**AP Biology - Investigation: Photosynthesis Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Background and Pre-Lab**

Photosynthesis fuels ecosystems and replenishes the Earth's atmosphere with oxygen. Like all enzyme-driven reactions, the rate of photosynthesis can be measured by either the disappearance of substrate, or the accumulation of products. The equation for photosynthesis is:

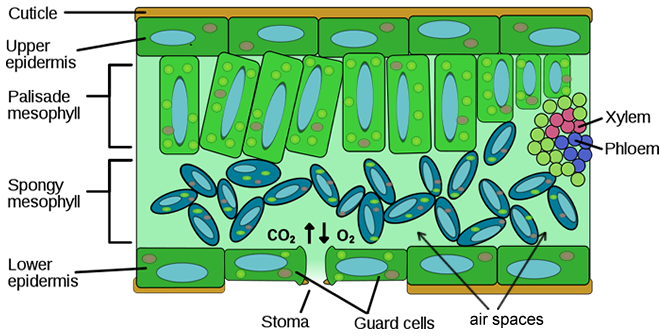
6CO2 + 6H2O ------light--------> C6H12O6 + 6O2 + H20

What could you measure to determine the rate of photosynthesis?

1) The production of oxygen, which is released as photosynthesis occurs  
2) The consumption of carbon dioxide

**Leaf Structure and Function**

In this investigation, you will use a system that measures the accumulation of oxygen in the leaf. Consider the anatomy of the leaf as shown below.



The leaf is composed of layers of cells. The spongy mesophyll layer is normally infused with gases, oxygen and carbon dioxide. Leaves (or disks cut from leaves) will normally float in water because of these gases. If you draw the gases out from the spaces, then the leaves will sink because they become more dense than water. If this leaf disk is placed in a solution with an alternate source of carbon dioxide in the form of bicarbonate ions, then photosynthesis can occur in a sunken leaf disk. As photosynthesis proceeds, oxygen accumulates in the air spaces of the spongy mesophyll and the leaf becomes buoyant and floats. Oxygen and carbon dioxide are exchanged through openings in the leaf called stoma.

While this is going on, the leaf is also carrying out cellular respiration. This respiration will consume the oxygen that has accumulated and possibly cause the plant disks to sink. The measurement tool that can be used to observe these counteracting processes is the floating (or sinking) of the plant disks. **In other words, the buoyancy of the leaf disks is actually an indirect measurement of the net rate of photosynthesis occurring in the leaf tissue**.

**Pre-Lab Questions** - these should be completed BEFORE the scheduled lab. You will find most of the answers in the pre-lab and diagram on the previous page.

1. How can the rate of photosynthesis be measured?

2. Where in the cells of the leaf do you find air spaces?

What is the function of the stoma?

3. What will happen if you remove the air from these spaces?

4. How will air return to these spaces?

5. Instead of carbon dioxide, what will be used as the carbon reactant in this lab?

6. List any factors that you think may affect the rate of photosynthesis. Consider environmental factors that you could manipulate during the lab.

7. Watch the video that shows the set-up for the floating leaf disk lab at Bozeman Science. Answer the following questions. <http://www.bozemanscience.com/photosynthesis-lab-walkthrough>

a) What is the ratio of water to baking soda you will need for your solution?

b) What is the purpose of the syringe?

c) Why did Mr. Anderson put a watch glass with water on top of the beaker?

d) How will you know when photosynthesis is occurring in your leaf disks?

**Part 1: Basic Procedure for Measuring the Rate of Photosynthesis**

Materials: baking soda, liquid soap, plastic syringes, leaves (spinach or ivy), hole punch, cups or beakers, timer, light source

Record all Data and Graphs in your Research Notebook!

1. Collect leaf disks by punching holes in the leaf (try to get them between the veins), you will need 20 leaf disks.

2. Make a solution of sodium bicarbonate by mixing 300 ml of water to 3 grams of baking soda.

3. Make a diluted solution of liquid detergent in a small beaker by adding 3 drops of dish soap to 70 ml of water. Do not make suds!

4. Add one drop of this dilute soap solution to your 300 ml bicarbonate solution. Swirl gently to avoid making suds.

5. Place 10 leaf disks into the syringe and pull in a small volume of the bicarbonate and soap solution. Replace the plunger and push out most of the air, but do not crush your leaves.

6. Create a vacuum by covering the tip of the syringe with your finger. Draw back on the plunger.

7. Swirl the syringe so that the leaf disks stay in the water and do not stick to the sides.

8. Release the vacuum so that the solution will enter the disks. It may take a few times to get the disks to sink. You may need to gently tap the syringe to dislodge discs from the sides.

9. You may need to hold your finger on the syringe opening and push up on the plunger to force the air out of the leaf disks and force water into the disks.

10. Once the disks sink, you can put them back into the sodium bicarbonate solution and expose the disks to light. (Use a heat sink!) Start a timer and record how many of the disks are floating at 1 minute intervals. (See data table.)

11. Repeat your set-up from above, but this time, do not place baking soda in the beaker or in the syringe. Use only soapy and water. This is your control. Place another set of sunken disks into this solution and record how many disks are floating at 1 minute intervals. Record your data on the Data Table.

12. Both the experimental group and the control should run until all the discs are floating or for 15 minutes.

13. ***Record your data*** on a Data Table in your Research Notebook or cut and paste the following table into the book.

14. ***Graph the Control Data and the Experimental Data*** on **one graph** in your Research Notebook.

**Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |  |  |
| --- | --- | --- |
| Time (min) | # of floating disks  (bicarbonate, water, + soap) | # of floating disks (control) ( only water + soap) |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |
| 11 |  |  |
| 12 |  |  |
| 13 |  |  |
| 14 |  |  |
| 15 |  |  |

**Analyzing Data**

To make comparisons between experiments, a standard point of reference is needed. Repeated testing of this procedure has shown that the point at which 50% of the disks are floating (the median or ET50) is a reliable and repeatable point of reference. In this case, the disks floating are counted at the end of each time interval. The median is chosen over the mean as the summary statistic. The median will generally provide a better estimate of the central tendency of the data because, on occasion, a disk fails to rise or takes a very long time to do so. A term coined by G. L Steucek and R. J Hill (1985) for this relationship is ET50, the estimated time for 50% of the disks to rise. That is, rate is a change in a variable over time. The time required for 50% of the leaf disks to float is represented as Effective Time = ET50.

Determine the ET50 for your experimental group and determine the ET50 for your control group.

Experimental Group \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Control Group \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Record the ET50’s in your Research Notebook.***

**Part 2: Design and Conduct Your Own Investigation**

Now that you have mastered the floating disk technique, you will design an experiment to test another variable that may affect the rate of photosynthesis. You will collect data, analyze data and present your findings in the form of a LAB REPORT. As you conduct your investigation, you may want to take photos to include in your report. Choose from the list of variables below. (If you have another variable that you would like to try, check with your instructor first.)

light intensity or distance from the light color of light

amount of sodium bicarbonate available water temperature