Topic 1.2

How do interactions supply energy to ecosystems?

Key Concepts

- Photosynthesis stores energy, and cellular respiration releases energy.
- Producers transfer energy to consumers through food chains and food webs.
- Interactions are needed to provide a constant flow of energy for living things.

Key Skills

Numeracy

Key Terms

photosynthesis
cellular respiration
producer
consumer
food chain
food web

No matter what you eat each day, your food choices always have one main thing in common. Each and every food item carried with it some of the Sun—the Sun's energy, to be more precise. The energy that you depend on to sustain your life is stored in the food you eat. And that energy came originally from the Sun.

Starting Point Activity

1. How does the adult cow in the smaller photograph depend on energy that comes originally from the Sun?
2. How does the young calf in the smaller photograph depend on energy that comes originally from the Sun?
3. Think about the foods you have eaten during the past week. Write down three of these foods. Use words, pictures, or both to show how you think each of the foods is linked to the Sun.

Photosynthesis stores energy, and cellular respiration releases energy.

photosynthesis: a process in the cells of plants, algae, and some bacteria that converts light energy from the Sun into stored chemical energy

cellular respiration: a process in the cells of most organisms that converts the energy stored in chemical compounds into usable energy

Green plants make their own food. To do so, they use a process called **photosynthesis** to capture light energy from the Sun and transform the light energy into chemical energy. The chemical energy is stored in energy-rich food compounds such as glucose, which is a type of sugar. During photosynthesis, plants also produce oxygen gas.

All living things need the chemical energy stored in glucose and other energy-rich compounds to live. Most living things use a process called **cellular respiration** to break apart these compounds to release their stored energy. Once the energy is released, it can be used for life functions. During cellular respiration, living things also produce carbon dioxide gas and water vapour.

Table 1.1 Comparing Photosynthesis and Cellular Respiration

	Photosynthesis
1. What is it?	A series of chemical changes in which green plants capture the Sun's light energy and transform it into chemical energy that is stored in energy-rich food compounds such as sugars
2. Which living things use it?	Only green plants and certain kinds of single-celled organisms
3. How is energy changed?	Light energy is changed to chemical energy.
4. What substances does it use?	• carbon dioxide • water
5. What substances does it produce?	• glucose and other sugars • oxygen
6. How can it be represented?	light energy + carbon dioxide + water ⟶ glucose + oxygen 
7. Why is it important?	**1.** Photosynthesis transforms the Sun's energy into a form that living things can use to survive. **2.** Photosynthesis produces the oxygen that most living things need to survive.

Photosynthesis and Cellular Respiration Balance Each Other

Go to **scienceontario** to find out more

Photosynthesis and cellular respiration take place in most ecosystems. **Table 1.1** shows how the two processes balance each other. In summary:

- Photosynthesis stores energy. Cellular respiration releases energy.
- Photosynthesis uses carbon dioxide and water, and produces glucose and oxygen. Cellular respiration uses glucose and oxygen, and produces carbon dioxide and water.

So each process makes the raw materials that the other process needs to store energy or to release energy. In this way, each process sustains the other. Together, both processes sustain life.

LEARNING CHECK

1. What forms of energy are transformed during photosynthesis and cellular respiration?
2. Which substances are used and produced by photosynthesis and by cellular respiration?
3. Use a diagram to show how photosynthesis and cellular respiration balance each other.
4. Summarize your diagram using one or two paragraphs.

Cellular Respiration	
A series of chemical changes that let living things release the energy stored in energy-rich food compounds such as sugars to fuel all life functions	**1.** What is it?
Nearly all living things on Earth	**2.** Which living things use it?
Chemical energy is changed to other forms of energy such as kinetic (motion) energy and heat.	**3.** How is energy changed?
• glucose and other sugars • oxygen	**4.** What substances does it use?
• carbon dioxide • water	**5.** What substances does it produce?
glucose + oxygen ⟶ carbon dioxide + water vapour + usable energy 	**6.** How can it be represented?
1. Cellular respiration releases the energy that living things use to survive. 2. Cellular respiration produces the carbon dioxide that green plants need to carry out photosynthesis.	**7.** Why is it important?

Producers transfer energy to consumers through food chains and food webs.

Many interactions between living things in ecosystems involve food and feeding. Because of this, you can describe living things based on how they get energy from food.

producer: any living thing that gets the energy it needs by making its own food

Producers are living things that *produce* (make) their own food to get the energy they need to live. They use photosynthesis to do this. Only green plants and some kinds of single-celled living things can carry out photosynthesis. So only these kinds of organisms are producers.

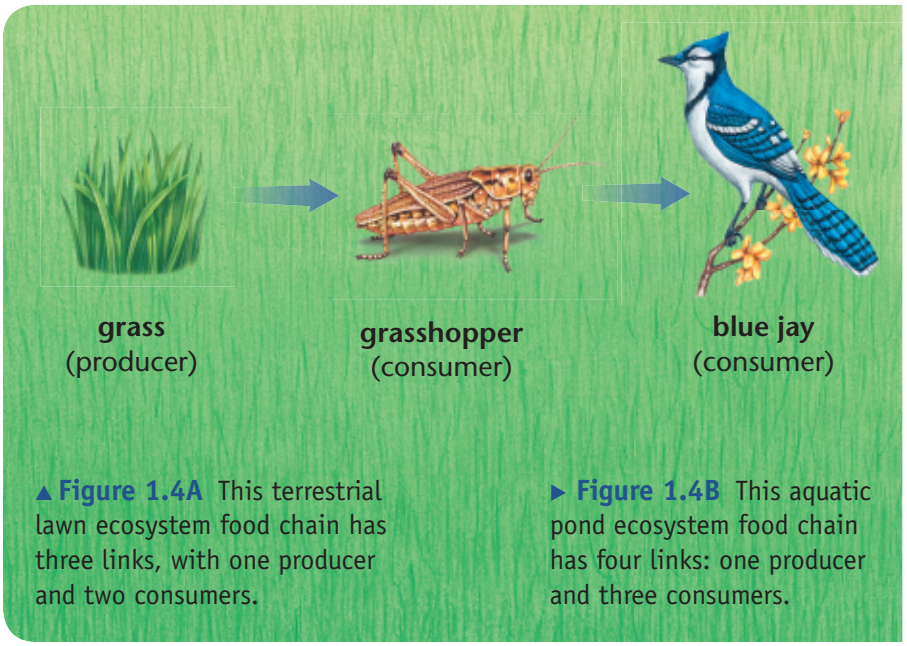
consumer: any living thing that gets the energy it needs by eating producers or other consumers

Consumers are living things that *consume* (eat) producers or other consumers to get the energy they need to live. Animals and most other kinds of living things are consumers.

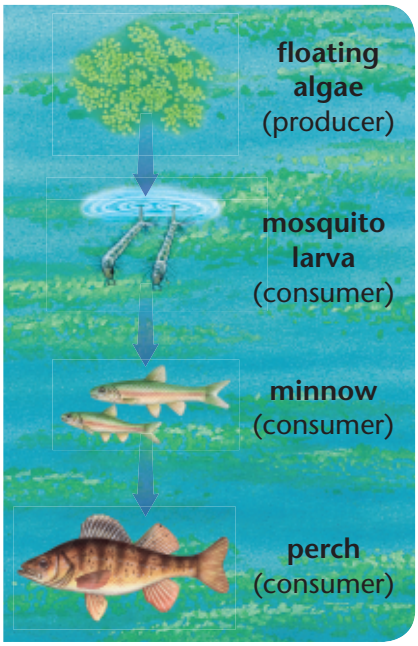
Food Chains Chart the Flow of Energy from Producers to Consumers

food chain: a model that describes how the energy that is stored in food is transferred from one living thing to another

A **food chain** is a model that describes how the stored energy in food is passed on from one living thing to another. You can use a food chain to show how energy flows in any ecosystem. Examples of food chains in a lawn ecosystem and a pond ecosystem are shown in Figure 1.4A and B. Notice that the flow of energy always goes from a producer to a consumer, and then onto one or more other consumers. Notice also that the path of energy always follows the path of a straight line. It doesn't matter if the path is shown up-and-down or side-to-side.



▲ **Figure 1.4A** This terrestrial lawn ecosystem food chain has three links, with one producer and two consumers.



▶ **Figure 1.4B** This aquatic pond ecosystem food chain has four links: one producer and three consumers.

Food Webs Map Many Food Chains

You eat many different kinds of organisms that are producers and consumers. In other words, you are part of many different food chains. The same is true for other organisms. In any ecosystem, a more realistic model of feeding relationships shows a network of interacting and overlapping food chains. Such a model is called a food web. A **food web** weaves together two or more food chains within any given ecosystem. Refer to Figure 1.5.

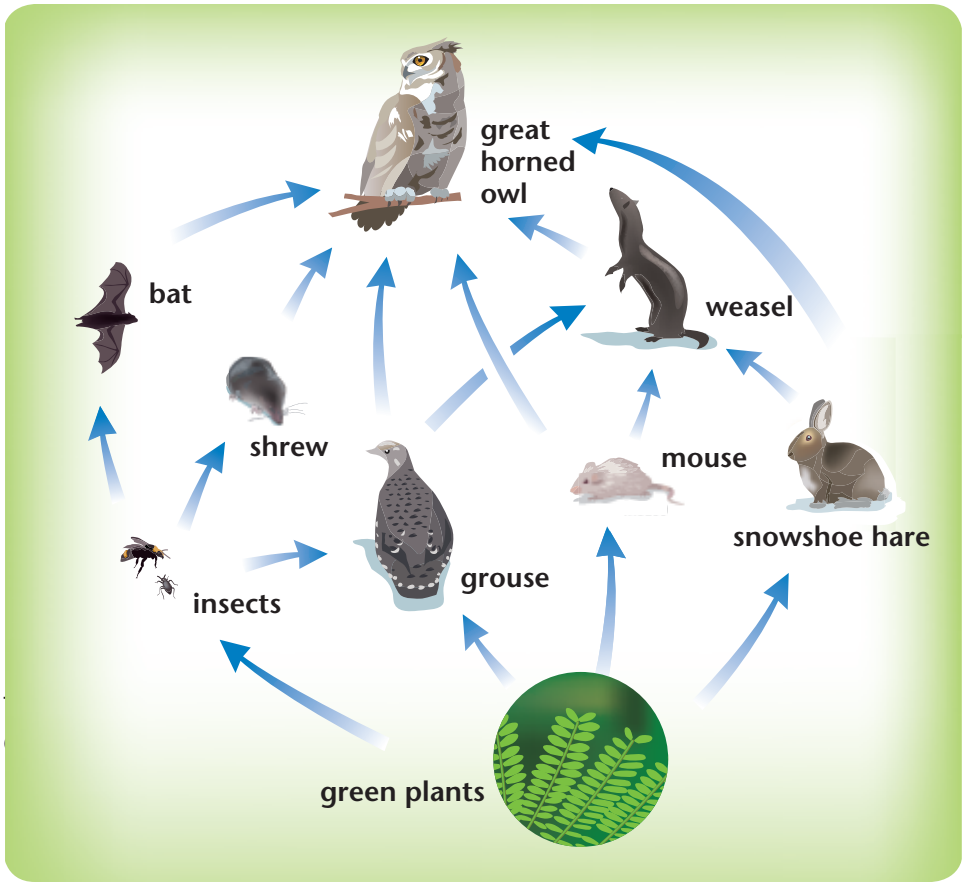
food web: a model that describes how energy in an ecosystem is transferred through two or more food chains

All organisms in a food web are connected to each other through their feeding relationships. As a result, a change in the number of one organism could affect several food chains within the food web. In this sense, all organisms in an ecosystem are connected to and depend on each other for survival. Their interactions are key factors to sustaining life in aquatic and terrestrial ecosystems.

LEARNING CHECK

1. In Figure 1.4, grass and algae are labelled as producers. What makes them different from other organisms in the food chains?
2. A food web is a more realistic model for feeding relationships in an ecosystem than a food chain. Explain why.
3. Identify four food chains in the food web in Figure 1.5.

INVESTIGATION LINK
Investigation 1A, on page 26



◀ **Figure 1.5** A food web such as this one includes many different food chains.

Interactions are needed for a constant flow of energy for living things.

Most food chains have three or four links. Some food chains have only two links. Some food chains might have as many as five or six links. Why are there limits to the length of a food chain?

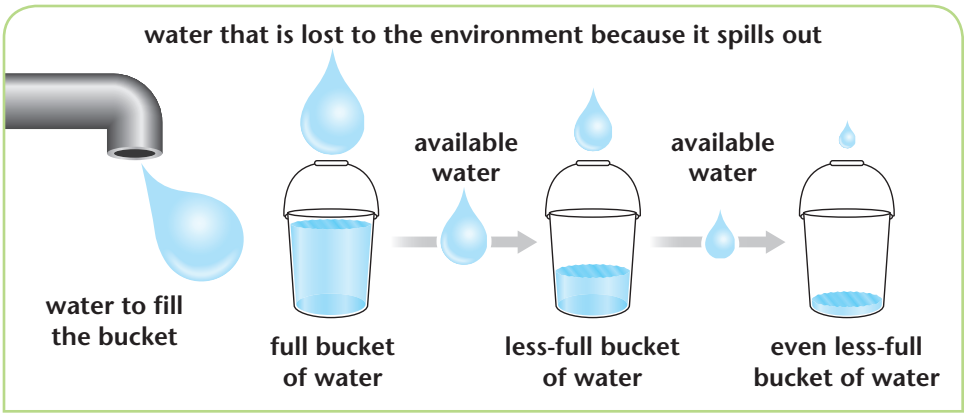
There are limits, because just a small amount of energy is transferred from one living thing in a food chain to the next. Only about 10 percent of the food energy for a producer is available to a consumer that eats it. And only 10 percent of the food energy for that consumer is available to the next consumer. Here are some of the reasons why.

- Some of the original food energy has been used already to support life functions, such as growth and cellular respiration.
- Some energy is changed into heat that is given off into the environment. This energy cannot be used by other living things.
- Some energy is stored in wastes (urine and feces) that are excreted into the environment. Bacteria, fungi, and other decomposers extract some of this energy, but most is lost to the environment as heat.

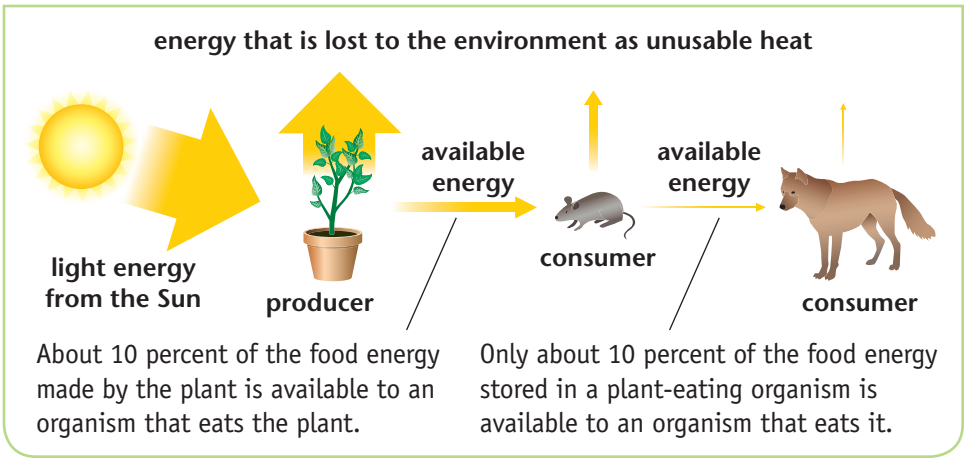
The transfer of energy along a food chain is like a bucket-toss relay game. Refer to **Figure 1.6A** and **B** and the rest of this paragraph to help you understand this idea. As each player passes a bucket of water to the next player, some of the water spills from the bucket. There is only a little water left when the bucket reaches the last player, because some of the water has spilled each time the bucket was passed. This is like what happens to energy in a food chain. Each time energy is transferred in a food chain, some of it is lost as unusable heat. The energy that is lost as heat cannot be used by other living things. So a constant supply of energy is needed to sustain living things in terrestrial and aquatic ecosystems.

LEARNING CHECK

1. Why are there limits to the length of food chains?
2. When a mouse eats a plant, only about 10 percent of the plant's energy is transferred to the mouse. What happens to the rest of the energy?
3. In **Figure 1.6**, an analogy of a bucket-toss relay game is used to explain the transfer of energy through a food chain. Create your own analogy to explain this transfer of energy.
4. Why is a constant supply of energy needed to sustain life on Earth?



◀ **Figure 1.6A** Most of the water in the bucket that is transferred from one player to another in a bucket-toss relay game is lost to the environment. Less and less water is in the bucket for each player in the relay.



◀ **Figure 1.6B** Most of the energy that is transferred from one organism to another in a food chain is lost to the environment as unusable heat. Less and less energy is available to each organism in the food chain.

Numeracy Focus

Activity 1.5

PASS IT ON!

You will model how much energy is available to consumers in each link of a food chain.

What You Need

- 100 pennies (or plastic game chips)
- calculator

What To Do

1. Work in a group of three or four. Make a food chain that has one producer and two consumers.
2. Have one person get 100 pennies and bring them back to your group.
3. Food energy is measured with a unit called the kilojoule (kJ). Each penny represents 1 kJ of energy. So if you have 100 pennies, your producer has 100 kJ of stored food energy.
4. Only 10 percent of the energy stored in an organism is transferred to the organism that eats it. How many pennies is 10 percent of the pennies you started with? Use a calculator to find out. (Hint: Multiply the number of pennies by 0.1.) This is the amount of energy available to the next consumer in the chain.
5. Determine the amount of energy available to the last consumer in the chain.

What Did You Find Out?

1. How did the amount of energy stored in the producer compare with the amount of energy available to the last consumer in the chain?
2. Most food chains in any ecosystem are 5 or 6 links long at the most. Use your experience in this activity to help you explain why.

Skill Check

- Initiating and Planning
- Performing and Recording
- ✓ **Analyzing and Interpreting**
- ✓ **Communicating**

What You Need

- writing materials
- 12 small pieces of paper

Plot the Pathway

Interactions between biotic and abiotic parts of an ecosystem provide a constant flow of energy through it. You will investigate a possible pathway of energy flow through a common Ontario forest ecosystem to better understand how these interactions affect energy transfer.

What To Do

1. Work with a group to complete this activity. On each piece of paper, write the name of one of the ecosystem components below.

   grasshopper
   willow tree
   Sun
   weasel
   red fox
   grass
   caterpillar
   great grey owl
   hermit thrush (a small ground-nesting bird)
   eastern fox snake
   bunch berry (a low-growing flowering plant)
   deer mouse

2. Beginning with the Sun, arrange the pieces of paper into the longest food chain you can. You will not use all the pieces of paper.
3. Draw your food chain in your science notebook.

What Did You Find Out?

1. Identify the following ecosystem components in your food chain:
   a) abiotic parts
   b) biotic parts
   c) producers
   d) consumers
2. **a)** Which of the organisms in your food chain stores energy through photosynthesis?
   b) Which of the organisms in your food chain releases energy through cellular respiration?
   c) What would happen to your food chain if the photosynthetic organisms died out? Explain your answer.
3. How many organisms are in your food chain? Why are all food chains limited in length?
4. The eastern fox snake is a threatened species in Ontario. This means that the numbers of eastern fox snakes are low enough that all could die out at some point in the near future. How might a food chain that includes this snake be affected if the number of eastern fox snakes continues to decline? Why would this be the case?

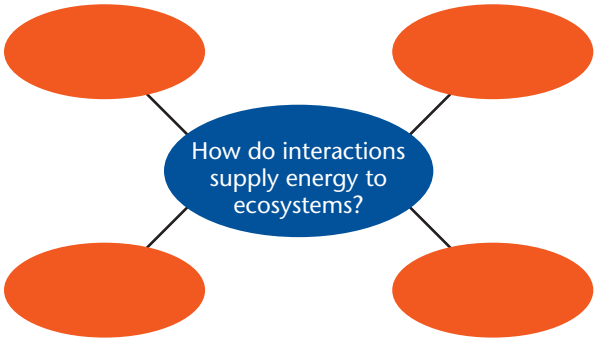
Topic 1.2 Review

Key Concept Summary

- Photosynthesis stores energy and cellular respiration releases energy.
- Producers transfer energy to consumers through food chains and food webs.
- Interactions are needed to provide a constant flow of energy for living things.

Review the Key Concepts

1. K/U Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. C Think about everything that you ate yesterday. Draw a food web that includes you.

a) Look at your food web and determine how many links are in the longest food chain within it.

b) What process did your body use to release the energy from the food you ate?

3. A Some people who adopt a vegetarian diet claim to feel more energetic than they felt when they were eating meat. Using your knowledge of energy and food chains, explain why they might feel this way.

4. K/U When two things are complementary, they balance each other. Explain why photosynthesis and cellular respiration are considered complementary processes.

5. C Refer to **Table 1.1**. Should photosynthesis win the Most Important Process on Earth Award? Write a supported opinion paragraph explaining your position.

6. K/U Why do food webs require a continual input of energy from the Sun?

7. K/U Copy this table into your notebook. Complete the table to compare photosynthesis and cellular respiration. (Do not write in this textbook.)

Comparing Photosynthesis and Cellular Respiration

Process	Photosynthesis	Cellular Respiration
Organisms in which the process occurs (Give three examples.)		
Substances used by the process		
Substances produced by the process		