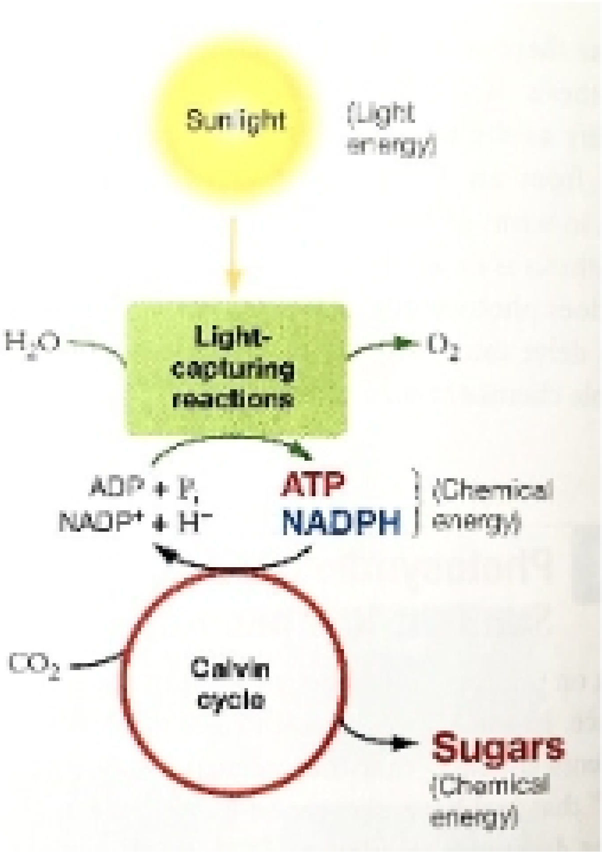
I. Chapter 10 Photosynthesis

A. 10.1 Photosynthesis Harnesses Sunlight to Make Carbohydrate

- **Photosynthesis** is an endergonic suite of redox reactions that produce sugars from carbon dioxide and light energy.
- In contrast, cellular respiration is an exergonic suite of redox reactions that produces carbon dioxide and ATP from sugar monomers.
- Early research showed that photosynthesis consists of two sets of reactions. One set is triggered by light; the other set, the Calvin cycle, requires the products of the light-capturing reactions. The light capturing reactions produce water oxygen from water; the Calvin cycle produces sugar from carbon dioxide.
- Light capturing reactions phosphorylate NADP+ to NADPH, which functions as a reducing agent similar to NADH from cellular respiration.
- Some of the energy released from these redox reactions is also used to produce ATP.



- During the Calvin cycle, electrons in NADPH and the potential energy in ATP are used to produce CO2 to carbohydrate.
- The resulting sugars are used in cellular respiration to produce ATP for the cell.

1. Photosynthesis occurs in chloroplasts

- **Chloroplast**- the interior is dominated by flattened, sack like structures called **thylakoids**, which often occur in interconnected stacks called **grana**.
- The space inside a thylakoid is its **lumen**.
- The fluid filled space between the thylakoids is the **stroma**.
- **Pigments** are molecules that absorb only certain wavelengths of light- other wavelengths are either reflected or transmitted (pass through).
- Pigments have colors because we see the wavelengths they do not absorb.

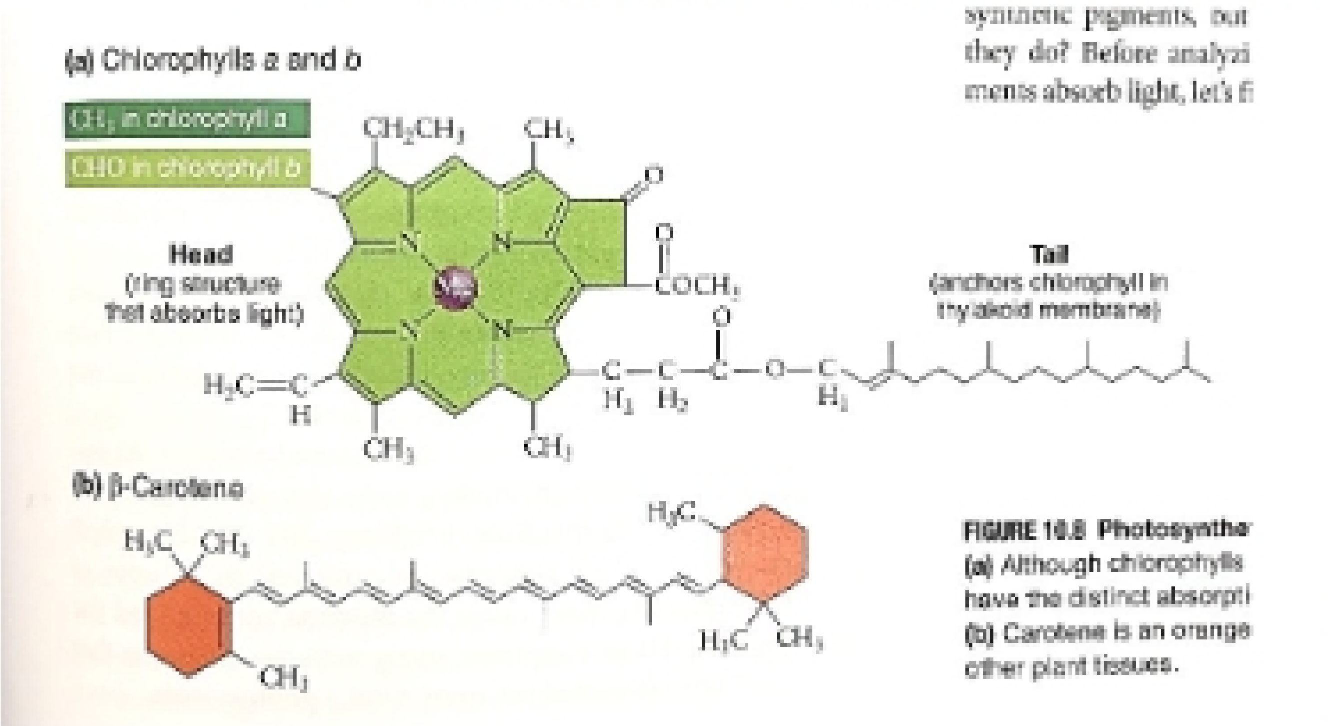
B. 10.2 How DO Pigments Capture Light Energy?

- Wavelength
- Electromagnetic spectrum
- Visible light
- Photons

1. Photosynthetic pigments absorb light

- Different pigments absorb different wavelength of light:
  - 1. **Chlorophylls**: designated ***a*** and ***b***, absorb blue and red regions of the visible spectrum. They reflect green light, which they do not absorb.
  - 2. **Carotenoids**: absorb blue and green parts of the visible spectrum. Thus, carotenoids appear yellow, orange, or red. Carotenoids found in plants belong to two classes, called *carotenes and xanthophylls*.

- **Action spectrum**: the wavelengths that drive the light-capturing reactions.
- Violet-to-blue and red photons are the most effective at driving photosynthesis. Because chlorophylls absorb these wavelengths, they are the main photosynthetic pigments.
- Both chlorophyll have two main parts: a long, isoprenoid tail, and a head consisting of a large ring structure with a magnesium atom in the middle.
- The tail structure interacts with proteins embedded in the thylakoid membrane; the head is where light is absorbed.
- The beta-carotene has an isoprenoid chain connecting two rings responsible for absorbing light.
- Carotenoids absorb wavelengths of light that are not absorbed by chlorophyll. As a result, they extend the range of wavelengths that can drive photosynthesis.



- Carotenoids "quench" free radicals by accepting or stabilizing unpaired electrons. As a result, they protect chlorophyll molecules from harm.

2. When light is absorbed, electrons enter an excited state.

- Fluorescence: when electron energy produces light.
- Only about 2% of the excited electrons produce fluorescence. 98% of the energized pigments use their excited electrons to drive photosynthesis.

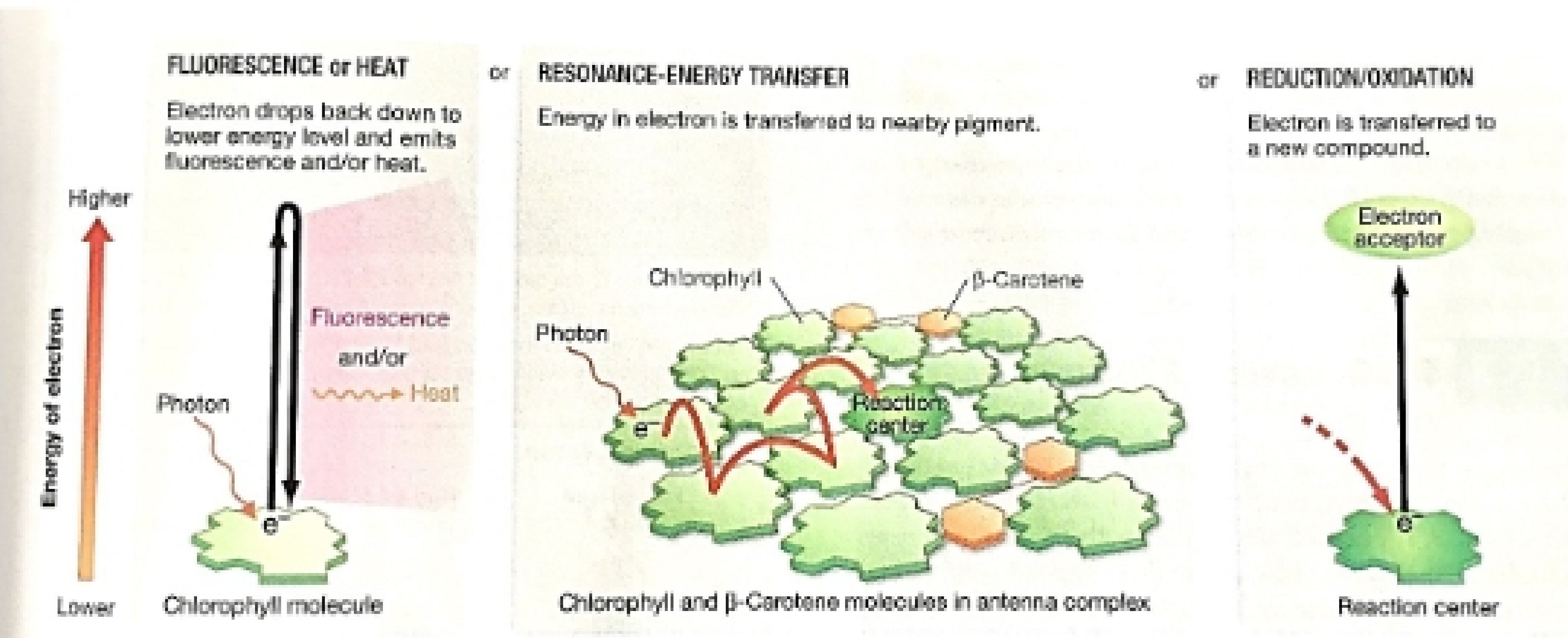


FIGURE 10.10 Four Fates for Excited Electrons in Photosynthetic Pigments. When sunlight promotes electrons in pigments to a high-energy state, four things can happen: They can fluoresce, release heat, pass energy to a nearby pigment via resonance, or transfer the electron to an electron acceptor.

- In the thylakoid membrane, 200-300 chlorophyll molecules and accessory pigments are organized by an array of proteins to form the **antenna complex** and the **reaction center**.

- These complexes, along with molecules that capture and process excited electrons, form a **photosystem**.
- *The antenna complex*: when a red or blue photon strikes a pigment molecule, in the antenna complex, the energy is absorbed and an electron is excited in response. This energy-but not the electron itself- is passed to a nearby chlorophyll molecule, where another electron is excited in response. This phenomenon is known as **resonance energy transfer**.
- Resonance transfer happens between pigments that absorb higher energy photons to those that absorb lower energy photons- moving between pigments as the potential energy drops at each step. The energy is transferred to the reaction center.
- *The reaction center*: when a chlorophyll molecule is excited in the reaction center, its excited electron is transferred to an electron acceptor. When the acceptor is reduced, the energy transformation event that started with the absorptions of light becomes permanent: electromagnetic energy is transformed to chemical energy. The redox reactions reaction that occur in the reaction center results in the production of chemical energy from sunlight.

C. 10.3 The Discovery of Photosystems 1 and 2

1. Photosystem 2

- **Photosystem 2**: Antenna complex transmits resonance energy to the reaction center, where the electron acceptor pheophytin begins to do its job.
- Pheophytin is identical to chlorophyll except that pheophytin lacks a magnesium atom in its head region.
- Instead of acting a pigment that energizes an electron when it absorbs a photon, pheophytin accepts high-energy electron from the excited reaction center chlorophylls.
- Electrons that reduce pheophytin are passed through additional carriers to an electron transport chain in the thylakoid membrane. In both structure and function, this ETC is similar to components in the mitochondrial ETC.
- Photosystem 2 triggers chemiosmosis and ATP synthesis in the chloroplast.
- **Plastoquinone** (PQ) similar to ubiquinone in the ETC of cellular resp.

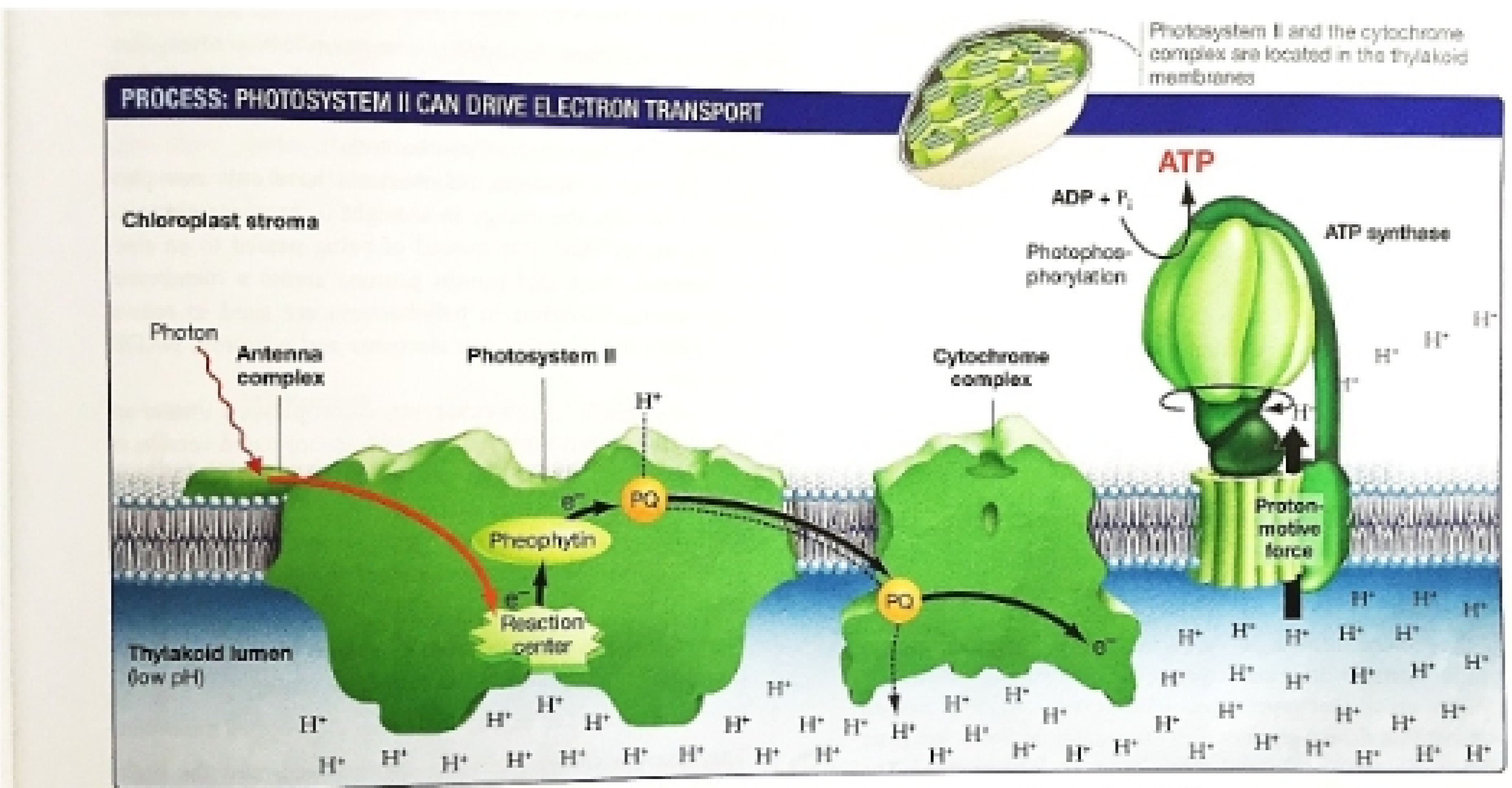


FIGURE 10.13 Electron Transport between Photosystem II and the Cytochrome Complex. Plastoquinone (PQ) carries electrons from photosystem II along with protons from the stroma. The cytochrome complex oxidizes plastoquinone, releasing the protons in the thylakoid lumen that drive ATP synthesis.