CHAPTER 7: PHOTOSYNTHESIS

1. Plants are autotrophs
   1. Make their own food.
   2. Capture light energy that has traveled from the sun and convert it to chemical
   3. Producers
   4. All organisms that produce organic molecules from inorganic molecules using light are called photoautotrophs
2. Photosynthesis occurs in chloroplasts in plant cells
   1. All green parts of a plant have chloroplast in their cells
      1. Color comes from chlorophyll
         1. Light absorbing pigment in the chloroplasts that plays a central role in converting solar energy
   2. Chloroplasts are concentrated in the cells of the mesophyll, green tissue
      1. Cells enter the leaf and leave through the stomata.
   3. Stroma: Thick fluid in the compartment of the chloroplast
   4. Grana is a compilation of thylakoid membrane
      1. Built into the thylakoid membranes are present lumen.
3. Plants produce 02 gas by splitting water
   1. The leaves of plants are often covered with bubbles.
   2. Basic equation was determined in 1800, assuming plants produce O2.
      1. Used heavy isotope of oxygen.
   3. Water is a reactant and a product in the reaction.
   4. Determined that O2 came from water, not from C02
4. Photosynthesis is a redox process like cellular respiration
   1. Water molecules split and are oxidized y loosing electrons along with H+ ions. C02 is reduced to sugar as electrons and hydrogen ions are added to it
   2. Cellular respiration is different. Oxidizes SUGAR and reduces 02 to H20.
5. Light Reactions:
   1. Convert light energy to chemical energy
      1. Occur in Thylakoid
   2. Water is split, providing a source of electrons and giving off 02 gas as a by product
   3. Absorbed by chlorophyll molecules to drive transfer of H+ from water to NADPH.
      1. (Final Electron acceptor)
   4. Provides the needed electrons for Calvin Cycle
6. Calvin Cycle
   1. Occurs in the stroma of the chloroplast
      1. Assembles sugar molecules using C02.
      2. Carbon fixation: Need C02 for the cycle. Makes sugars by reducing the Carbon compounds
   2. NADPH produced by light reactions that provides the electrons for reducing carbon in the Calvin cycle.
   3. Photo Synthesis
      1. Photo: Light reaction Synthesis: Sugar construction
7. Visible Radiation drives the light reactions
   1. Electromagnetic spectrum, full range of EM from short to long.
   2. Wavelength and energy are indirectly proportional
      1. As energy increases, the wavelength must decrease.
   3. Gamma, *Xrays*, UV, Visible, Infrared, Microwaves, RadioWaves
   4. Pigments: Light absorbing molecules built into the thylakoid
      1. Different pigments absorb different types of wave lengths
      2. Chlorophyll A: Absorbs blue-violet and red light. Reflects green
      3. Chlorophyll B: Absorbs blue and orange. Reflects yellow-green
   5. Chloroplasts contain a family of pigments called carotenoids, which are various shades of yellow-orange hues of longer lasting carotenoids
   6. Broaden the spectrum of colors of fall.
      1. Also protect
   7. Photo protection: Absorb and dissipate excessive light energy that would damage chlorophyll or interact with oxygen to form reactive oxidative molecules
   8. Photons: Fixed quantity of light, energy.
8. Photosystems capture Solar power:
   1. Pigment molecules absorbs a photon, jumps to a higher energy level farther from the nucleus.
      1. Unstable
   2. As it drops down, releases excess energy as heat.
   3. Some pigments release heat after absorbing photons.
   4. Photosystems: Consists of a number of light-harvesting complexes surrounding a reaction center complex. The light-harvesting complexes consist of pigment molecules.
      1. Photosystem, which may include Chlorophyll A, b and Carotenoids.
   5. Reaction center complex: Contains a part of chlorophyll a molecules called the primary electron acceptor.
   6. PS680,700
9. Two Photosystems connected by an ETC generate ATP and NADPH
   1. In light reactions, energy is transformed into the chemical energy of ATP and NADPH.
      1. Electrons removed from water molecules pass from PSII to PSI to NADP+
   2. PG. 114 For diagram + explanation.
10. Chemiosmosis powers ATP synthesis in the light reaction
    1. Process of chemiosmosis drives ATP Synthesis using potential energy of a concentration gradient of H+ Ions across a membrane. Gradient is created when an ETC uses the energy to pass electrons down the chain to pump hydrogen ions across the membrane
    2. Photo excited membranes pass down the system as h+ ions are pumped across the stroma to the lumen, which generates this gradient
    3. Energy of the concentration gradient drives H+ flow and creates ATP through phosphorylation.
    4. Final electron acceptor is NADP+, oxidized here. Stored as high state of potential energy NADPH.
11. Calvin Cycle
    1. Occurs in the stroma.
    2. Uses CO2 energy from ATP and high-energy electrons from NADPH, constructs an energy-rich three carbon sugar (G3P).
    3. Started material is RuBP.
       1. Carbon fixation, enzyme Rubisco attaches to C02.
       2. This creates 3-PGA
          1. For three C02 entering, 6 PGA result
       3. Consume energy from 6 molecules of ATP and oxidize NADPH. Six molecules of 3-PGA are reduced, producing six molecules of G3P.
       4. One of the G3P is released, becomes the net product of photosynthesis.
       5. Regeneration of RuBp. ATP is used to rearrange the atoms in the five 3GP molecules, forming 3RuBP molecules.
          1. NADPH reduces the organic acid 3-PGA to G3P.
12. Adaptations that save water in hot dry, limits
    1. Initial fixation of Carbon occurs when enzyme rubisco ( C02+ RuBP) are known as c3 plants.
       1. Very common. Problem is that when C3 plants face hot, dry ,weather crop production is decreased. Stomata closes to reduce water loss and 02 builds up in leaf, adding 02 to rubisco instead of C02. This is called photorespiration, drain away as much as 50% of the Carbon fixed by Calvin cycle
    2. C4 Plants
       1. Evolved so that they save water without shutting down photosynthesis.
       2. Keep stomato class and keeps making sugars by using the pathway shown on 118.
          1. Enzyme in mesophyll has high affinity for C02 and can continue carbon fixation.
          2. Moves to the bundle-sheath cells to do the Calvin Cycle.
          3. C02 concentration remains high enough.
       3. CAM Plants
          1. Dry climates. Conserves water by opening stomata at night. C02 enters as a 4-C carbon compound.
    3. SIMPLIFIED
       1. C4 occurs in bundle sheath cells, CAM occurs at night time.

Light fixation according to Khan Academy:

* Flat heads are called thylakoids
  + The fluid inside the thylakoid is called the thylakoid lumen
* A stack of several thylakoids is called a grana
* Thylakoid membrane
  + Phosphobilipid layer
  + Photosynthesis: Outside of membrane, stroma.
    - Inside is lumen
* On the membrane, you have PSII, PSI
* Light Dependent Reaction;
  + Some photons from the some travel 93 million miles
  + Excite electrons in chlorophyll molecule
  + Enter a high energy state
    - As they go from molecule to molecule and go down,, you have hydrogen protons get pumped into the lumen
  + Create a gradient of H+ Concentration gradient to drive ATP Synthase
    - To go back through stroma
    - Puts ADP + Phosphate
    - To produce ATP
* This process is called PHOTO PHOSPOHORYLATION
* If we’re talking about non cyclic light reactions
  + Final electron acceptor is sure NADP+ and is reduced
  + Accepts the Hydrogen to become NADPH
  + Water electrons are used to bring in the H20. It donates the Hydrogen and electrons to replace the electron that got excited.
  + Only can occur in PSII.
* Cholorphyll excited it
* Ph, pQ, BbF, pc make it less excited
* Now we are going to look at CYCLIC photo phosphorylation:
  + Ends up in PSII instead of PSI
  + Non Cyclic: NADPH+, 02 + ATP
  + Cylic: Only ATP
  + Used in conjugation with C02 + NADPH to produce actual carbs in the stroma., outside the thylakoid.