Topic 1.2
How do interactions supply energy to ecosystems?

Specific Expectations

- **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

- formulate hypotheses
- communicate results 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.

Overview

In this topic, students will determine how the processes of photosynthesis and cellular respiration supply energy to all organisms in diverse ecosystems. By examining both the raw ingredients and the products of the chemical reactions for both of these metabolic processes, students will gain an appreciation for how these processes complement each other and allow for the survival of all organisms.

Common Misconceptions

- **Students may think that plants take in food from the outside environment, and/or plants get their food from the soil via the roots.** While nutrients such as nitrogen and phosphorus come from the soil, carbon dioxide from the atmosphere is combined with water during photosynthesis to create glucose. Have students imagine the darkest place they can, perhaps a cave or deep forest. No plants grow there, because plants need light to create their food.
- **Students may believe that green plants are the only producers in ecosystems.** Some types of bacteria also perform photosynthesis to produce their own food.
- **Students may believe that a species high on the food web is a predator to everything below it.** Not all organisms are in the diet of higher predators in a food chain and/or food web. In Figure 1.5 on page 23, the great horned owl does not eat insects or green plants.

Background Knowledge

The Sun is the ultimate source of energy in any ecosystem. Green plants and some bacteria can absorb a small portion of all the Sun's available energy and convert that solar energy into chemical energy in the process called *photosynthesis*. The word equation for photosynthesis is as follows: carbon dioxide (gas) + water + sunlight will form glucose (a sugar which is a carbohydrate) + oxygen (gas). A similar metabolic process called *cellular respiration* takes the products from photosynthesis (glucose and oxygen gas) and converts them into the raw materials (carbon dioxide gas and water) for photosynthesis. Since plants require a continuous supply of energy to maintain their life functions such as growth, repair, and reproduction, they obtain their energy from the glucose through cellular respiration. Animals must also rely upon cellular respiration to provide them with their energy requirements. Since animals are incapable of carrying out photosynthesis, their food sources must come from plants or the consumers that eat plants. All producers make their own energy-rich food compounds using solar energy and all consumers obtain their energy by feeding on either producers or lower-level consumers.

The producers transfer the energy to the consumers through food chains and food webs. A food chain describes the feeding relationships among organisms and the food web weaves together two or more food chains. Through these interactions energy is supplied to any ecosystem. Energy is continuously being lost to the environment as heat. This means that at higher levels in the food chain, there is less available energy for consumption.

Literacy Strategies

Before Reading

- ELL Preview key vocabulary with English language learners. Ensure that they understand the terms energy, interaction, and transfer.
- Students can use **BLM G-29 K-W-L Chart** 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 (photosynthesis and food chains will be familiar to some students). Encourage the use of both words and diagrams when filling in the BLM.

During Reading

- Have students rewrite topic headings and subheadings in the form of questions (for example, "How does photosynthesis store energy?" and "How is energy transferred through food chains and food webs?") and search for the answers as they read.
- Have students use **BLM 1-8 What Do You Know About Energy Flow?**, to record definitions and examples of Key Terms and other related terms as they read.

After Reading

- Use Think-Pair-Share to have students consider questions such as "How do organisms in an ecosystem interact to get energy?" and "How does the information in this topic help you understand energy flow?" Students can write notes and draw diagrams, then share with a partner and contribute ideas to a class discussion.
- Have students use graphic organizers such as Venn diagrams to compare and contrast key terms from the Topic. They can record their ideas on **BLM G-38 Venn Diagram**. This will help students develop a firm grasp of related terms such as photosynthesis and cellular respiration or producers and consumers.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Learning Check, page 21	Students demonstrate an understanding of the similarities and differences between photosynthesis and cellular respiration.	• Use **BLM 1-6 Photosynthesis and Cellular Respiration**, to help students organize their responses.
Learning Check, page 23, Investigation 1A, page 26	Students describe the interdependence of components of an ecosystem using a food web or food chain.	• Use **BLM 1-7 Ecosystem Energy Flow** to assist students with other examples of food webs. • ELL Allow English language learners to draw and analyze food chains and food webs for an ecosystem they are familiar with.

Topic 1.2 (Student textbook pages 18–27)

Using the Topic Opener (Student textbook pages 18–19)

- Lead students in the construction of food webs from various ecosystems around the world (possibilities include a boreal forest, the ocean, the tundra, a tropical rain forest, etc.). Start by writing the names of animals, insects, and plants from the ecosystem on the board, then use arrows to indicate what each animal eats to gets its energy. Remember to add the Sun as the source of energy for the producers. Compare these food webs. Point out that these interactions provide the energy for all life.
- Using the sample food webs, discuss whether an organism can change its position in a food chain and what conditions in the ecosystem might allow this to occur. (If a new top consumer is added to the ecosystem, or if another consumer leaves it the positions of other organisms in the food chain may change.)

Starting Points Activity

Pedagogical Purpose

Students think about the variety of paths energy takes to get from the Sun to the food they eat and the food animals eat.

Planning	
Materials	None required
Time	15 min in class

Activity Notes and Troubleshooting

- Ask students about ways to gather energy from the Sun. Heat energy is observable: During winter, there is not enough heat from the Sun to warm a home in Canada, but in warmer months, there is no need for furnaces or heaters. Solar panels also capture energy from the Sun and convert it into electricity. Some students may mention that the energy in food and/or in fossil fuels originally came from the Sun.
- Have students think about the similarities between what plants need to live and what people need to live. Ask them what is so important about light to plants and if there are any other resources a plant cannot live without (air and water).
- Students could answer the questions on their own, then compare with a classmate.

Additional Support

- ELL Have English language learners work with a classmate for support, or read the questions aloud.
- ELL Encourage English language learners to use a translation tool or dictionary to support their language needs.
- ELL Use labelled diagrams on the board or overheads to illustrate the transfer of energy from the Sun to plants and animals.
- Enrichment—As an extension to the last question, have students pick any meal and have them trace the energy from the Sun to each of the foods.

Answers

1. The Sun provides the energy for photosynthesis in the grass that the cow eats.
2. The energy the calf gets from its mother's milk, which is made by the cow, using energy it got from the grass, which got its energy from the Sun.
3. Answers will vary. Cereal comes from grains. Jam comes from fruit. Orange juice comes from the orange tree. Yogurt comes from milk (which comes from grass-eating cows). All of these got their energy from the Sun.

Instructional Strategies for Topic 1.2

Photosynthesis stores energy, and cellular respiration releases energy.

(Student textbook pages 20–21)

- 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.
- A cycle can be used to demonstrate the relationship between photosynthesis and cellular respiration, but remind students that carbon dioxide, water, oxygen, and glucose are used in other processes and are not just passing between these two processes.
- Students could read Table 1.1 aloud as a choral reading. You could read the questions in the first column, one group could read the responses for photosynthesis, and the other group could read the responses for cellular respiration.
- ELL Use diagrams by other students or photographs to help English language learners see examples whenever a new concept is introduced.

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

(Student textbook pages 22–23)

- Have students preview the Key Terms in the margin before reading the text to themselves. This will aid them in understanding the concepts as they encounter them.
- ELL Ensure that English language learners understand the concepts of chain and web before reading this section. If possible, bring an example of each to class to illustrate the nature of the connections.
- Give students **BLM 1-7 Ecosystem Energy Flow** to complete. It will help them understand the different roles in a food web and give them practise thinking about the interactions is other ecosystems.
- DI Figure 1.4 and Figure 1.5 convey a lot of the important information on this spread. Invite students to share with the class what they can learn from these diagrams. This will appeal to visual learners and English language learners, and encourage others to broaden their repertoire of learning styles.
- Enrichment—Ask students to choose an ecosystem, then list as many producers and consumers in that ecosystem as they can. Use this list to create a food web for the ecosystem.

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

(Student textbook pages 24–25)

- An alternative to the bucket-toss relay in Figure 1.6A is a can or cup with holes through it that leaks as it is carried from one position to another. If weather permits, consider going outside to allow students to experience this. Alternatively, demonstrate the idea on a small scale over a sink or bucket.
- The result of only 10 percent of the available energy transferring from producer to consumer is that a consumer must eat 10 identical producers to get the energy available in one of them.
- Ask students what would happen to an ecosystem if the amount of oxygen or energy produced in photosynthesis was not adequate enough to sustain life for all the producers and consumers that lived there.

Learning Check Answers (Student textbook page 21)

1. During photosynthesis, light energy is transformed into chemical energy. During cellular respiration, the chemical energy in glucose is transformed into kinetic energy, heat energy, and other forms of energy needed for life.
2. Light energy, water, and carbon dioxide are needed for photosynthesis. Cellular respiration requires glucose and oxygen. Photosynthesis produces glucose and oxygen. Cellular respiration produces carbon dioxide, water vapour, and useable energy.
3. Answers may vary. Diagrams should show glucose and oxygen coming from photosynthesis and going into cellular respiration, as well as energy, carbon dioxide, and water coming from cellular respiration and going into photosynthesis. The energy for photosynthesis is light energy and the energy from cellular respiration is usable energy.
4. Answers may vary. Summaries should include data in question 3.

Learning Check Answers (Student textbook page 23)

1. Producers such as green plants get the energy they need from the Sun by the process of photosynthesis. Consumers must eat to get energy.
2. A food chain only shows one possible way producers and consumers are related instead of showing all possible feeding relationships like a food web does.
3. Answers may vary. Sample food chains:
   green plants → insects → bat → great horned owl
   green plants → insects → grouse → weasel → great horned owl
   green plants → mouse → weasel → great horned owl
   green plants → snowshoe hare → great horned owl

Learning Check Answers (Student textbook page 24)

1. There are limits because just a small amount of energy is transferred from one living thing in the food chain to another. If the food chain gets too long, the energy transferred is too small.
2. The energy escapes as heat or is used by the plant.
3. Answers may vary. For example: With each subsequent bounce, the maximum height the ball will reach is reduced because energy is lost to gravity each time the ball hits the ground.
4. A constant supply of energy is needed to sustain life on Earth because most of the energy produced is lost as heat and cannot be used by other organisms.

Activity 1.5 Pass It On! (Student textbook page 25)

Pedagogical Purpose

In this Numeracy Focus activity, students will use a model to investigate how much energy is actually available in each link of a food chain.

Planning	
Materials	100 pennies or plastic game chips calculator **BLM 1-9 Activity 1.5 Conversion Chart**
Time	15 min in class 10 min preparation

Background Knowledge

Only about 10 percent of the food energy for a producer is available to a consumer that eats it. This is also true for when a consumer eats another consumer. The loss of energy is due to various factors including energy lost as heat (the main cause of lost energy), energy being used by the producer or consumer before it is eaten, and energy stored in waste products.

Activity Notes and Troubleshooting

- Have a variety of other food chains displayed around the classroom for students to appreciate the diverse inter-connections of food chains.
- Small candies, coloured paper clips, or any small item available in large numbers could be used instead of pennies or plastic game chips.
- Model the initial calculation and conversion from pennies to kilojoules, especially if students demonstrate weak mathematics skills.

Additional Support

- DI If possible, have a logical-mathematical learner in each group to support the group with the mathematics. If it would help your students, distribute **BLM 1-9 Activity 1.5 Conversion Chart**.
- ELL Allow English language learners to use diagrams to summarize their results from the activity.
- If students would become distracted by manipulating the pennies, have a group of 3 demonstrate for the class, while others observe and record. Everyone can complete the What Did You Find Out? questions.
- Enrichment—Have interested students calculate how many pennies a producer would have to start if the organism at the end of a five-link food chain needed 1 kJ of energy. What pattern do students notice?

Activity 1.5 Answers

What To Do

4. Ten percent of the pennies you started with is 10 pennies.

5. One penny is available to the remaining consumer or 1 kJ of food energy.

What Did You Find Out?

1. The amount of energy stored in the producer is 100 times the amount available to the last consumer in the food chain.

2. Most food chains do not exceed 5 or 6 links because if they were longer, the amount of energy available to the last consumer in the food chain would be too small to provide for their survival.

Investigation 1A Plot the Pathway

Pedagogical Purpose

Students create, analyze, and interpret food chains. They recognize the diverse possibilities for food chains and consider how changes to one of the species might affect the whole chain.

Planning	
Materials	writing materials 12 small pieces of paper **BLM 1-10 Investigation 1A** **BLM 1-11 Plot the Pathway** (optional)
Time	30 min in class 5 min preparation

Background

All species interact with other species and with the environment in various ways. These interactions in turn supply the energy for the ecosystem to sustain itself. In a food chain, the arrows show the direction of food and energy flow and explains who consumes who. Interconnecting food chains form food webs.

Skills Focus

- formulate hypotheses
- analyze and interpret

Activity Notes and Troubleshooting

- Review the models of food chains and food webs with the students. Spend some time identifying the biotic and abiotic components of a sample ecosystem and the producers and consumers.
- Distribute **BLM 1-10 Investigation 1A** to students.
- Ensure students create the longest realistic food chain that they can. Consider offering a prize. When food chains are complete, allow students to review the food chains created by other groups.

Additional Support

- Refer those in need of guidance to Figure 1.5 on page 23 for a food web in a similar ecosystem.
- Provide **BLM 1-11 Plot the Pathway**. Have students cut out the ecosystem components instead of writing them. You could also enlarge these images, attach magnets, and use them to create food chains on the chalkboard. Manipulate the magnetized images to illustrate the diversity of food chains possible.
- DI Body-kinesthetic learners may wish to act out their group's food chain with each student representing a component.
- DI Assign the students a place in a food chain such as a producer, primary consumer, secondary consumer, or top carnivore. They have to decide which species would fit in their designated title. From there, the class could arrange themselves into a class size food web.
- Enrichment—Have students complete a food web based on the list.

Answers

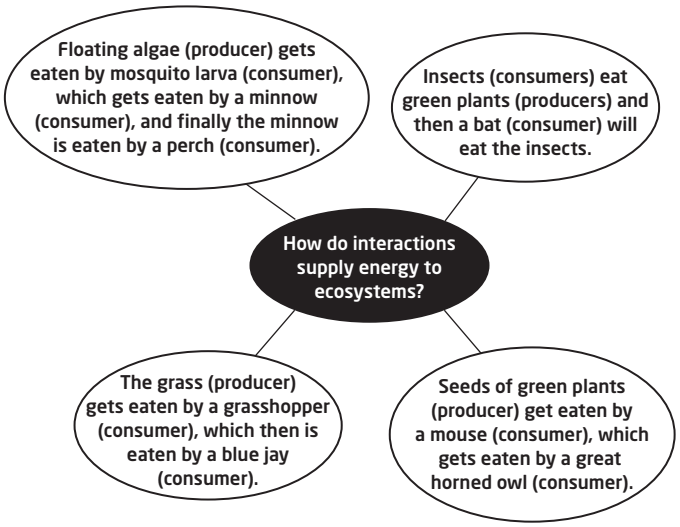
1. **a)** Abiotic parts: Sun
   b) Biotic parts: grasshopper, willow tree, weasel, red fox, grass, caterpillar, great grey owl, hermit thrush, eastern fox snake, bunch berry, deer mouse
   c) Producers: willow tree, grass, bunch berry
   d) Consumers: grasshopper, weasel, red fox, caterpillar, great grey owl, hermit thrush, eastern fox snake, deer mouse
2. **a)** The willow tree, bunch berry, and grass store energy through photosynthesis.
   b) All the organisms release energy through cellular respiration.
   c) If the producers died, the food chain could not survive as the consumers would starve.
3. Numbers of organisms may vary. Food chains are limited in length because the amount of useable energy available decreases with each extra link.
4. If the number of eastern fox snakes declined, then any of their predators might be in danger of extinction if they have no other food source. Similarly, if another species eats the same animals as the snake, their numbers might temporarily increase because there is less competition for their food.

Topic 1.2 Review (Student textbook pages 26–27)

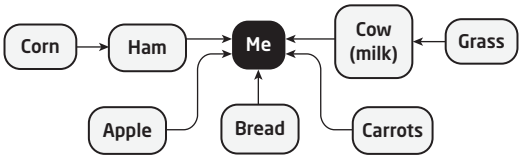
Please also see **BLM 1-12 Topic 1.2 Review (Alternative Format)**.

Answers

1. Answers may vary. For example:



2. Answers may vary. For example:



a) The longest chain is 3.

b) Cellular respiration.

3. Every link in a food chain loses some energy due to heat. Since plants are producers, the food chain involved with plants contains only two links, so most of the energy is conserved. While some people may feel this provides them with more energy, in reality we all get approximately ten percent of the energy in the food we eat, no matter what the source of that food is.

4. The products of cellular respiration are used for photosynthesis, and the products of photosynthesis are used for cellular respiration.

5. Answers may vary. For example:
The Sun is the basis of all energy on Earth. Without photosynthesis, the energy from the Sun would not be usable by other organisms and energy would never be transferred. In addition, almost all living things on Earth use cellular respiration. Photosynthesis provides the glucose and oxygen required for cellular respiration, so without photosynthesis, we would not have the raw materials to get energy.

6. Energy is lost at every step of energy transfer from the Sun through every link on each food chain. So if there was not a continual input of energy from the Sun, we would eventually run out of energy.

7. Answers may vary. For example:

Process	Photosynthesis	Cellular Respiration
Organisms in which the process occurs (Give three examples.)	Green plants and certain kinds of single-celled organisms. For example, trees, flowers, and algae.	Nearly all living things. For example, humans, bears, mosquitoes, and dandelions.
Substances used by the process	• carbon dioxide • water	• glucose and other sugars • oxygen
Substances produced by the process	• glucose and other sugars • oxygen	• carbon dioxide • water