Photosynthesis Notes

The Equation: $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 \ + \text{O}_2$

Carbon dioxide + water → glucose + oxygen

**Photosynthesis** uses the energy of sunlight to convert water and carbon dioxide into high energy sugars and oxygen.

I. **Light and Pigments** (in addition to water and carbon dioxide, photosynthesis requires light, chloroplasts, and chlorophyll)
   a. Sunlight is a mixture of different wavelengths of light, all of which correspond to different colors.
   b. Pigments are light absorbing molecules that gather the sun's energy.
      i. Chlorophyll is the principal pigment in plants. There are two main types: chlorophyll a and chlorophyll b. (see figure 8-5; pg207)
      ii. Chlorophyll absorbs light in the blue-violet and red regions, and reflects light in the green region, which is why plants look green.
      iii. Some plants contain red and orange pigments called carotene.
   c. Sunlight is a form of energy. Chlorophyll which absorbs light also absorbs the energy from that light and transfers it to electrons, which raises the energy level of the electrons.
   d. High-energy electrons make photosynthesis work.

II. **Electron Carriers**
   a. High-energy electrons need a carrier to transport them from chlorophyll to other molecules. Carriers accept a pair of high-energy electrons and transfer them to another molecule (electron transport chain).
   b. NADP$^+$ is a carrier. It holds two high-energy electrons and a hydrogen ion (H$^+$), which turns NADP$^+$ into NADPH.
      i. NADPH will carry the energy captured in chlorophyll to chemical reaction in the cell to build molecules.

III. **Light-Dependent Reactions**
   a. Takes place in: Chloroplast- Thylakoid
   b. What they do: Use energy from sunlight to produce oxygen and convert ADP and NADP$^+$ into the energy carriers ATP and NADPH
   c. What do they use: water, ADP, NADP$^+$
   d. What do they produce: oxygen, ATP, NADPH
   e. How they work:
      i. Photosystem 2 absorbs light, which is trapped by electrons. The high-energy electrons are then passed on to the electron transport chain (ETC). (Electrons are always readily available because plant enzymes break water into 2 electrons, 2 H$^+$ ions, and 1 oxygen atom. This reaction is the source of nearly all the oxygen in the Earth's atmosphere.)
      ii. High-energy electrons move from photosystem 2 to photosystem 1 through the ETC. Energy from the electrons is used in the ETC to pump H$^+$ ions across the thylakoid membrane.
iii. Pigments in photosystem 1 use energy from sunlight to reenergize electrons, which are picked up by NADP+. NADP+ also picks up H+ ions from the inner thylakoid membrane and becomes NADPH.

iv. As electrons are moved to NADPH more H+ ions are transported across the membrane. The inside of the thylakoid membrane becomes positive due to all the H+ ions inside, while the outside is slightly negative. This difference in charge provides the energy to make ATP.

v. H+ ions cannot move across the membrane on their own. ATP synthase allows H+ions to pass through the membrane. As H+ ions pass ATP synthase rotates and makes ATP, by putting an ADP and P group together.

IV. Dark Reactions- The Calvin Cycle
   a. Takes place in: Chloroplast- Stroma
   b. What they do: Use ATP and NADPH from light reactions to make high-energy sugars.
   c. What do they use: carbon dioxide, ATP, NADPH
   d. What do they produce: sugar (C6H12O6), ADP, NADP+
   e. How they work:
      i. Three CO₂ molecules from the atmosphere combine with 3 5-carbon molecules (RuBP) to make 6 3-carbon molecules (PGA).
      ii. 6 PGA are then converted to higher-energy forms, by using ATP and NADPH. The higher-energy form is 6 G3P(high energy 3-carbon molecules)
      iii. Of the 6 G3P only 1 is used to make glucose!
      iv. ATP is used to convert the other 5 G3P molecules back into 3 RuBP molecules.
      v. The process repeats!!

V. Factors that Affect Photosynthesis
   a. Water
   b. Temperature
   c. Light intensity