Name____Period_____Assignment #_____

Lab 5 Photosynthesis: What affects the rate of photosynthesis?

See lecture questions 3b, 4, 5, 6, 7, 8, 10-12, 13, 24-29

Pre-lab: Annotate and answer questions 1-11

_____Teacher initials practice data collection_____Teacher initials procedures

_____Teacher initials experimental data collection

Annotating Text
☐ **UNDERLINE** concepts you think might be useful for understanding or solving the problem
☐ **Box** information you think might be helpful for designing your investigation
☐ ← Write **notes** in the left margin
☐ → Write **questions and answers** in the right margin
Each paragraph (including each step of the procedures) must have something underlined or boxed, **AND** have something written in the margins (a question and/or note).

Introduction:

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 product (or by-products).

The general summary equation for photosynthesis is:

$$12H_2O + 6CO_2 + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

1) What could you measure to determine the rate of photosynthesis?

2) How many moles of O_2 are produced for one mole of sugar synthesized?

3) How many moles of CO_2 are consumed for every mole of sugar synthesized?

The amount of CO_2 dissolved in water at a given temperature and pressure combination is in equilibrium with ionic hydrogen, carbonic acid, bicarbonate, and carbonate

$$\underset{\text{carbon dioxide}}{CO_2} + \overset{\text{water}}{H_2O} \rightleftharpoons \underset{\text{carbonic acid}}{H_2CO_3} \rightleftharpoons \overset{\text{hydrogen ion}}{H^+} + \underset{\text{bicarbonate ion}}{HCO_3^-} \rightleftharpoons \overset{\text{hydrogen ion}}{H^+} + \underset{\text{carbonate ion}}{CO_3^{2-}}$$

4) Predict what would happen to the pH if the rate of photosynthesis increased and the rate of cellular respiration was kept constant.

5) Explain your prediction with reasoning

6) Predict what would happen to the pH if the rate of photosynthesis and the rate of cellular respiration decreased by the same magnitude

7) Explain your prediction with reasoning

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

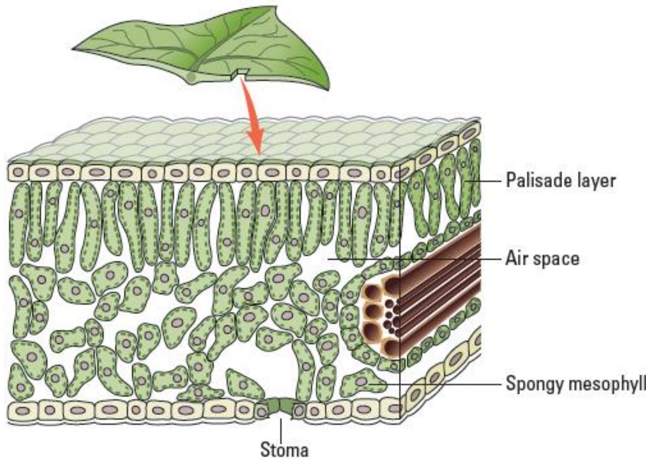


Figure 1. Leaf Anatomy

Because the spongy mesophyll layer of leaves (shown in Figure 1 above) is normally infused with gases (O_2 and CO_2), leaves, or disks cut from leaves, float in water.

8) What would you predict about the density of the leaf disk if the gases are drawn from the spongy mesophyll layer by using a vacuum and replaced with water?

9) How will that affect whether or not the leaf floats? Explain your answer with reasoning

When immersed in water, oxygen bubbles are usually trapped in the air spaces of the spongy mesophyll in the plant leaf. By creating a vacuum, the air bubbles can be drawn out of the spongy mesophyll, and the space is refilled by the surrounding solution. This allows the leaf disks to sink in the solution. If the 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. The leaf disk will begin to produce sugars and oxygen. Oxygen collects in the leaf as photosynthesis progresses, causing the leaf disks to float again.

The length of time it takes for leaf disks to float again is a measure of the rate of photosynthesis. However, there’s more going on in the leaf than that! You must remember that cellular respiration is taking place at the same time as photosynthesis in plant leaves (remember that plant cells have mitochondria too).

Aerobic respiration will consume oxygen that has accumulated in spongy mesophyll. Consequently, the two processes counter each other with respect to the accumulation of oxygen in the air spaces of the spongy mesophyll. The buoyancy of the leaf disks is actually an indirect measurement of net primary productivity occurring in leaf tissue.

This investigation also provides an opportunity for you to apply and review concepts that you have studied previously, including the relationship between cell structure and function, enzymatic activity, strategies for capture, store, and use of free energy, diffusion of gases across cell membranes, the properties of cell membranes, and the physical laws pertaining to the properties and behaviors of gases.

10) Watch the video below and summarize how to make leaf disks sink.
    http://www.youtube.com/watch?v=ZnY9_wMZZWI

11) The bicarbonate (HCO_3^-) will serve as a source of carbon dioxide for the leaf disks while they are in the solution. Describe the procedure for how you are going to make 300mL of 0.2% HCO_3^- solution

To measure NET photosynthesis rate, we will use the median time for 50% of the disks to float (ET_{50}).

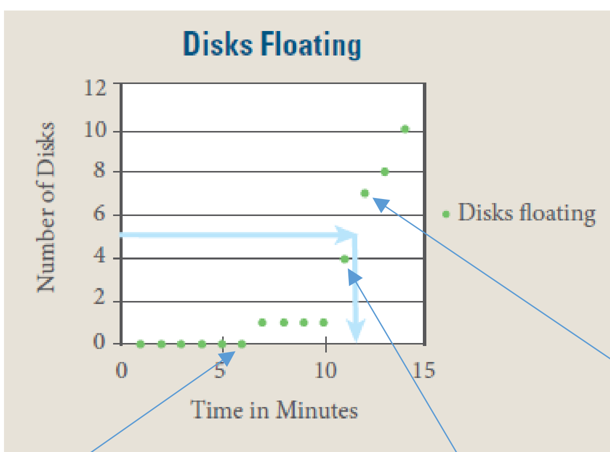


Figure 1. Disks Floating

0 disks floating at 6 minutes

4 disks floating at 11 minutes

6 disks floating at 13 minutes

The estimated time for 50% of disks to float (ET_{50}) for the trail above is 12minutes. When you compare the estimated time for 50% of disks to float (ET_{50}) across treatments, you will discover that there is an inverse relationship between ET_{50} and the rate of photosynthesis. ET_{50} goes down as rate of photosynthesis goes up, which plots a graph with a negative slope. This creates a counterintuitive graph when plotting your

ET_{50} data across treatments, as shown below. To correct this representation and make a graph that shows increasing rates of photosynthesis with a positive slope, the ET_{50} term can be modified by taking its inverse ($1/ET_{50}$). This illustrates a direct relationship between ET_{50} and net photosynthetic rate.

12) Define central tendency

13) Explain why median is a better estimate of central tendency than mean for this procedure.

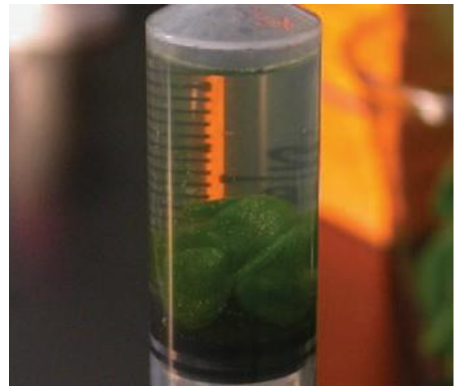
Materials:

1) 0.2% Baking soda (sodium bicarbonate) solution
2) Liquid soap (approximately 5mL of dishwashing soap in 250mL of water)
3) 2 plastic syringes without needle (10 mL or larger)
4) Living leaves
5) Hole punch
6) 2 250mL beakers
7) Timer
8) Light source

Procedure:

1) Pour 0.2% bicarbonate solution into a 250mL beaker to a depth of about 3cm. Label cup appropriately.
2) Fill a second 250mL beaker with tap water. Label control.
3) Add one drop of dilute liquid soap solution to each cup. The soap acts as a surfactant or "wetting agent". It wets the hydrophobic surface of the leaf, allowing the solution to be drawn into the leaf and enabling the leaf disks to sink in the solution.
4) Using a hole punch, cut 10 uniform leaf disks for each cup. Avoid major leaf veins.
5) Draw the gases out of the spongy mesophyll tissue and infiltrate the leaves with the sodium bicarbonate solution or the tap water
   a. Remove the piston or plunger from both syringes. Place the 10 leaf disks into each syringe barrel
   b. Replace the plunger, but be careful not to crush the leaf disks. Push in the plunger until only a small volume of air and leaf disk remain in the barrel (<10%)
   c. Pull a small volume (5cc) of bicarbonate solution or tap water from your prepared cups into the syringes
   d. Tap each syringe to suspend the leaf disks in the solution
   e. With the plunger inverted, make sure that the disks are suspended in the solution. Make sure no air remains. Move the plunger to get rid of air from the plunger before you attempt the next step
   f. Create a vacuum by holding a finger over the narrow syringe opening while drawing back the plunger. Hold this vacuum for about 10 seconds. While holding the

vacuum, swirl the leaf disks to suspend them in the solution. Release the vacuum by letting the plunger spring back. The solution will infiltrate the air spaces in the leaf disk, causing the leaf disks to sink in the syringe. You may need to repeat this procedure.



g. Placing the disks under vacuum more than 3 times can damage the leaf tissue
h. If you have difficulty getting your disks to sink, try adding a few more drops of soap to the beaker and replace the fluid in the syringe with it

6) Pour the disks and the solution from the syringe into the appropriate beaker
7) Place both cups under a light source and start the timer
8) At the end of each minute, record the number of floating disks, then swirl the disks to dislodge any that stuck against the side of the beaker or to other disks.

Your task:

Determine what affects the rate of photosynthesis.

1) What biotic factors affect photosynthesis?

2) What abiotic factors affect photosynthesis?

To determine *what type of data* you will need to collect, think about the following questions:

3) What will serve as your independent variable during your experiment?

4) What will serve as your dependent variable during each of your experiments?

5) What type of measurements or observations will you need to record during your experiment?

To determine *how you will collect your data*, think about the following question:

6) What will serve as your control condition?

7) What will you do to ensure conditions are same if it takes more than one class period to collect data?

8) What types of treatment conditions will you need to set up and how will you do it?

9) How many trials will you need to conduct?

10) How often will you collect data and how will you do it?

11) How will you make sure that your data are of high quality (how will you reduce measurement error?)

12) How will you keep track of the data you collect and how will you organize the data?

To determine *how you will analyze your data*, think about the following:

13) How will you determine if there is a difference between the treatment condition and the control condition? What statistics will you use?

14) What type of calculations will you need to make?

15) How will you present your data?

Connections to Crosscutting Concepts and the Nature of Science

As you work through your investigation, be sure to think about the following:

1) The importance of identifying the underlying cause for observations
2) How energy and matter move within or through a system
3) How structure is related to function in living things
4) The nature and role of experiments in science
5) How scientific knowledge develops over time

ADI Investigation Proposal TGB Version

Guiding Question:

Claim:

Alternative claims:

Method:	What data will you collect? How will this data help you answer the guiding question?

Data table(s) and chart(s)

Guiding Question:

Our Claim:

Our Evidence:

Analysis: break it down (Illustrate and describe your data)

Interpretation: What does the analysis mean?

Our Justification of the Evidence:

Use your scientific knowledge and analysis to support your interpretation