**Photosynthesis: Light Dependent and Light Independent Reactions**

**Instructor:**

**Grade level: 9-12**

**Created/last edited/submitted:**

**Lesson Summary:**

This lesson focuses on photosynthesis reactions that plants use photons of sunlight (light), water, and carbon dioxide to create carbohydrate (sugar) molecules. This is a lesson plan that is pretty teacher-center driven.

There are two stages of photosynthesis, light-dependent and light-independent reactions. These two reactions are occurring simultaneously. Light-dependent reactions occur in thylakoid membranes. Photons from sunlight (light) and water are needed to make light-dependent reactions to occur. Sunlight (light) excited electron of chlorophyll molecules in photosystem II complex. At this stage, the excited electrons have high energy. The electrons passes through one electron acceptor to another through electron transport chain, which is in the thylakoid membranes. Through the passing the energy of the electrons get lower and lower. Until the electrons get to photosystem I (light-harvesting complex), the electrons get recharge and become high energy again. When the molecules go to series high and low energy state that occur between inside (lumen) and outside (stroma) of a thylakoid membrane, the action pumps hydrogen protons (H+) from stroma to lumen. After lumen has high concentration of hydrogen protons, those protons want to go back to stroma, because of chemiosmosis to reach equilibrium. When hydrogen protons try to go back to stroma, the action drives ATP synthase. This event ultimately results in the making of ATP and NADPH from the ADP and NADP+. The process is called photophorylation.

In photosystem II (light-harvesting complex), when a chlorophyll molecule has an electron excited and the electron gets passed to the electron acceptors, the excited electron must then be replaced. In photosystem II, the electron comes from strips off the electrons in water to replace the electron that lost from chlorophyll molecules. After the hydrogens are strip off from water, there is only the molecular oxygen left, which release oxygen as a waste product. The process is called oxidizing. The final products from the light-dependent reactions are ATPs and NADPHs, and another important bi-product is oxygen.

As the light-independent reactions (Calvin Cycle), they take place in the stroma of the chloroplast. It is an enzyme-controlled process that uses ATP, and NADPH, which are produced from light-dependent reactions, and CO2 to produce G3P (glyceraldehyde 3-phosphate). Calvin cycle starts off with the compound called Ribulose Bisphosphate (RuBP). RuBP is a 5 carbon compound and gets convert into 2 PGA, 2 (c-c-c-p). The extra carbon is provided by CO2. Rubisco, a kind of enzyme, combines with CO2 toform 2 PGA. The energy from ATP and reducing power of NADPH is now used to convert to molecules of PGA to G3P. ATP supplies the phosphate groups for forming G3P molecules, while NADPH supplies hydrogen ions and electrons. In the final step of the Calvin cycle, an enzyme called rubisco converts the 10 G3P molecules into RuBP to allow the cycle to continue. Some of the G3P are used to synthesize glucose and other organic molecules. For every 12 G3P, 10 will go to from RuBP, and 2 will go to form products, such as glucose.

The light-independent reactions can be summarized as follows:

12 NADPH + 18 ATP + 6CO2 yields C6H12O6 + 12NADP+ + 18Pi +6 H2O

**Lesson Objectives:**

Students will be able to name the two phases of photosynthesis. In addition, students will be able to explain how light, water, CO2 and O2 play roles in light dependent and independent phase of photosynthesis.

**Materials:**

**Vocabulary:**

**Electron:** Electrons have a negative charge. If a compound gives away (losing) an electron is called Oxidation, and a compound gains an electron is called Reduction.

**Electron transport chain:** Electron transport chain is a series of compounds that transfer electrons from electron donors to electron acceptors.

**Light-dependent reactions (Photosystem I and Photosystem II):** The reaction involves sunlight and water (H2O) to form ATP, NADPH.

**Light-independent reactions (Calvin cycle):** The reaction involves CO2, and ATP and NADPH that are formed from light-dependent reactions to produce glucose.

**Photon:** Photon is an elementary particle. It is a small unit of light. Photon oscillate along a path that carrier for electromagnetic force, which is measured as wavelengths.

**Reducing agent**: In the photosynthesis light-dependent reaction, reducing agent particularly mean that a compound, such as NADPH, gets oxidized by losing the hydrogen and the electron with it. Reducing agent gives away hydrogen and electron associated with it, and so the other compound gets reduced.

**Time Required:**

1 hour

**Standards/Benchmarks Addressed:**

1. **Indiana Science Standards Biology**

B.2.1. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

B.1.3. Develop and use models that illustrate how a cell membrane regulates the uptake of materials essential for growth and survival while removing or preventing harmful waste materials from accumulating through the processes of active and passive transport.

1. **Next Generation Science Standards**

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

**Classroom Instruction:**

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| **Introduction:**1. Review students’ understanding of parts of a plant cell that plays important roles in photosynthesis, such as thylakoids, lumen, stroma, chlorophyll and so on.
2. Ask students to share their understanding about why for a plant grow, the plant needs water, sun light, CO2 to do photosynthesis.
 | **Comments:***This is a place for teacher notes and/or helpful hints* |
| **Activity (Science/Math/Design or Engineering):****I have not come up with a good interactive activity to teach the light-dependent and light independent reactions.**  | **Comments:** |
| **Closure:** | **Comments:** |

**Assessment:**

**Pre-Activity Assessment**

**Activity Embedded Assessment**

**Post-Activity Assessment**

 **Support Materials**

**Student Handout/Worksheet**

**Design Brief/Story/Context**

**References:**