

# 2.4

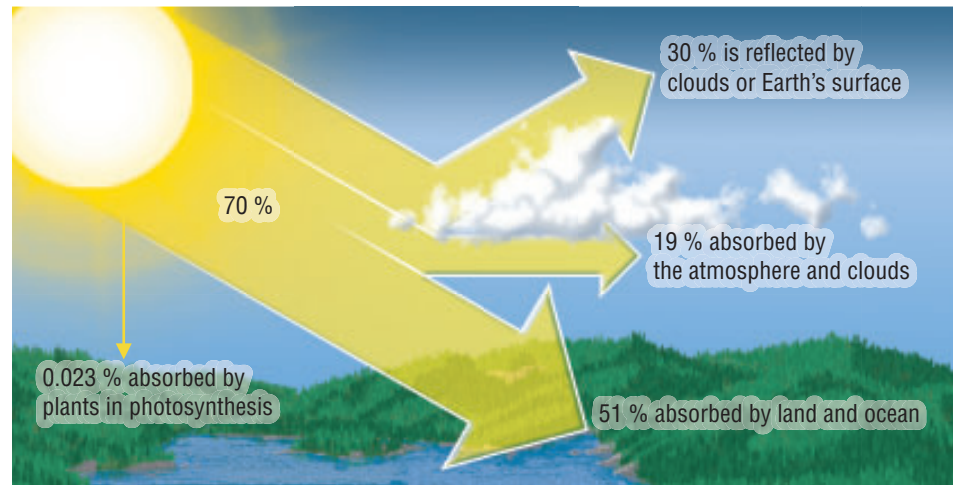
**radiant energy** energy that travels through empty space

**light energy** visible forms of radiant energy

**thermal energy** the form of energy transferred during heating or cooling

## Energy Flow in Ecosystems

All organisms require energy to stay alive and function. The source of almost all of this energy is **radiant energy**. This is the energy radiated from the Sun. Earth is being continuously bombarded with both invisible radiant energy, such as ultraviolet, and visible radiant energy, or **light energy**, from the Sun. About 70 % of the radiant energy is absorbed by the hydrosphere and lithosphere and converted into **thermal energy**. Thermal energy is what warms the atmosphere, evaporates water, and produces winds. The remaining 30 % of the radiant energy is reflected directly back into space. A small fraction of the radiant energy, a mere 0.023 %, is absorbed directly by living organisms in a process called photosynthesis (Figure 1).



**Figure 1** The distribution of incoming solar radiation

### READING TIP

#### Text-to-World Connections

To make text-to-world connections, sometimes it is necessary to conduct research online or in a library. Use a search engine to gather information about the topic or key ideas. List the three most important points about the topic. Beside each, make a note of the connections you can make.

**photosynthesis** the process in which the Sun's energy is converted into chemical energy

**producer** an organism that makes its own energy-rich food compounds using the Sun's energy

Thermal energy keeps Earth's surface warm, but it cannot provide organisms with the energy they need to grow and function. Light energy can be used by some organisms, but it cannot be stored and is not available during the night. In contrast, chemical energy can be stored in cells and then released when needed. Chemical energy is used by all organisms to perform functions, including movement, growth, and reproduction. As chemical energy is used, it must be replaced.

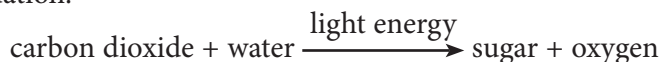
## Photosynthesis

Where does the chemical energy used by organisms come from? As you may know, the simple answer is the Sun. Many organisms are able to convert light energy into chemical energy using the process of **photosynthesis**. This conversion of energy is one of the most important chemical processes. Without it, most life on Earth would not exist.

Organisms that photosynthesize make their own energy-rich food compounds using light energy. These organisms are called **producers**. Most organisms that are unable to make their own food through photosynthesis depend on producers for food. You will learn more about this later in the section. On the land, the major producers are green plants. The green colour comes from a chemical called chlorophyll, which captures light energy.

In aquatic ecosystems, the main producers are microscopic organisms. These single-celled algae and cyanobacteria also contain chlorophyll (Figure 2). Virtually all of the chemical energy contained in food was once light energy captured in the process of photosynthesis.

Most producers use light energy to convert two low-energy chemical compounds (carbon dioxide and water) into high-energy compounds (sugars). In doing so, they release oxygen gas into the environment as a by-product. The photosynthesis reaction is represented by the following word equation:

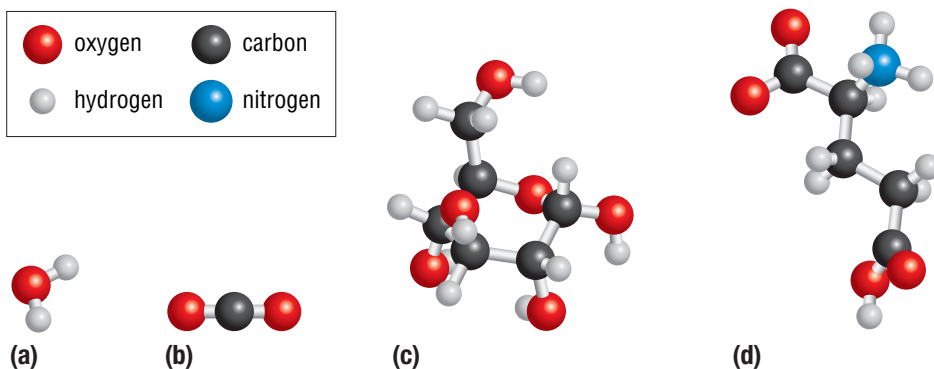


The sugar formed in this process contains stored chemical energy. This energy is stored in the roots, stems, leaves, and seeds of plants (Figure 3). Most plants convert the sugar to starch for storage.



**Figure 3** Chemical energy is stored in a variety of plant structures.

Not all of the sugar produced through photosynthesis goes toward energy storage. Some sugars are used as building materials. The carbon, hydrogen, and oxygen in the carbon dioxide and water are like building blocks. Using light energy, they are rearranged to form sugars and oxygen gas during photosynthesis. Then, components in the sugars are rearranged to form different combinations. For example, they may form carbohydrates (such as the cellulose used in cell walls) or in combination with nitrogen, proteins (Figure 4).



**Figure 4** The molecular structure of (a) water, (b) carbon dioxide, (c) glucose (a sugar), and (d) glutamic acid (a building block of protein)



**Figure 2** Algae are often the dominant producers in aquatic ecosystems.

### LEARNING TIP

#### Reading Word Equations

The arrow in a word equation can be read as “react to form.” The word equation for photosynthesis reads “carbon dioxide and water, in the presence of light energy, react to form sugar and oxygen.”

### DID YOU KNOW?

#### Plants Do Not Always Need the Sun!

Some Ontario plants, including Indian pipe, do not photosynthesize. Instead, this species obtains energy-rich food directly from fungi in the soil. Stranger still, the fungi obtain their food from the roots of neighbouring trees. With no need for green chlorophyll, these white plants have small, functionless leaves.



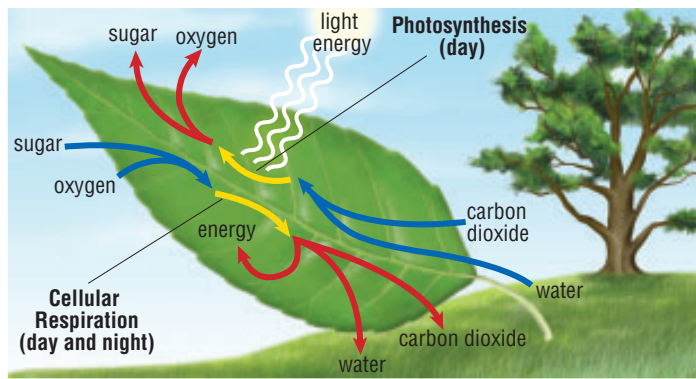
# Cellular Respiration

**cellular respiration** the process by which sugar is converted into carbon dioxide, water, and energy

Photosynthesis produces stored energy in the form of sugar. To make stored energy available for use, the plant performs the complementary reaction called cellular respiration. **Cellular respiration** is a chemical process in which energy is released from food. In this process, the sugar and oxygen are rearranged to form carbon dioxide and water. As this reaction takes place, energy is released. The plant is able to use this released energy for any of the activities carried out by its cells. The word equation for cellular respiration is



The energy originally stored in the sugar is released as a product of cellular respiration. Unlike photosynthesis, cellular respiration occurs continuously. No light energy is required for cellular respiration. Figure 5 illustrates the relationship between the processes of photosynthesis and cellular respiration.



**Figure 5** Photosynthesis and cellular respiration are complementary processes.

## TRY THIS PRODUCTS OF CELLULAR RESPIRATION

**SKILLS:** Questioning, Predicting, Performing, Observing, Analyzing

Cells require a continuous supply of energy to stay alive. Cellular respiration releases this energy from stored food. What observations support these statements? Is there evidence that the cells in your body are continuously performing cellular respiration?

**Equipment and Materials:** stopwatch or clock with second hand; large test tube or clear plastic cup; scissors; limewater; cardboard or paper disc; drinking straw

1. Review the word equation for cellular respiration noting what is used and what is produced by this chemical process.
2. Try holding your breath for as long as you can. Note the time at which you start to feel a strong urge to breathe. This is an indication of how long it takes for your body to begin running low on the supply of oxygen needed for cellular respiration.
3. Fill a large test tube or cup one-third full of limewater. Limewater turns cloudy when combined with carbon dioxide. Record the appearance of the limewater.
4. Cut an opening in a 5 × 5 cm piece of cardboard or paper just large enough to slip a straw through. This will act as a splash guard. Slide the splash guard halfway along the straw.

5. Place one end of the drinking straw in the limewater and the other end in your mouth. The splash guard should be just above the top of the test tube. Slowly breathe out a steady stream of bubbles through the limewater. You may wish to exhale several breaths through the limewater. Record any changes in the appearance of the limewater.



**Do not suck on the straw.**

- A. How long do you think human cells can last without oxygen? What evidence supports your answer? **T/I**
- B. By holding your breath, what necessary chemical are you preventing from entering your body? **K/U**
- C. If this chemical is not available, what will happen to the process of cellular respiration? **K/U**
- D. What effect, if any, would this have on your cells' ability to release energy from food? **T/I**
- E. Was there any evidence of limewater combining with carbon dioxide? Explain. **T/I C**
- F. If your body produces carbon dioxide during the process of cellular respiration, what else is most likely being produced? **K/U**

Many organisms cannot photosynthesize. Therefore, they are not able to make their own energy-rich sugar or building materials. These organisms, called **consumers**, obtain energy and building materials by eating other organisms. To obtain usable energy from food, they undergo cellular respiration. While only producers undergo photosynthesis, both producers and consumers perform cellular respiration. Unless you are a green human with chlorophyll in your skin, you are a consumer (Figure 6). Instead of photosynthesizing, you, like all consumers, obtain energy by eating other organisms or their products.

Perhaps no other set of chemical reactions provides better evidence of our dependence on other living things. Without photosynthesizing producers, we would be without a source of food. A major benefit of plants is that they release oxygen into the environment. However, we would have no use for oxygen if plants did not provide us with the food we need to perform cellular respiration.

Not all organisms require oxygen, and some of these organisms do not rely on photosynthesis either. Many soil micro-organisms, for example, use other chemical pathways to release chemical energy from sugar. This process occurs in the absence of oxygen.

**consumer** an organism that obtains its energy from consuming other organisms



**Figure 6** Humans are consumers, obtaining energy by eating other organisms.

## IN SUMMARY

- During photosynthesis, green plants use the Sun's energy to convert carbon dioxide and water into sugar (chemical energy) and oxygen.
- During cellular respiration, sugar and oxygen are converted into carbon dioxide, water, and energy.
- All organisms undergo cellular respiration.
- Producers make their own energy-rich food compounds using the Sun's energy.
- Consumers obtain energy by feeding on other organisms.
- Humans depend on photosynthesizing organisms for food and oxygen.

## CHECK YOUR LEARNING

1. How much of the energy reaching Earth is absorbed and converted to chemical energy by the process of photosynthesis? Where does the other energy go? **K/U**
2. What energy-rich substance is produced by green plants during photosynthesis? **K/U**
3. Explain how you know plants contain energy-rich substances. **T/I**
4. Plants do not just use photosynthesis to make sugars for energy storage. Identify other kinds of uses plants have for these substances. **K/U**
5. How are photosynthesis and cellular respiration related? **K/U**
6. What chemical process(es) do producers and consumers share? What chemical process(es) do they not share? **K/U**
7. List five foods that contain the high-energy products of photosynthesis. **T/I**
8. Prior to reading this section, would you have considered plants as more essential as producers of food or of oxygen? What are your thoughts now? **C**
9. Were you surprised to learn that plants use oxygen and perform cellular respiration just like animals? Explain. **C**
10. Animals are unable to make their own energy, yet you obtain energy when you eat animal food products. Explain how this illustrates the flow of energy through an ecosystem. **T/I**
11. Describe how plants can perform cellular respiration at night when they perform photosynthesis only during the day. **K/U**
12. It is a major advantage to be able to make your own food using photosynthesis. Can you think of any disadvantages to having this ability? Are there places you could not live or things you could not do? **A**