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HANDS-ON LAB

Investigating Light Sources and Photosynthesis

Have you ever wondered why plants can grow inside buildings, even under low light conditions and under sources that produce light that looks very different from sunlight? The color of light that you see is the result of many different wavelengths interacting with each other and with gases in the atmosphere. Different light sources produce different combinations of wavelengths. For example, light emitting diodes, or LEDs, can be designed to only give off certain colors, such as red, blue, or green, which correspond to different wavelengths of the visible light spectrum.

Scientists and engineers often study the inputs and outputs of a system in order to optimize that system. Imagine you wanted to optimize the rate of oxygen production by plants in a building such as a school or office. What type of light source would you use?

By measuring oxygen production indirectly, you can measure the rate of photosynthesis. Remember that a rate describes how one quantity changes compared with another. In this lab you will design an experiment to determine the effect of different light sources on the rate of photosynthesis in leaves.

MATERIALS

- beaker, 100 mL
- forceps
- hole punch
- plastic syringe, 10 cc
- sodium bicarbonate/detergent solution
- stopwatch
- strong light
- water
- young ivy leaves

PREDICT

Make a prediction about how differences light sources will affect the rate of photosynthesis. Which light sources do you think will lead to the highest rate of oxygen production in plant leaves, and why?

PROCEDURE

Part of the procedure for this lab requires punching out disks from a leaf, and indirectly measuring oxygen production by these leaf sections. You may preview the procedure for this part of the lab before writing the remainder of the procedure. Use the following list of questions as a guide when writing your procedure. Use the space provided, and have your teacher approve your plan before moving on to the next step.

- What materials will you need?
- How many experimental setups will you need? Is this number feasible in terms of time, cost, and safety?
- How many trials will you run?
- What will serve as your control setup?
- What variables will be kept constant for all setups?
- How will you measure and record data?

1. Write your procedure as a numbered list of steps. Include specific materials and quantities as necessary.

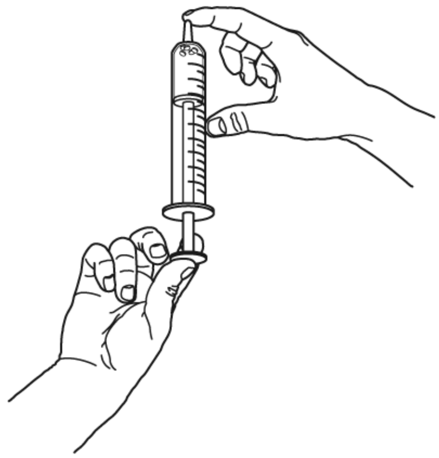
2. Use the hole punch to make five disks from an ivy leaf.

3. Fill one beaker halfway with the sodium bicarbonate/detergent solution. Fill a second beaker with water.

4. Remove the plunger from the syringe and place the ivy leaf disks into the syringe. Insert the plunger and draw 5 cc (5 mL) of the sodium bicarbonate/detergent solution into the syringe as shown below.

5. Hold the syringe so that the tip is pointing upwards. Push on the plunger to squirt out any air in the syringe.

6. Place your finger on the tip of the syringe, as shown below. Withdraw the plunger to form a vacuum, but be careful to not pull the plunger all the way out of the syringe. When the vacuum is formed, the gases in the air spaces in the leaf disks move into the syringe and the solution diffuses into the air spaces. Shake the syringe several times while your finger is on the tip.



7. Take your finger off of the tip of the syringe. This causes the leaf disks to sink to the bottom of the syringe because they become more dense from the diffusion of solution into the air spaces.

8. Open the syringe by pulling the plunger almost all the way out. Place your finger over the tip of the syringe and turn it so the tip is pointing down. Carefully remove the plunger and pour the contents of the syringe into the beaker of water. Use the forceps to remove the leaf disks if they stick to the walls of the syringe.

9. Before completing Step 10, make a data table in your Evidence Notebook. You will record the time it takes for each leaf disk to float to the top of the water. Be sure to include space to record data for each light source and trial you plan to complete.

10. Place the beaker with the leaf disks under the light source(s) and immediately start the stopwatch. As the leaf disks begin to photosynthesize, the production of oxygen replaces the solution in the air spaces and the disks become less dense and float to the top of the water. Continue collecting data until all five disks float in each experimental condition. (Note: If you test more than one condition at once, record a time and disk count for all of the beakers every time a disk floats in any of the beakers.)

11. Repeat Step 10 as necessary.

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ANALYZE

1. The leaf disks that floated to the top of the beaker the fastest had the highest rates of photosynthesis. Explain why this is true and how it is related to the products of photosynthesis.

2. Sodium bicarbonate is a source of carbon dioxide gas. Why was sodium bicarbonate applied to the leaves in this lab?

3. Show your calculations for the rate of photosynthesis for each light source. To calculate the rate of photosynthesis, use the formula below. Determine the average rate of photosynthesis in each condition of your experiment.

$$\frac{5\,(\#\text{ disks floating})}{\text{total time (sec)}} = \underline{\hspace{3cm}} \text{ disks / sec}$$

4. Determine the best type of graph to use to represent your data. Construct the graph in your Evidence Notebook. Be sure to carefully label the axes of the graph.

5. Which light source resulted in the highest rate of photosynthesis? Are there any other patterns you can identify in the data?

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EXPLAIN

Write a conclusion that addresses each of the points below.

Claim Which light source is best for optimizing oxygen production in this plant? Was your prediction correct?

Evidence Give specific examples from your data to support your claim.

Reasoning Explain how the evidence you gave supports your claim. Describe, in detail, the connections between the evidence you cited and the argument you are making.

EXTEND

Write a proposal to the building manager for an office building describing ways to optimize oxygen production in their indoor plants. Include a list of prioritized tradeoffs that should be considered. For example, installing lights that give off a very bright color may not be appropriate for an entire office building.