Name _____ Class _____ Date _____

Photo Finish

Comparing Rates of Photosynthesis

Question Which will photosynthesize at a faster rate, a young ivy leaf or an older ivy leaf?

Lab Overview In this investigation, you will compare rates of photosynthesis in old and young ivy leaves by measuring the length of time it takes pieces of each leaf type to generate enough oxygen gas to float upward in a solution-filled syringe.

Introduction You may recall that chloroplasts are located in the cells of the mesophyll, the green tissue in the center of a leaf. The cells of the mesophyll have air spaces around them used for gas exchange. You will use these characteristics of leaf structure and function to measure and compare the rates of photosynthesis in different leaves.

Rates describe how measurable quantities change over time. As oxygen gas is a product of photosynthesis, the rate of photosynthesis in a leaf can be determined by measuring the amount of oxygen the leaf produces in a certain period of time. In this investigation, you will measure oxygen production indirectly. You will suspend leaf disks in a solution and apply a vacuum. The air spaces inside each leaf disk will become filled with liquid and the leaf disks will sink downward. You will then measure how quickly the leaf disks float upward. When the light reactions produce oxygen, liquid is forced out of the air spaces and the leaf disks become more buoyant. In general, the more quickly the leaf disks become buoyant enough to float, the faster they are photosynthesizing.

Prelab Activity Compare the leaf "racers" shown and read the information below. Then, answer the Prelab Questions.

Final Heat: 10 cc dash

1.	**Racer 1** Young, actively growing, light green ivy leaf	
2.	**Racer 2** Older, fully grown, dark green ivy leaf	

A Photosynthesis Race

The race will take place in two solution-filled syringes. You will suspend 10 leaf disks in each syringe, pull back on the plungers to apply a vacuum, and let the air inside the leaf disks flow out. As the air is replaced by liquid, the leaf disks will sink downwards to the "starting line," which is the bottom of the syringe. When you place both syringes near the light source to start photosynthesis, the race begins. As the leaf disks produce oxygen gas and become more buoyant, they will (unknowingly) race to their own "finish line," which is the top of the syringe.

Winning the Photosynthesis Race

When 5 of its 10 leaf disks have reached the top of the syringe, your leaf "racer" has crossed the "finish line," and you will record the time.

Prelab Questions

1. If you could design a leaf that would photosynthesize "super fast," what characteristics would it have? (*Hint:* Think about the structure of a leaf and the structure of a plant cell.) Explain your reasoning.

_____

_____

_____

_____

2. Which ivy leaf do you predict will photosynthesize the fastest and win the race? Explain the reasoning behind your prediction. (This is your hypothesis.)

_____

_____

_____

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_____

3. A rate measures how a quantity changes over time. Give an example of something you could measure the rate of. What would the units of your measurement be (for example, meters/sec)?

_____

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_____

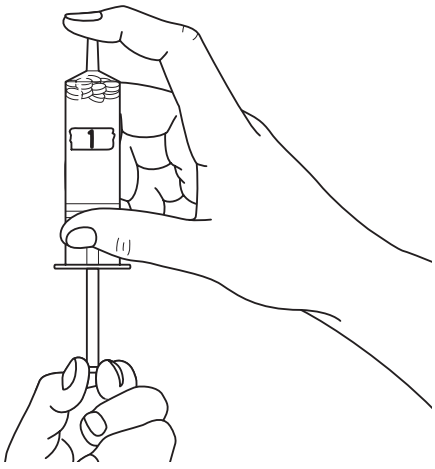
Name _____ Class _____ Date_____

Materials

- two ivy leaves from the same plant: a dark green older leaf and a light green young leaf
- two syringes
- marker
- bicarbonate/detergent solution in a plastic cup
- single hole punch
- strong light source
- clock or watch

Procedure

1. Obtain two ivy leaves: one younger, light green leaf (Racer 1) and one older, dark green leaf (Racer 2).
2. Using a single hole punch, punch out 10 leaf disks from the light green leaf (Racer 1).
3. Place the leaf disks you cut in a syringe barrel and immediately label the syringe.
4. Repeat steps 1–3 for the dark green leaf (Racer 2).
5. After both syringes are loaded and labeled, put in the plungers, pushing down until the plunger is touching the leaf disks. Take care not to squish them.
6. Draw up about 5 cubic centimeters (cc) of the bicarbonate/ detergent solution into each syringe.
7. Invert each syringe (turn it upside down) and tap it to release air bubbles.
8. Push in the plungers to move all the air out of the tips of the syringes.
9. Place your finger over the tip of one syringe while pulling the plunger back to 10 cc as shown below. Be careful not to pull back too far or you will pull the plunger out. This creates a vacuum, allowing air to flow out of air spaces in the leaf disks.



10. Hold the vacuum by keeping your finger on the tip and shake the syringe several times to release the bubbles.

11. With the tip of the syringe pointing up, let go with your finger and see if the leaf disks sink. If they do, stand the syringe up in front of the light source (which is turned off). If some of the leaf disks are still floating, repeat steps 8–11 until they sink. This may take several tries. If there are one or two stubborn disks, just leave them floating.

12. After both racers are in their "starting blocks" near the light source, turn on the light and start timing. The race begins! Whenever you see a disk rise to the top, fill in the time and total number of disks that have moved up in Data Table 1.

Race start time: _____

Data Table 1

Time in Minutes and Seconds	**Racer 1** (light green leaf)	**Racer 2** (dark green leaf)
Start time: 0 minutes	0 disks up	0 disks up

13. Every 2 or 3 minutes, you can rotate both syringes one turn to loosen any leaf disks that may be stuck to the sides of the syringe. When 5 of the 10 disks have floated to the top, a leaf has finished the race. Keep timing and recording data until both racers have finished.

Race Results:

The "Winner": _____ The "Loser": _____

Analysis and Conclusions

Before the race began, you predicted the relative rates of photosynthesis of the two different ivy leaves. You based your prediction on your understanding of photosynthesis. Perhaps the experimental results did not come out as you expected. Regardless of the results, you will need to consider doing further experiments. That is the way science works. Every scientist must keep experimenting and adjusting his or her hypotheses based on the data.

Name _____ Class _____ Date _____

1. Did you predict the winner?

_____

_____

_____

2. Calculate the winner's rate of photosynthesis by completing the calculation below:

5 disks up / _____ minutes = _____ disks/min

3. Discuss your results with other lab groups. Are their results consistent with yours? Pool your data and fill in Data Table 2.

Data Table 2: Class Results

Lab Group	Fastest	Slowest

4. How is it helpful to gather the results from several different lab groups? How is this similar to how scientific research is done?

_____

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5. If your results were different from the other groups, suggest a possible reason why your data might be different.

_____

_____

_____

_____

6. If the results were not as you predicted, suggest at least one possible reason to explain the different rates of photosynthesis you observed. Use your understanding of plants and photosynthesis in your answer.

7. **Revised Hypothesis:** Based on your data, revise your hypothesis.

8. Describe how you would set up the experiment to test your revised hypothesis.

9. What other factors (besides rate of photosynthesis) may be involved in the ability of the leaf disks to float to the top?

Extension

Write out the procedure for the experiment you designed in Question 8 to test your revised hypothesis. Have your instructor check it over. Then, with your instructor's permission, carry out the experiment. Afterwards, share your data and conclusions with the class.