CHAPTER 10
PHOTOSYNTHESIS

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10.1 WHAT IS PHOTOSYNTHESIS?

Photosynthesis is a process where the plants or cyanobacteria through specialized pigment molecules absorb the light energy and consume CO_2 and H_2O, and then release O_2 and fixed carbon in the form of carbohydrate. The reaction of photosynthesis is as follow:

$$\xrightarrow{\text{light}}$$
$$CO_2 + H_2O\ (CH_2O) + O_2$$

This reaction involves oxidation-reduction reaction (reverse of oxidative carbohydrate metabolism) which produces carbohydrates. Therefore, it serves as an energy source for the organisms that produce them and for non-photosynthetic organisms that directly or indirectly consume photosynthetic organisms. Specifically in plant cell, chloroplast is the main site where this reaction occurs. In plant, there is two-stage process in which light energy is harnessed to oxidize H_2O:

$$\xrightarrow{\text{light}}$$
$$2\ H_2O\ O_2 + 4\ [H\cdot]$$

The electrons thereby obtained subsequently reduce CO_2:

$$\longrightarrow$$
$$4\ [H\cdot] + CO_2\ (CH_2O) + H_2O$$

These two stages of photosynthesis are normally referred as *light reactions* and *dark reactions*. In the light reactions, the specialized pigment molecules capture light energy and are oxidized. A series of electron transfer reactions which end with the reduction of NADP to NADPH, generate a transmembrane proton gradient whose energy is tapped to synthesize ATP from ADP + P_i. The oxidized pigment molecules are reduced by H_2O, thereby generating O_2. Subsequently, the dark reactions use NADPH and ATP to reduce CO_2 and incorporate it into the three-carbon precursors of carbohydrates.

10.2 CHLOROPHYLL AND CHLOROPLASTS

The **chlorophylls** are green pigment molecules that resemble heme. In eukaryotes, *Chlorophyll a* absorbs light energy which drives photochemical events. *Chlorophyll b* acts as a light-harvesting pigment by absorbing light energy and passing it on to *Chlorophyll a*. While in plants and algae, photosynthesis takes place within specialized organelles called chloroplast as shown in **Figure 10.1.**

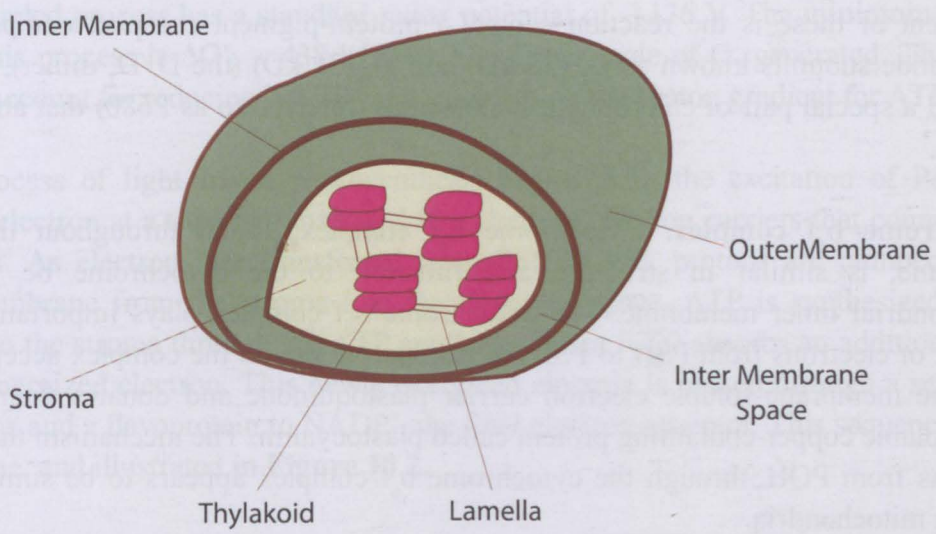

Figure 10.1: The structure of chloroplast.

Chloroplasts which resemble mitochondria in several aspects have an outer and an inner membrane with different permeable characteristics. The outer membrane is highly permeable while the inner one has specialized carrier molecules that regulate molecular traffic. The inner membrane also encloses an inner space, referred to as **stroma** which posses variety of enzymes (e.g. those that catalyze the light-independent reactions and starch synthesis), DNA and ribosomes. The chloroplasts are larger than mitochondria with spheroid shapes and in variety of sizes (4000 – 6000 nm in length and width of 2000 nm). There is another distinct membrane called **thylakoid membrane,** folded into a series of the disk-like vesicular structures called **grana**. The thylakoid membrane consists of pigments and proteins responsible for the light-dependent reactions of photosynthesis.

1. **Photosystem I.** Photosystem I (PSI) which energizes and transfers the electrons that eventually are donated to $NADP^+$, is a large membrane-spanning protein-pigment complex composed of several polypeptides. Although it consists of over 200 *Chlorophyll a* molecules, the role of PSI is performed by two special *Chlorophyll a* molecules referred as a special pair, located in the core complex of PSI, the AB dimer. Because they absorb light at 700 nm, the special pair is sometimes referred to as P700.

2. **Photosystem II.** Photosystem II (PSII) oxidizes water molecules and donates energized electrons to electron carriers that eventually reduce PSI. PHSII is a large membrane-spanning protein-pigment complex believed to possess at least 23 components. The most