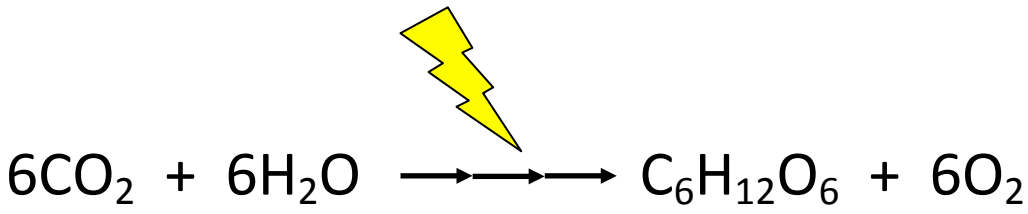
Photosynthesis

Photosynthesis is the process whereby certain organisms transform the energy of sunlight into chemical energy in the form of sugars. The process uses carbon dioxide and water as starting materials and produces oxygen gas as a by-product. The overall chemical equation can be summarized as follows:



In this lab, you will be measuring the rate of photosynthesis indirectly. The photosynthetic organism you will be using is a plant: samples of fresh spinach. The samples, called leaf chads, are dots of leaves that you punch out of baby spinach leaves. You place these leaves in a 1% baking soda solution, which can hold a lot of dissolved carbon dioxide.

One way to measure the rate of photosynthesis is to measure the amount of oxygen produced. At the start of the experiment, the leaf chads will be at the bottom of the beaker of baking soda solution. But as the leaves produce oxygen gas as a by-product of photosynthesis, the chads will float. The number of chads that reach the surface of the water per minute represents the relative rate of photosynthesis.

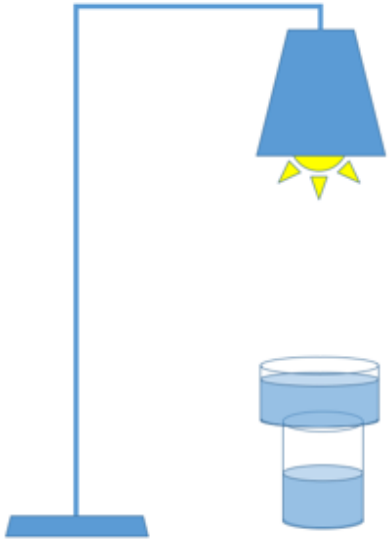
Procedure 1: Experimental setup and baseline rate of photosynthesis
You will be shown the following video before you proceed:
http://www.bozemanscience.com/photosynthesis-lab-walkthrough

Materials
Fresh baby spinach leaves
Hole punch
1% baking soda solution (see note at the end of the procedure)
Light
Syringe
Beaker
Small box to cover the beaker
Glass dish wider than diameter of the beaker
Timer (use the timer function on someone's cell phone)

Method

Punch holes in unblemished, firm spinach leaves, avoiding the major veins. Punch out 50 to 60 leaf chads. When you place these in the beaker with baking soda, they will float. Follow the procedure outlined in the Bozeman Science video to get your chads to sink. You will have to prep your chads in batches of 10-12. As you complete each batch, transfer the chads to your beaker of baking soda solution and cover it with the box. Keep the chads in the dark until all of them are prepped. Once you have approximately 60 chads prepped, use the graduated cylinder to measure the amount of baking soda solution they are sitting in. Add enough baking soda solution to adjust the total volume of chads + baking soda to 100 ml. Return the mixture of baking soda solution and chads to the beaker.

Set up the light source, water-filled glass dish that serves as a heat sink and beaker of chads as shown in the figure:



Before you turn on the light, remove any chads that are floating and adjust the light so that it is 30 cm from the bench top. Turn on the light and keep an eye on the chads. It may take a few minutes for the chads to begin to rise. Start the timer when the first chad just begins to rise from the bottom of the beaker. Count and record all chads that reach the surface in a 5-minute period. You can make a video recording of the floating chads with your cell phone if you wish.

Number of chads that floated in a 5 min period:_____
Rate of photosynthesis: _____chads/min

Questions:

1. Why use leaf chads rather than whole leaves?

2. Why do you have to keep your prepped chads in the dark until the start of the experiment?

3. You may see tiny bubbles clinging to the chads as they surface; what do the bubbles contain?

4. Is photosynthesis the only major energy-transfer pathway taking place in the leaf chads?

5. What else is going on inside the leaves?

6. Is this having an effect on your measured rate of photosynthesis?

Note: How to make up a 1% baking soda ($NaHCO_3$) solution

A 1 % solution is 1 gram of solute in 100 ml of solvent.

Weigh out 1 gram of baking soda
1. Turn on the balance.
2. Place the weigh boat (lightweight plastic dish) on the balance.
3. Press "zero" to tare, i.e., subtract the weight of the boat.
4. Use a metal spatula to carefully scoop out 1 gram of baking soda (it isn't much: roughly a pea-sized blob).
5. If you got too much baking soda, DO NOT put it back in the original container! This is bad laboratory practice, like double dipping in the guacamole at a party. You may be able to give the excess to someone else or you can throw it away.
6. You can bend the sides of the boat to pour it into a 100 ml beaker.

Measure 100 ml of water
1. Use distilled water.
2. Use a graduated cylinder to measure, NOT the beaker
3. You may use the metal spatula to gently stir, but you must then wash and dry it if you use it again to scoop from the original container.

Procedure 2: Rates of photosynthesis under different conditions
Design an experiment to test how changing one variable affects the rate of photosynthesis. Variables you could test are the temperature of the baking soda solution, the color of the light or another variable you and your group think of. Materials at your disposal include all those in procedure 1 plus ice, a hot plate, thermometers, food coloring, tin foil, baking soda, rulers and assorted glassware as needed. If you need materials not listed, please ask.

Discuss which variable you will test with your group and summarize your experiment here:

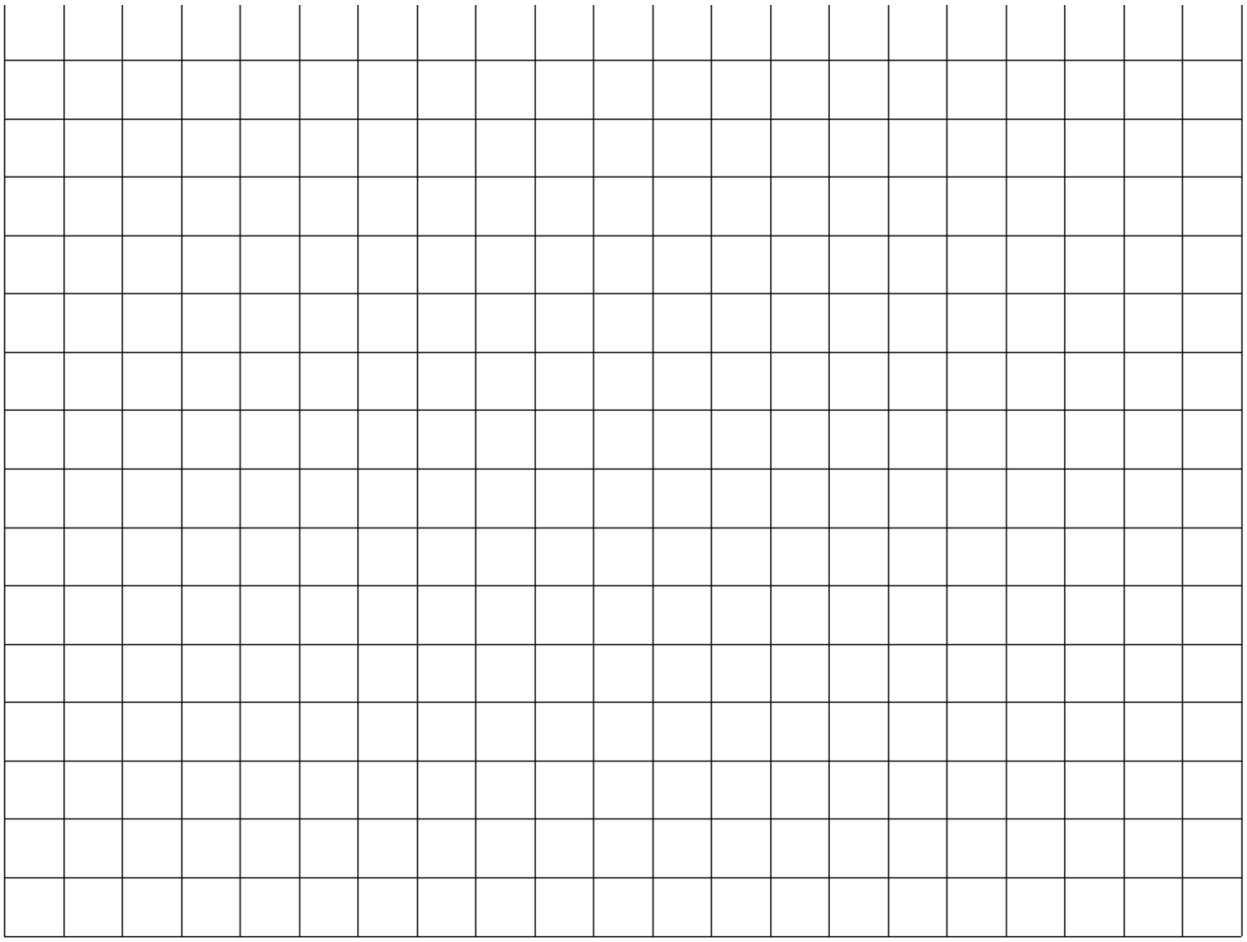
Next, discuss your experimental design with your lab instructor. You will be graphing your results. Plan on running the procedure several times so that you are testing different values of the same variable.

Write down your hypothesis here:

****HAVE YOU CLEARED YOUR EXPERIMENTAL DESIGN WITH YOUR INSTRUCTOR?**** Do not proceed until you have.

Perform your experiment and record your results below. You may want to record your results in a table of your design. Remember that the dependent variable (what you are measuring) is the number of chads that reach the surface of the baking soda solution per minute (chads/min).

Graph your results below. Remember that the dependent variable goes on the Y-axis. Label both axes, assign values, and give your graph a title.



Conclusion

Do the results support your hypothesis? Did other groups in your class test the same variable? If so, did they use the same methods as your group? How do their results compare to yours?