Photosynthesis
Biology metabolism to capture sunlight

"For He hath made Him to be sin for us who knew no sin that we might be made the righteousness of God in him" Second Corinthians 5:21

Life requirements

1. Energy
2. Nutrients
3. The chemical processes of using and modifying energy and nutrients is called metabolism.

Metabolism

1. Cellular chemistry of making and breaking molecules for the purpose of obtaining and using energy and materials to sustain life.
2. Anabolism is the making of molecules.
3. Catabolism is the breaking of molecules.
4. Anabolism and Catabolism is Metabolism.
5. Explains how life functions on earth.

Cellular Energy

1. Energy is required by all cells to maintain life.
2. Energy is stored in chemical bonds resulting from stabilized electron configuration.
3. Energy is lost in every reaction as heat energy.
4. More energy is lost than is used in every metabolic reaction.
5. All energy ultimately comes from the sun.
6. Photosynthesis: Converting sunlight energy into chemical storage energy.
7. Cellular Respiration: Converting chemical energy into usable energy.

Cellular nutrients

1. Source of chemical energy for life.
2. Source of structural materials for biological growth.
3. Nutrients form from basic elements.
4. Supplied in the dust of the earth and in the gasses of the atmosphere.

Energy flows through life

1. From sun to ATP to heat.
2. Photosynthesis converts radiant energy into chemical energy.
3. Ingestion is obtaining nutrients for energy and growth materials.
4. Digestion is breakdown complex foods into smaller molecules.
    a. Extracellular digestion: Secrete enzymes into environment to digest food, and then absorb the digested molecules.
    b. Intracellular digestion: inside the food vacuole.
    c. Autophagy: Body digest its own worn out parts.
5. Assimilation is absorption and modification of nutrients for metabolism.
6. Radiation is cellular loss of thermo energy during metabolism.
7. Egestion is elimination of waste materials from cells.

8. Reclamation is the recycling of materials for biological nutrients.

Photosynthesis

1. Captures and converts sunlight energy into chemical energy.
2. Sun -> radiant energy (photons) -> plant -> chemical energy
3. Carbon dioxide + water + light energy -> glucose + oxygen
4. $CO_2 + H_2O$ + light energy -> $C_6H_{12}O_6 + O_2$
5. Two steps
    1. Photo phase: light reaction
    2. Dark phase: dark reaction, synthetic phase

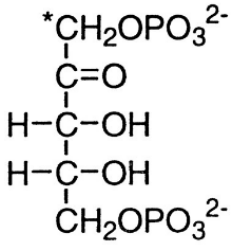
Photo phase of photosynthesis

1. Light dependent. Occurs only in light.
2. Releases Hydrogen ions, and produces ATP, and NADPH.
3. H+ is used to make ATP.
4. ATP is used to transport and supply energy to chemical reactions in the cell.
5. NADP+ is the result of the final electron acceptor resulting in the formation of NADPH.
6. Inside the chloroplast
    a. Chlorophyll: a green pigment containing Mg absorbs light.
    b. Plants make chlorophyll in the presence of light and Mg.
    c. Photosynthetic reaction centers (PRC) are complexes of proteins, pigments including chlorophyll, and co-factors involved in converting light to chemical energy.
    d. Transducers convert energy from one form into another (transduction).
    e. Photosynthetic reaction centers (PRC) are the core of photosystems.
    f. Photosystems include complexes that collect photons for the PRC.
        i. Antennae molecules collect and pass photons to PRC.
    g. Photosystems are located in the membranes of flat sacs called thylakoids.
    h. A stack of thylakoids is called a grana.
    i. Many grana float in the stroma (colloid matrix) of chloroplasts.
7. Photophosphorylation
    a. In the PRC, chlorophyll absorbs blue and red light frequencies for energy.
    b. Light energy is absorbed by and energizes ***chlorophyll a*** to initiate photophosphorylation (photons to ATP).
    c. Photons induce electron release by exciting electrons in the ***chlorophyll a*** molecule of photosystem II.
    d. Electrons are passed along a molecular chain through the thylakoid membrane from the stroma into the thylakoid lumen.
    e. Photons excite electrons a second time in the ***chlorophyll a*** molecule of photosystem I and continue the electron journey through the thylakoid membrane.
    f. H+ follow the negative charged electrons into the thylakoid lumen.
    g. The build up of H+ in the lumen creates a H+ pump due to the concentration gradient.
    h. The concentrated H+ diffuse out of cell through ATP synthase.
    i. The flow of H+ to the outside of the membrane acts as an ion pump to spin the ATP synthase molecule resulting in the production of ATP molecules.

j. NADP+ is the final electron acceptor to collect electrons (e-) resulting in NADPH.
k. H_2O is oxidized in photosystem II to supply electrons to replace the excited electrons.
l. Oxidized H_2O releases O_2 and releases two electrons with two H+.
m. The use of photons to make ATP is called photophosphorylation.
    i. Photons are collected by photosystem II to release electrons from oxidized O_2. Elections are passed along a chain of molecules from stroma to lumen across membrane of thylakoid. Photons energize the electrons in photosystem I to continue the electron movement into the lumen.
    ii. H+ (protons) follow the electrons into the lumen and accumulate.
    iii. H+ diffuses back into stroma across membrane through ATP synthase. The flow of protons through ATP synthase acts as a pump to produce ATP. This is called the proton pump.

Dark phase of photosynthesis

1. Calvin cycle
2. Light independent. Does not require light. Can occur in light or dark.
3. Uses the products of the photo phase (H+, ATP, NADPH).
4. Occurs in the stroma of the chloroplast.
5. CO_2 captured and used for making glucose. This is called <u>carbon fixation</u>.
6. Produces glucose and O_2.
7. 6 CO_2 + 6 RuBP (ribulose bisphosphate, $C_5H_{12}O_{11}P_2$, a five carbon molecule with a phosphate on the 1 and 5 carbons atoms) => 12 PGAL.



1.

8. PGAL (phosphoglyceraldehyde) = 3-phosphoglyceraldehyde = $C_3H_7O_6P$
9. The binding of CO_2 into PGAL is called <u>carbon fixation</u>.
10. Reaction requires energy from 12 ATP and 12 NADPH.
11. 10 PGAL (3 carbon molecules) are used to make another 6 RuBP (5 carbon molecules).
12. 2 PGAL are used to make glucose ($C_6H_{12}O_6$).

Summary

1. Photosynthesis requires water, CO_2, & Light energy
2. Photosynthesis chemical equation: 6 CO_2 + 6 H_2O => $C_6H_{12}O_6$ + 6 O_2
3. Major products of photosynthesis are glucose and O_2 (food and oxygen).
4. Autotrophs: Independent, self-feeders (plants, algae).
5. Heterotrophs: Dependent feeders (animals, fungi, most bacteria).

Chemosynthesis

1. Chemotrophs obtain energy from <u>inorganic</u> molecules to chemosynthesize carbohydrates.

ATP

1. Adenosine Triphosphate molecule: 1 Adenosine + three phosphates
2. Energy transfer molecule of the cell.
3. High energy bonds in the last two phosphates.
4. ATP -> ADP + energy; Energy + ADP -> ATP
5. Used for metabolism, active transport, cell movement, etc.