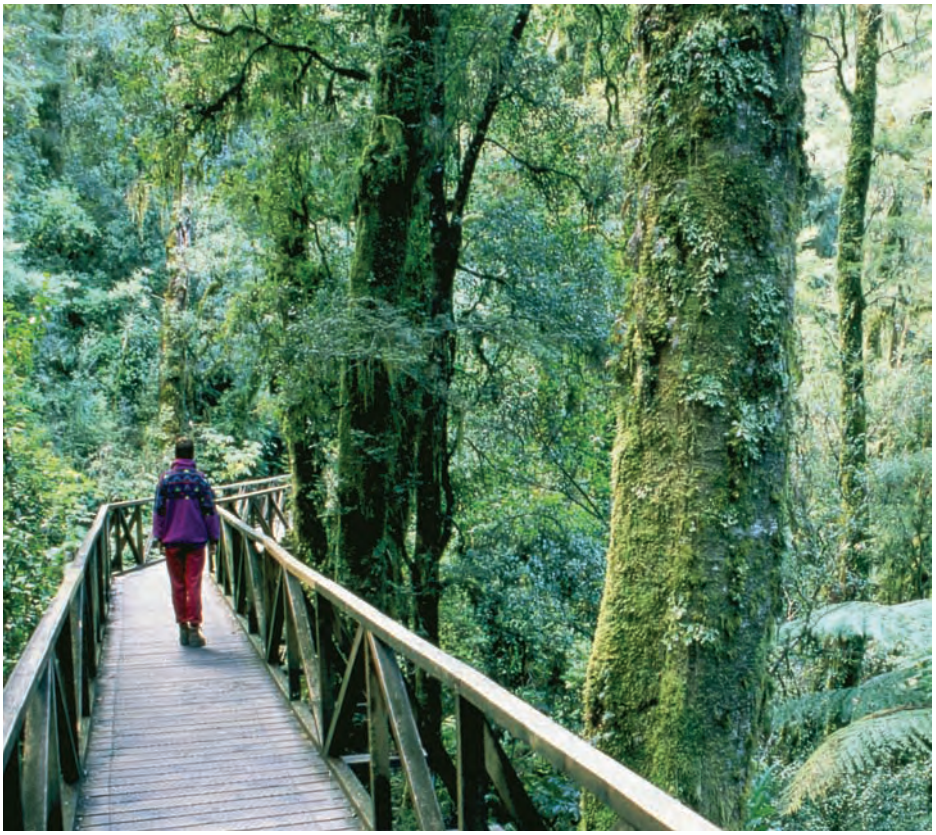


Figure 1.1 Hiking in Fiordland National Park, South Island, New Zealand

Figure 1.2 Hiking in Pacific Rim National Park, Vancouver Island

Did You Know?

The prefix "bio" comes from the Greek word *bios*, which means life. More than 90 percent of the total mass of living organisms on Earth is plant life. Most other living organisms depend on plants for survival.

Every environment, such as a rainforest, has living (**biotic**) and non-living (**abiotic**) components. Biotic components are the living organisms in an environment. Plants, animals, fungi, and bacteria are all examples of biotic components of an ecosystem. They interact with each other and with the physical and chemical environment in which they live. Abiotic components are the non-living parts of an environment such as sunlight, soil, moisture, and temperature.

Scientists study the biosphere by breaking it down into smaller divisions (Figure 1.3). The largest of these divisions is called a biome. (You will learn more about ecosystems and habitats in section 1.2.) A **biome** includes large regions that have similar biotic components, such as similar plants and animals, and similar abiotic components, such as similar temperature and amount of rainfall.

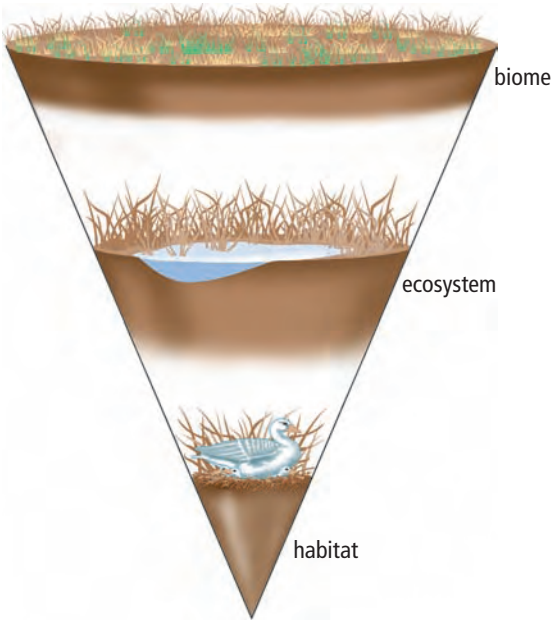


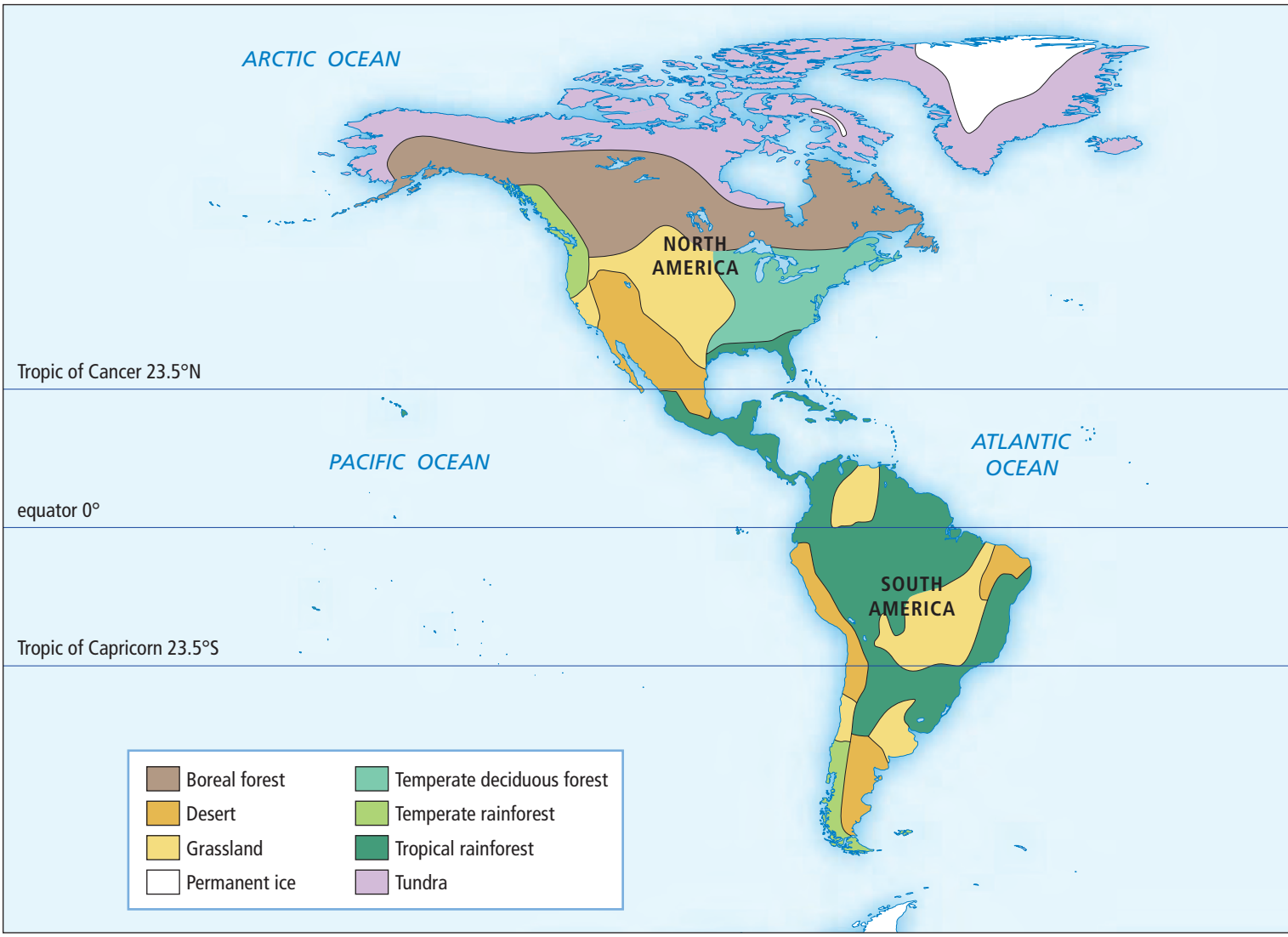
Figure 1.3 The biosphere consists of biomes. Each biome contains many ecosystems. Each ecosystem contains habitats in which a variety of organisms live.

Introducing the Biomes of the World

Much of Earth's biosphere consists of fresh water and oceans. These aquatic biomes are essential for life on land. Marine algae supply at least 75 percent of the world's oxygen and take in huge amounts of carbon dioxide from the atmosphere. In addition, seawater that evaporates produces rainwater for life on land. In this section, however, you will focus on the eight **terrestrial**, or land-based, biomes shown in Figure 1.4.

As you learn about terrestrial biomes, you may see different maps with 11 or even 16 different biomes. Some scientists classify biomes according to their temperature and the amount of moisture they receive. Other scientists classify biomes according to the type of plants that grow in them. Biomes are complex because of the many interactions that take place between abiotic factors, such as climate and soil, and biotic factors, such as plants and animals. Understanding how the biotic and abiotic components of a biome interact will help you understand how biomes are distributed across Earth and how changes in a biome may affect the organisms living in them.

Figure 1.4 Biomes of the world



1-1A Observing Patterns in World Biomes

Find Out ACTIVITY

A quick look at the world biome map (Figure 1.4) shows eight areas in eight different colours distributed across Earth. Some areas are the same colour and are in similar locations. Some areas are the same colour but are in very different locations. In this activity, you will identify some patterns about the distribution of biomes.

What to Do

1. Work with a partner. Study the map, using the key to familiarize yourself with the location of each biome.
2. Describe two patterns you see in the distribution of the biomes.
3. Compare your patterns with the patterns identified by another pair of students.
4. Record a class list that includes all the distribution patterns identified. Indicate which ones were identified by more than one pair of students.

What Did You Find Out?

1. Which distribution patterns were identified more than once? List the three most frequently identified patterns.
2. In a paragraph, provide an explanation for each of these three patterns based on your general knowledge.

Reading Check

1. What is a biome?
2. What are the biotic components of a biome?
3. What are the abiotic components of a biome?
4. Name the major biomes that are in Canada.

internet connect

The species in different parts of a biome may not be exactly the same. For example, the boreal forests of eastern and western Canada feature different coniferous species. Find out more about the boreal forest. Start your search at **www.bcscience10.ca**.

Factors That Influence the Characteristics and Distribution of Biomes

The rainforests in Figure 1.1 on page 8 and Figure 1.2 on page 9 are in the temperate rainforest biome. However, if you look again at the world biome map in Figure 1.4 on pages 10 and 11, you will see that the temperate rainforest biome is located in very different parts of the world. These temperate rainforests are considered to be in the same biome because they have similar characteristics. Both rainforests have similar temperatures, receive large amounts of rainfall, and have plants and animals that have adaptations for survival in cool, wet environments.

Temperature and precipitation

Temperature and precipitation (which includes rainfall, snow, mist, and fog) are two of the most important abiotic factors that influence the characteristics of biomes and the distribution of biomes on Earth. The slugs, ferns, mosses, and large trees that you would find in the rainforests of New Zealand and British Columbia would not survive in a hot, dry desert biome because they can survive only in environments that are cool and wet (Figure 1.5).

Figure 1.5 Ferns (A) and slugs (B) are characteristic of the cool, wet temperate rainforest biome.

Figure 1.6 shows world biomes in relation to average annual precipitation and average annual temperature. Notice also that the biomes overlap, which indicates that other factors influence precipitation and temperature. These factors include latitude, elevation, and ocean currents. Wind also plays a role, which you will learn more about in Chapter 11.

How to use the graph

Suppose you knew the average annual temperature and average annual precipitation of a region. To determine the type of biome of the region, you would locate the intersection point of these data on the graph. For example, if the average annual temperature is 15°C, locate 15°C on the *x*-axis. Then move up the graph in a line from 15°C until you reach 25 cm of average annual precipitation on the *y*-axis. This intersection point indicates that the region is in the grassland biome. You could also begin with the average annual precipitation on the *y*-axis and then find the intersection with the average annual temperature on the *x*-axis.

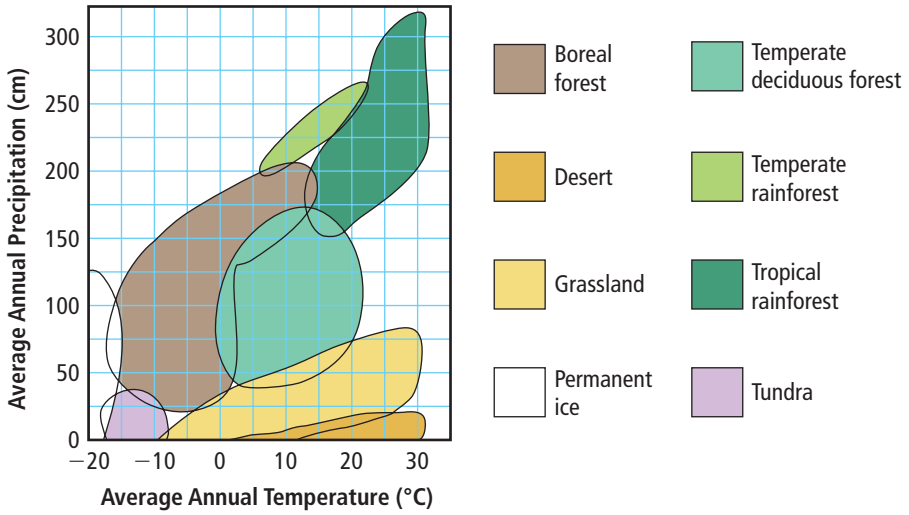


Figure 1.6 Average annual temperature and average annual precipitation of biomes

Practice Problems

Try the following biome identification problems yourself. Identify the biome of each region using the data provided.

1. The region has an average annual precipitation of about 175 cm and an average annual temperature of 5°C.
2. The region ranges in temperature between 0°C and 20°C and receives about 100 cm of rain.
3. The region has low average annual precipitation and an average annual temperature that ranges between −18°C and −8°C.
4. The region has high average annual precipitation and an average annual temperature of 15°C.

Answers provided on page 591

Latitude

Latitude is another abiotic factor that can influence the characteristics and distribution of biomes because it affects temperature and precipitation. **Latitude** is the distance measured in degrees north or south from the equator. The equator, which is at 0° latitude, divides Earth into the northern and southern hemispheres. At the equator, the rays of the sun shine down from almost directly overhead. As a result, the equator receives 12 hours of sunlight each day year-round and experiences little annual fluctuation in temperature.

If you look at the map in Figure 1.7, you will see that the Tropic of Cancer is located above the equator and the Tropic of Capricorn is below the equator. Since the zone between these lines of latitude, called the tropical zone, is close to the equator, it receives more direct sunlight and has warm temperatures. North of the Tropic of Cancer and south of the Tropic of Capricorn, the sun's rays hit Earth at an angle, due to the tilt of Earth. As a result, the sun's rays spread out over the larger surface area between these latitudes and the poles. Since the sun's rays are less intense farther away from the equator, the temperatures in these zones (the temperate zones) are lower than they are at the equator.

Connection

Section 11.1 has more information on the relationship between Earth's tilt and solar energy.

Latitude also affects precipitation. At the equator, the direct sunlight heats moist air, which quickly rises, cools in the upper atmosphere, and falls back to Earth as rain. The land and ocean that are on the equator receive the greatest amount of rainfall on Earth. In polar regions, little moisture can be picked up and carried in cold air, so clouds do not form readily and there is little precipitation. Temperate regions experience the collision of cold air masses from the poles and warm, moist air masses from the tropics that results in seasonal rainfall patterns.

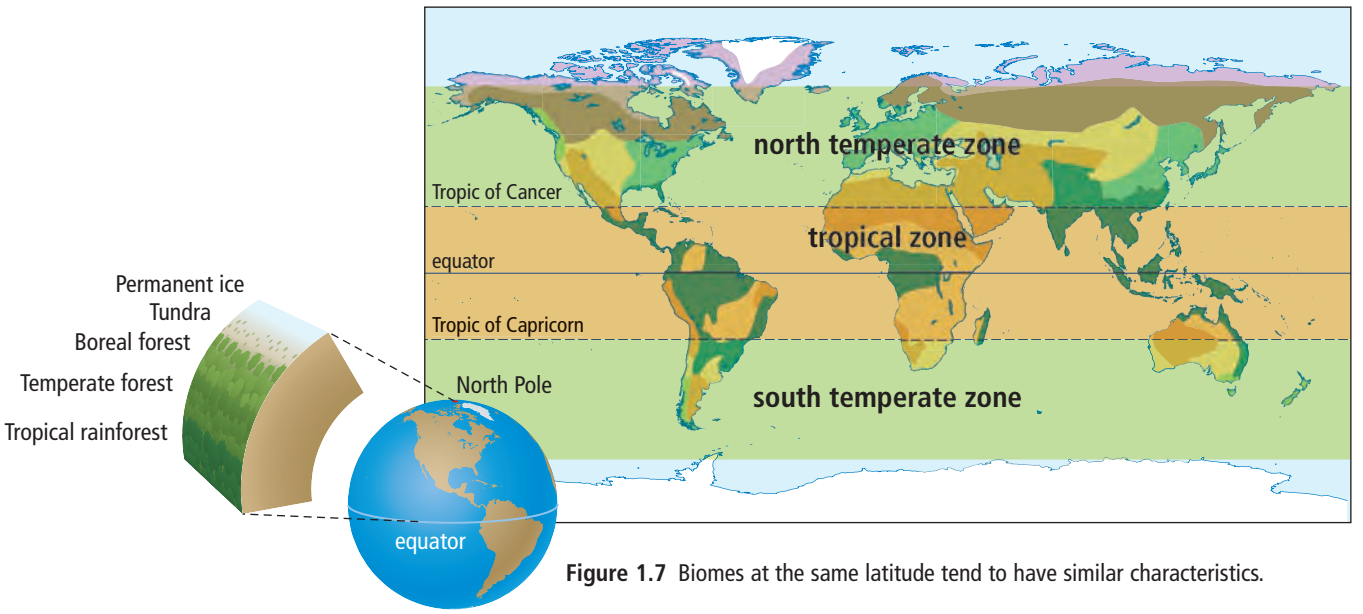


Figure 1.7 Biomes at the same latitude tend to have similar characteristics.

Elevation

Elevation also has an effect on temperature. **Elevation** is the height of a land mass above sea level. Temperature changes occur because the atmosphere becomes thinner at higher elevations, and a thinner atmosphere retains less heat. Elevation also has an effect on precipitation patterns. On the windward side of a mountain, clouds filled with moisture rise and cool, then release rain or snow. On the leeward side of a mountain, which is the side sheltered from the wind, the air warms again, which allows it to absorb water, creating a dry land area. Since elevation affects both temperature and precipitation, the type of biome found at a high altitude can be different from the type of biome found at a lower elevation. You may have noticed how changes in elevation can influence the type of biome if you have ever hiked up a mountain or looked at mountains while driving along the Coquihalla highway. Figure 1.8 shows an example of how biomes can change as elevation increases.

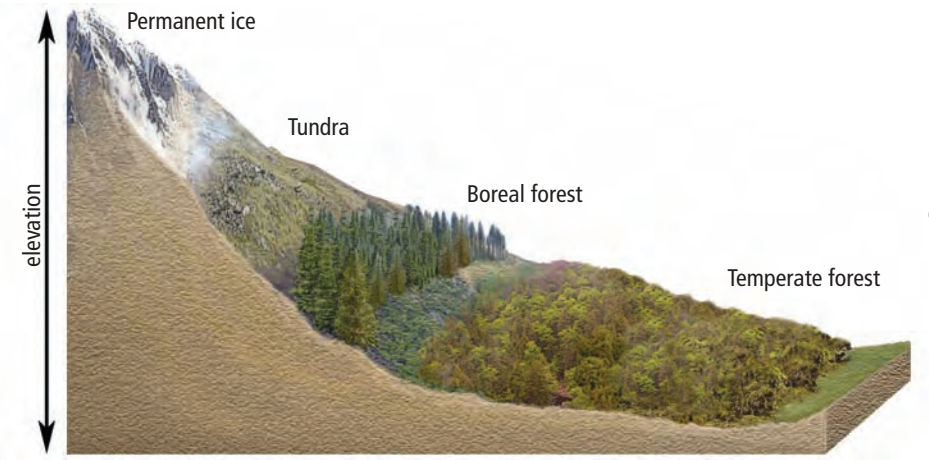


Figure 1.8 The effects of elevation

Ocean currents

Ocean currents are another abiotic factor that affects temperature and precipitation and therefore influences the characteristics of biomes. Canada's temperate rainforest biome is located along the coast of British Columbia. Both Canada's and New Zealand's temperate rainforest biomes are influenced by ocean currents, making them warmer and wetter than other temperate biomes.

Connection

Section 11.1 has information on ocean currents.

Reading Check

1. Name two abiotic factors that influence the characteristics of biomes.
2. How does temperature change with latitude?
3. How does precipitation change with latitude?
4. How can the temperate rainforest biome be located in two very different parts of the world?
5. Explain why you might find a permanent ice biome at the top of a mountain and a temperate forest biome at the bottom.

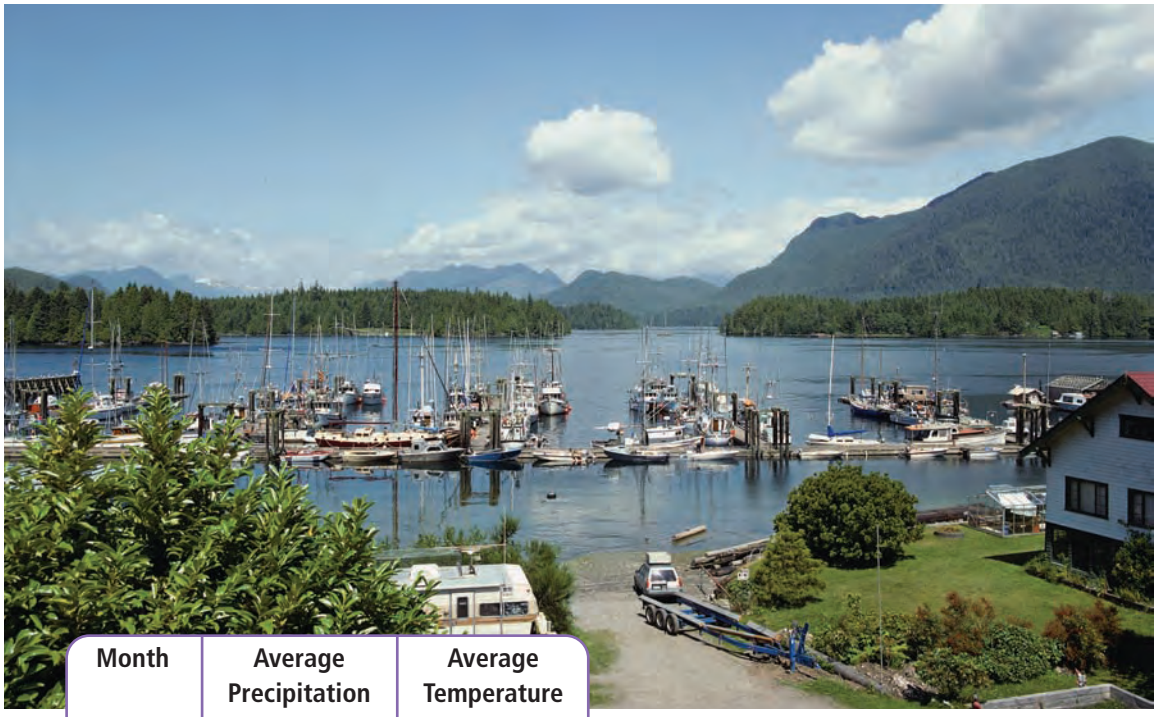
Climatographs

Suggested Activity

Conduct an Investigation 1-1C on page 30

Temperature and precipitation are two important factors that determine climate. **Climate** is the average pattern of weather conditions that occur in a region, which are observed and recorded over a period of years. (You will learn more about climate in Unit 4.)

A **climatograph** is a graph of climate data for a specific region and is generated from data usually obtained over 30 years from local weather observation stations. A climatograph includes average monthly temperature and an average of the total monthly precipitation for each



Month	Average Precipitation (mm)	Average Temperature (°C)
J	436	4
F	382	5
M	355	6
A	249	8
M	165	10
J	138	12
J	77	14
A	94	15
S	134	13
O	340	10
N	475	7
D	462	5

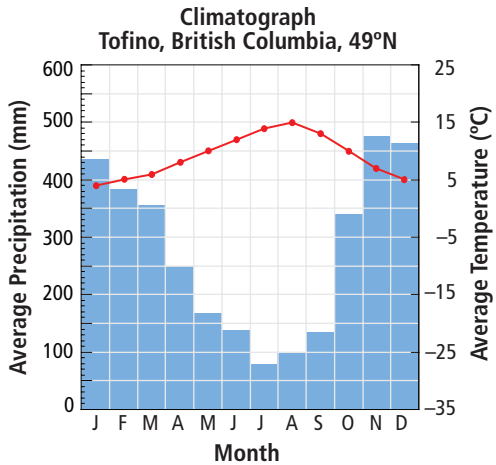
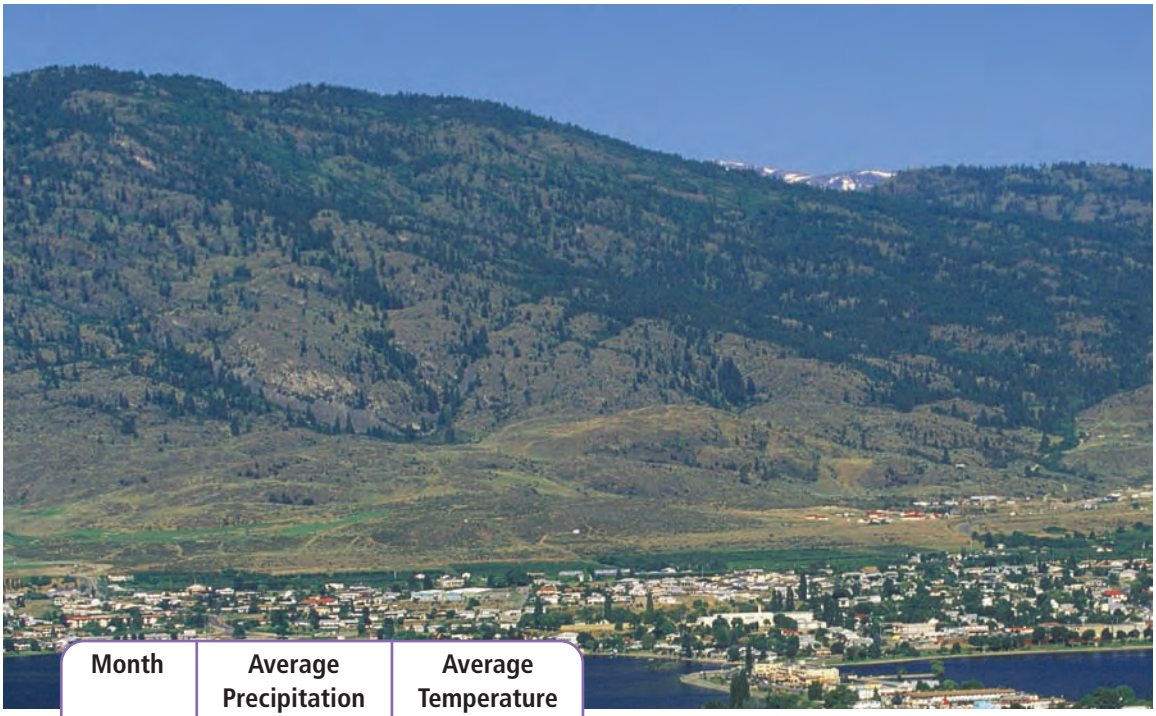


Figure 1.9 The statistics for this graph came from Tofino, British Columbia, which is in the temperate rainforest biome.

month. Comparing climatographs can give you a greater understanding of the temperature and precipitation patterns in regions within a biome. You can also use climatographs to compare temperature and precipitation patterns in regions that are in different biomes, as shown in Figure 1.9 on the previous page and Figure 1.10 below. On a climatograph, the month of the year is shown on the horizontal axis. Average temperature is shown on the right vertical axis, and average precipitation is shown on the left vertical axis.

Did You Know?

Osoyoos is home to Canada's only desert. It is the uppermost part of the Great Basin Desert and is called the Pocket Desert.



Month	Average Precipitation (mm)	Average Temperature (°C)
J	12	−2
F	18	1
M	20	6
A	23	11
M	37	15
J	36	19
J	24	22
A	21	21
S	16	16
O	17	10
N	26	4
D	17	−1

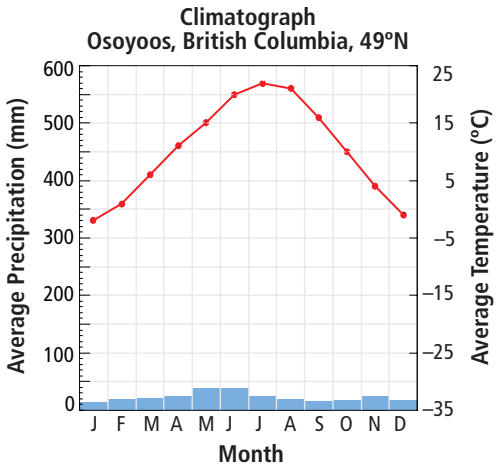


Figure 1.10 The statistics for this graph came from Osoyoos, British Columbia, which is in the desert biome.

Figure 1.11 The cone shape of pine trees is a structural adaptation. As a result, the branches do not break with the weight of the snow.

Adaptations and Biomes

When you think of a polar bear, you may think of northern Canada. When you think of a monkey, you may think of a tropical jungle. When you think of a cactus, you may think of a desert. Certain types of plants and animals are characteristic of certain biomes because they are better adapted for survival in the environmental conditions in those locations. **Adaptations** are characteristics that enable organisms to better survive and reproduce. There are three types of adaptations: structural, physiological, and behavioural.

A **structural adaptation** is a physical feature of an organism's body having a specific function that contributes to the survival of the organism. For example, pine trees are cone-shaped and therefore shed snow easily (Figure 1.11). Porcupines have sharp, stiff quills that function to defend against the attacks of other animals. The arctic fox has a thick, white coat in the winter and a brownish-grey coat in the summer. A change of coat colour provides camouflage for arctic foxes and improves their ability to hunt successfully. All these are examples of structural adaptations that enable the survival of plants and animals.

A **physiological adaptation** is a physical or chemical event that occurs within the body of an organism that enables survival. For example, wolves can maintain a constant body temperature regardless of weather conditions (Figure 1.12). This adaptation enables wolves to survive harsh Canadian winters. The process for converting solar energy into chemical energy (photosynthesis) in cacti (Figure 1.13) is different from photosynthesis in trees and ferns of temperate regions. This adaptation means that cacti require only half as much water for photosynthesis as trees and ferns do.

Suggested Activity

Think About It 1-1B on page 29

Figure 1.12 A physiological adaptation enables wolves to maintain a constant body temperature even in cold weather.

Figure 1.13 Photosynthesis in cacti requires a smaller amount of water than in plants from other biomes as a result of a physiological adaptation.

A **behavioural adaptation** refers to what an organism does to survive in the unique conditions of its environment. These adaptations may include how the organism feeds, mates, cares for its young, migrates, hibernates, or burrows to escape predators. (A predator eats all or part of another organism—its prey). For example, the burrowing owl (which is also a predator) builds its nest in abandoned prairie dog burrows in grassland areas (Figure 1.14). The owl lines the nest with grass, which keeps it cool during the day and warm at night. Cow dung placed at the entrance to the burrow hides the scent of the owl from other predators, such as snakes, skunks, and foxes, which prey on eggs, young, and adults.

Figure 1.14 Another behavioural adaptation of the burrowing owl is that it hisses like a rattlesnake to scare off predators.

Reading Check

1. What is an adaptation?
2. Name three types of adaptations.
3. Describe an adaptation that benefits an animal.
4. Describe an adaptation that benefits a plant.

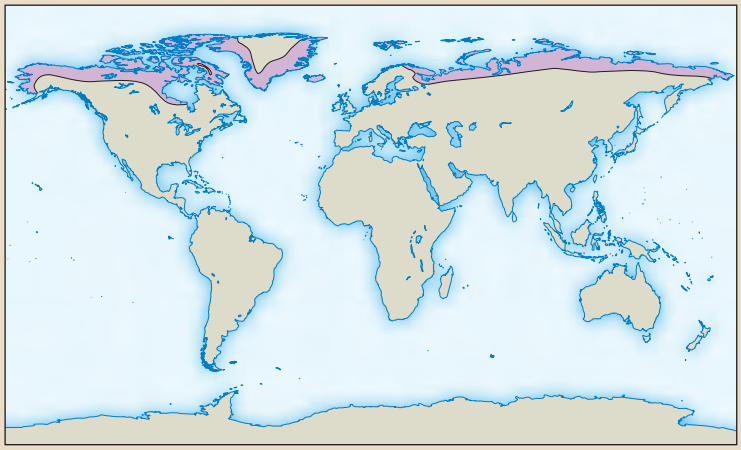
A Survey of Biomes

So far in this chapter, you have learned that a biome has regions with similar biotic components, such as similar plants and animals and similar abiotic components, such as similar temperature and precipitation. Biomes are often named for their dominant vegetation or for a geographical or physical characteristic. Seven of the following biomes are found in Canada: tundra, boreal forest, temperate deciduous forest, temperate rainforest, grassland, desert, and permanent ice.

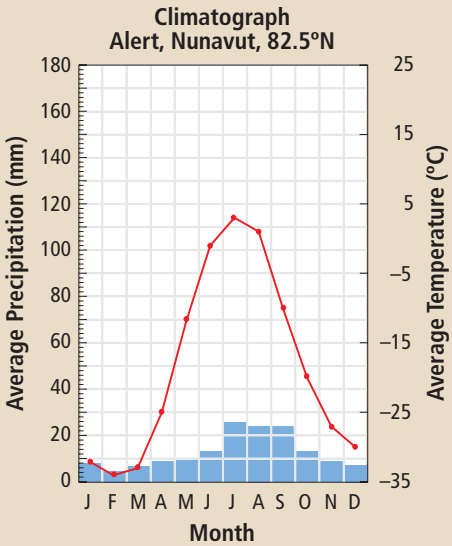
Word Connect

"Forest canopy," "understorey," and "forest floor" are three terms ecologists frequently use to describe the layers of forests in biomes. The forest canopy is formed by the tallest trees in the forest. The understorey is formed by the plants and shrubs that grow beneath the canopy. The forest floor is the bottom layer of the forest, which includes roots, fallen leaves, and soil.

Tundra

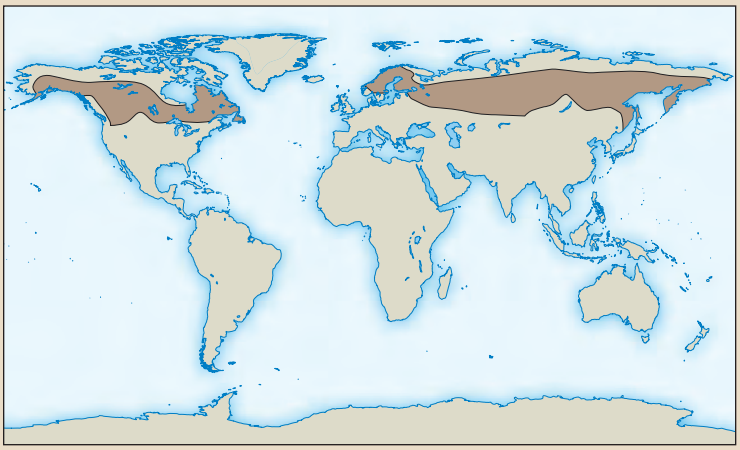


Caribou



Location: The tundra biome is in the upper northern hemisphere, just below the ice-covered polar seas, at 60° to 70° north latitude.
Climate: Precipitation is less than 25 cm annually. Annual summer average temperatures range from 3°C to 12°C. Winter temperatures range from −20°C to −30°C.
Physical features: The tundra biome always has a layer of permanently frozen soil called permafrost. Its flat terrain (the physical features of its land area) results in poor drainage. In summer, a thin layer of topsoil thaws, creating many pools and marshes. The tundra is cold and dark much of the year but has 24 hours of daylight each day during its brief summer.
Plant adaptations: No trees grow here since the growing season is too short. Roots cannot penetrate permafrost. Many plants grow close to the ground, where they absorb the warmth that has been trapped by the dark soil and are sheltered from the fierce winds. Short grasses, lichens, and mosses survive here. Some flowering plants, such as the arctic crocus, have fuzzy coverings on their stems, leaves, and buds that provide protection from the wind. Shrubs flower quickly during the long, sunlit summer days. The Labrador tea bush keeps its old leaves rather than dropping them, which conserves nutrients and helps protect the plant from cold, wind, and drying out.
Animal adaptations: Arctic foxes and hares have compact bodies and shorter legs and ears, which reduce heat loss. Many tundra animals grow more slowly and reproduce less frequently than animals in temperate biomes, therefore requiring less energy. The Greenland sulfur butterfly has a long life cycle, taking up to 14 years to become an adult. Caribou migrate to food sources in winter. In winter, the white feathers of the snowy owl prevent its prey from seeing it against the snow. Many birds migrate here in summer to eat insects that reproduce in great numbers in the marshy conditions.

Boreal Forest



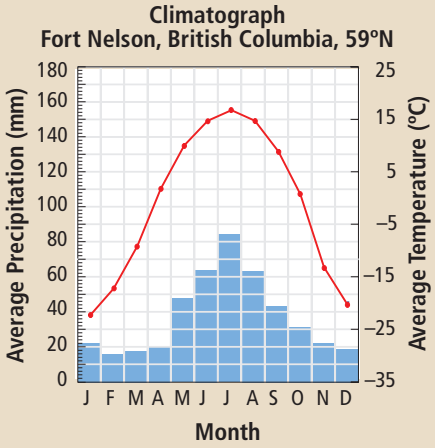
Location: Boreal forests are found in the northern hemisphere between 45° and 65° north latitude across Canada (shown above) and between 55° and 65° north latitude in Russia, Finland, and Scandinavia.

Climate: Precipitation is 30 cm to 85 cm annually, much of it falling as snow. Temperatures are below freezing half of the year and often drop to −40°C.

Physical features: There is a short summer growing season of an average of 50 days. The terrain is often rough. Many marshes, shallow lakes, and wetlands hold vast amounts of water. The soil is also very wet.

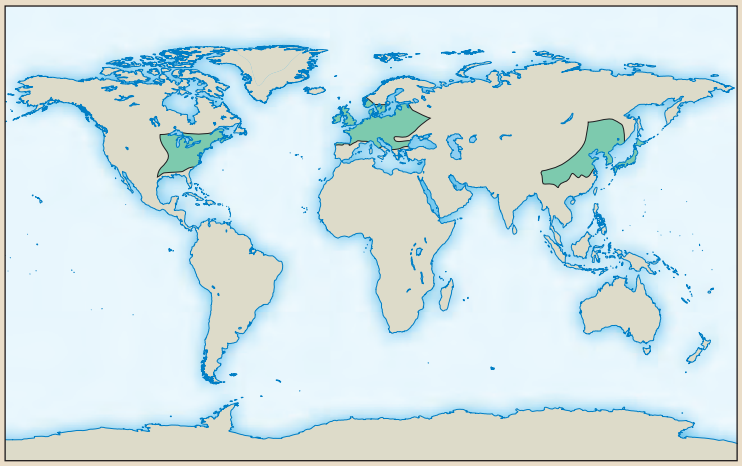
Plant adaptations: Trees are mainly coniferous (cone-bearing), such as black spruce and white spruce, with small, pointed, waxy needles that resist water loss and allow snow to slide off easily. In a balsam fir–white spruce forest, little light reaches the forest floor, so there are few understorey plants.

Animal adaptations: Insect-eating birds such as warblers migrate south in the fall. Seed eaters such as the finch stay year-round. Small mammals such as chipmunks and shrews burrow in winter to stay warm. Mammals such as moose have thick insulating coats and tend to be large. Large bodies enable moose to retain their body heat. The fur of snowshoe hares changes from summer brown to winter white, which camouflages them from predators. Insects multiply rapidly and in large quantities in the summer. Reptiles and amphibians are rare since they are not adapted to survive low temperatures.

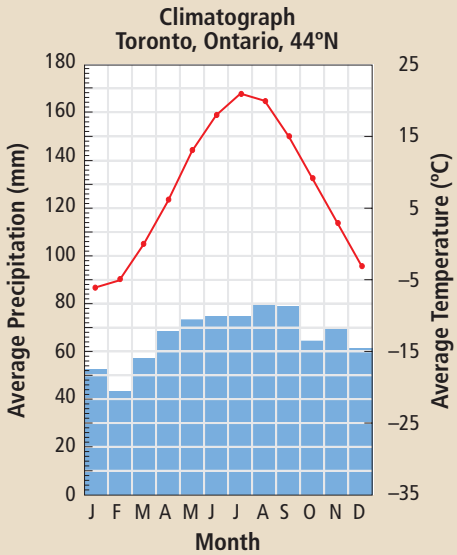


Snowshoe hare

Temperate Deciduous Forest



Canada goose



Location: These forests are found mainly in eastern Canada (shown above), the eastern United States, eastern Asia, and western Europe. Southern Australia and New Zealand also have areas of deciduous forest. They occur above 23.5° north latitude and between 23.5° and 38° south latitude.

Climate: The annual rainfall is about 75 cm to 180 cm, with precipitation equally distributed throughout the year. Temperatures range from −30°C in winter to 30°C in summer.

Physical features: Seasonal changes between summer and winter are very large. Temperature changes during a day can also be large. This biome has four distinct seasons and a long, warm growing season. The soil is enriched by fallen leaves that break down and provide nutrients.

Plant adaptations: Plants grow in four to five layers, with tall maple, oak, and birch trees in the canopy layer. Light penetrates the layers, resulting in an understorey that has great biodiversity. Shorter trees occupy the second layer, with shrubs in the third layer, berries in the fourth layer, and ferns, herbs, and mosses on the forest floor. Deciduous trees shed their large, broad leaves in winter, which prevents water loss and reduces breakage of limbs with heavy snow. Thick bark limits moisture loss from the trees.

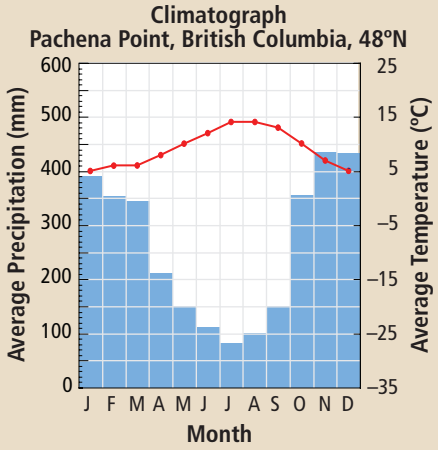
Animal adaptations: The many layers in the forest provide many habitats for squirrels, rabbits, skunks, cougars, deer, wolves, bears, and amphibians. Squirrels, chipmunks, and blue jays store nuts and seeds in tree hollows. Some mammals hibernate. Many birds migrate to warmer areas in winter.

Temperate Rainforest

Location: Temperate rainforests run from about 38° to 56° south latitude along the coast of Chile in South America and from 38° to 61° north latitude along the northwest coast of North America, including coastal British Columbia (shown above). New Zealand and part of southern Australia also have temperate rainforests.

Climate: Rainfall exceeds 200 cm a year with average temperatures ranging from 5°C to 25°C. Coastal fog supplies additional moisture.

Physical features: Temperate rainforests occur in narrow strips along coastlines that are backed by mountains, where the ocean winds drop large amounts of moisture on the windward side of the mountains.

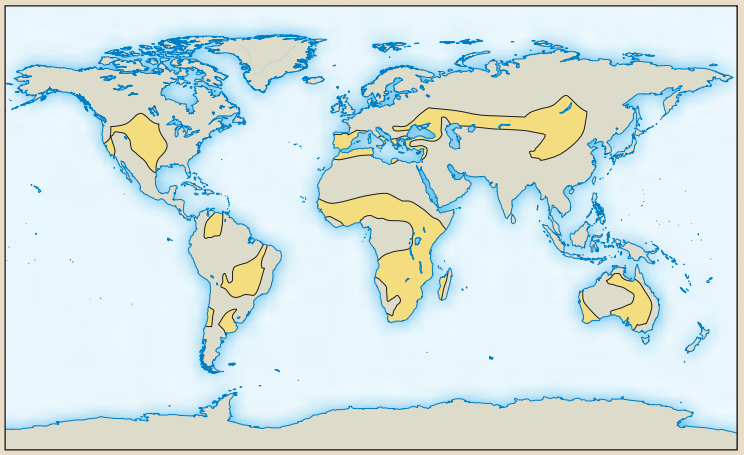


Plant adaptations: Trees can grow very tall because of high precipitation and include large evergreens such as the Sitka spruce (up to 48 m tall) and the Douglas fir (up to 60 m tall). Mosses are draped on trees, and lichens cling on tree trunks, where they receive more light than on the forest floor. Ferns, mosses, and fungi that survive in the shade blanket the forest floor.

Animal adaptations: Most animals live on or near the forest floor, where they are protected from the wind and rain. Many birds and small mammals, such as chipmunks, eat seeds that fall on the forest floor. Many insects live in the tree bark and decomposing plant matter. Birds with long beaks and amphibians with sticky tongues eat these insects.

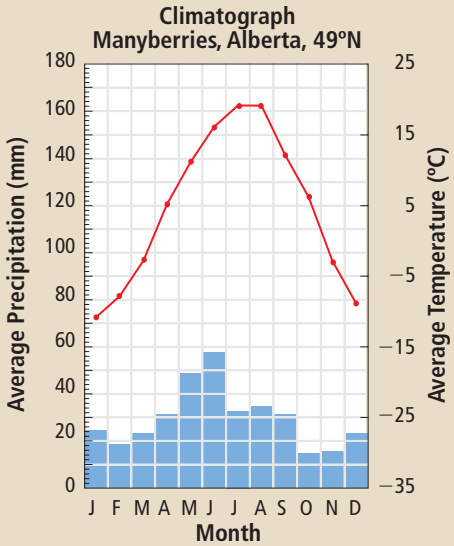
Long-toed salamander

Grassland (Temperate and Tropical)



Location: The grassland found in Canada is referred to as the temperate grassland or prairies (shown above). They are also called prairies in other locations in North America and steppes in Russia. Temperate grasslands are found above 23.5° north latitude and below 23.5° south latitude. Tropical grasslands or savannas are found from 5° to 20° north and south of the equator in Africa, South America, and northern Australia.

Climate: In temperate grasslands, the precipitation is 25 cm to 100 cm annually, with hot summers of 30°C and cold winters below −10°C. In tropical grasslands, precipitation is 50 to 130 cm annually, with daily temperatures ranging from 20°C to 30°C.



Physical features: In both temperate and tropical grasslands, the land is mainly flat. The soil is very rich and fertile in the temperate grassland created by the growth and decay of deep grass roots. The tropical grassland is less rich because nutrients are removed by occasional heavy rain. In both grasslands, strong winds may cause soil erosion. Precipitation usually occurs in late spring or early summer and is followed by an extended dry period. Grass fires are common in hot tropical grasslands but occur less frequently in temperate grasslands.

Plant adaptations: In both temperate and tropical grasslands, trees are scarce because of limited rainfall. Fire and grazing animals also kill seedlings. In temperate grasslands, grasses such as blue grama and buffalo grass are well adapted for drought as their roots are deep and form dense mats that collect water when it is available. Because of their well-developed root systems, plants can regrow after a fire. Flexible stalks enable these grasses to bend without breaking in the wind.

Grassland (Temperate and Tropical)

Many wind- and insect-pollinated wildflowers, such as asters, goldenrod, and clover, grow between the grasses. In tropical grasslands, grasses also have deep roots. Some trees, such as acacia, have thorns that deter animals from eating them. Some grasses have sharp edges or are too bitter for grazing.

Animal adaptations: Many large grazing mammals are present in large numbers because there is plentiful grass. Animals such as antelope are found in both biomes and have flat teeth that grind plant materials. In tropical grasslands, herds of antelope, giraffes, and zebras are found with predators such as lions, cheetahs, and leopards. In temperate grasslands, large mammals include antelope, wild horses, kangaroos, and predators such as wolves and coyotes. Animals such as mice, rabbits, gophers, and snakes are common to both grassland types. These animals burrow to escape fire, predators, and extreme weather.

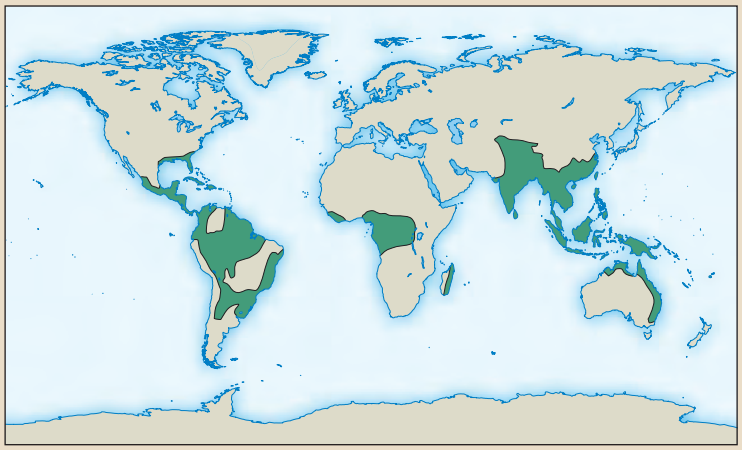
Pronghorn antelope (temperate grassland)

Zebra (tropical grassland)

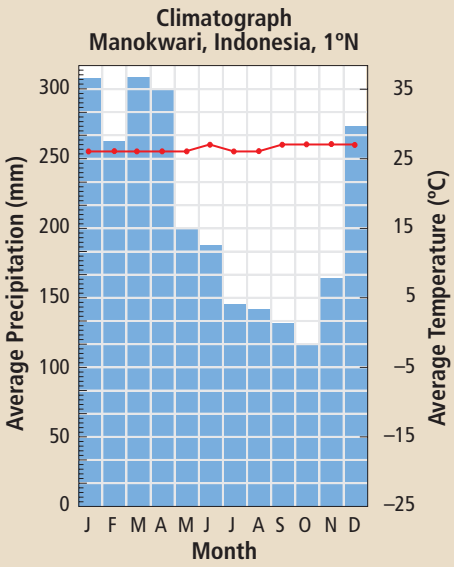
Reading Check

1. List three characteristics of the tundra biome.
2. List two characteristics of the boreal forest biome.
3. Describe the plant life of a temperate rainforest.
4. Identify the two types of grassland.
5. Explain why grassland plants can survive drought and prairie fires.

Tropical Rainforest



Toucan



Location: Tropical rainforests are located in a band 4800 km wide around the equator, mostly in the area between the Tropic of Cancer (23.5° north latitude) and the Tropic of Capricorn (23.5° south latitude). These forests cover much of northern South America (shown above), Central America, central Africa, and southeast Asia.

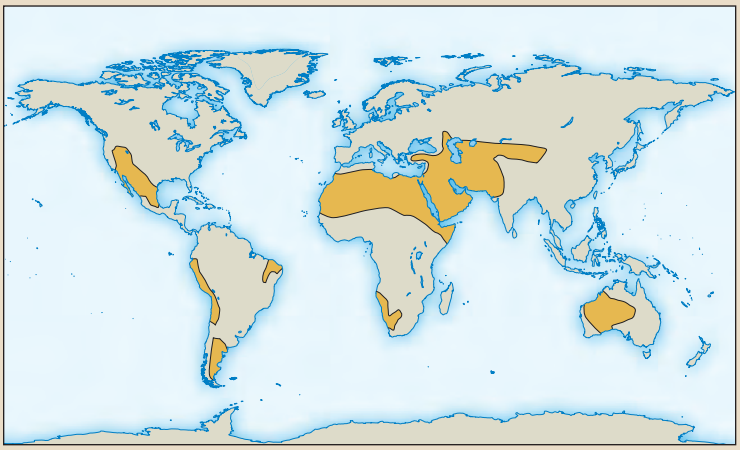
Climate: Rainfall is about 250 cm per year. Temperature is 20°C to 25°C year-round.

Physical features: The soil is poor as nutrients are quickly recycled and not retained. The soil is also poor because heavy rain washes minerals away. The forest floor is very dark, which limits plant growth.

Plant adaptations: This biome has the largest number of different plant species. Plants grow in many layers. Tall trees form a dense canopy that absorbs most of the sunlight. Only shrubs adapted to shade thrive in the understorey. Vines climb tree trunks into the canopy where there is more light. Many plants, such as orchids, reach sunlight by growing on tall trees. Leaves have narrow tips that allow rain to run off quickly, which reduces weight on the branches.

Animal adaptations: This biome has the greatest diversity of animals on Earth but has few large mammals. Most animals are adapted to live in trees since there is little vegetation on the forest floor. Many are specialists, adapted to a particular food or habitat, which reduces competition. Nut eaters like parrots and toucans have big, strong beaks that cut nuts from the trees and crack open the tough shells. Some rainforest animals secrete poisons that protect them from predators. The slow movement of the South American three-toed sloth, an adaptation to its low-calorie diet of leaves, also makes it less noticeable to predators such as jaguars.

Desert (Hot and Cold)



Location: Hot deserts are found on every continent around latitudes about 30° north and south and include the Kalahari and Sahara of Africa, the Simpson of Australia, the Atacama of South America, and the Sonoran (shown above) in the United States. Cold deserts are found in dry regions in the interior of continents above 30° north latitude and below 30° south latitude and in the rain shadows of mountains. Cold deserts include the Great Basin Desert of North America (which includes Canada's Pocket Desert), the Patagonian Desert of Argentina, and the Gobi Desert of central Asia.

Climate: In hot deserts, the rainfall is less than 25 cm annually, with hot days averaging 38°C and cold nights averaging 7°C. In cold deserts, the rainfall is also less than 25 cm annually, with summer days averaging 21°C to 26°C and winter days averaging −2°C to 4°C.

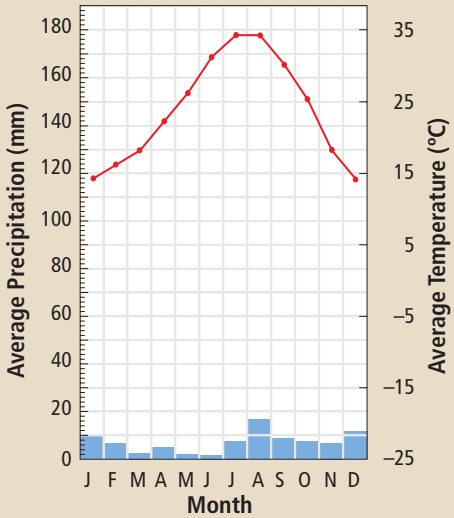
Physical features: In hot deserts, there is either very little rainfall or there is a lot of rain in a very short period. The soils are often salty because minerals do not get washed away. In cold deserts, most precipitation falls as snow, but there is rain in the spring. The soil is often salty and little water erosion occurs.

Plant adaptations: In hot deserts, there are few plant species. Spiny cacti that have thick, fleshy stems that conserve water are common. Their roots extend metres away from the plant to absorb water. Other plants have small, thick, waxy leaves that also store water. Many plants have spines or produce chemicals that protect them from being eaten. In cold deserts, there are few plant species and most are less than 1 m tall. Many plants, such as sagebrush, are deciduous and have spiny leaves. Sagebrush roots can extend 30 m and absorb water when available.

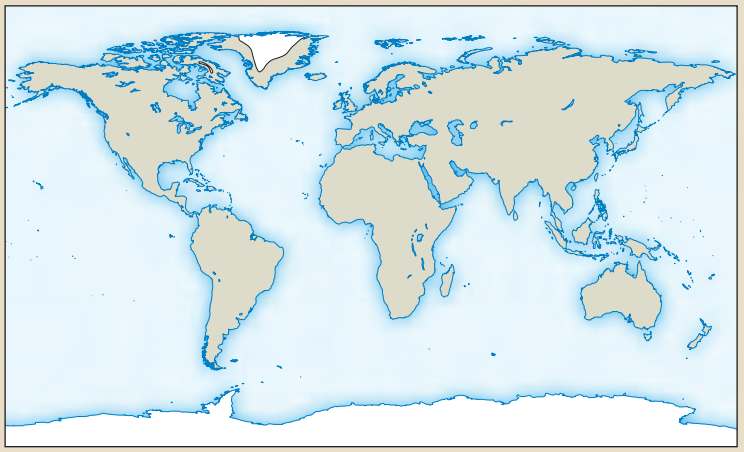
Animal adaptations: In the hot desert, reptiles are common and have thick skin and scales that prevent water loss. Animals such as desert spadefoot toads and scorpions bury themselves in the ground and sleep during times of heat and drought. Animals are active mainly at night when temperatures are lower. In the cold desert, fan-throated lizards, small mammals, such as foxes, coyotes, jackrabbits, and pocket mice burrow to escape the cold.

Scorpion

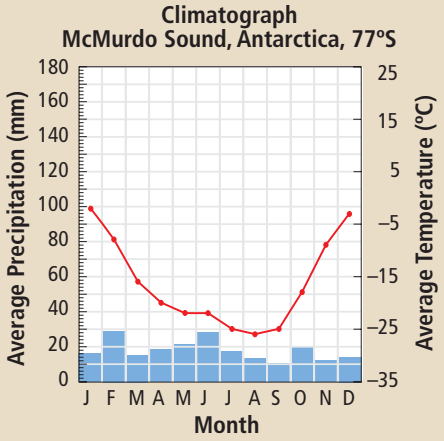
Climatograph
Yuma, Arizona, 32.5°N



Permanent Ice (Polar Ice)



King penguins of Antarctica



Location: This biome includes the polar land masses and large polar ice caps of the Arctic, Greenland, and Antarctica (shown above).
Climate: Annual precipitation is less than 50 cm, most falling as snow. Antarctica has recorded a temperature as low as −89°C. Average Arctic winter temperatures are −30°C. Average Antarctic summer temperatures range from 9°C on the coast to −30°C inland. Average Arctic summer temperatures range from 3°C to 14°C.
Physical features: This biome has very strong winds and little soil. Little fresh water is available because of freezing conditions. Antarctica is very cold almost all year-round.
Plant adaptations: Lichens (organisms that consist of fungi and algae) can tolerate drought and cold and are dark-coloured, thus absorbing more sunlight. Many species of moss survive in the Arctic, but few species of moss grow in Antarctica. There are only two flowering plants in Antarctica, but there are more than 100 species of flowering plants in the Arctic because of its brief growing season.
Animal adaptations: The Arctic has polar bears, walruses, seals, arctic foxes, and some insects. Antarctica has mostly penguins and marine mammals, such as leopard seals. Penguins have fat layers and tightly packed feathers that retain heat. Polar bears, seals, and walruses have thick coats and fat layers for warmth. Walruses have no external ear, which reduces heat loss, and they lie close together in herds of over a thousand animals, thus retaining heat.

Reading Check

1. Which biome has the greatest variety of plant and animal species?
2. Identify the two types of desert.
3. Give two examples of desert plant adaptations.
4. What limits the variety and numbers of living things that can survive in the permanent ice biome?
5. Give two examples of animal adaptations for life in Antarctica.

Explore More

If you ever go to Deception Island, be sure to pack your bathing suit. Find out why this island off the coast of Antarctica has quite a different climate than icy McMurdo Sound. Begin your search at **www.bcscience10.ca**.

1-1B Biotic and Abiotic Components of Biomes

Think About It

Biomes have both living and non-living components that affect the organisms living in them. In this activity, you will compare and contrast the biotic and abiotic components of two biomes.

What to Do

1. Your teacher will give you photographs of a variety of biomes. Work with a partner to identify which biomes are shown in the photographs.
2. Make a list of all the living components shown in each biome.
3. Make another list of all the non-living components of each biome.
4. Your teacher will give you photographs of a variety of organisms. Study the plant and animal photographs carefully.
5. Work with your partner to sort the photographs into groups of plants and animals that you would find in the biomes you have identified.
6. Brainstorm a list of plant characteristics you observe for each biome.
7. Brainstorm a list of animal characteristics you observe for each biome.
8. Consider other plant and animal characteristics that would be beneficial to organisms in these biomes, and add them to your lists.
9. Choose two biomes. Construct a full-page Venn diagram to compare and contrast the biotic and abiotic components of these biomes. Include animal and plant characteristics in the biotic section of the diagram.
10. Compare your results with those of your classmates.

Science Skills

Go to Science Skill 11 for information on making Venn diagrams.

What Did You Find Out?

1. What similarities in biotic components did you find between the biomes you compared in your Venn diagram?
2. What differences in abiotic components did you find between these two biomes?
3. How can you explain the differences in the biotic factors between these two biomes?
4. How can you explain the differences in the abiotic factors between these two biomes?

1-1C Analyzing Climatographs

SkillCheck

- Graphing
- Inferring
- Evaluating information
- Working co-operatively

You have learned that temperature and precipitation are two abiotic factors that influence the climate and the types of plants and animals in a biome. You have also learned that you can use climatographs to compare the climates of different biomes. In this activity, you will practise interpreting and graphing climatographs. Then, you will make an inference about which biomes are represented by the climatographs.

Question

How can you use the information in climatographs to infer which biomes are represented?

Materials

- ruler
- red and blue pencils
- graph paper

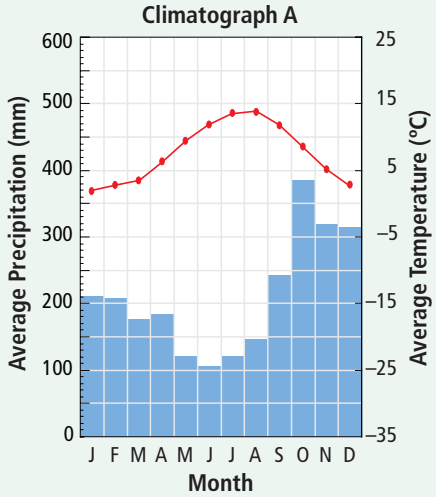
Science Skills

Go to Science Skill 5 for information on how to construct a graph.

Procedure

Part 1 Analyze a Climatograph

1. Working with a partner, study Climatograph A below and then answer the following questions.
   (a) What information is represented on the left-hand vertical y-axis ?
   (b) What information is represented by the letters along the horizontal *x*-axis?
   (c) What are the units of measurement for precipitation?
   (d) What are the units of measurement for temperature?
   (e) What is the total amount of precipitation in July?
   (f) What is the average temperature in December?



Inquiry Focus

Part 2 Graph a Climatograph

2. Construct a climatograph for the following climate data. Follow the directions in steps 3 to 7.

Month	Average Precipitation (mm)	Average Temperature (°C)
J	64	−10
F	51	−8
M	64	−2
A	67	6
M	81	13
J	91	18
J	88	21
A	87	19
S	86	14
O	79	8
N	77	1
D	74	−6

3. On the graph paper, mark 12 intervals on the horizontal axis. Label each interval with the first letter of the month, starting with "J" for January.
4. On the left vertical axis, mark 10 intervals beginning at 0 and extending to 100. Each interval has a value of 10. Label this axis "Average Precipitation (mm)."
5. Draw a second vertical axis for temperature on the right. On this axis, mark seven intervals beginning with −10°C and extending to 25°C. Label this axis "Average Temperature (°C)."
6. Present the data for each month's average precipitation as a bar graph. Use a blue pencil to shade in the bar graph.
7. Enter the data for each month's average temperature in the middle of the space allocated for that month. Use a red pencil to draw a curve between the points.
8. Add the title "Climatograph B."

Part 3 Compare Climatographs and Make an Inference

9. Compare Climatograph A to Climatograph B.
   (a) How do the monthly precipitation patterns in the two climatographs compare?
   (b) How do the monthly temperature patterns in each climatograph compare?
   (c) Infer which biome is represented by Climatograph A.
   (d) Infer which biome is represented by Climatograph B.

Analyze

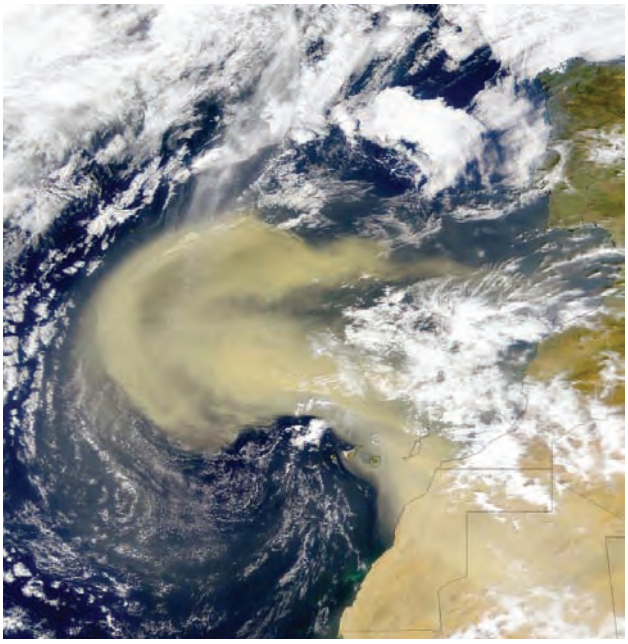
1. How would you describe the climate represented by Climatograph A?
2. How would you describe the climate represented by Climatograph B?
3. Which biome do you think is represented by Climatograph A? How do you know?
4. Which biome do you think is represented by Climatograph B? How do you know?
5. If temperatures above 5°C are required for plant growth, which biome has the longer growing season: the biome represented by Climatograph A or the biome represented by Climatograph B? Explain.

Conclude and Apply

1. One of the climatographs in this activity represents the climate of a city in British Columbia and one represents a city from another province in Canada. Which cities do you think are represented by these climatographs?
2. Some scientists predict that, due to global warming, Earth's average monthly temperatures will rise by 4°C by 2100. What effect might this have on the growing season in these two Canadian cities?

Science Watch

Dust on the Move



You may think the ground under your feet does not go anywhere, but soil and dust are constantly on the move, reshuffling particles around the biosphere. Fine particles of arid soil from the Sahara Desert are carried by winds across the Atlantic Ocean and reach the Americas within days. Soil, part of the abiotic environment, has an impact on the biotic environments in other areas of the world. While scientists have long known that soil can be transported vast distances, only recently have they begun to understand the full environmental impact of this movement.

Scientists estimate that the quantity of soil that moves large distances in Earth's atmosphere is approximately 3 billion tonnes annually. Plants in the Amazon rainforest have evolved in ways that take advantage of particles rich in iron, phosphorus, and organic matter that are carried in the wind from the African Sahara desert. In the South Atlantic Ocean and the Caribbean Sea, seaweed and algae flourish after dust storms.

It is believed that global warming is increasing the intensity of dust storms. Scientists are now hypothesizing that the increased amount of Saharan dust is also causing environmental distress. Some dust particles in clouds can stop rain droplets from falling, reducing precipitation in some areas.

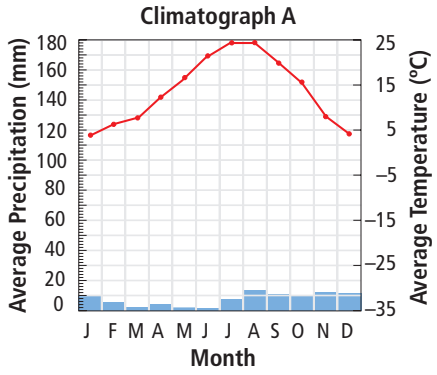
Of great concern is the devastation caused by the microbial hitchhikers (micro-organisms) in windborne soil. Concentrations of bacteria carried across the globe have been calculated to be from 10^6 to 10^9 bacteria per gram of soil. It is estimated that 30 percent of these dust micro-organisms can cause disease. Also along for the ride in soil are viruses and spores from fungi that are affecting many animal species. Evidence shows that the death of Caribbean staghorn corals and sea urchins is directly related to African dust deposits. The fungus *Aspergillus*, which is carried in the windborne soil, has also caused the death of coral sea fans. Disease caused by fungi has been found to affect Caribbean sugar cane and banana crops after dust storms. While African dust in the atmosphere is not new, huge amounts of dust blowing off Asia is a recent occurrence. Increased desertification (the creation of deserts) due to less precipitation and increased land use in Asia is also producing millions of tonnes of windborne dust. Although Hawaiian Island plants may gain nutrients from the dust of Asian deserts, the full extent of the negative effects of this increased soil movement has yet to be determined.

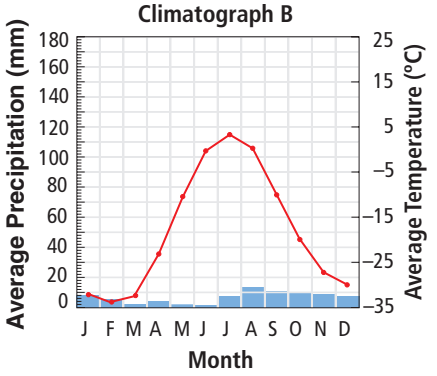
Questions

1. Explain how the Amazon rainforest biome has benefited from the Sahara Desert biome.
2. Give two damaging environmental effects caused by the Saharan dust.
3. How have microbial hitchhikers affected organisms in the Caribbean?

Checking Concepts

1. What is the biosphere?
2. List three abiotic components of a biome.
3. What factors influence the characteristics and distribution of life in a terrestrial biome?
4. Explain the importance of adaptations to the survival of plants and animals in their biome.
5. How are plants adapted to survive a short growing season?
6. List two boreal forest animals, and describe their adaptations.
7. Explain why temperate rainforest biomes are found along coastlines.
8. Explain why there is little vegetation on the floor of the tropical rainforest.
9. (a) Identify the biomes shown in the climatographs below.





(b) Explain how you identified each biome.

10. Match the following biomes to the descriptions in parts (a) to (g).
    (i) tundra
    (ii) boreal forest
    (iii) temperate deciduous forest
    (iv) grassland
    (v) tropical rainforest
    (vi) desert
    (vii) temperate rainforest
    (a) distinct seasons, moderate climate
    (b) permafrost
    (c) Douglas fir, moss, lichen
    (d) many layers of trees and plants, but light gets through
    (e) great biodiversity, many layers of trees and plants, but light does not get through
    (f) fleshy, spiny cacti
    (g) coniferous forest

Understanding Key Ideas

11. Explain how latitude influences temperature and precipitation.
12. Explain how temperature affects the biotic component of biomes.
13. Explain why the plants and animals of eastern Canada are similar to the plants and animals of eastern Asia.
14. Distinguish among the three types of adaptations, and provide an example of each type.
15. Imagine that you were travelling directly north from Venezuela near the equator to the North Pole.
    (a) List the terrestrial biomes that you would travel through.
    (b) Identify one plant and one animal that is typical of each biome.

Pause and Reflect

"The greatest biodiversity is found closest to the equator." Support or refute (argue against) this statement based on what you have learned in this section.

1.2 Ecosystems

The abiotic components of an ecosystem support the life functions of the biotic components of an ecosystem. Organisms within communities constantly interact to obtain resources such as food, water, sunlight, or habitat. Examples of these interactions in ecosystems include commensalism, mutualism, parasitism, competition, and predation. Every organism has a special role, or niche, within an ecosystem.

Words to Know

commensalism
competition
ecosystem
mutualism
niche
parasitism
predation

Understanding the history of ancient forests can help us manage forest ecosystems better in the future. Researchers from universities in British Columbia are studying natural records such as soil sedimentation patterns, ancient seed piles, tree ring growth, forest fire scars, and ice cores (Figure 1.15). They are also analyzing written materials, maps, land surveys, weather observations, photographs, and newspaper stories. This exciting new field of study is called historical ecology.

Historical ecology raises important questions about what natural ecosystems are. It also helps us determine whether we should restore them to a natural state. In an attempt to answer these questions, researchers are tracing the effects of human activities and natural events in forests over time. These records reveal the long-term effect of human activities such as livestock grazing, fire suppression, and timber harvesting. They also show how natural events such as drought and disease can affect forests over time.

Did You Know?

The Tl'azt'en First Nation is located in north-central British Columbia. Tl'azt'en peoples refer to themselves as "Dakelh," which means we travel by water.

Figure 1.15 Researcher measuring the circumference of a tree

Since there are many gaps in these records, projects have been undertaken to acquire more information. For example, the Tl'azt'en First Nation is working with the University of Northern British Columbia at the John Prince Research Forest near Fort St. John. This community has vast experience with the boreal spruce forests of the area, acquired over thousands of years of direct contact. The Tl'azt'en First Nation has also been involved in timber harvesting and land management. Incorporating their detailed knowledge of the plants, animals, and natural occurrences of the forest into the ecological history of the area will help people make better management decisions in the future. These efforts will help preserve this valuable forest ecosystem.

1-2A Your Local Environment

Find Out ACTIVITY

You have been asked by a local community group to create a video about the area in which you live. The video will be shown to people who have just moved into your area and want to know something about the local environment. In this activity, you will prepare the script that will be used to film the video.

What to Do

1. Work with a partner. Review the handout your teacher will give you about the elements of a good video script.
2. Brainstorm a point-form list describing the weather, landforms, streams, lakes, plants, animals, and other natural features in your area.
3. Brainstorm another list describing what you know about the history of your area or how the area has changed over the last 5 to 10 years.
4. Decide on the best way to present your information in a video, and write up your script.
5. Compare your script with those of other students in your class. Update your script with any new information.
6. For the next few weeks, collect Internet, newspaper, or magazine articles, maps, weather observations, and photographs about your area. Find out what changes have occurred in your area over the last 100 years and identify any environmental issues such as damage to natural areas or projects to repair environmental damage. If possible, interview family members, neighbours, and elders who have lived in your area for a long time.
7. Continue to revise your script based on any new information you gather or learn as you work through the rest of this unit.

What Did You Find Out?

1. Explain how you organized the information about your area in your script and why.
2. How did your script compare to other students' scripts? (For example, some scripts may be documentaries; others may be theatre plays.)
   (a) What information did the scripts have in common?
   (b) What information was different?
3. Describe one change you made to your script based on any new information you gained from the work of your classmates.
4. Identify one topic about your area you would like to research further and explain why.

Word Connect

Ecology is a branch of science that deals with the interactions of organisms and their environments. Scientists who study these interactions are called ecologists. "Eco" comes from the Greek word *oikos*, which means a dwelling place or habitation.

Parts of an Ecosystem

At the beginning of section 1.1, you learned that biomes can be subdivided into smaller divisions called ecosystems. An **ecosystem** has abiotic components such as oxygen, water, nutrients, light, and soil that interact with biotic components such as plants, animals, and micro-organisms. Biomes contain many types of ecosystems. Ecosystems can cover many hectares of land, such as the antelope brush grasslands of the South Okanagan Valley (shown on page 2) or the coastal Douglas fir ecosystems on Vancouver Island (Figure 1.16). Ecosystems can also be small, such as a tidepool or a rotting log.

Figure 1.16 Coastal Douglas fir ecosystem

Within ecosystems are habitats. A **habitat** is the place in which an organism lives. For example, the sculpin is a well-camouflaged fish that lives between the rocks at the bottom of a tidepool (Figure 1.17). Another example is the red-backed salamander, which makes its nest in the decaying wood of a fallen tree (Figure 1.18).

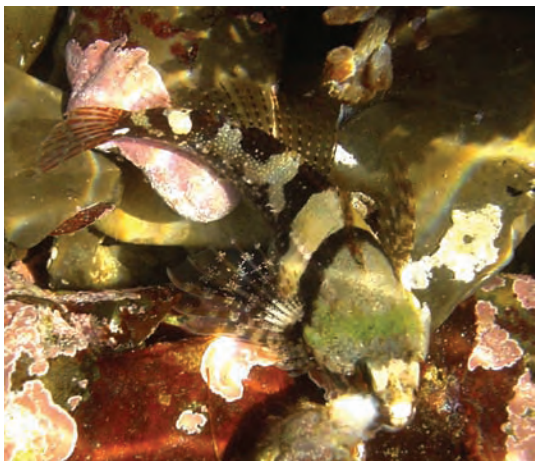


Figure 1.17 The sculpin blends in with its habitat so well that it is difficult to see.

Figure 1.18 Red-backed salamander and its nest

Abiotic Interactions in Ecosystems

The abiotic components of terrestrial ecosystems, such as oxygen, water, nutrients, light, and soil, are just as important as the organisms that live in them.

Plants and animals cannot survive without oxygen. Think about how you feel when you are stuck in a crowded, stuffy room. Without an adequate supply of oxygen, you may begin to feel dizzy. In wetlands, water plants such as certain types of grass and algae produce oxygen, which is used by other organisms that live in water. If the plant life in a wetland is damaged because of pollution (Figure 1.19), you may see fish gulping for air.

Figure 1.19 Gasoline or oil leaking from automobiles can reduce the amount of oxygen available to plants and organisms in a wetland ecosystem.

The cells of most living things contain between 50 and 90 percent water. Without water, no organism would survive. You can go longer without food than you can without water. Water also carries nutrients from one place to another in ecosystems. **Nutrients** such as nitrogen and phosphorus are chemicals that are required for plant and animal growth. You will learn more about nutrients and ecosystems in section 2.2.

Light is required for **photosynthesis**, a chemical reaction that converts solar energy into chemical energy usable by plants. Ecosystems vary in the amount of light they receive. For example, in marine ecosystems, the amount of light decreases in deeper water, so fewer plants can grow (Figure 1.20). In the forest canopy, much more light is available for photosynthesis (Figure 1.21). You will learn more about the importance of photosynthesis in ecosystems in section 2.2.

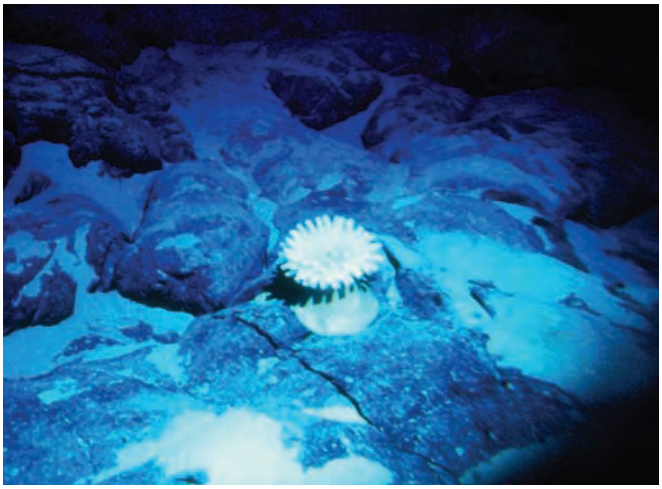


Figure 1.20 Marine ecosystems receive very little light for plant growth.

Figure 1.21 The forest canopy receives more light than lower layers of a forest.

Did You Know?

Topsoil, the surface layer of soil, is the richest soil layer in life and nutrients. In this uppermost layer, more oxygen and water are available for soil organisms, and there is more organic matter available from dead plant and animal materials and animal waste.

Soil is an important part of terrestrial ecosystems. Soil provides nutrients for plants and supports many species of small organisms. A square metre of soil may contain as many as 1000 different species of invertebrates (animals without backbones). Several thousand species of bacteria can be found in one gram of soil (Figure 1.22). Soil anchors plants in one place and absorbs and holds water, making it available for both plants and animals. Soil organisms maintain soil structure. For example, earthworms dig tunnels through the soil (Figure 1.23). The tunnels allow water and nutrients to move more easily through the soil, making them available to plants and other soil organisms. Some soil organisms, such as bacteria, break down pollutants, and others, such as ground beetles, store carbon by eating insects, because all living things, including insects, contain carbon.

Figure 1.22 One species of soil bacteria

Figure 1.23 Earthworms in soil

Reading Check

1. What is an ecosystem?
2. What is a habitat?
3. What are three abiotic components of ecosystems necessary for supporting life?
4. Explain why soil is important to ecosystems.

Biotic Interactions in Ecosystems

A **species** is a group of closely related organisms that can reproduce with one another. A **population** refers to all the members of a particular species within an ecosystem. In the ecosystem of Williams Creek, near Terrace, many populations interact, such as speckled frogs, mosquitoes, grizzly bears, moose, mountain goats, bald eagles, salmon, western red cedar, western hemlock, and black cottonwood trees. All of these populations form a community. A **community** is all the populations of the different species that interact in a specific area or ecosystem (Figure 1.24). These biotic interactions are sometimes ordered in an **ecological hierarchy** of organism, population, community, and ecosystem.

internet connect

You can design your own ecosystem in a bottle without leaving your computer. Find out how to build a virtual ecosphere. Start your search at **www.bcscience10.ca**.

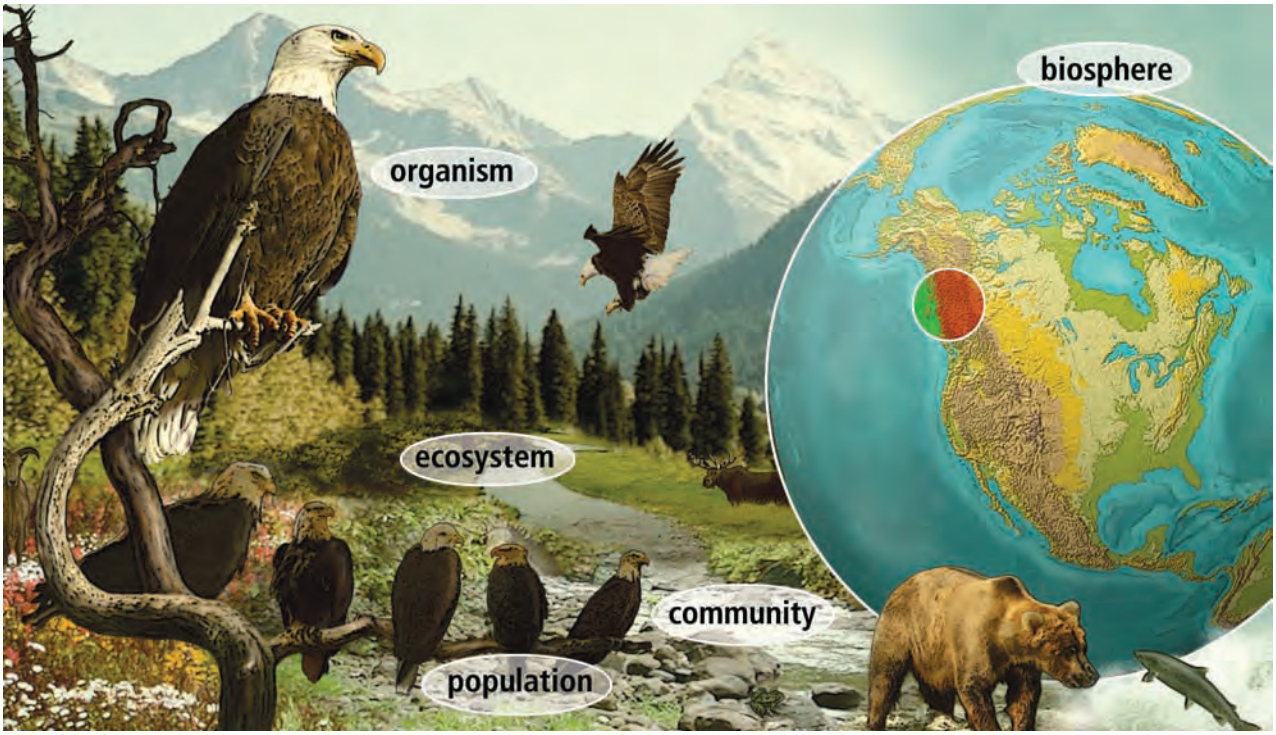


Figure 1.24 The Williams Creek ecosystem

Reading Check

1. What is a species?
2. What is a population?
3. What is a community?

Biotic Interactions in Populations

Within an ecosystem, organisms interact constantly within their species and with other organisms. Three kinds of interactions in ecosystems are commensalism, mutualism, and parasitism.

Figure 1.25 The candy-striped shrimp finds shelter on a crimson anemone.

Symbiotic Relationships

Commensalism, mutualism, and parasitism are examples of symbiosis or symbiotic relationships. **Symbiosis** refers to the interaction between members of two different species that live together in a close association.

Commensalism

Commensalism is a symbiotic relationship in which one species benefits and the other species is neither helped nor harmed. Often the host species provides shelter or transportation for the other species. For example, in Queen Charlotte Sound, the crimson anemone provides shelter and protection for the candy-striped shrimp (Figure 1.25). The colour of the crimson anemone is similar to that of the candy-striped shrimp. This colouring allows the shrimp to hide from predators, and the anemone is not harmed. Another example of commensalism is the relationship between barnacles and whales. Barnacles attach to whales and are transported to new locations in the ocean (Figure 1.26). Whales are not harmed in this process, and the barnacles benefit from new food sources.

Figure 1.26 The humpback whale transports barnacles that are attached to its pectoral fin.

Figure 1.27 Spanish moss

Spanish moss, which is commonly called old man's beard, can be found in the temperate rainforests of British Columbia (Figure 1.27). Spanish moss and the trees it grows on are another example of commensalism. Spanish moss lives on trees in rainforests and has no roots. It is an epiphyte, like the orchids of tropical rainforests. Epiphytes are plants that are supported by or anchored on other plants, but they usually do not obtain water or nutrients from these hosts. Spanish moss wraps its stem around trees and grows high into the forest canopy, where more sunlight, nutrients, and moisture are available. The feathery structure of Spanish moss captures nutrients and moisture from the air.

Mutualism

Mutualism is a symbiotic relationship in which both organisms benefit. In some mutualistic relationships, two species are unable to survive without each other. The relationship between certain plants and bees, wasps, bats, or other pollinators illustrates this dependent relationship. Moth-pollinated plants often have spurs or tubes that are the exact length of a certain moth's feeding tube. Snapdragon flowers open only for bumblebees that are of a specific mass (Figure 1.28).

Western red squirrels and northern flying squirrels (Figure 1.29) of the boreal forests of British Columbia feed on an underground fungus that is critical to the trees' ability to absorb water and nutrients. After eating the fungus, the squirrels spread fungal spores in their droppings over the forest floor. The dispersal and growth of the fungus promotes the growth of young tree seedlings.

In another type of mutualism, one species defends another species against attacks in return for food and shelter. For example, in savanna (tropical grassland) biomes, a species of aggressive ant lives in the hollow thorns of the bullhorn acacia bush. The ants sip nectar from the tips of the bullhorn acacia's leaflets (Figure 1.30). In return for food and shelter, the ants protect the plant by aggressively fighting off other insects and animals by stinging them.

Figure 1.28 A bumblebee collecting the pollen of a snapdragon

Figure 1.29 The northern flying squirrel eats almost nothing else except lichens and fungi.

Figure 1.30 Mutualism is demonstrated in the symbiotic relationship between these ants and the bullhorn acacia plant.

Figure 1.31 Lichens are often found on rocks and trees.

The most famous example of mutualism is that of lichens (Figure 1.31). Over 2500 types of lichens exist, and they can be found in every biome on Earth. Each lichen has an alga (plural: algae) and a fungus that live in a mutualistic relationship with each other. The alga produces sugars and oxygen for the fungus through photosynthesis. In return, the fungus provides carbon dioxide, water, minerals, and protection from dehydration for the alga.

1-2B Considering the Interactions between Species

Think About It

Mutualism is an important interaction between species. In this activity, you will create two fictional species that interact in a mutualistic relationship.

Materials

- paper
- coloured markers

What to Do

1. Working with a partner, decide on two imaginary species. Brainstorm the characteristics of each species that allow them to interact in a way that is beneficial to both species. (**Hint:** Think about the adaptations each species has that suit it to the other species.) Your species can live in water, in the air, or on the land. Try to come up with examples that have not been discussed in class. Be creative.
2. Choose an appropriate name for each species.
3. Draw and label a diagram that shows the interaction of the two species.
4. Write a paragraph about your diagram describing the mutualistic relationship of the two species.
5. Compare your diagram with those of the rest of the class.

What Did You Find Out?

1. Make a class list of all the types of adaptations shown in the mutualistic relationships of all the imaginary species.
2. Did any of the groups illustrate a mutual relationship that is actually found in nature? If so, describe it.

Parasitism

Parasitism is a symbiotic relationship in which one species benefits and another is harmed. Parasites are usually much smaller and more numerous than their hosts. Parasites may live in or on a host and obtain food from the host's blood or body tissues. Usually, the host is not killed, but a parasite can cause a great deal of damage to a host's body and organs, weakening it and sometimes causing it to die. Some parasites can live on different hosts. Other parasites can live on only one host.

There are about 3200 species of parasites that can infect humans, and 100 of these species are worms. For example, a type of worm that infects both humans and dogs is called a hookworm. *Ancylostoma caninum* is the species that infects dogs. Hookworms live in soil and animal feces. When dogs are exposed to soil or feces contaminated with hookworms, these blood-sucking microscopic parasites can penetrate their skin. The hookworm enters the bloodstream and travels to the intestine where it attaches by its teeth (Figure 1.32) to the intestinal wall.

The mountain pine beetle is a well-known insect parasite that is devastating the lodgepole pine and white pine forests of British Columbia. You will learn more about this parasite in Chapter 3. Not all parasites are small. In the jungles of southeast Asia lives a type of parasitic flowering plant called *Rafflesia arnoldii*. This plant produces the world's biggest flower, and it lives only on the tetrastigma vine (Figure 1.33). *Rafflesia arnoldii* has no leaves or stem, but it has strands of tissue called filaments that grow into the tetrastigma vine to obtain food, which weakens the vine.

Figure 1.32 *Ancylostoma caninum* has pairs of teeth that attach to the wall of a dog's intestine. The hookworm obtains food from a host's blood.

Figure 1.33 *Rafflesia arnoldii* grows close to the jungle floor. Its flower has a diameter of 100 cm and a mass of 11 kg.

internet connect

Another form of parasitism is called brood parasitism, in which one species of bird lays its eggs in the nest of another species. Cowbirds often lay their eggs in the nests of other birds, such as vireos, which can affect the survival rate of their hosts' offspring. Find out more about brood parasitism. Start your search at **www.bcscience10.ca**.

Reading Check

1. What is symbiosis?
2. What is commensalism?
3. Give an example of mutualism.
4. Give an example of parasitism.

Niches

Organisms have special roles in the ecosystems in which they live. The term **niche** is used to describe these roles. An organism's niche includes the way in which the organism contributes to and fits into its environment. All the physical, chemical, and biological interactions required for a species to survive, grow, and reproduce are part of the organism's niche. Within its niche, an organism interacts with other individuals of the same species or with individuals of other species. For example, great blue herons always live near water, where they can fish and nest in nearby trees and bushes. They often feed alone but will tolerate the presence of other birds. Because of their long legs, great blue herons can find food in deeper water, which allows them to occupy a niche that other heron species with shorter legs cannot (Figure 1.34). Often interactions involve competitions for food and other resources, such as water, sunlight, or habitat.

Figure 1.34 Great blue heron

Competition

Competition is a harmful interaction between two or more organisms that can occur when organisms compete for the same resource (such as food) in the same location at the same time. The health of an organism and its ability to grow and reproduce is reduced if the organism expends energy to compete against other organisms. For this reason, competition can limit the size of a population.

Some plants have characteristics that make them successful competitors. For example, spotted knapweed releases chemicals into the soil, which prevents the growth of other plants and allows the knapweed to populate a field quickly (Figure 1.35). This plant spreads rapidly and is also a successful competitor because one plant alone can produce 25 000 seeds. Because of these qualities, spotted knapweed is one of the worst rangeland weeds in British Columbia.

Animals such as coyotes usually hunt in packs to kill large animals, such as deer and elk. However, in areas where only smaller animals, such as rabbits, squirrels, and mice are available for food, coyotes will hunt on their own and compete with other coyotes, especially if these food sources are scarce (Figure 1.36).

Figure 1.35 Spotted knapweed

Figure 1.36 Although coyotes often hunt together, they will compete with each other over habitat or food sources.

Did You Know?

Some scientists believe that modern seabirds, such as pelicans and albatrosses, occupy the same niche once occupied by the pterosaur, a type of prehistoric flying vertebrate. Although pterosaurs were long thought to be a type of reptile, there is evidence that they may have been warm-blooded (able to maintain their own internal body temperature).

internet connect

Ecologists use the term "herbivory" to describe the predation of plants by herbivores (plant eaters). Many plants have adaptations, such as thorns and toxins, that reduce the impact of these predators. Find out more about these adaptations. Start your search at **www.bcscience10.ca**.

Predation

In ecology, **predation** is the term used to describe predator-prey interactions in which one organism (the predator) eats all or part of another organism (the prey). As a result, one organism benefits and the other is harmed. Predation, as you will learn in section 2.1, also moves energy through an ecosystem.

Predatory animals have adaptations that make them effective predators. Predator adaptations may include highly developed senses such as very good eyesight or a keen sense of smell. The sharp, pointed teeth, or "fangs," of a cougar (Figure 1.37) are an adaption that make this predator better able to catch its prey.

Figure 1.37 Cougars have long canine teeth.

Figure 1.38 Porcupines have sharp spines.

Prey animals also have adaptations that keep them from being eaten. For example, porcupines have spines (Figure 1.38). Turtles and clams have hard shells. Newts produce poisonous substances. Other forms of adaptation, such as camouflage, allow prey animals to hide from predators. For example, stick bugs, which are eaten by birds, look like twigs (Figure 1.39). Mimicry is an adaptation in which a prey animal mimics another species that is dangerous or tastes bad. For example, the viceroy butterfly looks like the bitter-tasting monarch butterfly and so is avoided by predators (Figure 1.40).

Figure 1.39 Stick bug

Figure 1.40 Viceroy butterfly (A) and monarch butterfly (B)

The size of a prey population can be affected by the number of predators. In Figure 1.41, the lynx is the predator and the snowshoe hare is the prey. In this example, the prey population grows when there are few predators. When the predator population is high, the prey population shrinks.

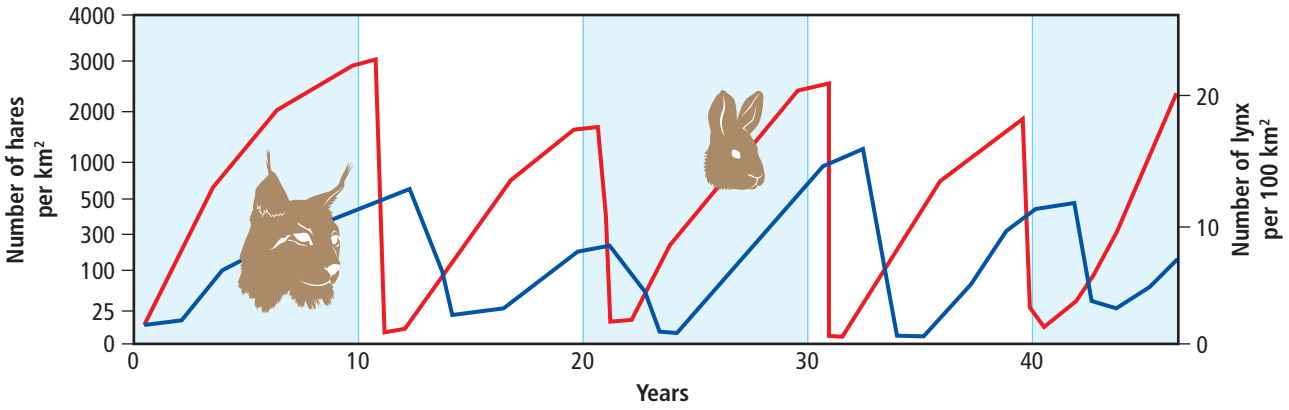


Figure 1.41 The predator-prey relationship between lynx and snowshoe hares

Suggested Activity

Find Out Activity 1-2C on page 49

Predator-prey relationships are extremely complex. Many prey populations are regulated by factors other than predation, such as availability of food and space and by rates of population growth.

Reading Check

1. What is a niche?
2. What resources do organisms compete for?
3. What is predation?
4. Provide one example of a predator.
5. State two ways in which prey avoid predators.

Explore More

The Vancouver Island marmot, which lives only on mountain slopes of Vancouver Island, is Canada's most endangered animal. Find out more about the marmot's ecosystem and how efforts are being made to save this unique animal. Start your search at **www.bcscience10.ca**.

Biodiversity in Ecosystems

A land area or water body that has a large variety of organisms, or great biodiversity, is often an indicator of the health of an ecosystem. Most biodiversity losses are a direct result of habitat loss. Each ecosystem, such as a forest or a wetland, has unique biotic and abiotic components that contribute to the availability of food, water, and nutrients for all organisms. Forest ecosystems, for example, prevent soil erosion, store nutrients, control climate, and provide habitat for many species of plants, mammals, birds, fish, and amphibians. Forests also benefit humans by providing a source for timber products (Figure 1.42) and medicine. Wetlands purify water and prevent flooding (Figure 1.43).

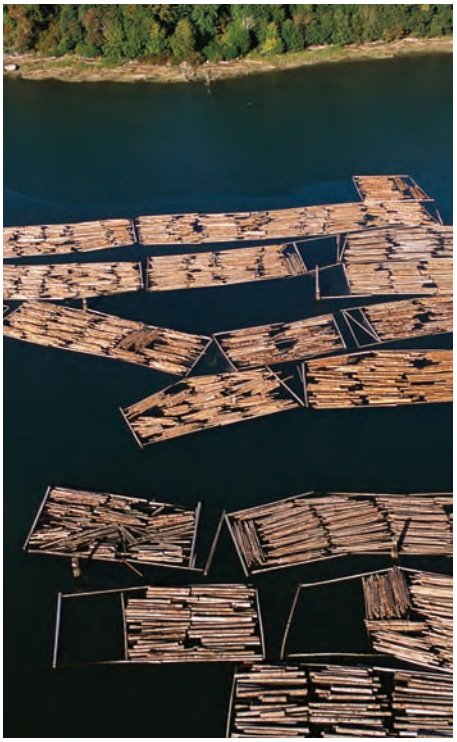


Figure 1.42 Forests have been an important part of the economy of British Columbia, providing logs for lumber and papermaking.

Figure 1.43 Wetlands provide habitat for a variety of water-tolerant plants, for birds such as herons, geese, ducks, and for other animals, such as fish, moose, deer, and beaver.

As humans continue to use and expand into ecosystems in all parts of the world, maintaining the biodiversity of ecosystems becomes more difficult. Many places, such as British Columbia, are developing ecosystem management plans, which try to balance human activities with the preservation of ecosystem biodiversity. In British Columbia, the greatest threat to ecosystems is human activity and the expansion of cities. Preserving enough of an ecosystem to maintain biodiversity will be an ongoing challenge in our province.

1-2C Predator-Prey Simulation

Find Out ACTIVITY

In this activity, you will simulate predator-prey relationships and graph your findings.

Materials

- 8 textbooks
- 200 small (2 cm) cardboard squares (each represents a prey animal)
- 12 large (8 cm) cardboard squares (each represents a predator)
- data table
- graph paper
- coloured pencils

What to Do

1. Working in a group of three, decide who will control the prey animals, who will control the predators, and who will be the data recorder. Your teacher will give you a data table.
2. Clear all other materials off your table. Construct a forest habitat as instructed by your teacher.
3. Read the following rules. You will need to refer back to them as you do the simulation.
    - Controllers of prey animals and predators must stand 0.5 m from the habitat entrance when tossing the squares.
    - When one half or more of a prey animal square is covered by a predator square, the prey animal has been captured and is removed from the habitat.
    - In each round, each predator that captures at least three prey animals survives.
    - If fewer than three prey animals are captured, the predator dies and is removed from the habitat.
    - In each round, each predator that captures at least three prey animals survives and reproduces (producing a new generation). Therefore, one additional predator will be tossed into the habitat for every three prey animals caught.
    - If all predators die, then a new predator is tossed into the habitat.
    - The prey population doubles each generation, so if 10 prey animals survive, the next generation (round) starts with 20 prey animals.
    - The maximum carrying capacity of this forest habitat is 200 prey animals. (Carrying capacity is the ability of an ecosystem to supply enough resources such as food, water, and shelter for continued survival.)
4. Begin the simulation. The prey animal controller tosses three prey animals into the habitat. The predator controller then tosses one predator into the habitat at these prey animals.
5. Continue the simulation for 20 generations or until all the prey animals are captured. The data controller records all data for each generation in the data table provided by your teacher.
6. Construct a graph with two lines using the data from the "Total Prey Animals" and "Total Predators" columns for each generation. Label the *x*-axis from generations 1 through 20. Label the *y*-axis "Population Numbers." Determine the intervals you will use to plot the population numbers.
7. Use one colour of pencil to plot the points for the total prey animals. Use another colour of pencil to plot the points for the total predators for each generation.
8. Connect the points to form the prey animals' graph line. Use another colour of pencil to connect the points for the predators' graph line.

Science Skills

Go to Science Skill 5 for information on how to construct a graph.

What Did You Find Out?

1. Describe the relationship between the prey and predator lines on your graph.
2. Predict what the graph would look like after 12 generations if all the predators were lost to a disease. Sketch this graph.
3. Predict what the graph would look like after 12 generations if all the prey animals were lost to a disease. Sketch this graph.
4. Predict what would happen to the predator and prey populations if half of the prey animals' habitat were destroyed by the construction of a shopping mall.

Wild, Weird, Wonderful

www Science

Beware the Rough-Skinned Newt

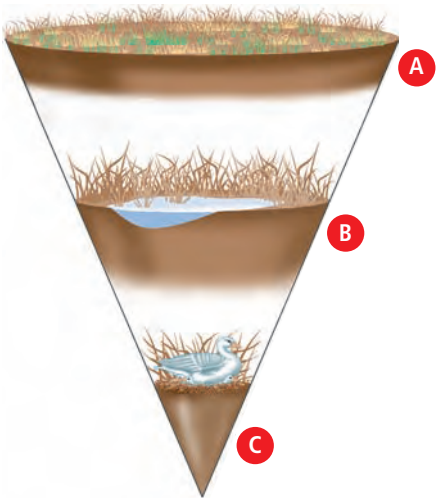
The rough-skinned newt, which is native to British Columbia, has two remarkable adaptations for defence. When threatened, the newt flips up to show its bright red-orange belly, and takes on a U shape, which is read as a stop sign by predators. If a predator is not frightened away by the defensive posture, the newt then releases a neurotoxin (a chemical that affects the nervous system) that causes nerves to stop functioning, paralyzing the predator. The toxin from one newt could kill 100 humans.

If a newt produces a lot of toxin, it will have less energy to reproduce. If the newt produces too little toxin, it will be eaten. Today, the only predator of the rough-skinned newt is the garter snake. Some garter snakes have a genetic mutation that makes them resistant to the toxin. Scientists have discovered that this mutation changes a protein on nerve cells that bind to the toxin so the toxin does not paralyze the snake. However, this ability to resist the toxin also comes at a cost. The more resistant the snake is to a newt's neurotoxin, the more slow moving it becomes. Why? Because the mutated protein causes less effective nerve and muscle function and makes the snake more vulnerable to its predators.

In areas where newts produce low levels of toxin, garter snakes have a low resistance to the toxin. In areas where populations of newts produce intermediate levels of toxin, garter snakes have an intermediate resistance. In populations where newts produce very high levels of toxin, garter snakes have high resistance. In these populations with high toxin levels, there will be fewer newts because they will produce fewer offspring. There will also be fewer garter snakes because the toxin makes them so slow moving and vulnerable to capture by their predators. Thus, the populations of newts and garter snakes are kept in balance.

Checking Concepts

1. List the following terms in order from smallest to largest: biome, biosphere, community, ecosystem, single species, population.
2. How is a habitat different from a niche?
3. Identify which letter represents a biome, which represents a habitat, and which represents an ecosystem in the diagram below.



4. What requirements for life are provided by ecosystems?
5. Why is soil important for terrestrial ecosystems?
6. Why are some organisms in an ecosystem in competition?
7. Give one example of a plant adaptation and one example an animal adaptation for:
   (a) mutualism
   (b) predation
8. Identify each of the following as an example of commensalism, mutualism, parasitism, competition, or predation.
   (a) Some bacteria live in roots of soybean plants, obtain sugars from the plant, and provide nitrogen to the plant.
   (b) Orchids grow high in the canopy of tropical rainforests. The trees on which the orchids grow are not harmed, nor do they benefit from the orchids.
   (c) Tapeworms can live in the intestines of humans. The tapeworm feeds off the nutrients a human host has ingested, making the nutrients unavailable to the host. This can result in malnutrition for the host.
   (d) A western red cedar seedling and a Sitka spruce seedling are both growing in a temperate rainforest. Both require sunlight, nutrients, and water from the environment.
   (e) Some flowers are pollinated by bats. In return, bats receive nectar from the flowers.
9. Provide several reasons why ecosystems are important to the survival of humans.

Understanding Key Ideas

10. Think about the organisms that live in your community. Identify one example of each of the following.
    (a) a competitive relationship
    (b) a predator-prey relationship
    (c) a commensal relationship
    (d) a mutualisitic relationship
11. Many people believe that plants are defenceless. Provide an argument to refute this statement.
12. What will happen when two species compete for the same resources?
13. Describe the effect of the following conditions on a population of predators.
    (a) The number of prey animals is low.
    (b) The number of prey animals is high.

Pause and Reflect

Suppose a city official recently told reporters "Every type of ecosystem must be preserved." Consider what you have learned about ecosystems. Use examples from this section to support the statement.

Prepare Your Own Summary

In this chapter, you investigated the factors that influence the characteristics and distribution of biomes and the adaptations of the plants and animals within them. You have also investigated the interaction of the biotic and abiotic components within biomes and ecosystems. Create your own summary of the key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 11 for help with using graphic organizers.) Use the following headings to organize your notes:

1. Factors that Influence the Characteristics of Biomes
2. The Distribution of Biomes
3. Adaptations and Biomes
4. Abiotic Interactions in Ecosystems
5. Biotic Interactions in Ecosystems

Checking Concepts

1. Explain the relationship between the biosphere, a biome, and an ecosystem.
2. (a) Name three factors that influence the characteristics of biomes.
   (b) Describe how each of these factors might influence where a biome is located in the world.
3. What two factors are the most important for determining a region's climate?
4. What is a climatograph?
5. Explain the term "adaptation."
6. Use examples to explain the difference between a structural adaptation and a behavioural adaptation.
7. Explain why the temperate rainforest biome is usually found along the coasts of continents.
8. Explain why there are few trees in the grassland biome.
9. What effect does elevation have on the characteristics of a biome?
10. What type of biome might you find at the top of a mountain? Explain.
11. Identify three abiotic components of an ecosystem, and relate their importance to the plant and animal life in an ecosystem.
12. Explain what is meant by "ecological hierarchy."
13. Explain the difference between commensalism and mutualism.
14. How is parasitism different from predation?
15. List three adaptations of prey animals.

Understanding Key Ideas

16. Predict what would happen to a plant if it were moved from a wetland to a desert. Explain your prediction.
17. Why do you think biomes are often classified according to their plant species rather than by the animals that live in the biomes?
18. Explain why hot desert ecosystems can exist on every continent on Earth except Antarctica.
19. Are symbiotic relationships part of an organism's niche? Explain.
20. Why are hosts often not killed in parasitic relationships?
21. Explain how competition can affect the health of an organism and its ability to reproduce.
22. How can the size of a prey population be affected by the number of predators?
23. Use the world map and the graph on the next page to answer this question.
   (a) Match the numbers of the biomes on the world map with the letters on the average annual temperature and average annual precipitation graph.
   (b) Identify the biome for each match.

Applying Your Understanding

24. The yellow-bellied marmot is found in British Columbia and southwestern Alberta. Although the marmot usually lives at elevations of over 3000 m, it is also found on agricultural land in foothills and valleys. Like other members of the marmot family, the yellow-bellied marmot is a major hole digger. Many animals, such as raccoons, foxes, rabbits, and snakes, are successful in marmot country because of the shelter provided by marmot holes. The yellow-bellied marmot primarily eats plants, such as grasses, and occasionally insects, such as grasshoppers.

(a) What type of symbiotic relationship exists between marmots and raccoons? Explain.

(b) Is the marmot primarily a herbivore, a carnivore, or an omnivore? Explain.

Pause and Reflect

In this chapter, you have learned that soil is an important part of terrestrial ecosystems. Franklin D. Roosevelt, who was president of the United States from 1933 to 1945, said "The nation that destroys its soil, destroys itself." Think about what you have learned about soil and ecosystems in this chapter and support or refute (argue against) this statement.