

SECTION 1 **Energy in Living Systems**

KEY IDEAS

As you read this section, keep these questions in mind:

- What type of energy is used in cells?
- How is an organism’s metabolism related to the carbon cycle?
- How is energy released in a cell?

READING TOOLBOX

Ask Questions Read this section quietly to yourself. As you read, write down any questions you have. When you finish reading, work in a small group to figure out the answers to your questions.

Background

Recall that *homeostasis* is the process of maintaining consistent internal conditions, even if the outside environment changes.

Critical Thinking

1. Predict What would happen to life on Earth if all the autotrophs disappeared?

LOOKING CLOSER

2. Identify Where do autotrophs get food?

Where Do Organisms Get Energy?

Why do you shiver when you are cold? Your body is trying to maintain homeostasis. When you shiver, your muscles produce heat to help warm you up. You and all other organisms need chemical energy to maintain homeostasis. This chemical energy comes from carbon compounds in food.

Almost all of the energy in carbon compounds comes from the sun. Plants, algae, and some prokaryotes use energy from sunlight to change carbon dioxide and water into carbon compounds. This process is called **photosynthesis**. During photosynthesis, the energy in sunlight is stored in chemical bonds in carbon compounds. Organisms that carry out photosynthesis are called *autotrophs*.

Other organisms, including all animals and fungi, cannot perform photosynthesis. They get energy by absorbing carbon compounds from other organisms or by eating other organisms.



Watermelon plants, like other autotrophs, produce their own food through photosynthesis. Humans, like many other animals, get energy by eating autotrophs.

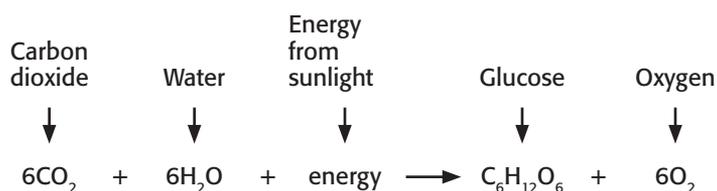
SECTION 1 Energy in Living Systems *continued*

How Is Metabolism Part of the Carbon Cycle?

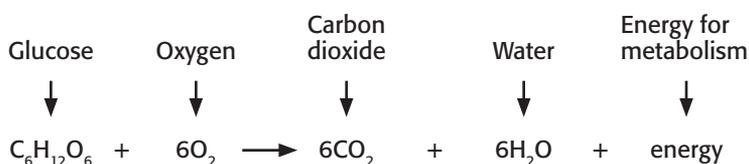
Metabolism involves either using energy to build carbon compounds or breaking down carbon compounds to release the energy in them. Therefore, metabolism is part of Earth's carbon cycle. The processes of the carbon cycle move carbon compounds between and within ecosystems. Because organisms obtain energy from carbon compounds, the carbon cycle also delivers chemical energy to organisms. ✓

How Do Cells Use the Energy from Food?

The main organic compound that cells use is glucose. Glucose is produced during photosynthesis. The overall chemical reaction that occurs during photosynthesis is shown below.

Photosynthesis: Overall Chemical Reaction

In order to get energy from glucose molecules, most organisms use cellular respiration. During **cellular respiration**, glucose combines with oxygen to produce carbon dioxide, water, and energy, as shown below.

Cellular Respiration: Overall Chemical Reaction

If glucose and oxygen combined in a single step, all of the energy would be released as heat. Therefore, within a cell, the reaction between glucose and oxygen is broken up into several steps. The energy that is released at each step is stored as chemical energy in a molecule called adenosine triphosphate, or **ATP**.

ATP is the main energy source for cell processes. The figure at the top of the next page shows how ATP is produced. ✓

Background

Recall that *metabolism* is all of the chemical reactions that occur within an organism.

**READING CHECK**

3. Explain How is metabolism part of the carbon cycle?

LOOKING CLOSER

4. Compare How is the overall chemical reaction for cellular respiration related to the overall chemical reaction for photosynthesis?

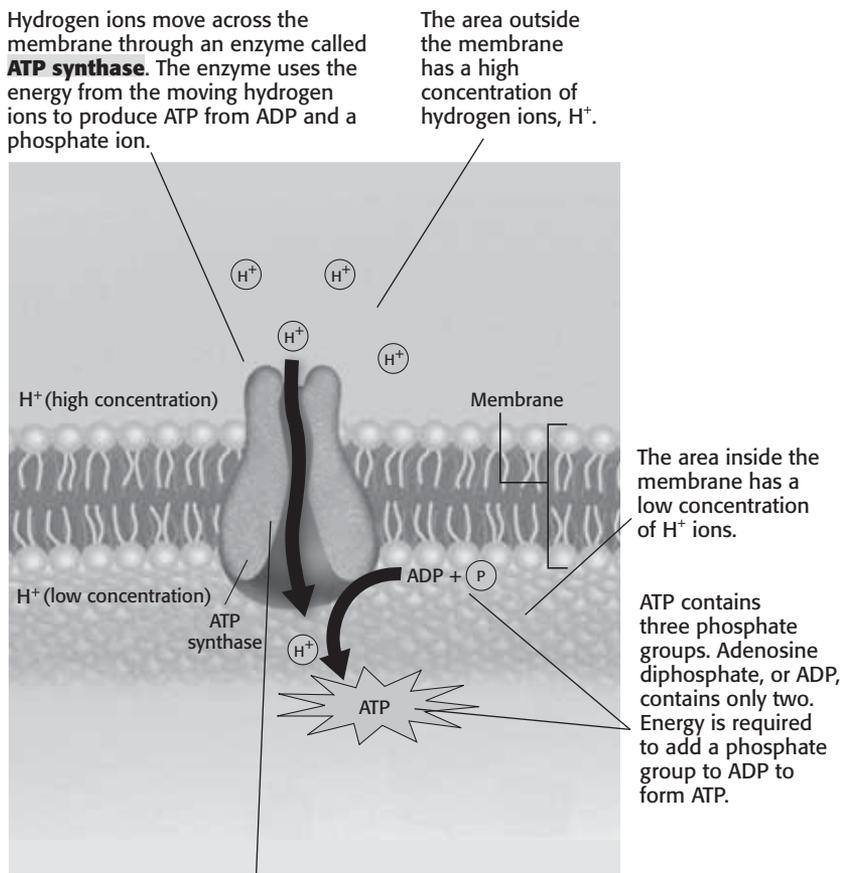
**READING CHECK**

5. Identify What molecule is the main energy source for cell processes?

SECTION 1 Energy in Living Systems *continued*

Talk About It

Summarize Review this figure by yourself. Then, describe what is shown in the figure to a partner.



LOOKING CLOSER

6. Identify What two molecules combine to form ATP?

The H^+ ions flow from the area of high concentration (outside the membrane) to the area of low concentration (inside the membrane). They can flow only through the ATP synthase molecule.

The diagram above shows that the concentration of H^+ ions outside the membrane is higher than that inside the membrane. Remember that ions flow from areas of high concentration to low concentration. How, then, is the area of high concentration outside the membrane produced? The cell must use energy to move the hydrogen ions from inside the membrane to outside. This energy comes from an electron transport chain.

In an **electron transport chain**, energy is released as electrons move between different molecules. This released energy is used to move hydrogen ions from areas of low concentration to areas of high concentration. ✓

There are three main molecules that are part of electron transport chains: NADH, $FADH_2$, and NADPH. Each of these molecules can release energy by losing electrons. The energy can then be used to move hydrogen ions across the membrane.

READING CHECK

7. Describe How is energy released in an electron transport chain?

Section 1 Review

SECTION VOCABULARY

<p>ATP adenosine triphosphate, an organic molecule that acts as the main energy source for cell processes; composed of a nitrogenous base, a sugar, and three phosphate groups</p> <p>ATP synthase an enzyme that catalyzes the synthesis of ATP</p> <p>cellular respiration the process by which cells produce energy from carbohydrates; atmospheric oxygen combines with glucose to form water and carbon dioxide</p>	<p>electron transport chain a series of molecules, found in the inner membranes of mitochondria and chloroplasts, through which electrons pass in a process that causes protons to build up on one side of the membrane</p> <p>photosynthesis the process by which plants, algae, and some bacteria use sunlight, carbon dioxide, and water to produce carbohydrates and oxygen</p>
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1. Describe How does ATP synthase produce ATP?

2. Explain How does the carbon cycle deliver energy to organisms?

3. Identify How do organisms that are not autotrophs get energy?

4. Explain In cells, glucose is combined with oxygen in a series of steps instead of all at once. What is the reason for this?

5. Describe What happens in an electron transport chain?

6. Identify Name two molecules that can release energy as part of the electron transport chain.
