CHAPTER 2

Energy flows and matter cycles in ecosystems.

KEY IDEAS

- The Sun is the source of all the energy in most ecosystems.
- Energy flows through ecosystems.
- A model can be used to show how energy flows through an ecosystem.
- A model can be used to show how the amount of energy that is available to organisms decreases at each level in a food chain.
- Matter cycles within ecosystems.

This orca needs a lot of materials to maintain its large body. Where do the materials that make up its body come from? Where do they go if the orca dies of disease or old age? Such a large animal also needs a great deal of energy for movement. Where does the energy come from? Where does the energy go when the orca dies? How does an ecosystem meet the needs of its many plants and animals? Why do ecosystems not run out of materials and energy?

In this chapter, you will study the flow of energy and the cycling of matter in ecosystems. Some of the things you will study, however, are difficult to observe in nature. As well, it is important not to disturb ecosystems. For these reasons, you will use models to track energy and materials through ecosystems.

Food for All

2.1

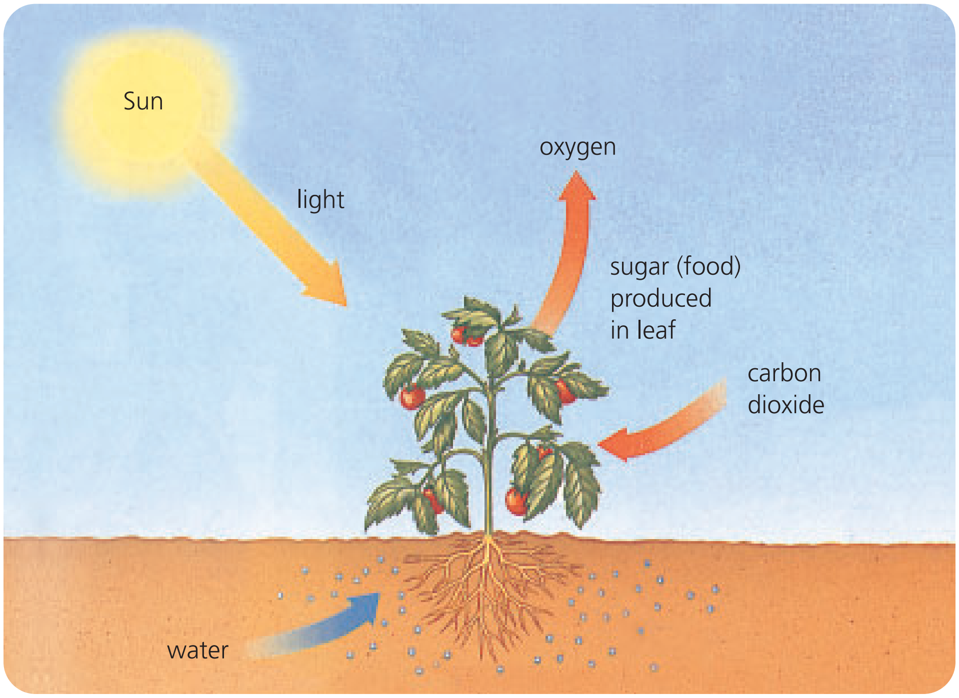
All living things need food. An organism's role in an ecosystem depends on how it obtains its food because this affects how it interacts with other organisms in the ecosystem. The combination of where an organism lives (its habitat), how it obtains its food, and how it interacts with other organisms is called its **niche** [NEESH]. Plants and animals obtain food from their surroundings in two very different ways. Therefore, they have very different roles in an ecosystem.

Producers

Green plants make their own food using materials from the non-living environment. Light energy from the Sun reaches Earth, and plant leaves absorb this energy from the Sun. Along with this energy, plants use water from the soil and carbon dioxide from the air to produce their own food. This process is called **photosynthesis** [foh-toh-SIN-thuh-sis](**Figure 1**). The food that plants produce is sugar and starches. Plants also produce oxygen, which is released into the environment. Humans and other animals breathe the oxygen that is produced by plants.

LEARNING TIP

The process of photosynthesis is described in three ways on this page—in words, in an illustration, and in a chemical equation. Check to make sure you understand how each way matches the others.



carbon dioxide + water $\xrightarrow{\text{photosynthesis}}$ food (sugar) + oxygen

Figure 1
Plants make food through the process of photosynthesis.

LEARNING TIP

Learning what the parts of words mean can help you remember their meanings. *Vore* means "to eat," *herbi* means "plants," *carne* means "meat," *omni* means "all," and *detritus* means "waste" in Latin.

Organisms that can make their own food from non-living materials are called **producers** (**Figure 2**). Producers include plants on land and in water.

Figure 2
This tree and this kelp are both producers.

Consumers

Animals cannot carry out photosynthesis. They must get their food from the living environment by eating, or consuming, other organisms. This is why animals are called **consumers.**

Consumers that eat plants are called **herbivores** (**Figure 3(a)** and **(b)**). Consumers that eat other animals are called **carnivores** (**Figure 4(a)** and **(b)**). Consumers that eat both plants and animals are called **omnivores** (**Figure 5(a)** and **(b)**).

Figure 3(a)
Deer are herbivores that feed on producers, such as grass and other plants, on land.

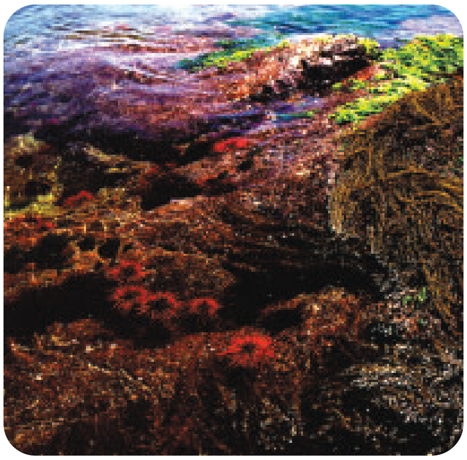


Figure 3(b)
Sea urchins are marine herbivores that feed on marine producers called kelp.

Figure 4(a)
A wolf is an example of a carnivore in a land ecosystem.

Figure 4(b)
An orca is an example of a carnivore in an ocean ecosystem. Why do you think orcas are sometimes called the "wolves of the sea" in Aboriginal legends?

Figure 5(a)
British Columbia's provincial bird, the Steller's jay, is an omnivore that eats insects, eggs, nuts, and seeds.

Figure 5(b)
The bat (or webbed) star is a marine omnivore that eats other sea stars, as well as worms and algae.

Detrivores and Decomposers

Not all plants and animals die because they are eaten. Some just die when their life span is over. Dead plants and animals become food. Organisms that feed on large bits of dead and decaying plant and animal matter are called **detrivores** (Figure 6). Crabs and some sea birds are the detrivores in ocean ecosystems. Earthworms, dung beetles, and wolverines are three examples of detrivores in land ecosystems.

Figure 6
Earthworms are common detrivores in land ecosystems, and crabs are common detrivores in ocean ecosystems.

Even detrivores, however, leave behind some waste materials: parts of the dead plant and animal matter and their own waste. Bacteria and fungi break down these waste materials. Organisms that get their food energy by breaking down the final remains of living things are called **decomposers.** Fruit rotting on the ground, a sandwich moulding in the bottom of a locker, and a shrinking pile of seaweed on the beach are all examples of decomposers at work (**Figure 7**).

Figure 7
Decomposers at work in an ecosystem

CHECK YOUR UNDERSTANDING

1. Explain how producers and decomposers link the living and non-living parts of ecosystems.
2. In this section, you learned about six categories of organisms: producers, herbivores, carnivores, omnivores, detrivores, and decomposers. Describe how the organisms in each category obtain food from their environment.
3. In your notebook, make a chart like the one below. List examples of organisms in each category that live on land and in the oceans.

3.

	Land	Oceans
producers	tree	
herbivores		
carnivores		
omnivores		Bat Star
detrivores		
decomposers		

4. What type of consumer are you? Are all people the same type of consumer?

Food Chains and Food Webs

2.2

Energy flows through ecosystems. When a herbivore eats a plant, the food energy that is stored in the plant passes into the herbivore's body. When the herbivore is eaten by another consumer, the food energy that is stored in the herbivore's body passes into that consumer's body. A model that shows how food energy passes from one organism to another in a feeding pathway is called a **food chain** (**Figure 1**). Each organism in a food chain depends on the organism before it in the chain for its food energy.

LEARNING TIP

Flow charts like the ones in **Figure 1** are used to show a sequence of steps or a timeline. Where else have you seen flow charts used?

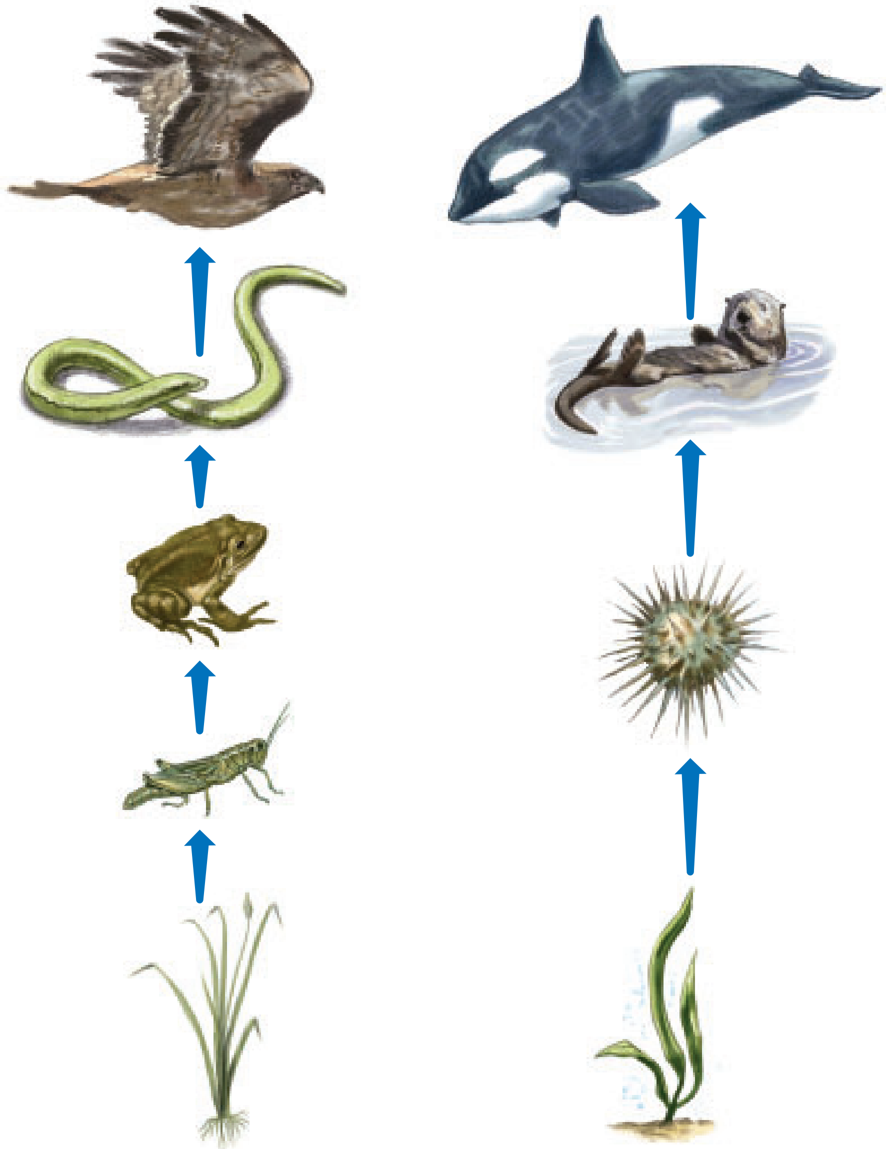


Figure 1
The flow of energy through two different food chains: The arrows show the direction of the energy flow. What is the original source of energy for each food chain?

TRY THIS: DRAW A LUNCH FOOD CHAIN

Skills Focus: classifying, inferring

1. Write down everything that you had for lunch, either yesterday or today.
2. List all the organisms that were required to produce your lunch. For example, a sandwich may require wheat and yeast for the bread, and meat or cheese for the filling. Did your lunch include products from both plants and animals?
3. Choose several items from your lunch. Draw a food chain for each item, with you at the top in each case. Which is the longest food chain?

Consumers do not usually rely on only one source of food. For example, a coyote eats rabbits, but it will also eat mice, grouse and their eggs, and many other animals. The mice that the coyote eats consume the seeds, inner bark, and shoots of many different plants. Thus, most organisms are part of several food chains. A model that shows several different food chains, and the connections between them, is called a **food web** (**Figures 2** and **3**).

LEARNING TIP

Evaluate the food web in **Figure 2** by comparing it to what you have learned about the Khutzeymateen Valley. Do you think that all of the organisms in the valley have been shown?

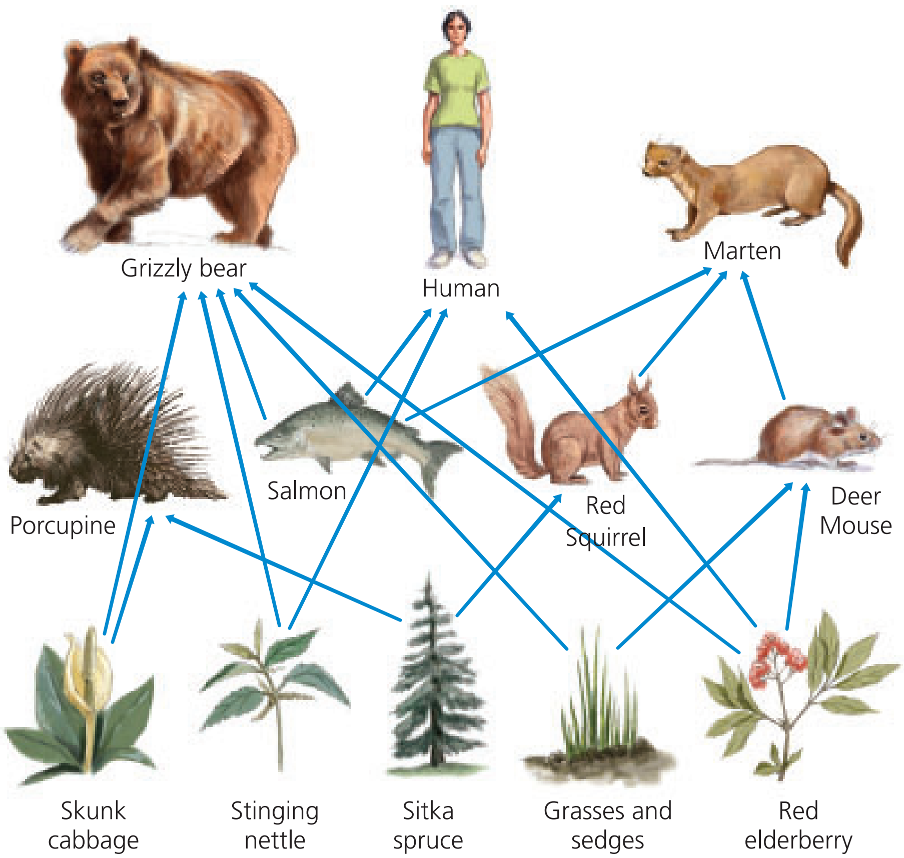


Figure 2

This food web shows some of the organisms in the Khutzeymateen Valley ecosystem. It is made up of many food chains.

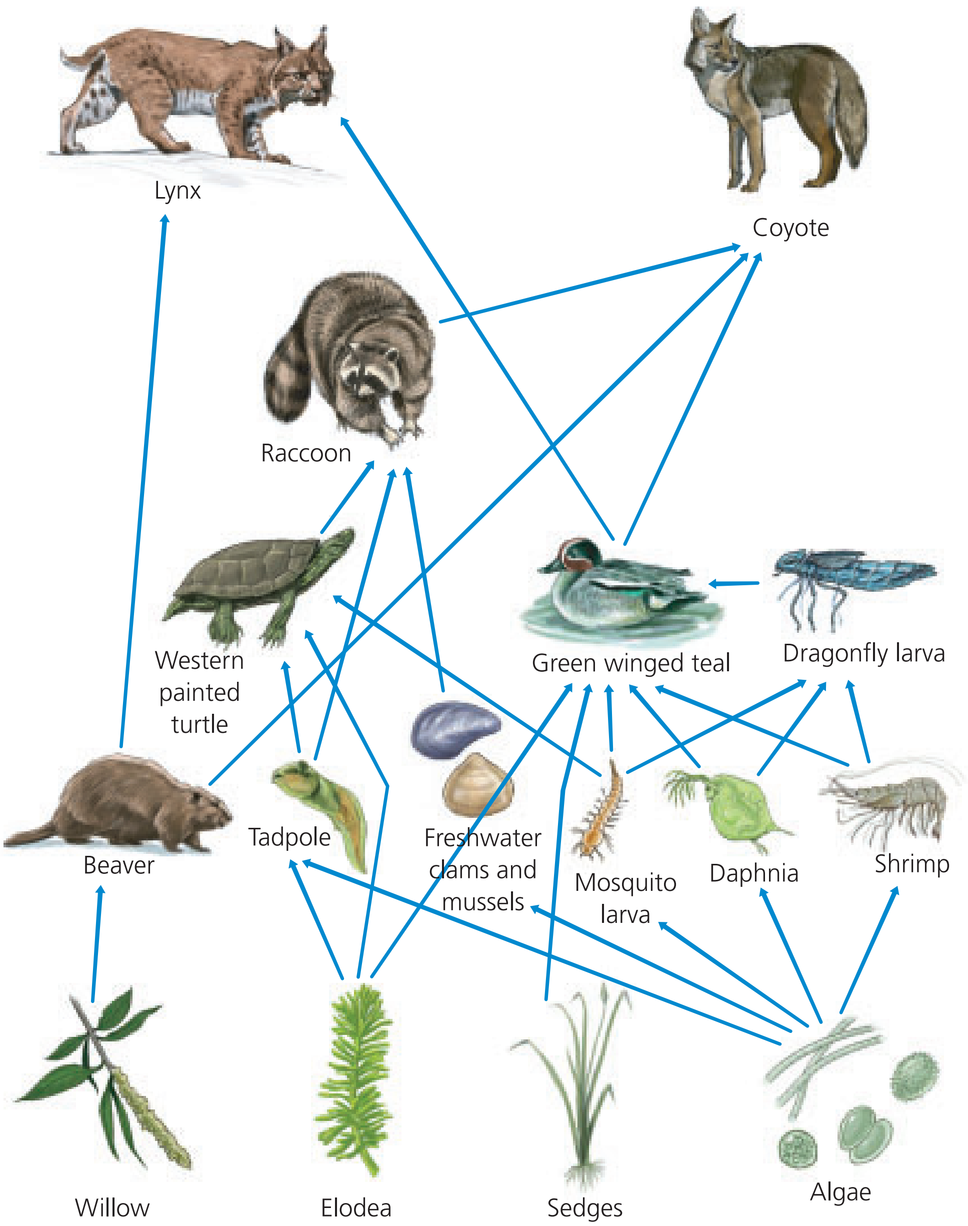


Figure 3

This food web shows some of the organisms in a pond.

Food chains and food webs show who eats whom. They also show how energy flows through ecosystems from producers to consumers to detrivores to decomposers.

CHECK YOUR UNDERSTANDING

1. What type of living thing does a food chain always begin with? Why?
2. Draw a food chain that ends with a pet.
3. How are food chains related to a food web?

2.3 Conduct an Investigation

SKILLS MENU

○ Questioning	○ Observing
○ Predicting	○ Measuring
○ Hypothesizing	● Classifying
○ Designing Experiments	● Inferring
○ Controlling Variables	● Interpreting Data
● Creating Models	○ Communicating

Modelling a Food Web

In this investigation, you will link a variety of different organisms in a food web.

Question

What are the links between producers, consumers, detrivores, and decomposers?

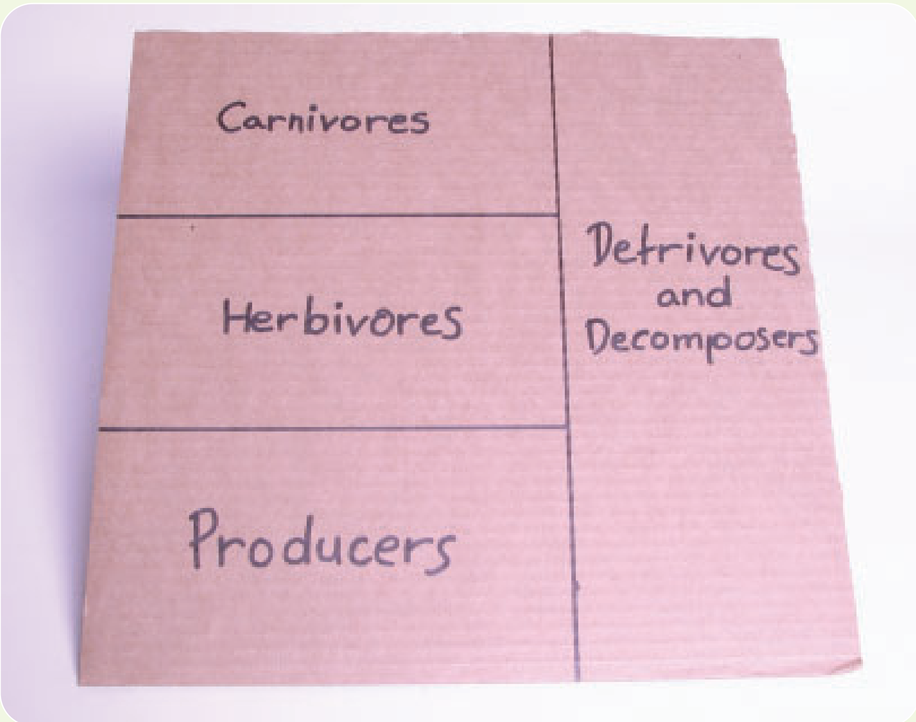
Materials

- square or rectangular piece of corrugated cardboard, at least 30 cm by 30 cm
- pen
- paper
- pushpins
- thread or string
- scissors

Be careful with sharp objects such as pushpins and scissors.

Procedure

1 Divide and label your cardboard as shown below.



2 Choose one of the following three ecosystems:

Ecosystem in a Decaying Log

Organism	What it needs for food
decaying fallen tree	none now; used sunlight to make its own food when alive
mosses	sunlight to make their own food
ferns	sunlight to make their own food
beetles	decaying wood
fungi and bacteria	decaying wood, dead plants and animals, and animal waste
truffles	decaying wood
termites	decaying wood
mites	decaying wood
carpenter ants	decaying wood
spiders	termites, mites, and carpenter ants
newts	termites, mites, carpenter ants, and spiders
winter wrens	termites, mites, carpenter ants, and spiders
martens	voles, chipmunks, and birds' eggs
voles	moss, termites, carpenter ants, spiders, and truffles
chipmunks	young leaves and shoots of ferns; termites, carpenter ants, and truffles
owls	winter wrens, voles, and chipmunks

West Coast Ocean Ecosystem

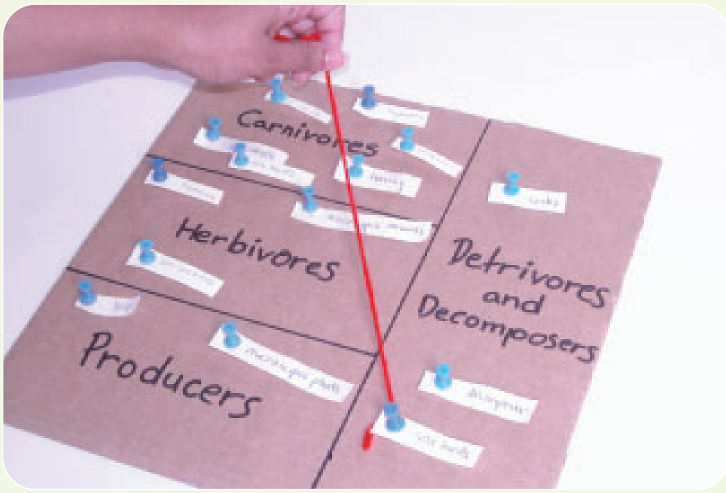
Organism	What it needs for food
microscopic plants	sunlight to make their own food
kelp	sunlight to make its own food
microscopic animals	microscopic plants
sea urchins	kelp
herring	microscopic animals
salmon	herring
sea otters	sea urchins
seals	herring and salmon
humans	herring, sea urchins, salmon, crabs, and kelp
orcas	seals, sea otters, and sea birds
sea birds	herring and dead animals
crabs	dead animals
decomposers	dead plants and animals

Antelope Brush Ecosystem in the South Okanagan

Organism	What it needs for food
antelope brush	sunlight to make its own food
needle and thread grass	sunlight to make its own food
Behr's hairstreak butterflies	antelope brush for larvae (caterpillars)
mule deer	grass seeds and antelope brush leaves and twigs
Great Basin pocket mice	grasses and seeds from antelope brush
burrowing owls	Great Basin pocket mice, scarab beetles, and grasshoppers
Northern Pacific rattlesnakes	Great Basin pocket mice and ground nesting birds (western meadowlarks)
scarab beetles	animal waste and decaying plants and animals
western meadowlarks	beetles, caterpillars, and grasshoppers
prairie falcons	burrowing owls and western meadowlarks
grasshoppers	grasses and leafy plants
humans	mule deer
cougars	mule deer

3 Decide whether each organism is a producer, herbivore, carnivore, detrivore, or decomposer. Put a pushpin in the section where your organism belongs. If it fits in two sections, for example, if it is an omnivore, use two pushpins. Label the pushpin by writing the name of the organism on the cardboard beside it or by attaching a "flag" to the pushpin.

4 Use the thread or string to connect each organism to the organisms it feeds on. Wrap the thread or string around the pushpin a couple of times so that it does not fall off.



Analyze and Evaluate

1. Your food chains all begin with producers. Where do the producers obtain their food?
2. Describe the effect on other organisms in your food web if you remove
   - one of the producers
   - one of the herbivores
   - one of the carnivores

Apply and Extend

3. A farmer or gardener uses a toxic spray against insect pests. A few weeks later, a large quantity of the insecticide is found inside the body of a dead hawk that hunted in the area (**Figure 1**). Explain, using a diagram, how the insecticide might have found its way into the hawk's body.

Figure 1
The number of Swainson's hawks is declining because of the use of pesticides in Argentina, where it winters.

CHECK YOUR UNDERSTANDING

1. Models are used to explain scientific concepts. What concept did your food web explain?
2. Models provide an opportunity to show what may happen in a situation that you cannot easily observe. How did your food web provide an opportunity for you to observe something that you would not normally have an opportunity to observe?
3. Any model has limitations. What limitations did your food web have?

LEARNING TIP

For further information on creating and using models, see "Creating Models" in the Skills Handbook.

Hydrothermal Vents

In 1977, scientists were exploring the ocean in a submersible called *Alvin* when they found a deep-sea hot spring, or hydrothermal vent.

The vent was 2.5 km below the surface of the ocean. The scientists were not surprised to find the vent since they had predicted that vents existed. They were very surprised, however, to find it surrounded by large numbers of strange animals, most of which had never been seen before. Since then, hydrothermal vents have been discovered in many parts of the ocean, including west of Vancouver Island, British Columbia.

Sunlight cannot reach the deep parts of the ocean, where hydrothermal vents have been discovered. Therefore, no plants can photosynthesize. But if there are no plants, what are the producers in these deep-sea ecosystems?

Scientists have discovered that the producers at hydrothermal vents are bacteria. These bacteria can make food from chemicals that are released at the vents. The process of making food from chemicals is called chemosynthesis. Animals, such as limpets and mussels, consume the chemosynthetic bacteria. Predators, such as octopuses and vent crabs, prey on the limpets and mussels. The vent crabs also serve as detrivores, making a complete food web based on the chemosynthetic bacteria.

The most fascinating creatures that are found at the vents are tubeworms (**Figure 1**). Adult tubeworms have no mouths or stomachs. They survive because the chemosynthetic bacteria live inside them.

Figure 1
The ecosystem at this hydrothermal vent is based on producers that use chemicals, rather than light, to make food.

Energy Flow through Ecosystems

2.4

As energy flows through ecosystems, from producers to consumers to detrivores to decomposers, some energy is lost at each level.

The Sun is life's main energy supply. Using energy from the Sun, plants make their own food through the process of photosynthesis. Plants need to use most of the energy from the food they make for everyday life processes, such as growing and producing flowers and seeds. On average, only about one-tenth ($\frac{1}{10}$ or 10%) of a plant's food energy gets stored as nutrients in the roots, leaves, and other parts of the plant. So, when a plant is eaten by a consumer, such as a deer, only one-tenth of its energy is available to the consumer.

Similarly, the deer uses most of the energy from its food (the plant) to support its everyday life functions, such as breathing, moving, and chewing. Energy is also is given off as body heat. Consequently, when the deer is eaten by a consumer, such as a cougar, only about one-tenth of its energy is available to the consumer. Thus, very little energy is passed on from one organism to the next in a food chain (**Figure 1**).

LEARNING TIP

Try to make a mental picture of how energy enters and leaves your own body.

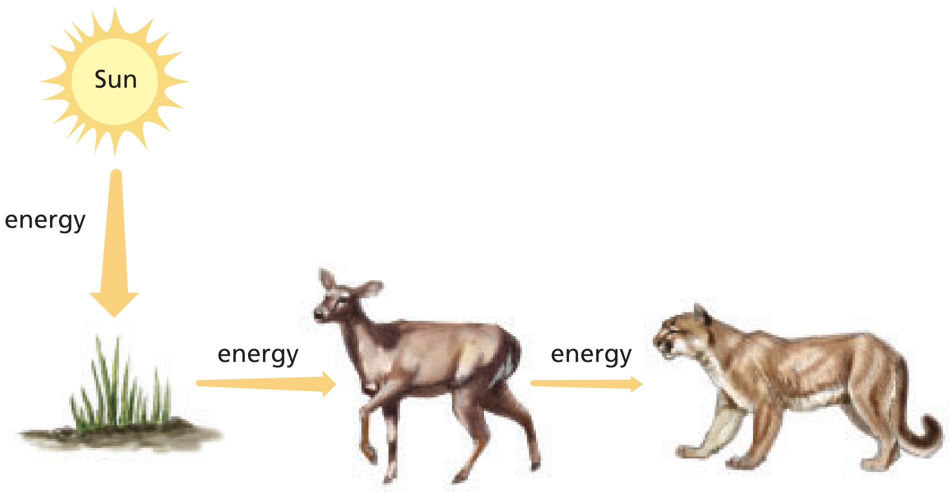


Figure 1
Energy flow through an ecosystem

TRY THIS: MODEL ENERGY LOSS

Skills Focus: creating models

1. Form groups of three and assign the following roles: producer, herbivore, and carnivore.
2. The producer takes ten sheets of paper from the recycling box and spreads them out in a row on the table. This represents the amount of energy from the Sun that the producer has stored as food.
3. The herbivore takes one-tenth of the producer's energy (one piece of paper) from the producer and puts it on the table above the producer's papers.
4. The carnivore takes one-tenth of the herbivore's energy by tearing off one-tenth (a 2-cm strip) of the herbivore's paper and putting it on the table above the herbivore's paper.
5. As a group, calculate the percentage of the energy in the producer that was transferred to
   a) the herbivore
   b) the carnivore

The model you made to show energy loss in a food chain is called an **ecological pyramid** (**Figure 2**).

LEARNING TIP

As you study **Figure 2**, ask yourself, "What is the purpose of this model? What do scientists use it to illustrate? What am I supposed to notice and remember?"

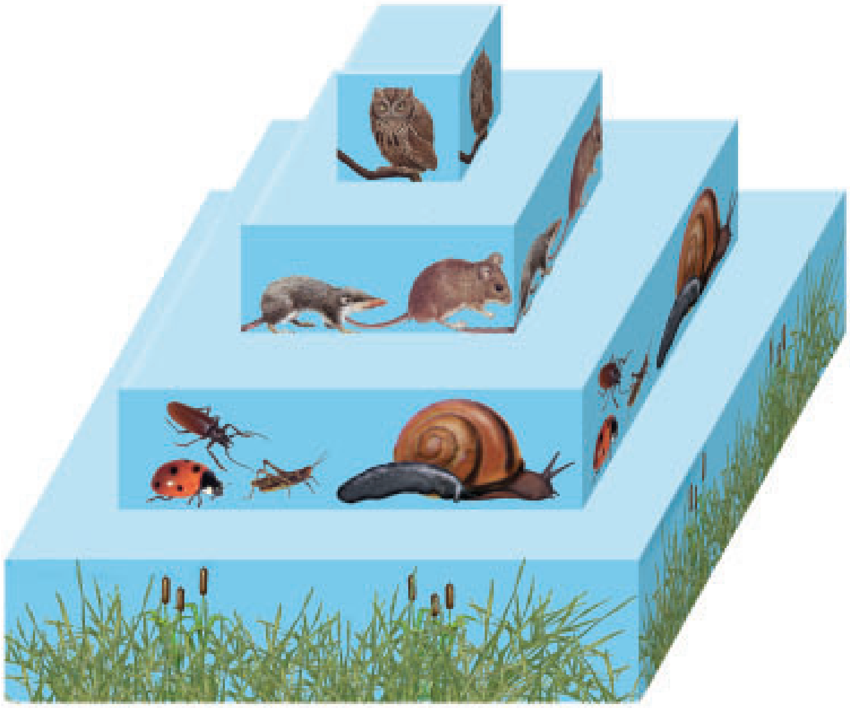


Figure 2

The base of the pyramid holds producers (plants). At each level above the producers, the amount of available energy is reduced. This explains why, in an ecosystem, you might find a huge number of insects to eat the plants, a much smaller number of shrews to eat the insects, and only a very few owls to eat the shrews.

Each level of an ecological pyramid matches a level of producers or consumers in a food chain. At each level, the amount of available energy is less than the amount of available energy in the level below. Usually the number of organisms also decreases at each higher level of the pyramid (**Figure 3**).

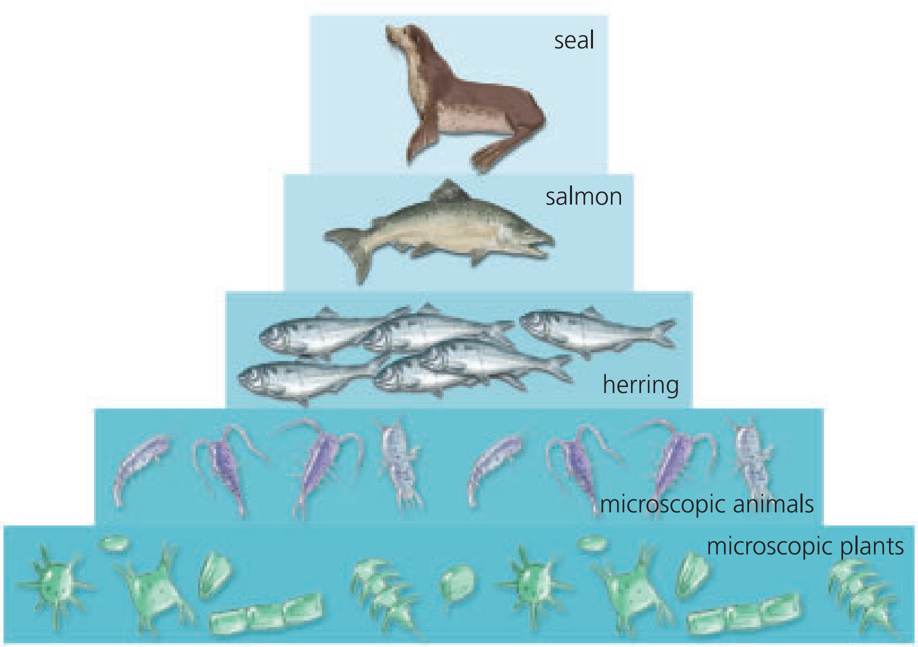


Figure 3

An ecological pyramid in an ocean ecosystem.

LEARNING TIP

Check your understanding of ecological pyramids by comparing **Figures 2** and **3**. How are they the same? How are they different?

CHECK YOUR UNDERSTANDING

1. Why is some energy lost at each level in a food chain?
2. Using your own words, describe why there are usually fewer large carnivores than herbivores or producers in an ecosystem?

2.5 The Role of Decomposers in Recycling Matter

LEARNING TIP

Make connections to your prior knowledge. What do you already know about decomposers?

Earth is often compared to a spaceship (**Figure 1**). It has been launched, and nothing more can be added to it. Because a spaceship is closed, air and water must be recycled or the astronauts will die. The same is true on Earth. Life depends on the recycling of matter. How does this recycling occur? How much do we depend on the recycling of matter? What is the role of living things in the recycling of matter?

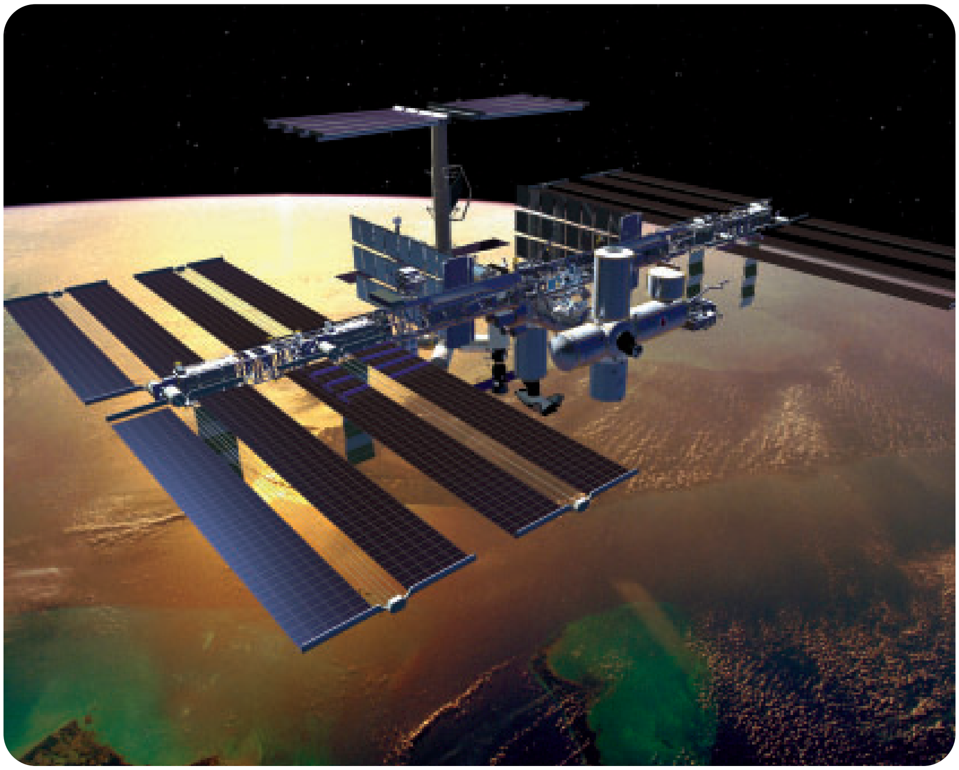


Figure 1
Life on this spaceship depends on careful recycling of matter, as does life on Earth.

Food chains and food webs show how matter and energy are moved from one organism to another. We often forget, however, about a very important part of this cycle: the decomposers (**Figure 2**). As decomposers break down their food, they use the last of the energy in the food chain. They also release nutrients. Nutrients are chemical substances that organisms need to grow and survive. Nutrients are released into the soil, water, or air. They can be taken up by plants and used again to help the plants grow. Decomposers keep matter moving between the living and non-living parts of an ecosystem.

Figure 2
These bracket fungi are decomposers.

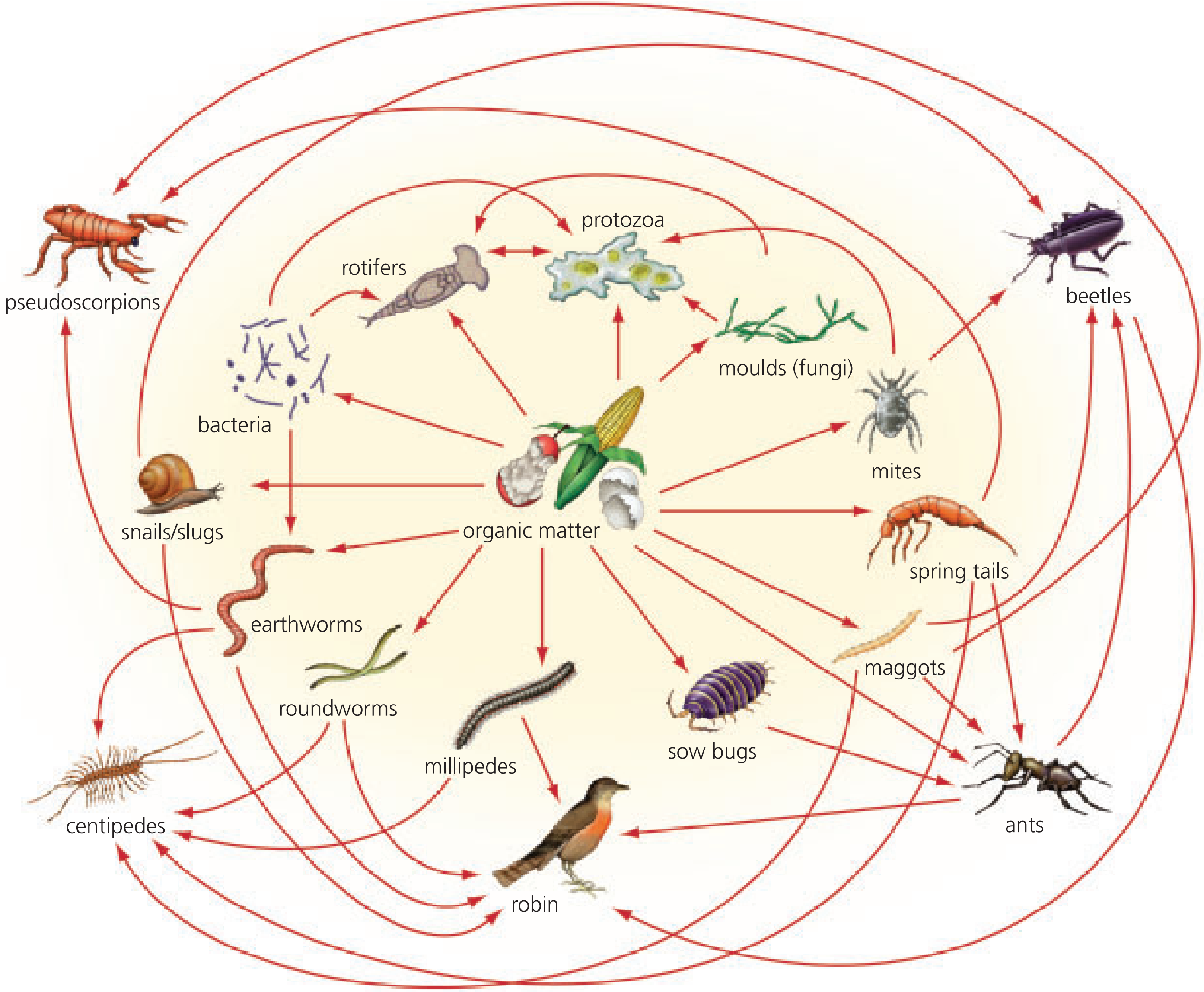
The importance of decomposers in an ecosystem should not be underestimated based on their small size. Imagine what your schoolyard would look like with years of accumulated leaves and grass clippings still in their original forms. Without decomposers, nutrients would remain locked in the tissues of dead plants and animals. Decomposers break down matter and turn it into the nutrients that living things need every day (**Figure 3**).

Figure 3
Moulds and bacteria spoil food, but by doing so they recycle nutrients within the ecosystem.

Composting

If you compost your kitchen scraps or plant waste, you are relying on the work of decomposers to break down the waste and release the nutrients it contains. In a compost ecosystem (**Figure 4**), small detrivores, such as earthworms, mites, grubs, insects, and nematodes (microscopic worms), chew, digest, and mix the waste. As detrivores mix the waste, air is added to the compost mixture. Decomposers, such as bacteria and fungi (moulds), then help to break down the waste further. This makes the nutrients available to plants when you put the compost on a garden. Putting compost on a garden is like giving the soil a giant vitamin pill.

Figure 4
A food web of a compost heap



Dying Salmon

Salmon return from the ocean to their home stream to reproduce and die (**Figure 5**). Some onlookers are sad to see the masses of dying fish. The death of the salmon, however, helps to ensure the survival of the species. First detrivores (such as gulls, eagles, and bears) take their share of the dying and dead salmon. Then bacteria and fungi finish decomposing the salmon and turn the tissue into a liquid. This allows the nutrients from the salmon to be dissolved in the stream. In the spring, the nutrients in the stream help to nourish plankton, an important part of the salmon fry's food chain. If you visit a salmon stream in the spring, you will no longer find piles of rotting salmon, thanks, in part, to these decomposers.

LEARNING TIP

Close your eyes and try to "see" the process of the nutrients from the salmon being returned to the ecosystem.

Figure 5
Spawning sockeye salmon in the Adams River

The nutrients from the decomposing salmon are not only used by the next generation of salmon. The nutrients also fertilize the forest. Scientists believe that some forests have high levels of nutrients in the soil because of dead salmon, deposited there by feeding bears and wolves. Bears and wolves don't eat the whole salmon. The rest is left to be consumed by crows and other detrivores, and by decomposers. The nutrients that are released by the decomposers fertilize trees and other plants in the forest. Many of these nutrients entered the bodies of the salmon while they lived in the open ocean. The migration of the salmon moves these nutrients from ocean to forest, linking ecosystems that are thousands of kilometres apart.

CHECK YOUR UNDERSTANDING

1. Explain how decomposers link the living and non-living parts of an ecosystem.
2. What would happen if there were no decomposers in an ecosystem?

2.6 Conduct an Investigation

SKILLS MENU

○ Questioning	● Observing
○ Predicting	○ Measuring
○ Hypothesizing	○ Classifying
○ Designing Experiments	● Inferring
○ Controlling Variables	● Interpreting Data
○ Creating Models	● Communicating

Composting

Decomposers are a very important part of any ecosystem. They reduce matter and make nutrients available to the soil. In this investigation, you will observe decomposers at work on dead plant materials.

Question

How long does it take decomposers to break down dead plant materials?

Materials

- apron or old oversized T-shirt
- bottom half of clear plastic pop bottle
- garden waste (such as dead leaves, grass, pine needles, or straw)
- raw vegetable and fruit peels and scraps, cut into small pieces
- soil
- water in a spray bottle
- paper or screening
- rubber band
- tape
- black marker
- stick for stirring

Some students have serious allergies to some decomposers. Minimize the time your compost is uncovered. Do not breathe the air over your set up.

Procedure

1 Put on your apron or old T-shirt.

2 In the bottom of the plastic bottle, put a 5-cm layer of garden waste, then a 5-cm layer of fruit and vegetable scraps, then a 5-cm layer of soil. Add more layers in the same order until the bottle is almost full (**Figure 1**). Decomposers work more quickly when they have a variety of "food." Dry and brown materials, such as dead leaves and pine needles, provide some nutrients. Green and wet materials, such as vegetable scraps, supply other nutrients. Do not add meat, bones, grains, pasta, dairy products, or fatty foods to your compost. If you do, it will get very smelly and may attract rodents.

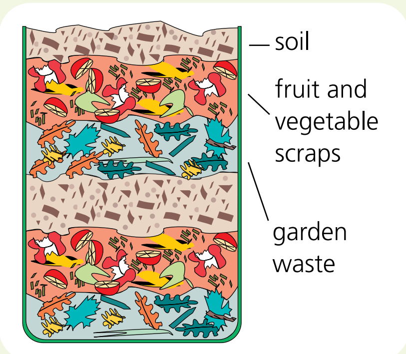
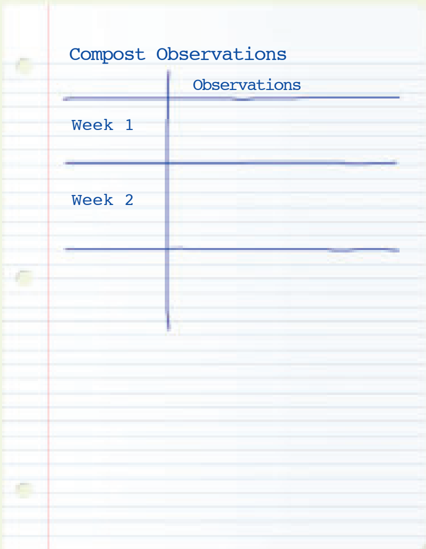


Figure 1
Composting in a plastic bottle

3 Add enough water to make the mixture damp but not wet. To keep out flies, make a cover from paper or screening, and a rubber band. Using the tape and black marker, label the bottle with your name. Put the bottle in a warm place for one week.

4 In your notebook, make a table like the one below.



5 After a week, stir the mixture in the bottle and examine the materials. In your notebook, record how the materials look and smell. (Remember not to put your nose directly over the bottle.) If a camera is available, take a photo to help you accurately record the changes over time.

6 Make sure that the mixture is still damp. If necessary, add a small amount of water. Put the bottle in the warm place again. Wash your hands well.

7 Repeat steps 4 to 6 each week, until you can see changes occurring.

8 Describe the materials in the bottle after four weeks.

9 When you have finished your investigation, ask your teacher where you should add your compost to the soil.

Analyze and Evaluate

1. How long did it take for the dead plant materials to start decomposing? How long did it take for them to seem completely decomposed?
2. You make many inferences every day. For example, when you see your physical education teacher getting out soccer balls, you infer that you will be learning ball skills. Make an inference about this composting investigation, using the following questions to help you:
   - Did you put decomposers in the bottle?
   - How do you think the decomposers got in the bottle?
3. What kinds of decomposers do you think were in your bottle?

LEARNING TIP

For help with inferring, see the Skills Handbook section "Inferring."

Apply and Extend

4. What are the advantages of backyard composters, for both homeowners and the community (**Figure 2**)?

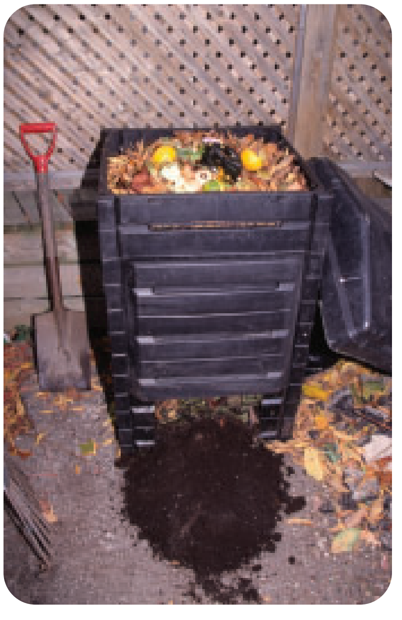


Figure 2
Decomposers are turning kitchen waste into soil in this backyard composter.

CHECK YOUR UNDERSTANDING

1. Why is it important to read and follow the procedure in an investigation carefully?
2. During this investigation, you made and recorded observations weekly, using your senses. Explain why it is important to include qualitative data, such as your observations, rather than just stating that changes have or have not occurred.

Dollars from Decomposers

Wastewater is usually treated with chemicals so we can use it again. In this section you will learn how scientists are treating wastewater naturally, and making money too.

It's true! There is money in sewage! Tiny organisms at one of the wastewater treatment plants at the University of British Columbia (UBC) are making money every day. The treatment plant uses naturally occurring bacteria, instead of chemicals, to decompose waste and clean the wastewater. This means that money is not needed to buy chemicals for treatment, nor to dispose of chemical sludge at the end of the process. The bacteria also help to make a saleable product. By controlling certain environmental conditions, such as available oxygen, the bacteria will remove specific particles, such as nitrogen and phosphorus, from the sewage. The removed nitrogen and phosphorus can be processed to make fertilizers, such as those that are sold in garden centres. The UBC treatment plant can thus make money by selling these fertilizers (**Figure 1**).

Many cities and towns in the Prairie provinces are using this method to treat their wastewater. As well, Kelowna, Summerland, and Salmon Arm in British Columbia are using this method. Most of the treatment plants are not yet set up, however, for processing the nutrient sludge to make fertilizers. The communities are using this method because it is less costly for both taxpayers and the environment.

Figure 1
Professor Don Mavinic (left) and Fred Koch (right) with phosphorus fertilizer made from nutrient sludge.

2.7 The Water and Carbon Cycles

Plants constantly trap new energy from the Sun. This new energy replaces the energy that was lost as heat in every level of the food chain. In this way, energy is constantly being added to ecosystems. Although new energy continues to arrive from the Sun, no new water arrives. The water that is on Earth now is the same water that was here when the dinosaurs lived. It has been reused and recycled many, many times.

The Water Cycle

Anything that happens over and over again, like the seasons of the year or the phases of the moon, is called a cycle. Water moves through a **cycle** (Figure 1).

LEARNING TIP

Follow the arrows on the diagram as you read about the water cycle. Check your understanding by using the diagram to explain the water cycle to a partner.

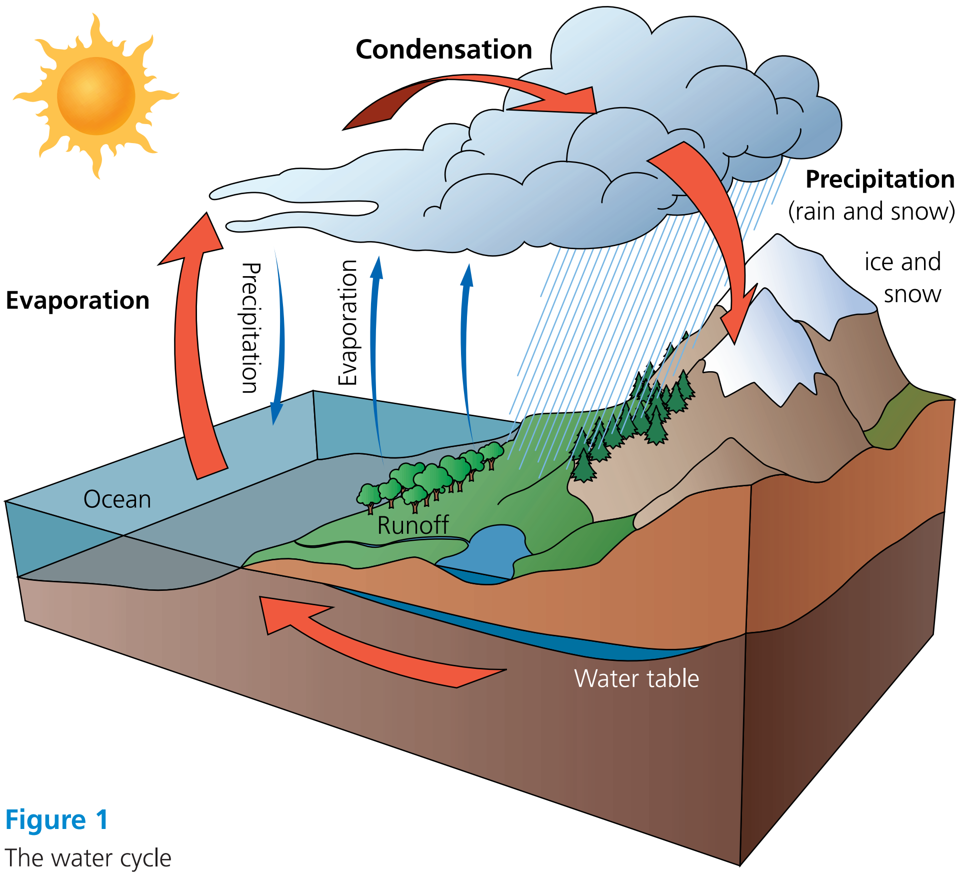


Figure 1
The water cycle

Energy from the Sun warms Earth's surface and causes water to evaporate from oceans and lakes. Water turns into water vapour when it evaporates, and the water vapour enters the atmosphere. In the atmosphere, the water vapour cools and changes back to liquid water in the form of clouds (condensation). The water then returns to the surface of Earth as rain or snow (precipitation). Some rain and melting snow sinks into the ground. This groundwater seeps down through the rocks and soil to the water table. It may remain underground for many years, but eventually returns to the ocean. Some rain and melting snow runs off into rivers. The rivers flow into lakes and oceans, where the cycle begins again.

Water cycles through the living parts of ecosystems as well as through the non-living parts. Animals drink water, which later leaves their bodies as urine or sweat. Plants take up water from the soil with their roots. Much of the evaporation of water in land ecosystems occurs from the leaves of plants (**Figure 2**).

LEARNING TIP

Work with a partner. Read aloud the two paragraphs about the water cycle while your partner follows the explanation on **Figure 1** with his or her finger. Then, switch roles.

Figure 2
The many leaves in this British Columbia coastal rain forest return a large amount of water to the atmosphere.

How much water goes from plants into the atmosphere? Do all types of leaves lose water at the same rate? To find out the answers to these questions, try the activity on the next page.

Water does not stay in the atmosphere or the bodies of plants and animals very long. On the other hand, water can spend thousands of years in the deepest parts of oceans and trapped in glaciers.

LEARNING TIP

For help with hypothesizing, see the Skills Handbook section "Hypothesizing."

TRY THIS: OBSERVE WATER LOSS FROM LEAVES

Skills Focus: observing, measuring, hypothesizing

Find a tree with large leaves. Put a small plastic bag around one of the leaves (**Figure 3**). Use a twist tie to gently close the bag. Put another bag over a small branch of a tree with needles (**Figure 4**). Leave the bags on the trees overnight. The next day, carefully pour the water from each bag into a graduated cylinder and measure it. Which type of leaf lost the most water? Create a hypothesis to explain the difference.

Figure 3

Figure 4

The Carbon Cycle

Just as no new water arrives on Earth, no new carbon arrives. Carbon is found in many parts of our world. For example, it is found in the chemicals that make up rocks. It is found underground in coal, oil, and natural gas. It is also found in the air in the form of carbon dioxide. Plants use carbon dioxide to photosynthesize and produce food. When animals break down this food to produce energy, they produce water and carbon dioxide as well, which plants can then use. All living things contain carbon. Decomposers that break down dead plants and animals return the carbon to the non-living parts of ecosystems. The carbon cycle (**Figure 5**) illustrates how carbon moves throughout ecosystems.

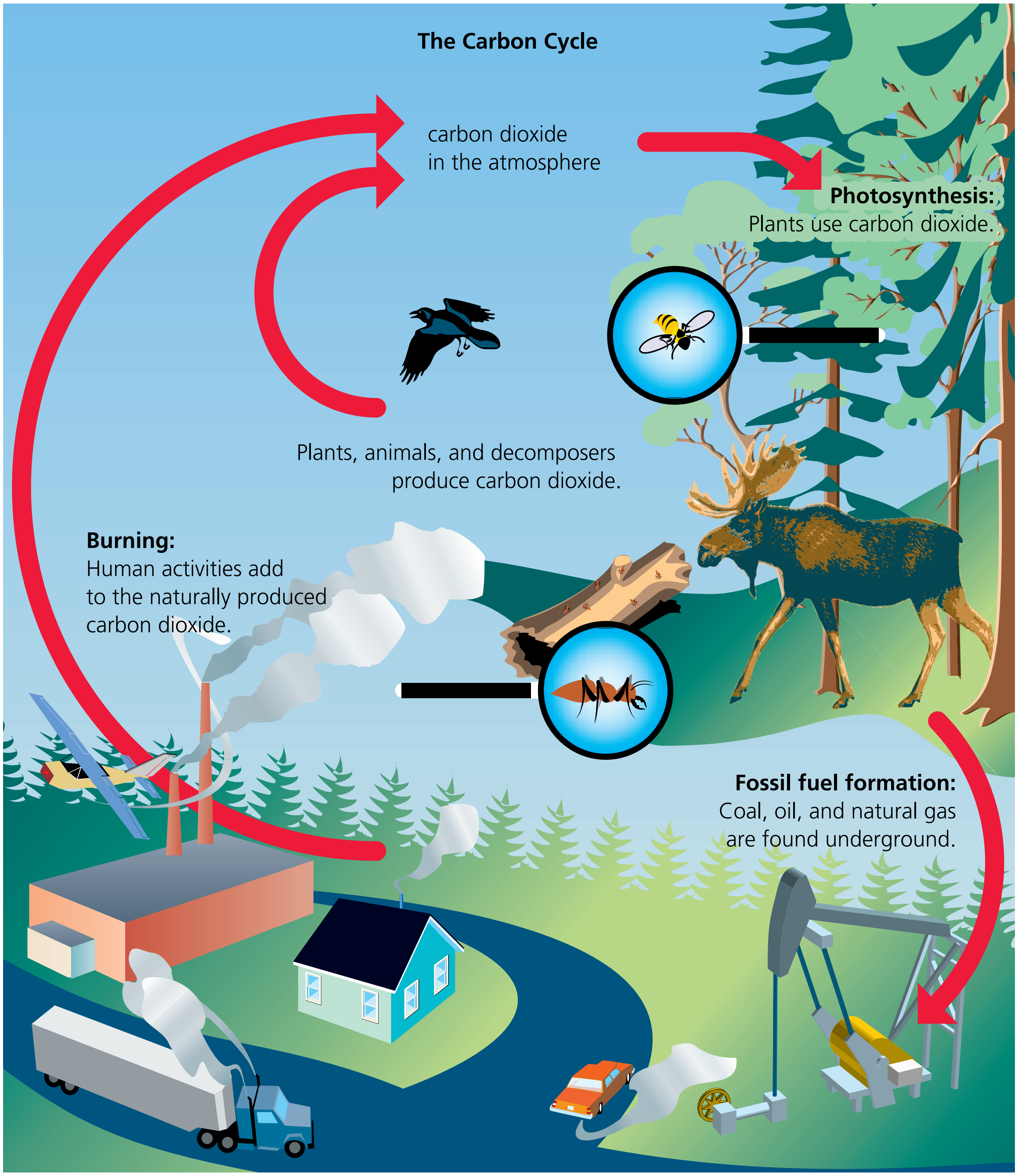


Figure 5
The carbon cycle

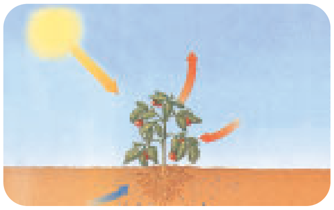
CHECK YOUR UNDERSTANDING

1. If no new water ever arrives on Earth, where do rain and snow come from?
2. Give three examples of sources of carbon in your schoolyard.
3. Explain what would happen to the carbon cycle if there were no decomposers?

2 Chapter Review

Energy flows and matter cycles in ecosystems.

Key Idea: The Sun is the source of all the energy in most ecosystems.



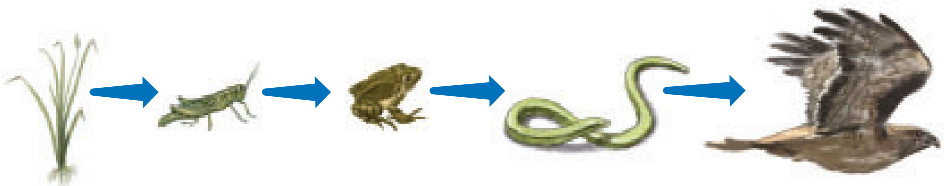
Vocabulary

niche p. 29

photosynthesis p. 29

producers p. 30

Key Idea: Energy flows through ecosystems.



Vocabulary

consumers p. 30

herbivores p. 30

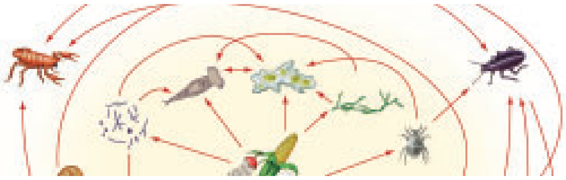
carnivores p. 30

omnivores p. 30

detrivores p. 31

decomposers p. 32

Key Idea: A model can be used to show how energy flows through an ecosystem.

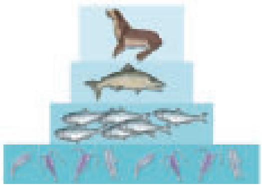


Vocabulary

food chain p. 33

food web p. 34

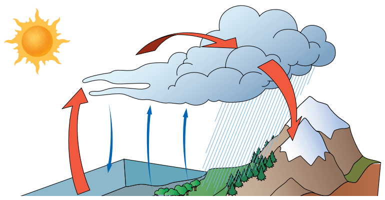
Key Idea: A model can be used to show how the amount of energy that is available to organisms decreases at each level in a food chain.



Vocabulary

ecological pyramid p. 42

Key Idea: Matter cycles within ecosystems.



Vocabulary

cycle p. 52

Review Key Ideas and Vocabulary

When answering the questions, remember to use vocabulary from the chapter.

1. How does energy enter the food chain?
2. Your friend tells you that all the energy you get from eating a pizza comes from the Sun. Draw a food chain to explain this statement.
3. The gopher snake lives in southern British Columbia. It eats small rodents and sometimes eggs and young birds from birds' nests. Rodents eat seeds and plants, including crops that humans grow to feed the cattle they raise for food. Hawks eat snakes and birds. Draw a food web using all of these organisms.
4. Explain how energy is lost at each level in a food chain.
5. What role do plants play in the water cycle? What role do they play in the carbon cycle?

Use What You've Learned

6. Wolves do not eat plants, but they could not live in an ecosystem that did not have plants. Explain.
7. Draw two food chains that you could find in your local ecosystem—one that is land based and another that is water based. Draw an ecological pyramid for each food chain.
8. Aboriginal people recognize the importance of healthy eel-grass beds in the coastal ecosystem. The Nuu-Chal-Nulth people are working with scientists to re-establish eel-grass beds. Research the living and non-living parts of an eel-grass bed ecosystem. Then draw a possible food web for this ecosystem.
9. In a small group, research what producers, herbivores, carnivores, omnivores, decomposers, and detrivores are found in your local ecosystem. Record your results in a table like those in section 2.3. Then use your table to make a food web for your local ecosystem.
10. Contact your nearest municipality and ask for a brochure on the wastewater treatment plant. Does the plant use decomposers? If not, how does the waste get broken down?
11. Design a board game to teach people about the interactions within a food web.

Think Critically

12. Explain the meaning of the following statement: The importance of decomposers is out of proportion to their size.
13. A keystone is a stone at the top of an arch. It supports the other stones and keeps the entire arch from falling. A keystone species is a species in an ecosystem that many other species in the ecosystem depend on for survival. Look over the food webs for different ecosystems in this chapter. Which species do you think is the keystone species in each ecosystem? Explain why.

Reflect on Your Learning

14. Make a list of things you learned in this chapter. Put an asterisk (*) beside any that surprised you. Why did they surprise you?