Explore: Investigating Photosynthesis

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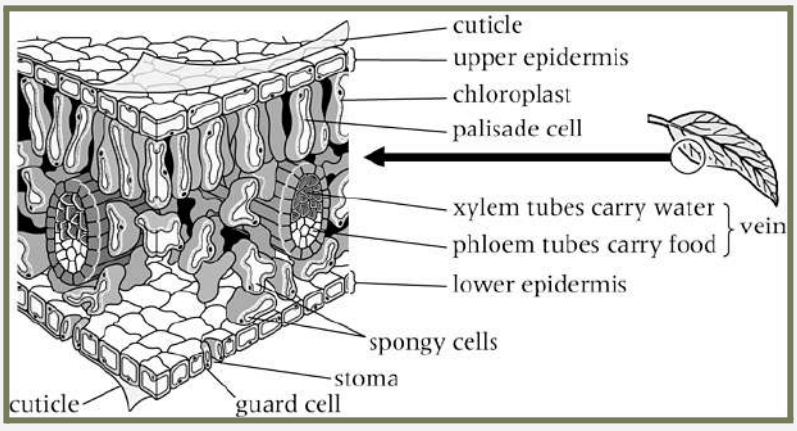
Background

All living things need a source of outside energy. Animals get their energy from the food they eat. Plants obtain this energy from sunlight and convert it into sugars in the process called photosynthesis. Plants capture sunlight using chlorophyll molecules found in the chloroplasts of their cells. Chlorophyll gives plants their green color. The highest concentration of chloroplasts is found in plant leaves. A leaf can be thought of as a solar antenna, an adaptation that allows the plant to collect as much sunlight as possible. Chlorophyll molecules absorb the sun's energy and start the process whereby carbon dioxide is fixed into more complex molecules (sugars). The sugars produced are food not only for the plant producing them, but for other living things. Therefore, the energy that we obtain from our food ultimately comes from the sun. Within each leaf are cells containing chloroplasts. These cells, called palisade mesophyll cells, are the plant's main sites for photosynthesis. A cross section of a plant leaf reveals tight layers of mesophyll cells, again an adaptation allowing plants to collect more sunlight. Below the tightly packed cells are more loosely arranged spongy mesophyll cells that allow for intercellular spaces. These spaces are continuous, with small openings in the leaf surface called stomata (plural for "stoma"). Stomata allow gasses to enter and exit the leaf.

For photosynthesis to occur, carbon dioxide is also needed. This gas is found in the atmosphere and can enter the leaf through the stomata and then diffuse into the mesophyll cells. Using the energy from the sun, photosynthesis occurs by fixing carbon dioxide into organic molecules like glucose (sugar) shown in the following reaction.

$$\_CO_2 + \_H_2O \rightarrow C\_H\_O\_ + \_O_2$$

As you can see from the equation, oxygen is also produced by photosynthesis. This is very important to us since we could not survive without this plant by-product. It is possible to investigate photosynthesis by carrying out an experiment that demonstrates the production of oxygen. In this experiment, you will remove all oxygen and carbon dioxide from a plant leaf.



Name: _____ Date: _____

When leaves are exposed to light, photosynthesis will occur and oxygen will be produced. We can study the rates of photosynthesis by increasing the amount of light for our leaves. Since photosynthesis needs carbon dioxide as well, we can study the effect of carbon dioxide supplies on the rates of photosynthesis. A small amount of dissolved carbon dioxide is normally present in water. A baking soda solution, sodium bicarbonate, will increase the amount of carbon dioxide dissolved in water, making it available to our plant leaves.

$$NaHCO_3 + H^+ \rightarrow Na + H_2O + CO_2$$

Materials

***For each pair of students*:**

- 50 mL of 0.1% sodium bicarbonate solution or water
- 1 straw
- 1 10-mL syringe
- 1 syringe stand

Needed, but not supplied

- Plant leaves from spinach or local flora (bushes / trees outside)
- Grow light, lamp, or flashlight

Procedure for Constructing and Using a Photosynthetic Chamber

Follow the steps below to construct a photosynthetic vacuum chamber composed of a 10-mL syringe containing leaf disks and water or a water-baking soda solution. You will use a straw to cut out 10 leaf disks, and may need more than one leaf to make all 10 disks. Teacher will demonstrate this procedure. Make sure to ask any questions before, during, and after the demonstration!

1. Pull the plunger out of the syringe.
2. To cut out a disk, cover a fingertip on one hand with part of a leaf, then with the other hand, press the end of a straw against the leaf and your fingertip.
3. Place each leaf disk into the syringe. You may need to blow on the end of the straw to remove the disk.
4. After 10 leaf disks are in the syringe, use the straw to position them at the bottom. Replace the plunger.
5. Place the syringe tip into your group's designated liquid (either baking soda solution or water). Pull the plunger back to fill the syringe to the 5-mL mark. (It will probably work best to overfill, tap the bubbles out, then expel the extra until you reach 5 mL.)
6. Push the syringe tip firmly onto the syringe stand and pull the plunger back until you feel vacuum pressure. This vacuum will pull any air from the spaces within the tissue of the leaf disks. You should see air bubbles form on the disks as you create more negative pressure.
7. Gently shake the syringe or tap it on the side of your desk while maintaining the vacuum. This will remove the air bubbles from the disks.

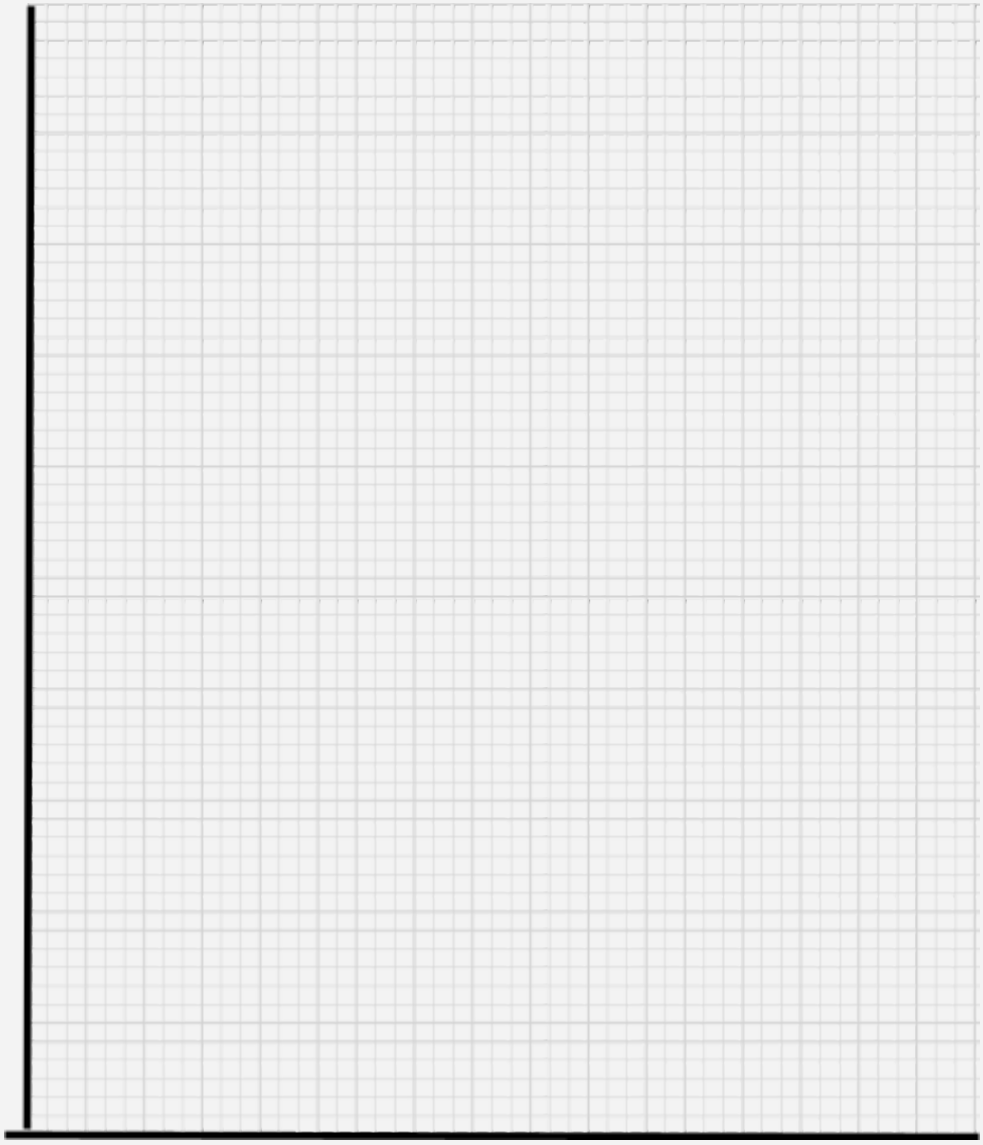
8. Slowly release the plunger. When you turn the tip of the syringe upward, the leaf disks should start to sink. You may need to repeat this process several times to get all 10 disks to sink. After the disks have sunk, remove the stand and fill the syringe to the 10-mL mark.
9. If using bright light, place your syringe with its tip upward about 10 cm from a grow light, lamp, or flashlight.
10. If using room lighting, place your syringe with its tip upward on a desk.
11. If using no light, place your syringe with the tip upward away from direct light. You may need to cover your chamber to ensure that it is not exposed to light.
12. After 2 minutes, tap the sides of your syringe and count how many leaf disks are floating. Continue to observe and record the results every 2 minutes for a total of 20 minutes.
13. Record your results on Table 1.
14. After completing your experiment, compare your findings with other student pairs in your group and fill in Table 2 with this data.
15. Graph your group's results. Title the graph and supply the following information:
    a. The independent variable on the x-axis.
    b. The dependent variable on the y-axis.

Data Table:

Treatment	Time in Minutes	0	2	4	6	8	10	12	14	16	18	20
Light												
Dark												

Name: _____ Date: _____

Graph:



Reflection Questions:

1. **What does a plant need for photosynthesis?**
   - A plant needs _____ for photosynthesis to occur.

2. **What are the products of photosynthesis?**

- The products of photosynthesis are [_____] and [_____].

3. What is a by-product of photosynthesis?

- A by-product of photosynthesis is [_____].

4. Where does photosynthesis occur in a plant?

- Photosynthesis occurs in [_____] of a plant.

5. Write a hypothesis that this experiment is designed to test.

- I hypothesize that [_____] because [_____ _____ _____ _____].

6. Which syringe had the most leaf disks floating after 20 minutes?

- The syringe with [_____] leaf disks floating after 20 minutes was [_____ _____ _____ _____ _____ _____].

7. Were there any syringes without floating disks?

- Yes, there were [_____] syringes without floating disks.

8. How do floating disks correspond to the rate of photosynthesis?

- The more leaf disks that float, the [_____] the rate of photosynthesis.

9. According to your data, does light intensity affect the rate of photosynthesis? Explain.

- According to my data, light intensity [did/did not] affect the rate of photosynthesis because [_____ _____ _____ _____ _____ _____]

_____ _____

_____ _____].

10. How did the baking soda solution affect photosynthetic rates?

- The baking soda solution [increased/decreased/no effect on] photosynthetic rates because [_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____]