Section Summary

In the first part of photosynthesis, the light-dependent reaction, pigment molecules absorb energy from the sunlight. The most common and abundant pigment is chlorophyll *a*. Light energy strikes photosystem II to initiate photosynthesis. Energy travels through the electron transport chain, which pumps hydrogen ions into the thylakoid space. This forms a concentration gradient. The ions flow through ATP synthase from the thylakoid space into the stroma in a process called chemiosmosis to form molecules of ATP. ATP is used for the formation of sugar molecules in the second stage of photosynthesis, the Calvin cycle. Photosystem I absorbs a second photon, which results in the formation of an NADPH molecule. NADPH is an energy carrier that transports high energy electrons to the Calvin cycle. A total of 6 water molecules will be oxidized during the light dependent reactions, which releasees electrons to the photosystem, and 6 O_2 molecule as waste products. 12 NADPH and 18 ATP are generated during the light-dependent reactions and will then be used in the Calvin cycle.

Exercises

1. What is light energy used for in the light-dependent reactions?
    a. split a water molecule
    b. energize an electron
    c. produce proteins
    d. synthesize glucose
2. Which molecule absorbs light energy?
    a. ATP
    b. glucose
    c. chlorophyll
    d. water
3. Plants produce oxygen when they photosynthesize. Where does the oxygen come from?
    a. splitting water molecules
    b. ATP synthesis
    c. the electron transport chain
    d. chlorophyll
4. Which color(s) of light does chlorophyll *a* reflect?
    a. red and blue
    b. green
    c. red
    d. blue
5. Describe the pathway of energy in light-dependent reactions.

Answers

1. (b)
2. (c)
3. (a)
4. (b)
5. The energy is present initially as light. A photon of light hits chlorophyll, causing an electron to be energized. The free-electron travels through the electron transport chain, and the energy of the electron is used to pump hydrogen ions into the thylakoid space, transferring the energy into the electrochemical gradient. The energy of the electrochemical gradient is used to power ATP synthase, and the energy is transferred into a bond in the ATP molecule. Also, energy from another photon can be used to create a high-energy bond in the molecule NADPH.

Glossary

chlorophyll *a*: the form of chlorophyll that absorbs violet-blue and red light

chlorophyll *b*: the form of chlorophyll that absorbs blue and red-orange light

light-dependent reactions: convert light energy into chemical energy in the form of ATP and NADPH

photon: a distinct quantity or "packet" of light energy

photosystem: a group of proteins, chlorophyll, and other pigments that are used in the light-dependent reactions of photosynthesis to absorb light energy and convert it into chemical energy

wavelength: the distance between consecutive points of a wave

7.3: The Calvin Cycle

Learning objectives

By the end of this section, you will be able to:

- *Describe the Calvin cycle*
- *Define carbon fixation*
- *Explain what photorespiration is*
- *Explain how photorespiration has led to the evolution of C4 and CAM plants*
- *Be able to define and explain all bolded terms*

After energy from the sun is converted and packaged into ATP and NADPH, the cell has the chemical energy needed to build carbohydrates. However, chemical energy alone is not enough; the cell also must have a carbon source. Where does the carbon come from? The carbon atoms used to build carbohydrates come from carbon dioxide. The **Calvin cycle** is a set of chemical reactions that uses the ATP and NADPH generated in the light-dependent reactions to form glucose and other carbohydrates (Figure 7.19).

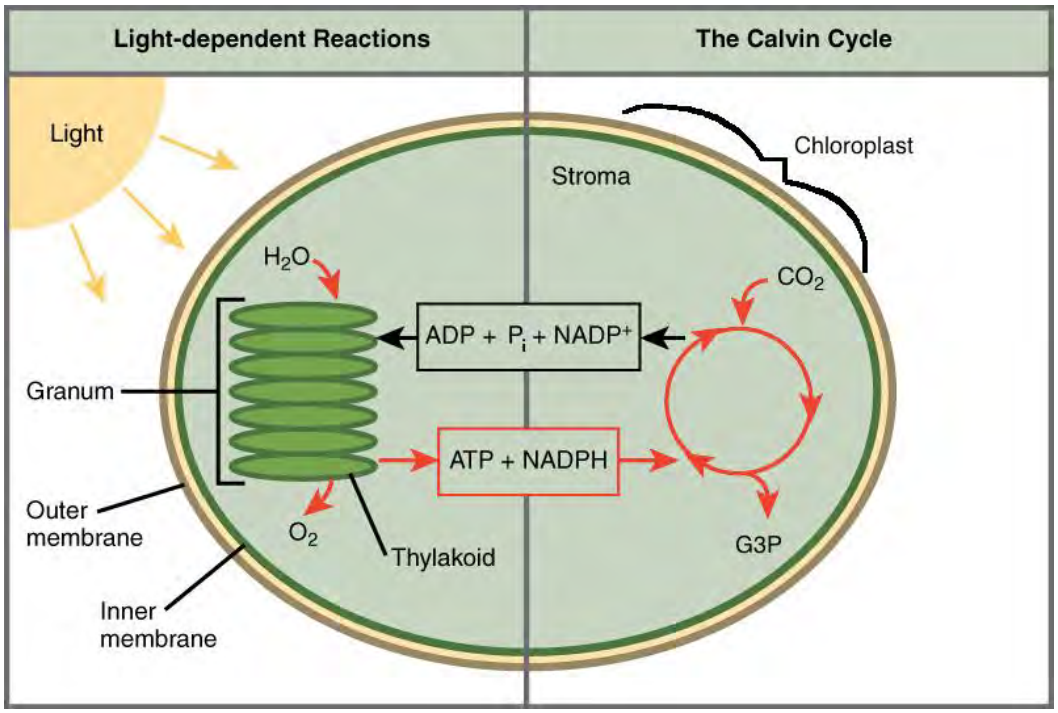

Figure 7.19 Photosynthesis takes place in two stages: light-dependent reactions and the Calvin cycle. (credit: Kahn Academy / original work by Clark et al. / Biology 2E OpenStax)