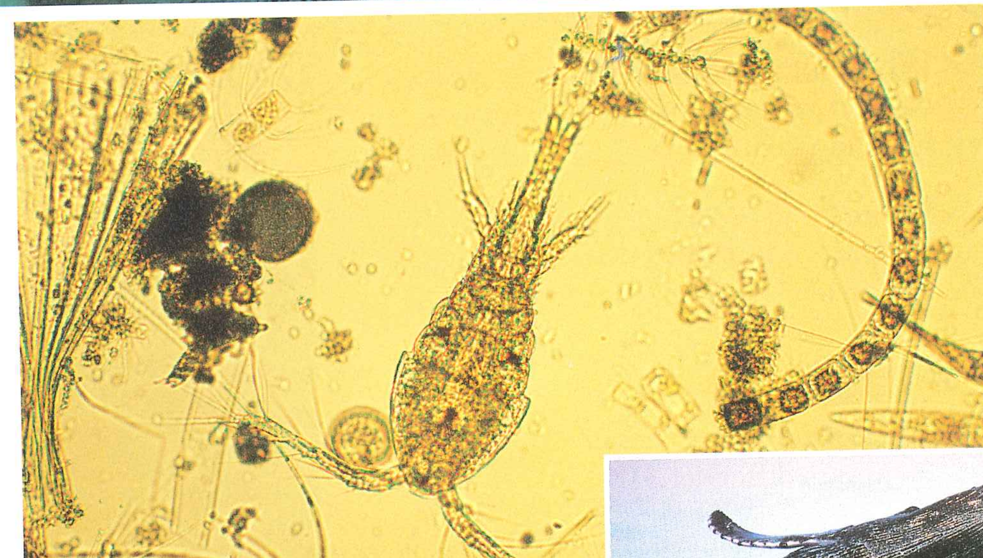
CHAPTER 2

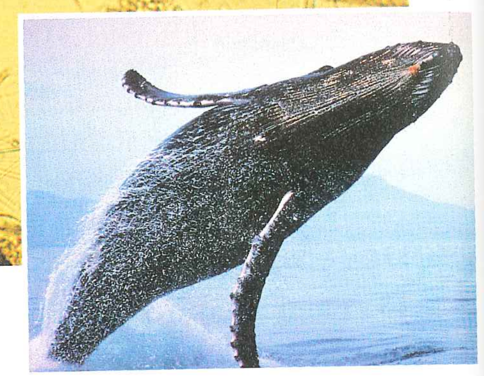
Cycles in Ecosystems

Getting Ready...

- How can plants grow when no one feeds them?
- What prevents dandelions from covering the surface of Earth?
- Why do "vacant" lots never remain vacant?



You need a microscope to see these tiny organisms that drift in the ocean.



This 50 t whale lives on small fish and plankton.

Swimming through the ocean is like swimming through a bowl of vegetable and meat soup. The ocean is filled with tiny floating organisms, shown above, called phytoplankton [fih-toh-PLANK-tuhn] and zooplankton. Without these tiny organisms, there would be no life at all in the ocean. In fact, life on Earth would be quite different. Plankton are food for many of the animals in the ocean. Even giant whales, such as this humpback whale, eat plankton.

Humpback whales were once hunted off British Columbia's west coast. When humpback whales were finally protected in 1966 and the hunting stopped, there were only a few thousand humpback whales left. Today, there are over 125 000. Since people no longer hunt these whales, their population has recovered. Their population will not continue to grow and grow, however. There are only so many humpback whales that an ocean ecosystem can support.

In this chapter, you will explore connections between organisms and what they eat. You will also learn about some of the reasons that the sizes of populations are limited.

What You Will Learn

In this chapter, you will learn

- how plants and animals are interconnected in ecosystems
- how energy is transferred through ecosystems
- what abiotic and biotic cycles occur in ecosystems
- what factors limit the sizes of populations
- how ecosystems change over time

Why It Is Important

- You need living things in order to survive. It is important to learn about the connections between you and other living things.
- Every day, you make choices that affect the environment in which you live. When you understand the connections among organisms in your environment, you can make choices that will not harm your environment.

Skills You Will Use

In this chapter, you will

- infer connections between producers and consumers
- observe the water cycle
- observe and record the food chain of a mealworm
- control variables to determine conditions that affect the growth of plants
- model changes in an ecosystem over time

Every organism in an ecosystem affects the other organisms.

Starting Point ACTIVITY 2-A

Ant Alert

Ants are found all over the world. They have adapted to many different environments. How do ants live? How do they obtain food?

What to Do

1. With a partner, look outside for some ants on the ground or on a sidewalk. Watch the ants for a little while. Look for patterns in their activities.
   - Do the ants ever bump into each other?
   - What happens when they meet a different kind of insect?
   - Do any ants seem to be carrying food?
2. Scatter a few grains of sugar in front of the ants, and **observe** what they do.
3. Now scatter a few pieces of grass, and **observe** the ants.
4. Try different types of food, such as a small piece of meat or cheese, or birdseed.
5. Make some notes that will help you remember what you observed.

What Did You Find Out?

1. Describe the foods that the ants seem to prefer.
2. Did the ants seem to follow a particular path? Explain your answer by referring to your observations.
3. How did the ants behave when they met an obstacle, such as a piece of grass? Explain your answer by referring to your observations.
4. Compare your observations with the observations of other students in your class.

Section 2.1 Food Chains, Food Webs, and Energy Flow

Did you ride your bicycle to school today? Did you play a sport in gym class? Have you ever mowed a lawn or shovelled snow? Do you sleep, breathe, and grow? All of these activities require energy. To obtain energy, you consume food. In this section, you will trace the path of food energy as it is passed from one living organism to another.

Food Chains

A **food chain** is a model that shows how food energy passes (flows) from organism to organism. A food chain begins with a source of energy, which is usually the Sun. Plants trap energy from the Sun. They convert the energy into a form that can be stored in food. Animals eat the plants to obtain this energy. Some animals eat other animals to obtain this energy. Microscopic organisms called phytoplankton (shown on page 34) also trap energy from the Sun and convert it into food. Many of the fish and other organisms that live in the sea depend on phytoplankton for food. Figure 2.1 shows three examples of food chains.

Figure 2.1 In a food chain, the arrows show the direction in which the energy flows from organism to organism. These three food chains exist in ecosystems in British Columbia.

Producers in Food Chains

The plants and phytoplankton in food chains are producers. Producers can make their own food because they contain chlorophyll [KLOHR-uh-fil]. **Chlorophyll** is a green chemical that traps the energy of the Sun. Producers use the trapped energy to make food, in a process called **photosynthesis** [foh-toh-SIN-thuh-sis].

During photosynthesis, the trapped energy is used to convert carbon dioxide gas and water into foods such as sugar and starch. As a result of photosynthesis, oxygen gas is released back into the air. The overall process of photosynthesis is shown in Figure 2.2.

READING Check

How is every bite of food you eat like eating sunshine? Explain your answer.

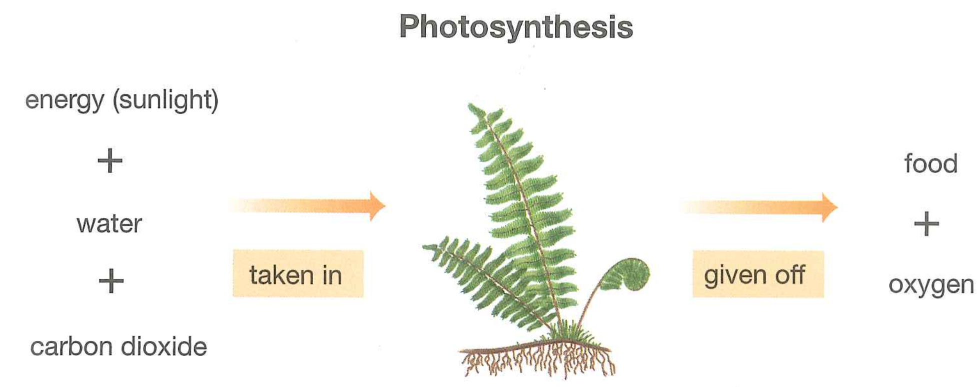


Figure 2.2 Photosynthesis occurs in organisms that contain chlorophyll.

Consumers in Food Chains

Consumers follow producers in a food chain. The carnivore at the end of the food chain is known as the **top consumer**. In the food chains in Figure 2.1, the wolf, the owl, and the sea star are the top consumers.

A consumer's only source of energy is producers or other consumers. A consumer obtains the energy it needs by breaking down high-energy foods, such as sugar and starch, in a process called **cellular respiration**. Cellular respiration occurs inside all living cells. Even plant cells need the energy from cellular respiration when the Sun is not shining.

During cellular respiration, oxygen is used to help break down the high-energy foods. Carbon dioxide, water, and energy are released. The energy is used to carry out all the functions of life, such as growing, repairing tissues, eliminating wastes, breathing, and digestion. The process of cellular respiration is shown in Figure 2.3 on the next page. The relationship between photosynthesis and cellular respiration is shown in Figure 2.4 on the next page.

Pause & Reflect

Aboriginal peoples honour the importance of the Sun. The Nisga'a tell the story of Txeemsim [KLEE-suhm] bringing the Sun to the world. In the village of Hesquiaht, on the west coast of Vancouver Island, one person was responsible for observing the exact spot where the Sun rose on the horizon each morning.

INTERNET CONNECT

www.mcgrawhill.ca/links/BCscience7

Read more Aboriginal stories about the Sun by visiting the web site above. Click on **Web Links** to find out where to go next.

READING Check

Where do humans fit in a food chain? Write a food chain that includes you.

INTERNET CONNECT

www.mcgrawhill.ca/links/BCscience7

Learn more about food chains by trying a quiz, playing a game, or watching a movie. Go to the web site above, and click on **Web Links** to find out where to go next.

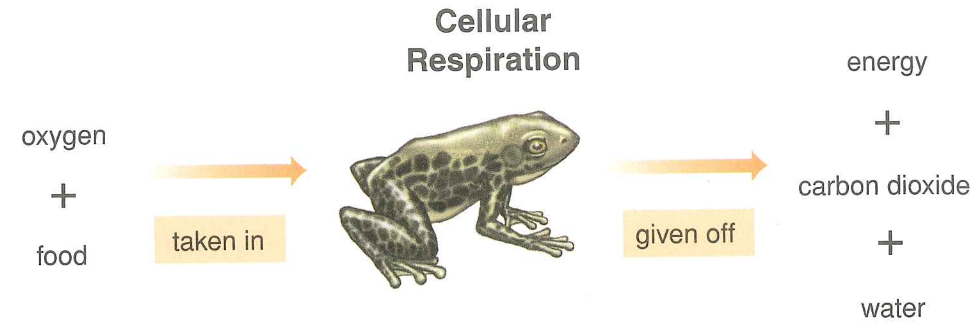


Figure 2.3 Cellular respiration occurs in all living cells. The oxygen that cells use was produced during photosynthesis.

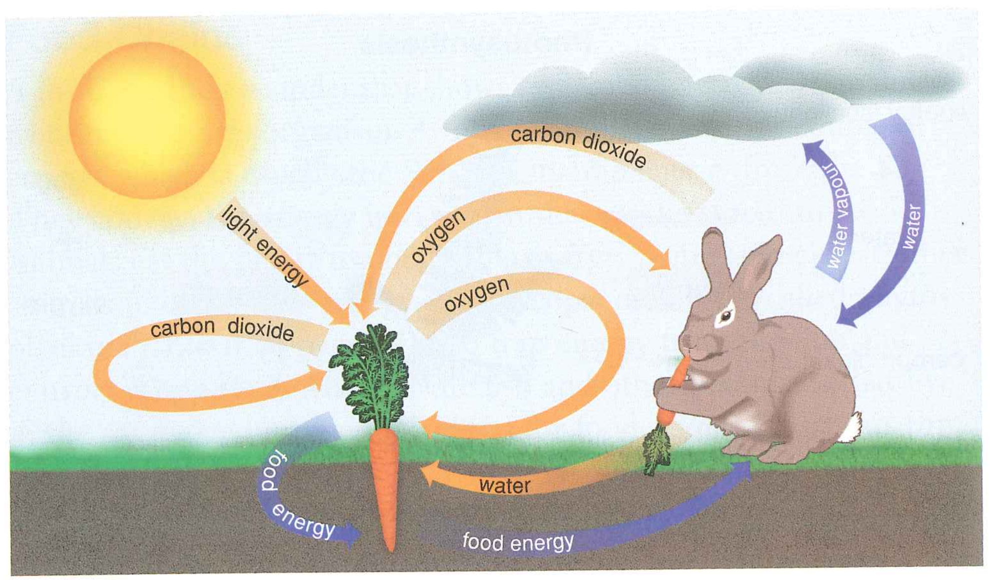


Figure 2.4 Photosynthesis and cellular respiration work together in a cycle.

A Very Special Food Chain

Scientists have discovered that not all producers rely on the Sun for energy. No sunlight reaches the deep ocean yet an ecosystem teeming with life exists 3 km below the surface of the Pacific Ocean off British Columbia's west coast. Water over 370°C bubbles up through deep cracks, called *hydrothermal vents*, in the ocean floor. A certain type of bacteria gains its energy from chemicals released by the vents. This bacterium is the first link in the food chain. Other organisms then eat the bacteria. These organisms include clusters of tubeworms that look like huge lipsticks (see Figure 2.5), giant white crabs, blind shrimp, and yellow mats of bacteria. British Columbian scientists have been leaders in exploring this new frontier.

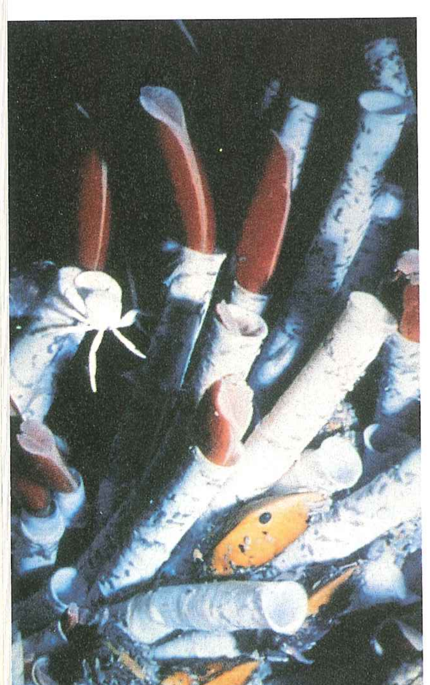


Figure 2.5 Producers in the deep ocean hydrothermal vents are bacteria that obtain energy from chemicals in a process called *chemosynthesis*. These tubeworms are lined with bacteria, which provide them with nutrients.

DESIGN YOUR OWN

INVESTIGATION 2-B

SKILLCHECK

- Predicting
- Designing Experiments
- Controlling Variables
- Observing

A Mealworm's Food Chain

Mealworms are not really worms. They are the larvae of a species of beetle. What type of food do you think mealworms prefer? What would a food chain for a mealworm look like? Design your own investigation to find out.

Question

What type of food do mealworms prefer?

Prediction

Make a prediction about the type of food that mealworms prefer.

Safety Precautions

- Never eat any food during science class.
- Wash your hands thoroughly, using soap, when you have completed this investigation.
- Dispose of all the food you used immediately after completing this investigation, according to your teacher's instructions.

Materials

15 mealworms

approximately 50 mL of 5 different foods, such as oats, bran, flour, grass, shredded lettuce, and cornmeal

aluminum pie plate

plastic wrap

masking tape

Procedure

1. Read through the Procedure. **Predict** the types of food that you think mealworms might prefer.
2. Use the mealworms, pie plate, and five different foods to design your investigation.
3. Write your experimental procedure, and review it with your teacher before beginning. In your procedure, you must indicate how you will keep the mealworms from escaping from the pie plate.
4. Conduct your investigation, and **record** your observations.

Skill POWER

For tips on making predictions and designing experiments, turn to SkillPower 6.

Analyze

1. **(a)** What variables did you control in this investigation?
   (b) What was the independent variable in this investigation?
2. Summarize your results in words or with a clearly labelled diagram.
3. Compare your results with the results of other students in your class. Did everyone have the same results? If not, what could have caused the differences?

Conclude and Apply

4. Based on your observations, which food(s) do mealworms prefer?
5. Draw at least one food chain that includes mealworms.

Food Webs

Figure 2.6 The food web of a hoary marmot includes all its predators, as well as all the plants that the marmot eats.

In an alpine meadow, high in British Columbia's Rocky Mountains, a hoary marmot (see Figure 2.6) whistles an alarm. Perhaps the marmot sees a golden eagle soaring overhead or a grizzly bear or wolf nearby. These three animals are potential predators of the marmot. As well, the marmot itself eats more than one type of food. Its diet includes grasses, roots, flowers, and berries. To model all the possible food chains that include marmots and other organisms, you can use a food web. A **food web**, such as the one in Figure 2.7, shows the network of interconnected food chains in an ecosystem.

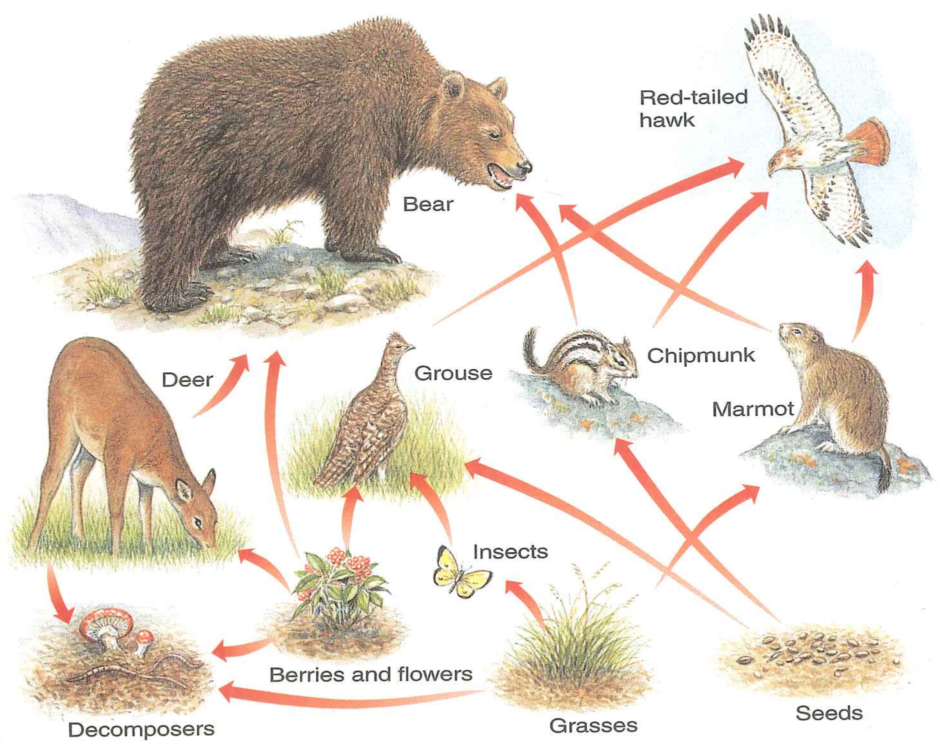


Figure 2.7 A food web provides a more complete model of the feeding relationships in a community than does a food chain.

READING Check

Why is a food web a better model than a food chain for describing the relationships among organisms in an ecosystem?

A food web is more realistic than a food chain for showing the feeding relationships in ecosystems. Producers are usually eaten by many different consumers. Most consumers are eaten by more than one kind of predator.

INVESTIGATION 2-C

SKILLCHECK
- Observing
- Controlling Variables
- Interpreting Data
- Modelling

Dinner at the Copepod Café

Think About It

Copepods [KOH-puh-podz] are tiny floating animals that are related to shrimp and crabs. They are an important food source for many creatures in the ocean and in estuaries. (An estuary is a place where a river meets the ocean.) Copepods are part of the diet of young salmon, called smolts. In this activity, you will play a game that models a food chain in an estuary.

What You Need

20 strips of cloth, 30 cm long (10 of one colour and 10 of a second 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

- This activity involves tagging other people as you play a game. Make sure that you tag people gently.
- Play this game in a large area, such as a field or gymnasium.
- Do NOT eat the popcorn you use in this activity.

What to Do (Group Work)

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

Number of live organisms	copepods	salmon smolts	herons
Trial 1			
Start of game (0 min)			
After 1 min			
After 2 min			
After 3 min			
Trial 2			
Start of game (0 min)			
After 1 min			
After 2 min			
After 3 min			

2. Your teacher will divide you into three groups of equal size. Copepods, salmon smolts, and great blue herons. Tie strips of cloth of one colour around the arms of all the students who are copepods. Tie strips of cloth of the second colour around the arms of all the students who are salmon smolts. The students who are herons will not wear arm bands.

3. Mark off the boundary of your playing area. Spread the popcorn throughout the playing area.

4. Play the game as follows:
   (a) Spread throughout the playing area.
   (b) When your teacher blows the whistle, the copepods can begin to "eat" decaying plants (popcorn) off the ground by picking up the popcorn and putting it in their "stomachs" (plastic bags). After 30 s, 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 can begin to feed.

continued

- Copepods continue to "eat" the popcorn.
- Salmon smolts "eat" copepods by tagging them and putting the contents of the copepods' plastic bags into their own plastic bags. Salmon smolts cannot eat herons.
- Herons "eat" salmon smolts by tagging them and putting the contents of the salmons' plastic bags into their own plastic bags. Herons cannot eat copepods.
- If you are a copepod or salmon smolt that has been eaten, you are out of the game. After you have given the contents of your plastic bag to the predator, wait on the sidelines.

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

(e) When your teacher blows the whistle, continue to "hunt" until the whistle sounds again (after 1 min). Count and record the number of copepods, salmon, and herons that are still alive. Play one or two more rounds.

5. Play the game again, but this time your class will be divided into three groups with the approximate ratio of 9 copepods: 3 salmon: 1 heron. So, for a class of 26 students, there will be 18 copepods, 6 salmon smolts, and 2 herons.

6. Graph the results for each game.

Analyze

1. In Trial 1, the populations of copepods, salmon, and herons were the same size. In Trial 2, the population of copepods was larger than the population of salmon, which was larger than the population of herons. Which trial is closer to what actually happens in nature? Explain your answer.
2. Copepods feed on decaying plants. What might happen to the food chain if only half as much food (popcorn) was available to the copepods?
3. Suppose that there were no salmon in the estuary one year.
   (a) What might happen to the copepod population?
   (b) What might happen to the heron population?

Skill POWER

For tips on drawing graphs, turn to SkillPower 5.

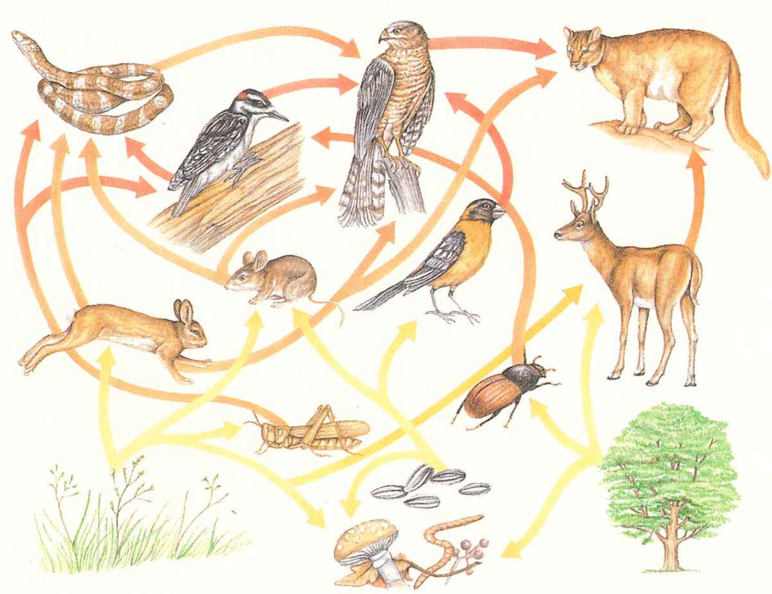


Figure 2.8 Food webs show *how* energy is transferred, but not how many organisms are involved in each step of the energy transfer.

Pyramids of Numbers

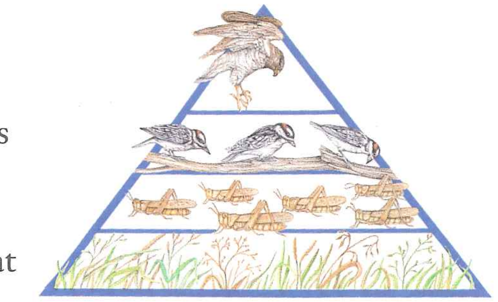


Figure 2.9 A pyramid of numbers is a model of an ecosystem that represents the number of organisms at each level. Producers always form the broad base in a pyramid of numbers.

Food chains and food webs show how food energy moves through an ecosystem. They do not, however, show the *number* of organisms that are involved in each step. For example, the food web in Figure 2.8 shows that snakes eat grasshoppers. It does not show how many grasshoppers the snakes eat.

To show how many organisms are at each level in a food chain, ecologists use a model called a **pyramid of numbers**. A pyramid of numbers includes the same organisms that are in a food chain, but the size of each level shows the number of organisms involved. There is always a large number of producers at the bottom of a pyramid and fewer organisms at the top. For example, in Figure 2.9, the hawk is the top consumer at the peak of the pyramid. There can be one hawk eating three woodpeckers, but not three hawks eating one woodpecker.

Energy Flow

Animals high on a food chain must eat many organisms on lower levels because they need the energy. **Energy flow** is the transfer of energy that begins with the Sun and passes from one organism to the next in a food chain. Only a small amount of energy is stored in the body tissues because most of it is used for life processes. Consider the cow in Figure 2.10. About 4 percent of the stored energy in the grass goes to build and repair the cow's body tissues and, thus, stays in the tissues. This is the "stored" energy, which is available to an organism that eats the cow. Most of the energy in the grass that the cow eats is not passed to the next animal in the food chain.

DidYouKnow?

Sea otters are the only marine mammals without blubber (a thick layer of fat). Instead of blubber, sea otters have a special, thick fur with more than 100 000 hairs per square centimetre! The mass of the food an otter eats every day is equal to about 25 percent of its own body mass.

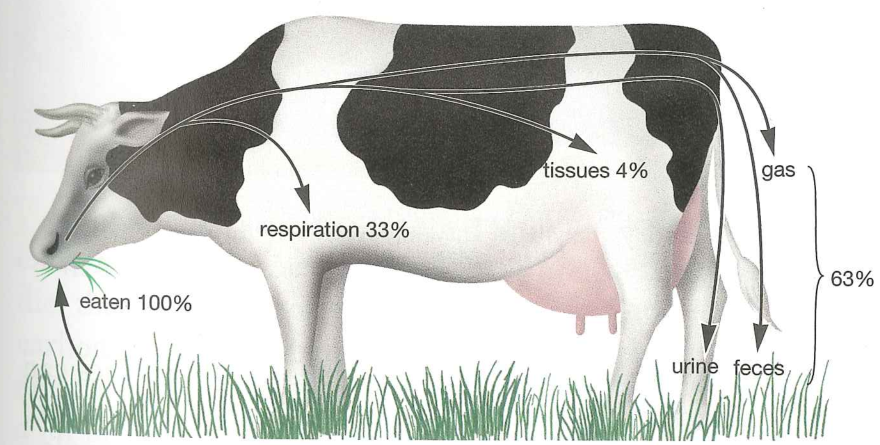


Figure 2.10 Only 4 percent of the energy stored in the grass that a cow eats is eventually stored in the cow's body.

READING Check

Why are there always fewer organisms at the top of a pyramid of numbers?

Section 2.1 Summary

Food chains, food webs, and pyramids of numbers are models that show how energy passes from one organism to the next in an ecosystem.

- A food chain shows how energy that is stored in food passes from organism to organism.
- A food web shows a number of interconnected food chains. It gives a more accurate picture of what really happens in an ecosystem.
- A pyramid of numbers is a model that illustrates approximately how many organisms are at each level in a food chain.

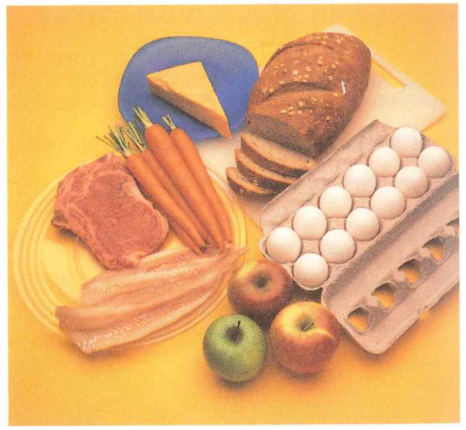
Producers are necessary in all food chains. Producers use energy from the Sun to make their own food through a process called photosynthesis. Not all the energy that is stored in food passes directly to the next organism in a food chain. A lot of the energy is used to fuel daily activities, such as breathing and digesting food.

Key Terms

food chain
chlorophyll
photosynthesis
top consumer
cellular respiration
food web
pyramid of numbers
energy flow

Check Your Understanding

1. Use a Venn diagram to compare a pyramid of numbers with a food chain.
2. Why is all the energy in one level of a food pyramid *not* available to the organisms at higher levels of the pyramid? Explain.
3. Most humans eat foods from all levels of a food chain, such as the foods in the photograph shown here. Construct two different food chains based on foods you typically eat. Include four or more levels in at least one of your food chains. Use words and diagrams to describe your food chains.



4. **Apply** Suppose that you found hawks, field mice, and corn in the same ecosystem. What roles would each organism have in the food chain?
5. **Thinking Critically** Changes to the population of a species can affect other organisms in the ecosystem. Describe one situation in which changes in a food chain have had an impact on people. Explain your answer.

Skill POWER

For tips on using Venn diagrams, turn to SkillPower 1.

Section 2.2 Cycles of Matter

In section 2.1, you learned how plants absorb energy from the Sun and convert it into food energy. Animals eat the plants to obtain the stored energy. Eventually, the stored energy is converted into heat and lost to the abiotic environment. Plants must then trap more energy from the Sun to replace the lost energy.

Unlike energy, many types of matter are used over and over again by living systems. In other words, they are cycled through the environment. In this section, you will learn about two important cycles: the carbon cycle and the water cycle.

The Carbon Cycle

Plants use energy from the Sun to convert water and carbon dioxide into foods. These foods contain the carbon from the carbon dioxide. As one organism becomes food for the next organism in the food chain, the carbon-containing materials are passed along. When organisms use the food for energy, the carbon is converted back into carbon dioxide, and is available for plants to use again. Scientists use a model called the **carbon cycle** (Figure 2.11) to show how carbon is used over and over again in ecosystems.

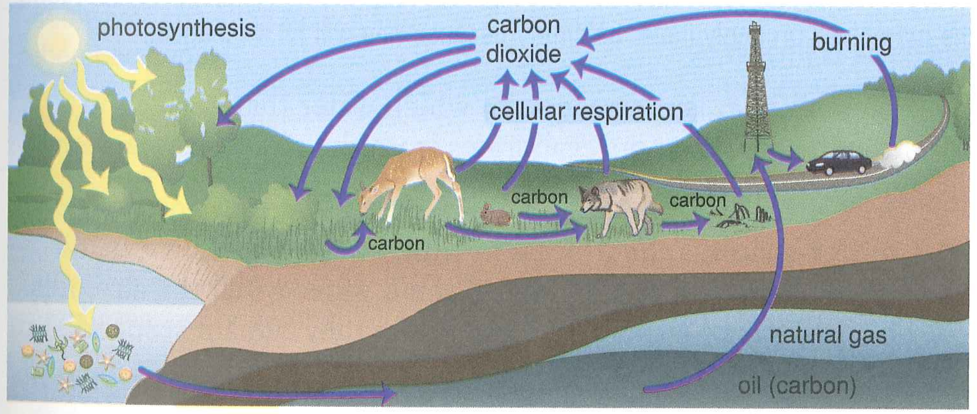


Figure 2.11 The amount of carbon in the environment does not change. It is used over and over again by organisms. Some carbon is stored in the ground for millions of years in the form of coal, oil, and natural gas.

Not all the carbon in plants and animals is converted back into carbon dioxide immediately. When organisms in oceans and lakes die, their tissues often drift to the bottom and form a thick layer of carbon-containing materials. These materials are covered with sand and silt, and buried deeper and deeper. After millions of years, under a lot of pressure, the carbon-containing materials are converted into coal, oil, and natural gas. When people burn the coal, oil, and natural gas for fuel, the energy is released and the carbon is converted into carbon dioxide. These processes also contribute to the carbon cycle.