CHAPTER 3

Community Ecology

Chapter Preview

The forest ecosystem shown here is amazingly complex. It is a vast community of relationships, some more obvious than others. Small voles depend on cold temperatures and precipitation in order to burrow under the snow during the winter. Other organisms depend on the small voles as a food source. If changes occur in the vole populations, the larger organisms are affected. This forest system and other ecosystems are extremely complex, yet there are only a few basic principles at work. The relationships between organisms in the forests of B.C. would be impossible to describe entirely at any one time. Yet at the root of this complexity are a few basic rules that govern how the interactions occur. What moves between organisms in an ecosystem? How do changes in one community impact on other communities?

KEY IDEAS

- **The biosphere contains distinct biological communities.**
- **Species adapt to changes in environmental conditions and to other organisms.**
- **Species in communities interact in many different ways.**
- **Succession is an indication of change in an ecosystem.**

TRY THIS: Modelling Interactions in an Ecosystem

Skills Focus: predicting, analyzing, communicating

In this activity, you will try to model the relationships that exist within an ecosystem. You will then be able to appreciate how a single change can impact the entire system.

Materials: ball of string or yarn, index cards from your teacher (1 for each member of your group)

1. Your teacher will provide your group with cards representing organisms. As a group, suggest relationships that may exist among the organisms.
2. Model these relationships by passing the ball of yarn between students holding the cards representing related organisms until each organism is connected.
3. Model an organism leaving the area or dying by letting go of the connecting string.

A. In what ways was a single disturbance able to impact the entire community?

B. Consider an organism that is connected to a large number of organisms. How would a disturbance of this population compare with a disturbance in a population with fewer connections?

3.1 The Distribution of Organisms in the Biosphere

Organisms are specialized for different living conditions in the biosphere. At its most basic level, the distribution of life in the biosphere is largely determined by two factors: average temperature and average precipitation (Figure 1). The long-term pattern of temperature and precipitation is called **climate**. These long-term weather patterns are largely affected by location on Earth. Particularly important are **latitude** (the distance from the equator) and **elevation** (height above sea level), as shown in Figure 2, and distance from a body of water. The abiotic factors that tend to differ by location and influence global climate patterns are amount of solar energy, wind patterns, and ocean currents. You will learn more about these factors in Unit E.

LEARNING TIP

You will notice that Chapter 3 includes many new terms. These are words that you need to know. To get a head start on your studying, make vocabulary cards. On one side of the card, write the word, and on the other side, write a brief definition.

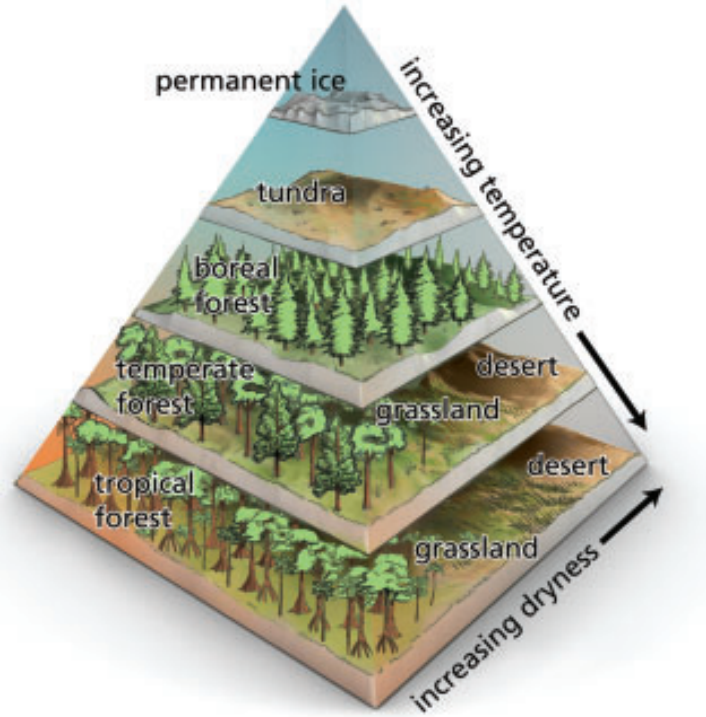


Figure 1 Variations in temperature and precipitation create different plant communities with distinct characteristics.

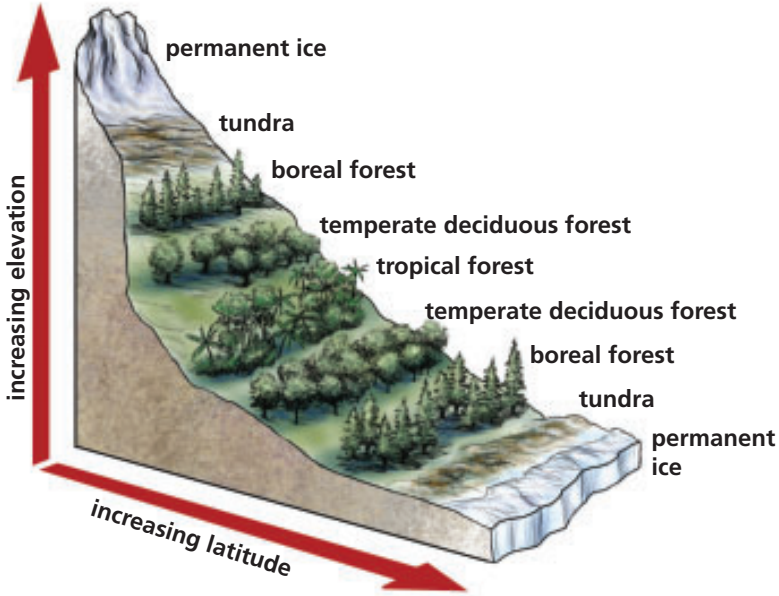


Figure 2 Changes in both latitude and elevation are responsible for establishing ecosystems with distinct vegetation.

Factors Affecting Abiotic Conditions

Solar Energy

Solar energy is responsible for determining average temperature at various locations on Earth. In the region near the equator, the Sun's rays hit Earth directly, creating a climate with a higher average temperature than at Earth's poles. The solar energy is less intense at the Earth's poles because it is

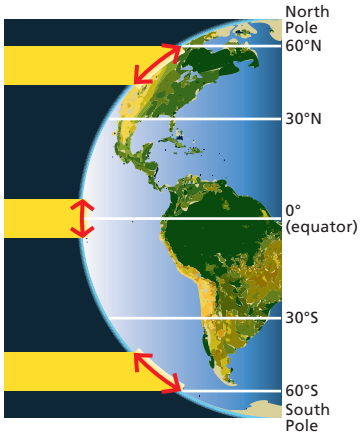


Figure 3 Earth is a sphere, so solar energy striking Earth near the polar regions is spread over a greater area than a similar amount of energy striking Earth near the equator.

striking a greater amount of surface area (Figure 3). Similar changes in temperature are seen with changing elevation, where there is a marked decrease in the temperature with increased elevation. As a result, the same climate changes that occur with increasing latitude can occur with increasing elevation.

Earth is tilted on its axis, which affects the seasonal temperatures in many regions. On Earth's annual journey around the Sun, the northern and southern regions of the globe spend part of the year tilted toward and part of the year tilted away from the Sun. For example, during the northern hemisphere's winter period, Earth is tilted away from the Sun. This creates noticeable variation in temperature and precipitation throughout the year. In tropical regions, there are no noticeable seasonal changes since the region is continually exposed to the direct solar rays of the Sun (Figure 4).

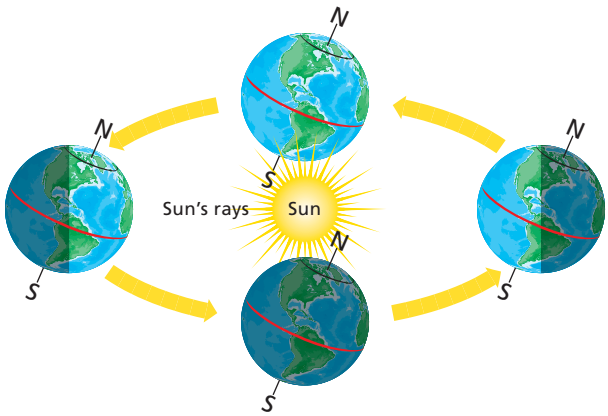


Figure 4 The tilt of Earth creates warm and cold seasons in most regions on Earth.

Learn more about the world's major climate zones and ocean currents, and test your knowledge, at **www.science.nelson.com**

Winds and Currents

The movements of warm and cold air masses create winds (Figure 5). As air masses move from warm regions near the equator to cold regions near the poles, they cause wind patterns that affect the climate.

Wind patterns drive the movement of ocean currents, which in turn are involved in circulating heat. The ocean has a greater heat capacity than land, so it absorbs solar energy and releases it at a slower rate than land does. The movement of large bodies of water in currents and the release of energy from them affect the climate of nearby regions. Airflow is disrupted where oceans meet continents (Figure 6). Warm, moist air from over the ocean rises over coastal mountains and cools, releasing large amounts of precipitation. On the far side of the mountain range, a rain shadow exists where dry mountain air warms as it descends and releases very little moisture.

You will learn more about global patterns of wind and water in Chapter 15.

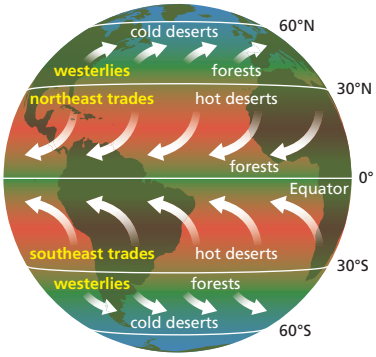


Figure 5 The location of warm and cold air masses causes global wind systems that are responsible for climate condition.

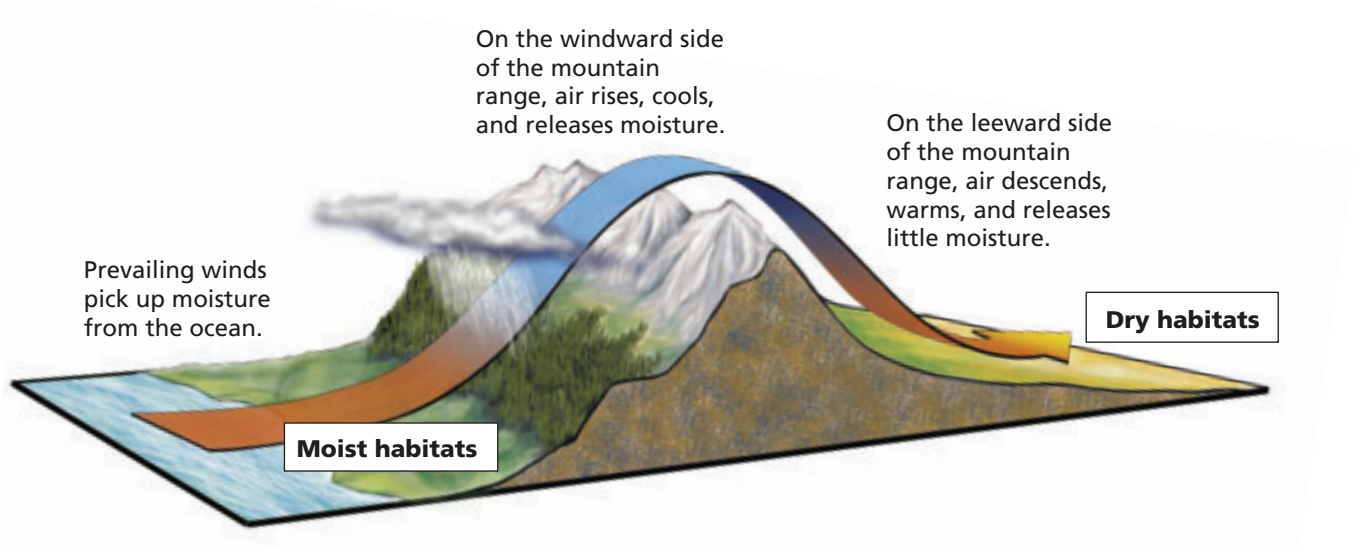


Figure 6 Warm, moist air rises and cools near mountain ranges. Most precipitation falls before the air passes over the mountain.

Precipitation and temperature are the abiotic factors that seem to be the most influential in determining the characteristics of the plant and animal communities within an ecosystem. The long-term climatic trends in precipitation and temperature are described using climatographs. A **climatograph** is a graphical way to show the monthly changes in temperature and precipitation throughout a year (Figure 7). You will explore climatographs further in Investigation 3A. 3A *Investigation*

3A *Investigation*

Working with Climatographs

To perform this investigation, turn to page 74.

In this investigation, you will analyze climatographs and determine the characteristic conditions that they represent.

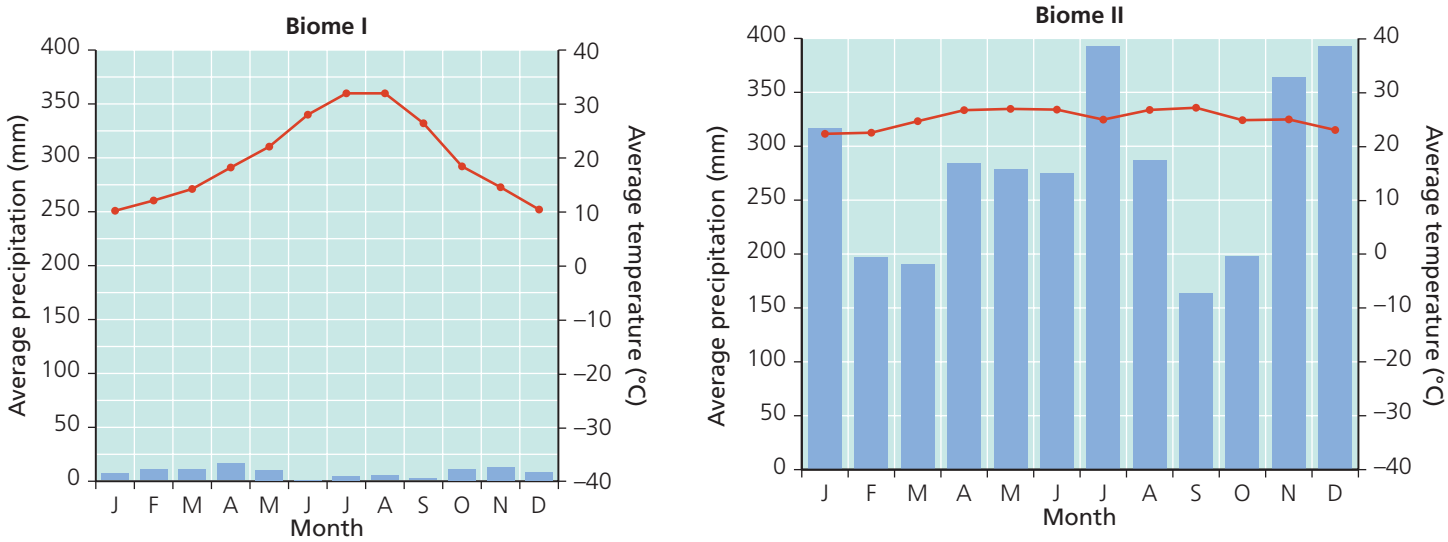


Figure 7 The two climatographs represent two very different ecosystems. Can you figure out which one is a desert and which is a tropical rainforest?

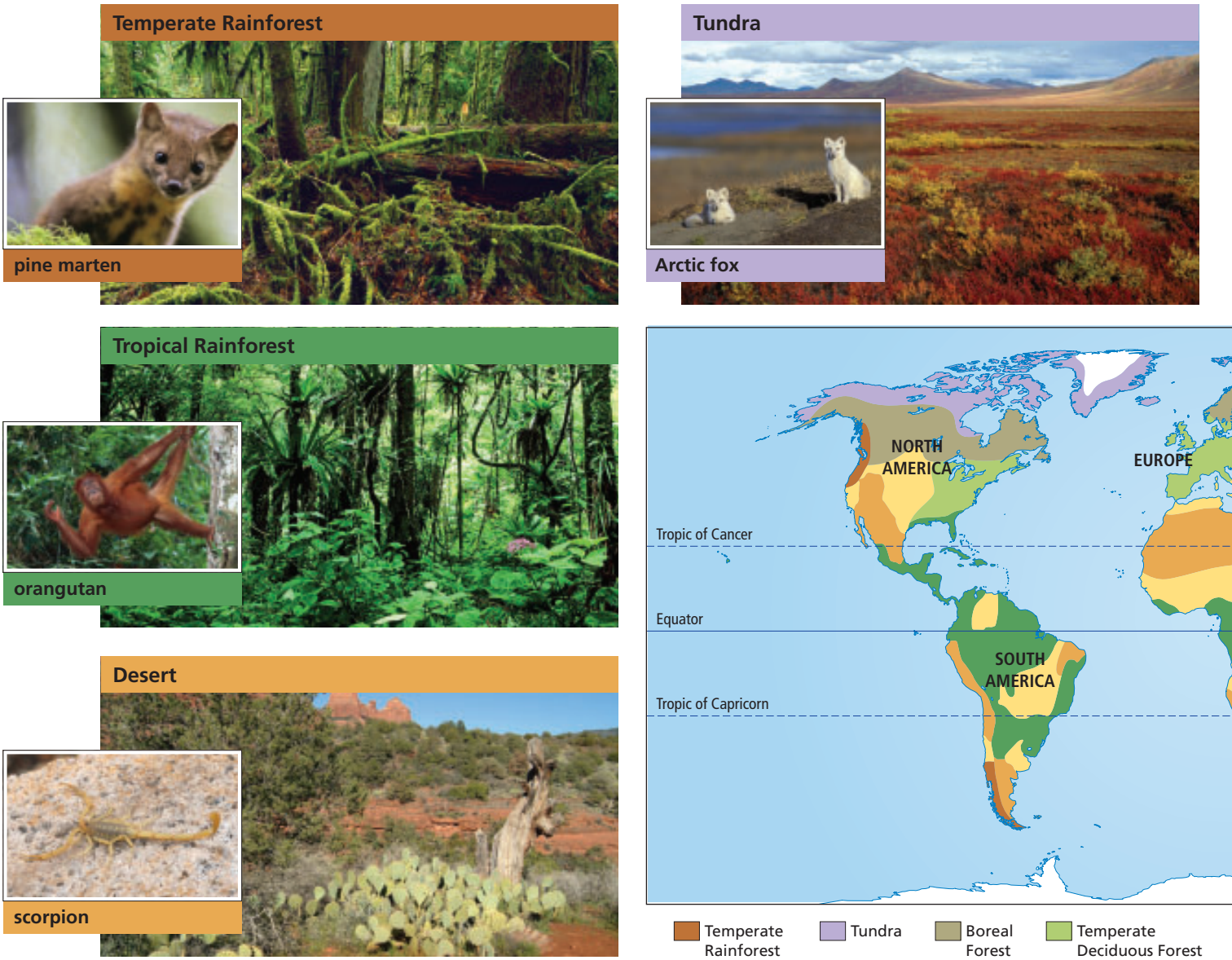


Figure 8 The distribution of Earth's major biomes indicates locations where abiotic factors are similar, resulting in similar biotic communities.

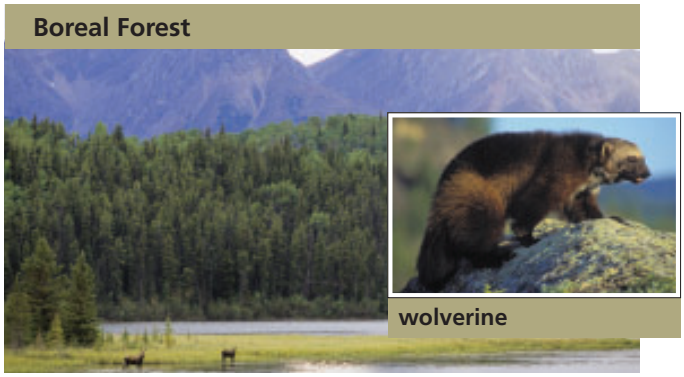
World Biomes

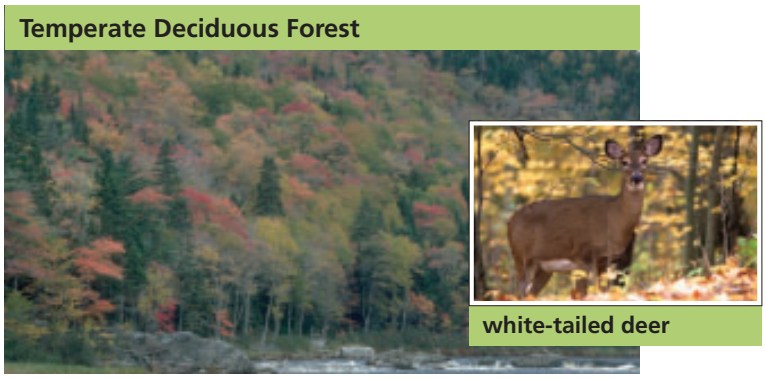
STUDY TIP

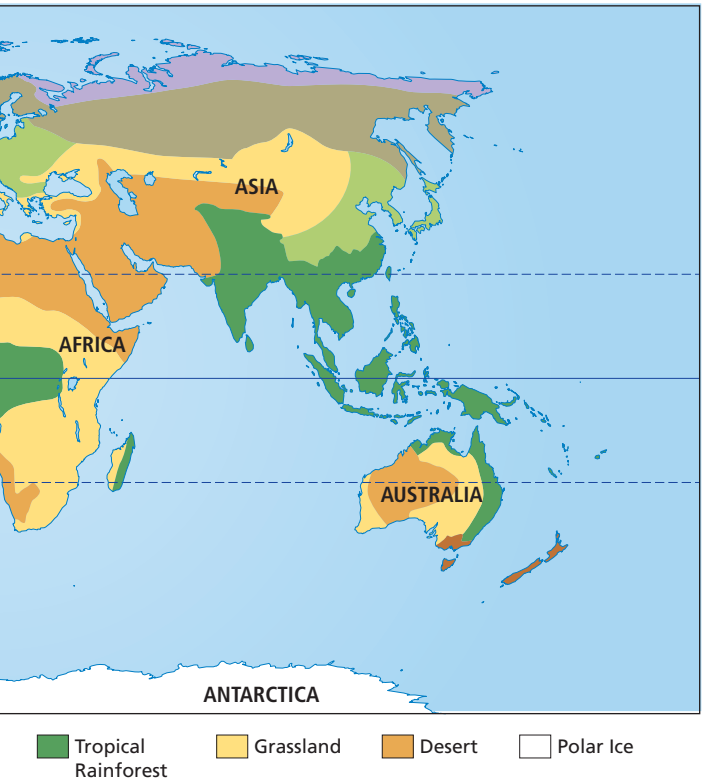
Making study cards is important for learning and remembering. To help you remember the information in the World Biomes section, make a study card for each biome. Include a description and examples of the species that live in each biome.

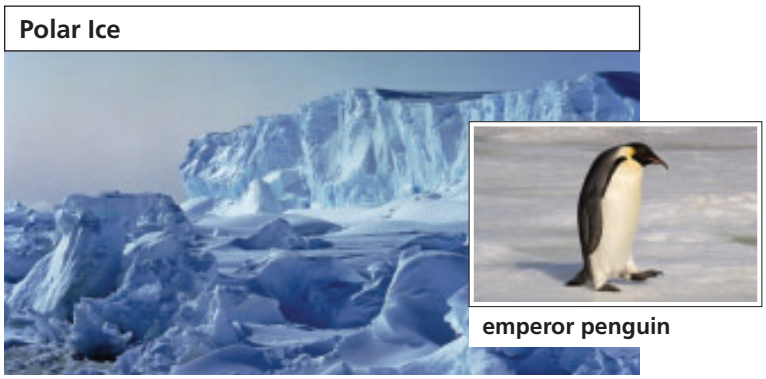
In some areas on Earth, abiotic factors are similar and create similar yet distinct ecosystems in different geographical locations. If you were to travel across Canada or visit other countries of the world, you would see some of these different environments. You would also notice an important pattern: similar organisms live in different locations that have similar environmental conditions. Each of these large terrestrial ecosystems that have similar environments and exist over a wide area is called a **biome**. There is much less variation within a biome than there is between two different biomes.

The region between two neighbouring biomes is usually a transition zone where one form of plant life might slowly give way to another form. There is some disagreement about the actual number and boundaries of the world









biomes because the lines between biomes are not always distinct. This section introduces eight terrestrial biomes: the tundra, boreal forest, temperate deciduous forest, temperate rainforest, grassland, tropical rainforest, desert, and polar ice (Figure 8).

Tundra

The **tundra** is a massive biome that extends in a continuous belt across Canada, Alaska, Asia, and Europe. There is very little precipitation, usually less than 25 cm per year. **Permafrost**, a layer of permanently frozen soil, is usually present within a metre of the surface. Small, slow-growing plants such as grasses and mosses survive in the harsh conditions, and reindeer lichen, which can grow on bare rock and absorb water without the use of

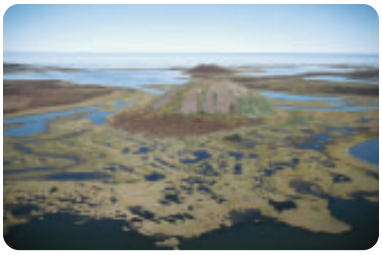


Figure 9 Tuktut Nogait National Park in Northwest Territories illustrates the unique landscape of the tundra biome.

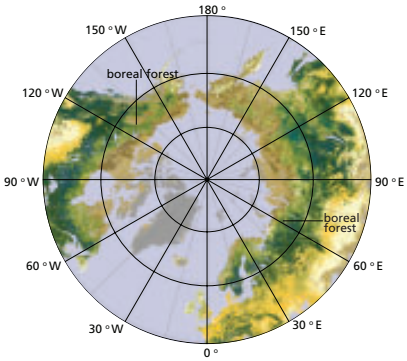


Figure 10 The world's boreal forests encircle the northern part of Earth.

To explore the boreal forest in more depth, go to **www.science.nelson.com** GO

Figure 11 Broadleaf deciduous forests grow rapidly during warmer months and lose their leaves each fall.

roots, carpets the northern-most regions of the tundra (Figure 9). The growing season is limited to a brief period of about 8 weeks during the summer, preventing any significant tree growth.

Caribou, musk oxen, arctic foxes, arctic ground squirrels, collared lemmings, and ptarmigan survive and even thrive in the harsh climate. The summer thaw creates temporary ponds and bogs that support swarms of mosquitoes and black flies. Insect-eating birds as well as snow geese and tundra swans arrive for the summer, and predatory birds like the peregrine falcon and snowy owls find abundant food as the number of small mammals grows quickly.

Boreal Forest

To the south of the tundra lies the **boreal forest** biome, also known as taiga. It forms a great circle around the northern reaches of the globe, stretching across North America, Asia, and northern Europe (Figure 10). It covers more than half of the land surface of Canada and is present in every province and territory. There is more moisture each year than in the tundra (35–75 cm), but the air is very dry during the winter.

Conifers (cone-bearing evergreen trees like pines, spruces, and firs) dominate this biome, and they limit the number of other species that can thrive in the boreal forest. The trees form a dense **canopy**, or cover, that prevents most sunlight from reaching the forest floor, and the soil itself is quite acidic due to the decay of fallen needles. Just a few bird and animal species can survive by eating only the conifer cones, needles, and buds. Other herbivores such as elk, moose, and deer also forage on the plants of the forest floor to get the added nutrition they require. Carnivores such as wolves, bears, lynxes, and wolverines, which live in the boreal forest, feed on small rodents and birds. GO

Temperate Deciduous Forest

The **temperate deciduous forest** is located south of the boreal forest, covering regions in southeastern Canada, the eastern United States, and large areas of Europe and Asia. Higher temperatures and abundant growing season rain (75–220 cm per year) support the growth of huge forests of broadleaf trees like birches, poplars, oaks, and maples. Fallen leaves and other organic matter quickly decompose, creating a richer soil than that of the boreal forest. During the early spring, flowers, small trees, shrubs, and ferns grow in the **understorey** beneath the canopy of larger trees. This is the best opportunity for them to grow rapidly before the forest canopy becomes too thick (Figure 11).

The rich soil of the forest floor provides an ideal environment for many different insects that become food for many predators, including amphibians, reptiles, birds, and small mammals. Other herbivores, such as deer, feed on the abundant forest vegetation in the understorey, while larger predators, such as wolves, eat a wide selection of prey. The forest canopy provides food and shelter for many species of birds and mammals.

Temperate Rainforest

Temperate rainforests are among the most rare of the world's biomes. Significant areas of temperate rainforest are found only in British Columbia, New Zealand, and Chile. Coastal mountains cause moist ocean air to rise and cool, dropping between 200 cm and 350 cm of precipitation each year. The abundant moisture and mild climate cause material to decay rapidly on the forest floor, which supports the growth of shrubs and small trees (Figure 12). Many plants of the forest floor produce fruits such as huckleberries and blackberries, which provide a nutritional food source for small herbivores and larger omnivores. The thick, rich soil littered with decaying matter also provides food and shelter for many kinds of insects, supporting mammals such as shrews and voles, as well as many amphibians and birds. Small predators including weasels, raccoons, and owls feed on small mammals and birds, while larger predators like wolves, bears, and cougars are able to capture larger herbivores like deer or elk. Other large mammals, such as the spirit bear (Figure 13), can be found in the temperate rain forest.

Did You **KNOW**?

The Link to a Watery World

Salmon are often considered part of the temperate rainforest biome. They are closely linked to the forest through the insects and bears that live there. Once they spawn and die, the materials contained in their bodies move through the detritus food chain and provide nutrients that support the growth of these rich forests.

Figure 12 Nurse logs are common in the temperate rainforest. They provide nutrients for new growth as the fallen tree decays.

Figure 13 The Kermode, or "spirit bear," is a subspecies of black bear that inhabit some areas of the coastal temperate rainforest of British Columbia.

Grassland

In the **grassland** biome, rainfall is generally between 25 cm and 75 cm per year, insufficient to support the growth of trees. Grasses are able to grow quickly, however, because they penetrate deeply into the fertile soil. Of all the biomes, tropical grasslands called **savannas** support the greatest number and variety of large herbivores. These include elephants, giraffes, and rhinoceros. Much of the world's grasslands, including those of Canada and the tropical grasslands in Africa, have been converted into farmland and pastureland. In Canada and the United States only small, undisturbed patches of natural grassland remain. Small mammals including rabbits, mice, and ground squirrels dig burrows in which to avoid predators such as hawks, snakes, coyotes, badgers, and foxes. GO

To learn more about the grassland biome, go to **www.science.nelson.com** GO

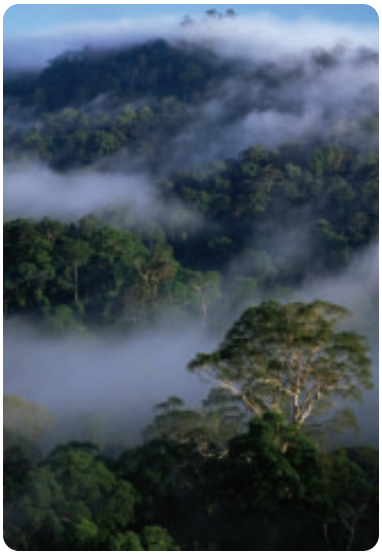


Figure 14 Tall, broad-leaved trees form a dense, leafy canopy in a tropical rainforest.

Figure 15 At over 9 000 000 km^2, the Sahara Desert is the largest in the world.

Tropical Rainforest

Tropical rainforests receive between 200 cm and 450 cm of rainfall annually, and temperatures remain between 20 °C and 35 °C throughout the year. The tropical rainforest is believed to contain at least half of Earth's terrestrial organisms. A 10 km^2 region of tropical rainforest may contain 750 species of trees! Just one of these trees could support several thousand insect species (Figure 14).

Most of the nutrients in the tropical rainforest are contained in the plants and animals themselves. The roots of enormous trees spread in the top few centimetres of soil, as it is relatively thin and infertile.

Desert

The **deserts** of North Africa, central Australia, southwestern North America, eastern Asia, and the southeast tip of South America receive less than 25 cm of precipitation each year (Figure 15). The vegetation of the desert is usually sparse and made up of small plants specialized to conserve water. Leaves are generally small and covered with a waxy layer to slow down evaporation. Some, such as cacti, store water in their fleshy tissues.

Animals, as well, are adapted to eliminate excess heat and conserve water. Most are nocturnal and are active only during the cooler nights, hiding in burrows during the day. Often the animals have large ears to improve heat loss.

Polar Ice

The most obvious feature of **polar ice** biome is the presence of permanent ice and the absence of significant terrestrial vegetation. Some microscopic algae may grow briefly on the ice and snow, but no significant plant growth exists. Herbivores are essentially non-existent on the polar ice.

In the Arctic, highly specialized predators like the polar bear are able to take advantage of the diverse marine ecosystem that lies beneath the ice (Figure 16).

The continental margins of the Antarctic ice sheet support large colonies of fish-eating sea birds such as penguins and cormorants. Some species, such as the skua, feed on the eggs or chicks of other sea birds, but like the Arctic, most life exists beneath the ice in the ocean.

Did You **KNOW?**

Polar Politics

In 1925, Canada laid claim to the North Pole, and the claim has been generally undisputed. Receding polar ice has now brought renewed interest from other nations, specifically Norway, Denmark, Russia, Greenland, and the United States. Why all the interest in an isolated sheet of floating ice? The North Pole could provide easy access to huge petroleum and natural gas deposits on the ocean floor. As ice melts and shipping routes open up, the lower cost of removal will make drilling there more profitable.

Figure 16 The polar bear is one of the very few terrestrial predators living on the ice of the Arctic.

Biogeoclimatic Zones of British Columbia

You have the privilege of living in Canada's most ecologically diverse province. It covers 95 million hectares of extreme landscapes. Some of Canada's wettest and driest, warmest and coldest locations, including rainforest, grassland, and desert, all exist within our borders. With this diversity come many challenges and issues related to managing and enjoying the rich resources of our province. The standard classification used for world biomes is not adequate to describe the variety of ecosystems present in British Columbia.

Beginning in the 1970s, scientists have collected data from 30 000 different study sites around the province. This data has been combined into the Biogeoclimatic Ecosystem Classification (BEC) system describing fourteen distinct ecological zones in the province. Nowhere else in the world is a more detailed level of ecosystem classification in use! The name of the system is derived from the three areas that are considered in describing the zones: plants (bio), landforms (geo), and climate (climatic). These characteristics are used to describe the ecological diversity of the province, a useful tool in managing natural resources and maintaining ecological diversity in British Columbia. Each biogeoclimatic zone has a characteristic climax community containing a predominant type of vegetation. Many of the fourteen zones are named in consideration of the dominant trees within them, such as the sub-boreal pine–spruce, spruce–willow–birch, mountain hemlock, Engelmann spruce–subalpine fir, and ponderosa pine zones. GO

Did You KNOW?

B.C. Deserts

British Columbia has a small pocket desert. The region surrounding Osoyoos is the northern-most tip of the Great Basin Desert, which extends as far south as Mexico. Over 100 rare plants and over 300 invertebrates are among the at-risk species that live in this fragile landscape.

www.science.nelson.com GO

To learn more about the biogeoclimatic zones of British Columbia, go to **www.science.nelson.com** GO

TRY THIS: A Creature Feature

Skills Focus: questioning, communicating, analyzing

The different biomes of the world present specific challenges to the organisms that live within them. Stresses might be environmental factors such as temperature, lack of water, or flooding, but might also include competition for resources like food and living space. Animals living in each area could not survive without the special adaptations that help them survive.

Materials: common materials of your choice

1. Select one of Canada's biomes and design an organism that would survive the environmental stresses that are present. You can use common everyday materials to build your creature.
2. While you are designing the creature, consider the following questions:
   - What challenges does your organism face, living in the biome you chose?
   - What does it eat?
   - How is its mouth specialized for this kind of food?
   - How does it move?
   - What kind of limbs does it have (arms, legs, flippers, gills, wings, tail)?
   - How is it specialized to move around in its environment?
   - What kind of body covering does it have that makes it well suited for living in its environment?
   - What other special features does it have for surviving?

A. Share your creatures with the rest of your class.

B. Highlight the specializations your creature has for the biome you chose, including finding food, eating, and avoiding other organisms.

C. What threats exist to your biome? How would your creature adjust to these as well as human-made changes? Would this creature disappear or would it be able to survive?

3.1 CHECK YOUR Understanding

1. What two environmental conditions are largely responsible for the distribution of life on Earth?
2. What three characteristics of location have an impact on climate?
3. Contrast weather and climate.
4. How are the effects of increasing elevation and increasing latitude similar?
5. What is the difference between an ecosystem and a biome?
6. Which of the following biomes would be expected to have the greatest number of producers?
   A. tundra
   B. desert
   C. polar ice
   D. grassland
7. What factors are responsible for making the soil in grasslands more fertile than the soil in boreal forests?
8. For each of the following, indicate which of the world biomes is being described:
   (a) highest annual precipitation
   (b) lowest average temperature
   (c) fewest number of herbivores
   (d) most consistent annual temperature
   (e) forest with the shortest growing season
9. Why is climate considered the dominant factor in determining the composition of an ecosystem?
10. Which biome is found in the region between the polar ice and boreal forest biomes?
11. Why would it be unusual to find a tree in the tundra?
12. Which of the following is a characteristic of the tundra biome?
    A. permafrost layer
    B. deciduous forests
    C. high plant growth
    D. annual rainfall in excess of 120 cm per year
13. Provide two similarities and two differences between each of the following:
    (a) desert and tundra
    (b) climate and biome
    (c) tropical rainforest and temperate rainforest
    (d) boreal forest and temperate deciduous forest
14. Rank the five biomes found in Canada in descending order according to each of the following abiotic factors:
    (a) amount of annual precipitation
    (b) average annual temperature
    (c) length of growing season
15. Which of the following is the best explanation for seasonal change?
    A. circulation of ocean currents
    B. the daily rotation of Earth on its axis
    C. warm, moist air falling near the equator
    D. the tilt of Earth as it orbits around the Sun
16. Which of the following is responsible for the presence of temperate rainforests along the coastline of B.C.?

I	proximity to the ocean
II	presence of a stable cold air mass
III	presence of a coastal mountain range

    A. I and II only
    B. I and III only
    C. II and III only
    D. I, II, and III
17. Explain why it is important for B.C. to subdivide its biomes into biogeoclimatic zones.

3.2 Adapting to the Environment

Organisms do not live in isolation. Some interactions between organisms are obvious, like the dependence of an organism on a food source, but other interactions are more subtle and require a closer look. In this section, we will look in more detail at the ways that organisms interact.

When faced with a change in the biotic or abiotic conditions in an ecosystem, a population will adapt to the changes, leave the area, or die out. An **adaptation** is any genetic trait that improves an organism's chance of surviving and reproducing. Certain individuals will be able to survive changes in conditions better than others. **Natural selection** is a process that favours the survival of organisms with traits that make them better adapted to the environment. At the same time, natural selection tends to eliminate those individuals that are poorly adapted.

Individuals in a population may be adapted to survive a change in the environment, but it is important to realize that they were this way before the change occurred. If the organism does not have the necessary traits to adapt to the change, it will die. If more organisms with a specific characteristic survive and reproduce, then those traits become more common in the population. For example, big brown bats used to depend on trees as roosts in order to survive. Urban development for human housing has reduced the number of roost trees, but many individual big brown bats were well adapted to roosting in human structures instead of trees (Figure 1). Populations of big brown bats have increased, and in fact, many big brown bats now need human structures for roosting! So, while natural selection acts on the individual organism, it is the population as a whole that changes as a result. Individuals with characteristics that give them an advantage over other organisms manage to survive. If the characteristics are genetic, the individual may pass the trait on to its offspring.

LEARNING TIP

Preview Section 3.2 to note headings, words in bold, and graphics. Ask yourself, "What is this section about? How is it organized?"

Figure 1 Populations of big brown bats have increased after they switched to roosting in human-made structures.

Natural selection does not occur only because of abiotic factors. Predator–prey interactions are also a strong selective force. Natural selection favours adaptations that improve the ability of predators to find, capture, and consume prey. Characteristics that help predators catch prey include being faster and stronger than the prey, such as when hawks and lynx prey upon rodents and other small animals (Figure 2).

Figure 2 This hawk is highly adapted to capture this prey.

Other adaptations for predators include coloration or body shapes that provide camouflage (Figure 3). This adaptation can be quite effective and requires very little energy from the predator, since an exhausting chase is not required. GO

To learn more about camouflage in nature, go to **www.science.nelson.com** GO

Figure 3 The coloration of this fox makes it difficult for its prey to see it against the snowy background.

TRY THIS: Surviving Predation

Skills Focus: predicting, observing, measuring, recording, reporting

Materials: 40 coloured toothpicks (10 of each colour: red, green, yellow, blue), large plastic hoop, stopwatch

1. Place the plastic hoop on a section of grass.
2. Have one partner scatter the coloured toothpicks through the area enclosed by the plastic hoop. The other partner will have 30 seconds to pick up as many toothpicks as possible, one at a time. Repeat for four trials.
3. Copy Table 1 and record your team's data.

Table 1

Trial	Number of each colour toothpick			
	Red	Yellow	Green	Blue
1				
2				
3				
4				

A. Which colours of toothpicks were picked up most often?

B. Which colours of toothpicks were picked up least often?

C. How do you explain this outcome?

Natural selection also affects prey species that must adapt in order to survive. Camouflage is an adaptation that allows the prey to hide from predators and avoid being eaten (Figure 4). Other prey, such as poison dart frogs, wasps, and skunks, have adapted by developing chemical defences (Figure 5). These organisms often have warning coloration to advertise that they are harmful or poisonous to predators. Predators learn very quickly to leave these organisms alone.

STUDY TIP

When you are learning many new things, it is easy for the new concepts to interfere with remembering ones you learned a week ago. To prevent this problem, build review into every study session.

Figure 4 What is the benefit of blending into the background like this stick insect?

Figure 5 What is the benefit of having warning coloration like these skunks?

To see what can happen when animals use chemical defences, go to **www.science.nelson.com**

Some prey species have adapted a strategy called **mimicry**. In mimicry, one species resembles another that is poisonous, dangerous, or distasteful. The king snake is a well-known example of a mimic because it looks very similar to the poisonous coral snake (Figure 6). Mimicry also refers to situations where two harmful species have similar coloration, such as bees and wasps. When several species have the same coloration, the message to stay away is reinforced.

(a)

(b)

Figure 6 Mimicry is a successful prey defence strategy. The (a) king snake mimics the (b) poisonous coral snake, protecting it from predators.

Predator and prey species may adapt in response to each other's adaptations. This type of interaction and the adaptation of two species in response to each other is called **coevolution**.

Many plant and herbivore adaptations have co-evolved. Herbivores respond with adaptations such as specialized beaks, or teeth, as well as digestive systems that are capable of breaking down cellulose and plant toxins. Plants adaptations include sharp thorns, spines, sticky hairs, and tough leaves that make the plant more difficult to eat (Figure 7). As well, scientists have identified over 10 000 defensive chemicals in plants. Some, such as caffeine, nicotine, and cyanide, are poisonous to herbivores. Other substances, like pepper and mustard, are natural repellents.

Figure 7 Certain grazing herbivores such as cows are able to eat the sharp pointed flowers of thistle plants.

Did You KNOW?

Biodiversity Hotspots

Ecosystems with high primary productivity show very high biodiversity. Some of these regions are called biodiversity hotspots because they contain so many species relative to their area and because the region is highly threatened. About 20 % of all species live in these regions, which only cover about 1 % of Earth's surface. The island of Madagascar and the Great Barrier Reef of Australia are examples of biodiversity hotspots.

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Biodiversity

Biodiversity refers to the variety of, and the variation among, organisms within a given ecosystem or biome or for the entire Earth. Biodiversity is closely linked to **primary productivity**, which is a measure of the available energy provided by the producers in an ecosystem. The abundance of producers in turn supports a complex and diverse community of consumers. Temperate and tropical rainforests as well as estuaries (where rivers flow into the ocean) are all regions with high primary productivity and biodiversity.

In contrast, environments with low primary productivity, such as those found in deserts, high mountains, and polar regions, have low biodiversity. These ecosystems also tend to be more fragile and are easily disrupted. In areas of low biodiversity, the removal of a single species could have a major or even devastating effect on the entire ecosystem.

A decrease in one species, whether it is a predator or prey, can have a serious effect on the entire ecosystem. **Extinction** results when a species is gone completely from Earth or when so few individuals remain that reproduction is not possible. **Extirpation** refers to the phenomenon of local extinction, which occurs when a species ceases to exist in one area, but still exists elsewhere in the world.

Keystone Species

When stone arches are built, one stone at the top, called the keystone, is particularly important to support the arch. If this keystone is removed, the arch will collapse (Figure 8). **Keystone species** are species whose presence plays an important ecological role in determining the types and numbers of other species in particular communities. When these species are eliminated, the effects on the ecosystem are dramatic.

Sea otters are an important keystone species along the west coast of North America. They live in kelp forests (Figure 9) where they feed on bottom-dwelling invertebrates, such as sea urchins and crabs that live in and feed on the kelp. Kelp forests also provide important nursing grounds for juvenile

Figure 8 If the keystone of this arch is removed, the arch will collapse.

Figure 9 Sea otters are the keystone species in kelp forests. They keep the population of kelp-eating invertebrates in check.

fish of many species. This very intricate ecosystem was kept in balance by the interrelationships among the organisms. Before the arrival of Europeans, both kelp and sea otters were abundant in the intertidal zones. However, sea otters on the west coast of Vancouver Island were almost extirpated as they were hunted for their valuable pelts. As a result, the otters' prey, sea urchins that graze on the kelp, proliferated, causing the collapse of the kelp forest community. The kelp forests disappeared, taking with them the habitat for others including juvenile fish.

Between 1969 and 1972, 89 sea otters from a population in Alaska were transplanted to the west coast of Vancouver Island. This new population has survived and is now upwards of 3000 sea otters.

Scientists are only beginning to understand the importance of biodiversity. It seems that biodiverse ecosystems are more stable and less affected by environmental change. They tend to recover after a disturbance such as drought, flooding, or fire. Biodiversity also provides humans with many benefits, including many of our natural resources. The foods we eat, the wood we use to build our homes, and the medicines we use to treat our diseases are only available because of biodiversity. The recreational activities we enjoy, the water we drink, the food we eat, and even the air we breathe are tied to the biodiversity of fragile ecosystems on this planet that we call home.

British Columbia has the greatest biodiversity in Canada, but that doesn't mean we shouldn't be concerned about losing species. Over the years, several species have become extinct, and many more, such as the Vancouver Island marmot, are listed as endangered or threatened.

LEARNING TIP

Check your understanding. Ask yourself, "What are the main ideas in this section? How would I explain them in my own words? What additional information about keystone species can I get from Figures 8 and 9, on page 64?"

TRY THIS: Exploring B.C.'s Biodiversity

Skills Focus: evaluating, recording, identifying, communicating

Scientists at the B.C. Ministry of Environment conduct research on wildlife in B.C.'s ecosystems and estimate the risks to species. They recommend strategies for wildlife management and conservation. In this activity, you will explore the status of some of B.C.'s wildlife.

Materials: computer access

1. Log on to the Nelson website and follow the links to Exploring B.C.'s Biodiversity.

   www.science.nelson.com GO

2. Click on B.C. Species and Ecosystems Explorer.
3. Select your "search type" and species "name" or "group."
4. Select the type of list you want (red, blue, or yellow).
5. Continue to use the B.C. Species and Ecosystems Explorer to answer the following questions:

A. How many "red-list" mammal species are there in B.C.?

B. Name four endangered amphibians in B.C.

C. How many exotic vascular plants are there in B.C.?

D. Make a list of three new searches you are interested in. Perform the searches.

E. Prepare a detailed report on two B.C. species of your choice. Include a species that is threatened or endangered in your forest district or ecological zones.

3.2 CHECK YOUR Understanding

1. The relationship between predators and prey is often compared to a "weapons arms race." In what way is this comparison useful?
2. Sea stars are known to feed on two different species of mussels. Explain how the removal of the sea star from an area could lead to the elimination of one of the two mussel species.
3. Explain why humans are considered to be a keystone species.
4. Consider the two islands shown in Figure 10. One island is on the equator, and the other island is 500 km north of the equator. Which island is likely to have the greatest biodiversity? Provide two reasons to support your answer.

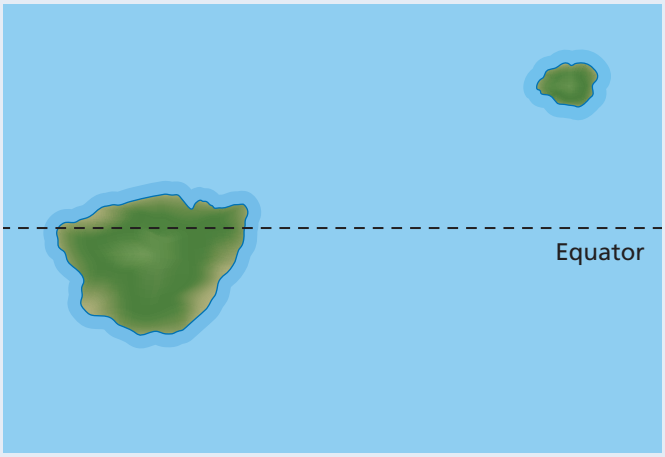


Figure 10

5. Which of the following characteristics applies to an organism that uses mimicry as a survival strategy?
   A. The mimic is a parasite.
   B. The mimic is always poisonous.
   C. The mimic is similar to another harmful species.
   D. The mimic is identical to another harmless species.
6. (a) Describe two predators whose adaptations improve their success.
   (b) Describe two prey whose adaptations improve their survival.
7. Some harmless flies resemble bees and wasps. What is the benefit to the fly to have this coloration? What is this survival mechanism called?
8. Explain how each of the following adaptations might improve the organism's chance of survival.
   (a) the parachute-like seed of a dandelion
   (b) the white colour of a snowshoe hare
   (c) the silent wings of a great horned owl
   (d) the rapid growth rate of tundra grasses
   (e) the keen eyesight of a bald eagle
9. Explain in your own words the link between primary productivity and biodiversity.
10. Explain in your own words the term "biodiversity."
11. Why is biodiversity important for ecosystems?
12. Explain why a tundra ecosystem is more fragile than a deciduous forest ecosystem.

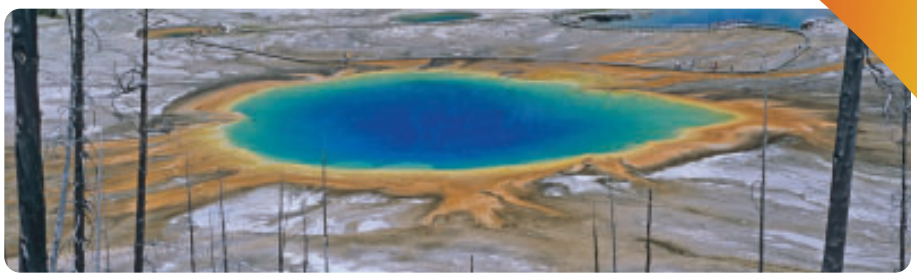
Awesome SCIENCE

LIVING LIFE TO THE EXTREME

You might expect the harshest environments on the planet to be empty of all life, but some amazing organisms exist in almost impossible conditions!

Some organisms really take living to the extreme. You couldn't survive being chilled to the core, soaked in acid, or boiled alive. But many bizarre creatures thrive in the harshest habitats on the planet, including volcanic vents on the ocean floor, where the temperatures reach 110 °C, and sub-zero temperatures of the upper reaches of the atmosphere. Some hang out inside hot rock nearly 3 km beneath Earth's surface, while others enjoy taking an acid bath in waters near hot springs or cooking in the desert Sun (Figure 1). These organisms are called extremophiles (Figure 2). There are many different categories of extremophiles, and each has its own unique name (Table 1).

Many scientists and industry researchers are very interested in extremophiles. Some acidophiles are used by mining companies to remove gold and other precious metals from rock ores. Researchers in medicine, genetics, and molecular biology use an enzyme produced by an extremophile called *Thermus aquaticus* to copy fragments of DNA. The ability of extremophiles to live in environments that would kill most organisms means that they must have adaptations to counteract the conditions. Understanding how they manage to survive could lead to many more practical uses for extremophiles and their enzymes.



(a)

(b)

Figure 1 Extremophiles not only survive but thrive in environments where other organisms cannot, including (a) acidic hot springs or (b) the baking sand of the nearly lifeless Atacama desert.

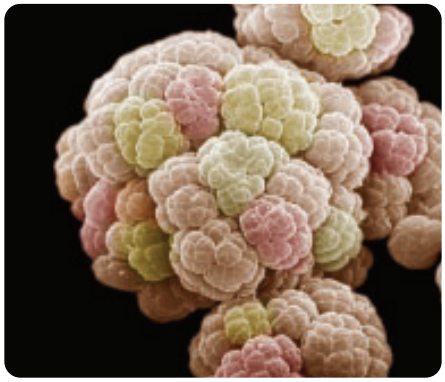


Figure 2 Most extremophiles are extremely small, like this microscopic archaebacteria.

Table 1 Some Types of Extremophiles

Acidophile	An organism that lives in acidic environments. Some could survive in battery acid.
Alkaliphile	An organism that lives in basic condition. Some could live in solutions containing ammonia.
Endolith	An organism that lives in microscopic spaces within rocks or in cracks filled with water deep within Earth.
Hyperthermophile	An organism that can thrive at temperatures between 80 °C and 121 °C, such as those found in hydrothermal areas.
Polyextremophile	An organism that is an extremophile in more than one category.
Xerophile	An organism that can grow in the driest environments on Earth.

3.3 Community Interactions

STUDY TIP

The best way to avoid test anxiety is to be well prepared. How will I improve my study habits? Write down a plan that includes:

1. How will I build review into each study session?
2. How will I distribute my studying during each week?

Within a community there are many species that live in the same general area, but each species occupies a different niche. A **niche** is the overall role of an organism in a community, including the range of biotic and abiotic conditions that the organism can tolerate. A niche is not just an organism's habitat but also what it eats, what eats it, how it reproduces, how much water it needs, and many other factors. Two species may share the same habitat, but no two species occupy the same niche (Figure 1).

(a) (b)

Figure 1 The (a) lynx and (b) wolf might share the same habitat, but different behaviours such as hunting strategies and daily activity patterns separate these species into different niches.

Did You KNOW?

Partitioning the Coastal Waters

Several populations of killer whales occupy the coastal waters of B.C. "Resident" killer whales eat fish, and "transient" whales feed on seals and sea lions, while "off-shore" populations eat sharks and turtles. In this way they avoid direct competition for the same resources, ensuring the survival of each population.

Competition occurs when two organisms make use of the same resource so that their niches overlap. Competition between different species is called **interspecific competition**. Each species competes for a limited common resource such as food or nesting sites. When organisms of the same species compete among themselves, it is called **intraspecific competition.** This form of competition is usually more intense than interspecific competition because the requirements of each organism are more similar.

Some species develop adaptations that allow them to reduce or avoid competition for resources with other species. This can result in **resource partitioning**, where different species have different traits that allow them to use a resource at a different time, in a different way, or in a different place. For example, hawks and owls feed on similar prey, but hawks hunt during the day while owls hunt at night.

To explore how organisms use resource partitioning to exploit different parts of their shared habitat, go to **www.science.nelson.com**

When species adapt differently to changes to the environment, it is called **adaptive radiation**, and species become specialized to exploit smaller parts of the niche. One well-known example of adaptive radiation is the finches of the Galapagos Islands (Figure 2). Originally, all of the finches were similar. Over time, natural selection caused populations and species to adapt to different environments and diets with different adaptations, resulting in a partition of resources and reducing competition. **Proliferation** of species occurs as the numbers of individuals with each new trait increases.

Populations with the new adaptations will proliferate until competition increases once again and selective pressure leads to further adaptations and further resource partitioning. 3B Investigation

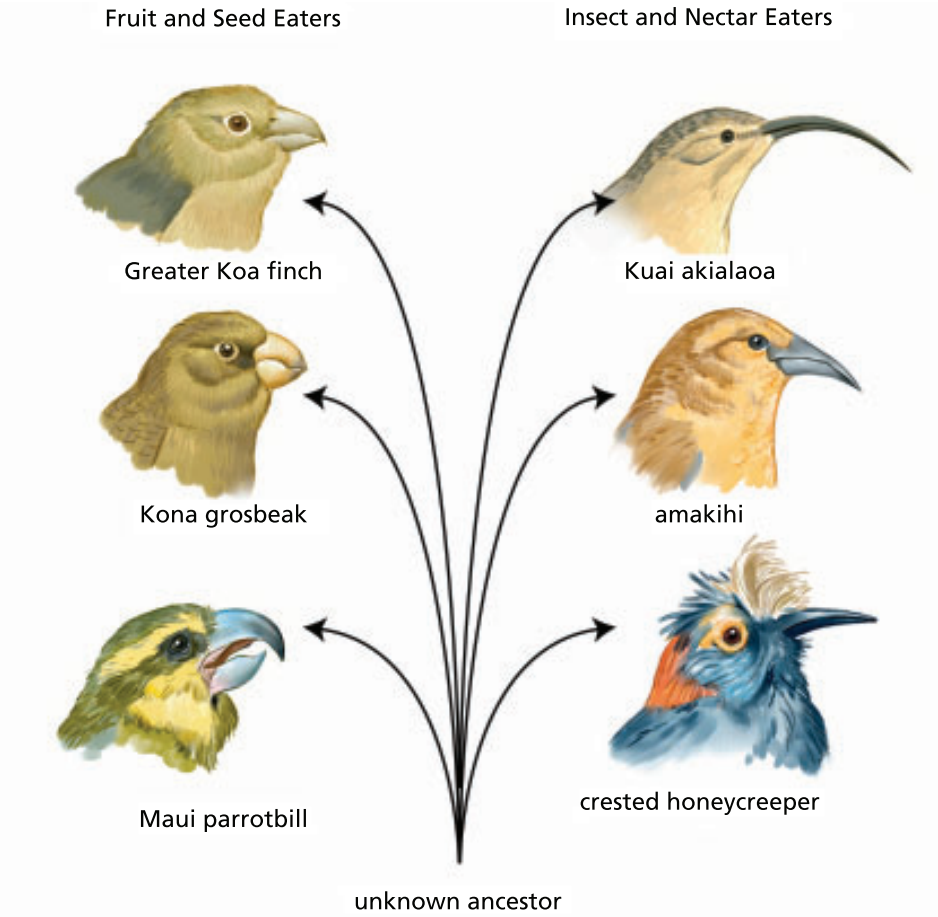


Figure 2 The beaks of finches found on the Galapagos Islands show the outcome of adaptive radiation.

3B Investigation

Fine-Feathered Feeding Frenzy

To perform this investigation, turn to page 76.

In this investigation, you will investigate natural selection and 'beak' shape.

The Impact of Foreign Species

Ecosystems are dynamic; they are always changing. Animal species are mobile and can move to new ecosystems naturally when barriers are removed. Micro-organisms, fungi, and plants can be transported by wind or by animals to new ecosystems where they establish. These new species are called **foreign species** because they are not native to that particular ecosystem. Foreign species often out-compete the existing native species for a particular niche, with dramatic results since they rarely have predators in their new habitats. When this happens, the foreign species pose a serious threat to biodiversity.

Humans are responsible for the introduction of many foreign species. Some of these introductions are intentional and often beneficial. For example, many of our food crops such as corn and wheat, as well as certain tree species, have been successfully introduced without harmful effects. However, the introduction of many foreign species is often unintentional, and humans may carry these species across oceans and mountains and from one waterway to another in (or attached to) boats and ships (Figure 3).

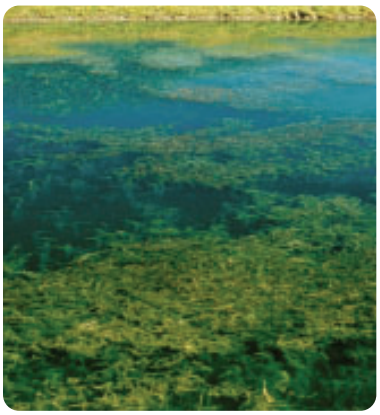


Figure 3 Eurasian watermilfoil was first observed in B.C. in 1970 in Okanagan Lake. It was probably attached to the propeller of a boat that was moved from another lake where the aquatic plant grew.

British Columbia has its share of foreign species. Purple loosestrife and Scotch broom (Figure 4) are two highly visible perennial plants that proliferate during the spring. Purple loosestrife invades wetlands, choking out native species. Scotch broom grows well in disturbed areas such as logged areas or along the sides of highways where it out-competes Douglas fir seedlings. No consumers appear to feed on either of these foreign species.

To find out more about foreign species, go to **www.science.nelson.com**

(a)

(b)

Figure 4 (a) Purple loosestrife probably arrived from Europe as seed in ballast soil of ships or carried by passengers to plant in gardens; (b) Scotch broom was intentionally brought from Europe.

Did You KNOW?

Introducing Foreign Species

All of the Scotch broom in North America originates from three seeds that germinated in Sooke on Vancouver Island. The seeds, planted by Captain Walter Grant, came from Europe by way of the British consulate in Hawaii.

British Columbia is also home to some foreign animal species. According to the B.C. Ministry of Environment there are sixteen foreign bird species in the province. Probably the most successful species is the European starling (Figure 5). The Pacific or Japanese oyster (Figure 6) was intentionally introduced to B.C. coastal waters in the 1920s to be farmed. Since this oyster does not reproduce well in the cooler B.C. coastal waters, oyster seed is regularly imported. Although regulated by the Department of Fisheries and Oceans, other species have been introduced inadvertently along with the Pacific oysters, including several other bivalves (two-shelled aquatic invertebrates), worms, and snails. One of these, the oyster drill snail, feeds on bivalves by drilling holes in the shell and digesting the internal organs (Figure 7).

Figure 5 All North American starlings are descendants of European starlings, intentionally introduced into New York City's Central Park.

Figure 6 Pacific oysters introduced from Japan. This is the most predominant commercially raised oyster in the world.

Figure 7 Oyster drill snails drill through the shells of other shelled animals.

Succession

Have you ever noticed that a newly cleared lot does not remain bare for long? With time, it becomes overgrown with grasses and weeds. Eventually taller weeds will replace the shorter ones, and in time shrubs and trees will appear. This gradual change in the types of plants that represent the structure of a community is called **ecological succession**. In this process, **pioneer species** arrive first and colonize the new environment. The presence of these pioneer species changes the environment, creating acceptable conditions for other species. Over time, plant species that are better adapted to the new environmental conditions arrive, out-competing and replacing the pioneer species.

Depending on the initial conditions, there are two types of ecological succession. **Primary succession** begins in an area that is lifeless and lacking nutrients, such as bare exposed rock (Figure 8). Figure 9 (a) shows primary succession occurring in such a location. Lichens and mosses arrive first and begin slowly breaking down the rock and trapping tiny pieces of wind-blown soils from nearby fertile areas. Over time, physical weathering by the Sun and water also contribute to form soil. Once the soil is deep enough and required nutrients are present, grasses and small shrubs begin to grow. Left undisturbed with sufficient water or rainfall, the community will eventually develop into a complex, stable ecosystem called a **climax community**.

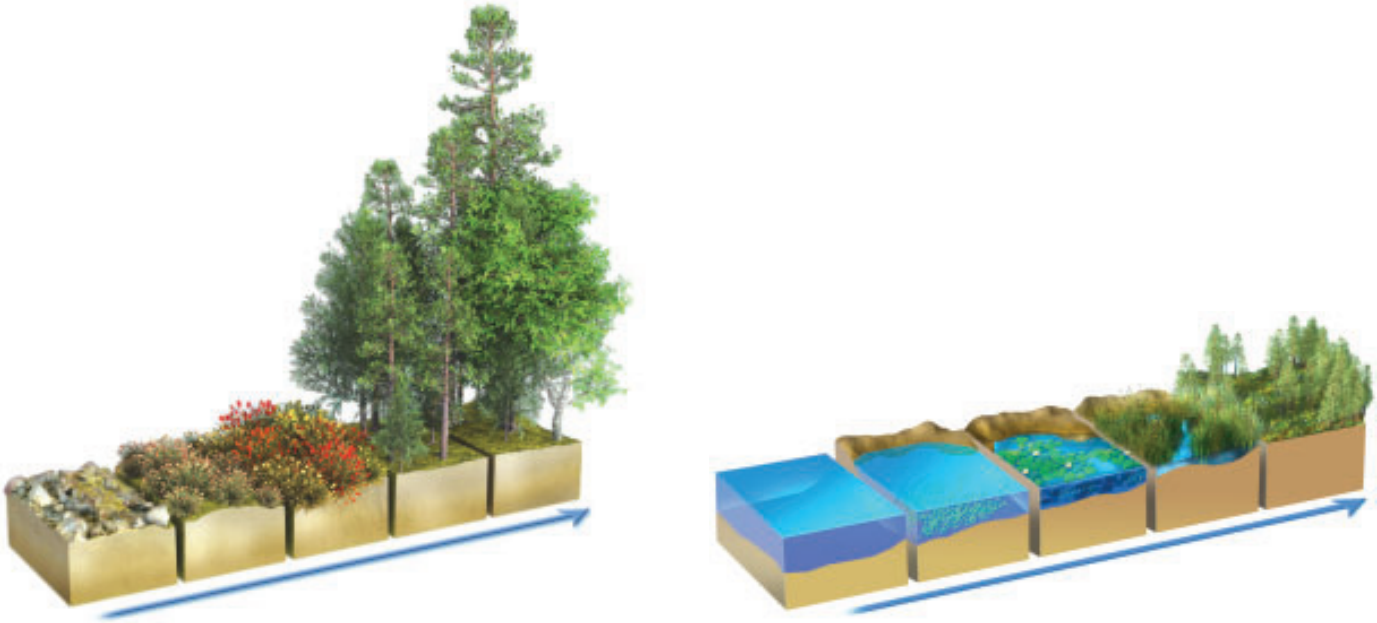
Primary succession can also occur in newly created ponds (Figure 9 (b)), beginning as sediments run into the water from surrounding land. Seeds are blown into the water or introduced by animals. In time, the plants and animals become part of a newly formed aquatic community. Eventually the waters become overgrown with vegetation. Succession continues transforming the pond into a marsh and eventually into dry land.

LEARNING TIP

Key terms are often illustrated. When you come across words in bold, examine the pictures and diagrams, along with the captions.

To find out more on the types of ecological succession, view the animation at **www.science.nelson.com**

Figure 8 Lichens often begin primary succession by breaking down rock to produce soil.



(a) (b)

Figure 9 Primary succession happens (a) on land and (b) in aquatic environments.

(a)

(b)

(c)

Figure 10 Regions disturbed by (a) fire, (b) flooding, and (c) erosion are starting points for secondary succession.

Secondary succession begins in areas that already have soil or sediments but where there has been a significant disturbance such as fire, flooding, landslides, or forest harvesting (Figure 10). The dominant plants are destroyed but the soil remains, and so new plants begin to grow within a few weeks. Seeds hidden in the soil or brought by birds and other animals become the pioneer species. As in primary succession, the process of secondary succession eventually leads to a climax community characterized by a complex mature ecosystem.

Ecological succession often focuses on changes in the plant community in an area. But it is important to realize that the consumers and decomposers in the community change as well. As changes in the plant community occur, it often becomes less suitable for the existing consumers and more suitable for others.

For example, certain species of field mice may only be able to live in the area after enough tall grasses exist to provide cover for them. In turn, the mice alter the plant community by feeding on the grasses while at the same time improving the soil with their waste. The improved soil allows other plants to take hold and grow, so in this way, the organisms in each stage alter the physical environment. Therefore, each stage of succession paves the way for the next stage.

Ecological succession is a simplified model to help us understand a very complex process. Succession has traditionally been presented as a slow steady change from a pioneer community to a stable climax community, but disruptions like fires and flooding are common and often prevent climax communities from forming. In other situations the rate of succession may be accelerated by human activity, for example if fertilizers are added to the soil.

TRY THIS: Identifying Succession

Skills Focus: observing, recording, concluding, communicating

In this activity, you will observe and record details of succession.

Materials: diagrams or photographs showing different stages of succession

1. Copy Table 1 in your notebook, and leave plenty of room for your observations. You will need one row for each diagram.

Table 1

Image	Observations	Successional stage
1		
2		

2. Visit each of the images around your classroom. Take care to record your observations in the appropriate row of your data table. You will not necessarily begin at diagram #1.
3. Look for different types of plants or animals that may be good indicators of whether the community is in the early, middle, or late stages of succession.

A. Using your observations, order the diagrams to represent the correct sequence of succession based on what you know about the stages of succession. Justify your answer.

B. If possible, state whether each image shows primary or secondary succession. Why is it sometimes difficult to tell?

3.3 CHECK YOUR Understanding

1. Describe the difference between a habitat and a niche.
2. Describe your ecological niche. Consider your habitat and your place in the food web.
3. What happens when two species with the same niche move into the same ecosystem?
4. Describe the relationship between resource partitioning and competition.
5. Explain, using examples of your own, the difference between interspecific and intraspecific competition.
6. What role do pioneer species have in primary succession?
7. Which of the following is a characteristic of many climax community producers?
   A. able to grow in the absence of soil
   B. able to grow in the shady understorey of forests
   C. able to develop effective defenses against carnivores
   D. able to reproduce quickly before other plants arrive
8. Which of the following is a characteristic of producers that grow during the middle stages of succession?
   A. able to grow in the absence of soil
   B. able to grow in the shady understorey of forests
   C. able to develop effective defences against carnivores
   D. able to reproduce quickly before other plants arrive
9. Suggest two human activities that could lead to secondary succession.
10. What characteristics do pioneer plants have?
11. Distinguish between primary and secondary succession. Which of these two processes usually proceeds more rapidly? Explain your reasoning.
12. What characteristics would allow you to identify a climax community?
13. Describe the role of pioneer plants in the formation of soil.
14. Explain how herbivores can influence the stages of primary succession.
15. Describe the process occurring Figure 11. Can this process also occur on land? Explain your answer.

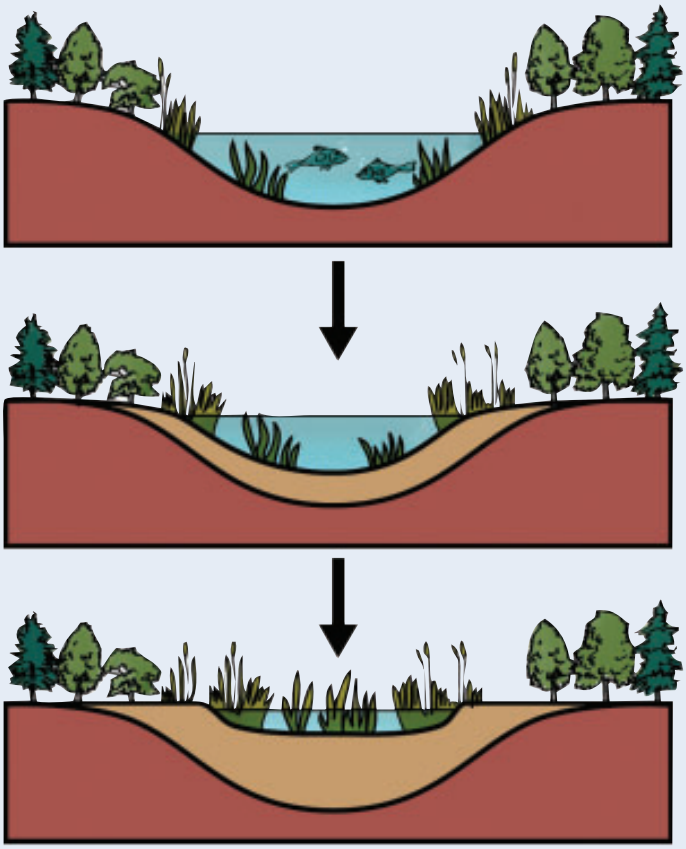


Figure 11

3A Investigation

Working with Climatographs

The distribution of living things is directly affected by the long-term climatic conditions and the ability of organisms to adapt to these conditions. The climatic trends of a biome are often expressed as a climatograph that shows the monthly changes in temperature and precipitation throughout a year (Figure 1). These two factors are effective indicators of plant and animal distribution and adaptations within the world's biomes.

In this investigation, you will use climate data to produce and analyze climatographs in order to discover trends in seasonal climate variation.

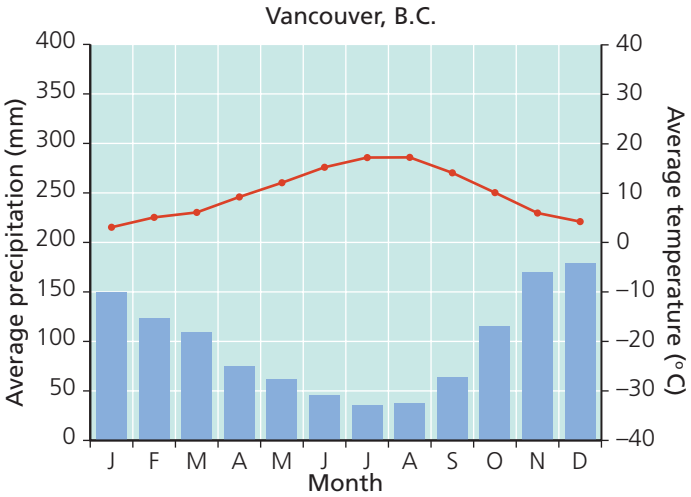


Figure 1 This climatograph for Vancouver, B.C., shows average monthly precipitation as bars and average temperature as connected data points.

Question

Is it possible to identify biomes by analyzing climatographs?

INQUIRY SKILLS

- ● Questioning
- ○ Hypothesizing
- ○ Predicting
- ○ Planning
- ● Conducting
- ● Recording
- ● Analyzing
- ● Evaluating
- ● Synthesizing
- ● Communicating

Experimental Design

In this investigation, you will use five sets of climate data to produce climatographs representing some of Earth's distinct biomes. Each climatograph will be used to determine the biome that the data represents.

Materials

- graph paper
- 2 coloured pencils
- climate data

Procedure

1. On graph paper, create a blank climatograph. Draw a horizontal axis for the months of the year.
2. Draw two vertical axes. On the left-hand side, use a scale of 0 mm to 400 mm for average precipitation. On the right-hand side, use a scale of –40 °C to 40 °C for temperature data. Label each of the axes and include appropriate units.
3. Plot the climate data for Biome A found below on your blank climatograph.
4. Use coloured bars to represent average monthly precipitation.
5. Join the individual data points for temperature with a trend line.
6. Repeat Steps 1 to 5 for Biomes B through E.

Climate Data

Biome A	J	F	M	A	M	J	J	A	S	O	N	D
Average Temp. (°C)	27	25	27	26	25	24	22	25	27	27	27	27
Total Precipitation (mm)	210	199	171	123	54	16	10	11	58	115	154	194

Biome B	J	F	M	A	M	J	J	A	S	O	N	D
Average Temp. (°C)	1	3	4	6	8	11	13	13	11	8	4	2
Total Precipitation (mm)	251	217	188	181	142	120	113	163	245	379	284	270

Biome C	J	F	M	A	M	J	J	A	S	O	N	D
Average Temp. (°C)	−14	−19	−27	−29	−32	−33	−34	−35	−36	−31	−21	−14
Total Precipitation (mm)	6	4	2	1	5	3	2	1	0	1	2	3

Biome D	J	F	M	A	M	J	J	A	S	O	N	D
Average Temp. (°C)	23	25	29	32	35	34	32	32	33	32	28	25
Total Precipitation (mm)	0	0	0	0	4	5	46	75	25	5	1	0

Biome E	J	F	M	A	M	J	J	A	S	O	N	D
Average Temp. (°C)	−27	−24	−18	−5	5	13	17	14	7	0	−14	−23
Total Precipitation (mm)	15	13	11	10	17	23	35	42	29	35	24	15

Conclusion

Complete the following items to answer the question posed at the beginning of the investigation.

Analysis

(a) Which biome has the highest annual precipitation? Explain your answer.

(b) Which biome shows the greatest seasonal variation in temperature? Explain your answer.

(c) Which biomes have measurable snowfall? Explain your answer.

(d) Based only on the given data, predict which biome is likely to have the longest growing season.

(e) Which biome lies closest to the equator? Explain your answer.

(f) Which biome lies furthest from the equator? Explain your answer.

(g) Use your analysis and the climatographs you produced to predict which world biome is represented by each set of data.

Evaluation

(h) Which set of data was most difficult to match with a world biome? Why?

(i) What is the benefit of using a climatograph rather than a data table to represent climate trends in an area?

Synthesis

(j) Find climate data for a city near you and create a climatograph for the biome in which you live.

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3B Investigation

Fine-Feathered Feeding Frenzy

An adaptation is any inherited trait that improves an organism's chance of surviving and reproducing. In some cases, an adaptation is a behaviour or strategy that provides an advantage. It may also be a structure that permits organisms to take better advantage of a certain type of resource such as food. When resources are limited, organisms that are best able to exploit a resource will survive. If you have ever looked carefully at different types of birds, you will have noticed several different beak shapes (Figure 1).

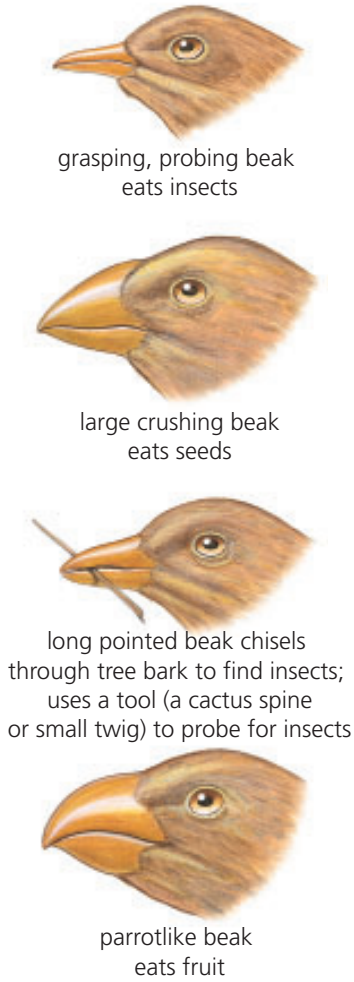


Figure 1 The shape of a bird's beak is often an adaptation to exploit food resources.

INQUIRY SKILLS

- ● Questioning
- ○ Hypothesizing
- ● Predicting
- ● Planning
- ● Conducting
- ● Recording
- ● Analyzing
- ● Evaluating
- ○ Synthesizing
- ● Communicating

Question

Which beak adaptations provide the greatest feeding advantage?

Prediction

Predict which tool will provide the greatest advantage for each food type. Record your prediction before each set of data.

Experimental Design

In this investigation, you will simulate the competition for food between different birds on an island with different food sources.

Materials

- pliers
- net
- skewer
- tweezers
- eyedropper
- plastic container
- various food samples from your teacher

Procedure

1. Work as a group. First, read the procedure carefully. Look for what you need to record and prepare a blank copy of Table 1 for each station. Your teacher will direct you to a station to begin.

Table 1

Station # :					
Food source:					
Predicted winner:					
Beak Description	Trial #1	Trial #2	Trial #3	Average	Ranking
Pliers					
Net					
Skewer					
Tweezers					
Eyedropper					

2. Obey the following rules during this investigation:
   - Do not use your hands to pick up the food. Use the tool instead.
   - Food must be picked up and placed in your "stomach" (plastic container).
   - Your "stomach" must remain on the table.
   - You may not steal from the other "birds."
3. Each person in your group will use one of the tools—this will be your beak.
4. You will compete against the other "birds" in your group to acquire as much food as possible in 30 seconds and put it in your "stomach" (plastic container).
5. Before beginning each competition, predict which beak will win.
6. Each group will perform three competition trials at each station. Record the number of food items caught for each trial and average the result.
7. Rank each beak according to the average amount of food caught.
8. When directed by your teacher, rotate to the next station and repeat Steps 4 to 7.

Conclusion

Complete the following items to answer the question posed at the beginning of the investigation.

Analysis

(a) Which beak shape won in each of the feeding situations?

(b) For each station, draw a bar graph that shows the average amount of food gathered by each of the beak types.

Evaluation

(c) When an organism is able to survive in several different environments, it is called a "generalist." Which of the beak types would most likely belong to a generalist?

(d) When an organism is able to do very well in one environment but performs poorly in others, it is called a "specialist." Which of the beak types would most likely belong to a specialist?

Synthesis

(e) How might the results change if the size of the food items changed? How might the results change if the size of the beak changed?

(f) The beak of a bird is also needed for nest building. Which adaptation is more likely to influence beak shape, nest building ability or feeding ability? Explain your reasoning.

(g) What is the advantage to *all* of the birds by having different beak shapes?

CHAPTER 3

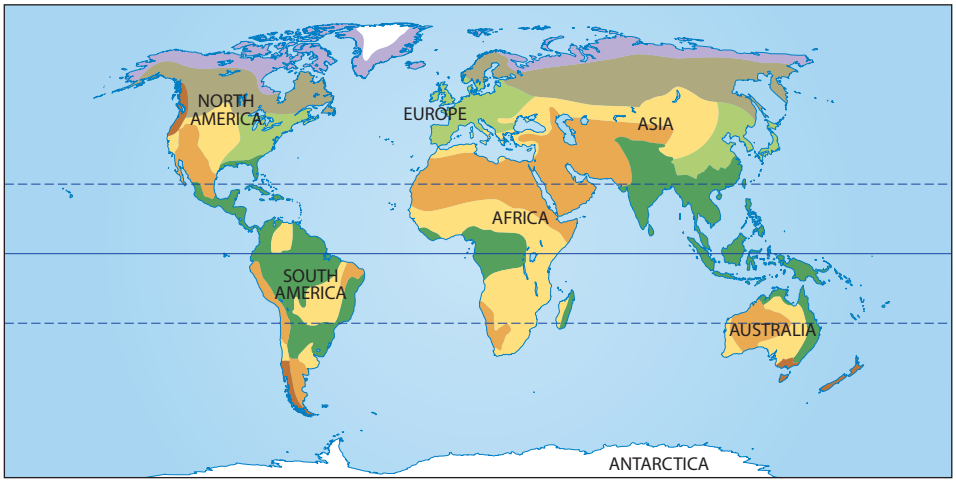
Review

Community Ecology

Key Ideas

The biosphere contains distinct biological communities.

- The distribution of living things is limited by the environmental conditions in different areas of Earth.
- Factors such as solar energy, latitude, elevation, wind patterns, and ocean currents influence climate, which in turn influences the distribution of world biomes.
- Biomes are major ecosystems with similar abiotic conditions containing similar organisms.
- British Columbia has fourteen distinct biogeoclimatic zones.



Species adapt to changes in environmental conditions and to other organisms.

- Competition leads to adaptation that allows organisms to occupy separate niches.
- In predator–prey relationships, prey populations adapt to avoid being eaten, while predator populations adapt to improve capturing prey.
- Biodiversity varies from one location to another as a function of abiotic factors.

Vocabulary

climate, p. 51
latitude, p. 51
elevation, p. 51
climatograph, p. 53
biome, p. 54
tundra, p. 55
permafrost, p. 55
boreal forest, p. 56
canopy, p. 56
temperate deciduous forest, p. 56
understorey, p. 56
temperate rainforest, p. 57
grassland, p. 57
savanna, p. 57
tropical rainforest, p. 58
desert, p. 58
polar ice, p. 58
adaptation, p. 61
natural selection, p. 61
mimicry, p. 63
coevolution, p. 63
biodiversity, p. 64
primary productivity, p. 64
extinction, p. 64
extirpation, p. 64
keystone species, p. 64
niche, p. 68
competition, p. 68
interspecific competition, p. 68
intraspecific competition, p. 68

Species in communities interact in many different ways.

- Keystone species play an important role in determining the types and numbers of other species in the community.
- Competition can occur between different species in the community or between individuals of the same species.
- Foreign species may be introduced to ecosystems and out-compete native species.

Succession is an indication of change in an ecosystem.

- Succession is a process of gradual change in the types of plants that represent the structure of a community.
- Primary succession describes the changes that occur in a newly formed habitat that has not yet sustained life.
- Secondary succession describes the changes that occur in an area where there has been previous growth such as abandoned fields or forest clearings.

resource partitioning, p. 68
adaptive radiation, p. 68
proliferation, p. 68
foreign species, p. 69
ecological succession, p. 71
pioneer species, p. 71
primary succession, p. 71
climax community, p. 71
secondary succession, p. 72

Many of these questions are in the style of the Science 10 Provincial Exam. The following icons indicate an exam-style question and its cognitive level.

K Knowledge U Understanding and Application HMP Higher Mental Processes

Review Key Ideas and Vocabulary

K **1.** Which of the following is an abiotic condition that could lead to low biodiversity?
A. abundant rainfall
B. poor soil conditions
C. stable annual temperature
D. few plant species growing in the area

2. Distinguish between pioneer species and climax community.

3. What is meant by the statement: "Each stage of succession paves the way for the next"?

4. Which stage of succession is most likely to exist in a dynamic equilibrium?

K **5.** In which of the following situations would primary succession occur?
A. on bare rock
B. after a forest fire
C. only in terrestrial ecosystems
D. after the logging of a climax forest

6. List two chemical defences of plants.

7. Compare predator and prey (similarities and differences).

K **8.** Which of the following abiotic factors is a characteristic of the tundra biome?
A. nutrient-poor soil
B. direct solar radiation
C. high average annual temperature
D. over 200 cm of precipitation each year

9. Explain how the distribution of the world's biomes are influenced by abiotic factors.

10. What characteristics do both the desert and tundra biomes share in common?

K **11.** Which of these characteristics applies to the temperate rainforest?
A. thin nutrient-poor soil
B. occupy coastlines in middle-latitudes
C. approximately 75 cm of precipitation annually
D. temperatures remain near freezing throughout most of the year

Use What You've Learned

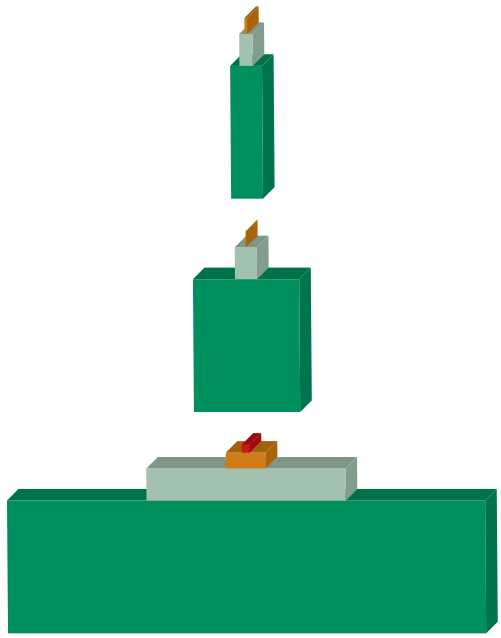
U **12.** In which of the following biomes will the removal of a species have the greatest impact?
A. tundra
B. boreal forest
C. tropical rainforest
D. temperate deciduous forest

13. Match each of the energy pyramids shown below with the correct biome: tundra, grassland, or temperate rainforest.

(a)

(b)

(c)



U **14.** Which of the following four ecosystems has the greatest rate of photosynthesis?
A. desert
B. polar ice
C. boreal forest
D. temperate deciduous forest

U **15.** Which of the following processes is most likely to lead to a decrease in biodiversity?
A. extinction
B. biodegradation
C. adaptive radiation
D. species proliferation

U **16.** Which of the following is a biome?
A. the Pacific Ocean
B. the Arctic tundra
C. the continent of North America
D. the province of British Columbia

U **17.** Which of the following processes describes an interaction between abiotic and biotic factors?

A. commensalism
B. predator–prey cycle
C. rate of photosynthesis
D. interspecific competition

18. How does the angle at which Earth is tilted on its axis relate to the distribution of tropical regions?

19. Summarize the effect of each of the following on climate patterns:

(a) solar radiation hitting Earth directly
(b) solar radiation hitting Earth at an angle
(c) annual path of Earth around the Sun
(d) the presence of mountain near the coastline of continents
(e) effect of warm ocean currents near continents

20. For each of the following statements, indicate which of the biomes labelled in Figure 1 is described.

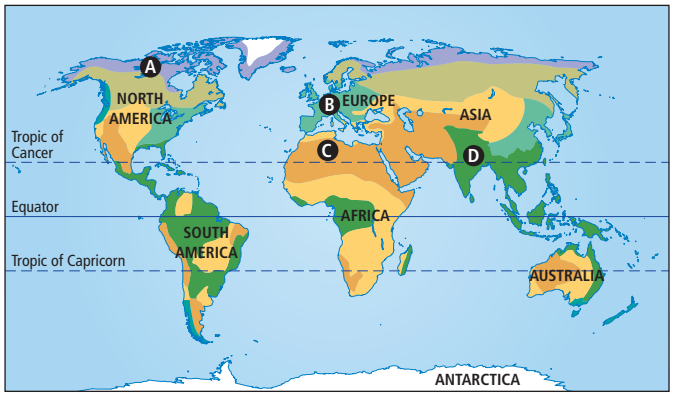


Figure 1

(a) smallest variation in seasonal temperature
(b) caribou feed on lichen and mosses
(c) producers are adapted to extreme heat and low precipitation
(d) soil with the highest nutrient levels
(e) seasonal deciduous forests dominate

21. Design an investigation that could be performed in order to determine whether an organism is a keystone species.

U **22.** Which of the following factors is responsible for the distribution of the world biomes?

I	latitude
II	altitude
III	annual precipitation
IV	average annual temperature

A. I only
B. I and III only
C. II and IV only
D. I, II, III, and IV

Think Critically

23. What factors may be responsible for fluctuations in size of the predator and prey populations?

24. Explain how specialization to a narrow niche can be both an advantage and a disadvantage to an organism.

25. Explain how a broad niche may lead to increased competition.

26. Explain why it is more likely that adaptive radiation will result from intraspecific competition than from interspecific competition.

27. Describe two host adaptations that help to defend against parasites.

28. Describe two adaptations that improve a parasite's success in occupying a host body.

Reflect on Your Learning

29. When the term "climax community" was first introduced, it referred to a final stable community. Today, most ecologists believe that no ecosystem has an end point. What types of changes do you think might continue to occur in a climax community? What types of disturbances might affect a climax community?

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