4.4 Overview of Cellular Respiration

KEY CONCEPT The overall process of cellular respiration converts sugar into ATP using oxygen.

MAIN IDEAS

- Cellular respiration makes ATP by breaking down sugars.
- Cellular respiration is like a mirror image of photosynthesis.

VOCABULARY

cellular respiration, p. 113
aerobic, p. 113
glycolysis, p. 113
anaerobic, p. 113
Krebs cycle, p. 115

Review
mitochondria, ATP, electron transport chain

MICHIGAN STANDARDS

B2.1A Explain how cells transform energy (ultimately obtained from the sun) from one form to another through the processes of photosynthesis and respiration. Identify the reactants and products in the general reaction of photosynthesis.

B2.1B Compare and contrast the transformation of matter and energy during photosynthesis and respiration.

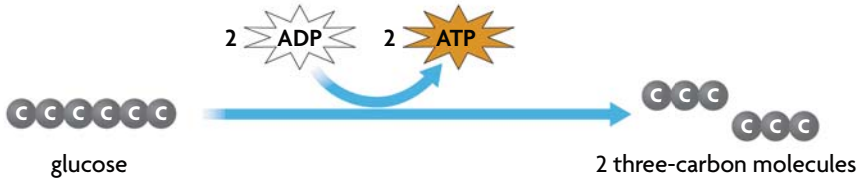
Connect The term *cellular respiration* may lead you to form a mental picture of cells breathing. This image is not correct, but it is useful to remember. Your cells need the oxygen that you take in when you breathe. That oxygen helps your body release the energy in sugars and other carbon-based molecules. Indirectly, your breathing is connected to the ATP that your cells need for everything you do.

MAIN IDEA

Cellular respiration makes ATP by breaking down sugars.

Plants use photosynthesis to make their own food. Animals eat other organisms as food. But food is not a direct source of energy. Instead, plants, animals, and other eukaryotes break down molecules from food to produce ATP. **Cellular respiration** releases chemical energy from sugars and other carbon-based molecules to make ATP when oxygen is present. Cellular respiration is an **aerobic** (air-OH-bihk) process, which means that it needs oxygen to take place. Cellular respiration takes place in mitochondria, which are often called the cell's "powerhouses" because they make most of a cell's ATP.

A mitochondrion, shown in **FIGURE 4.10,** cannot directly make ATP from food. First, foods are broken down into smaller molecules such as glucose. Then glucose is broken down, as shown below. **Glycolysis** (gly-KAHL-uh-sihs) splits glucose into two three-carbon molecules and makes two molecules of ATP. Glycolysis takes place in a cell's cytoplasm and does not need oxygen. Glycolysis is an **anaerobic** process because it does not need oxygen to take place. However, glycolysis is necessary for cellular respiration. The products of glycolysis are broken down in mitochondria to make many more ATP.



Explain **What is the function of cellular respiration?**

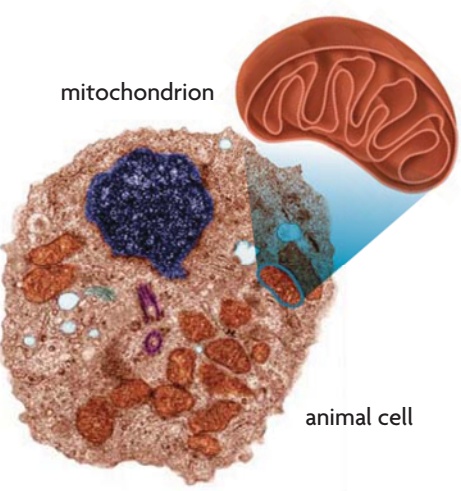


FIGURE 4.10 Mitochondria, found in both plant and animal cells, produce ATP through cellular respiration. (colored TEM; magnification 4500×)

MAIN IDEA

Cellular respiration is like a mirror image of photosynthesis.

Connecting CONCEPTS

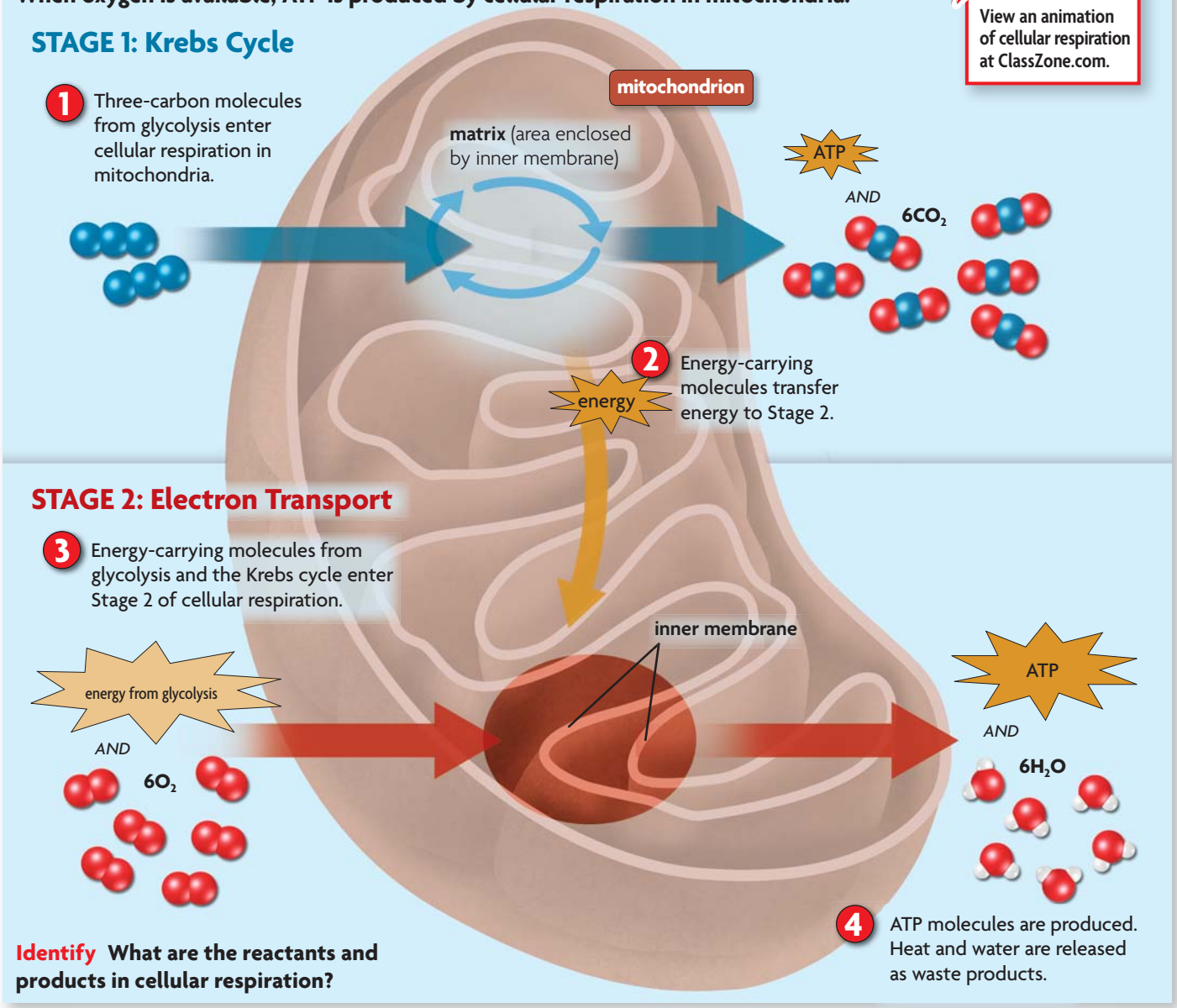
Photosynthesis Review the overall process of photosynthesis in **Section 4.2** and compare photosynthesis to cellular respiration.

Photosynthesis and cellular respiration are not true opposites, but you can think about them in that way. For example, chloroplasts absorb energy from sunlight and build sugars. Mitochondria release chemical energy to make ATP. The chemical equation of cellular respiration is also basically the reverse of photosynthesis. But the structures of chloroplasts and mitochondria are similar. A mitochondrion is surrounded by a membrane. It has two parts that are involved in cellular respiration: the matrix and the inner mitochondrial membrane. In mitochondria, cellular respiration takes place in two main stages, as shown in **FIGURE 4.11.**

FIGURE 4.11 Cellular Respiration Overview

When oxygen is available, ATP is produced by cellular respiration in mitochondria.

Animated BIOLOGY
View an animation of cellular respiration at ClassZone.com.



Identify **What are the reactants and products in cellular respiration?**

The **Krebs cycle** produces molecules that carry energy to the second part of cellular respiration. The Krebs cycle, named for the scientist who discovered the process, takes place in the interior space, or matrix, of the mitochondrion.

1. Three-carbon molecules from glycolysis are broken down in a cycle of chemical reactions. A small number of ATP molecules are made. Other types of energy-carrying molecules are also made. Carbon dioxide is given off as a waste product.
2. Energy is transferred to the second stage of cellular respiration.

An electron transport chain made of proteins needs energy-carrying molecules from the Krebs cycle and oxygen to make ATP. This part of the process takes place in and across the inner mitochondrial membrane.

3. Energy is transferred to a chain of proteins in the inner membrane of the mitochondrion.
4. A large number of ATP molecules are made. Oxygen enters the process and is used to make water molecules. Water and heat are given off as waste products.

Up to 38 ATP molecules are made from the breakdown of one glucose molecule—2 from glycolysis and 34 or 36 from cellular respiration. The equation for cellular respiration is shown below, but it actually has many more steps. For example, the cellular respiration equation includes glycolysis. And many enzymes are also part of the process.

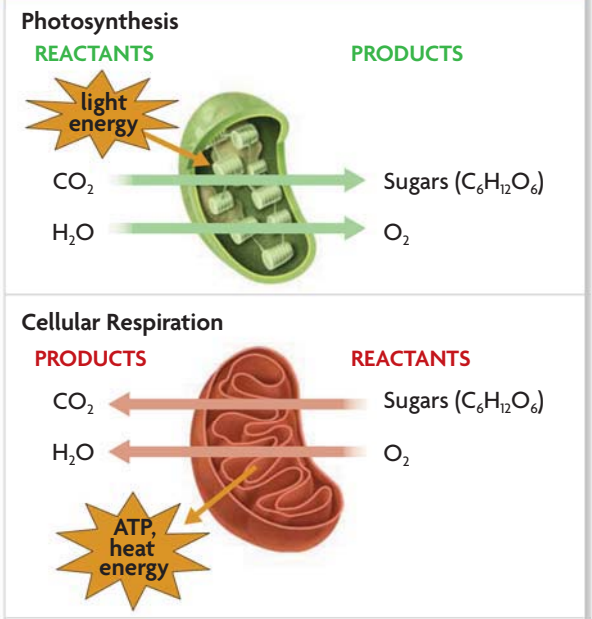
$$\underset{\text{a sugar}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \longrightarrow \underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O}$$

Use **FIGURE 4.12** to compare cellular respiration with photosynthesis. As you can see, photosynthesis uses the products of cellular respiration. It converts energy from sunlight into sugars. Cellular respiration needs the products of photosynthesis. It releases stored energy from sugars to make ATP that can be used by cells.

Apply **Does glucose actually react with oxygen during cellular respiration? Explain.**

NSTA SCILINKS scilinks.org
To learn more about ATP and how it is used, go to scilinks.org.
Keycode: MLB004

FIGURE 4.12 COMPARING PROCESSES



The products of photosynthesis—sugars and O_2—are the reactants in cellular respiration.

4.4 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. How are **cellular respiration** and **glycolysis** related?
2. Summarize the **aerobic** stages of cellular respiration. Be sure to discuss the **Krebs cycle** and the electron transport chain in your answer.

CRITICAL THINKING

3. **Analyze** Describe the relationship between cellular respiration and photosynthesis. Discuss the functions of chloroplasts and mitochondria.
4. **Apply** Is glucose a reactant in the aerobic stages of cellular respiration? Explain.

Connecting CONCEPTS

5. **Chemical Reactions** Is the process of cellular respiration exothermic or endothermic? Explain your answer.