

4.2

Overview of Photosynthesis

KEY CONCEPT The overall process of photosynthesis produces sugars that store chemical energy.

▶ MAIN IDEAS

- Photosynthetic organisms are producers.
- Photosynthesis in plants occurs in chloroplasts.

VOCABULARY

photosynthesis, p. 103

chlorophyll, p. 103

thylakoid, p. 104

light-dependent reactions, p. 105

light-independent reactions, p. 105

Review

chemical reaction, carbohydrate, enzyme, chloroplast



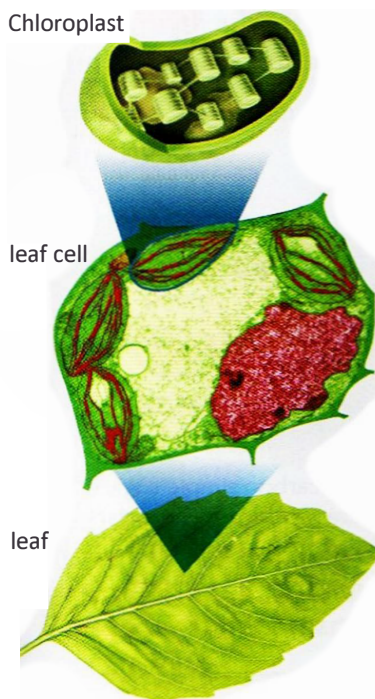
CALIFORNIA STANDARDS

1.f Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.

Review Life Science

7.1.d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

FIGURE 4.4 Chloroplasts in plant cells contain a light-absorbing molecule called chlorophyll.



Connect Solar-powered calculators, homes, and cars are just a few things that use energy from sunlight. In a way, you are also solar-powered. Of course, sunlight does not directly give you the energy you need to play a sport or read this page. That energy comes from ATP. Molecules of ATP are often made from the breakdown of sugars, but how are sugars made? Plants capture some of the energy in sunlight and change it into chemical energy stored in sugars.

▶ MAIN IDEA

Photosynthetic organisms are producers.

Some organisms are called producers because they produce the source of chemical energy for themselves and for other organisms. Plants, as well as some bacteria and protists, are the producers that are the main sources of chemical energy for most organisms on Earth. Certainly, animals that eat only plants obtain their chemical energy directly from plants. Animals that eat other animals, and bacteria and fungi that decompose other organisms, get their chemical energy indirectly from plants. When a wolf eats a rabbit, the tissues of the rabbit provide the wolf with a source of chemical energy. The rabbit's tissues are built from its food source—the sugars and other carbon-based molecules in plants. These sugars are made through photosynthesis.

Photosynthesis is a process that captures energy from sunlight to make sugars that store chemical energy. Therefore, directly or indirectly, the energy for almost all organisms begins as sunlight. Sunlight has several types of radiant energy, such as ultraviolet radiation, microwaves, and the visible light that lets you see. Plants absorb visible light for photosynthesis. Visible light appears white, but it is made up of several colors, or wavelengths, of light.

Chlorophyll (KLAWR-uh-fihl) is a molecule in chloroplasts, shown in **FIGURE 4.4**, that absorbs some of the energy in visible light. Plants have two main types of chlorophyll, called chlorophyll *a* and chlorophyll *b*. Together, these two types of chlorophyll absorb mostly red and blue wavelengths of visible light. Neither type absorbs much green light. Plants have other light-absorbing molecules that absorb green light, but there are fewer of these molecules. As a result, the green color of plants comes from the reflection of light's green wavelengths by chlorophyll.

Apply Describe the importance of producers and photosynthesis.

Photosynthesis in plants occurs in chloroplasts.

Chloroplasts are the membrane-bound organelles where photosynthesis takes place in plants. Most of the chloroplasts are in leaf cells that are specialized for photosynthesis, which has two main stages as shown in **FIGURE 4.5**. The two main parts of chloroplasts needed for photosynthesis are the grana and the stroma. Grana (singular, *granum*) are stacks of coin-shaped, membrane-enclosed compartments called **thylakoids** (THY-luh-KOYDZ). The membranes of the thylakoids contain chlorophyll, other light-absorbing molecules, and proteins. The stroma is the fluid that surrounds the grana inside a chloroplast.

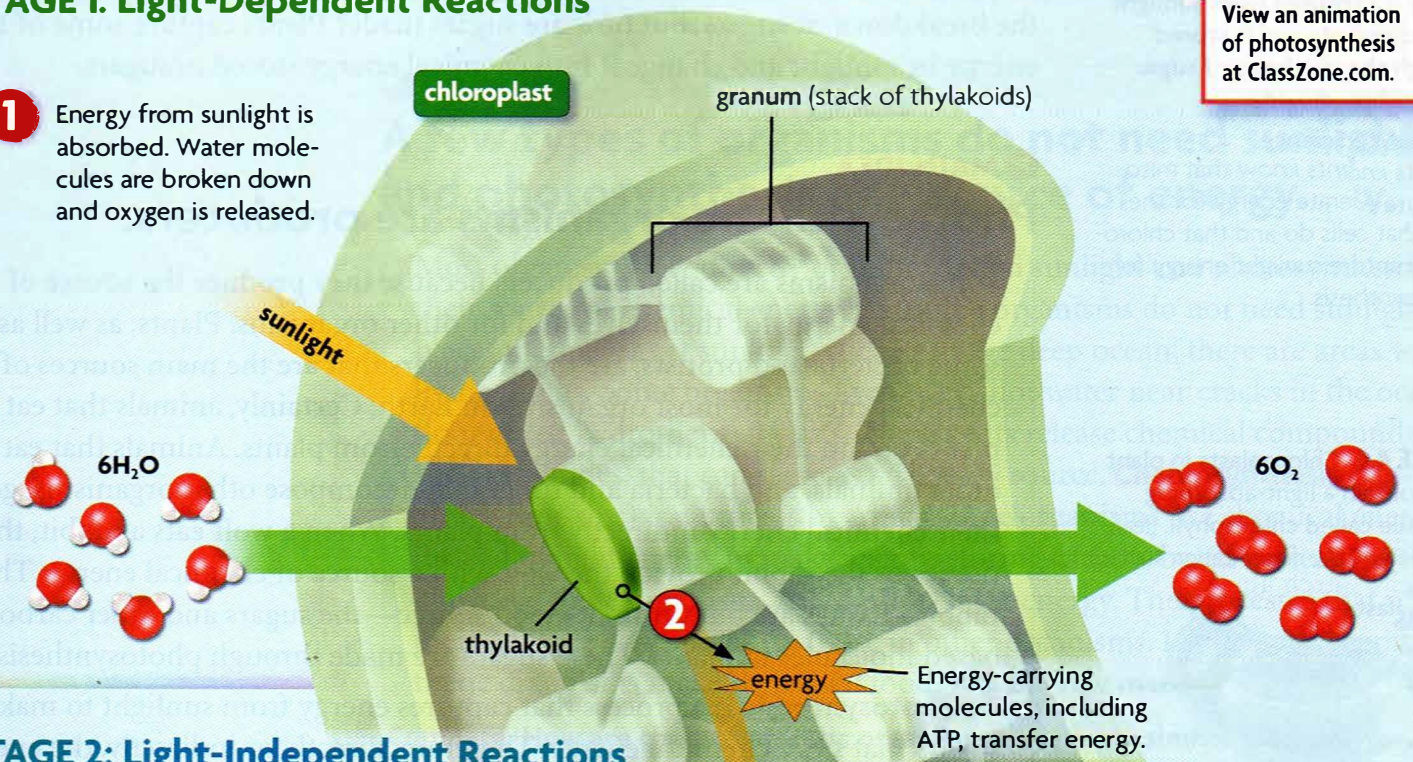
FIGURE 4.5 Photosynthesis Overview

Chloroplasts absorb energy from sunlight and produce sugars through the process of photosynthesis.

Animated
BIOLOGY
View an animation of photosynthesis at ClassZone.com.

STAGE 1: Light-Dependent Reactions

- 1 Energy from sunlight is absorbed. Water molecules are broken down and oxygen is released.



STAGE 2: Light-Independent Reactions

- 3 Carbon dioxide molecules are used to build sugars.

- 4 Six-carbon simple sugars are produced. The sugars are often used to build starches and cellulose.



Identify What are the reactants and the products in photosynthesis?

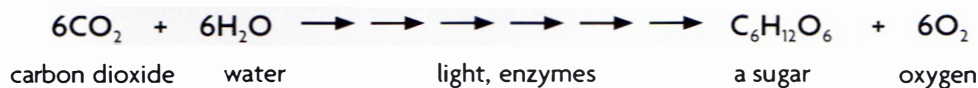
The **light-dependent reactions** capture energy from sunlight. These reactions take place within and across the membrane of the thylakoids. Water (H₂O) and sunlight are needed for this stage of photosynthesis.

- 1 Chlorophyll absorbs energy from sunlight. The energy is transferred along the thylakoid membrane. H₂O molecules are broken down. Oxygen molecules (O₂) are released.
- 2 Energy carried along the thylakoid membrane is transferred to molecules that carry energy, such as ATP.

The **light-independent reactions** use energy from the light-dependent reactions to make sugars. These reactions occur in the stroma of chloroplasts. Carbon dioxide molecules (CO₂) are needed during this stage of photosynthesis.

- 3 CO₂ is added to a cycle of chemical reactions to build larger molecules. Energy from the light-dependent reactions is used in the reactions.
- 4 A molecule of a simple sugar is formed. The sugar, usually glucose (C₆H₁₂O₆), stores some of the energy that was captured from sunlight.

The equation for the whole photosynthesis process is shown below. As you can see, there are many arrows between the reactants—CO₂ and H₂O—and the products—a six-carbon sugar and O₂. Those arrows tell you that photosynthesis has many steps. For example, the light-independent reactions need only one molecule of CO₂ at a time, and the six-carbon sugar comes from a reaction that combines two three-carbon sugars. Also, enzymes and other chemicals are needed, not just light, carbon dioxide, and water.



Glucose and other simple sugars, such as fructose, are not the only carbohydrates that come from photosynthesis. Plants need the simple sugars to build starch and cellulose molecules. In effect, plants need photosynthesis for their growth and development. You will learn more about the importance of another product of photosynthesis—oxygen—in Sections 4.4 and 4.5.

Summarize How is energy from sunlight used to make sugar molecules?

Connecting CONCEPTS

Calvin Cycle The light-independent reactions include a series of chemical reactions called the Calvin cycle. You can read more about the Calvin cycle in Section 4.3.

4.2 ASSESSMENT



REVIEWING MAIN IDEAS

1. What are the roles of chloroplasts and **chlorophyll** in **photosynthesis**? 1.f, 7.1.d
2. Describe the stages of photosynthesis. Use the terms **thylakoid**, **light-dependent reactions**, and **light-independent reactions** in your answer. 1.f

CRITICAL THINKING

3. **Apply** Suppose you wanted to develop a light to help increase plant growth. What characteristics should the light have? Why?
4. **Analyze** Explain why photosynthesis is important for building the structure of plant cells.

Connecting CONCEPTS

5. **Chemical Reactions** Overall, do you think photosynthesis is endothermic or exothermic? Explain your answer.