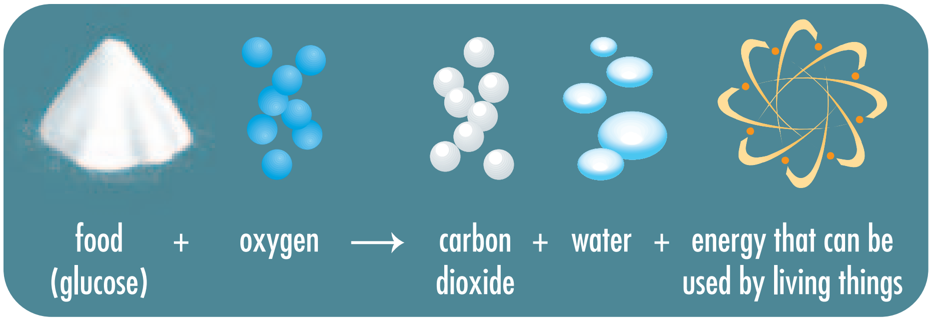

Figure 2.6 Word equation for cellular respiration

A Vital Interaction

You may have noticed a vital interaction that occurs between photosynthesis and cellular respiration. In photosynthesis, plants take in carbon dioxide and water, and produce food and oxygen. In cellular respiration, plants and animals use food and oxygen to produce carbon dioxide and water. The products of one chemical reaction are used by the other. For example, we exhale carbon dioxide when we breathe. We also give off water when we exhale and when we perspire. Plants use this carbon dioxide and water to produce oxygen that we breathe and food that we eat.

A Special Group of Consumers: Scavengers and Decomposers

All living things eventually die. As well, all consumers generate waste materials from the food they eat. Our planet would be littered with dead bodies and waste materials if not for a special group of consumers. These consumers get the matter and energy they need from wastes and dead plants and animals. Some of these consumers are **scavengers**. Others are **decomposers**.

Scavengers are consumers that don't usually kill for their own food. Instead, they feed off the remains of living things that are killed by other consumers. Crows, ravens, and housefly larvae (maggots) are examples of scavengers. Can you name two more? Decomposers are consumers that break down (decompose) dead plants and animals. They also break down animal waste materials. Fungi such as mushrooms and the mould you see growing on bread, fruits, and vegetables are decomposers. So are many kinds of bacteria.

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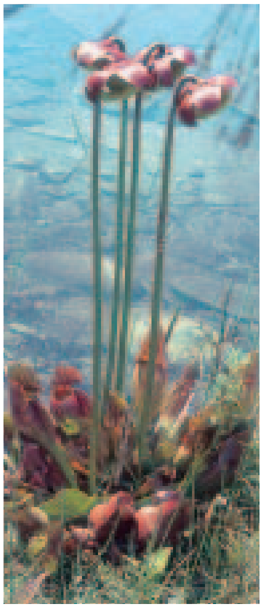
A Carnivorous Plant!
The pitcher plant eats insects such as grasshoppers and snails. Find out where it lives and how it "eats" its prey.



Decomposers Can Be Helpful or Harmful

Helpful or harmful? Baker's yeast—single-celled decomposers. They feed on sugars that are naturally present in foods such as grains and fruits. The carbon dioxide that they emit, or give off, is a by-product that bakers count on to make breads and pastries rise.

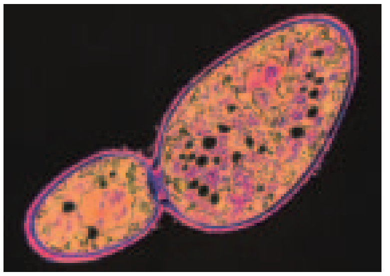


Figure 2.7a) Baker's yeast

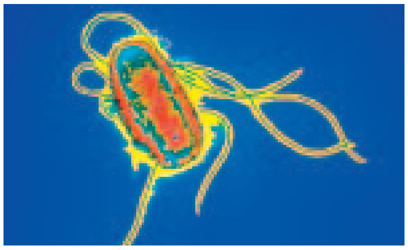


Figure 2.7b) *E. coli*

Helpful or harmful? *E. coli* (short for *Escherichia coli*—bacteria found in your large intestine. They break down nutrients in the food you eat for their own food. In the process, they manufacture several vitamins that your body needs to stay healthy.

Helpful or harmful? *Candida albicans*—a kind of yeast found in the moist mucus or mucus-producing areas of your body, such as your throat and mouth. When the body's immune system is weak, these decomposers can grow and reproduce rapidly. This results in a disease called thrush. It is characterized by raised white spots, usually on the tongue or inner cheeks of the mouth.

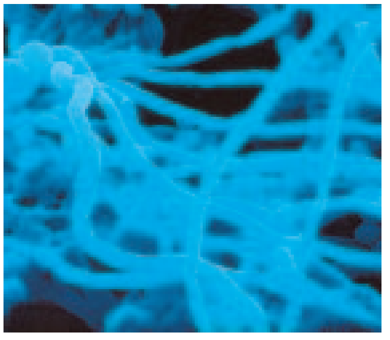


Figure 2.7c) *Candida albicans*

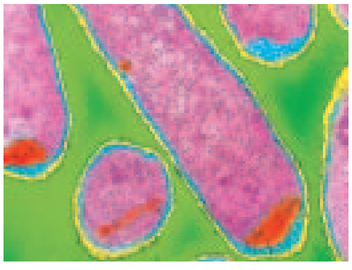


Figure 2.7d) *E. coli bacteria 0157:H7*

Helpful or harmful? *E. coli bacteria 0157:H7*—a form of *E. coli* sometimes found in common food products such as ground beef, milk, and apple juice. When these decomposers break down food, they produce highly toxic chemicals that can cause food poisoning.

Helpful or harmful? Nitrogen-fixing nodules—round swellings on the roots of some plants that are home to millions of bacteria. The bacteria make nitrogen available to the plant, and in return, the bacteria get their nutrients from the plant.

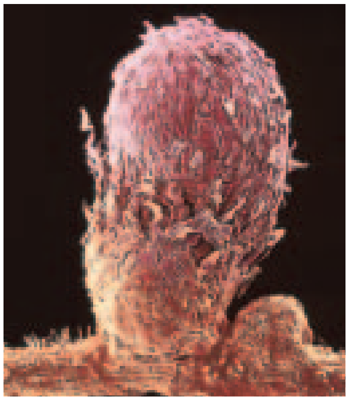


Figure 2.7e) Nitrogen-fixing nodules

Decomposers Are Essential to All Ecosystems

Decomposers keep us and other living things from being buried in dead bodies, dead plant parts, feces, and urine. It's funny to think about it that way, but it's true! However, decomposers are more than just nature's "clean-up crew." Their actions mean that plants always have a supply of nutrients available to them. In fact, decomposers act like a bridge that connects the biotic factors of ecosystems to the abiotic factors.

Check and Reflect

1. Compare the role of producers and consumers in ecosystems. How are they related? How are they different?
2. Plants can make their own food through photosynthesis to supply the matter and energy they need to survive.
   a) What are the raw materials for photosynthesis?
   b) What are the products of photosynthesis?
   c) Name a process in plants that uses oxygen. Compare the raw materials and products of this process with those of photosynthesis.
3. Write a poem or descriptive paragraph describing producers or what producers do in ecosystems.
4. Create a Venn diagram to show helpful and harmful decomposers.

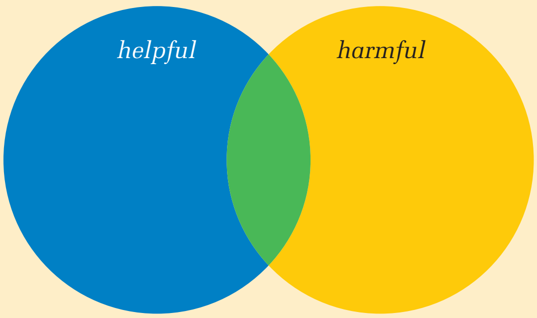


Figure 2.8 A Venn diagram

List the decomposers in the appropriate parts of your diagram. Decomposers that are both helpful and harmful should go in the overlapping section of the circles.

Continued on next page →

Check and Reflect

5. Which of the organisms shown below are scavengers and which are decomposers? Explain your choice for each organism.

Figure 2.9a) Millipede

Figure 2.9b) *Russula rosacea* mushroom

Figure 2.9c) Turkey vulture

Figure 2.9d) Wolverine

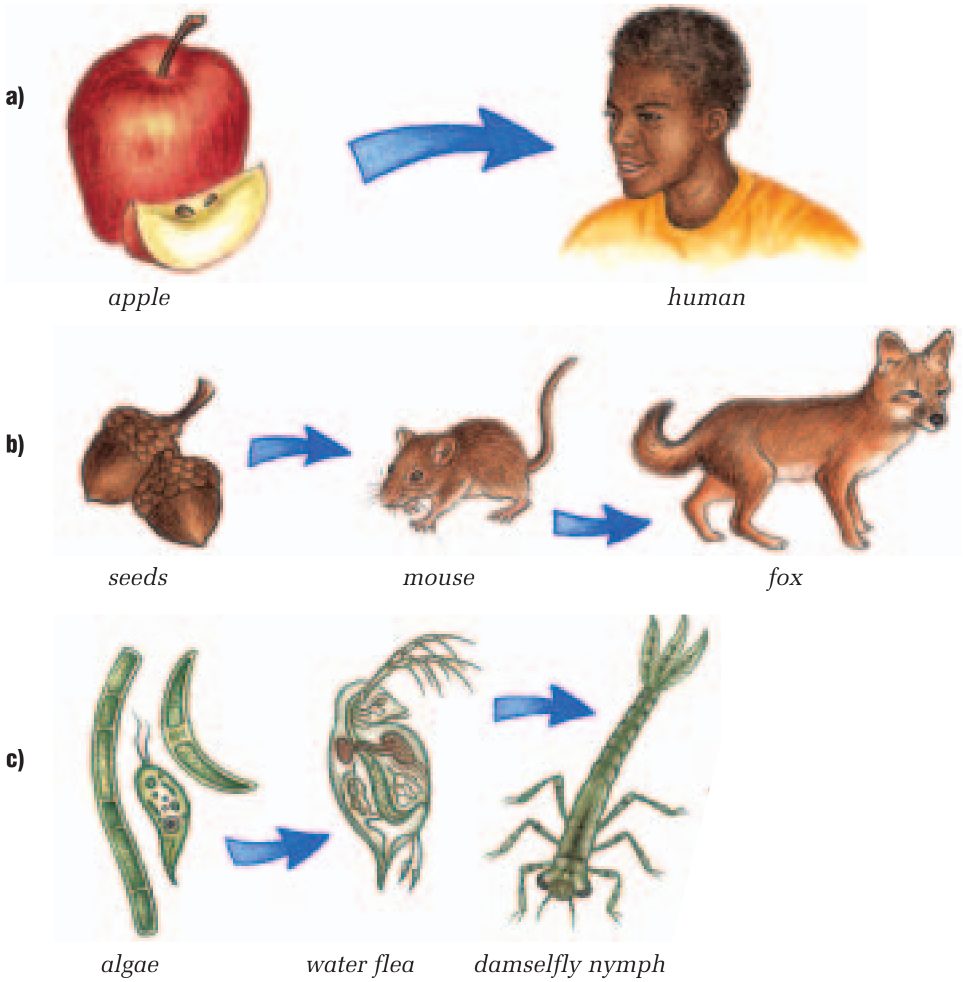
Figure 2.9e) Earthworm

Figure 2.9f) Cinnabar red polypore fungus

6. What similarities do you notice about the word equations for photosynthesis and cellular respiration? What are the differences? Make a table comparing the two.

2.2 Food Chains Demonstrate the Flow of Energy in Ecosystems

In general, food and energy in an ecosystem flow from the producers to the consumers. A **food chain** is a convenient way to show how energy moves among living things in an ecosystem. Here are a few examples of food chains.



Figures 2.10a)–c)
Three food chains

A food chain starts with the original food source: a producer. Then an arrow points to a consumer that eats that producer. In many cases, a primary consumer may, in turn, point to other secondary consumers. An example of a primary consumer is a herbivore, and an example of a secondary consumer is a carnivore that feeds on a herbivore, but not another carnivore. Notice that some food chains can be quite short, while others are longer. In Figure 2.10a)–c) above, which is the primary consumer? Which is the secondary consumer?

Give it a **TRY** ACTIVITY

WHERE DID THAT FOOD COME FROM?

Think of something you ate in the past day. Write it down near the right edge of a sheet of paper. Draw an arrow pointing to this food.

Decide what living thing was used to make or feed the food you ate. For example, if you had a piece of cheese, the source of the cheese might have been milk from a cow. Write this food source to the left of the arrow, as shown here.

→ cow → cheese

Draw another arrow pointing to this source. In this example, you could put grass to show that the cow ate grass to produce the milk. Keep adding arrows until you are not sure what the next step in the flowchart might be.

Repeat this process for five other food items.

When you have finished, review your flowcharts and look for similarities or patterns. Using this information, answer this question: What food sources do I seem to depend on for all the foods I eat?

ENERGY FLOW IN ECOSYSTEMS

Most ecosystems on Earth get their energy from the sun. Through photosynthesis, plants provide a way for other organisms in an ecosystem to use the sun's energy. This makes plants essential to almost all ecosystems. Plants play such an important role as producers that there are usually many more plants in an ecosystem than there are consumers. Within the consumers, there are usually more herbivores than carnivores in an ecosystem.

Figure 2.11 is an example of what happens to energy in an ecosystem. Light energy from the sun is used by plants in photosynthesis to make food. The food contains chemical energy that plants use for their life functions. A plant uses as much as 90% of the energy it gets from its food to support its life functions. The rest—or only about 10%—is stored as nutrients in the plant's roots, leaves, and other parts. So only about 10% of the plant's energy is available to the herbivore that eats the plant. The herbivore then uses as much as 90% of the energy from its food to support its life functions. A large part of this energy is given off as body heat. This leaves 10% as stored energy for a carnivore to eat.

Figure 2.11a) Plants use sunlight to make food to store and use for their life functions.

Figure 2.11b) A rabbit eats the plants and stores the food in its body. The rabbit's body changes some of the food into energy for its life functions.

Figure 2.11c) The predator eats the rabbit and uses the energy gained to carry out its life functions.

You can see that much of the energy doesn't get passed from one living thing to another. The largest percentage of energy is used for body heat, which just escapes into the environment. Other plants and animals cannot use this energy. The energy is not "used up"—it still exists. But it is now in a form that other plants and animals can't use.

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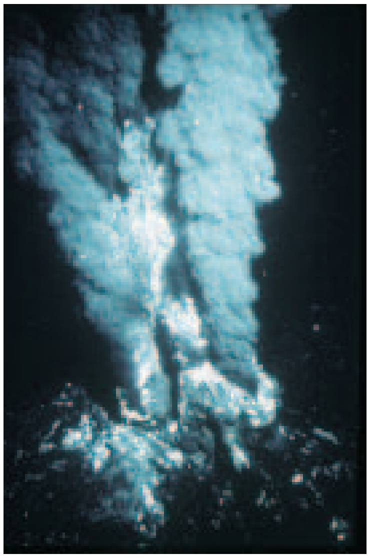
Deep-Ocean Community

Scientists once thought that all life on Earth depended on the sun's energy. Then, in 1977, a crew of scientists on board a deep-sea submarine made a discovery in the Pacific Ocean. They found an ecosystem 2.5 km below the water's surface in cracks along the ocean's floor, where the sun's rays cannot reach. Heat energy from inside Earth creates warm areas in the normally frigid water. Bacteria live in these waters. They are the producers for food chains that include unusual aquatic herbivores and carnivores.



Black smokers

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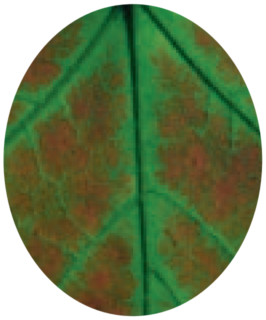
Why Do Autumn Leaves Turn Colour?



What happens to the green-coloured chlorophyll in plants in autumn? Why do leaves change colour before they fall off a tree? Research what happens to leaves every autumn. Write a paragraph explaining what you have learned.

Energy, therefore, is not recycled in an ecosystem. It follows a one-way path. In each ecosystem, producers depend on a constant supply of energy from the sun to survive. Herbivores depend on plants, and carnivores depend on herbivores for their energy. Finally, scavengers and decomposers depend on everyone else for the energy they need. Figure 2.12 is another way of representing the flow of energy through an ecosystem.

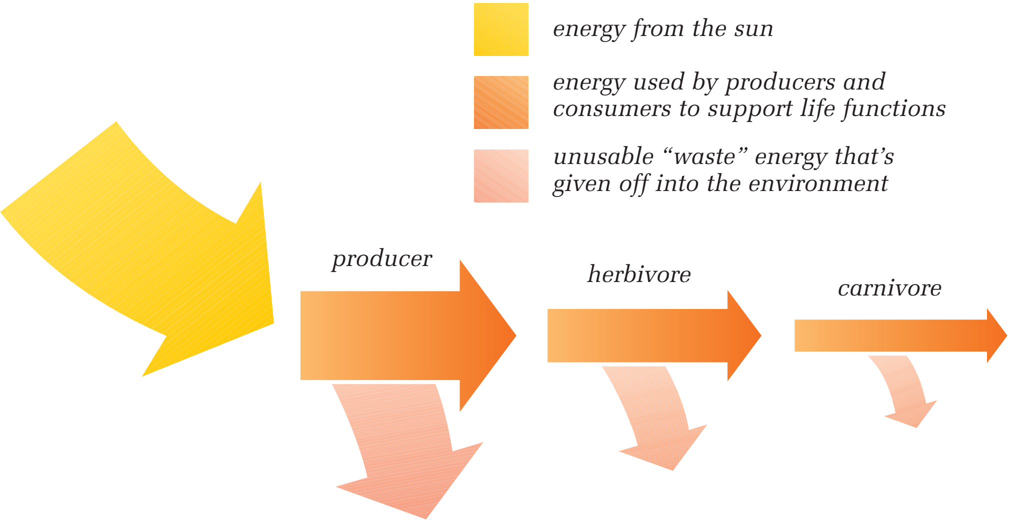


Figure 2.12 A plant uses much of the energy it gets from its food to support its life functions. The rest is stored as nutrients in its roots, leaves, and other plant parts. That leaves very little energy available to a herbivore that eats the plant. The herbivore also uses much of the energy from its plant food to support its life functions. What do you think that means for a carnivore that eats the herbivore?

Check and Reflect

1. What is the difference between the energy used in photosynthesis and the energy used in cellular respiration?
2. What happens to the energy in cellular respiration not used to support life functions?
3. In terms of the flow of energy through an ecosystem, which is the correct order for each of the following situations?
   a) rabbit, sun, rose, wolf, earthworm
   b) seaweed, sea urchin, otter, sun, bacteria
4. Provide an example of how a plant or animal stores nutrients.

2.3 Food Webs

You have been using food chains to help you understand how all living things are connected with one another. However, food chains are simplified ways of showing these interactions.

In real ecosystems, there are usually many carnivores, many more herbivores, and many, many more producers—and there are countless decomposers. In real ecosystems, there can be dozens, hundreds, or even thousands of different food chains. Each living thing is a part of many food chains. Many of these food chains are linked. If you link food chains in an ecosystem, you get a **food web**.

Food Webs and Ecosystems

Changes in either the abiotic or biotic factors affect the members of the food web. These changes can have a great effect on living things in an ecosystem.

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Size and the Food Chain

Larger animals are not necessarily higher on the food chain. For example, herbivores, which are primary consumers, include small animals such as grasshoppers, and large animals such as elephants.

Give it a **TRY** — **Activity**

Disappearing Organisms

Food webs are made up of a wide variety of living things. If you were to count the number of organisms in a typical food web and graph the results, this is what the graph might look like.

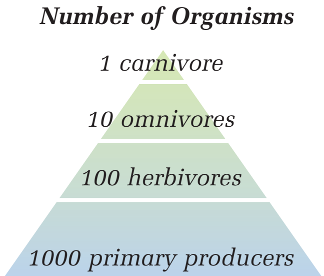

Figure 2.13 A food web pyramid

Suppose that one type of living thing were to disappear from an ecosystem. Which type do you think would have the greatest impact on the other living things? the least impact?

Write a paragraph or create a table identifying what would happen if one of the groups of organisms were removed.

Inquiry Activity

Food Web Chain Reaction

The Question

How do abiotic and biotic factors in the forest ecosystem affect the complete food web of the forest?

Materials & Equipment

- 30–40-m length of strong string or yarn, or light rope
- "forest identity" cards

Figure 2.14 The forest ecosystem

Procedure

Part 1 Modelling a Forest Ecosystem

1. In this activity, you will be creating a model of some interactions that can occur in a forest ecosystem. Using this model, you will investigate the impact of various situations on the ecosystem.
2. Your teacher will hand out a forest identity card to everyone in your group. When you get your card, quietly think about your new identity and how you fit into a forest ecosystem. Think of the role you play in the forest. Think of a part of the forest (biotic or abiotic) that depends on you. Think of a part of the forest that you depend on or use. One person in the group will be assigned the task of recorder.
3. Your teacher will give someone in your group a ball of string. That person may be you. While holding onto one end of the string, you will pass the ball to another person who has a role in the forest that depends on or uses you.
4. As this person receives the ball, he or she explains the relationship to you. The recorder sketches the connection between the two factors (you and the other person).
5. Repeat steps 3 and 4 until all members of your group are connected by the string. Some members may be connected more than once. You now have a model of some of the interactions that occur in a forest ecosystem.

Part 2 Impacts on the Forest Ecosystem

6. Once everyone is connected, find the person who is water. Pretend that there's a drought this year, so there's very little water for the forest. The water person should tug gently on the string. Do you feel the tug? Does anyone else in the circle feel the tug?
7. Repeat the process followed in step 6 for each of the following situations:
   a) Disease has killed the foxes.
   b) Too many trees have been cut down.
   c) The air has become heavily polluted.
8. If you wish, make up some of your own situations to test. When you've finished, answer the following questions.

Analyzing and Interpreting

9. When the water person tugged on the string, how many people felt it? Did this surprise you? Why or why not?
10. In the other situations, how many people felt the tug? Again, did this surprise you? Why or why not?
11. a) Make a sketch of the forest ecosystem that you were part of in this activity. (See the partially completed diagram, Figure 2.15.) You might want to use different colours for some of the connections. If you like, add any other living things that you want to include.
    b) Label all the biotic and abiotic factors. Then draw lines to connect all biotic parts of the ecosystem into a food web.

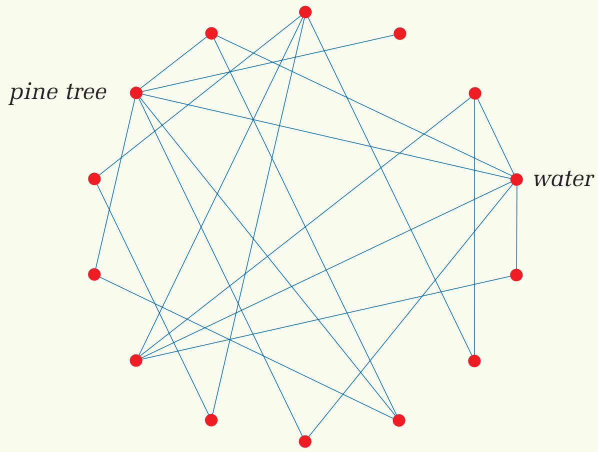

Figure 2.15 A sketch of the forest ecosystem, partially completed

Forming Conclusions

12. Summarize this activity by answering the following:
    a) What do you think are the most important things about food webs?
    b) What did you learn about food webs that you didn't know before?
    c) What is one thing about food webs you would like to know more about?

Applying and Connecting

In late February 2000, floods devastated much of southeastern Africa. Mozambique was one of the places hit the hardest. Floods destroyed much of the crops and left hundreds of thousands homeless. Research what is presently happening in Mozambique. How did the Mozambicans recover from the flood?

Figure 2.16 A food web. Describe two food chains in this web.

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Earthworms and Ecosystems

Earthworms are an important part of many ecosystems. Use print or electronic resources to find out why. What would happen if all the earthworms in a lawn or field disappeared? Write a report, design a poster, or prepare a multimedia presentation to share your discoveries.

Study this food web of a meadow community. The dark-coloured arrows show the direction in which energy and nutrients are being passed in the food chain. You can find the food chains that make up this food web by starting with the plants and grasses in the middle of the picture. Then, follow the dark-coloured arrows until they end. When any of the organisms in the food web die, the decomposers will break them down, and the cycle will start again. The light-coloured arrows show how energy and nutrients are being passed to the decomposers.

But what would happen if the number of grasshoppers changed? If the number increased, then more grass and plants would be eaten. This would mean less grass and plants would be available for the mice and rabbits. With the increase in the number of grasshoppers available, the number of frogs might increase. However, when the number of grasshoppers decreases again, the frogs would not have enough food, and some would starve. As you can see, each part of the food web depends on the other parts. If one part changes, the rest of the web also changes in some way.

Check and Reflect

1. Think of a food web in a forest that contains trees, foxes, rabbits, mushrooms, and ferns.
   a) Create a food web that would use all of the above organisms.
   b) Add yourself to this web and redraw the food chains to include you.
2. Think about a forest food web and a desert food web. List three differences and three similarities between the food webs.
3. Compare a forest food web with a food web in any other ecosystem of your choice. How are they different? How are they similar?
4. a) Think of a park or other green space. Name two producers, two herbivorous consumers, and two carnivorous consumers that you would find in this ecosystem.
   b) Explain how these living things are related to one another.
   c) Would you expect to find scavengers and decomposers in a park ecosystem? Why or why not?
5. Here are components of a Northern food web. Draw a food web using each component.

Figure 2.17a) Mink

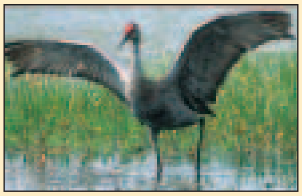

Figure 2.17b) Sandhill crane

Figure 2.17c) Wood frog

Figure 2.17d) Pike

Figure 2.17e) Shiners

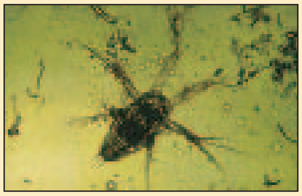

Figure 2.17f) Plankton

Figure 2.17g) Mayfly larva

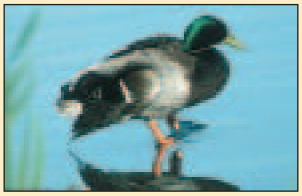

Figure 2.17h) Mallard

2.4 Matter Cycles in Ecosystems

You have learned that energy flows in ecosystems, and can show that energy flows through food chains and food webs. Both matter and energy are abiotic factors. Both are required for ecosystems. Together they influence all areas of the ecosystem. Now you will investigate how water and carbon cycle through ecosystems. Study the pictures and read the captions on this page. What does the information presented say about what happens to matter in ecosystems? Write a paragraph that summarizes what you think these pictures are telling you.

Figure 2.18a) Sunlight, soil, and water from the abiotic environment provide plants with what they need to grow and live their lives.

Figure 2.18b) Plants serve as food for herbivores. The herbivores can sometimes serve as food for other consumers.

Figure 2.18c) Plants and animals grow, reproduce, produce wastes, and in time, die.

Figure 2.18d) Scavengers and decomposers feed on the wastes and remains. This process breaks down once-living matter into smaller, simpler particles. In time, even solid skeletons are broken down.

Figure 2.18e) Skeletons are made up of chemicals such as calcium, phosphorus, and carbon. These chemicals (minerals) are nutrients that other living things (such as plants) need to survive. Mineral nutrients are non-living, so they are part of the abiotic environment.

Water and Carbon Cycles

You are made up of matter. So are all living things and non-living things. The matter that makes up all living and non-living things on Earth has been here for several billion years. On occasion, a meteorite or a comet has struck our planet. When this happens, matter from outer space is added to our planet. For the most part, though, all the matter that exists here today has been here for a long, long time.

So where does the matter that living things need come from? Matter continually moves from the abiotic environment (non-living things) to the biotic environment (living things) and back to the abiotic environment. This over-and-over-again movement of matter is referred to as a **cycle**.

There are many cycles of matter in nature. In each of these cycles, matter is used by living things and then returned to the abiotic environment to be used again by living things. The diagrams below and on the next page show two important cycles of matter: the **water cycle** and the **carbon cycle**.

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Raindrops Keep Falling on My Head

Scientists, using high-speed cameras, have discovered that raindrops are not tear-shaped. They actually look like the shape of a small hamburger bun.

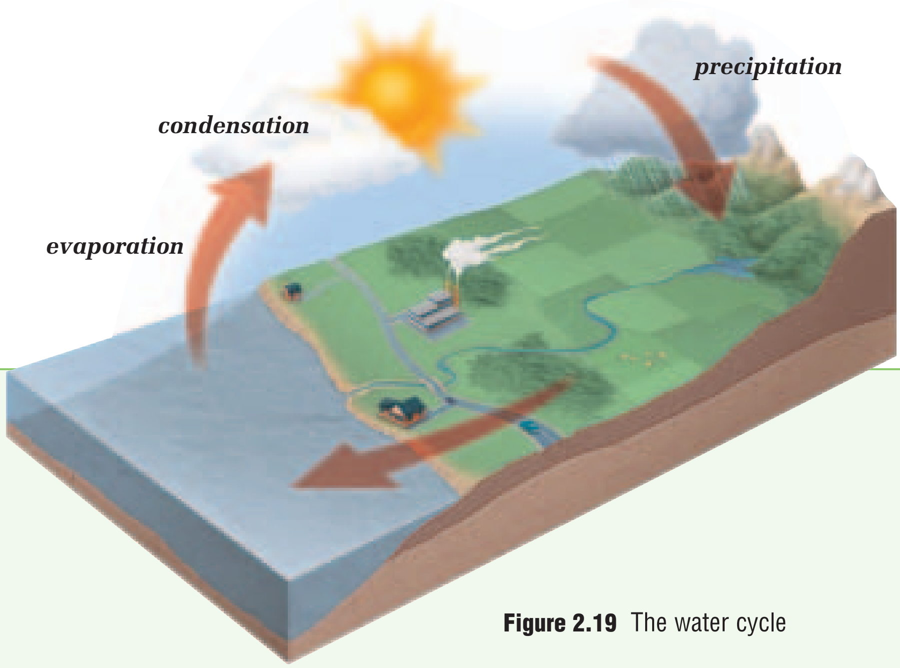

Figure 2.19 The water cycle

Three main processes are responsible for the water cycle: evaporation, condensation, and precipitation.

- According to this diagram, what sources add water vapour to the atmosphere?
- What happens to the water that falls back to Earth?

Heat from the sun causes water in bodies such as oceans, rivers, and lakes to evaporate (change from liquid water to water vapour). Water vapour condenses into clouds. It returns to Earth in the form of precipitation (rain, hail, and snow).

Fuel-burning factories and motor vehicles add water vapour (steam) to the atmosphere. People and other animals drink water. They give off water vapour into the atmosphere whenever they exhale or perspire. Plants take in water from the soil through their roots. They give off water vapour.

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Cycles of Matter

There are cycles of matter for other substances living things need, such as nitrogen, phosphorus, and sulphur. Choose one of these substances to investigate further. Find out why the substance is important for living things and how it is cycled in nature. Present your findings in the form of a diagram similar to the water cycle or carbon cycle diagrams.

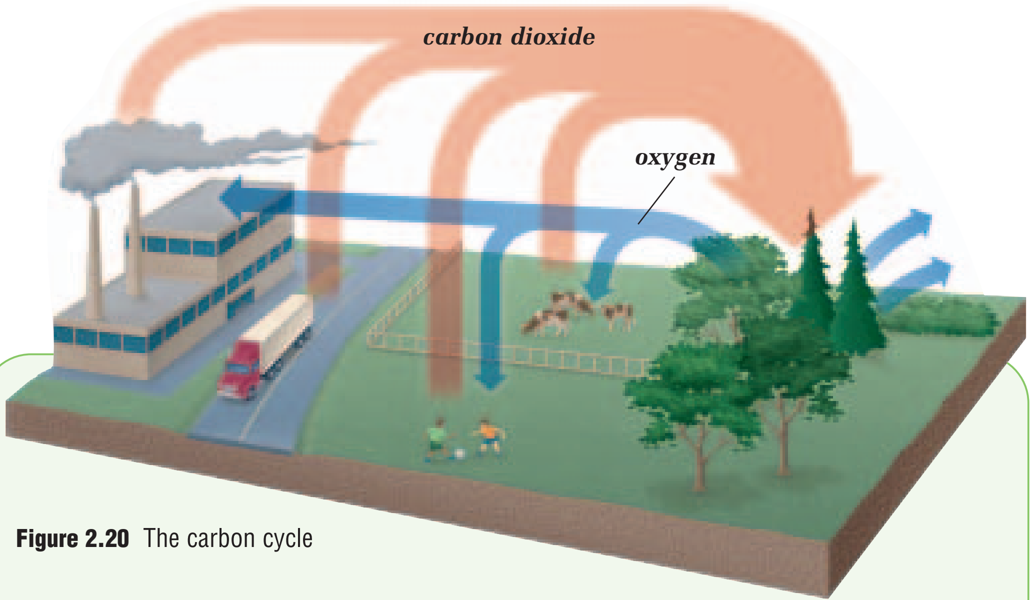


Figure 2.20 The carbon cycle

The carbon substances may, over millions of years, change to become fuels such as coal, oil, and natural gas.

- According to this diagram, what sources add carbon dioxide to the air, water, and soil?
- What happens to the carbon dioxide?

Animals use oxygen in combination with food to release the energy they need to survive. (This is called cellular respiration.) This process gives off carbon dioxide as a by-product. Animals on land add carbon dioxide mainly to air. Animals in bodies of water add carbon dioxide mainly to water. Plants take in carbon dioxide from the atmosphere and water from the soil. Photosynthesis transforms these substances into food and oxygen. Fuel-burning factories and motor vehicles add carbon dioxide to the atmosphere. Decomposers add other forms of carbon to the soil and to water.

Check and Reflect

1. The following statements have to do with the carbon cycle. Put them in order. Hint: Begin with carbon in the form of oil being found underground.
   a) A car fuel tank is filled up with gasoline.
   b) Plants die and are put in a composter.
   c) Driving the car burns the fuel; this creates exhaust gases including carbon dioxide.
   d) Decomposers in a composter add carbon to the soil.
   e) Oil is pumped from the ground and refined into gasoline.
   f) Plants combine carbon dioxide from the air with water to create food and oxygen.
2. Describe the cycle water goes through, from evaporating from a lake to returning to the lake. Your description should include the following words: evaporation, condensation, precipitation, clouds, plants, roots, animals, soil, and cars.

Careers and Profiles

Naturalists—Our Environmental Watchdogs

Do you want to know more about preserving and protecting the natural environment? If so, you can become a naturalist. These are people interested in protecting endangered species, preserving animal habitats, reducing pollutants that affect ecosystems, and other environmental issues. While many naturalists have a background in science, some are just concerned citizens. Here are two examples of people who didn't start out studying science but who had a great influence on the environment.

Figure 2.21 Jack Miner (1865–1944) was a farmer who became one of Canada's first naturalists. He set up bird sanctuaries and did research on bird migration.

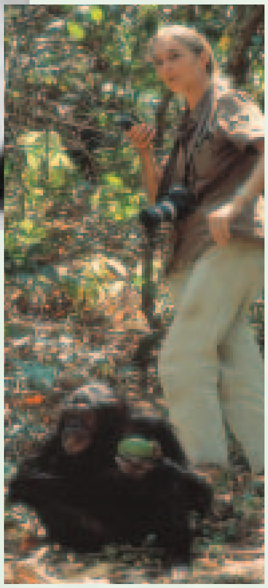


Figure 2.22 Even though Jane Goodall (1934–) has no formal science training, she has become world famous for her research on chimpanzees. She later received a Ph.D. from Cambridge University in England without first having earned an undergraduate degree.

Ethnobotanists

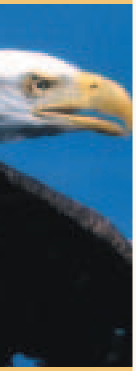
Figure 2.23 The inner bark of the red-osier dogwood shrub is used to heal sores and swellings.

Figure 2.24 Canadian ethnobotanist Nancy Turner works with plant specialists like Mary Thomas, a Shuswap elder.

What do leukemia, high blood pressure, diabetes, multiple sclerosis, and cerebral palsy have in common? They've all been treated with drugs that have originally come from plants. In fact, about one-quarter of today's prescription drugs have been developed from plants.

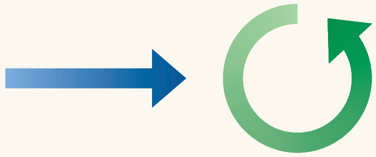
There are probably even more treatments in ecosystems just waiting to be discovered. Unfortunately, finding them is very difficult and costly. That's where an ethnobotanist comes in. Ethnobotanists study Aboriginal cultures to find out how their people use plants. They work closely with plant specialists and elders of Aboriginal communities.

1. Why do ethnobotanists work with Aboriginal peoples? Why do you think this is a good idea?
2. Why is it important to preserve and protect the natural environment?
3. How could you start a naturalist club in your school? What people outside the school would you like to contact to help you get started?



SECTION REVIEW

Assess Your Learning



1. a) Which of the arrows at right describes the path that energy moves in ecosystems?
   b) Which describes the path that matter moves in ecosystems?
   c) Give reasons to explain your answers to a) and b).
2. Figure 2.25 shows a typical food web.

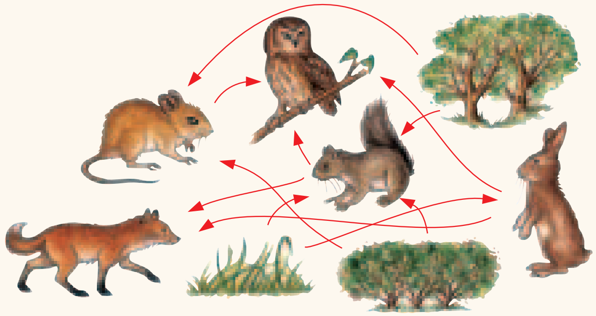
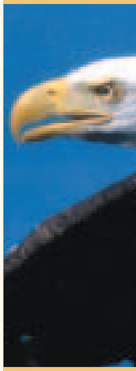


Figure 2.25 Question 2

   a) Name an ecosystem in which you would find a food web like this.
   b) Identify at least three food chains in this food web.
   c) Why does a food web give a more realistic picture of the interactions in an ecosystem?
   d) How is energy supplied to and through this food web?
3. Describe a change in an ecosystem that would affect plants and animals living there. What are the positive and negative effects of this change?
4. What would happen if matter in the abiotic environment wasn't recycled? How do you know?
5. What would happen if an ecosystem's supply of sunlight was removed? How do you know?
6. Compare and contrast two similarities and two differences of carbon and energy in ecosystems.
7. The list below shows typical producers and consumers you would find in a pond ecosystem.

algae	fish	roundworm
bladderwort	fox	spider
bullrush	frog	toad
deer	heron	water flea
dragonfly	mosquito	water horsetail
duckweed	reed sweet grass	water lily
		wolf



a) The list is in alphabetical order. Reorganize it to make two lists: one showing all the producers and the other, all the consumers. (If you aren't sure what some of these living things are, make an inference, or look them up in a reference such as an encyclopedia.)
b) Construct as many food webs as you can using the living things in your lists.
c) Choose two of your food webs. Explain how energy flows through them. How is matter recycled in these food webs?

8. How do you think the number of producers in an ecosystem usually compares with the number of herbivores? (In other words, are there more producers than herbivores, or fewer?) How do you think the number of carnivores compares with the number of herbivores? Give reasons to support your answers.

Focus On SOCIAL AND ENVIRONMENTAL CONTEXT

Consider how science and technology provide opportunities for many diverse careers, hobbies, and interests, and for meeting personal needs. Think about how this relates to the work done in this section and your project at the end of this unit.

1. Why do you think information on energy flows in ecosystems might convince a city to have more parks?

2. What personal needs and environmental concerns should be considered when designing a land use plan?

3. How might understanding the cycling of water and carbon be important in developing a land use plan?

4. What types of careers are related to the water and carbon cycles?

5. Use the following examples to demonstrate how people can affect energy flow and the cycling of matter in an ecosystem:
a) A developer fills in a wetland to build houses.
b) A farmer plows a natural grassland to plant a crop.
c) A town changes the drainage system in an ecosystem to reduce flooding.
d) A logging company cuts down trees over a large area.
e) A city builds roads.

3.0 Changes can be observed and monitored in ecosystems.

Key Concepts

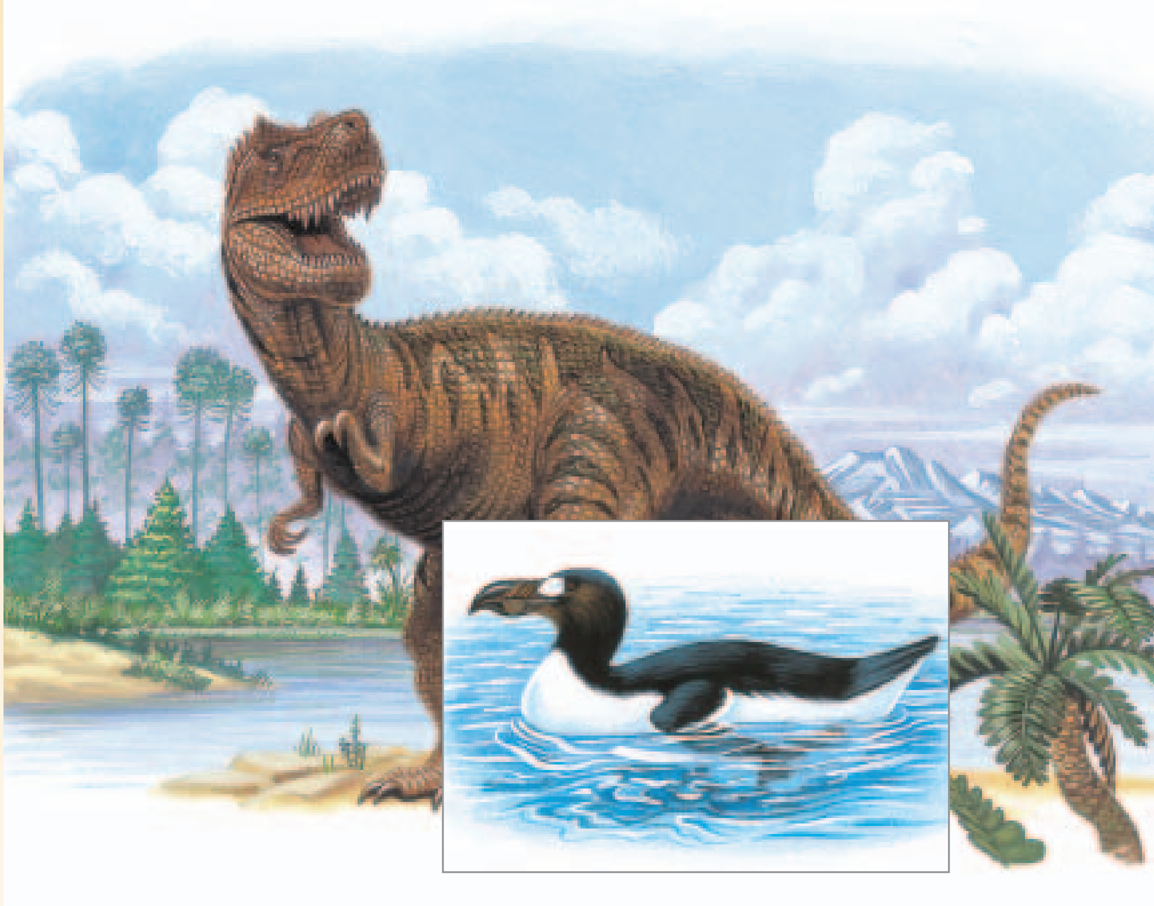
In this section, you will learn about the following key concepts:

- interactions and interdependencies
- environmental monitoring
- environmental impacts
- species distribution
- succession

Learning Outcomes

When you have completed this section, you will be able to:

- recognize the distribution of living things in an environment
- recognize interactions and changes in ecosystems
- identify succession in ecosystems



These two animals once roamed our planet. Now they're both gone. The last *Tyrannosaurus rex* died about 65 million years ago. A dramatic, natural change in its ecosystem may have led to its death. The last great auk died around the year 1844. Its ecosystem changed forever with the arrival of Europeans. Overhunting by humans led to its death. Ecosystems are always changing. Sometimes these changes are natural. Drought or floods can cause massive, long-term changes to ecosystems. Sometimes these changes are the result of human activity. Building dams and clearing forests can cause great, long-term changes to ecosystems. What kinds of changes do you think drought, floods, dams, and forest-clearing cause? How do these changes affect living things? How do you think these changes can be measured and monitored?

For Web links relating to 3.0, visit **www.pearsoned.ca/scienceinaction**