Photosynthesis: An Introduction

- Life on Earth is solar powered.
- The chloroplasts of plants use a process called **photosynthesis** to capture ***light energy*** from the sun and convert it to ***chemical energy*** stored in sugars and other organic molecules.

General Formula for photosynthesis:

$$12\ H_2O + 6\ CO_2 \rightarrow 6\ O_2 + C_6H_{12}O_6 + 6H_2O$$

- Photosynthesis is a ***redox*** reaction.
  - Carbon dioxide is reduced to form glucose *(so the C's and the O's are used to make glucose)*
  - Water is oxidized to form oxygen gas (*water is split up, and the "O" in water pairs up with another "O" to be come oxygen gas)*
- *Solar radiation* is the source of energy for photosynthesis
  - Known as electromagnetic energy, or *electromagnetic radiation*
    - Travels in rhythmic *waves*
    - Waves are disturbances of electrical and magnetic fields
    - Distance between crests of electromagnetic waves is called a *wavelength*
    - Energy content inversely proportional to wavelength
- Entire range of radiation is known as the *electromagnetic spectrum*
  - Segment most important to life is *visible light*
    - Narrow band that ranges from 380 to 750 nm in wavelength

Components of Photosynthesis

- Photosynthesis occurs in the plant organelle called the ***chloroplast***
  - Any green part of a plant has chloroplasts.
  - Leaves are the major site of photosynthesis for most plants.
  - There are about half a million chloroplasts per square ***millimeter*** of leaf surface.
- Chloroplasts are found mainly in ***mesophyll cells*** forming the tissues in the interior of the leaf.
- A typical mesophyll cell has 30-40 chloroplasts, each about 2-4 microns by 4-7 microns long.
- O_2 leaves and CO_2 enters the leaf through microscopic pores, called ***stomata***, in the leaf.
- Veins deliver water from the roots and carry off sugar from mesophyll cells to other plant areas.
- Each chloroplast has *two* membranes around a central aqueous space (fluid-filled), called the *stroma*.
- In the stroma are membranous flattened sacs, called the *thylakoids*.
- These have an internal aqueous space, the thylakoid lumen or thylakoid space.
- Thylakoids are stacked into columns called *grana*
- The color of a leaf comes from *chlorophyll*, the green pigment embedded within the thylakoids of chloroplasts.
- Chlorophyll plays an important role in the absorption of light energy during photosynthesis.

The light reactions and the Calvin cycle cooperate in converting light energy to the chemical energy of food: *an overview*

- Photosynthesis consists of two processes, each with multiple stages.
- The *light reactions* convert solar energy to chemical energy.
- The *Calvin cycle* changes CO_2 from the atmosphere into an organic molecule and uses energy from the light reaction to reduce the new carbon piece to sugar.
- In the light reaction, light energy absorbed by chlorophyll in the thylakoids drives the transfer of electrons and hydrogen from water to NADP+ (nicotinamide adenine dinucleotide phosphate), forming NADPH.
    - NADPH, an electron acceptor, provides energized electrons (reducing power) to the Calvin cycle.
- The light reaction also generates ATP by photophosphorylation for the Calvin cycle.
    - Photophosphorylation – addition of a phosphate group to ADP – similar to oxidative phosphorylation in CR
- The Calvin cycle is named for Melvin Calvin who worked out many of its steps in the 1940s with his colleagues.
- It begins with the incorporation of CO_2 into an organic molecule by a process called ***carbon fixation***.
- This new piece of carbon backbone is reduced with electrons provided by NADPH.
- ATP that was synthesized from the light reaction also powers parts of the Calvin cycle.
- While the light reactions occur at the thylakoids, the Calvin cycle occurs in the stroma.