Topic 1.3
How do interactions in ecosystems cycle matter?

Overview

In this topic, students will investigate various cycles (such as water, oxygen, and carbon) and how any ecosystem cycles matter. They will also describe nutrient cycles and how producers and consumers are closely linked in nature. By examining conservation practices and other methods to restore the balance in any ecosystem, students will gain an appreciation for the role that human activities can play in threatening or maintaining this delicate balance.

Common Misconceptions

- **Students may get the impression that the carbon cycle consists solely of photosynthesis and cellular respiration.** These metabolic processes are only two parts of the carbon cycle. For example, carbon is also stored in organic matter that becomes fossil fuels, such as coal and oil, which release carbon dioxide when burned.
- **Students may think that all human activities have detrimental effects on ecosystems.** Activities such as recycling and composting can have positive effects on ecosystems. Students will learn more about positive actions people can take in Topic 1.6.

Background Knowledge

Energy and matter move throughout ecosystems through biogeochemical cycles such as the water cycle, the carbon cycle, the nitrogen cycle, and the phosphorus cycle. As nutrients are recycled between producers and consumers, the role of the decomposers becomes paramount. Photosynthesis and cellular respiration allow for the movement of carbon. Our propensity for burning fossil fuels for transportation and warmth is slowly destroying the delicate balance each of the cycles represent. Other human activities such as deforestation and watershed pollution have altered our access to water availability and have elevated worldwide temperatures thus disrupting ecosystems.

Literacy Strategies

Before Reading

- Ensure that students are familiar with the use of the word matter as a noun. This will help them to understand the title and main idea of the topic.
- Students can use **BLM G-29 K-W-L Char**t to organize what they Know, Want to Know, and Learned in this Topic. Have students fill in any background information they already possess about the topic or the keywords.
- Create a large concept map with student input to show what students understand already about interactions in ecosystems. Leave this on display for students to refer to as they read and to revise or complete after reading.

During Reading

- Have students use the GIST method to complete a summary statement about the role of decomposers in the biotic components of an ecosystem. Students can use **BLM G-30 Summarizing**, to help them organize the main ideas as they read and create a summary.

After Reading

- Have students summarize in a sentence or two how the nutrient cycles sustain an ecosystem as a way of checking they understand the material.
- Have students use graphic organizers or **BLM G-34 Flowchart** to organize what they learned about the biotic and abiotic components of a nutrient cycle or how both photosynthesis and cellular respiration sustain the carbon nutrient cycle.

Specific Expectations

- **B1.1** analyze, on the basis of research, how a human activity threatens the sustainability of a terrestrial or aquatic ecosystem
- **B3.2** describe the interdependence of the components within a terrestrial and an aquatic ecosystem, and explain how the components of both systems work together to ensure the sustainability of a larger ecosystem
- **B3.3** describe the complementary processes of cellular respiration and photosynthesis with respect to the flow of energy and the cycling of matter within ecosystems, and explain how human activities can disrupt the balance achieved by these processes

Skills

- analyze and interpret
- communicate ideas and conclusions

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-37 for a summary of the materials required in this topic.

- Students who require additional structure can complete **BLM 1-13 The Nutrient Cycle,** to show what they have learned.
- Have students reflect on what they have read. Ask students to reflect upon one thing they could do, or stop doing, that would help to maintain balance in the ecosystem and share the idea with a classmate. You could brainstorm a class list, and encourage students to try changing one behaviour.
- Together, complete (and if necessary revise) the concept map you drew before reading this topic.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check, page 30 Activity 1.6, page 31 Activity 1.7, page 33	Students describe the general flow of a nutrient through an ecosystem.	• Invite students who require scaffolding to complete **BLM 1-13 The Nutrient Cycle**. • To help students see connections, review the food chains and food webs in Topic 1.2 and discuss with students how they relate to the nutrient cycle.
Learning Check, page 32 Activity 1.7, page 33	Students explain how cellular respiration and photosynthesis cycle carbon and oxygen in ecosystems.	• Review cellular respiration and photosynthesis from Topic 1.2. Distribute, or refer students to, **BLM 1-6 Photosynthesis and Cellular Respiration**, from Topic 1.2. • Students can demonstrate understanding in a less language intensive way using **BLM 1-14 Photosynthesis and Cellular Respiration Cycle**.
Learning Check, page 35 Activity 1.8, page 34	Students explain how human activities can disrupt the balance achieved by nutrient cycles.	• Give students examples of human activities and ask them how they might affect the carbon cycle. Let students discuss and decide whether each one is harmful or beneficial. Give examples involving changing the numbers of producers or consumers, and increasing the amount of carbon dioxide. For example, flying in an airplane, buying a used car, planting trees, or turning forests into farmland. Students can use BLM G-32 through BLM G-39 to answer Learning Check question 3.

Topic 1.3 (Student textbook pages 28–39)

Using the Topic Opener (Student textbook pages 28–29)

- Invite students to suggest cycles that they are familiar with. These could include the seasons in a year, the path of dishes in a home, and others. Sketch a couple of them on the board, to emphasize that they never end. Examine the aluminum cycle and the water cycle on pages 28–29 together.
- Some of the nutrient cycles covered later in the Topic are not exact cycles like the life cycle of aluminum on page 28 and the simplified water cycle shown on page 29. To prepare students for these more complicated cycles, suggest variations in the cycles shown. For example, some aluminum cans are thrown in the garbage and therefore leave the cycle. Also, there could be a problem with a rolled sheet of aluminum, so it is shredded and melted again, skipping two stages of the cycle.
- Enrichment—Ask students about other items that they recycle. Have them modify the life cycle of aluminum for other recycleables such as glass, paper, and polyethylene terephthalate plastic (PET). Ask students how these products begin before they enter the cycle and whether they can return to that initial state.
- Have students identify human activities that are affecting a local ecosystem. Invite a guest speaker to help students develop their own local campaign to improve an ecosystem. This could be someone working to improve a local park or help a plant or animal species in the neighbourhood.

Starting Points Activity

Pedagogical Purpose

Students analyze the water cycle as an example of a natural cycle and begin to explore the idea that water at some parts of the cycle is not always available in any given place. We depend on balance in the cycle.

Planning	
Materials	Map of Ontario
Time	20 min in class 10 min preparation

Activity Notes and Troubleshooting

- The questions in this activity could be answered orally in a class discussion, or in pairs then discussed as a class.
- Ask students how photosynthesis and cellular respiration work in the water cycle. Point out that question 4 of the Starting Point Activity states that the amount of water on Earth always stays the same, then ask students what that tells them about the water used in photosynthesis and cellular respiration. How would the diagram change if the roles of photosynthesis and cellular respiration were included?

Additional Support

- Enrichment—Have students draw one of the cycles mentioned on page 28 or another cycle of their choice. Have them present the cycle to the class and explain in what ways the cycle relies on balance.
- DI Bodily-kinesthetic learners may benefit from acting out the stages of a cycle such as the life cycle of aluminum or the water cycle by moving objects or themselves around the classroom.

- DI Logical-mathematical or spatial learners may want to investigate the idea of a giant sphere containing all the water in the world. Encourage them to research where the water comes from (oceans, fresh water, polar ice) and assist them as necessary to perform calculations such as determining the volume.
- ELL As with the food chains and webs in the previous Topic, diagrams showing the movement of matter in cycles are helpful to English language learners. Review the meanings of the labels in the water cycle diagram with students.

Answers

1. In the water cycle, water circulates around to every part of the cycle and ends up where it started, to begin again.
2. Answers may vary. For example, yes this is a lot of water because not only is the ball 1400 km across, it is also that tall. The volume is about 1.437×10^{15} L.
3. During a drought, there is more evaporation than precipitation in the location. The water is somewhere else on the planet.
4. We are concerned about conserving water resources because not all areas have equal access to these resources and in some areas, the resources are contaminated. At some times of year, evaporation may cause much of the liquid water in one place to "disappear".

Instructional Strategies for Topic 1.3

Abiotic and biotic interactions cycle matter in terrestrial and aquatic ecosystems. (Student textbook pages 30–31)

- Have students construct a Picture Glossary using key terms as they are introduced. Recommendations for creating a Picture Glossary can be found in the Unit 1 Review, question 4 on page 84.
- Point out to students that organisms they may consider unpleasant, such as maggots, are not only useful as decomposers, but necessary for cycling nutrients and therefore life.
- The general nutrient cycle on page 31 is more complicated than the example of aluminum in the Topic Opener. Have students compare the different cycles. Point out that although energy enters and exits the system, nutrients continue to cycle, even if the route is not always the same.
- Other nutrient cycles are more complicated than the carbon and oxygen cycles that students will see in this Topic; they will be covered in higher grades. Encourage students to research the nitrogen cycle or the phosphorous cycle as an extension.

Photosynthesis and cellular respiration cycle carbon and oxygen in ecosystems. (Student textbook pages 32–33)

- Have students refer to their work in Topic 1.2 to remind them of the ingredients and products of photosynthesis and cellular respiration.
- Challenge students to think of what would happen if either photosynthesis or cellular respiration were to stop occurring.
- Challenge groups of students to create simplified versions of Figure 1.7 on chart paper. They can use small illustrations, short sentences, and/or equations to convey what each part of the diagram shows. This exercise will help English language learners build vocabulary, while it encourages all students to analyze the diagram carefully, and summarize the key ideas. Place these simplified diagrams on display for students to refer to later.
- Work with students to compare the energy cycle or the general nutrient cycle on page 31 with the carbon and oxygen cycles on page 33.

Human activities can affect ecosystems by affecting nutrient cycles.
(Student textbook pages 34–35)

- Use visuals or manipulatives to demonstrate how the balance in the carbon cycle is affected by human activity. By using several counters, pennies, or similar objects, and volunteers to take the roles of photosynthesis and cellular respiration, show a regular exchange of carbon atoms through photosynthesis and cellular respiration. Then show human activities as they introduce more carbon dioxide (burning fossil fuels) and reduce the amount of photosynthesis (deforestation). Ask students what will happen if these influences continue.
- ELL Use a diagram of the carbon cycle with interruptions due to human activity to help explain the material to English language learners.
- If the students have researched other nutrient cycles, have them consider what human activities might interfere with those cycles.

Learning Check Answers (Student textbook page 30)

1. Answers may vary. For example:
   A nutrient is any substance that living organisms require to sustain life.
   A nutrient cycle is the pattern of continual use and reuse of a nutrient.
2. Decomposers return the nutrients from the dead producers and consumers to the environment.
3. Without decomposers, dead plants and animals would build up and there would not be recycled carbon, nitrogen, iron, and other chemicals that living things need and use as nutrients.
4. They transform what was once a biotic factor into useable abiotic nutrients.

Activity 1.6 Interactions and Nutrient Cycles (Student textbook page 31)

Pedagogical Purpose

Students examine and analyze a general nutrient cycle.

Planning	
Materials	None required
Time	20 min in class 5 min preparation (prepare overhead)

Skills Focus

- select and organize relevant information
- communicate ideas

Activity Notes and Troubleshooting

- There is a lot of terminology in this activity. Review key terms that apply before beginning the activity (biotic, abiotic, producer, consumer, photosynthesis, cellular respiration, decomposer, nutrient). Students can refer to earlier in the textbook or their glossary to refresh the meaning of the terms.
- Have students work in pairs to analyze the diagram as well as to answer the questions.
- Prepare an overhead or projection of the diagram in the activity to facilitate class discussion.

Additional Support

- Have students redraw the general nutrient cycle two or three times with different specific producers and consumers to help them visualize how the general version applies to all cases.
- In What Did You Find Out?, students are asked for evidence. This might be best discussed as a class so that you can model how to select relevant evidence to support each statement.

Activity 1.6 Answers

1. Energy follows the yellow path.
2. Matter follows the green path.
3. Photosynthesis takes place in the producers.
4. Cellular respiration takes place in the producers, consumers, and decomposers.
5. If energy was not constantly flowing into the producers, then producers would die and there would be no energy for consumers and decomposers.

What Did You Find Out?

Statement 1: The nutrients pass through biotic and abiotic parts of an ecosystem as they move through the cycle. Both are needed to keep the cycle moving.
Statement 2: The decomposers transform what was once a biotic factor into useable abiotic nutrients.

Learning Check Answers (Student textbook page 32)

1. carbon dioxide and water
2. carbon dioxide and water
3. The substances required for cellular respiration are the products of photosynthesis (sugar and oxygen). The substances required for photosynthesis are the products of cellular respiration (carbon dioxide and water).

Activity 1.7 Cycle It (Student textbook page 33)

Pedagogical Purpose

Students gain an appreciation for the role of cycling in ecosystems by comparing the oxygen and carbon cycles and then creating a storyline that each student in the group adds to.

Planning	
Materials	None required
Time	20 min in class

Skills Focus

- communicate ideas

Activity Notes and Troubleshooting

- This is a good activity for developing group dynamics and sharing ideas. Have groups of at least four students sit together in a circle. Larger groups (six to eight students) will make for more interesting storylines. Have them complete the What To Do section. Once the storyline reaches the student that started, diagrams can be created to encompass the group's findings.

- The picture introduces the useful terminology "primary consumer" for consumers that eat producers and "secondary consumer" for consumers that eat other consumers. Students may wish to use this terminology elsewhere in the Unit.
- Have each group present their storyline to the class. Ask students if the other storylines influenced their understanding of nutrient cycling.

Additional Support

- ELL Encourage students to ask group members for clarification if an organism or process is mentioned in the story that they are not familiar with.
- DI Encourage linguistic learners to create a new storyline on their own.

Activity 1.8 Helping to Restore Balance (Student textbook page 34)

Pedagogical Purpose

Students will gain a better understanding of how human activities can upset the balance of carbon in any ecosystem and how we might restore the balance.

Planning	
Materials	**BLM G-32 Cause and Effect Map** (optional)
Time	20 min in class 5 min preparation (prepare copies of the BLM)

Skills Focus

- communicate ideas

Activity Notes and Troubleshooting

- This activity can be done individually or as a class.
- Brainstorm ways humans upset the balance of carbon dioxide with the class. It may be helpful to look at the carbon cycle section of the picture on page 33. Point out that the balance can be upset by reducing the number of producers, increasing the number of consumers, or adding more carbon dioxide by other means.
- Follow up with a discussion of how to reverse or offset the ideas students come up with during the first brainstorming session.
- Distribute **BLM G-32 Cause and Effect Map** to students to organize their ideas of how to restore balance to the of carbon dioxide.
- Have students suggest ways producers are reintroduced to urban settings such as parks and green roofs or roof gardens.

Additional Support

- ELL English language learners can include drawings in their responses if it helps them convey their ideas. Alternatively, they can respond orally.
- If the activity is done individually, have students share their understanding with another classmate to help them reflect on their own responses.
- Enrichment—Ask students to identify activities within the school that might upset the balance studied in the activity. Have them brainstorm ways to restore the balance through the school or community.

Activity 1.8 Answers

1. Answers may vary. For example, the use of fossil fuels (releasing extra carbon dioxide), cutting down trees (killing producers), and factory farming (having more consumers than normal in an area).

2. Answers may vary. Possible solutions to include in the cause and effect map include reducing fossil fuel consumption, reforestation, recycling, car pooling or bicycling, and using hybrid/electric vehicles.

Learning Check Answers (Student textbook page 35)

1. Wood, coal, oil, and natural gas all contain carbon that can be released into the air as carbon dioxide when these products are burned (oxidized).
2. Living organisms require nitrogen as a building block for protein.
3. Answers may vary. For example, students may create a flow chart. Graphic organizers should show steps similar to Steps A–E in Figure 1.8.

Using Strange Tales

Literacy Support

Before reading

- Have students look at the images and predict what the text is about. Ask them what the title means by "an immortal carbon" and how this relates to the images. Clarify the meaning of "immortal."

During reading

- Have volunteers take turns reading each panel of the activity aloud.
- Have students draw a food chain or carbon cycle that illustrates the specific path this carbon atom has travelled. They can update the diagram after each panel.

After reading

- Challenge students to summarize the seven panels in a short sentence or two to check on comprehension.
- Ask students how a carbon atom could follow a similar path today by being used in photosynthesis and then consumed.
- Ask students what part of the carbon cycle has not taken place yet and why.

Instructional Strategies

- Ask students what they know about paleontology and any discoveries besides dinosaur bones such as fossilized plants and footprints.
- ELL The diagrams are almost sufficient to explain the story without the text. You may want to work with students to create a one-sentence summary of what is happening in each panel.
- Allow students the option to describe the next step instead of drawing it, if they prefer.

Answers

1. Answers may vary. Students should show a way for the carbon atom to return to carbon dioxide, possibly through burning or decomposition.
2. Diagrams may vary. Photosynthesis converted the carbon atom in the second panel. Cellular respiration converted the carbon atom in the third and fourth panel.
3. Answers may vary. Many dating methods involve determining how much of a radioactive substance is left in organic remains and knowing how quickly the substance decays. Carbon dating calculates the amount of time based on how much carbon-14 is left. It is useful for items up to 60 000 years old. Note that fossils are not dated, but the rocks and soil around them.
4. Dr. Karen Chin is an American paleontologist specializing in fossilized dung (coprolites). From these fossils she can learn about the types of food dinosaurs ate and what micro-organisms were around.

Activity 1.9 Recycling on Mars (Student textbook page 38)

Pedagogical Purpose

In this activity, students apply what they have learned about cycles in ecosystems to design a model ecosystem—a colony on Mars.

Planning	
Materials	**BLM A-28 Presentation Rubric** (optional)
Time	45 min in class

Background Knowledge

Mars is the most similar planet to Earth in the solar system. It is smaller (nearly half the diameter) and farther from the sun, so it has less gravity and colder temperatures. It has very low atmospheric pressure and the air is about 95 percent carbon dioxide with only trace amounts of oxygen. A day on Mars is about 24 h 40 min long, and a year is 687 Earth days. Mars is tilted on an angle, so it has seasons just like Earth. A return mission to Mars could take more than two years to complete.

For many years, scientists have dreamed about forming a colony on another planet such as Mars. NASA, China, Japan, Russia, and the European Space Agency have all sent unmanned missions to Mars and manned missions have been considered since the beginning of the space program.

Skills Focus

- analyze information to draw conclusions
- communicate ideas and conclusions

Activity Notes and Troubleshooting

- Have students form groups of three to five to work on their Mars colony. Suggest that they imagine that they will be the first colonists and have groups pick names for their missions.
- Provide students with as much information about the conditions on Mars as possible. Allow research if further information is needed.
- Make sure students are making informed decisions about food production, waste disposal, heating and cooling, and generation of energy. Encourage them to refer to the matter and energy cycles they have seen previously to make sure they are designing a realistic colony.
- What Did You Find Out? questions can be answered individually or by each group. If they are answered in a group, tell students that all of the members of a group are responsible for making sure that everyone understands the answer well enough to explain it.

Additional Support

- Encourage groups to develop creative ways to present their proposals for a self-sustaining colony on Mars to the class. Some groups might enjoy drawing a diagram of the colony or writing instant messages to Earth. You can use **BLM A-28 Presentation Rubric,** to assess student presentations. If you do, distribute the rubric to students as they begin to plan their presentation, so that they will be aware of how they will be assessed.
- Enrichment—Interested students could research the Arthur C. Clarke Greenhouse experiment before starting this activity. For useful Web sites about the Arthur C. Clarke Greenhouse experiment, go to **www.scienceontario.ca**.
- Enrichment—Students could research the current state of Mars exploration and report to the class any plans for future missions.

Activity 1.9 Answers

Answers will vary based on the results of the What To Do section.

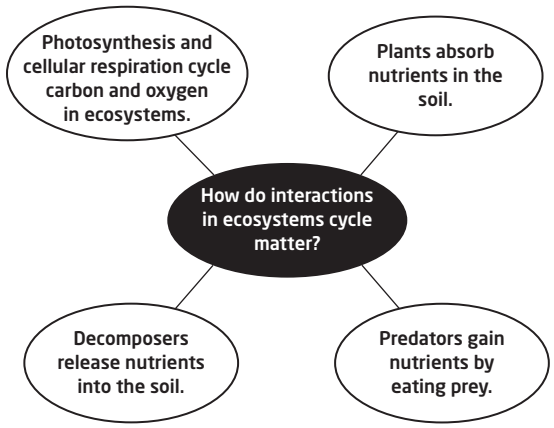
1. The colony must maintain a balance between production and consumption and have some adequate means to decompose waste. It is not like an ecosystem because it is completely shut off from other ecosystems.
2. **a)** Water, carbon, oxygen, and nitrogen cycles must be maintained.
   b) If one cycle is disrupted, the colony will probably fail.
   c) Answers will vary. Students should justify why their nutrient is the most difficult to cycle.
3. Students should use this information to decide to include both producers and consumers in their colony.
4. Answers will vary. Students should recognize that they could use this water supply to sustain their colony but must provide a means to recycle the water back because it is a finite supply.
5. Nitrogen can be recycled using the excess biomass to further enrich the water.

Topic 1.3 Review (Student textbook page 39)

Please see also **BLM 1-15 Topic 1.3 Review Answers (Alternative Format)**.

Answers

1. Answers may vary. For example:



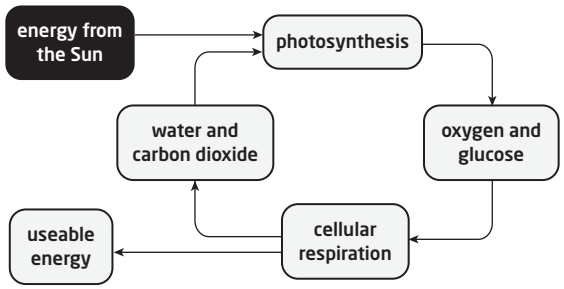
2. Through consumption and defecation we absorb nutrients from our food and then release the nutrients back into the environment, continuing the cycle. By driving cars and burning fossil fuels, humans introduce a large amount of carbon dioxide into the air, which could upset the balance in the carbon cycle. By using fertilizers, rain water can carry some nitrogen into aquatic ecosystems causing algal bloom.

3. Answers may vary. For example, not only is riding a bicycle healthy, but it costs less for fuel and releases less carbon dioxide.

4. Answers may vary. For example: all living organisms rely on water and nutrients, so if recycling does not occur, the amount of water and nutrients in any one part of the system will not be renewed, and the needs of the living organisms will not be met since these nutrients are not being renewed.

5. Answers may vary. For example: Biotic and abiotic interactions are essential in the recycling of nutrients. The energy and nutrients absorbed through consumption (like squirrels eating nuts) is released back into the soil through the decomposition of organic materials (like worms decomposing a dead animal).

6. Answers may vary. For example:



7. Answers may vary. For example: The carbon atom could be reintroduced to the environment through decomposition. The carbon could then get reabsorbed into a plant carrying on the carbon cycle. After many cycles, the carbon atom could end up in a plant that we could eat today, and the carbon atom could be introduced into our systems.

8. a) Carbon cycle

b) From 49–59%, depending on what is covered by the "Other" category.