In eukaryotes and some prokaryotes, two photosystems exist. The first photosystem used in the light-dependent reactions is called photosystem II. Photosystem II was named for the order of its discovery rather than for the order in which it functions (Figure 7.16).

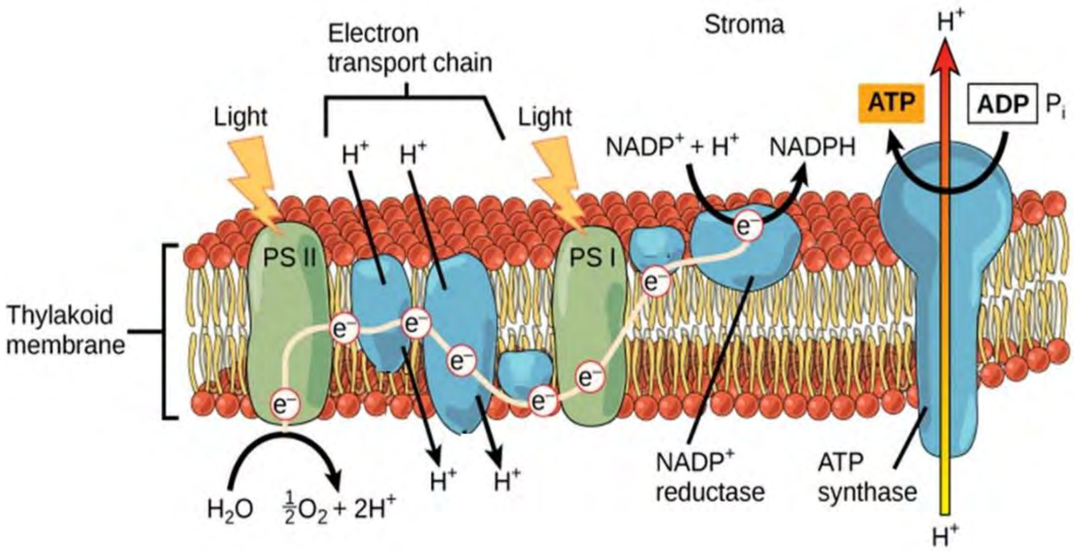

Figure 7.16 From photosystem II, the electron travels along the electron transport system, and energy from the electron is used to pump hydrogen ions into the interior of the thylakoid. (credit: Modified by Elizabeth O'Grady original work of Fowler et al. / Concepts of Biology OpenStax)

As pigments in photosystem II absorb light energy, it is passed to a special pair of chlorophyll *a* molecules located in the reaction center of the photosystem (Figure 7.17). The reaction center is located in the middle of the photosystem and contains both the special chlorophyll *a* molecules and a primary electron acceptor molecule.

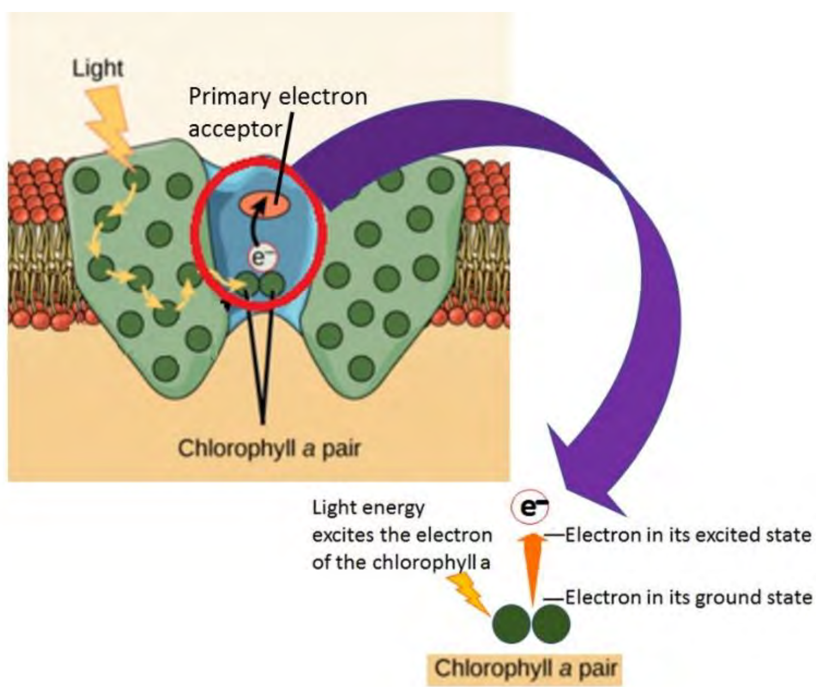

Figure 7.17 Light energy is absorbed by pigments and passed to the special pair of chlorophyll *a* molecules where the electron is excited from its ground state to its excited state. (credit: Modified by Elizabeth O'Grady original work of Clark et al. / Biology 2E OpenStax)

Light energy causes an electron in the reaction center chlorophyll *a* molecules to become "excited" (Figure 7.17). As the electron is excited, the energy associated with the electron increases. In the excited state, the electron is donated by the chlorophyll *a* molecules and passed to the primary electron acceptor, also located in the reaction center (Figure 7.17).

High-energy electrons in photosystem II are passed through a series of proteins in the thylakoid membrane called the electron transport chain (Figure 7.18). As the electrons are passed along, energy from the electrons is transferred to membrane proteins that function as pumps. Using active transport, protein pumps use the energy to move hydrogen ions against their concentration gradient from the stroma into the thylakoid space. Because of their charge, hydrogen ions can only diffuse across the thylakoid membrane through integral proteins. ATP synthase allows hydrogen ions to diffuse across the thylakoid membrane generating ATP.

The process of using light energy to synthesize ATP from ADP plus inorganic phosphate is called **photophosphorylation** (Figure 7.18). Using photophosphorylation, a plant cell must generate 18 ATP molecules to synthesize one molecule of glucose in the Calvin cycle.

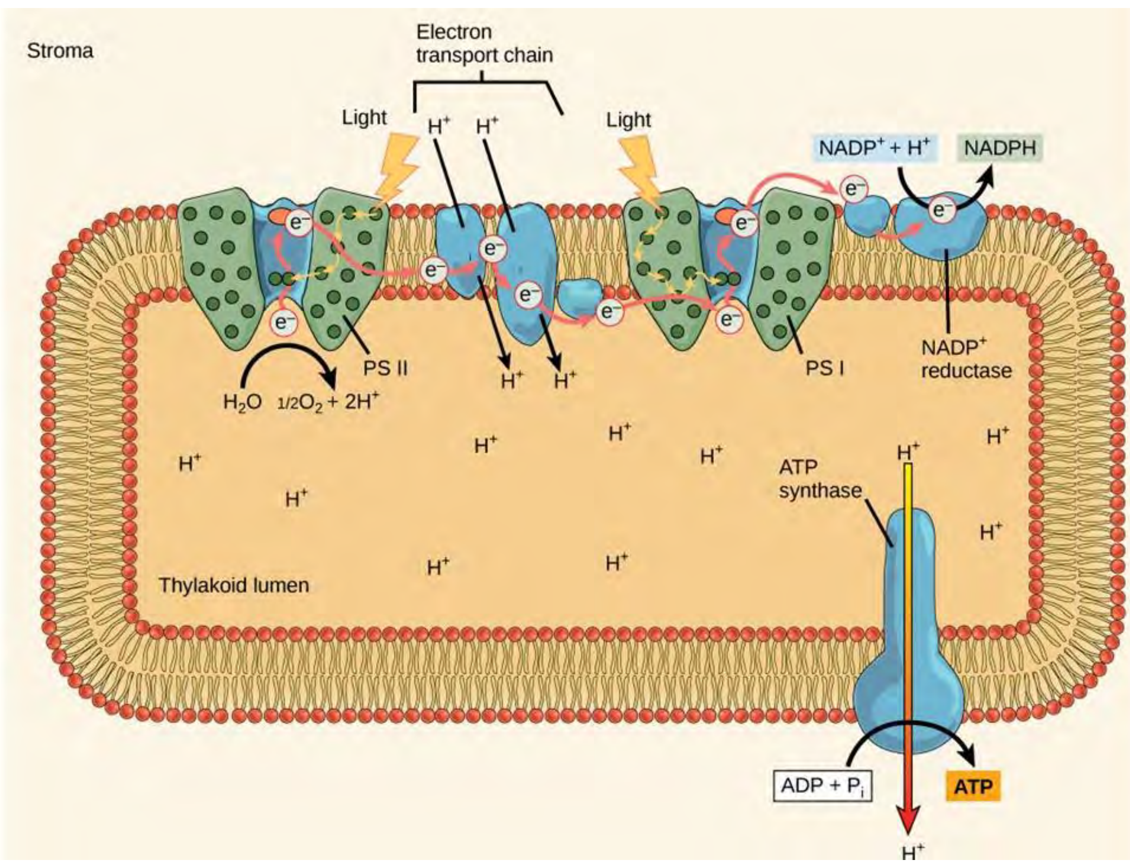

Figure 7.18 shows the light-dependent reactions in the thylakoid. (credit: Clark et al. / Biology 2E OpenStax)

Once the electron returns to its ground state, it is accepted by a pigment molecule in the reaction center of the next photosystem. This photosystem is called photosystem I (Figure 7.18). At photosystem I, the electron is re-energized with more light energy. The excited electron is oxidized from photosystem I and passed to $NADP^+$. When $NADP^+$ accepts two high energy electron and a hydrogen ion (H^+), it is reduced to NADPH. The NADPH will now carry the high energy electrons to the stroma where they will be used in the Calvin cycle.

To synthesize one molecule of glucose, the plant cell must generate 12 NADPH molecules in the light-dependent reactions. For this to be done, the electrons from the reaction center chlorophyll *a* molecules in photosystem II must be replaced. To replace the electrons, water is oxidized (Figure 7.17). When water is split, oxygen (O_2) and hydrogen ions (H^+) are formed and accumulate in the thylakoid space. The oxygen molecules are released to the surrounding environment, and the hydrogen ions become part of the hydrogen ion gradient, which is used to generate ATP.

The light-dependent reactions are necessary because they provide energy in the form of ATP and NADPH to generate sugar. ATP and NADPH carry energy from the thylakoid membrane to the stroma where the second stage of photosynthesis, the Calvin cycle, will now take place.

Check your knowledge

What part of the electromagnetic spectrum is used by plants?

You know plants need water. Now explain what they use water for?

Answers: Plants use the visible light spectrum. Violet, blue and a small bit of red are used most heavily. Plants use water as a source of electrons as part of the electron transport chain during the light-dependent reactions. Those electrons will be used to power carbon fixation in the Calvin cycle.