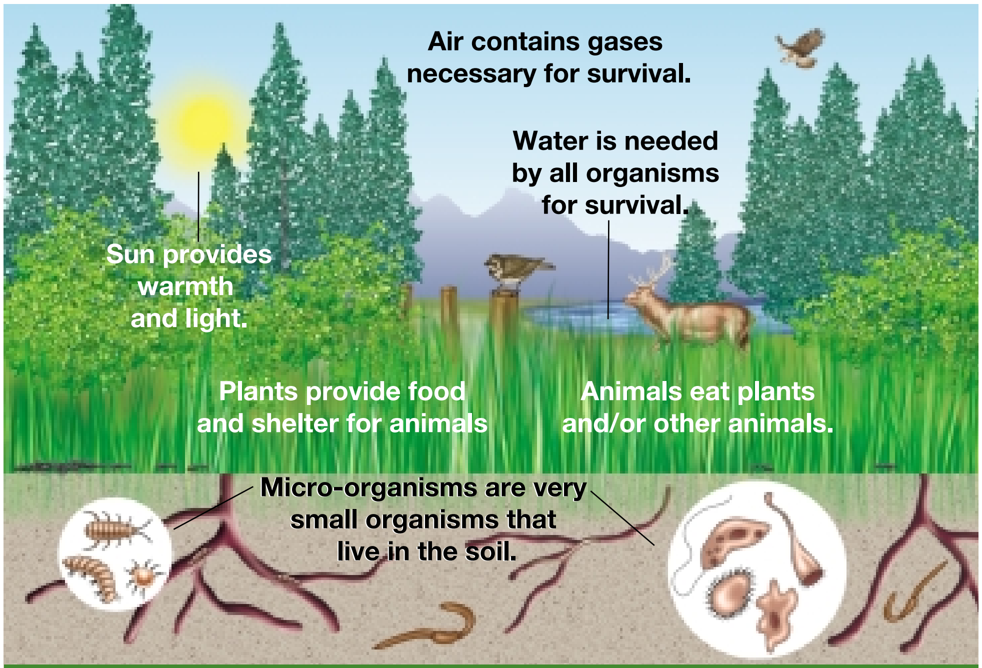
TOPIC 4 How Organisms Interact

As this lynx chases the hare, two living organisms are interacting in an environment. The lynx and the hare are two examples of the **biotic**, or living, parts of an ecosystem. All living organisms — including humans, bacteria, insects, and plants — are the biotic part of an ecosystem. The lynx and the hare are also interacting with the **abiotic**, or non-living, parts of their ecosystem. For example, if this photograph were taken in the summer, the hare's fur would be brown, not white. This is because the hare interacts, or responds, to the changing seasons (a non-living part of an environment) and it moults its fur as the seasons change. The abiotic parts of an ecosystem include the air, water, and soil.



Soil contains abiotic parts, such as minerals, and biotic parts, such as decaying bodies of dead organisms. Soil provides a home for many animals that live underground. Soil also provides minerals and other nutrients for plants.

INQUIRY

INVESTIGATION 1-D

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

A Mealworm's Ecosystem

Mealworms are a type of insect. Their home is usually their food — stored grains such as wheat. What type of habitat conditions do you think they would prefer — warm or cold, light or dark, wet or dry? Devise an experiment for finding their preferred habitat in this investigation.

Question

Which habitat conditions do mealworms prefer — warm or cold, light or dark, wet or dry?

Hypothesis

Form a hypothesis about the kind of habitat conditions that mealworms prefer.

Safety Precaution

Wash your hands when you have completed this investigation.

Materials

15 mealworms
3 petri dishes
materials of choice to complete investigation

Procedure

1. Read through the procedure and write a hypothesis about the kind of habitat conditions that mealworms prefer. Predict what will happen in each experiment.
2. Using mealworms, a petri dish, and other simple materials of your choice (such as black or white paper) **design** three experiments that test whether mealworms prefer a habitat that is warm or cold, light or dark, and wet or dry. Use five mealworms for each experiment.
3. **Write** your experimental procedures, and review them with your teacher before beginning.

4. Conduct your experiments and **record** your observations.

Analyze

1. What variable(s) did you manipulate in this investigation? What was the responding variable(s)? Which variable(s) did you control in this experiment?
2. Summarize your results in words or diagrams.
3. Compare your results with those of others in your classroom. Did everyone have the same results? If not, what could be causing the differences?

Conclude and Apply

4. Based on your observations, which habitat conditions do mealworms prefer?
5. How could you improve your experiment?

Extend Your Knowledge

6. Choose one of the experiments you designed and repeat it three times. Do you get the same results every time?

The Roles of Organisms in an Ecosystem

You, like all other members of human communities, play several different roles in your daily life. At school, you are a student. On the weekend, you might be a member of a sports team, or a volunteer at a food bank. Similarly, the organisms in a community of plants and animals play different roles, too. Each of these roles is known as a **niche**. One organism usually fills several niches.

Knowing an organism's niche can help explain why organisms act and interact as they do. To determine an organism's niche, you must look at what it eats, where it lives, and how it interacts with other organisms in its ecosystem.

Pause & Reflect

The swift fox occupies several niches. It eats small mammals, birds, insects, grasses, and berries and lives in dens dug into the ground. The presence of swift foxes affects the biotic and abiotic features of the southern prairie ecosystem in Alberta. What niche does your study animal occupy? Record your findings in your Science Log.

Figure 1.28 What are the niches of the various organisms shown here?

Plants and algae are able to grow using energy from the Sun and nutrients present in the soil. They fill the niche called **producers** because they produce food energy for themselves. Producers make life possible for all other organisms on Earth.

All other organisms are called **consumers**, because their niche is to consume (eat) the food made by the producers. Consumers occur in all sizes and shapes and may also eat other consumers. For example, the coyote in the ecosystem above is a consumer, so it must find food to eat by hunting and foraging. It also fills different niches when it finds or builds shelter, and stays safe from other organisms.

Figure 1.29 Although there are over 600 kinds of eucalyptus, koalas eat only the leaves of 35 kinds that grow in eastern Australia. Today, koala bears are endangered because eucalyptus forests were cut down to make room for farms and other developments.

Consumers can be divided into three different groups: herbivores, carnivores, and omnivores. **Herbivores** are animals that eat producers and fill the plant-eating niche. Cows, prairie dogs, deer, herring, and tadpoles are examples of this group of consumers. **Carnivores** are animals that eat other consumers, filling the meat-eating niche. Lynx, cod, minnows, and dragonflies are examples of carnivores. **Predators** are consumers that kill and eat other animals called **prey**. Red foxes and golden eagles are examples of predators. **Omnivores** are animals such as raccoons, skunks, and humans (that are not vegetarians) that eat both producers and consumers.

THINK & LINK

INVESTIGATION 1-E

SKILLCHECK

Initiating and Planning

Performing and Recording

Analyzing and Interpreting

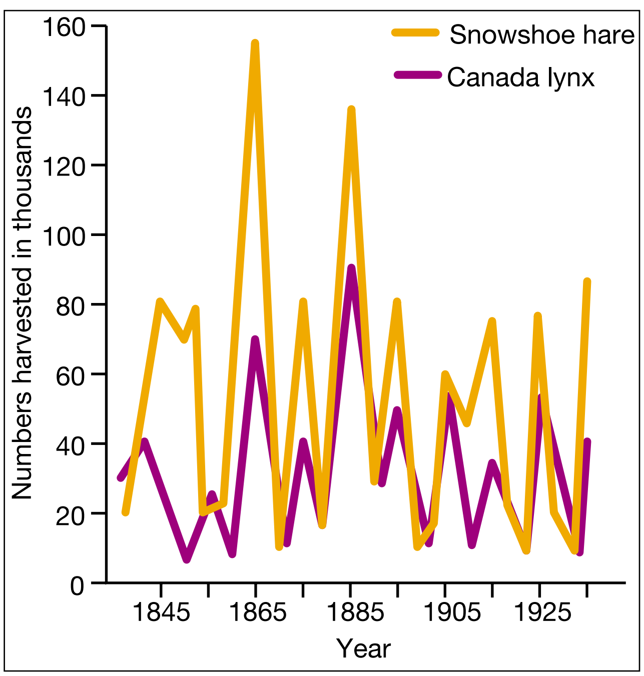
Communication and Teamwork

What Goes Up Must Come Down

Think About It

The niches of the Canada lynx and the snowshoe hare are linked together. The Canada lynx feeds mainly on snowshoe hares. Snowshoe hares eat plants. When there are lots of plants for snowshoe hares to eat, more of them survive and reproduce. This means that the lynxes that feed on snowshoe hares have more food. Therefore, more lynxes survive and reproduce.

However, after several years there are so many lynxes killing snowshoe hares that the hare population starts to decline. Then the lynxes do not have enough food, and *their* numbers decline. Plants are able to grow because there are fewer snowshoe hares around to eat them. As new generations of snowshoe hares are born, there is plenty of food for them. Since there are fewer lynxes to hunt them, the hare population begins to increase. There is more food for the lynxes, so *their* numbers increase, too. So this whole cycle, which lasts about ten years, begins again. The graph below shows how the numbers of lynxes and hares harvested by trappers changed over a period of 90 years.



What to Do

Use the data in the graph to answer the following questions.

(a) In 1845, approximately how many lynxes were harvested by trappers?

(b) In 1845, how many hares were harvested by trappers?

(c) How many of each were harvested in 1855?

(d) In 1865, two years before Canada's Confederation, how did the two populations compare? What led to this change in the relative numbers of the two populations? What food that affects both hares and lynxes does not appear on this graph?

Analyze

1. Use the graph to explain how changes in the lynx population appear to follow changes in the hare population.

2. How can prey be said to control a predator's population? How can predators be said to control a prey's population?

3. The data in the graph are incomplete after the year 1935. Based on the data in the rest of the graph, estimate the populations of harvested lynxes and hares in 1940. Hypothesize about what might happen with these populations in 1945.

4. The last few years shown in the graph are the years of the Great Depression (1929–1939), a time of mass unemployment. How might this unemployment have affected populations such as these?

Food Chains

Grass and other plants grow by using energy from the Sun and nutrients in the soil as sources of food. The energy of the Sun is then stored in plants. When an animal, such as a cow, eats a plant, it obtains the Sun's energy indirectly in a useful form. When a meat-eating animal eats a steak, some of the stored energy in the cow is passed on to the consumer.

A **food chain** is a model that shows how energy stored in food passes from organism to organism (see Figure 1.30).

Word CONNECT

The word "herbivore" comes from the Latin words *herba* (herb or plant) and *vorare* (to devour). Using this knowledge, write what you think the Latin words *carnis* and *omnis* mean.

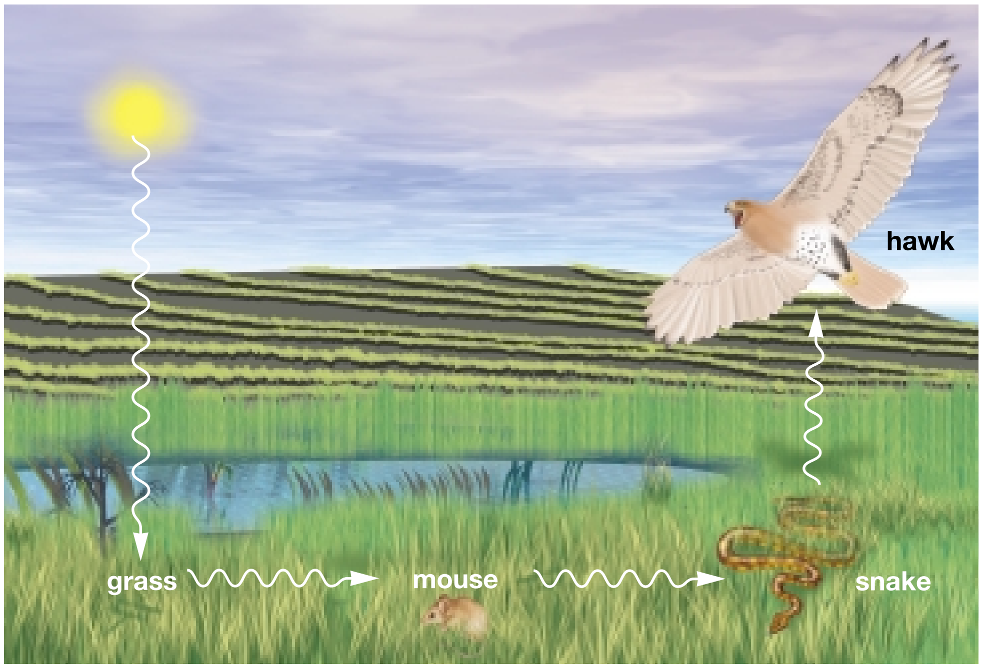


Figure 1.30 In this prairie slough food chain, arrows show the flow of energy through the chain. At the top of the food chain is the top carnivore. This organism eats other carnivores. For example, a hawk preys on smaller insect-eating birds. In some cases top carnivores may also feed on herbivores, for example, the lynx eats snowshoe hares, and the wolf eats moose.

STRETCH Your Mind

Approximately 10 percent of available food energy is passed to the next level of a food chain. If tuna fish are four steps up a food chain, what mass of phytoplankton (the producers in the ocean) would be required to provide a human with 126 g of tuna for a sandwich?

How does energy move through a food chain? At each step along the chain, energy is taken in by an organism and is used as fuel. As the organism uses the fuel, some energy is also released as heat. Some of the energy is stored in the organism's body tissues, while the energy that cannot be used passes out of the animal as waste. For example, when a grazing cow eats 2 kg of grass in one day, its mass does not increase 2 kg. Where does the mass of the grass go? Examine Figure 1.31.

Energy flow is the movement of energy, starting from the Sun, and passing from one organism to the next. In a food chain, as Figure 1.30 shows, very little energy that is stored in one organism is passed on to the next organism.

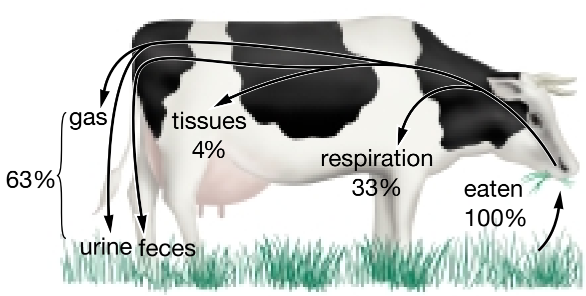


Figure 1.31 Most of the energy in grass eaten by a cow is not passed along the food chain. Only the 4 percent that goes to build and repair the cow's body tissues stays in the tissues. A little over 30 percent fuels the cow's normal activities such as breathing, mooing, and pumping blood through its body. Over 60 percent is passed out of its body as waste.

Food Webs

Food chains are rarely as simple as in Figure 1.30. Producers are usually eaten by many different consumers, and most consumers are eaten by more than one kind of predator. A mouse, for example, eats several kinds of plants and seeds. The mouse may be eaten by a hawk, a raccoon, or a snake. Figure 1.32 shows a typical **food web**. (network of interconnected food chains). Food webs can quickly become very large and complex.

Figure 1.32 Food webs are a combination of several food chains. They show the connections among the food chains.

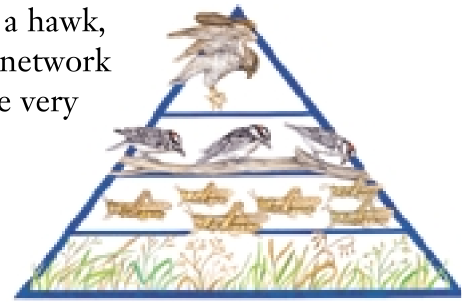


Figure 1.33 A pyramid of numbers is a model of an ecosystem that represents the number of organisms consumed at each level. Producers always form the broad base.

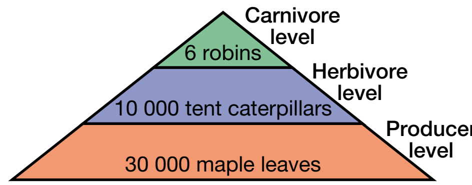


Figure 1.34 Each time a caterpillar eats a maple leaf, energy is lost and only a small amount is stored in its tissues. Thus, 10 000 caterpillars store only enough energy to feed six robins.

Pyramid of Numbers

Food chains and food webs show how food energy moves through an ecosystem, but not how many organisms are involved in the total energy transfer. In Figure 1.32, we do not know how many grasshoppers the snakes eat. We know only that snakes eat grasshoppers.

To solve this problem, ecologists build a **pyramid of numbers** (see Figure 1.33). It includes the same organisms as in a food chain, but the size of each level changes to show the number of organisms involved. There are always more animals being eaten than there are animals eating. There may be one hawk eating three woodpeckers, but not three hawks eating one woodpecker.

A pyramid of numbers does not indicate exactly *how much* energy is consumed. We can find this out by looking at how much each level of the pyramid weighs — how many kilograms of grasshoppers are needed to feed a kilogram of woodpeckers. **Biomass** is the total mass of all the organisms in an ecosystem. Just as each level in the pyramid of numbers has fewer organisms than the level below it, it also has less biomass. In any pyramid of numbers, the most biomass is in the base formed by the producers (see Figure 1.34).

Find Out ACTIVITY

What Was for Dinner?

Looking at an animal's scat (feces) or what an animal has in its stomach is one way to find out what niche it occupies! In this activity you will examine the contents of an owl pellet. Owl pellets are not scat, they are pellets of undigested food that are regurgitated by owls.

Safety Precautions

Wash your hands when you have completed this investigation.

Materials

owl pellet

paper towel

forceps or a fine probe

magnifying glass

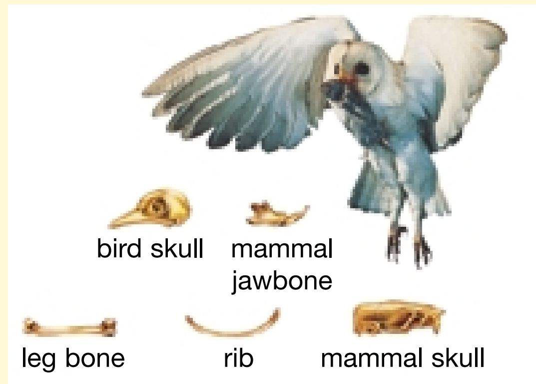
Procedure * Performing and Recording

1. Place the owl pellet on a paper towel. Using forceps or a fine probe, carefully break the pellet apart, separating out all of the smaller pieces.

2. Describe each item you were able to separate out from the pellet. Be as specific as possible.

3. Identify as many of the items from the pellet as you can. Study the illustration of contents of a pellet shown here.

4. Clean up as your teacher directs, and wash your hands after this activity.



What Did You Find Out? * Analyzing and Interpreting

1. How many different organisms were represented by the remains in the pellet? Explain your answer.

2. What is the niche of an owl in its ecosystem? (Where does it live, and what and where does it eat?)

3. Is the owl a producer or a consumer? Explain your answer.

STRETCH Your Mind

You may have seen a robin eat a worm, but have you ever seen a worm eat a robin? Try to explain how this might happen.

The Clean-Up Squads: Scavengers and Decomposers

Have you ever wondered why you seldom see a dead carcass in a natural environment? If dead organisms stayed whole, Earth would soon be covered in bodies! In every ecosystem, there must be "clean-up squads" that get rid of garbage and waste. These organisms break down dead material and waste. As the material breaks down, the nutrients that had been stored within it are released back into the ecosystem. They can then be taken in by other organisms and used for growth and other functions.

In a biological community, the clean-up squads are consumers called scavengers and decomposers. **Scavengers** are organisms that feed on dead or decaying plant or animal matter. Scavengers eat the dead material and break down the large carcasses into smaller pieces during digestion (see Figures 1.35A and B).

Decomposers are different from scavengers because they do not actually eat dead material. Instead, they grow on or in the dead or waste material, absorbing some of the nutrients into their own cells. The remaining nutrients recycle back into the ecosystem.

Figures 1.35A and **B** The magpie (above left) and the wolverine (above right) are common scavengers in Alberta. They eat dead and waste material, breaking it down into smaller parts and spreading the stored nutrients back into the ecosystem.

Have you ever found food covered in mould in the refrigerator? If so, you have witnessed decomposers at work. Many bacteria and fungi are decomposers. Although bacteria are micro-organisms (too small to see without a microscope), some fungi are quite large and visible (see Figure 1.36). In fact, you can see common fungi called mushrooms in any grocery store or vegetable market.

Decomposers play a key role in breaking down much of our kitchen waste. We can assist this process by composting lettuce leaves, apple cores, carrot peelings, and other kitchen wastes in a composter like the one shown in Figure 1.37. When we compost, we let nature's decomposers turn our kitchen wastes into rich soil we can use for fertilizing the garden. In the next investigation you will experiment with composters.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus7

Find out more about decomposers by researching them on the Internet. Go to the above web site, click on **Web Links** to find out where to go next. Create a display of different decomposers and the ways in which they affect humans.

Figure 1.36 Bracket fungus digests the dead cells of tree bark.

Figure 1.37 Kitchen wastes can be composted in a backyard composter.

Did You Know?

The wreck of the *Titanic* could disappear completely from the ocean floor by 2030. Bacteria are removing the iron from its hull at a rate of one-tenth of a tonne a day.

INQUIRY

INVESTIGATION 1-F

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Don't Waste It!

Under the right conditions, kitchen wastes, such as potato peelings, lettuce leaves, and eggshells, can be composted. Composting breaks them down so the nutrients that are trapped in them are released. The composted material can then be recycled, for instance, as garden fertilizer. What kinds of materials break down well? What kinds of materials do not break down at all? This investigation will enable you to explore the process of composting. (**Note**: While all food wastes will break down eventually, not all are appropriate to add to a home composter. Do not add meat, cooked food, and dairy products to home composters.)

Question

How can you find out which materials will decompose, and how long it takes for decomposition to occur?

Hypothesis

Form a hypothesis about the kinds of materials that can decompose.

Safety Precautions

Apparatus

- large clay pots with drainage holes (1 per test material)
- labels for the pots
- saucers to go under the pots
- pieces of window screen or a similar material
- magnifying glass

Materials

- garden soil (not sterilized)
- small stones
- water
- some or all of the following test materials: banana peels, paper, cabbage leaves, grass clippings, aluminum foil, orange peels, plastic, glass, potato peels, carrot peels, eggshells

Procedure

1. Before starting this investigation, **predict** what will happen to each of the materials you are going to test. Explain your prediction on the basis of your hypothesis.

2. Set each clay pot on a saucer.

   (a) Put a few small stones over the drainage hole in the bottom of each pot.

   (b) Add garden soil to each pot until the pot is about half full.

3. Put one test material in each pot. **Label** the pot to show what material is in it.

   (a) Cover the materials in the pots with an equal amount of soil.

(b) Water the soil in each pot until a little water comes out the bottom into the saucer.

(c) Cover the open top of each pot with a piece of window screen.

(d) Put the pots in a permanent location for a few weeks. Moisten the soil every few days.

4. After a week, remove the upper layer of soil and check that it is moist. **Observe** the amount of decomposition. You could use the magnifying glass to examine the test materials. **Record** your observations. Replace the soil and continue the process until you can detect a difference in the condition of the materials.

5. Clean up your work area as your teacher directs, and wash your hands thoroughly after completing this investigation.

Skill FOCUS

For tips on graphing, turn to Skill Focus 10.

Analyze

1. What variable(s) did you manipulate in this investigation? What was the responding variable(s)? Which variable(s) did you control in this investigation?
2. Which test materials decomposed rapidly?
3. Which test materials decomposed slowly?
4. Which materials did not decompose over the course of the investigation?
5. Was your hypothesis supported by your observations?

Conclude and Apply

6. Considering the health of the environment, what should be done to dispose of the materials you listed for questions 3 and 4?
7. What factors might speed up the decomposition of materials listed in question 3?

Extend Your Skills

8. Design an experiment to determine what effect, if any, temperature would have on the rate of decomposition. Make sure that your experiment is a fair test, and have your teacher approve your procedure before you carry out your experiment. (Hint: Your hypothesis should state whether you expect one variable, such as the rate of decomposition, to change when you alter another variable, such as temperature.)
9. Design an experiment that will test what effect, if any, using sterilized soil (such as potting soil) would have on the rate of decomposition. Your experiment should be a fair test, and your teacher must approve your procedure before you carry out your experiment. (Hint: Your hypothesis should state whether you expect one variable, such as the rate of decomposition, to change when you alter another variable, such as the type of soil.)

Math CONNECT

For each test material, estimate and record the percentage of decomposition every week. For example, strawberries may be half their original size, so they have decomposed about 50 percent. A plastic bag may have not have changed, so it has decomposed 0 percent. At the end of your investigation, graph your results. Finally, interpret your graphed data.

Across Canada

Dr. Kevin Vessey

"Curiosity is probably the most important characteristic that leads someone into a career in science," says Dr. Kevin Vessey, a scientist from the University of Manitoba. Kevin grew up in Prince Edward Island. As a teenager, he enjoyed watching marine biology shows, such as "The Undersea World of Jacques Cousteau," on television. Kevin's curiosity inspired him to study biology at Dalhousie University in Halifax, Nova Scotia, and then at Queen's University in Kingston, Ontario.

Dr. Vessey is interested in the many types of good bacteria in soil that help plants grow. The most common type of helpful bacteria are called rhizobia. They convert nitrogen from the air into ammonium, the mineral form of nitrogen. Plants cannot use nitrogen in the air, but they can use this mineral form of nitrogen to make protein. Rhizobia live in tumourlike growths on the roots of plants. When rhizobia attach themselves to a plant, they "infect" it. Dr. Vessey studies the development of infection by rhizobia in peas and soybeans (legumes). He says that this process of "nitrogen fixation" is similar to plants having their own fertilizer factory in their roots!

The research Dr. Vessey is doing will help farmers use helpful bacteria and fewer pesticides. You might have a chance to hear Dr. Vessey if you listen to "The Science Quiz" portion of "Quirks and Quarks" on CBC radio. He has taken part in this show in the past and plans to contribute more science questions for curious minds in the future.

Find Out ACTIVITY

No Fishing Allowed

Bull trout are large fish that live in the rivers flowing from the eastern slopes of the Rocky Mountains down into the Prairies. Bull trout are part of a food chain that involves many other organisms. Recently, the bull trout have been disappearing from Alberta rivers and lakes. This affects different parts of the ecosystem.

Procedure

Performing and Recording
Analyzing and Interpreting

1. Use the library and the Internet to research bull trout in Alberta. Look for answers to these questions.
   - What other organisms are in the food chain? Where do the bull trout fit into the chain?
   - What has caused the reduction in the numbers of bull trout?
   - If the bull trout become extinct, what might happen to the food pyramid in which the bull trout are found?
2. Use a concept map to organize your findings. Write a brief report with the information that you found.

TOPIC 4 Review

1. Define the following terms in your own words, and give an example of each.
   (a) producer (b) omnivore
   (c) predator (d) decomposer
2. Use a Venn diagram to compare a pyramid of numbers and a food chain.
3. Explain why all of the energy in one level of a food pyramid is not available to other organisms in the pyramid.
4. Use arrows and words to draw three food chains you might find in the prairie ecosystem found on page 42. If you wish, you may add other prairie organisms not shown in the illustration.
5. **Thinking Critically** Choose and observe an ecosystem in your community (a local park, a ravine, or your own backyard). List the biotic and abiotic features. Indicate the niche occupied by each organism in your ecosystem.

TOPIC 5

Cycles in the Environment

When you or another animal breathe out, the gases are recycled in the air and are used by other living organisms. When an animal or tree dies, it eventually decomposes and the nutrients are recycled back into the environment. Even as the tree in Figure 1.38 dies and decays, many forest animals rely on it. Woodpeckers feed on insects that, in turn, feed on the bacteria in the decaying wood. Burrowing birds build nests in holes in the rotting tree. Bats find a home under the bark during the day. In this Topic you will learn about natural cycles in the environment.

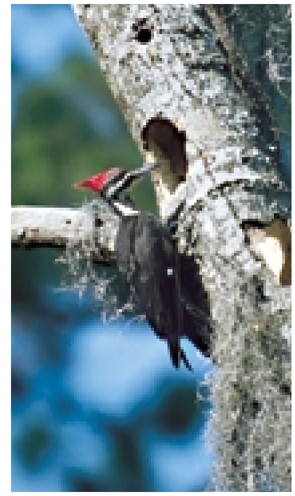


Figure 1.38
The environment is the ultimate recycler — it uses gases, water, and nutrients over and over again.

The Carbon Cycle

Plankton are microscopic plants, animals, and other organisms that float in the ocean. All of these organisms contain carbon, which is what fossil fuels are made of. Phytoplankton are plankton, such as algae, that use sunlight to make their own food through photosynthesis. Over time and under great pressure, decomposing plankton changes into fossil fuels. (You will learns about fossil fuels in Units 3 and 5.) These fuels still contain the carbon that was present in the original organisms.

Carbon is necessary for all life to exist. Plants use carbon dioxide from the air in order to make their own food. Moose, mice, and other organisms eat the plants and release carbon dioxide when they exhale. Wolves, foxes, and other organisms eat the moose and mice, and obtain their stored carbon. They also exhale carbon dioxide into the air. Thus, carbon circulates around and around an ecosystem in the **carbon cycle** (see Figure 1. 39).

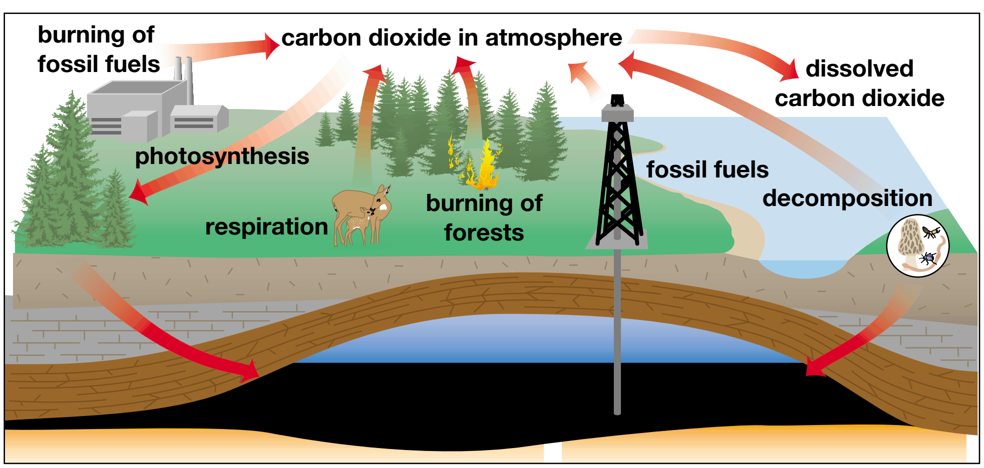


Figure 1.39 This diagram shows the carbon cycle. The oil derrick is pumping oil from deep under the ground

Looking Ahead

Fossil fuels are non-renewable resources. If the carbon cycle is really a cycle, why is there concern about using up all of the fossil fuels? You will want to consider the issue of renewable and non-renewable resources as you prepare for your end-of-unit debate.

INQUIRY

INVESTIGATION 1-G

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Telltale Snails

Bromthymol blue is a liquid that changes colour from blue to green to yellow when carbon dioxide levels increase. How could you use it to demonstrate that snails give off carbon dioxide?

Question

How can you design an experiment to show that snails give off carbon dioxide when they breathe?

Hypothesis

Form a hypothesis about what will happen to the bromthymol blue when the snails breathe.

Safety Precautions

- Handle chemicals with care. Bromthymol blue may stain clothing.
- Follow your teacher's directions for disposing of materials safely.
- Always handle the creatures with care and respect, and return them to their habitat after you have studied them.

Apparatus

2 Erlenmeyer flasks

2 small, clear cups or similar containers

modelling clay

flexible drinking straws

small, live aquarium snails

Materials

bromthymol blue indicator

distilled water

Procedure

1. Before you begin, read carefully through all of the steps and design your hypothesis. **Predict** what will happen to the bromthymol blue. Explain your prediction, on the basis of your hypothesis.
2. With your group, decide how you might use the materials. Decide how you can demonstrate that any observed changes in the bromthymol blue are due to carbon dioxide given off by the snails.
3. **Draw** a labelled diagram of your set-up for the investigation. On your diagram, indicate how long you think your set-up should be in place. Show your diagram to your teacher for approval.
4. Set up your investigation.
5. **Observe** the experimental set-up. **Record** your observations.
6. Clean up as your teacher directs, and wash your hands after this investigation.

Analyze

1. What variable(s) did you manipulate in this investigation? What was the responding variable? What variable(s) did you control?
2. Was your hypothesis supported by your observations?
3. Was it clear that the snails gave off carbon dioxide? If not, how could you make it clear if you repeated the investigation?

Conclude and Apply

4. Predict what might happen if you put water plants in with the snails. With your teacher's permission, try it.
5. Did any group come up with a better way to carry out the investigation? How did the procedure or set-up differ from yours?

Extend Your Skills

6. Design a fair test to show that humans exhale carbon dioxide.

The Water Cycle

All living things require water. As Figure 1.40 shows, an apple is 84 percent water, a carrot is 88 percent water, and a tomato is 94 percent water. The human body is 60–70 percent water. Water is used for life processes such as supplying food throughout an organism's body in a form it can use in its cells, and carrying away wastes from those cells. Water moves constantly around the environment, changing form as it moves from the air to the ground to your body.

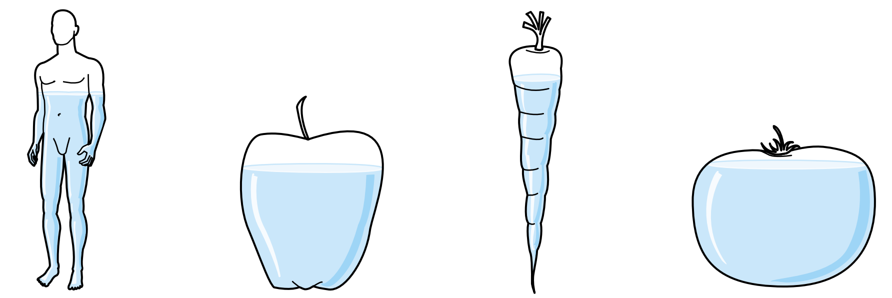


Figure 1.40 All living things contain large amounts of water.

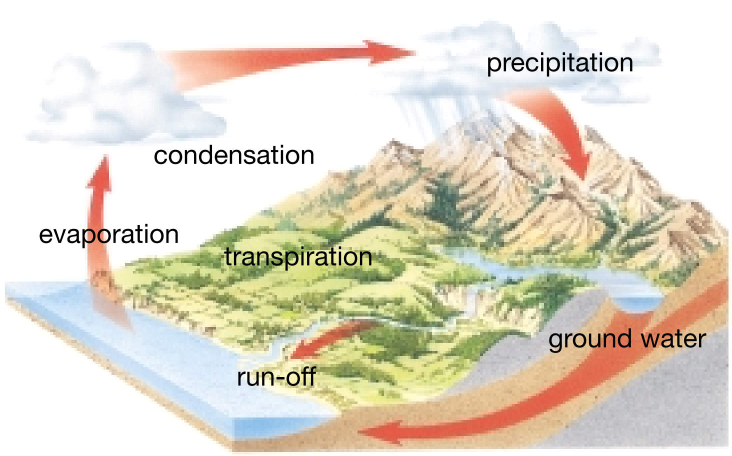
The **water cycle** is the continuous movement of water through an ecosystem (see Figure 1.41). This cycle involves four main processes. The first two processes — evaporation and transpiration — move water up from Earth into the atmosphere. The second two — condensation and precipitation — return water to Earth.

STRETCH Your Mind

You know that water can change from a gas to a liquid or from a liquid to a solid. Can water change from a solid to a gas without becoming a liquid? Can you think of an example of this?

DidYouKnow?

Does it surprise you to know that the amount of water on Earth always stays more or less the same? The same water particles that were present hundreds of years ago in the days of your great-great-great-great-great-grandparents are still around today.



Evaporation is the process in which a liquid changes into water vapour. Liquid water evaporates to form invisible water vapour.

Transpiration is the process in which water that is taken in through a plant's roots evaporates from the plant's leaves, stem, and flowers.

Condensation is the process in which water vapour changes into a liquid. Warm air contains water vapour. As air cools, however, it is able to hold less and less water. Condensation happens when air becomes so cool that it can no longer hold as much water vapour, and liquid water is released. This creates clouds, fog, or dew.

Precipitation is the process in which liquid water forms from condensation occurring inside clouds, and then falls as rain, sleet, snow, and hail.

Ground water is water in the soil. Plant roots can grow down to reach ground water. People can reach ground water by digging wells.

Run-off is water that runs off the ground into lakes, rivers, or streams.

Figure 1.41 The water cycle is the continuous movement of water through an ecosystem.

Figure 1.42 These trees were damaged by acid rain.

Pollution in the Environment

You have seen that matter, energy, carbon, and water all constantly cycle throughout ecosystems. Other substances can also enter and cycle throughout ecosystems. **Pollution** occurs when a substance is added to the environment at such a fast rate that it cannot be broken down, stored, or recycled in the air, land, or water in a non-damaging form. **Pollutants** are substances that cause pollution.

Many substances that occur naturally become pollutants when they are present in concentrations too high for the environment to absorb without a negative effect. For example, carbon dioxide is naturally present in the atmosphere. However, at this time, excess carbon dioxide, caused by burning fossil fuels, is damaging the environment.

Acid rain occurs when pollutants containing sulfur and nitrogen are found in high levels in the air. When fossil fuels are burned, sulphur and nitrogen are released as waste. These pollutants mix with water vapour, making it acidic. When it falls from the atmosphere as precipitation, it damages ecosystems. For example, entire lakes can "die," because the water is too acidic for fish and plants. Water with a pH value below 5.6 is considered acidic. Figure 1.43 shows the **pH** scale.

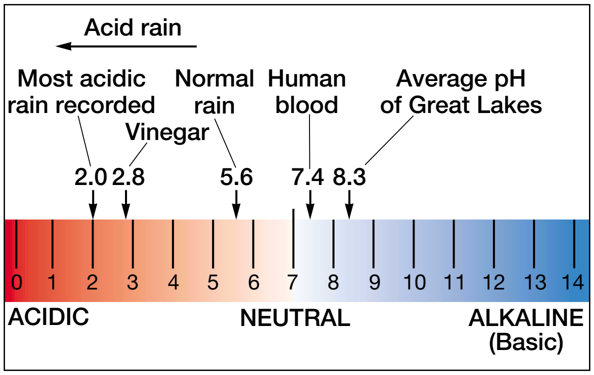


Figure 1.43 The pH scale measures the acidity of liquids, and ranges from 0 (very acidic) to 12 (not acidic).

Find Out ACTIVITY

Checking the pH

In this activity, you will determine how acidic the rain and water systems are in your area.

Materials

samples of rainwater collected from various areas

samples of water from water systems in your area

a sample of tap water

pH indicator paper

Safety Precautions

Procedure ✷ Performing and Recording

1. Collect water samples from different sources in your area (puddles, streams or nearby sloughs, or melted snow).
2. Dip a piece of pH indicator paper into the sample. Observe the colour of the paper and compare it to the pH chart on the paper's container. Record the pH of the sample.
3. Repeat the procedure for each sample of water that you have.
4. Clean your work area if necessary, and wash your hands after this activity.

What Did You Find Out? ✷ Analyzing and Interpreting

1. Were your samples acidic, basic, or neutral?
2. How does the pH of the tap water compare with the pH of the samples you collected?
3. Based on your results, do you feel the water in your area has been affected by acid rain?

The Movement of Pollution

There are many different pollutants moving through the environment. For example, PCBs (polychlorinated biphenyl) are substances that were commonly used for a variety of purposes, including paints and packaging materials. PCBs were never meant to enter into the environment, but they accidentally leaked into the air, water, and ground through waste-disposal sites. PCBs break down very slowly, so they remain in the ground and in water for years and years. Once in the ground and in the water, they can cause harm to organisms.

Mercury is another substance that does not naturally move through the environment. Mercury was used by many different industries, including gold mining, and was disposed of as waste. Sometimes, mercury leaked out from the waste-disposal sites and dissolved in water. Then it would soak into the ground and end up in a body of water such as a river or lake. The bird in Figure 1.44 has been damaged by mercury poisoning.

DDT is a pesticide that was commonly used across Canada. In the 1940s, 1950s, and 1960s, it was sprayed onto crops and trees to kill harmful insects. DDT did control insect populations. However, it was very poisonous, and it started to damage other organisms as well. DDT is now banned in Canada, but it is not banned everywhere in the world. How do poisons such as DDT cycle through the environment?

Figure 1.44 This robin's beak has been deformed by poisons in its ecosystem.

Figure 1.45 Insecticides protect our trees, but do we always know the full extent of their impact on the environment?

Did You Know?

A scientist named Rachel Carson (1907–1964) popularized the study of ecology by writing and speaking clearly about important ecological issues of her time. Her observations led to studies that showed that the pesticide, DDT, caused the death of thousands of young eagles and hawks. The pesticide was eventually banned from use in many countries, including Canada.

Bioaccumulation

Pollutants move from level to level in a food web. They are stored in organisms in the same way that food energy is stored. This effect is called **bioaccumulation**. Bioaccumulation occurs when pollutants enter into the food web and accumulate in the higher level consumers (see Figure 1.46). For example, the large fish accumulates all of the pollutants contained in all of the small fish it ate. Most humans eat a variety of different foods from all levels of the food web. This means that we are at risk of accumulating many different types of poisons that have been stored in the organisms we consume. When we understand how pollutants enter the system, we can work toward reducing the levels of pollutants moving through the environment.

A Mercury enters the water after leaking out of a waste-disposal site and settles on the bottom of the lake.

B The mercury enters the systems of micro-organisms living in the sediment and algae in the water.

C Small fish eat the micro-organisms and the algae, and the mercury accumulates in their systems.

D Larger, carnivorous fish eat the smaller fish, and absorb the mercury contained from the small fish into their systems. The mercury stays dissolved in the fatty tissue in the fish.

E Finally, the large fish are caught and eaten by a human. The human needs several fish to make a meal, and accumulates the mercury that was in both of the fish eaten.

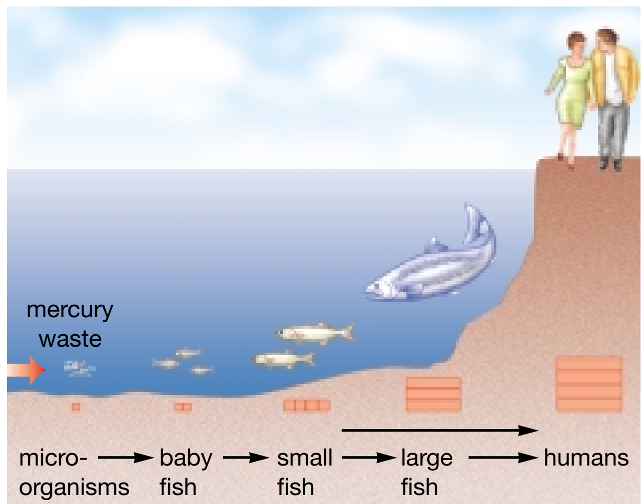


Figure 1.46 Pollutants are passed through a food chain along with energy

TOPIC 5 Review

1. The carbon cycle is balanced in stable ecosystems. What events might occur to upset this balance?

2. Pesticides are commonly used to control agricultural pests. In your own words, explain how this affects carnivores.

3. In your notebook draw a diagram of the water cycle, explaining the four main points.

4. Explain two ways in which cutting down forests and then burning the debris left behind can increase the level of carbon dioxide in the atmosphere.

5. **Thinking Critically** Explain the statement "Earth is an excellent recycler." Use examples to support your answer.

Wrap-up TOPICS 4-5

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

biotic
abiotic
niche
producers
consumers
herbivores
carnivores
predators
prey
omnivores
food chain
energy flow
food web
pyramid of numbers
biomass
scavengers
decomposers
carbon cycle
water cycle
evaporation
transpiration
condensation
precipitation
ground water
run-off
pollution
pollutants
acid rain
pH
bioaccumulation

Reviewing Key Terms

1. (a) In an ecosystem, _____________ make their own food using the Sun's energy, and all other organisms are _____________ because they cannot make their own food, they must acquire it. (4)

(b) _____________ are animals that kill and eat other animals called _____________. (4)

(c) Organisms that eat only producers are called _____________ and organisms that can eat anything are called _____________. (4)

(d) Energy moves through the ecosystem, starting at the Sun and passing from organism to organism. This is called _____________. (4)

(e) The two types of organisms that break down dead and waste material are called _____________ and _____________. (4)

(f) A _____________ is a network of interconnected _____________. (4)

(g) To show how much energy is moving through a system, scientists use a _____________. (4)

(h) The two main naturally occurring cycles in the environment are the _____________ and the _____________. (5)

(i) Pollutants enter a food chain and move from one organism to the next. The buildup of pollutants because of this movement is called _____________. (5)

Understanding Key Concepts

2. If you found hawks, field mice, and corn in the same ecosystem, what role would each be playing in a food chain? (4)

3. List, with examples, five different niches in an ecosystem. (4)

4. Why are scavengers and decomposers important in an ecosystem? How do they differ? (4)

5. Explain the difference between a food web and a food chain. (4)

6. Draw a pyramid of numbers for the ecosystem described in question 2. Explain your answer. (4)

7. Humans usually eat food from all levels of a food chain, like those shown in the photograph. Construct two food chains based on food you typically eat. Make one food chain long (at least four levels), the other food chain short (two levels). Illustrate your food chains, or simply use words and numbers. (4)