Main Structures and Summary of Photosynthesis

Photosynthesis is a multi-step process that requires specific wavelengths of visible sunlight, carbon dioxide, and water (Figure 7.5). After the process is complete, producers release oxygen and produce glyceraldehyde-3-phosphate (G3P). G3P is a simple carbohydrate molecule that can be converted into glucose, sucrose, or dozens of other sugar molecules.

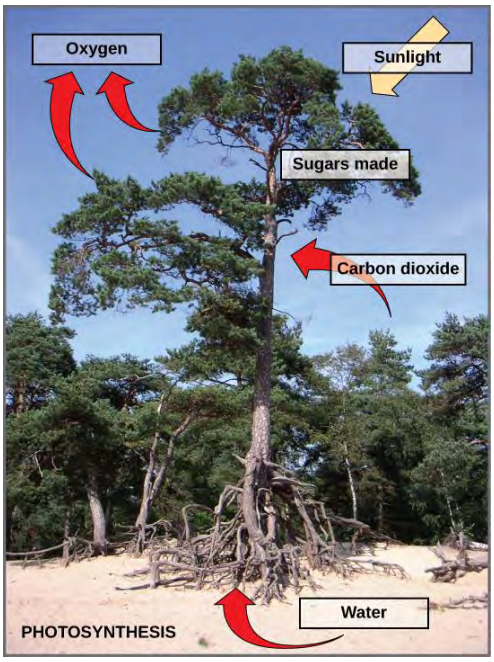

Figure 7.5 Photosynthesis uses solar energy, carbon dioxide, and water to release oxygen to produce energy-storing sugar molecules. (credit: Fowler et al. Concepts of Biology / OpenStax)

The complex reactions of photosynthesis can be summarized by the chemical equation shown in Figure 7.6. Although the equation looks simple, many steps must take place, and photosynthesis is quite complex. To better understand photosynthesis, students will first become familiar with leaf anatomy.

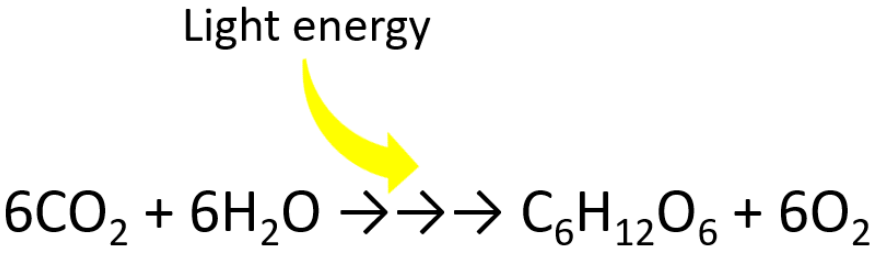

Figure 7.6 The process of photosynthesis can be represented by an equation. Inorganic carbon dioxide and water are combined with light energy to form glucose and oxygen. As with cellular respiration in chapter 6, the multiple arrows in this equation indicates that multiple chemical reactions are involved. (credit: Jason Cashmore).

Basic Photosynthetic Structures

In plants photosynthesis generally takes place in the leaves, which consist of several layers of cells. The process of photosynthesis occurs in a middle layer called the **mesophyll** (Figure 7.7). There are two layers that make up the mesophyll, the palisade mesophyll and the spongy mesophyll. The palisade mesophyll is made up of elongated cells that contain a large quantity of chloroplasts. The palisade mesophyll is the major site of photosynthesis. Spongy mesophyll cells also contain chloroplasts, but fewer than the palisade mesophyll. These cells are irregularly shaped with spaces between them. The spaces allow gases such as oxygen and carbon dioxide to pass through to and from the palisade mesophyll.

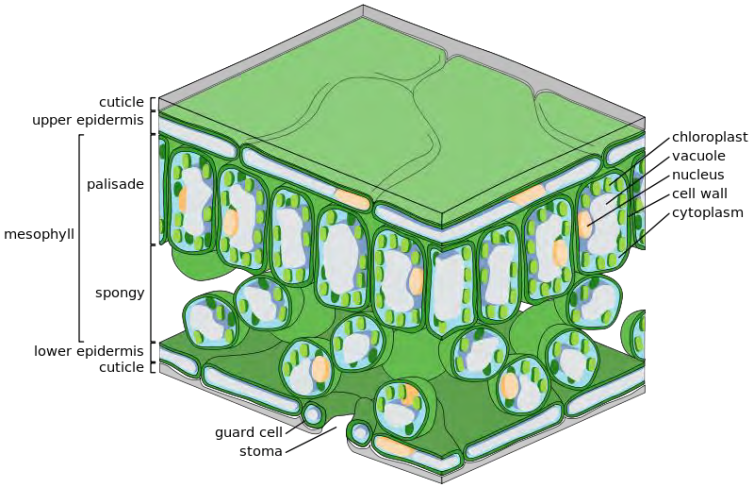

Figure 7.7 Cross section of a plant leaf. (credit: Zephris / Wikimedia commons)

During photosynthesis, plants take in carbon dioxide and release oxygen. Gas exchange into and out of the leaf occurs through small openings called **stomata** (singular: stoma). Stomata play roles in both the regulation of gas exchange and water balance. The stomata are typically located on the underside of the leaf, which helps to minimize water loss due to higher temperatures on the upper surface of the leaf. Each stoma is flanked by **guard cells** that regulate and control the opening and closing of the stomata. Guard cells close the stomata when too much water is evaporating from the leaf. In many plants the stomata are located in the **epidermis**, a protective outer cell layer covering leaves, stems, and roots. The epidermis can be found on both the upper and lower surfaces of leaves and secretes a waxy substance called the cuticle. The **cuticle** is an important adaptation that helps plants conserve water and acts as a protective barrier limiting water intake.

In all autotrophic eukaryotes, photosynthesis takes place inside an organelle called a **chloroplast**. Chloroplasts have a double membrane envelope composed of an outer and an inner plasma membrane. The inner membrane is ancestrally derived from ancient free-living cyanobacteria. **Thylakoids** are stacked, disc-shaped structures found within the chloroplasts. Thylakoids are made up of membranes embedded with proteins and chlorophyll. **Chlorophyll** is a pigment molecule necessary to absorb light. The thylakoid membrane encloses an internal space called the thylakoid lumen. As shown in Figure 7.8, a stack of thylakoids is called a **granum**, and the liquid-filled space surrounding the granum is called **stroma.** Do not confuse the stroma with the stoma, an opening on the leaf epidermis used for gas exchange.

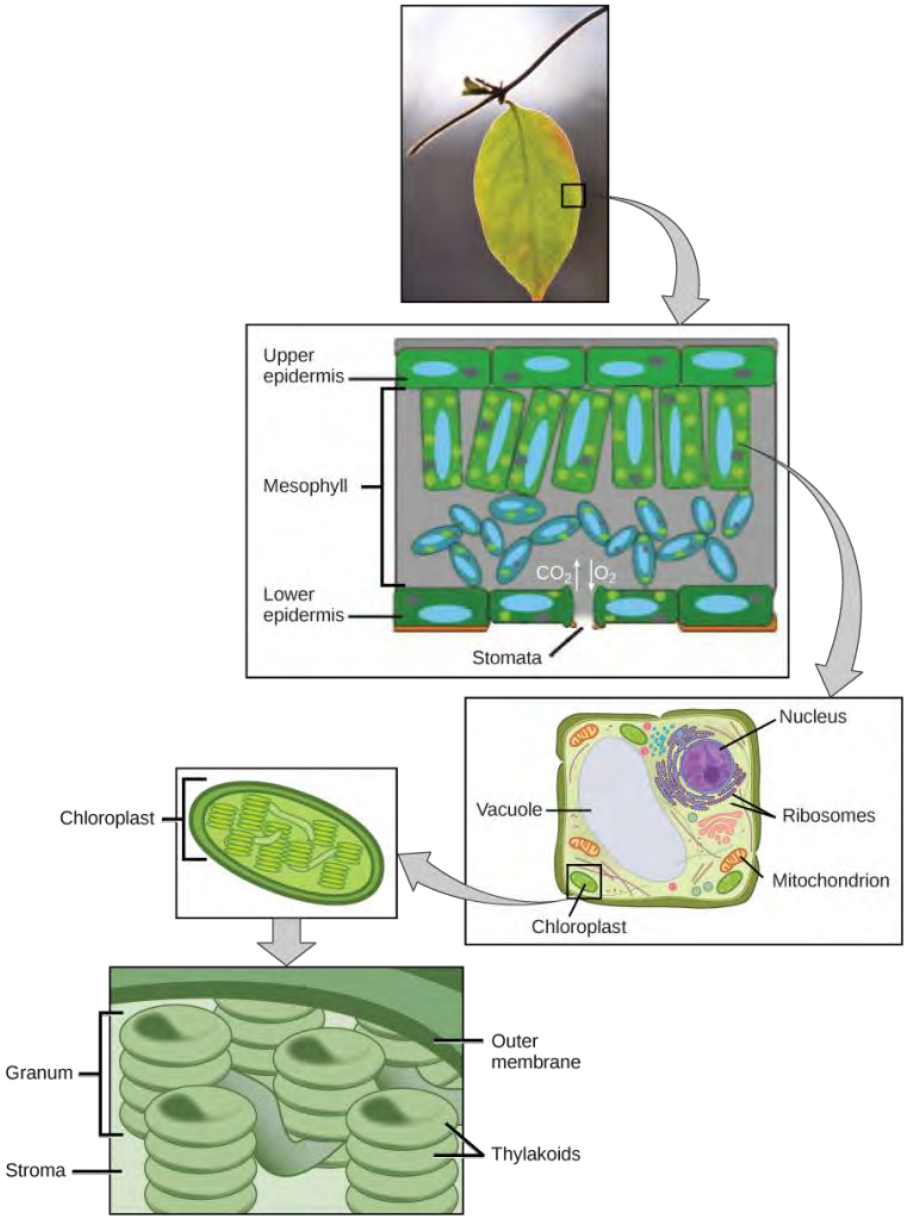

Figure 7.8 Cells within the middle layer of a leaf have chloroplasts, which contain the photosynthetic apparatus. (credit: modification of work by Cory Zanker / Concepts of Biology OpenStax)

Check your knowledge

On hot, dry days, plants close their stomata to conserve water. What impact will this have on photosynthesis?

Answer: With the stomata closed, plants cannot exchange gases. If plants cannot take in carbon dioxide, they cannot carry out the process of photosynthesis.