

Investigation 5.C: The Rate of Photosynthesis

Question: What variables affect the rate of photosynthesis?

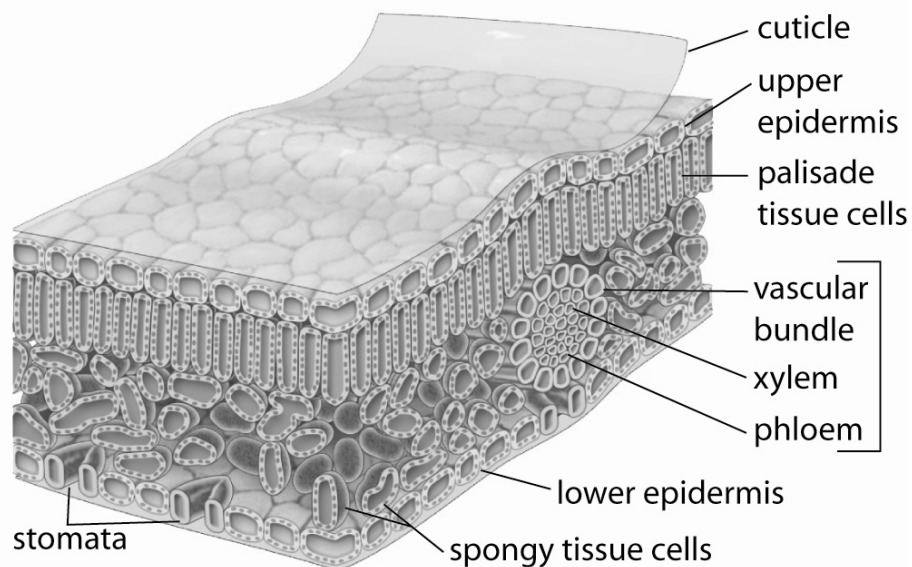
Part 1: Floating Leaf Disk Assay

Materials



- plant leaf
- single-hole punch
- 10 mL plastic syringe (without the needle) and 150 W bulb
- liquid dish soap
- 0.25% sodium bicarbonate
- medicine dropper
- 200 mL beaker
- lamp with a reflector
- timer

A cross-section of a leaf, showing specialized cells



- Palisade tissue cells:** long, narrow cells packed with chloroplasts. These cells lie under the upper surface of the leaf and are the sites where most photosynthesis occurs in the leaf.
- Vascular tissue cells:** cells that form bundled arrangements of tubes that transport fluids throughout the plant. Xylem tubes carry water and minerals from the roots to the leaves. Phloem tubes carry sugars to various parts of the plant.
- Spongy tissue cells:** round and more loosely packed than palisade cells, with many air spaces between them. These cells have chloroplasts, so they perform some photosynthesis. Their structure helps the cells to exchange gases and water with the environment.
- Stomata:** small openings in the outer (epidermal) layer that allow carbon dioxide into the leaf and oxygen out of the leaf. Water also diffuses out of the leaf through stomata.

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Procedure

1. Obtain 100 mL of the 0.25% sodium bicarbonate solution and place it in the beaker.
2. Use the medicine dropper to add 5 drops of liquid dish soap to the bicarbonate solution.
3. Use the single-hole punch to cut 10 uniform leaf disks. Avoid cutting through major leaf veins. Remove the plunger and place the leaf disks in the barrel of a plastic syringe. Tap the syringe gently until the leaf disks are near the bottom of the barrel.
4. Replace the plunger in the syringe. Push the plunger down until only a small volume of air remains in the barrel. Be careful, however, not to crush any of the leaf disks.
5. You are going to infiltrate the leaf disks with sodium bicarbonate solution by removing most of the air from the leaf tissue and replacing it with the sodium bicarbonate solution. To do this:
 - Use the plunger to draw 5 mL of solution into the barrel of the syringe.
 - Tap on the syringe to suspend the leaf disks in the solution.
 - Hold a finger over the open end of the syringe and draw back on the plunger. This creates a vacuum inside the syringe.
 - Hold this vacuum for 10 to 15 seconds and then remove your finger from the open end of the syringe. The sodium bicarbonate solution will gradually infiltrate the air spaces inside the leaf disks.
 - Hold the open end of the syringe over the beaker of solution and slowly push the plunger back down, again taking care not to crush the leaf disks.
 - Repeat the infiltration procedure at least 5 times; otherwise your leaf disks may not sink to the bottom of the solution in the beaker.
6. Pour the disks and solution from the syringe back into the beaker of sodium bicarbonate and dish soap.
7. If your leaf disks are still floating, carefully add more dish soap—1 drop at a time. You may have to remove the leaf disks and repeat the infiltration procedure if you can't get the disks to sink to the bottom of the beaker.
8. Once all of the leaf disks are resting on the bottom, direct white light onto the plant and start the timer.
9. At the end of each minute, record the number of disks that have floated to the surface of the solution. Swirl the beaker gently if some disks get stuck to the side, but keep the beaker in the light.
10. Record your results in the data table on the following page.

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Time elapsed (min)	Number of leaf disks at surface of solution

Analysis

1. Use a computer and spreadsheet software to construct a graph of your data.
2. Using the graph, estimate the time at which 50 percent of the leaf disks were floating on the surface. The point at which 50 percent of the leaf disks are floating will be your point of reference for future investigations.
3. Normally the extracellular spaces within the mesophyll layer of a plant leaf are filled with air for purposes of gas exchange. As a result, leaf disks float on the water. Explain how you removed most of the air from these extracellular spaces. What was the result of the removal of most of the air from the air spaces in the leaf disks?

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Conclusions

4. What variable were you testing in this experiment?
5. Based on your current understanding of photosynthesis, explain why the leaf disks started to float after being exposed to white light.

Part 2: Design your Own Investigation

There are a number of variables that affect the rate of photosynthesis in a plant leaf. The variables include the amount of carbon dioxide in the water, different wavelengths of light, and the intensity of light, to name only a few. Your challenge is to design an investigation to test the effects of one of these variables on the rate of photosynthesis. Be sure to:

- state your own question
- make a hypothesis based on this question
- identify the materials that you will require
- write out the experimental procedure you will use
- conduct your investigation
- collect and graph your data
- determine if your results support or disprove your hypothesis
- communicate the results of your investigation in the form of a formal lab report.

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