Topic 1.3 How do interactions in ecosystems cycle matter?

Key Concepts

- Abiotic and biotic interactions cycle matter in terrestrial ecosystems and aquatic ecosystems.
- Photosynthesis and cellular respiration cycle carbon and oxygen in ecosystems.
- Human activities can affect ecosystems by affecting nutrient cycles.

Key Skills

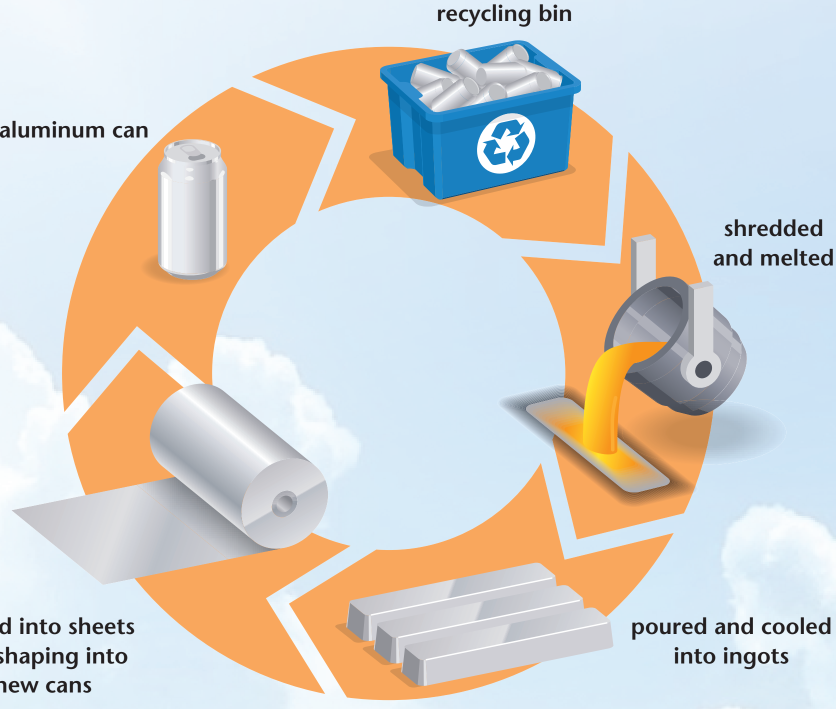
Inquiry
Literacy

Key Terms

decomposer
nutrient
nutrient cycle

Day changes to night, which changes to day. Spring leads to summer, then to autumn, to winter, and back to spring. These examples of changes whose ending leads back to where they begin are known as cycles. Another cycle that plays a major role in your life is the yearly celebration of the date of your birth. In fact, all calendar systems—Julian, Gregorian, Islamic, Jewish, Chinese, Indian, Mayan, Bahá'i, Aboriginal, or any other—involve cycles.

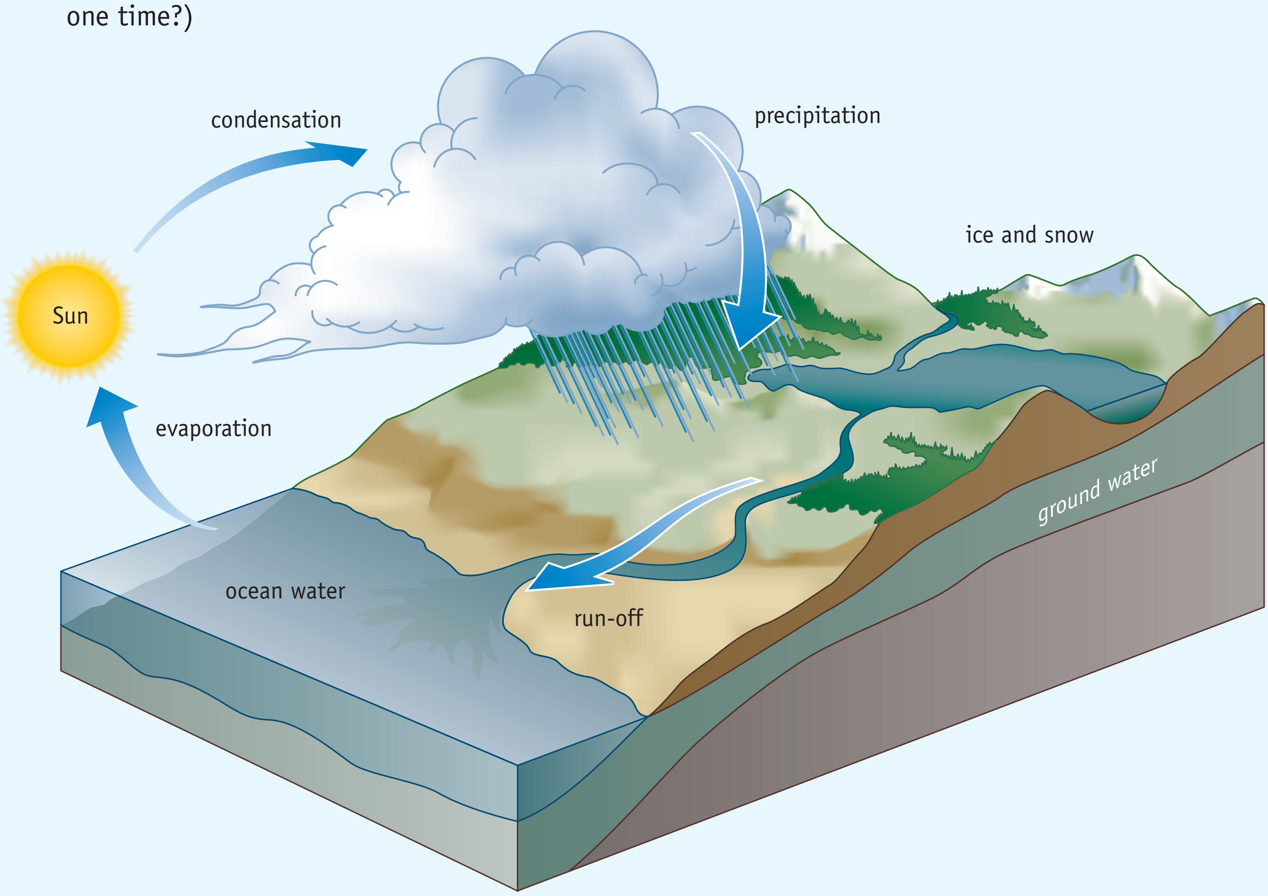
You know other cycles from science class, too. There are life cycles of frogs, moths, and other animals. There are product life cycles, which depend on you and your commitment to recycling. There are also cycles that involve substances in nature. Water is one example. A simple diagram of the water cycle is shown here.



The product life cycle of aluminum is based on the fact that 100 percent of an aluminum can is able to be recycled.

Starting Point Activity

1. A cycle is a pattern of change that repeats itself forever. In what way does the water cycle demonstrate the features of a cycle?
2. On a map of Canada or Ontario, locate Toronto and Thunder Bay. The distance between these two cities is nearly 1400 km. Now picture a ball with a diameter of 1400 km. (In other words, the ball is 1400 km across.) All the water on Earth could fit into that ball. Do you think that is a lot or not? Explain.
3. During a drought (lack of rain for a long time), the amount of water in a body of water can drop a great deal. What happens to this missing water? Is it really missing? Explain.
4. The water cycle ensures that Earth will never run out of water. In fact, the total amount of water on Earth (the amount in that 1400 km-diameter ball) always stays the same. So why are we concerned about conserving water resources? (Hint: What is the difference between the total amount of water on Earth and the amount of water that is available in any one place at any one time?)



There is water on Earth's surface in the form of ponds, lakes, rivers, and the ocean. There is water under Earth's surface in the form of ground water. And there is water in the air in the form of water vapour. All this water continuously cycles through ecosystems by means of the interaction of three processes: evaporation, condensation, and precipitation.

Abiotic and biotic interactions cycle matter in terrestrial and aquatic ecosystems.

decomposer: organism that obtains energy by consuming dead plant and animal matter

nutrient: any substance that a living thing needs to sustain its life

nutrient cycle: the pattern of continual use and re-use of a nutrient

Some people love searching the soil for bugs and worms and all types of "creepy-crawlies." For other people, these organisms really do give them "the creeps." But you and all other living things owe your lives to these organisms. They are a group of consumers called **decomposers**.

In addition to soil insects and earthworms, decomposers include moulds, mushrooms, and certain kinds of bacteria. They get their food energy by digesting wastes such as urine, feces, and the bodies of dead organisms. As decomposers digest these wastes, some of the chemical substances that make up the wastes enter the soil, water, and air. These substances include carbon, nitrogen, iron, and other chemicals that living things need and use as nutrients. A **nutrient** is any substance that a living thing needs to sustain its life.

All producers and consumers use nutrients to grow and build their bodies and to help them carry out their life functions. When organisms die, decomposers return the nutrients to the environment. Then the nutrients are available to be used once again by living things. This pattern of use and re-use of nutrients has been taking place for millions of years in all ecosystems, all over the Earth. The pattern of continual use and re-use of the nutrients that living things need is called a **nutrient cycle**.

LEARNING CHECK

1. Use pictures, words, or a graphic organizer to explain the following terms: nutrient, nutrient cycle.
2. What role do decomposers play in nutrient cycles?
3. Explain what is meant by the statement "You and all other living things owe your lives to decomposers."
4. The living things that decompose dead organisms link the biotic and abiotic parts of ecosystems. How do they do this?

Literacy Focus

Activity 1.6

INTERACTIONS AND NUTRIENT CYCLES

What To Do

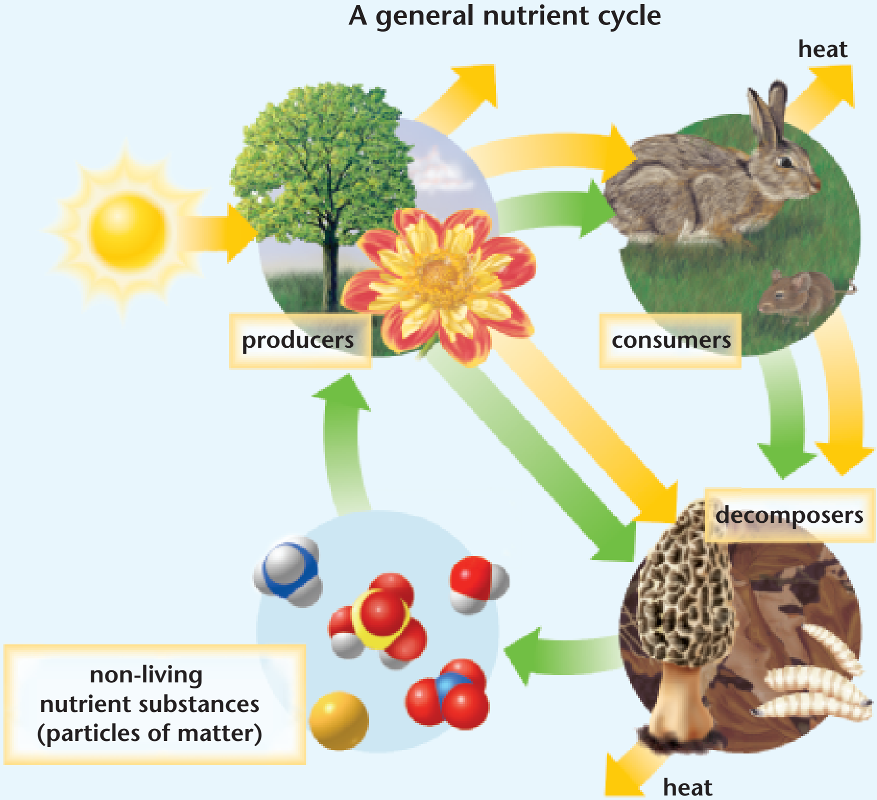
The diagram below is a general nutrient cycle. It shows the path of energy and matter in an ecosystem. Use the questions to interpret what the diagram shows.

1. What path (arrow colour) does energy follow in the diagram?
2. What path (arrow colour) does matter follow in the diagram?
3. Which part of the diagram shows where photosynthesis takes place?
4. Which part of the diagram shows where cellular respiration takes place?
5. How does the diagram show that a constant flow of energy is needed for living things?

What Did You Find Out?

1. Use the information communicated by the diagram to show how you know that these two statements are true.
   - Statement 1: The biotic parts and the abiotic parts of an ecosystem work together in a nutrient cycle.
   - Statement 2: Decomposers link the biotic parts of an ecosystem with the abiotic parts of an ecosystem.

A general nutrient cycle

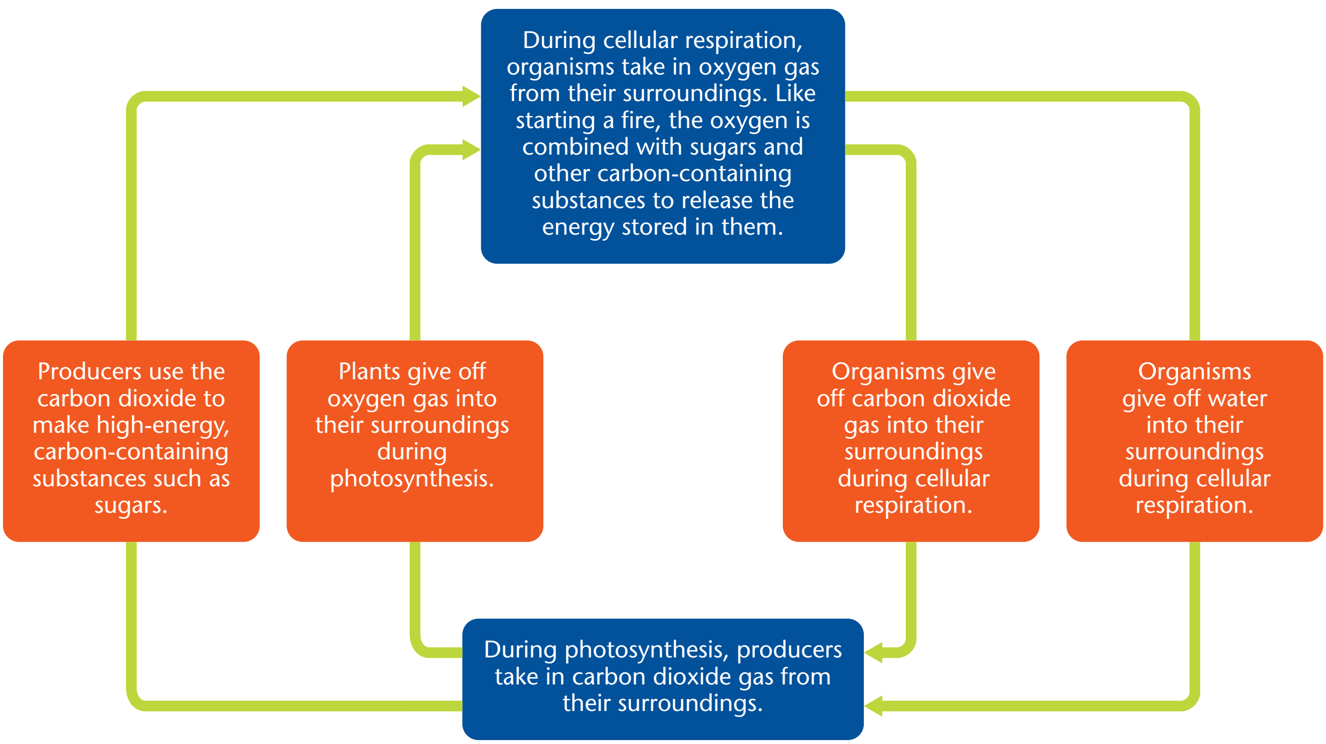


Photosynthesis and cellular respiration cycle carbon and oxygen in ecosystems.

In Topic 1.2, on pages 20 to 21, you learned the role that photosynthesis and cellular respiration play in the transfer of energy through ecosystems. These two processes also play a key role in the cycling of matter such as carbon and oxygen in ecosystems. Scan the large cycle picture shown in **Figure 1.7**. The labels will help you see how photosynthesis and cellular respiration are complementary processes for the cycling of carbon and oxygen. Because this is a cycle picture, you can start reading it anywhere and follow the arrows.

LEARNING CHECK

1. What substances do plants require to carry out photosynthesis?
2. What substances are released by all organisms—including both plants and animals—during cellular respiration?
3. Photosynthesis and cellular respiration are complementary processes. Use specific examples from **Figure 1.7** to support this statement.



▲ **Figure 1.7** Photosynthesis and cellular respiration interact with each other as part of a cycle that uses and re-uses carbon and oxygen. This interaction takes place in both terrestrial and aquatic ecosystems.

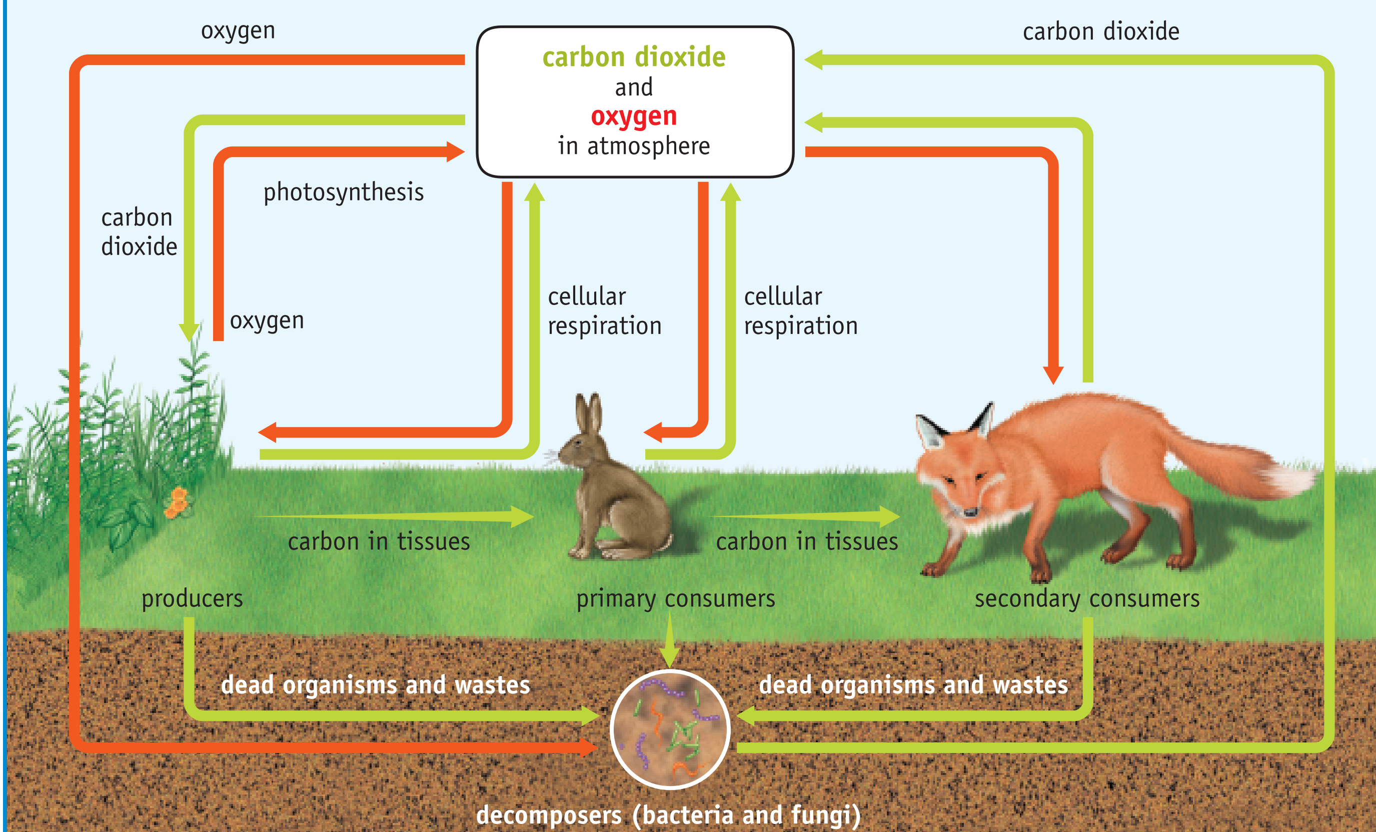
Literary Focus

Activity 1.7

CYCLE IT

What To Do

1. Work in a small group. Arrange yourselves so you are sitting in a circle.
2. With your group, examine the picture of interactions that are involved in the cycling of carbon and oxygen. Follow the coloured arrows for oxygen to see how it is cycled. Then do the same with carbon.
3. Help each other understand what happens to oxygen and to carbon as they cycle in an ecosystem. To do this, choose an ecosystem. Then choose one group member to start the story of how oxygen or carbon cycles through the ecosystem. This person will describe how the nutrient leaves the environment and enters a producer.
4. Each person in turn will describe what happens to the nutrient next.
5. End the story when the nutrient has returned to the person who started the story.
6. On your own, make a cycle diagram with labelled sketches to record the whole story that your group created together.



This picture shows interactions that are involved in the cycling of oxygen and carbon. The bodies of all organisms contain carbon as a key part of their make-up.

Human activities can affect ecosystems by affecting nutrient cycles.

Not all the carbon involved in the carbon cycle is used immediately by living things. Some is stored in the woody tissues of long-living trees. Some is stored in the slowly decomposing remains of organisms, which become buried deeply in the ground. With the passage of time, some of this stored carbon will eventually be transformed into the carbon-rich fuels that we know as coal, oil, and natural gas. This is what happened about 300 million years ago to form the coal, oil, and natural gas that we use today as fuel.

The amount of carbon dioxide that is used by photosynthesis and given off by cellular respiration is nearly the same. In other words, the amount of carbon dioxide is balanced. When we burn trees, coal, oil, and natural gas for fuel, the carbon stored long ago is released into the air in the form of carbon dioxide. So we upset that balance. As well, human activities have removed huge numbers of trees to make space for homes, buildings, and farmland, and to make products such as furniture and paper. So there are fewer trees available to use the extra carbon dioxide. As a result, the extra carbon dioxide builds up in the air and helps to trap heat in the atmosphere. This is one of the sources of the extra carbon dioxide that adds to the process known as global warming.

Literacy Focus

Activity 1.8

HELPING TO RESTORE BALANCE

1. The amount of carbon dioxide used by producers and given off by producers and consumers is balanced. Name two ways that human activities upset that balance.
2. Think about three human activities that could help to restore this balance. Use a cause-and-effect map to explain in each case.

ACTIVITY LINK
Activity 1.9, on page 38

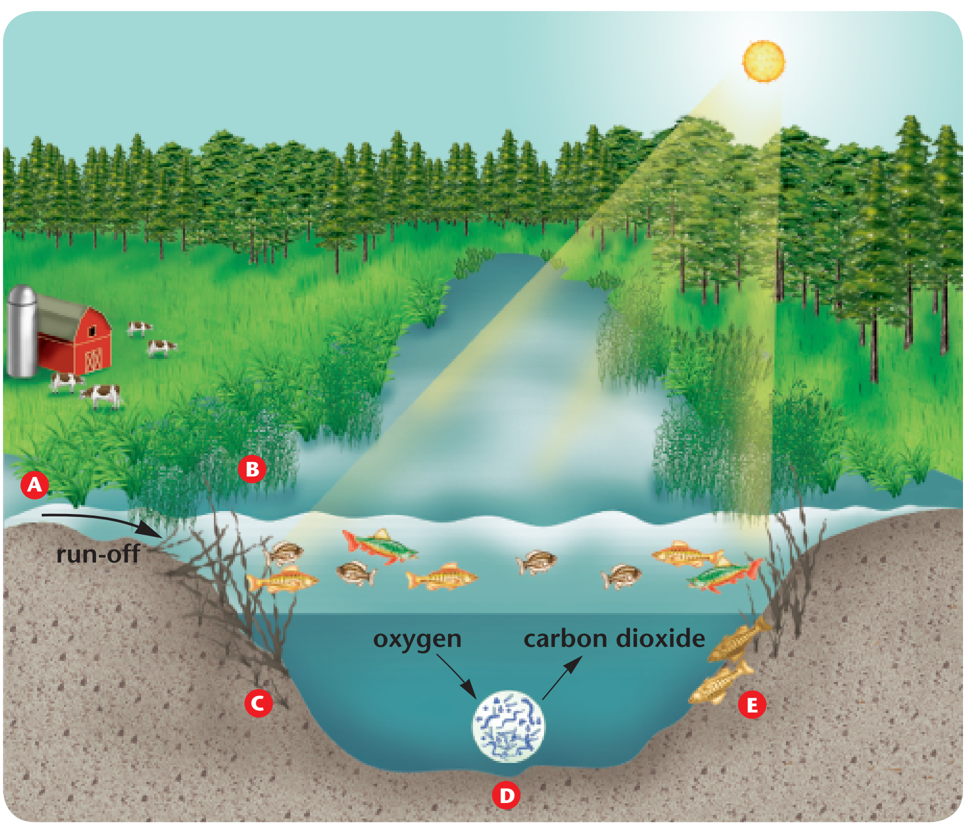
Other Effects on Nutrient Cycles

Nitrogen is another nutrient that cycles in ecosystems. It is a major part of all cells and a key building block for proteins, which all cells need. Nitrogen makes up 78 percent of air, but most living things cannot use nitrogen from the air. Instead, they depend on certain kinds of bacteria in the soil and water to change the nitrogen into forms that plants can use.

Many human activities affect the nitrogen cycle. For instance, nitrogen is a key part of fertilizers. Farmers and gardeners use fertilizers to enhance the growth of their plants. Not all the nitrogen in the fertilizers is used by the plants, though. Some stays in the soil. When it rains, or when fields are watered, some of the nitrogen is carried into aquatic ecosystems. This excess nitrogen can cause an overgrowth of algae called an algal bloom. **Figure 1.8** shows how an algal bloom can affect an aquatic ecosystem.

LEARNING CHECK

1. How does burning wood, coal, oil, and natural gas affect the amount of carbon dioxide in the atmosphere?
2. Why is nitrogen essential for all living things?
3. Use a graphic organizer to show how fertilizers, algal blooms, and the death of aquatic organisms are linked.



A: Rain carries nitrogen from farms, gardens, and lawns into aquatic ecosystems.

B: Algae and plants at the water's surface grow quickly. This blocks sunlight from reaching deeper water.

C: Deep-water plants get no sunlight. They cannot carry out photosynthesis, so they no longer give off oxygen, and they soon starve to death.

D: When the plants die, decomposers have lots of food. The number of decomposers increases quickly. They use up the oxygen in the water as they carry out cellular respiration.

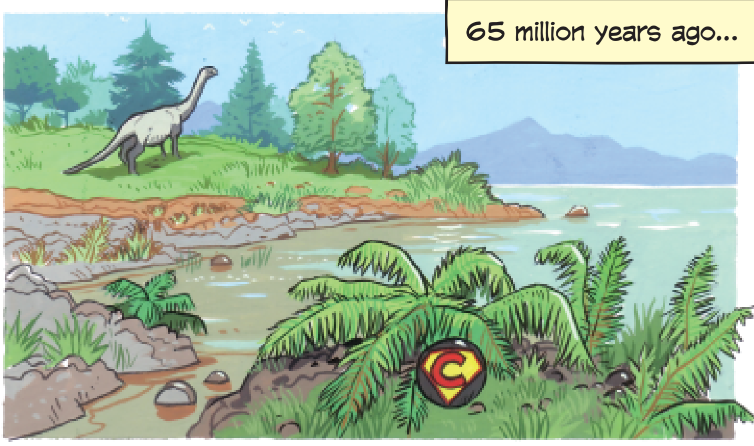
E: As oxygen in the water is used up, aquatic organisms that need the oxygen suffocate and die.

Figure 1.8 An algal bloom is caused by too much of a nutrient, such as nitrogen, entering an aquatic ecosystem.

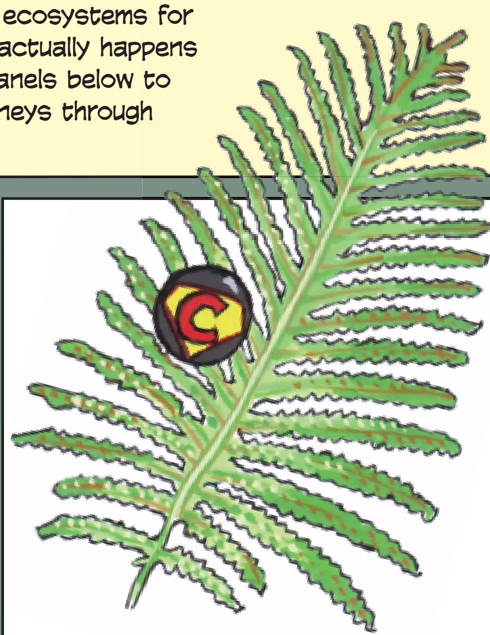
Strange Tales of Science

Journey of an Immortal Carbon Atom

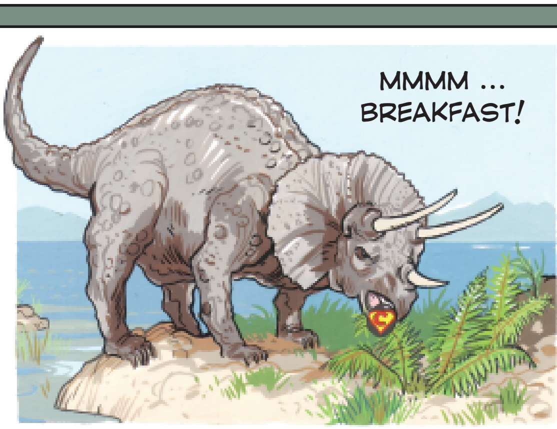
Carbon, oxygen, and other nutrients have been cycling through ecosystems for eons, and they will continue to do so for eons more. But what actually happens to a nutrient as it travels though a nutrient cycle? Read the panels below to find out what adventures befall one lone carbon atom as it journeys through time and space in its quest for immortality.



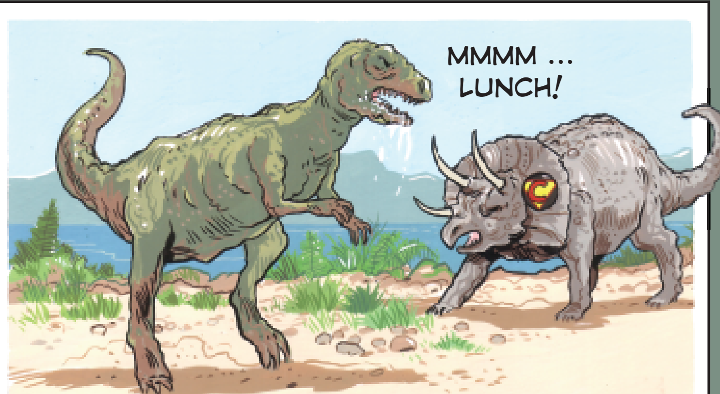
A fern lives on the bank of an inland sea covering much of North America. On a sunny day, it takes up an atom of carbon to become part of a carbon dioxide molecule. The atom is one of many used to make carbon-rich compounds by photosynthesis. To do this, the fern also uses the Sun's energy and water from the soil.



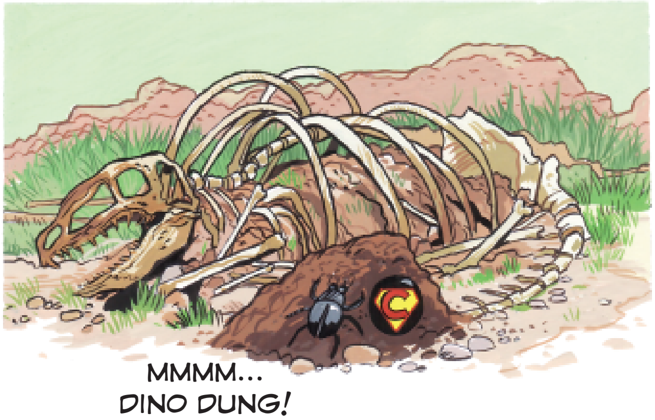
Through cellular processes, the fern uses the carbon atom, along with some oxygen and hydrogen atoms, to build a fat molecule. It incorporates the fat in a membrane surrounding one of its cells.



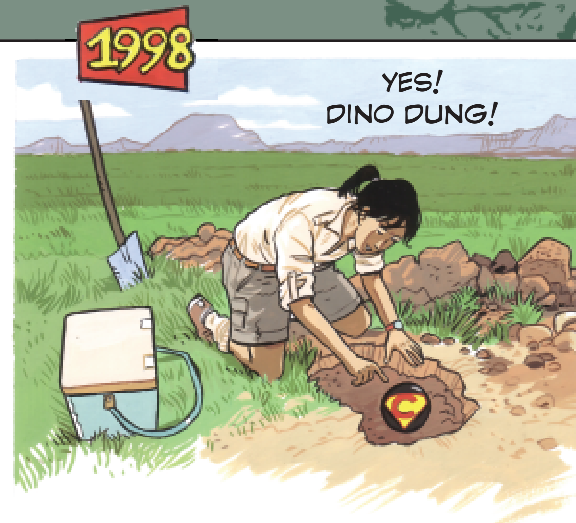
A plant-eating triceratops lumbers up to the fern and grabs a mouthful. The fat in the fern cell is digested in its stomach. The dinosaur uses oxygen to access the energy in the fat by cellular respiration.



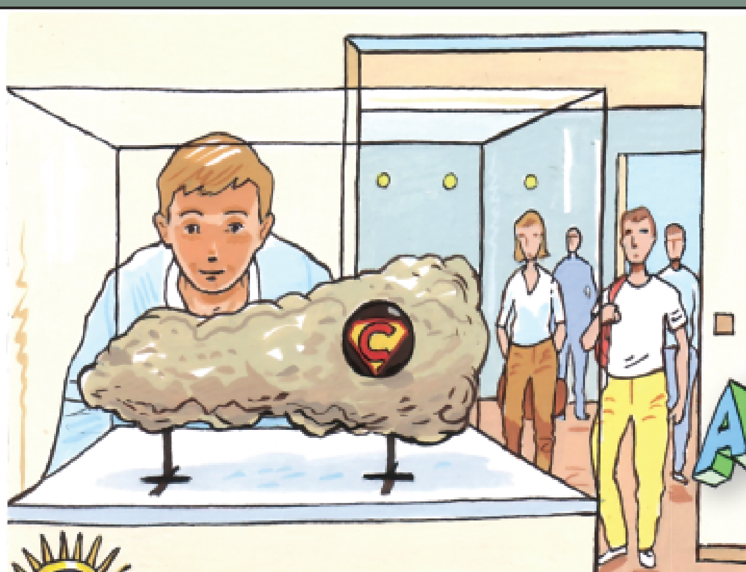
In the process, both carbon dioxide and water are released into the air again. But our carbon atom does not leave the triceratops. Instead, it ends up in a cell in the dinosaur's bony head frill—and, a short time later, in the stomach of a Tyrannosaurus rex (T.Rex).



The carbon in the triceratops' bone passes through the T. rex undigested and re-enters the environment in its dung. Decomposers return many nutrients in the dung to the soil. However, the bone with our carbon atom becomes fossilized and stays in the ground until...



...1998. This is the year that Dr. Karen Chin, the world's leading expert on dinosaur dung, finds the bone fragment in a huge (44 cm) fossilized sample of T. rex dung in southern Saskatchewan.



The fossil is now stored at the Royal Saskatchewan Museum, along with the carbon atom we've been following for 65 million years!

AND THE JOURNEY CONTINUES.... BUT HOW?

So... What do you think?

1. Continue this graphic novel to reveal the next installments in the journey of the immortal carbon atom.
2. Draw a diagram showing how photosynthesis and cellular respiration were involved in the cycling of this carbon atom.
3. The fossilized dung in this story is 65 million years old. Find out different methods paleontologists use to date fossils. (One of them involves carbon atoms.)
4. Find out more about Dr. Karen Chin and what dinosaur dung tells her about the prehistoric past.

Go to **scienceontario** to find out more

Inquiry Focus

Activity 1.9

RECYCLING ON MARS

If humans ever colonize another planet, Mars is a good choice. Its conditions are more Earth-like than on any other planet. To live on Mars, we would have to create ecosystems that can sustain themselves for long periods of time, just as they do on Earth. For instance, a Mars colony would have to recycle and re-use all its materials. This includes nutrients such as water, carbon, oxygen, and nitrogen. In this activity, you will consider some of the factors that would be needed for a self-sustaining Mars colony.

What To Do

1. With your group, make a list of the things that a Mars colony would need and how you could maintain them over time. Use the following questions to help you:
   a) Mars has a maximum temperature of 20°C and a minimum temperature of –140°C. How could your colony maintain temperatures that are friendlier to life?
   b) How would your colony deal with food production and waste disposal?
   c) How would you generate energy for your colony?
   d) Because you can only bring supplies and materials to Mars once, all materials must be recycled. How would nutrients like water, oxygen, and carbon dioxide be continuously cycled within the colony?

What Did You Find Out?

1. How is the colony you created like an ecosystem? How is it different?
2. a) What cycles would have to be maintained to sustain a colony on Mars?
   b) How might the colony be affected if one of these cycles became disrupted?
   c) Which nutrient is the most difficult to cycle in your colony? Why?
3. You have learned that photosynthesis and cellular respiration are complementary processes. Did this knowledge help you cycle oxygen and carbon in your colony? Explain.
4. On Mars, large amounts of water are frozen in the polar icecaps and under the surface. How could this water be used to sustain your colony?
5. We don’t know yet if the soil on Mars can be used to grow crops. One solution to this problem is to grow crops in greenhouses like the one below, which uses hydroponics. This technology uses nutrient-enriched water instead of soil to grow plants. Suggest a way that nitrogen, an important nutrient for plant growth, might be recycled within the greenhouse.

Canada’s Devon Island, in Nunavut, is a barren landscape used by research scientists as a “stand-in” for the barren landscape of Mars. The Arthur C. Clarke Greenhouse experiment has been running since 2003.

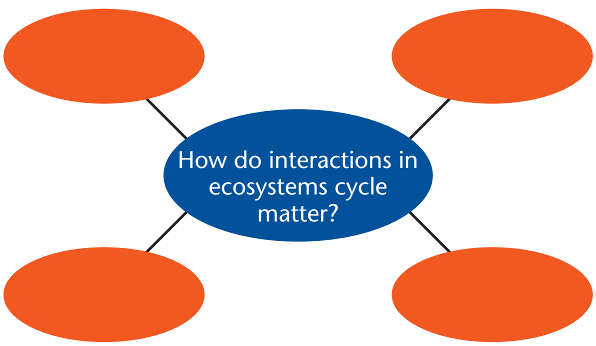
Topic 1.3 Review

Key Concept Summary

- Abiotic and biotic interactions cycle matter in terrestrial and aquatic ecosystems.
- Photosynthesis and cellular respiration cycle carbon and oxygen in ecosystems.
- Human activities can affect ecosystems by affecting nutrient cycles.

Review the Key Concepts

1. 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. A What are some ways in which you and your family and friends affect nutrient cycles? Use a graphic organizer to demonstrate the cause-and-effect relationships involved in the examples you provide.

3. C In Activity 1.8, you identified three human activities that could restore the balance of carbon dioxide. Select one activity and write a letter to a classmate explaining why you would choose to do that activity.

4. K/U Water and chemical nutrients such as carbon and nitrogen are recycled through ecosystems. Explain why this recycling is necessary.

5. K/U Explain how biotic and abiotic interactions cycle matter in ecosystems. Use at least two examples to support your explanation.

6. C Refer to **Figure 1.7**. Create your own flowchart to show the cycling of carbon dioxide and oxygen through photosynthesis and cellular respiration.

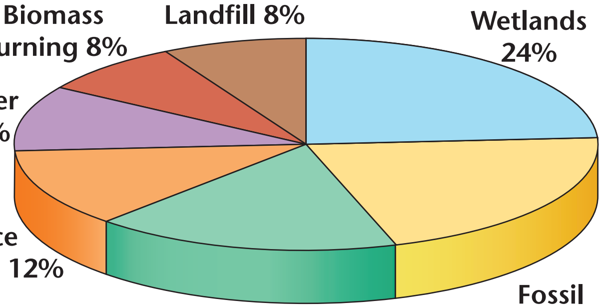
7. C Use words or diagrams to illustrate how a carbon atom that was part of a dinosaur 70 million years ago could be part of you today.

8. T/I Methane is a substance that is made up of carbon and hydrogen. It is a greenhouse gas that is about 21 times more potent than carbon dioxide. The pie graph below shows sources of methane emissions around the world. Use the graph to answer the following questions.

a) Which nutrient cycle is methane part of?

b) What percentage of methane emissions come from human activities, as opposed to natural sources?

Sources of Global Methane Emissions



Environment Canada, 2000