Photosynthesis

Key Concepts:
- Photosynthesis
- The scientific process

Grade Level: 9-12

Education Subject: Science

Success Indicator:
After completing this lesson, learners will:
- Be able to list some of the factors that affect the rate of photosynthesis.
- Be able to explain the connection between light and energy storage in plants.
- Use the scientific process to investigate photosynthesis.
- Suggest next experiments to do related to photosynthesis.

Materials and Methods

(**Note:** This experiment is best performed by groups of one to three learners, but it can be done as a demonstration by the teacher if absolutely necessary.)

Preparation Time: 20 minutes

Lesson Time: 50 minutes

Space: Any
- A dark room (such as a closet)
- A windowsill, shelf space under artificial plant lights or greenhouse space

Materials:
- Geraniums or other broad-leaved plants that are the same species and roughly the same size (enough to provide one leaf per learner or work group)
- Permanent markers
- Electrical tape (one short strip of tape per learner)
- Hot plate (one or more; can be shared)
- Tongs or tweezers (one pair per learner or work group)
- 600 ml beakers (one per learner or work group)
- 200 ml beakers (one per learner or work group)
- Petri dishes (one per learner or work group)
- Ethanol (approximately 100 ml per learner or work group)
- Iodine (approximately 20 drops per learner or work group)
- 300 ml water per learner
- Safety glasses (one pair per learner)
- Hot pads (two per learner or work group)

Introduction:

Plants are rather amazing and can do something that animals, even humans, cannot do — make their own food. Plants can take sunlight (light energy) and convert it into sugars and starch (chemical energy) through a process called photosynthesis. This process of converting carbon dioxide to oxygen is vital to all life on earth. Plants use up carbon dioxide and release oxygen as part of the process, using up a byproduct from humans and producing an element essential for us all. As you can see, photosynthesis is very important, and it is a process that we should explore and understand. After all, our very survival depends on it!

When scientists (like you) do research, perform experiments and collect data, they utilize the scientific process. It is important that we know and use this process. In fact, we all use scientific processes every day — we just don't take the time to stop and think about it.

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Developed by Norm Lownds, Ph.D., Curator, Michigan 4-H Children's Garden

Instructions:

Before class:

1. Read through the lesson plan and gather the supplies in the materials list.

2. Water the plants, then place them in the dark for 48 hours before starting this experiment. Just before it's time for the lesson, place the plants at the front of the classroom.

During class:

1. Tell the learners that over the next couple of days they're going to study photosynthesis by looking for the presence of starch in the leaf of a plant. Read aloud or paraphrase the following information:

   Photosynthesis is the process that plants use to convert the energy of light into the stored chemical energy of sugars. Photosynthesis can be summarized with a chemical equation that looks like this: (**Note:** Write the equation on the board where everyone can see it.)

   $$6CO_2 + 6H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6O_2$$

   Plant cells convert carbon dioxide into carbohydrates by the process of photosynthesis. To investigate this process, we need a way to measure the amount of the sugar glucose that a plant produces. We will be looking for starch, a compound that is closely related to glucose. Starch is produced by plant leaves as an energy storage product when they have excess sugars. To make the starch visible, we'll use the indicator chemical iodine. Any part of a plant leaf that iodine stains a dark color has starch in it.

2. Distribute the plants, electrical tape and permanent markers to the learners. Have them write their names on their plant containers. Explain that these plants have been deprived of light for 48 hours so that the process of photosynthesis to convert sunlight into sugar has either stopped or slowed a great deal.

3. Now tell them to place a piece of electrical tape over part of the top side of one leaf on their plants. Have them sketch, photograph or diagram the leaf and where the tape is on it. Then have them move their plants to the space you've arranged on a windowsill, under artificial lighting or in a greenhouse. Tell them the plants will stay in that lighted space for 24 hours.

Measuring starch in the leaves:

4. The next day, have each learner or work group collect the safety goggles, hot plates, beakers, petri dishes, tongs or tweezers, hot pads, water, ethanol and iodine they'll need. Caution learners about the dangers of hot plates, boiling water and the careless use of chemicals, then tell them to heat about 300 ml of water to boiling in the larger beaker.

Michigan High School Content Expectations:

B2.1A Explain how cells transform energy from one form to another through the processes of photosynthesis and respiration.

B2.5C Explain how energy is transferred and transformed from the sun to energy-rich molecules during photosynthesis.

B2.5F Relate plant structures and functions to the process of photosynthesis and respiration.

B3.1A Describe how organisms acquire energy directly or indirectly from sunlight.

B3.1C Recognize the equations for photosynthesis and respiration and identify the reactants and products for both.

B3.1D Explain how living organisms gain and use mass through the processes of photosynthesis and respiration.

5. Next have them pinch or cut the taped leaves off of their plants, remove the tape and place those leaves in the boiling water for about 1 minute. While the leaves are boiling, tell them to put ethanol in their smaller beakers.

6. After the minute is up, have the learners place their leaves in the ethanol-filled beakers, then very carefully put the smaller beaker into the larger beaker and continue heating it.

7. When the leaf is very pale green or white, have them use the tongs or tweezers to remove it from the ethanol, rinse it with tap water and place it in a petri dish. (Remind them to turn off the hot plate!)

   Next tell them to add enough iodine to the leaf to cover the top surface and let it sit for about 10 minutes. Over that period, the areas on the leaf that have been producing starch will turn dark blue or purple.

8. Have them sketch or photograph their leaves again, this time indicating where the stained areas are.

9. Ask them to compare their sketches of where they put the tape on the leaf and their sketches or photos of the leaves showing where starch appeared. When all have completed their sketches and cleaned up the work area, draw their attention back to the group.

Check for Understanding:

Ask the group the following processing questions:

- What conclusion can you draw from comparing the two sketches or photos you made of your leaves?
- What happened to the plant's chlorophyll levels when it was in the dark room for 48 hours? When you moved it back into the light for 24 hours?
- Why did we test for the presence of starch in the leaves?
- What parts of the leaves would you expect to produce starch?
- Did starch appear in any areas of the leaf where you *didn't* expect to see it?
- What color is chlorophyll?

Ways to Extend:

Examine the effects of different colors of light on photosynthesis in leaves.