

CHAPTER 8**The Working Cell:
Energy from Sunlight****Summary of Key Concepts****Concept 8.1 Photosynthesis uses light energy to make food. (pp. 160–162)**

Photosynthesis takes place in a cellular organelle called a *chloroplast*. Chloroplasts contain chemical compounds called *chlorophylls* that give chloroplasts a green color. While all the green parts of a plant contain cells with chloroplasts, leaves contain the most chloroplasts. Chloroplasts have an inner and outer membrane. The inner membrane encloses a thick fluid called *stroma*. Suspended in the stroma are many disk-shaped sacs called *thylakoids*. The thylakoids are arranged in stacks called *grana*. These structures within chloroplasts organize the chemical reactions that make up photosynthesis.

Photosynthesis occurs in two main stages: the light reactions and the Calvin cycle. The *light reactions* convert the energy in sunlight to chemical energy. These reactions depend on molecules built into the membranes of the thylakoids. The light reactions result in the formation of NADPH and ATP molecules. The *Calvin cycle* makes sugar from the atoms in carbon dioxide, plus hydrogen and the high-energy electrons carried by NADPH. The Calvin cycle occurs in the stroma. The chemical equation for photosynthesis is



1. What stage of photosynthesis occurs in the thylakoid membranes? _____

2. What are the products of photosynthesis? _____

Concept 8.2 The light reactions convert light energy to chemical energy. (pp. 163–167)

Sunlight is a form of electromagnetic energy. Electromagnetic energy travels in waves. The distance between two waves is called a *wavelength*. The range of different types of electromagnetic energy is called the *electromagnetic spectrum*.

A substance's color is due to chemical compounds called *pigments*. When light shines on a material containing pigments, the different wavelengths of light can be absorbed, transmitted, or reflected. A laboratory test called *paper chromatography* is used to separate and analyze the different pigments in a leaf. Chloroplasts contain chlorophyll *a* and chlorophyll *b*, as well as other helper pigments. Chlorophyll *a* absorbs mainly blue-violet and red light and reflects mainly green light. It plays a major role in the light reactions of photosynthesis.

Within thylakoid membranes, pigment molecules are arranged in clusters called *photosystems*. When a pigment molecule in a photosystem absorbs light energy, one of the pigment's electrons gains energy and becomes excited. Almost immediately, the excited electron transfers its energy to a neighboring molecule. In this way, energy "jumps" from molecule to molecule until it arrives at the reaction center of the photosystem. At the reaction center, an electron acceptor traps the electron.

Two photosystems are involved in the light reactions. The first photosystem traps light energy and transfers the light-excited electrons to an electron transport chain. These excited electrons are replaced by splitting a molecule of water, which releases oxygen. The electron transport chain releases energy, which is used to make ATP. The second photosystem produces NADPH by transferring excited electrons and hydrogen ions to NADP⁺. In summary, the light reactions convert light energy to the chemical energy of ATP and NADPH.

3. Describe the structure of a photosystem. _____

4. What happens when a pigment molecule absorbs light energy? _____

5. What are the chemical products of the light reactions? _____

Concept 8.3 The Calvin cycle makes sugar from carbon dioxide. (pp. 168–171)

The Calvin cycle is called a cycle because the starting material, RuBP, is regenerated each time the process occurs. The inputs for the Calvin cycle are carbon dioxide from the air and ATP and NADPH from the light reactions. The Calvin cycle uses carbon from carbon dioxide, energy from ATP, and high-energy electrons and hydrogen ions from NADPH to make a small sugar named G3P. The plant cell uses G3P to make glucose and other organic molecules.

The overall equation for photosynthesis is



The light reactions use the reactant water and release the product oxygen. The Calvin cycle uses ATP and NADPH generated in the light reactions to convert the reactant carbon dioxide to the product sugar. Photosynthesis is the ultimate source of all the food you eat and all the oxygen you breathe.

6. What happens during the Calvin cycle? _____

7. Which stage uses the reactant water from the overall photosynthesis equation? Which stage produces sugar? _____

Concept 8.4 Photosynthesis has a global impact. (pp. 172–173)

Some processes that occur on a global scale depend on tiny mitochondria and chloroplasts. An example is the *carbon cycle*, the process by which carbon moves from inorganic compounds to organic compounds and back. In the carbon cycle, producers convert inorganic carbon dioxide to organic compounds. Certain consumers obtain the organic compounds by eating the producers. These consumers may in turn be eaten by other consumers. Cellular respiration by both producers and consumers returns carbon dioxide to the atmosphere.

Together, all the organisms on Earth have a large effect on the amount of carbon dioxide in the atmosphere. Carbon dioxide in the atmosphere provides plants with carbon for photosynthesis. It also traps heat from the sun that

would otherwise escape from Earth back into space. This important property, known as the *greenhouse effect*, keeps the world climate warm enough for living things.

8. How is carbon dioxide returned to the atmosphere? _____

9. How does carbon dioxide in the atmosphere affect Earth's climate?

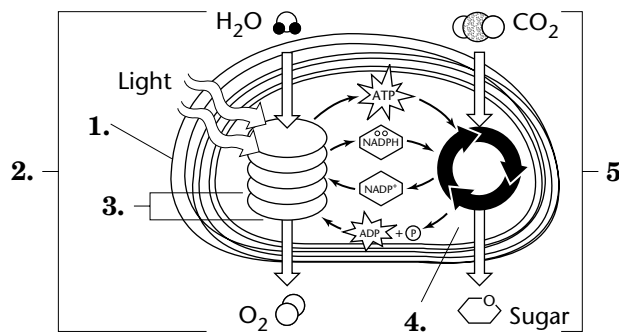
Reading Skills Practice

Writing a summary Write a summary of the process of photosynthesis. Include the two main stages of photosynthesis and the reactants and products for each stage.

Vocabulary Review and Reinforcement

In 1–5, study the diagram. Then fill in the blanks with the appropriate terms from the chapter.

1. _____
2. _____
3. _____
4. _____
5. _____



In 6–10, write the letter of the correct definition on the line next to each term.

- | | |
|----------------------|---|
| _____ 6. wavelength | a. green pigment in chloroplasts |
| _____ 7. photosystem | b. chemical compound that gives a substance color |
| _____ 8. chlorophyll | c. distance between two adjacent waves |
| _____ 9. chloroplast | d. cellular organelle in which photosynthesis occurs |
| _____ 10. pigment | e. cluster of pigment molecules in the thylakoid membrane |

In 11–15, fill in the blanks with the appropriate terms from the chapter.

11. The process by which carbon moves from inorganic to organic compounds and back is called the _____.
12. The range of types of electromagnetic energy is called the _____.
13. Carbon dioxide enters a leaf through tiny pores called _____.
14. The trapping of heat from the sun by carbon dioxide in Earth's atmosphere is called the _____.
15. The laboratory technique _____ is used to separate the different pigments in a green leaf.

WordWise

Solve the clues by filling in the blanks with Key Terms from the chapter. Then write the numbered letters in the correct order to find the hidden message.

Clues

1. chemical compound that gives a substance color
2. The trapping of heat from the sun by carbon dioxide that keeps Earth’s climate warm is called the greenhouse _____.
3. stage of photosynthesis in which sugar is made
4. distance between two adjacent waves
5. organelle in which photosynthesis occurs
6. stage of photosynthesis in which sunlight is converted to chemical energy
7. thick fluid within the inner membrane of a chloroplast
8. The range of types of electromagnetic energy is the electromagnetic _____.
9. pigment that makes plants green
10. disk-shaped sacs suspended in the stroma

Terms

1.	_ _ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
		22	12			9			
2.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
		4		13					
3.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
			2						14
4.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
			1		3	20			
5.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
		19					8		
6.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
			10			16		23	
7.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
		5	6						
8.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
		7				15			
9.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
			18					17	
10.	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
			11			21			

Hidden Message

8	15	3	18	22	12	19	5	10	23	2	13	7	17	21	4	14
1	9	16	6	20	11											