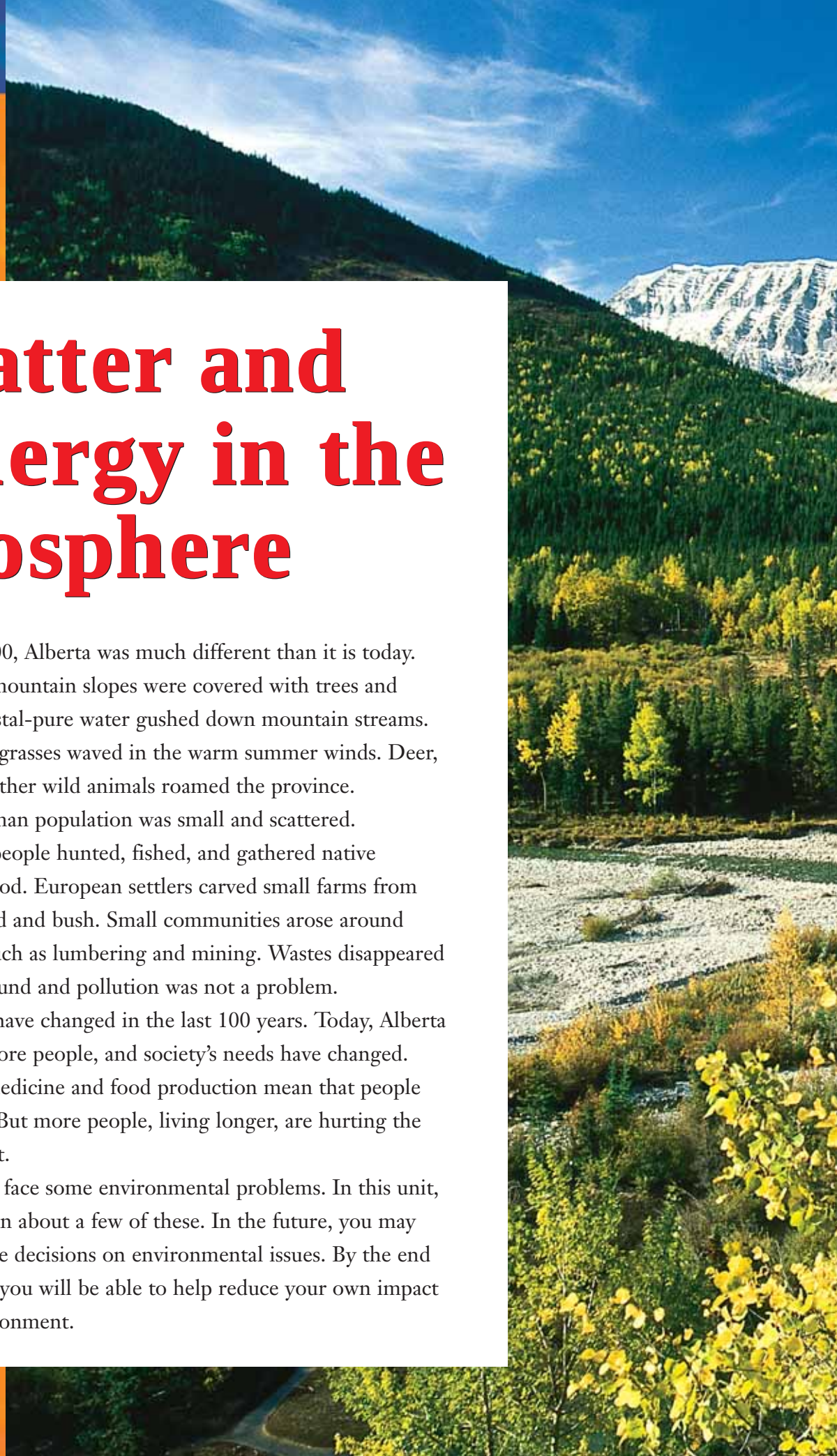
UNIT D



Matter and Energy in the Biosphere

Before 1900, Alberta was much different than it is today. The lower mountain slopes were covered with trees and shrubs. Crystal-pure water gushed down mountain streams. The prairie grasses waved in the warm summer winds. Deer, bison, and other wild animals roamed the province.

The human population was small and scattered. Aboriginal people hunted, fished, and gathered native plants for food. European settlers carved small farms from the grassland and bush. Small communities arose around industries such as lumbering and mining. Wastes disappeared into the ground and pollution was not a problem.

Things have changed in the last 100 years. Today, Alberta has many more people, and society's needs have changed. Improved medicine and food production mean that people live longer. But more people, living longer, are hurting the environment.

We now face some environmental problems. In this unit, you will learn about a few of these. In the future, you may have to make decisions on environmental issues. By the end of this unit, you will be able to help reduce your own impact on the environment.

Unit Contents

CHAPTER 12

The Web of Life

Getting Ready...

- What is energy and where does it come from?
- How is energy transferred from one organism to another?
- How is matter cycled in the environment?

A. Breaking ground with a horse-drawn plough

Science Log

To answer the questions in Getting Ready, recall what you know about ecosystems. When you finish this chapter, review your answers. Make any changes based on what you learn.

In 1900, only about 73 000 people lived in Alberta. Grasslands were cleared and tilled by horse-drawn implements. People raised horses and oxen to work on their farms; they raised chickens, pigs, and cattle for food. Horses and sled-dogs provided local transportation. People took trains for longer trips.

By 1911, the population had risen to nearly 375 000 people. There was still plenty of room for everyone. The low population, and the fact that most of their waste materials eventually decomposed, prevented problems with the environment.

Today, Alberta's population is approximately three million. Albertans use cars, trucks, airplanes, and snowmobiles to get from place to place. Many of the products that we throw away take hundreds of years to break down.

Chapter 12 begins your study of ecology. In this chapter, you will learn how energy flows through the biosphere. You will discover how energy is stored in plants and how it is transferred from organism to organism in food chains. Finally, you will describe how matter is recycled in nature.

B. Modern farm equipment

C. Red Deer's Main Street in 1906

Starting Point ACTIVITY

How Have Things Changed?

In this activity, you will compare what Alberta was like in 1900 to what it is like today.

What to Do

1. Look at the photographs of early Alberta and those of Alberta today.
2. Describe life as shown in the old photographs.
3. Describe the same feature of life in Alberta today.
4. What new technologies have people developed?

D. Red Deer's Main Street in 2000.

What You Will Learn

In this chapter you will learn:

- that living things need a constant supply of energy
- that the Sun is the energy source for most living things
- how energy is transferred from one organism to another
- why less energy is available as you move up the food chain
- how water, carbon dioxide, oxygen, and nitrogen cycle in the environment

Why It Is Important

- All organisms, including you, need matter and energy to live. Humans grow and eat many different foods. For this reason, *you* are an important component of many food chains and webs.

Skills You Will Use

In this chapter you will:

- investigate how social changes led to new technology
- construct models showing the flow of energy in an ecosystem
- investigate your position in food chains
- investigate how plants store food as starch

12.1 What Is Energy?

DidYouKnow?

Three food grains — wheat, rice, and corn — provide more than half of the world's food energy. This has been true for about 10 000 years.

For thousands of years, humans have worked to find enough food for their families. Unlike plants, your body cannot manufacture its own food to give you energy. You must get your energy from the food you eat.

As discussed in Chapter 5, energy is not a substance. Unlike matter, energy does not have mass and it does not take up space. **Energy** is a property or quality of a thing that gives it the ability to move, do work, or cause changes.

Energy cannot be created or destroyed. However, it can be transformed from one form to another. It can also be transferred from one object to another.

Food has high-energy compounds that contain chemical energy. This is where we humans get our energy. The chemical energy from food fuels our life processes.

But where do plants get their energy?

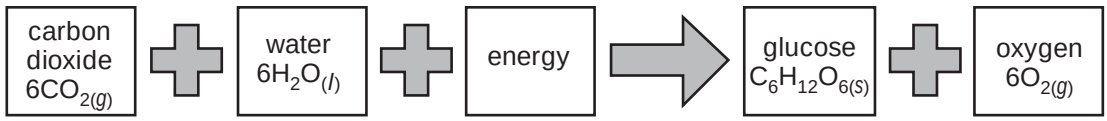


Figure 12.1 Green plants capture light energy and use it to make sugar (glucose) from carbon dioxide and water. Oxygen is released during this reaction.

READING Check

What is energy?

Energy Comes from the Sun

Plants get their energy from the Sun. Green plants capture light energy from the Sun during **photosynthesis**. They transform this light energy into chemical energy by making a sugar called **glucose**. Carbon dioxide and water are the raw materials of this process (see Figure 12.1).

Glucose is one of the main sources of chemical energy for plants and animals. All organisms use this source of chemical energy. They transform the chemical energy in glucose to thermal energy, mechanical energy, and other types of energy. Biologists call this process **cellular respiration** (see Figure 12.2).

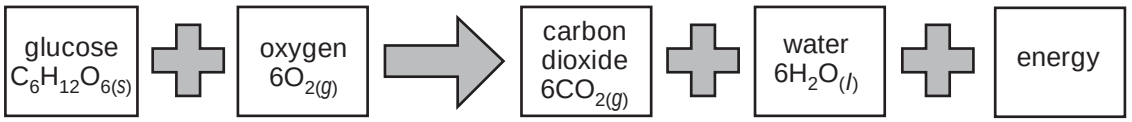


Figure 12.2 Most living things use cellular respiration to convert the chemical energy in glucose into a form they can use for their life processes. Carbon dioxide gas is released during cellular respiration.

Find Out ACTIVITY

Forms of Energy

Energy comes in many different forms. These include light, chemical, thermal (heat), electrical, and sound energy. You need the chemical energy in food for your daily activities.

SKILL CHECK

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

What to Do

1. Study the pair of pictures on this page, and those on pages 236–237. List the forms of energy used in each activity.

What Did You Find Out?

1. Compare your list with those of others in your class.
2. What is the source of energy for all of the living things shown in these pictures?
3. Identify four ways in which energy is transformed from one form to another in these scenes.

A. In 1915, chickens were fed by hand.

B. Today, thousands of cattle are fed at a feedlot.

Check Your Understanding

1. The following statements are false. Rewrite each statement to make it true. Place the corrected statements in your Science Log or notebook.
   - **(a)** Energy has mass and takes up space.
   - **(b)** Energy can be created and destroyed.
   - **(c)** Energy can be transformed only from light energy into chemical energy.
   - **(d)** Energy cannot be transferred from one object to another object.
2. Review Figure 9.4 on page 185, and the two figures on page 238. Design a table to compare the processes of photosynthesis and cellular respiration. How are these reactions similar? How are they different?
3. Read the Did You Know? on page 238. What is the primary source of energy in the human diet? Has this source of energy changed much in the last 100 years? Explain.

Key Terms

- energy
- photosynthesis
- glucose
- cellular respiration

12.2 Storing Energy from the Sun

Disc CONNECT

Organisms that carry out photosynthesis provide food for nearly all other organisms on Earth. Cellular respiration releases the energy from food. What do the processes of photosynthesis and cellular respiration have in common? What are the chemical reactions for these two processes? To answer these and other questions, load the student CD-ROM onto your computer. Launch the **Photosynthesis** applet to learn more about photosynthesis and cellular respiration.

Plants use the energy from glucose for their own life activities. If they make more sugar than they need, plants store the excess glucose as **starch**.

The starch is stored in the plant's leaves, stems, seeds, and roots. You consume the starch when you eat carbohydrate foods such as bread or French fries. Your body breaks down the starch into glucose during digestion. You use the energy for your life activities. The mitochondria in your cells release the chemical energy stored in the glucose.

CONDUCT AN INVESTIGATION 12–A

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

How Do Plants Store Energy from the Sun?

Problem

How does the amount of sunlight affect the amount of starch in leaves?

Hypothesis

Read the problem and the procedure for this investigation. Use this information to develop your own hypothesis. Write your hypothesis in your Science Log or notebook.

Safety Precautions

- Tie back long hair.
- Be careful with hot water and hot alcohol.
- Do not place alcohol near an open flame.
- Follow your teacher's instructions for the disposal of all chemicals.
- Use caution when handling iodine. It can cause irritation to the skin and eyes, and may discolour skin and clothing. Clean up any spills immediately.

Apparatus

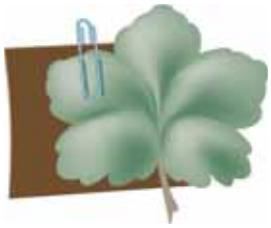
1 small beaker
1 large beaker
hot plate
stopwatch or watch with second hand
tongs
petri dish
medicine dropper

Materials

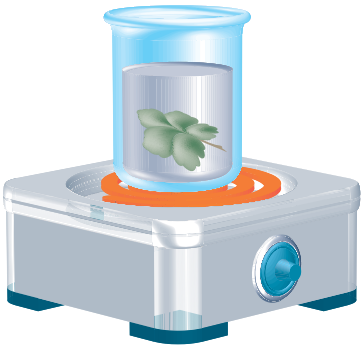
house plant, such as a geranium
small piece of dark paper
paper clip
water
alcohol
iodine solution

Procedure

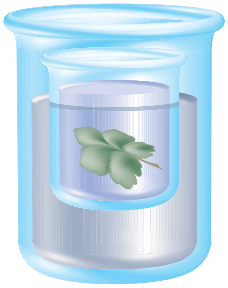
1. Cut the dark paper into a unique shape and secure it to the leaf with the paper clip.



2. Leave the plant in full Sun for 24 hours.
3. Remove the entire leaf from the plant and detach the dark paper.
4. Place the leaf in a hot water bath for 1 minute.



5. Place the leaf into a small beaker containing alcohol. Place the beaker into a hot water bath for 5 minutes. Shut off the hot plate once the alcohol comes to a boil.



6. Dip the leaf back into the hot water bath for 20 seconds.
7. Spread the leaf in the bottom of a petri dish.
8. Use a medicine dropper to add iodine solution to the leaf.

9. Wash your hands thoroughly and clean up the work area.

Analyze

1. Was starch present in your leaf?
2. Where did the starch come from?

Conclude and Apply

3. Was your hypothesis supported or rejected by the results of your investigation? Explain.
4. Why did you use the iodine?
5. Why did you place the leaf in hot alcohol before you tested it with iodine?

Extend Your Knowledge

6. Do you think the leaves of a plant that has been kept in the dark for three days would contain starch? Explain your answer.
7. Design your own investigation that would test your answer to question 6.

Key Terms

starch

Check Your Understanding

1. Where do plants get the chemical energy they need?
2. Why do you think plants store excess chemical energy in their leaves and roots?
3. What is the source of chemical energy for animals?

12.3 Energy Pathways in an Ecosystem

READING Check

Name the two types of components in all ecosystems.

Alberta's Aboriginal groups were hunter-gatherers. They ate what nature provided: wild berries, roots, bison, rabbits, and other game.

The European settlers tilled the natural grasslands of Alberta and planted the seeds they brought with them from Europe. By doing this, they changed the ecosystem.

An **ecosystem** is a community of living things and the environment in which they live. An ecosystem contains:

- living components (such as plants, animals, and bacteria); and
- non-living components (such as rocks, weather, and water).

In any ecosystem, the components are interrelated. If one component is changed, the whole system is affected.

Food Chains

Many relationships are based on feeding. The energy and matter from feeding pass through an ecosystem by way of **food chains**.

Look at Figure 12.3. Organisms at the bottom of a food chain are able to make their own food and are called **producers**. What is the producer in this figure?

The next links are the **consumers**. These are organisms that eat either a producer or another consumer. List the consumers in this figure.

The arrows in Figure 12.3 show the direction in which energy flows in the food chain. During photosynthesis, the leaves of plants capture light energy from the Sun and transform it into chemical energy (glucose). Plants store the chemical energy.

Energy flows from the producer to the consumer, the animal that eats the plant. As you can see, the flow of energy is only one way. The grouse cannot give energy back to the plant.

Waste products, as well as the bodies of dead plants and animals, do not accumulate in the ecosystem. A very important group of living things, called **decomposers**, eats them. What decomposer is breaking down the green plants, using the energy, and returning chemical elements to the environment?

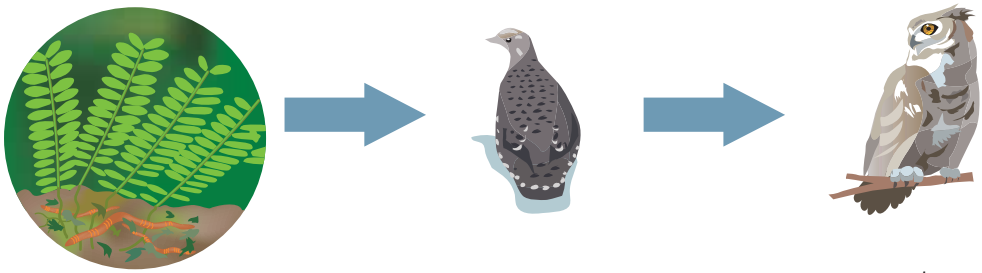


Figure 12.3 A simple food chain. Identify the producer, consumers, and decomposer.

Find Out ACTIVITY

Food and You

SKILLCHECK

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

How have the foods we eat changed in the last 100 years?

Some of the food you eat today may be similar to the food eaten by Albertans in the early 1900s. In this activity, you will consider the foods eaten by people 100 years ago and describe where each food might have got its energy.

What to Do

1. Read the list of foods people in Alberta ate in the early 1900s. Choose five foods that they ate.
2. Draw possible food chains to show where each food received its energy.

   Example: Sun → grass → deer → human

What Did You Find Out?

1. What is the original source of energy for the food chains?

Extend Your Knowledge

2. **(a)** Draw food chains for five foods you eat today.
   (b) How do the food chains for the foods we eat today compare with those for foods eaten 100 years ago?
3. Exchange food chains with five other people. What is the longest food chain created by one of you?

Breads
bannock (flour & animal fat)
turnip bread
wheat bread

Fruits & Vegetables
berries
cabbage
roots
turnip

Meat
beef
buffalo
deer
elk
fish
pork
prairie chicken
rabbit

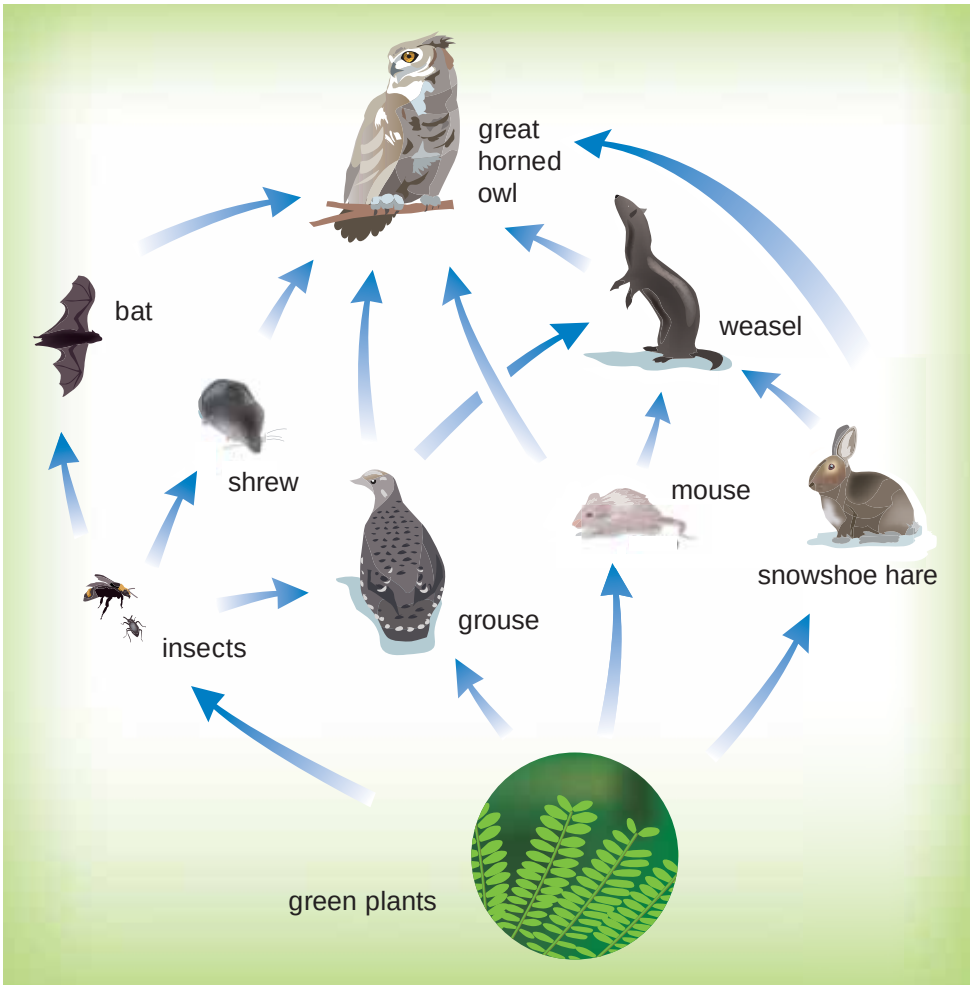


Figure 12.4 A food web shows how energy is transferred from one organism to other organisms in an ecosystem.

Food Webs

Few consumers eat only one type of food. Most organisms have several predators, not just one.

Using this knowledge, a simple food chain can become a complex food web. Figure 12.4 shows a food web that may have existed in a natural grassland ecosystem. Identify four or five food chains in this food web.

A **food web** is a more complete model showing how energy moves in an ecosystem. Food webs are more accurate than food chains because they show that some organisms feed on more than one level.

In Figure 12.4, the grouse is
- a **primary consumer** when it eats plants, and
- a **secondary consumer** when it eats insects.

Primary consumers eat plants. Secondary consumers eat animals that eat plants.

The great horned owl is:
- a secondary consumer when it eats the mouse or hare, and
- a **tertiary consumer** when it eats the weasel or shrew.

Tertiary consumers eat animals that eat other animals.

Key Terms

ecosystem
food chain
producer
consumer
decomposer
food web
primary consumer
secondary consumer
tertiary consumer

Check Your Understanding

1. The following food chain is incorrect: sparrow → hawk → seeds
   Draw a correct food chain in your Science Log or notebook. Explain why your version is correct.
2. Use arrows and words to draw a food web of plants and animals in your area of the province. Try to include at least four related food chains.

12.4 Energy Transfers

Figure 12.5 Thousands of bison used to roam the vast grasslands now known as Alberta.

At one time, large herds of bison (buffalo) roamed the plains of western Canada and the United States. Although the bison ate huge amounts of grass, there were many more individual grass plants than bison.

The organisms in such a food chain can be represented by an **ecological pyramid** (see Figure 12.6). Producers, such as the native grasses, are at the base of this pyramid. Above the producers are the different levels of consumers.

Bison are primary consumers. They eat plants and form the second layer in the food pyramid.

Wolves are secondary consumers or predators. They kill and eat sick or old bison. In this food chain, wolves form the top level of the food pyramid.

READING Check

List the members of a three-level ecological pyramid.

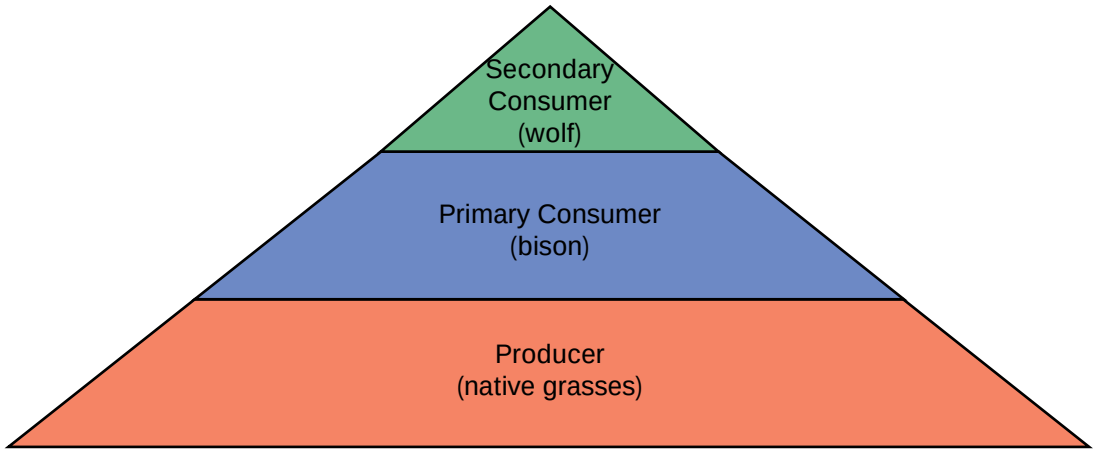


Figure 12.6 A typical ecological pyramid with three levels. A pyramid may show the relative numbers of organisms or the amount of energy available at each level in a food chain.

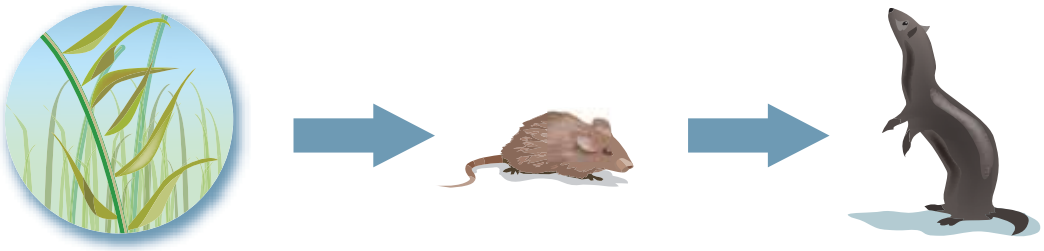
Pyramid of Energy

A **pyramid of energy** shows the total amount of chemical energy that flows through each feeding level in an ecosystem. Only about 10 percent of the energy in one level is transferred to the next level.

Safety Precautions

What You Need

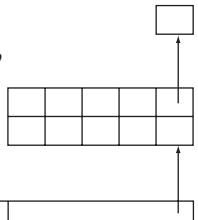
pencil
ruler
scissors
notebook paper

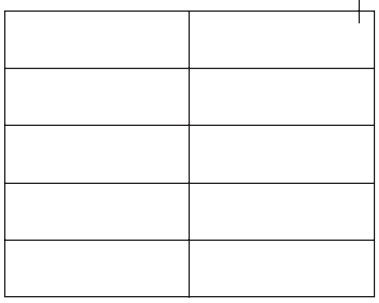


A grassland food chain with three levels.

What to Do

1. Pretend that a piece of notebook paper represents the amount of energy available to the producers.
2. Mark off a piece of notebook paper into 10 pieces of equal size. Each piece represents the amount of energy available to the primary consumers.
3. Cut out one rectangle.
4. Cut this square into 10 pieces of equal size. Each of these tiny pieces represents the energy available to the secondary consumers.
5. In your Science Log or notebook, draw an energy pyramid similar to the one in Figure 12.6 on page 245.
6. Label each level.





Analyze

1. Name some specific organisms that could be found on the bottom level of the pyramid of energy. Are they producers or consumers?
2. Name some specific organisms that could be found at the top of this pyramid of energy. Are they producers or consumers?
3. Why do you think there are fewer organisms at each higher level?

Extend Your Skills

4. A pyramid is used to show what happens to the energy.
   a) What happens to the amount of energy available at the bottom compared to the amount available at the top?
   b) Explain why there is less energy at the top than at the bottom of the pyramid.
5. What do you think would happen to the other levels if the producers were eliminated from this food chain?

What Happens to the Energy?

READING Check

How much energy is lost at each level?

Energy is lost from the food chain at each level. In fact, only about 10 percent of the energy in one level is transferred to the next level. The reasons for the loss of energy include:

- Many organisms are not eaten. For example, mice do not eat all of the grass in an area.
- Organisms use some energy for their own growth and reproduction.
- Organisms use some energy for body functions, such as digestion and circulation.
- Energy remains in organisms when they die. Decomposers break down the dead organisms and extract the remaining energy.
- Energy transformations are never 100 percent efficient. Some energy is always changed into heat.

The loss of energy at each level helps to explain why food chains seldom contain more than three or four organisms.

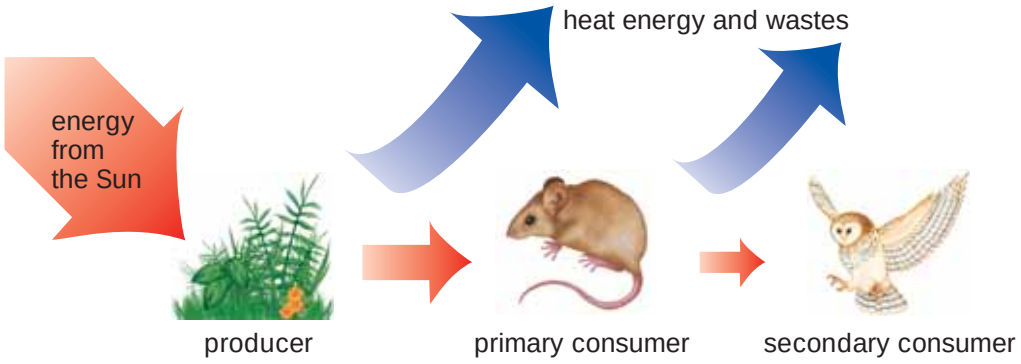


Figure 12.7 Energy is lost as heat at each level in a food chain.

Check Your Understanding

Key Terms

ecological pyramid
pyramid of energy

1. Place the following organisms into a food chain.
   - moose
   - twigs, leaves, and bark of willows and aspen
   - wolves
2. Identify one animal that could be both a primary and a secondary consumer. Draw two food chains illustrating the feeding relationships of this animal.
3. Food chains have few large carnivores. Explain why this might be so.
4. Study the following food chains that involve humans:
   green plants → humans
   green plants → cow → humans
   green plants → insect larva → fish → humans
   (a) In which food chain does the most energy escape as heat? Why?
   (b) Which food chain provides the maximum amount of energy for humans? Why?

12.5 The Cycles of Matter

DidYouKnow?

Each year, producers convert more than 10 percent of the total carbon dioxide in the atmosphere into sugars.

Matter recycles in nature. Plant matter is broken down by the animals that eat it. The matter is then recombined to form animal tissues. In this way, matter is moved through food chains from organism to organism.

The same matter is cycled over and over again. The water you drank at breakfast may have rained on a nearby river three days ago, and evaporated from the ocean last week. Ecologists refer to these re-uses as **cycles**.

Water evaporates constantly from streams and lakes and from the bodies of plants and animals. The **water cycle** maintains fresh-water environments and supplies the vast quantities of water necessary for life on land.

The Water Cycle

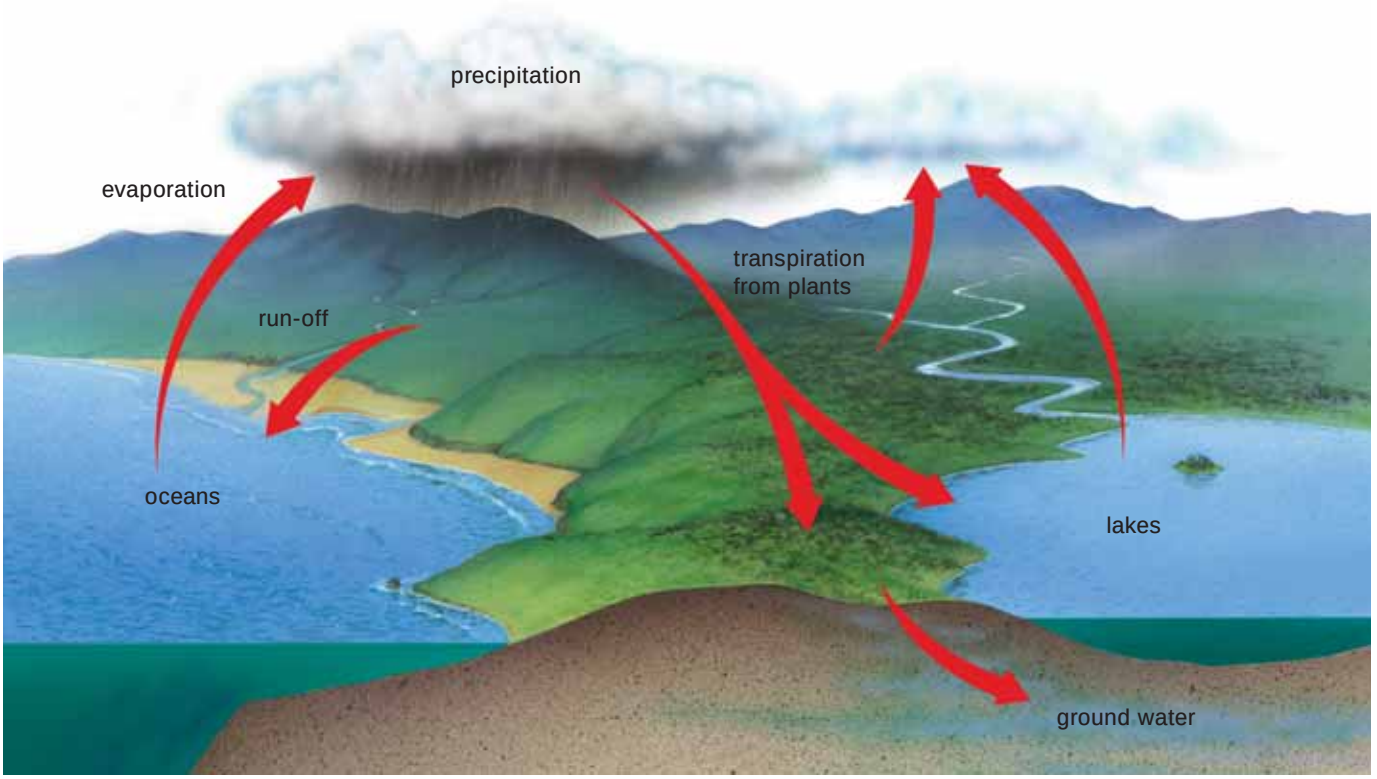


Figure 12.8 Water falls to Earth as rain, evaporates back into the atmosphere, condenses as clouds, and falls again as rain. When rain falls on the land:
- some of it is absorbed by plants or drunk by animals,
- some runs off the surface of the land into streams and lakes, and
- some seeps through the soil into the ground water.

Disc CONNECT

The water molecules on Earth are on a constant journey. They rise into the atmosphere, fall to land or the ocean as rain or snow, and flow into rivers and oceans. What is the source of energy for the water cycle? What are the components of this cycle? To answer these and other questions, load the student CD-ROM onto your computer. Launch the **Water** applet and follow the instructions.

DidYouKnow?

The Sun is the driving force behind all cycles of matter.

The Carbon and Oxygen Cycles

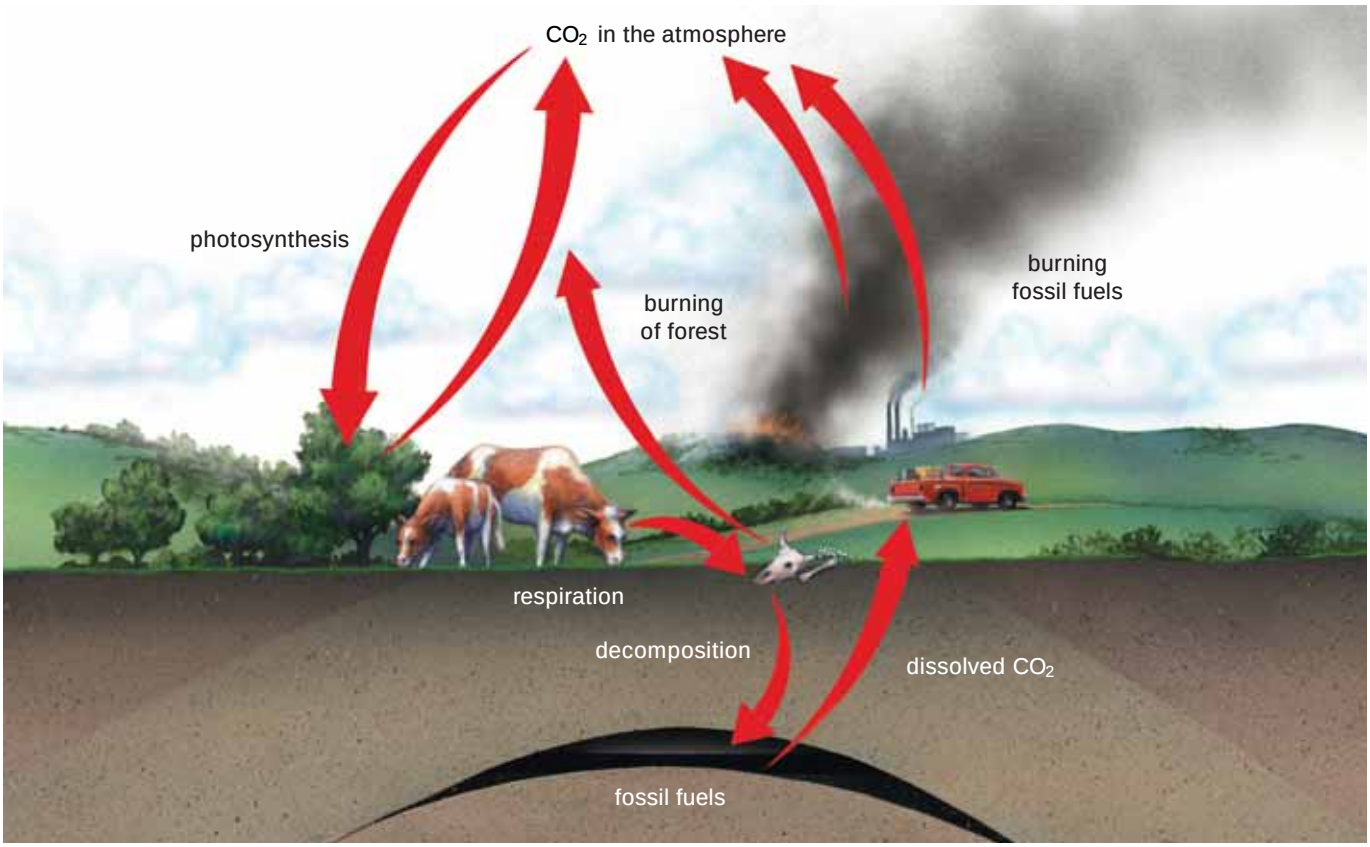


Figure 12.9 Oxygen and carbon dioxide cycle together through the ecosystem. Oxygen is given off by plants during photosynthesis. Carbon dioxide is used by plants during photosynthesis.

Carbon dioxide and oxygen are gases. They cycle together in the following ways.

- During photosynthesis, plants make glucose from carbon dioxide and water, using the Sun's energy. Plants give off oxygen during this process.
- During cellular respiration, glucose and oxygen are changed into carbon dioxide, water, and energy. The carbon dioxide is released back into the atmosphere.
- Decomposers use oxygen when breaking down dead organisms and animal waste. They return carbon dioxide to the atmosphere.

The **carbon and oxygen cycles** are shown in Figure 12.9.

Figure 12.10 Carbon dioxide is returned to the atmosphere in many ways — for example, by the combustion of fossil fuels.

The Nitrogen Cycle

Nitrogen is a gas in the atmosphere. It is an important nutrient that all plants and animals need for growth. However, plants and animals cannot use nitrogen gas. Instead, the gas must be converted to nitrates, which they can use. This is done during the **nitrogen cycle**.

Figure 12.11 shows this cycle. The steps include:

- Certain bacteria, and even lightning, convert nitrogen gas to forms that are useful to plants.
- Plants and animals die and decay.
- The compounds in their bodies that contain nitrogen are converted by other bacteria to make nitrates.
- The nitrates are used again by plants or returned to the atmosphere as nitrogen gas.

READING Check

Name three important natural cycles and list what each cycles.

DidYouKnow?

The Composting Council of Canada estimates that about 50 percent of all household waste could be composted!

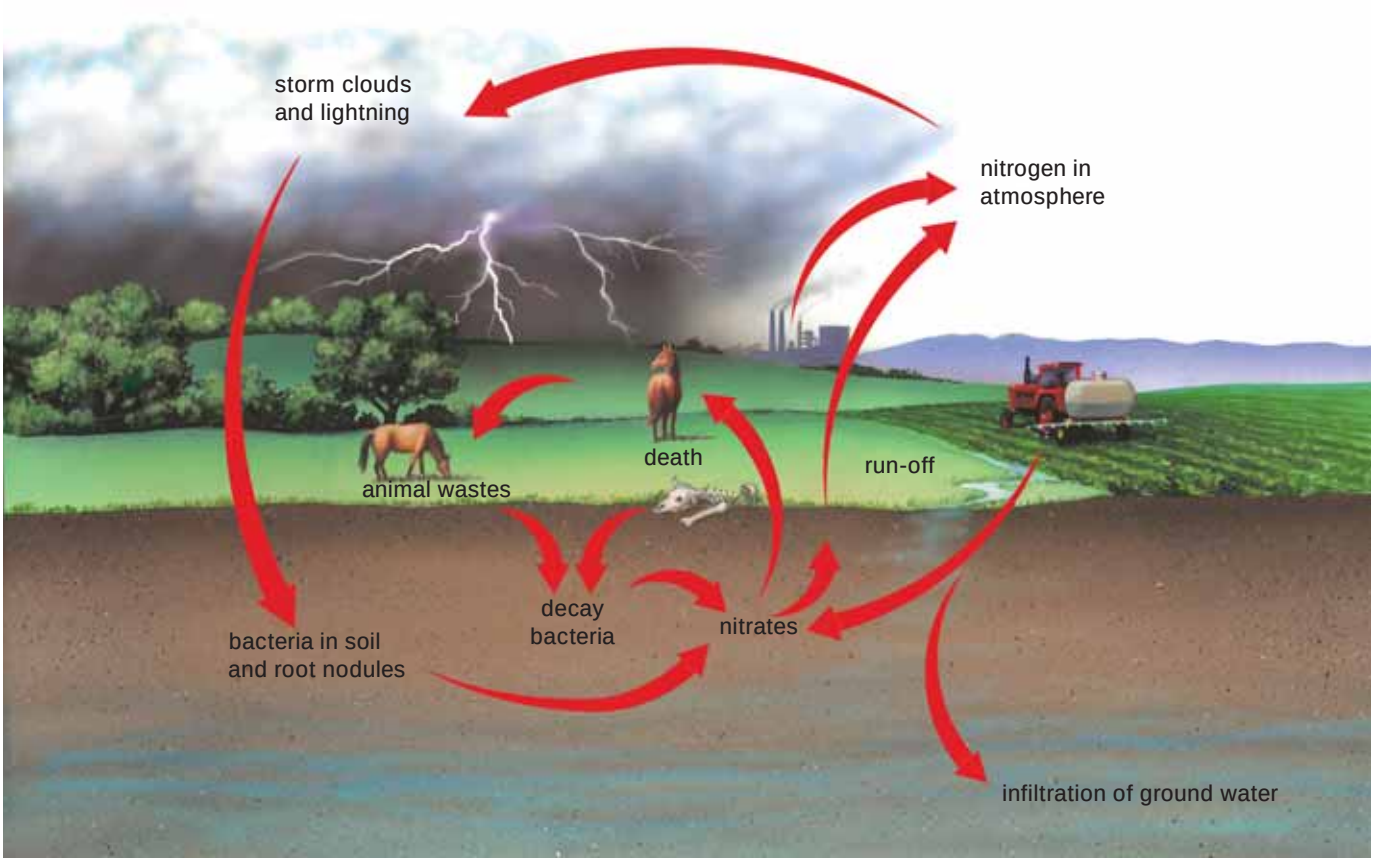


Figure 12.11 Trace the movement of nitrogen through this cycle.

Working with Natural Cycles

Decomposing plants and animal wastes contain nitrates and other nutrients. One hundred years ago, farmers spread these on the soil to help plants grow.

A mixture of decomposing plants and soil is called **compost**. Today, many people add this to their house plants, lawns, or gardens.

Composting is one way to recycle yard and kitchen wastes and to reduce the volume of garbage sent to landfills for disposal.

Figure 12.12A One hundred years ago, most farmers kept a few cattle. They spread the manure on their fields.

Figure 12.12B Today, thousands of cattle and other animals are raised in feedlots. There is so much waste that the run-off must be carefully handled. Run-off from the feedlots can contaminate drinking water supplies.

Internet CONNECT

www.mcgrawhill.ca/links/science.connect1

Imagine having your own composter right under your kitchen sink. You can if you use worms. To learn more about building a worm composter, visit the web site above. Go to Internet Connects, Unit D, Chapter 12, and then to Composting With Worms.

Try This!

Use your library and electronic sources to find information on how to make a composter for your classroom. Talk to your teacher about using the composter to decompose coffee grounds and other food wastes from the staff lounge at your school.

If you live in a house with a yard, you might want to make your own compost pile. Apartment and condominium residents might try vermicomposting — using earthworms to recycle kitchen wastes.

Check Your Understanding

1. Why must matter, such as water, carbon, oxygen, and nitrogen, be recycled in the environment?
2. Sketch one of the cycles in your Science Log or notebook. Show and label each part of the cycle.
3. Review the carbon and oxygen cycles. What roles do photosynthesis and cellular respiration play in these cycles?
4. Explain what part *you* play in one of these cycles.

Key Terms

- cycle
- water cycle
- carbon and oxygen cycles
- nitrogen cycle
- compost

CHAPTER

12 Review

Key Terms

energy
photosynthesis
glucose
cellular respiration
starch
ecosystem
food chain
producer
consumer
decomposer
food web
primary consumer
secondary consumer
tertiary consumer
ecological pyramid
pyramid of energy
cycle
water cycle
carbon and oxygen cycles
nitrogen cycle
compost

Reviewing Key Terms

If you need to review, the section numbers show you where each term was introduced.

1. In your Science Log or notebook, match each description in column A with the term in column B.

A	B
(a) most living things use this process to get energy from glucose	i. nitrogen cycle (12.5)
(b) green plants use this process to produce sugars (glucose)	ii. compost (12.5)
(c) nitrates are formed in this process	iii. heat (12.4)
(d) at each step in a food chain, energy is lost in this form	iv. food chain (12.3)
(e) plants store excess glucose in this form	v. cellular respiration (12.1)
(f) you can do this to reduce the amount of kitchen waste put into landfills	vi. tertiary consumer (12.3)
(g) a simple way to illustrate the flow of energy in an ecosystem	vii. starch (12.2)
(h) this term is used to describe a consumer that eats a secondary consumer	viii. photosynthesis (12.1)
(i) this term is also used to describe animals that eat producers	ix. primary consumer (12.3)

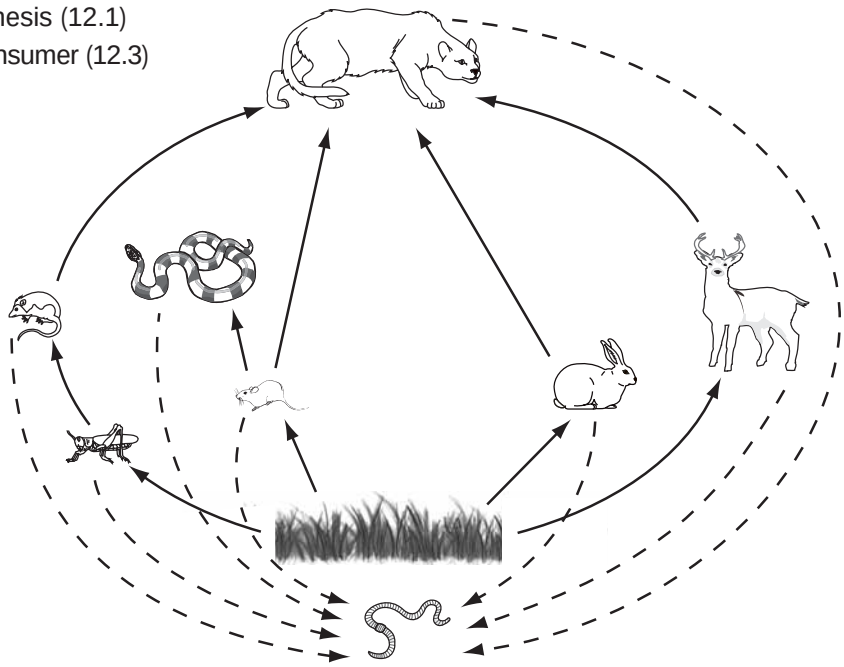
Understanding Key Ideas

Section numbers are provided if you need to review.

2. (a) In a group, discuss what is meant by the following statement: (12.1)
"Energy cannot be created or destroyed. It can, however, be converted from one form to another or transferred from one object to another."

(b) Use a diagram to show one example of how this statement works in nature.

3. Study the drawing below. Write the following sentences in your Science Log or notebook. Fill in the blanks using a Key Term or the name of an organism found on the diagram. (12.3)



(a) This diagram illustrates a _____ .
(b) The only producers shown on this diagram are the _____ .
(c) Two primary consumers shown on the diagram are _____ and _____ .
(d) Two secondary consumers shown on the diagram are _____ and _____ .
(e) The decomposers in this diagram are represented by the _____ .

4. The following statements are based on the drawing that you used in question 3. Each statement below is false. In your Science Log or notebook, rewrite the statements to make them correct. (12.3)
(a) There are more individual primary consumers than individual producers.
(b) The decomposers provide the original source of energy for all of the other organisms.
(c) The snake can be either a primary or a secondary consumer.

5. Use labelled diagrams to explain how carbon dioxide and oxygen are cycled in an ecosystem. (12.1)

6. List the steps it takes for energy from the Sun to get to a top predator such as a hawk or a mountain lion. (12.3)

7. About 10 percent of the energy in food eaten by a consumer is available to the next consumer in the food chain. What happened to the other 90 percent? (12.4)

8. Copy the following food chains into your Science Log or notebook and answer the questions that follow.
1: green plants → grasshoppers
2: seeds → mice → snakes
3: tree leaves → beetles → insect-eating birds → hawks
4: green plants → hares → snakes → hawks → mountain lions
(a) Which food chain has the largest loss of energy? Why? (12.3)
(b) Which food chain loses the least amount of energy? Why? (12.4)
(c) Why would you expect to see more snakes than mountain lions? (12.4)
(d) Draw an energy pyramid for Food Chain 2. Label the organisms as well as the producers, primary consumers, and secondary consumers. (12.4)

Developing Skills

9. What test or indicator can you use to determine if a substance contains starch? (12.2)

Critical Thinking

10. Over the last 100 years, technological advances have allowed us to switch from animals to cars as our primary method of transportation. Explain both the positive and the negative effects of this change. (12.5)

11. Domestic livestock, such as cattle, produce solid waste called manure. Do research to answer the following questions. (12.5)
(a) Is manure better for soil than chemical fertilizers?
(b) Can the use of manure affect human health?

Pause & Reflect

1. In prehistoric times, humans hunted and gathered food and built shelters without greatly affecting their environment. As the human population increased, so has our impact on the environment. How have we affected the environment? How have we changed the flow of energy and the cycles of matter?
2. Go back to the beginning of this chapter on page 236, and check your answers to the Getting Ready questions. How has your thinking changed? How would you answer those questions now that you have finished this chapter?