Names _____ Period _____

Lab Investigation: Photosynthesis

BACKGROUND AND PRELAB

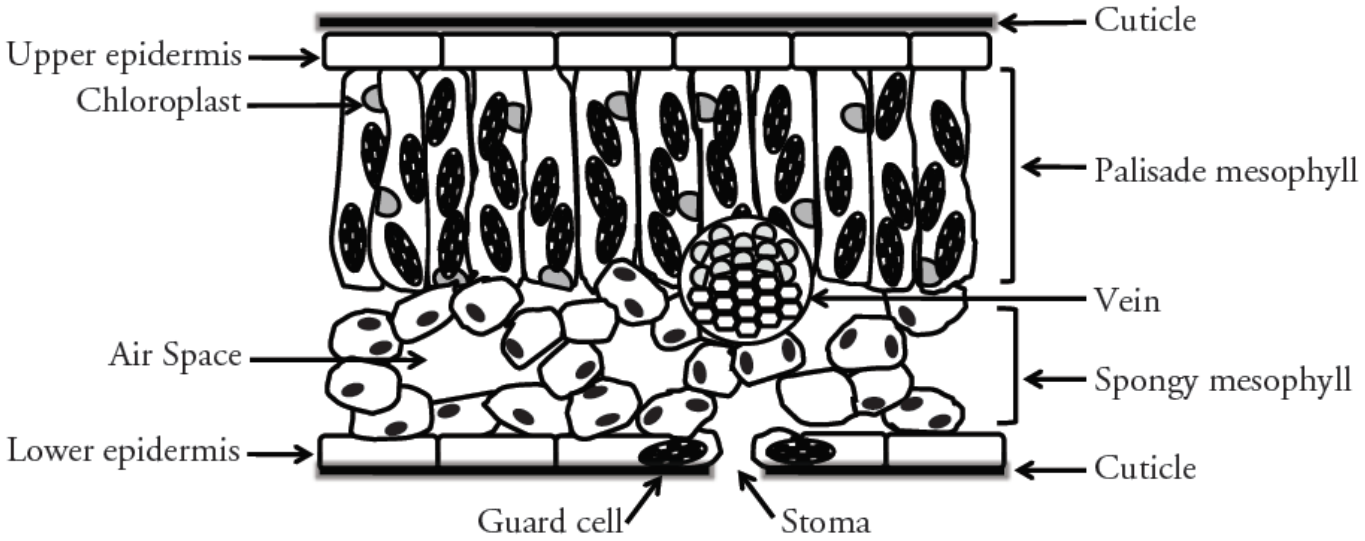
Photosynthesis fuels ecosystems and replenishes the Earth's atmosphere with oxygen. Like all enzyme-driven reactions, the rate of photosynthesis can be measured by either the disappearance of substrate, or the accumulation of products. The equation for photosynthesis is:

$6CO_2 + 6H_2O$ -------- light -------> $C_6H_{12}O_6 + 6O_2 + H_2O$

What could you measure to determine the rate of photosynthesis?

1. The production of oxygen, which is released as photosynthesis occurs (how many oxygens are produced for each glucose?).
2. The consumption of carbon dioxide (how many carbon dioxides are consumed for each glucose?).

LEAF STRUCTURE AND FUNCTION



In this investigation, you will use a system that measures the accumulation of oxygen in the leaf.

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 denser than the 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 (or stomata).

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.

OBJECTIVES OF THE LAB

1. To conduct an experiment to explore factors that affect photosynthesis
2. To connect and apply concepts, including the relationship between cell structure and function, strategies for capture and storage of energy and the diffusion of gases across membranes.

PRELAB QUESTIONS – these should be completed before you begin the lab

1. How can the rate of photosynthesis be measured?

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

    a. 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 reactant in this lab?

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

7. Based on the Bozeman video you just watched:
    a. What is the purpose of the syringe?

    b. How will you know when photosynthesis is occurring in your leaf disks?

LAB

MATERIALS:

- Baking soda
- liquid soap
- 2 plastic syringes
- spinach leaves
- 1 hole punch
- 3 plastic cups
- 1 timer
- 1 light source

PART 1

QUESTION: If leaf disks are treated in a way you know increases the net rate of photosynthesis, should they start to float faster or slower? Why?

PROCEDURE FOR MEASURING THE RATE OF PHOTOSYNTHESIS IN SPINACH LEAF DISKS

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 in a plastic cup by mixing 100 ml of water with 1g of baking soda.
3. Make a dilute solution of liquid detergent in a plastic cup by adding 2 drops of dish soap to 50 ml of water. Stir gently to mix in the detergent. **Do not make suds!!!!**
4. Add 1 drop of this dilute soap solution to your 100 ml bicarbonate solution. Stir gently to avoid making suds.
5. Place 10 leaf disks into the syringe and pour 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. 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 disks from the sides.
7. Once all of the disks sink in the solution in the syringe, put them back into the sodium bicarbonate solution in the plastic cup and expose the disks to the light source. Start a timer and begin recording how many of the disks are floating at 1 minute intervals. Record this in the data table below – this is your experimental group. You may need to gently swirl the solution to dislodge disks that become stuck to each other.
8. Run for 15 minutes or until all the disks are floating.
9. Repeat your set-up from above, but this time do not add baking soda to the water in the plastic cup. Add 1 drop of your dilute soap solution to the water in the plastic cup and stir gently (to avoid making suds).

10. Place the remaining 10 disks into the syringe and pour in a small volume of the water and soap solution. Replace the plunger and push out the air (without crushing your leaves) as described above.
11. Once all of the leaf disks sink in the solution in the syringe, put them into the water and soap solution in the plastic cup and expose the disks to the light source as above, recording how many of the disks are floating at 1 minute intervals. Record this in the data table below – this is your control group.
12. Run for 15 minutes or until all the disks are floating.

DATA ANALYSIS

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 leaf disks are floating (the median or ET_{50} – the Estimated Time it takes 50% of the disks to float) is a reliable and repeatable point of reference for this procedure.

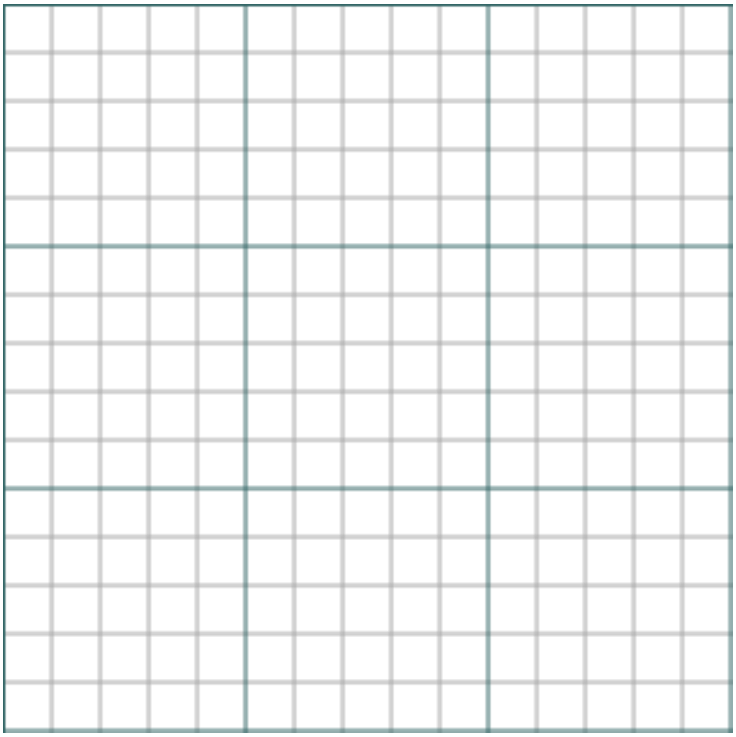
Graph your data for the experimental group and for the control group. Determine the ET_{50} for your data (the time at which 50% of your leaf disks were floating). Note the control group may not yield an ET_{50}. Be sure to **Label** your axes and **Title** your graph.

ET_{50} Analysis	
	ET_{50} (minutes)
Control	
Experimental	

DATA TABLE #1

Time (minutes)	**# floating disks (experimental) (bicarbonate, water + soap)**	**# floating disks (control) (water + soap)**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

GRAPH



PART 2

DESIGN AND CONDUCT AN EXPERIMENT TO TEST ONE FACTOR THAT CAN AFFECT THE RATE OF PHOTOSYNTHESIS.

What factors affect the rate of photosynthesis in living plants? In this part of the lab you will design an experiment to test another variable that might affect the rate of photosynthesis. Some ideas include the following (but don't limit yourself to just these):

- Environmental variables that might affect the net rate of photosynthesis (light source, temperature, available CO2, etc.)
- Features or variables of the plant leaves that might affect the rate of photosynthesis (color, texture, etc.)

QUESTION: _____

VARIABLE TESTED: _____

HYPOTHESIS: _____

DESCRIBE YOUR EXPERIMENTAL PROCEDURE TO TEST THE VARIABLE:

Follow the procedures described above to prepare your leaf disks (i.e. get them to sink using a vacuum) and record your data in Data Table #2. Graph your data and analyze for ET_{50} as described above.

ET_{50} Analysis	
	ET_{50} (minutes)
Control	
Experimental	

DATA TABLE #2

Time (minutes)	# floating disks (experimental)	# floating disks (control)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

GRAPH