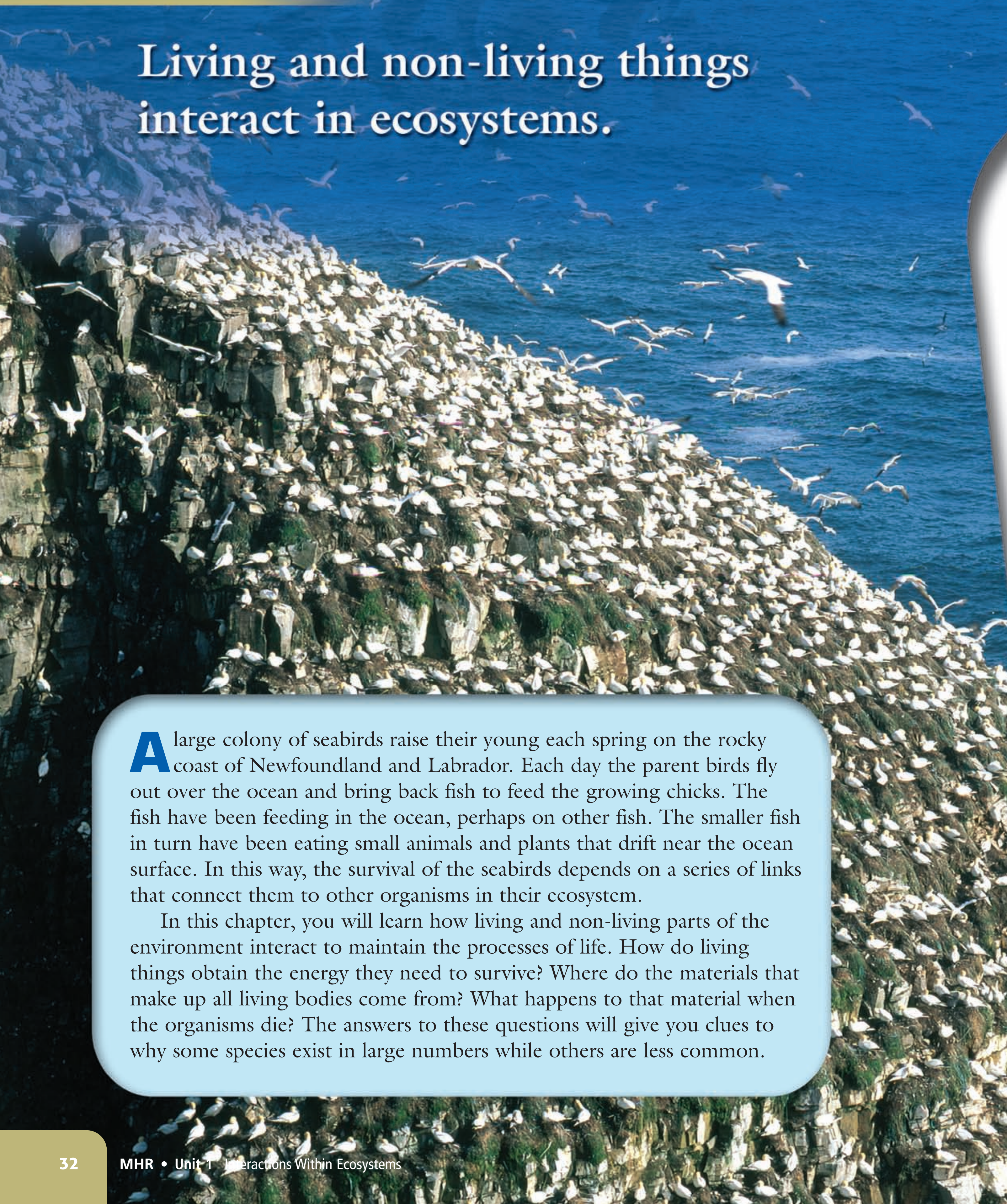
Chapter 2

Living and non-living things interact in ecosystems.



A large colony of seabirds raise their young each spring on the rocky coast of Newfoundland and Labrador. Each day the parent birds fly out over the ocean and bring back fish to feed the growing chicks. The fish have been feeding in the ocean, perhaps on other fish. The smaller fish in turn have been eating small animals and plants that drift near the ocean surface. In this way, the survival of the seabirds depends on a series of links that connect them to other organisms in their ecosystem.

In this chapter, you will learn how living and non-living parts of the environment interact to maintain the processes of life. How do living things obtain the energy they need to survive? Where do the materials that make up all living bodies come from? What happens to that material when the organisms die? The answers to these questions will give you clues to why some species exist in large numbers while others are less common.

What You Will Learn

In this chapter, you will
- **describe** interactions between biotic and abiotic parts of an ecosystem
- **distinguish** the different roles of organisms in ecosystems
- **investigate** how energy flows through a food chain
- **examine** how matter is cycled in an ecosystem

Why It Is Important

In order to solve problems such as pollution, people need to know how different parts of an ecosystem normally interact to keep the environment stable.

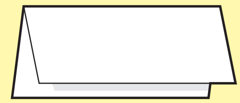
Skills You Will Use

In this chapter, you will
- **observe** what happens to dead organisms
- **model** the way in which energy flows through ecosystems
- **illustrate** and explain the nutrient cycle

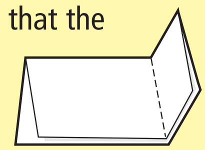
FOLDABLES™
Reading & Study Skills

Make the following Foldable to take notes on what you will learn in Chapter 2.

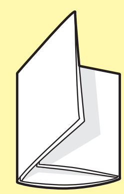
STEP 1 **Fold** an 8.5 × 11″ sheet of paper along the long axis.



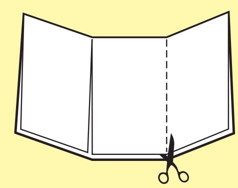
STEP 2 With the paper horizontal and the fold at the top, **fold** the right side in toward the centre so that the right fold covers half of the remaining paper.



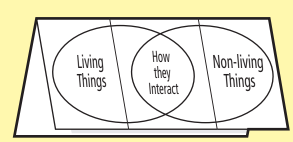
STEP 3 **Fold** the left side in toward the centre to make a three-page book.



STEP 4 **Open** the folded book and **cut** upwards along the folds on the inside layer of paper only.



STEP 5 **Draw** two overlapping ovals across the three tabs to create a Venn diagram. **Label** the left oval "Living Things", the right oval "Non-living Things", and the middle section "How they Interact".



Organize As you read the chapter, make notes under the tabs of the Foldable, giving examples of biotic and abiotic parts of an environment and explaining how they interact.

2.1 Types of Interactions

The biotic and abiotic parts of the environment interact together in many different ways. Symbiosis is an example of interactions between biotic parts of the environment. Symbiotic relationships include parasitism, mutualism, and commensalism. Eating is another interaction between organisms. Feeding relationships can affect the population size of the organisms that are eaten and of the organisms that eat them.

Key Terms

commensalism
host
mutualism
parasites
parasitism
symbiosis
symbiotic

One of the key ideas in ecology is that everything is connected to everything else. Each part of the environment is constantly interacting with other parts of the environment. For example, as you read this book, you are breathing in and breathing out. This is an interaction between you and an abiotic part of your environment.

Figure 2.1 This photo shows an interaction between two biotic parts of the environment.

In the last chapter, you learned that plants are affected by light, water, temperature, and soil. These are examples of interactions between biotic and abiotic parts of the environment. As Figure 2.1 shows, plants are also eaten by animals. Eating is an example of an interaction between two biotic parts of the environment.

Can you think of an example of an interaction between two abiotic parts of the environment? Here's one: after a rainfall, the sun evaporates puddles on the ground. In this chapter, you will explore how ecological interactions like these help maintain life on Earth.

Living Relationships

The barnacle is a distant relative of crabs and lobsters. Young barnacles drift in the ocean currents until they find a solid surface on which to attach. Once fixed to the surface, they grow a hard protective shell and remain in the same place for the rest of their lives. Barnacles may attach themselves to rocks, to the hulls of boats or, as shown in Figure 2.2, to the bodies of whales!

Figure 2.2 The back of this whale is covered with clusters of barnacles.

This relationship between barnacles and whales is an example of **symbiosis**, a biological interaction in which two species live closely together over time. There are three main types of **symbiotic** relationships: parasitism, mutualism, and commensalism.

Parasitism

Ticks (Figure 2.3) and tapeworms (Figure 2.4) are examples of **parasites. Parasitism** is a symbiotic relationship between two species in which one benefits and the other is harmed. The parasite obtains its food from its partner. The organism that provides food for a parasite is called a **host.**

Figure 2.3 Ticks feed on the blood of other animals such as cats, dogs, and birds.

Figure 2.4 Tapeworms live inside the intestines of other animals, including humans, and absorb nutrients from them.

Did You Know?

Newfoundland is the only location in North America where the caribou roundworm is found. This parasite is believed to have been introduced into the island's caribou population when reindeer were shipped from Norway to Newfoundland in the early 1900s.

Fleas, ticks, and lice are all examples of *external* parasites, which live on the surface of their hosts. These parasites may stay with their host only for a brief time while they feed or reproduce. Tapeworms and roundworms are examples of *internal* parasites, which live inside the bodies of their hosts. They may stay with their host for their entire lifetime.

Parasites usually do not kill their hosts, or else they would lose their source of food and might die as a result. Sometimes, however, a large population of parasites can weaken their host and shorten its life. For example, in the late 1990s, many woodland caribou on the Avalon Peninsula of Newfoundland were found dead, or weak and staggering. The cause was a large number of parasitic roundworms found in their lungs and brains.

Some plants are also parasitic. For example, the mistletoe plant attaches itself to trees and grows root-like structures into the host to extract nourishment. Different species of mistletoe grow on different species of trees.

Figure 2.5 Termites have micro-organisms in their digestive tract that break down the wood on which termites feed.

Mutualism

Termites are insects that eat dead wood (Figure 2.5). Although this source of food is plentiful, wood is very difficult to digest. In fact, termites cannot digest wood! However, their guts contain tens of thousands of micro-organisms that can. The micro-organisms break down the wood into sugars that nourish both the micro-organisms and the termites.

This type of relationship, in which both partners benefit, is called **mutualism.** The micro-organisms benefit by living in a warm, safe environment and having their food delivered to them. The termites benefit by being able to use a common source of food that few other animals can use.

Figure 2.6 This crusty lichen growing on a rock is an example of mutualism.

Another example of mutualism is found in lichens, commonly seen growing on rocks (Figure 2.6). Lichens are a combination of two organisms living together: a species of alga (plural: algae) and a species of fungus (plural: fungi).

Figure 2.7 shows the structure of a typical lichen. The algae produce food, which is used by both organisms. The threads of fungi make a sponge-like structure that anchors the lichen to rocks, protects the algae, and holds water essential to both. This combination allows the two species to live in environments where neither could survive alone.

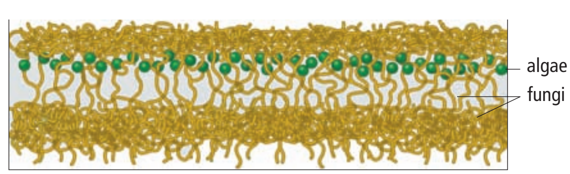


Figure 2.7 Lichen consists of algae and fungi living together in a relationship of mutualism.

Commensalism

The brightly-coloured clownfish in Figure 2.8 swims among the poisonous stinging tentacles of an anemone. The clown fish, however, is immune to the poison. It gets shelter from the anemone and eats scraps left over from the anemone's meal. This type of symbiotic relationship, in which one partner benefits and the other appears neither to lose nor gain from the relationship, is known as **commensalism.** The barnacles and the whale described on page 35 are another example of commensalism.

Figure 2.8 This clownfish is unharmed by the poisonous tentacles of the anemone with which it lives.

Reading Check

1. Define "symbiosis."
2. Give an example of symbiosis from this chapter and an example from your own experience.
3. Define and give an example of each of the following terms: mutualism, parasitism, and commensalism.

Food and Populations

Symbiosis helps organisms survive by providing food or shelter to one or both partners in the relationship. For animals, eating food is essential for survival. It is an important interaction between different species.

Figure 2.9 How might the number of hares in an ecosystem affect the population of lynxes that prey upon them?

Word Connect

Organisms that hunt and kill their food are called *predators*. Organisms that are hunted and killed for food are called *prey*.

When the lynx in Figure 2.9 catches and eats the hare it is chasing, there will be one less hare in the population. In this way, lynxes can affect the population size of the hares. What might happen if there were very few hares? It would then be difficult for lynxes to find and catch enough food to survive. Many lynxes would die of starvation. In this way, the population size of hares can affect the population size of the lynxes.

2-1A The Ups and Downs of Living Together

Think About It

In northern Canada, the main prey of the Canada lynx is the snowshoe hare. Snowshoe hares eat plants. How might an increase in the population of plants affect the hares? How might an increase in the population of hares affect the number of lynxes? When the number of predators increases, what effect might that have on their prey?

In this activity, you will analyze some actual data on populations of hares and lynxes. Use what you already know about predator–prey relationships to interpret the pattern shown by this data.

What to Do

1. The following table shows the approximate numbers of lynxes and hares caught by trappers each year over a period of 20 years. Plot this data, showing both lines on the same graph, and then answer the questions.

Year	Approximate Number of Hares Trapped	Approximate Number of Lynxes Trapped
1900	30 000	4 000
1901	47 000	6 000
1902	70 000	10 000
1903	77 000	35 000
1904	36 000	59 000
1905	21 000	42 000
1906	18 000	19 000
1907	21 000	13 000
1908	22 000	8 000
1909	25 000	9 000
1910	27 000	7 000
1911	40 000	8 000
1912	57 000	12 000
1913	77 000	20 000
1914	52 000	46 000
1915	20 000	51 000
1916	11 000	30 000
1917	8 000	16 000
1918	15 000	10 000
1919	16 000	10 000
1920	25 000	9 000

What Did You Find Out?

1. Describe the pattern shown by the population of
   (a) hares
   (b) lynxes.
2. Explain why changes in the lynx population appear to follow changes in the hare population.
3. How can a predator species control the population size of its prey?
4. How can a prey species control the population size of its predator?
5. What might happen to the number of lynxes if the plants in the ecosystem became rare? Explain your answer.
6. Use the pattern shown in the graph to predict the probable size of each population in 1945.
7. Do you think that using the numbers of animals trapped is an accurate method of estimating population size? What other factors might affect the numbers of animals trapped?
8. The northern habitat where these data were collected has relatively few different species. In other ecosystems, such as a forest, the populations of different species do not usually fluctuate so much. Suggest a reason for this.

Checking Concepts

1. Give two examples of an interaction between two abiotic parts of the environment.
2. Give two examples of an interaction between an abiotic and a biotic part of the environment.
3. What is the difference between parasitism and mutualism?
4. What is the difference between a parasite and a predator?
5. Explain how a growing population of owls might affect the number of mice in their ecosystem.
6. (a) Graph the following data on the moose population in one of Canada's national parks.

Year	Number of Moose
1971	35
1972	52
1974	95
1978	184
1979	192
1984	186
1989	212
1995	295
2000	265

(b) Wolves are natural predators of moose. Would you expect to see the same pattern of population change for the wolf population? Why or why not?

Understanding Key Ideas

7. Consider each of the following pairs of organisms and name the type of symbiotic relationship the partners might have. What are the benefits or disadvantages for each partner?
   (a) a flowering plant and a bee
   (b) a dog and a flea
   (c) a barnacle and a whale

Pause and Reflect

What is the relationship between bees and people? What effect might a decline in the population of bees have on people?

2.2 Roles of Organisms in Ecosystems

Animals obtain their food from the biotic environment by consuming other organisms. They are called consumers. Plants produce their food from the abiotic environment by the process of photosynthesis. They are called producers. Waste and dead matter are a source of food for scavengers and decomposers.

Key Terms

carnivores
consumers
decomposers
fermentation
herbivores
omnivores
producers
scavengers

Figure 2.10 What role does each of these animals have in an ecosystem? Which animals have similar roles?

Animals must eat in order to survive. **Herbivores** are animals such as moose and hares that eat only plant materials. **Carnivores** are animals such as owls and spiders that eat only other animals. **Omnivores** are animals such as bears and chickens that eat both plants and animals.

The food that each organisms eats is more than a matter of taste. Feeding relationships give scientists a way of classifying different organisms according to their role or niche in an ecosystem. For example, the shark, owl, and spider in Figure 2.10 all hunt other animals for their food. Although they are very different species, they all have the role of carnivore. The moose, hare, and grasshopper all have the role of herbivore.

Word Connect

Photosynthesis is the process that green plants use to trap the sun's energy to make food. It comes from the words *photo*, meaning "light" and *synthesis*, meaning "to make by combining different things."

Consumers and Producers

Another way of classifying organisms is to consider *how* they obtain their food from the environment. Whatever animals eat, they must get their food from the biotic environment by consuming other organisms. Because of this, animals are called **consumers.**

In contrast, plants can produce their own food from the abiotic environment. They use energy from sunlight, carbon dioxide from the air, and water from the soil to make sugars, as shown in Figure 2.11. Because they produce their own food, rather than consuming other organisms, plants are called **producers.**

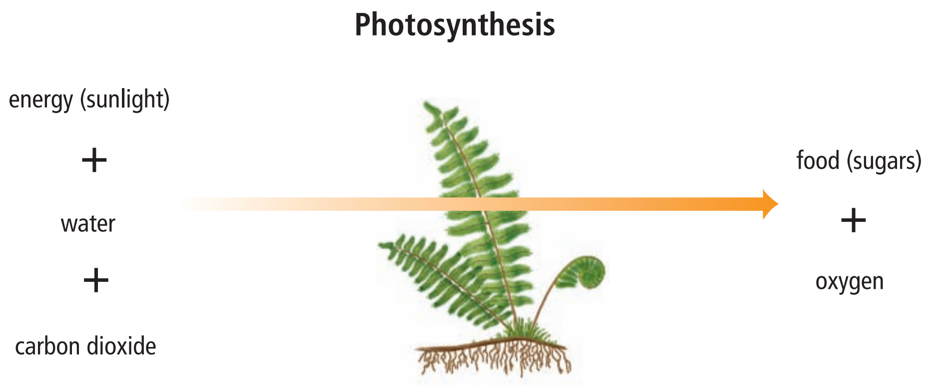


Figure 2.11 Plants make their own food by the process of photosynthesis, using materials from the abiotic environment. Food is not the only product of photosynthesis. Oxygen gas is another product. Plants give off oxygen gas into the air. Nearly all other living things depend on this oxygen to survive.

Scavengers and Decomposers

After animals have eaten, they produce waste matter made up of undigested parts of their meal. What happens to this waste matter? What happens to the bodies of animals and plants after they die? Why do we not see great piles of waste matter and dead bodies in ecosystems?

Did You Know?

The larvae of dung beetles, like the one shown below, feed on animal wastes. A species of dung beetle introduced to Texas in the 1970s is estimated to remove 80 percent of the cattle droppings in some areas.

The answer to these questions lies in a third group of organisms, whose role is to clean up these materials. **Scavengers** are animals such as vultures and dung beetles that eat decaying animals and waste materials. The turkey vulture in Figure 2.12 has a bald head, which is easier to keep clean after this bird has stuck its beak into a carcass to feed. Dung beetles dig burrows under animal droppings and lay their eggs there. Their larvae feed on the dung. Other scavengers include houseflies, crows, and some species of gulls.

Figure 2.12 Vultures such as this turkey vulture are scavengers that feed on dead animals.

Figure 2.13 Fungi are decomposers that help to break down this rotting tree stump.

Decomposers are organisms that break down dead and waste materials into their basic parts. Decomposers include many species of microscopic bacteria and fungi. They do not eat their food as scavengers do. Instead, they release chemicals that break apart dead tissues and cells. Then the decomposers absorb the nutrients into their own cells. The fungus growing on a rotting log in Figure 2.13 is a common example of a decomposer.

Suggested Activitiy

Investigation 2-2C on page 46.

Reading Check

1. What do herbivores eat?
2. What do carnivores eat?
3. What is the role of producers?
4. What are decomposers?

Decomposers and Food

Have you ever forgotten a sandwich in a locker for a few days, only to discover it later covered with green or black mould? Or perhaps you have found smelly milk or slimy lettuce leaves in your refrigerator. When our food begins to "spoil" or "go bad" it is because bacteria, fungi, or other decomposers are feeding on it. They are using *our* food as *their* food!

From the beginning of human history, people have looked for ways to protect food from decomposers. This can be done in two ways:

- by keeping micro-organisms out of it; and
- by killing or slowing the growth of micro-organisms that are already on it.

Keeping Micro-Organisms Out of Food

Decomposers can be found everywhere: in the soil, in water, in the air, and on the surface of objects, including your skin. That is why it is important to wash your hands and to have a clean countertop and use clean utensils when preparing food. Micro-organisms can be kept out of stored food by keeping it well covered, or in a sealed container.

2-2A Food Preservation

Think About It

In this activity, you will think about some of the many ways that people have invented to keep micro-organisms from feeding on our food.

What to Do

1. Make a three-column table with the headings "Food Product", "Preservation Method", and "How It Works".
2. Look at the food products in the picture. A different method of preserving each food is used to protect it from micro-organisms. Fill in the table based on what you know or can infer about each food product. If you are not sure, write "research needed" for that food product.
3. When you are done with the table, do research for each product you were not sure about.

Figure 2.14 In the 1960s, the majority of salt cod produced in Newfoundland was packed in barrels.

Preventing the Growth of Micro-Organisms

Canning, vacuum packing, freezing, freeze-drying, and radiation are all fairly recent methods of preserving food. Canning and vacuum packing keep out air. Freezing keeps out warmth and removes moisture. Freeze-drying removes moisture, and radiation kills micro-organisms.

Few micro-organisms can survive without moisture. Drying food is a traditional preservation method that has been used for many centuries. Some fruits were dried simply by leaving them in the sun. For example, dried grapes become raisins and dried plums become prunes. Meat and fish were cut in thin strips and hung to dry. Sometimes, they were hung in the smoke from a wood fire, which added flavour to the meat.

Figure 2.14 shows barrels of salted cod from Newfoundland. Salting is a very old method of preserving food. Salt draws moisture from cells. The resulting lack of moisture prevents decomposer micro-organisms from growing. Sugar has a similar dehydrating effect. It is used to preserve such products as candied fruit.

Another old method of preserving food is pickling. The simplest method of pickling vegetables is to place them in vinegar. Vinegar is an acid in which few bacteria can survive. Most of the pickled vegetables sold in stores are preserved in this way. Herbs and spices are added to the vinegar to improve the flavour of the vegetables.

A second method of pickling is to soak vegetables in brine (a strong salt solution). Desirable bacteria that can live in brine carry out fermentation and produce lactic acid, which prevents the growth of undesirable bacteria. Foods preserved by pickling include dill pickles, sauerkraut, kimchee (pickled cabbage), and silage (pickled plant material used to feed cattle).

Did You Know?

Workers who built the Great Wall of China over two thousand years ago ate sauerkraut, a kind of fermented cabbage.

Micro-Organisms That Make Food

Did you ever look at the list of ingredients on a container of yogurt or sour cream? It usually includes: "bacterial culture." Many types of micro-organisms are used in processes that help produce certain types of food.

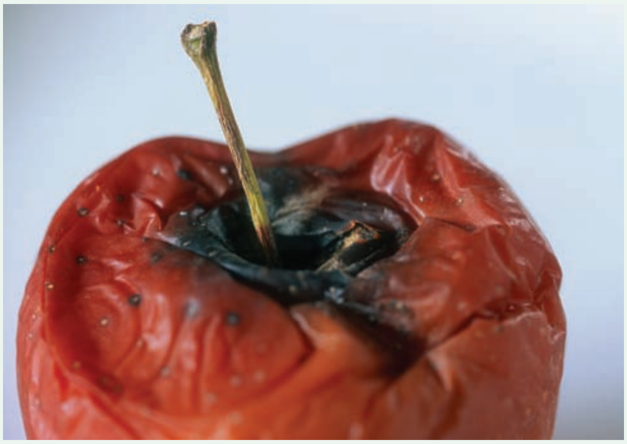
For example, yeasts are single-celled fungi that are carried through the air by wind. When yeast cells land on something sugary, such as soft fruit, they start to feed on it. As they break down the sugars, they produce alcohol and carbon dioxide gas. This process is known as **fermentation.** It is used to make such products as beer, wine, bread, cheeses, pickled vegetables, and some sausages.

Word Connect

The word fermentation comes from the Latin word, *fermentare,* meaning "to foam or rise by bubbling."

2-2B Defending Against Decomposers

Decomposers play a vital role in ecosystems by breaking down waste and dead matter. Stored foods such as fruits, vegetables, grains, meat, and fish are materials that micro-organisms normally would start to decompose. In this activity, you will research ways that people have developed to help preserve stored foods and delay or prevent decomposition.



What to Do

1. Read the list of ideas for research projects given in step 3. Make a brief proposal of the project you wish to do, using these suggestions or an idea of your own. With your teacher's approval, carry out your project and make a presentation to the class.
2. Your presentation can be in the form of a display, collage, demonstration, or other technique. It must include some information about the link between methods of food preservation and the conditions needed by micro-organisms to grow and reproduce.
3. Project suggestions:
   - Compare methods of food preservation in the past and present.
   - Conduct a test to determine which preservation technique is best for preserving a perishable food item.
   - Research how food is preserved for shipping from other countries to supermarkets in your province.
   - Report on the history of food preservation and describe the effect of new technologies.
   - Interview a health inspector about the links between food preservation, micro-organisms, and food poisoning.

What Did You Find Out?

1. How is food preservation related to the role of decomposers in ecosystems?
2. Are decomposers harmful or helpful to humans? Explain your answer.
3. Why do people still use methods of food preservation that are hundreds of years old when new techniques have been developed?

2-2C The Dirt on Decomposers

Skill Check

- Observing
- Predicting
- Controlling Variables
- Interpreting Data

Safety

- Do not handle the soil with bare hands.
- Dispose of soil and vegetable matter as directed by your teacher.

Materials

- 2 identical large plastic pots (approx. 750 mL) with drainage holes
- saucers to go under pots
- pieces of window screen or similar mesh
- magnifying glass
- small stones
- labels for pots
- garden soil (not sterilized)
- sterilized soil
- water
- measuring cup
- approximately 500 mL of waste vegetable matter such as peels from carrots, apples, or potatoes, or leaves from cabbage or lettuce

Most decomposers are microscopic and cannot be seen with the naked eye. However, you can see the results of their work in this activity!

Question

How do different variables affect the activity of decomposers?

Procedure

1. Based on what you know about decomposers, predict what will happen to waste vegetable matter when buried in
   (a) garden soil.
   (b) sterilized soil. (Soil has been sterilized by placing it in a hot oven to kill any organisms in it.)
2. Work in small groups. Place each pot on a saucer and put a few small stones over the drainage holes in each pot.
3. Add garden soil to one pot until it is about half full. Add the same amount of sterile soil to the second pot. Label each pot.
4. Place half of the vegetable matter in each pot.
5. Cover the material in each pot with more garden soil or sterilized soil as appropriate until the pots are nearly full.
6. Estimate the volume of water you can add to each pot before water begins to empty from the drainage holes. Measure this volume into a measuring cup. Add the same amount of water to each pot.
7. Cover both pots with a piece of window screen.
8. Place the labelled pots in a secure location where they can remain for three or four weeks. Moisten the soil every few days if necessary, adding the same amount of water to each pot.

9. After a week, remove the uppermost layer of soil and observe the condition of the vegetable matter in each pot. Use a magnifying glass. Record your observations. Replace the soil.
10. Continue your observations until there is a clear difference between the vegetable matter in the two pots.
11. Wash your hands thoroughly after completing each part of the experiment. Clean up your work area as your teacher directs.

Analyze

1. Did either of the samples have little or no sign of decomposition? Suggest why.
2. Did your observations support your hypothesis in step 1? Explain.
3. What variables were controlled in this activity? What was the responding variable?

Conclude and Apply

4. What factors might speed up the decomposition of the materials you studied?
5. What factors might slow down the decomposition of the materials?
6. Based on this activity, design an experiment to observe the effect of one of the following variables on the growth of micro-organisms: temperature, moisture, light, acidity, or salinity. Outline your materials and procedures, using diagrams if necessary.

Career Connect

Professor of Environmental Design

There is no job description for what Professor Tang Lee does, but everything he does relates to sustaining the health of the planet and its inhabitants. As an architect and a Professor of Environmental Design, he teaches and conducts research into topics such as indoor air quality and sustainable building design. He is often called on to give expert testimony in court and to be interviewed on radio and television. As well, he is also a co-owner and operator of a tilapia, fish farm.

Q. What is sustainability?

A. It can be as simple as conducting our lives so that we don't adversely affect future generations. There are many different definitions. You can sustain health, energy resources, food. To my mind, it is all of the above.

Q. Why do you run a fish farm?

A. I look at the oceans being over-fished, and it's destroying water ecosystems. And there's so much pollution being dumped into the ocean—heavy metals, like mercury, cadmium, and lead. … I worry about the health of my children and grandchildren. To make a long story short, I decided to raise fish in a way that does not deplete the oceans—in a way that does not use chemicals, and hormones, and antibiotics, which of course go up the food chain.

Q. How do you operate your fish farm?

A. Lots of fish farms have what's called a flow-through system, which means they take water out of the river and put it through the tank. Waste from the fish and uneaten fish food gets discharged (untreated) into the river. We don't do that. We have a greenhouse, and so the wastewater is put in a hydroponics system as well as soil culture. To make the soil culture we grind up any dead fish and mix this into the soil. We have beautiful compost that we donate to the garden clubs!

We only bring in about 10 percent of the water we use to replace water lost to evaporation, spillage, and so forth. And because of this, we don't discharge large amounts of nutrients downstream. We have equipment and the hydroponics system to filter the water. We also have a constructed wetland on our site, which does the final polishing. After the water goes through the wetland, it's completely clear. Nature is incredible in terms of how it can purify, as long as we don't overload the system.

Q. You also design solar-powered buildings. What motivates you to do this?

A. We live in a privileged period of civilization in which we have fossil fuels to consume. The future is going to be different. … We're not going to be able to use, in the same way, fossil fuels for heating, cooling, and powering our buildings, or for transportation.

Q. What keeps you in a positive frame of mind?

A. I'm hopeful because there are people who are working toward renewable energies, like solar and wind, different types of planning systems, and new types of vehicles. … We see a lot of what we call ecovillages springing up, in which communities are trying to be as self-sufficient as possible.

Checking Concepts

1. What is the role of spiders, cats, and owls in an ecosystem? Name one other animal that has the same role.
2. Classify each of the following as either a producer or a consumer: dandelion, robin, grass, grasshopper, butterfly, cod, algae, spruce, spruce budworm, lobster.
3. Explain what happens to the remains of a moose that dies of natural causes deep in the woods.
4. Name three places where you might find decomposers.
5. If you leave a plum and a prune on your kitchen counter for several days, which will decompose first? Why?
6. Name a food produced by fermentation.
7. Identify the role being performed by each of the organisms shown.

(a)

(b)

(c)

Understanding Key Ideas

8. Are you a producer or a consumer? Explain your answer.
9. Are you a carnivore, herbivore, or omnivore? Explain your answer.
10. How does the method of food preservation shown below prevent the growth of micro-organisms?

11. One day you throw some potato peels into a composter. Two weeks later there is no sign of them. What has happened?

Pause and Reflect

What would happen if all the decomposers in the world suddenly disappeared?

2.3 Food Chains, Food Webs, and the Transfer of Energy

Energy from sunlight is used by plants to make food. Some of this energy is transferred to the animals that eat the plants. Energy in these animals is transferred to the carnivores that eat them. These links form food chains and food webs. Energy is lost at each step in a food chain.

Key Terms

energy pyramid
food chain
food web

Eating is a process that transfers energy from one organism to another. This transfer takes place, for example, when you eat an apple, when a frog eats a worm, and when a moose eats a water lily. Animals consume food in order to get the energy they need to carry out their daily activities. For example, you need energy to ride a bicycle, to shovel snow, and also to breathe and grow.

Food Chains

You can get energy by eating an apple, but where does the apple get its energy? Apple trees, like all plants, trap energy from sunlight to produce sugars, as you learned from Figure 2.11. Some of the stored energy in plants passes into the bodies of organisms that eat the plants (Figure 2.15). In turn, some of the energy in these organisms passes into the bodies of the animals that eat them. This transfer of energy from organism to organism can be illustrated in a model called a **food chain,** as shown in Figure 2.16.

Figure 2.15 Eating transfers energy from the water plants to the moose.

The Roles of Organisms in Food Chains

On page 41, you learned about the roles of producers and consumers in ecosystems. Look at the three food chains in Figure 2.16. Can you see any pattern in the position of producers and consumers in each food chain? Can you see a pattern in the position of herbivores and carnivores?

Because producers are the only organisms that can make their own food using the energy of sunlight, all food chains begin with a producer. Producers include green plants, algae and some micro-organisms.

The second link in all food chains consists of the consumers that eat producers. These are known as herbivores or primary consumers. Herbivores come in all shapes and sizes, from leaf-eating insects to blue whales and elephants.

The third link in all food chains is the consumers that eat other consumers. These are known as carnivores or secondary consumers. Carnivores range from dragonflies and spiders to wolves and sharks.

Food chains may have four or more links. These places are filled by carnivores that eat other carnivores. For example, a hawk can eat a snake that has eaten a frog that has eaten a worm. In all food chains, the energy flows from the producers to the consumers, and from the herbivores to the carnivores.

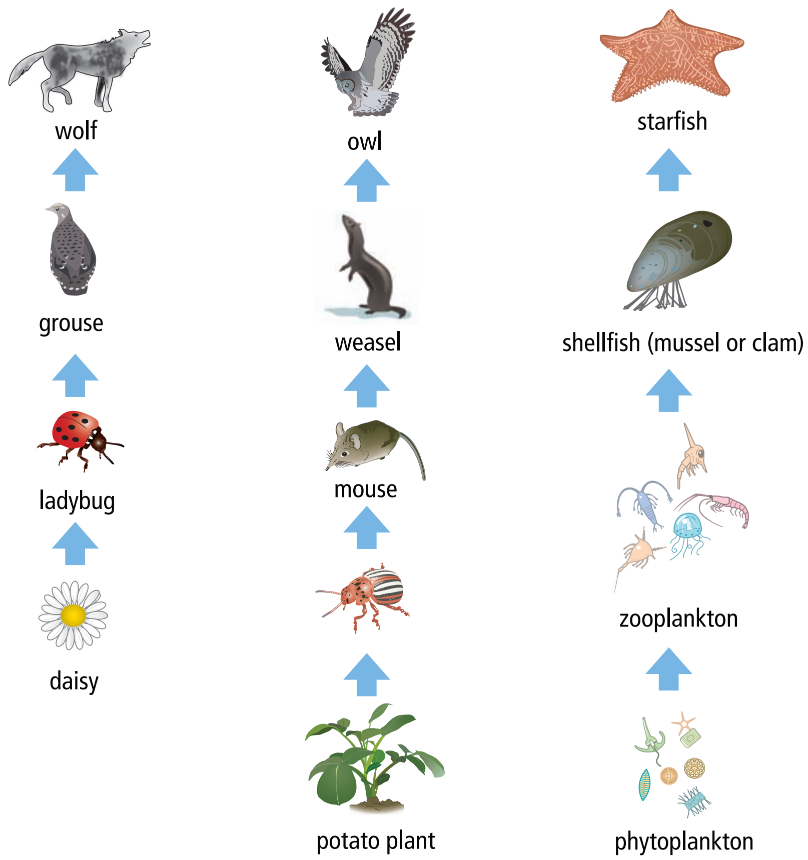


Figure 2.16 Three examples of food chains found in different ecosystems in Newfoundland and Labrador. The arrows show the direction in which energy passes from organism to organism.

2-3A Eating at the Copepod Café

Find Out ACTIVITY

Copepods are tiny shrimp-like animals. They are an important source of food for many animals living in oceans and estuaries, such as herons and fish. In this activity, you will play a game that models a food chain in an estuary.

Materials

- 20 strips of cloth, 30 cm long (10 of one colour, 10 of a different colour)
- 1 large plastic self-sealing bag per student
- 4–5 L of popped popcorn or foam "peanuts" used for packing
- stopwatch
- whistle

Safety Precautions

- Do NOT eat the popcorn you use in this activity.
- This activity involves tagging people as you play the game. Be sure to tag people gently.

What to Do

1. Before you start the game, copy the following tables into your science notebook. Give your table a title.

Number of Live Organisms			
	Copepods	Fish	Herons
Trial 1			
Start of game (0 min)			
After 1 min			
After 2 min			
After 3 min			

Number of Live Organisms			
	Copepods	Fish	Herons
Trial 2			
Start of game (0 min)			
After 1 min			
After 2 min			
After 3 min			

2. Your teacher will divide your class into three groups of equal size: copepods, fish, and herons. Students representing copepods will each tie a strip of one colour around their arms. Students in the fish group will wear strips of the second colour. Students who are herons will not wear armbands.
3. On your school playing field or in the gym, mark off an area to represent an estuary. Spread popcorn throughout this area.
4. Play the game as follows:
   (a) Spread out over the "estuary."
   (b) When your teacher blows the whistle, the copepods begin to "eat" microscopic organisms (popcorn) by picking them off the ground one by one and putting them in their "stomachs" (plastic bags). After 30s, once the copepods have some food in their stomachs, your teacher will blow the whistle again. The copepods stop feeding and stand still.
   (c) When your teacher blows the whistle a third time, everyone will begin to eat:
   - Copepods continue to "eat" the popcorn.
   - Fish "eat" copepods by tagging them and transferring the contents of the copepods' plastic bags into their own plastic bag.
   - Herons "eat" fish by tagging them and transferring the contents of the fish's plastic bags into their own plastic bag.

When you have been eaten, you are out of the game. After you have given the contents of your bag to the predator that tagged you, wait on the sidelines.

(d) After 1 min, your teacher will blow the whistle. Stop where you are. Count and record the numbers of copepods, fish, and herons that are still alive.

(e) When your teacher blows the whistle, continue to hunt for food until the whistle sounds again after 1 min. Stop where you are. Count and record the numbers of copepods, fish, and herons that are still alive. Repeat the procedure one more time.

5. Play the game for a second trial, but this time with different numbers of students in each group. Use the ratio of 1 heron to 3 fish to 9 copepods. For example, if there are 26 students, there will be 2 herons, 6 fish, and 18 copepods.

Analyze

1. Compare the starting populations of copepods, fish, and herons in Trial 1 and Trial 2. Which trial is closer to the situation found in nature? Explain your answer.
2. Predict what might happen to all three populations if the food supply for copepods was reduced by one half.
3. Suppose that there were no fish in the estuary. What might happen to
   (a) the copepod population?
   (b) the heron population?
4. Suppose this model included other species, forming an estuary food web. What effect might this have?

Food Webs

Every organism (including you) is part of a food chain. But feeding relationships in an ecosystem are rarely as simple as single food chains. Most consumers eat, and are eaten by, more than one kind of organism. For example, a mouse eats grasses, bulbs, seeds, flowers, and sometimes insects. Mice, in turn, are eaten by foxes, coyotes, owls, hawks, mink, and snakes!

The interconnection of several different food chains produces a more complex model of feeding relationships called a **food web.** Figure 2.17 shows a typical example of a food web. The arrows indicate the transfer of energy among organisms. Notice how the energy can follow a number of different paths from a particular producer through various consumers.

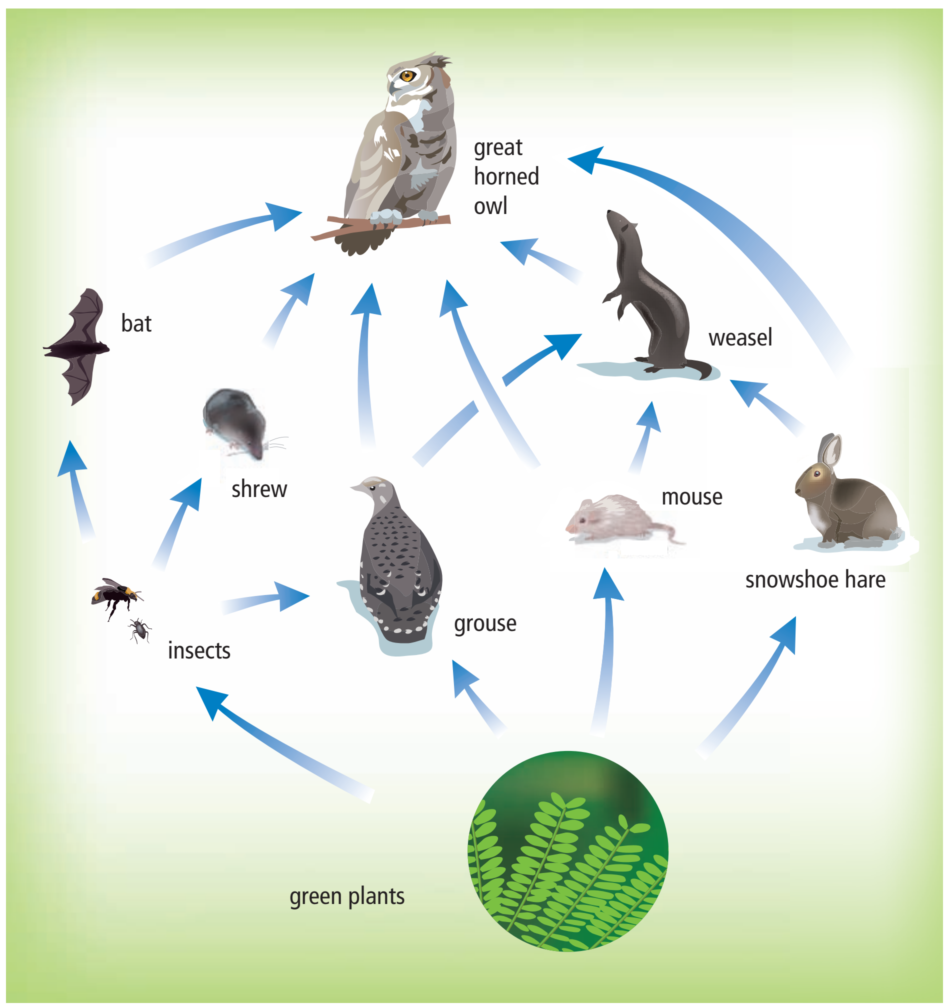


Figure 2.17 A food web shows how energy is transferred from one organism to other organisms in an ecosystem.

Energy Transfer

What happens to the energy in the food you eat after the food enters your body? If you eat a meal with a mass of 100 g, does your body mass increase by 100 g? To answer these questions, you need to consider that energy exists in different forms. Some energy is stored in the bodies of organisms. For example, the fat in your body contains stored energy. Other energy is used to carry out life processes, such as respiration, growth, and movement. This energy is not stored but passes out of the body as heat or waste gases.

The energy in your food consists of the stored energy in the plant or animal that you are eating. You use most of this energy for life processes. Only a small amount becomes a part of your stored energy. Figure 2.18 illustrates this, using a moose eating plants as an example.

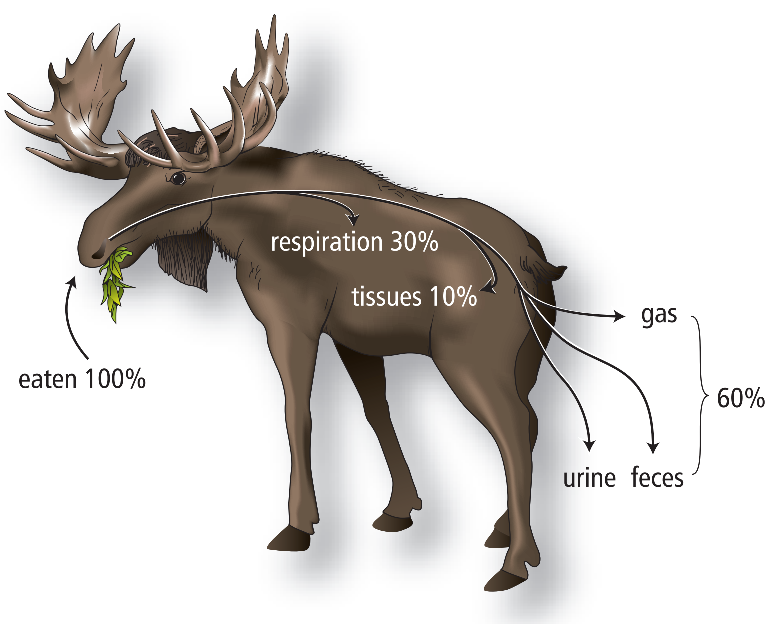


Figure 2.18 Only about ten percent of the energy stored in the plants eaten by a moose eventually becomes stored energy in the moose.

Notice that respiration uses about one third of the energy in the moose's food. All cells in the body carry out respiration. This process releases the energy that the body cells use to grow, reproduce, repair tissues, and produce materials needed by the body.

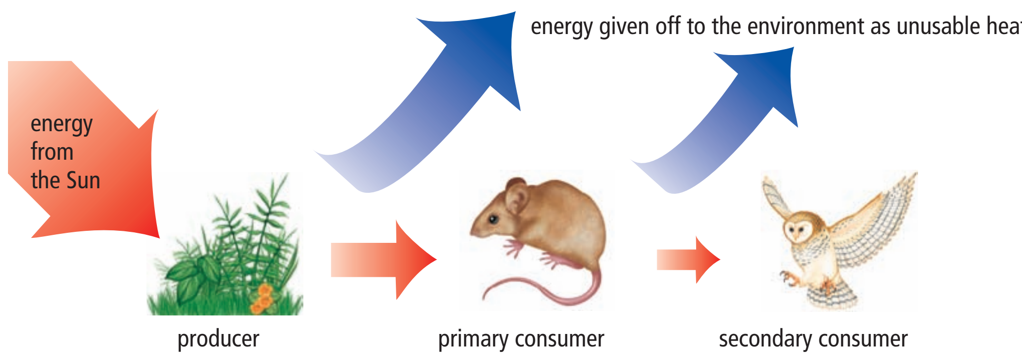
About 60 percent of the energy in the moose's food leaves the moose in waste matter. Only about ten percent is stored in the moose's body. You can see from this example that most of the energy in the plants that the moose eats is not passed on to the next animal in the food chain.

Energy Pyramids

How might the transfer of energy through ecosystems affect the populations of organisms at different links in a food chain? Since only a small amount of the energy in food is passed from organism to organism, there is less energy at the top of a food chain (the last consumer) than there is at the beginning (the producer).

The largest amount of food energy in an ecosystem is always found in the first link, in the producers. On average, only about ten percent of the energy in producers is transferred to the second link, the herbivores. In turn, only about ten percent of the food energy in the herbivores is transferred to the next level, the carnivores. At each level, most of the energy is lost from the food chain, as shown in Figure 2.19.

Figure 2.19 Energy is lost as unusable heat from metabolic processes at each link in a food chain. Therefore, less energy is available to the next organism in the food chain.



Ecologists model the gradual loss of energy in food chains as an **energy pyramid,** like the one in Figure 2.20. Because there is less energy available to organisms at each link in a food chain, the animals at the top of a food chain are generally less numerous than those below them. You can make an energy pyramid yourself in the next activity.

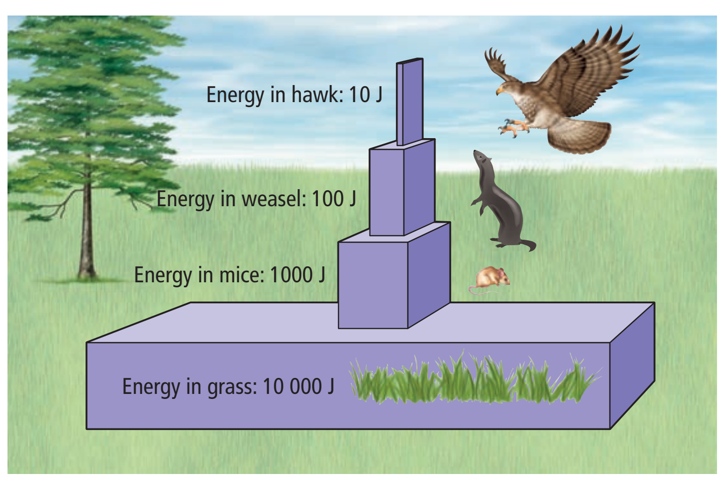


Figure 2.20 Above is a typical energy pyramid. There is a decrease in the total energy available to organisms at each level up the food chain.

Reading Check

1. Draw a food chain with the following organisms in the correct order: hawk, mouse, snake, and berries.
2. What is the difference between a food chain and a food web?
3. What does an energy pyramid show?

2-3B Riddle of the Pyramids

Think About It

Energy is transferred along a food chain when one organism consumes another. When this happens, only about ten percent of the energy is transferred to the consumer. A pyramid of energy shows the different amounts of energy available at each feeding level in the food chain.

Materials

- pencil
- ruler
- scissors
- large sheet of blank paper

What to Do

1. The sheet of paper represents the total energy found in a population of producers at the base of a food chain. Mark off the sheet into ten rectangles of equal size.
2. Cut out one of the rectangles. This represents the energy available to the population of primary consumers in the food chain.
3. Divide the rectangle into ten pieces of equal size.
4. Cut out one of the pieces. This represents the energy available to the population of secondary consumers in the food chain.
5. Arrange your three pieces of paper into a pyramid. Use this model to draw an energy pyramid in your notebook. Label each level in the pyramid. Write the name of an organism you might find at each level.

What Did You Find Out?

1. Why do you think there are fewer numbers of individual organisms at each level up a food chain?
2. Why do you think there are usually not more than three or four links in most food chains?

wheat plant (producer) | mouse (primary consumer) | weasel (secondary consumer)

Science Watch

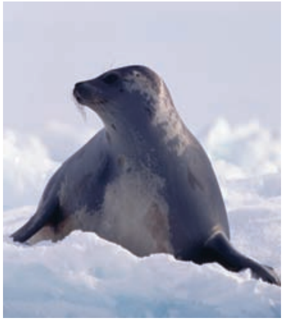
Fisheries and Ecosystems

The Atlantic cod fishery began in the 1500s, when explorer John Cabot reported huge numbers of cod in the waters off the island of Newfoundland. There were so many, in fact, that an empty bucket lowered into the water could be pulled back up full of fish! For 500 years, the cod stocks surrounding Atlantic Canada continued to be a rich resource for the fishing industry. At its peak during the 1960s, the industry brought in almost two million tonnes of cod per year! The ocean ecosystem, however, could not support high levels of fishing forever. Between 1984 and 1992, northern cod hauls fell from around 39 000 tonnes to less than 12 000 tonnes.

What caused the numbers of cod to fall so low? Scientists have studied biotic and abiotic factors within the ecosystem to determine the reason for the decline. The main problem was the overabundance of a top predator within the food chain: humans. People were simply catching too many cod. The number of fishing boats off the coast had grown considerably since the industry began, and people were using better techniques that allowed them to catch huge numbers of cod. Large *trawlers*, or fishing boats that drag nets through the water to scoop up the catch, even had fish factories on board to freeze and package the fish while at sea. Cod were called the "Newfoundland currency" because of their economic importance to the region.

Scientists studied the rest of the food chain as well. Cod are carnivores in the middle of the food chain, filling the role of both predator and prey. Young cod feed on small *crustaceans*, or shellfish, and other animal plankton. Juveniles eat shrimp, shellfish larvae, small crustaceans, and small fish. Adults feed on an even wider variety of organisms, including jellyfish, capelin, flounder, herring, and other fish, as well as shrimp, crabs, and other shellfish. Since the cod are not dependent on only one species for food, they have the ability to survive when one form of prey is not abundant. However, some scientists believe that declines in the number of capelin and other prey species have put additional pressure on the cod stocks.

Predators of cod include seals, whales, squid, seabirds, and other fish such as haddock and mackerel. Harp seals not only act as predators, but as competitors, since they also feed on capelin and other cod prey. If seals are present in large numbers, they can affect the cod population. Government restrictions on seal hunting may have provided an opportunity for greater competition and predation. The Atlantic Seal Research Project was begun in 2003 to address this concern.



Questions

1. Use the information given in the text to draw a food chain.
2. What abiotic factors could affect the cod population?
3. What would happen to this ecosystem if the entire cod stock died off?
4. Do some research to find out
   (a) what the government has done to help rebuild the cod stocks,
   (b) what the current state of the cod fishery is,
   (c) whether similar regulations are in place for other fish species.

Checking Concepts

1. Place the following three organisms in a food chain: moose, willow, and wolf.
2. Name an omnivore. Draw two food chains to illustrate the feeding relationships of this animal.
3. Why is all the energy in one level of a food chain not available to organisms at higher levels of the food chain?

Understanding Key Ideas

4. What might an energy pyramid look like for the food chain you created in the Science Watch on page 58?

5. Most people eat foods from several levels of a food chain, such as the foods shown in the photograph. Draw two different food chains based on foods you typically eat, which may include some of the items shown. Include at least four levels in one of your food chains.
6. Study the following three food chains that involve humans:
green plants → humans
green plants → cow → humans
green plants → insect larvae → fish → humans
(a) In which food chain is the most energy in green plants lost before it reaches humans?
(b) Which food chain provides the maximum amount of energy for humans? Why?
7. The organisms shown below can be found throughout Canada. They are all members of a single food web. Create as many food chains as you can from this group.

Pause and Reflect

How is every bit of food you eat like eating sunshine?

2.4 Cycles of Matter in Ecosystems

Food contains matter as well as energy. Nutrients are used to build and repair cells and tissues. The only source of the nutrients used by all living things is the matter found on Earth. Nutrients are continuously recycled through the biotic and abiotic environment.

Key Terms

nutrients
nutrient cycles

Food is the source of energy for all living things. Food also contains **nutrients,** such as carbon and nitrogen. Organisms need these materials to build and repair their bodies.

You have learned that the energy needed by living things flows continuously to Earth as sunlight. But where do the nutrients come from? The only sources of nutrients for living things are all on Earth. Producers like the tree in Figure 2.21 obtain nutrients from the soil, water, and air. Consumers obtain nutrients from their food.

Because there is a limited supply of nutrients available for organisms, nutrients are continuously re-used. The processes that move nutrients back and forth between the biotic and abiotic environment are called **nutrient cycles.**

Figure 2.21 This maple tree was once a small seed. All the nutrient materials used to build the trees came from the soil, air, and water.

Reading Check

1. Name two examples of nutrients.
2. What do organisms use nutrients for?
3. What is a nutrient cycle?

Nutrient Cycles

Figure 2.22 shows how nutrients are recycled in a simple nutrient cycle. Starting with the plants, nutrients move through a food chain from one consumer to another. Some of the nutrients quickly return to the abiotic environment in waste matter from these organisms. The rest of the nutrients return when the organisms die.

Decomposers play a key role in the cycle. They break down waste matter and dead organisms. This releases the nutrients into the soil, air, or water. Producers take up the nutrients, which they use to help them grow. The nutrients are now back in the biotic part of the environment and start another cycle.

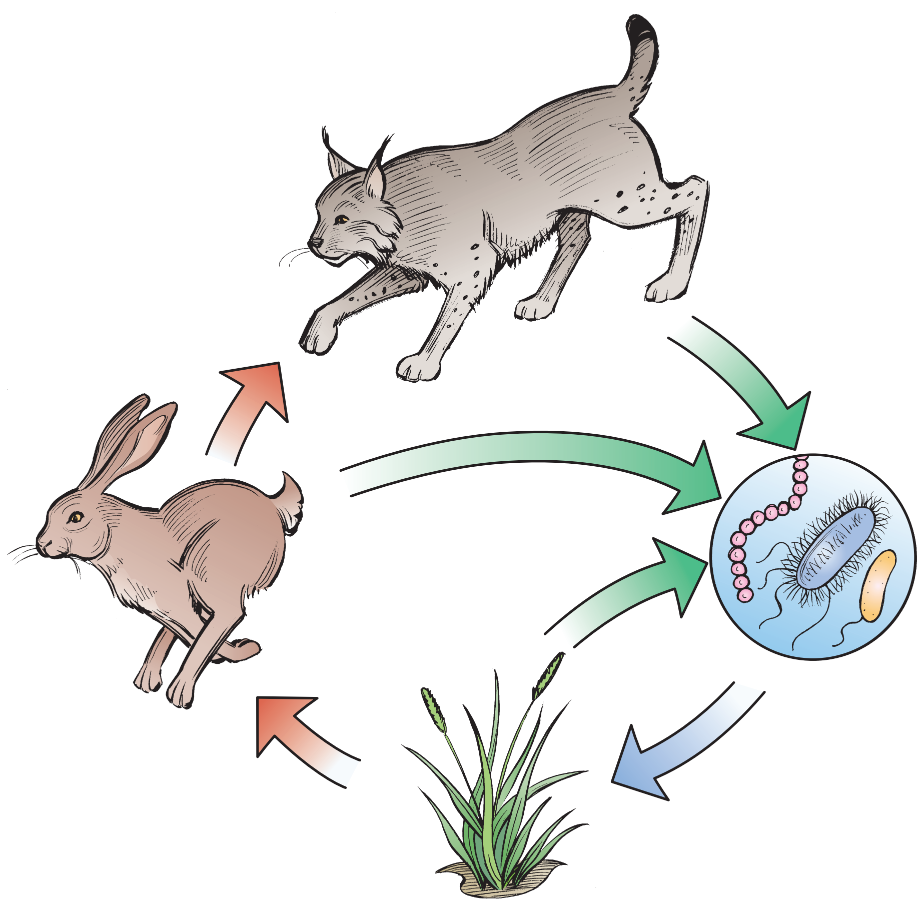


Figure 2.22 Nutrients are recycled between the biotic and abiotic parts of the environment.

Just think about it. All of the basic materials that make up your body were once in another part of the environment. Some were in the soil and water and air. Some were in plants and animals. They have come together to be a part of your body today. In the future they will move on to become parts of something else. Without this continuous recycling of matter, life on Earth would not be possible. In the next chapter you will learn how human activities affect nutrient cycles.

2-4A Round and Round It Goes

Find Out ACTIVITY

You have probably heard the expression: "What goes around comes around." In this activity, you will use a model of the nutrient cycle to illustrate how something that you throw away as waste may eventually become part of your food!

What To Do

1. Work in groups of five. Each person in the group will take one of the following roles:
   - student
   - apple
   - soil bacteria (decomposer)
   - dandelion
   - chicken
2. Each group will have one tennis ball. The ball represents nutrients in the cycle that you will model.
3. Read the following story. Act out the story by passing the nutrient ball from person to person in the order described in the story. Each person will explain their role in the cycle when they receive the ball and when they pass the ball to the next person in the cycle.

THE STORY

After finishing a picnic lunch one day, a student tossed an apple core over a hedge into a meadow. Time passed, and the apple core decomposed. The next spring, some chickens were feeding on weeds in the meadow. Some time later, one of the chickens was made into a chicken pie. The student ate some of the chicken pie for lunch.

What Did You Find Out?

1. Name the producers, consumers, and decomposers in this story.
2. Draw or make a model of a nutrient cycle using the five organisms in the story.
3. Draw two alternative food chains to show what other paths the nutrients in the apple core might have taken through different organisms.

Checking Concepts

1. How do producers obtain nutrients?
2. How do consumers obtain nutrients?
3. What is the role of decomposers in a nutrient cycle?
4. There is only a limited supply of nutrients on Earth. Why doesn't this supply run out?
5. How do the leaves in the picture below contribute to the nutrient cycle?

Understanding Key Ideas

6. One day you notice a dead butterfly by a fence. A week later, you observe that the butterfly wings are still there but the rest of the insect has disappeared. How would you explain this observation?
7. Draw an example of a nutrient cycle including all of the following organisms: mussels, algae, cod, bacteria, and orcas.
8. Suppose a poisonous chemical is spilled into a pond. How might this chemical end up inside the body of an osprey?
9. The farmer in the following picture is using a cultivator to till the soil. Why might this be an important step in growing crops?

Pause and Reflect

What would happen to the nutrient cycles on Earth if organisms did not die?

Prepare Your Own Summary

In this chapter, you investigated how living and non-living things interact in ecosystems. Create your own summary of key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 9 for help with using graphic organizers.) Use the following headings to organize your notes:

1. Symbiosis
2. Producers, Consumers, and Decomposers
3. Food Chains
4. Energy Transfer
5. Nutrient Cycles

Checking Concepts

1. Name three types of symbiotic relationships. Give an example of each.
2. How might a species of prey affect the population size of its main predator? Use a specific example in your answer.
3. Explain the difference between a food chain and a food web.
4. What model do scientists use to show how energy is lost at each feeding level as it moves through an ecosystem?
5. Why is there less energy available to a population of owls than to a population of mice?
6. Why are scavengers and decomposers important in an ecosystem? How do they differ?
7. About how much of the energy in your food is stored in your body? What happens to the rest of the energy in your food?
8. Draw a food web including all the organisms shown below.

9. State the role of each organism in the food web you drew for question 8.

Understanding Key Ideas

10. The following food chain is incorrect: leaves → frog → caterpillar → heron Explain the error and draw a correct version of this food chain.
11. Give an example of a food chain that connects a person to grass.
12. Why must nutrients be recycled in ecosystems?
13. Food chains generally have few large carnivores. Explain why this might be so.
14. Many micro-organisms grow well in an environment with:
    - moisture
    - warmth
    - oxygen
    - non-acidic conditions.

    For each of these conditions, describe a method of preserving food that deprives micro-organisms of an environment that is favourable to them.
15. Imagine you are a nutrient in a blade of grass. Describe the journey you might make through various different organisms and the abiotic environment before you end up in another blade of grass to start another cycle.
16. Some of the following statements are true and some are false. Identify which is which. Rewrite the false statements to make them correct.
    (a) A tick and a deer have a mutualistic relationship.
    (b) A snake is a predator.
    (c) Cod, spiders, cats, and seaweed are all consumers.
    (d) Decomposers are an essential part of the nutrient cycle.
    (e) There is more energy at the top of a food chain than at the base.
17. If you eat a meal with a mass of 500 g, why doesn't your mass increase by the same amount?
18. Lucy digs manure into the soil around her roses. Explain how this helps her roses to grow.

Pause and Reflect

The largest animals on Earth—blue whales—eat plankton, some of the smallest things on Earth. Based on your understanding of food webs and energy loss in food chains, write a paragraph explaining why these animals can grow so large while eating something so small.