Photosynthesis: How do plants get energy?
Student Advanced Version

In this lab, students explore the process of photosynthesis in spinach leaves. As oxygen is produced, the density of the leaves change and they will begin floating in a sodium bicarbonate solution. The time it takes for a certain number of leaves to float can be used to calculate the rate of photosynthesis.

Key Concepts:

- **Photosynthesis** is the primary means by which plants get their energy. They derive this energy from a sugar called **glucose** ($C_6H_{12}O_6$).
- To make glucose, sunlight is captured in pigments like **chlorophyll**, the substance that gives leaves their green color.
- The sun's energy is passed through a chain of events that breaks **water** (H_2O) into **oxygen** (O_2) and creates a store of energy-rich molecules. These molecules will enter a continuous cycle of events to build glucose out of **carbon dioxide** (CO_2) from the air.

Hypotheses:

Q1. What do you think the effects of varying the type of plant leaf we use will be on the net rate of photosynthesis (i.e. which one will have a faster rate, the cabbage or the spinach and why?)? (provide literature values and an explanation at the end.)

Q2. What do you think the effect of light versus dark will be on the net rate of photosynthesis?

Q3. How do you think varying the intensity of light (i.e. distance from the light source) affect the net rate of photosynthesis?

Procedure:

1) **Label** 5 cups and the 5 syringes in the following manner: “No BS light”, “BS + red”, “BS + green”, “BS light”, and “BS dark”.

2) **Mix** 4 tsp of baking soda and 4 tsp of detergent with 800 mL of water in the beaker. **Label** is as “BS solution”.

3) **Mix** 1 tsp detergent with 200 mL of water into the cup labeled “No BS light”. **Label** this as “No BS solution”

4) **Place** the red cellophane over Hole 1. **Place** the green cellophane over Hole 2. **Leave** Hole 3 open.

Q4. What type of light will enter each region of the boxes? What type do you think is most favorable to plants?

5) **Hole punch** 70 spinach leaf disks. Note: this experiment works best with very fresh leaves.

6) **Put** 10 disks into each syringe

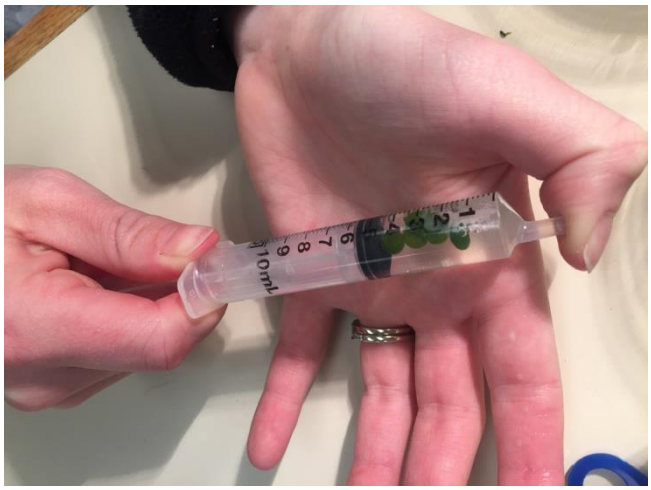
7) **Insert** the plunger without crushing the disks.

8) **Suck up 3-4 mL** of the BS solution in the BS syringes**; suck up 3-4mL** of the No BS solution in the No BS syringe. Be sure that the leaves are suspended and floating in the solution, not sticking to the sides.

Q5. Why should the leaves still be floating at this stage?

9) **Point the syringe tip upward and press the plunger** to remove excess air. There should be virtually no air in the syringe – just a few bubbles.

10) **Create a vacuum** in the syringe by placing your finger on the hole at one end of the syringe and pulling the plunger up. **Hold the plunger** up like this for 10 seconds while swirling the leaf disks in the solution and then release.



Q6. What do you think the purpose of the vacuum is? What do you think the vacuum we made is "sucking"?

11) **Repeat this vacuum** until leaf disks are no longer floating in solution and have sunk to the bottom of the syringe. This may take several strong "tugs". If the leaves fail to sink add more detergent to the solution.

Q7. Why do you think adding more detergent will help?

12) **Pour the leaf disks** and their solution into the appropriately labeled cup. Fill the BS cups with the baking soda solution from the beaker until the cups are 3/4 full. Note: you already filled the "No BS" cup with the appropriate solution. Check that all disks are resting at the bottom of their cups. Prod or stir the solution with a clean stir stick or pencil to loosen any clinging disks.

13) **Arrange the cups** under the appropriate holes in the shoeboxes. Make sure the side flaps are closed to keep light out. Leave the "No BS" cup uncovered next to the boxes. Place the light so that it shines from above onto the three holes and uncovered cup.

14) Using the side flaps for viewing, **record the number of floating disks** after each minute in the data table handout for each experimental condition until all of the disks are floating. Be sure that none of the disks are stuck to the sides of the cups. (Note: data table handout is one of the attachment files)

Q8. Why do the disks start to float?

15) **Graph your results.**

Q9. What do you think is the most effective way to graph the results? Why are we calculating a "net" rate and not just a rate? What would be the units of the rate, and thus what would be the independent variable (on the x axis) and what would be the dependent variable (on the y axis)?

Q10. How do we calculate a rate using the graphs?

Concept questions

Q11. What was the best source of light for photosynthesis? Was this what you predicted?

Q12. Describe any sources of error in the experiment. Was there anything that made your results hard to read or gave no results? Why?

Q13. What other controls would you suggest using in this experiment? We would expect that this prospective experiment would also test the rate of photosynthesis, but under different conditions.