Lab 3: Respiration and Photosynthesis in Plants

OBJECTIVES

- In this laboratory exploration, you will
- Use a pH probe to measure the pH of water.
- Use pH measurements to make inferences on the amount of carbon dioxide dissolved in water.
- Use the inferences about the amount of carbon dioxide in the water to make conclusions about whether plants consume or produce carbon dioxide in the light.
- Use the inferences about the amount of carbon dioxide in the water to make conclusions about whether the plant is respiring or photosynthesizing more in the light.
- Reinforce concepts about respiration and photosynthesis.

PREPARATION

Before coming to class, it is very important that you read this handout. After reading the handout, fill out the "worksheet" below. Then fill out hypotheses for Tables 3 and 4 at the end of the lab.

INTRODUCTION

➢ **<u>We can measure rates of respiration</u>** in several ways, all of which come from the basic equation of respiration:

$$C_6H_{12}O_6 + 6O_2(g) \rightarrow 6\ H_2O + 6\ CO_2\ (g) + \text{energy}$$

Thus, we can measure

- Rates of the disappearance (consumption) of glucose
- Rates if the disappearance (consumption) of oxygen
- Rates of the production of water
- Rates of the production of carbon dioxide
- Rates of the production of energy

Because we are measuring respiration in living organisms, it is not easy to measure the consumption of glucose or the production of water or energy. Also, remember that the energy produced is captured as ATP (and some is lost as heat). The easiest things to measure, then, are the consumption of oxygen and the production of carbon dioxide. In this laboratory exploration, we will concentrate on the production of carbon dioxide.

To perform the necessary tests, you will need to determine the presence of carbon dioxide. We will make use of the fact that aquatic organisms that respire directly in the water produce carbon dioxide directly into the water. If carbon dioxide dissolves in

water, it forms carbonic acid, H_2CO_3, and the pH decreases. If carbon dioxide is removed from pond water, the amount of carbonic acid goes down and the pH increases. Therefore, we have an indirect measure of the amount of carbon dioxide in the water: the pH of the water. A pH probe can be used to monitor pH and thus determine whether carbon dioxide is released into the water or is removed from the water.
Since plants are composed of cells, and all cells must respire, it stands to reason that we should be able to measure respiration in a plant.

- **We can measure rates of photosynthesis** in several ways, all of which come from the basic equation of photosynthesis:

$$6\ H_2O + 6\ CO_2\ (g) + \text{sunlight energy} \rightarrow C_6H_{12}O_6 + 6O_2(g)$$

Thus, we can measure

- Rates of the appearance (production) of glucose
- Rates of the appearance (production) of oxygen
- Rates of the disappearance (consumption) of water
- Rates of the disappearance (consumption) of carbon dioxide
- Rates of the consumption of light energy

Of these possibilities, again the easiest to measure is the appearance of oxygen or the disappearance of carbon dioxide. For this lab exploration, we will measure the disappearance of carbon dioxide.

To perform the necessary tests, you will need to determine the presence of carbon dioxide. We will make use of the fact that aquatic organisms that photosynthesize directly in the water consume carbon dioxide directly from the water. As in the respiration experiment, we have an indirect measure of the amount of carbon dioxide in the water: the pH of the water. A pH probe can be used to monitor pH and thus measure how much carbon dioxide is released into the water.

Since plants also photosynthesize, we should also be able to measure rates of photosynthesis. However, as you know from last week, plants also are made of cells and so respire. Therefore, we will be measuring both respiration and photosynthesis by measuring pH changes under light conditions. Based on what you know about photosynthesis and respiration, which would you expect to be more prevalent in a plant under light conditions compared to dark conditions? What would happen to pH in light compared to dark conditions? These are questions you will address as part of this exploration.

Discuss these questions with your lab partners and **fill-in the worksheet** on the following page.

Name: ________________________

Lab 3 Worksheet

a. Do plants respire in light? _________

b. Do you expect that plant photosynthesize in the light? _________

c. Why do plant cells respire? To produce _____________________.

d. Why do plant cells photosynthesize? To produce _________________, which will be used in the set of reactions called ___________________.

e. Given your answer to the last question, what would happen to a plant cell that did not photosynthesize and why?

f. Given your answer to the previous question, which should faster, the rate of photosynthesis or the rate of respiration and why?

g. Given your answer to the previous question, what do you predict will happen to the pH in the light, and why?

Now:

❖ Propose and enter into Tables 3 and 4 the appropriate hypotheses and predictions for our experiments, testing whether photosynthesis and/or respiration occur in a plant in light and/or dark conditions. Also indicate which beaker you would use to test the prediction, and indicate which beaker is the control beaker. Be prepared to present what you came up with and why to the class. Remember that a prediction is an "If…then…" statement.

MATERIALS (per group)

4 large test tubes	2 sprigs of *Elodea*	scale
400-ml beaker to rinse probe into	wax pencil	1 weigh boat
distilled wash water in squirt bottle	well water	1 pH probe

PROCEDURE

1. Work in groups of 4. To work efficiently, split up the work!
2. Obtain and label 4-250 ml beakers, and label them "Light-Control", "Light-Experimental", "Dark-Control", and "Dark-Experimental", and with your group name, using the wax pencil.
3. Obtain a pH meter, open it and turn it on to warm up.
4. Fill each test tube with well or pond water.
5. Obtain 2 large sprigs of *Elodea* (or other aquatic plant). Obtain enough to fill the water in the test tube with plant. Pat the plants dry with a paper towel, **weigh them** and record the data in Table 1.
6. Place one sprig in test tube "Light-Experimental", and the other sprig in test tube "Dark-Experimental". The sprigs should be under water.
7. Remove the cap on the pH probe. Rinse the probe thoroughly with distilled water (you may rinse into a sink or the 400-ml beaker).
8. Place the probe into beaker "Light-Control" and gently swirl briefly to allow water to move past the probe's tip. When the reading stabilizes, or after 2 minutes, record the pH value in Table 1; do not wait longer than 2 minutes. Assume that the pH of beaker "Light-Experimental" is the same as for beaker "Light-Control", since you used the same well water, and fill in the pH in the spaces in Table 1.
9. Place the probe into beaker "Dark-Control" and gently swirl briefly to allow water to move past the probe's tip. When the reading stabilizes, or after 2 minutes, record the pH value in Table 1; do not wait longer than 2 minutes. Assume that the pH of beaker "Dark-Experimental" is the same as for beaker "Dark-Control", since you used the same well water, and fill in the pH in the spaces in Table 1.

10. When all readings have been taken, rinse the pH probe with distilled water, replace the cap, and turn off the meter.
11. Place beakers “Light-Control” and “Light-Experimental” under light conditions in the light rack in the back of the room. Leave the beakers for 40 minutes.
12. Place beakers “Dark-Control” and “Dark-Experimental” under dark conditions in the cabinet under your table. Leave the beakers for 40 minutes.
13. After 40 minutes, measure pH (using the pH probe) for **each** of the 4 beakers. Record the data in Table 1 below.
14. Repeat step 10, this time putting a drop of distilled water in the cap to prevent the probe from drying out.
15. Clean up by returning the well water and *Elodea* to the *Elodea* container, and putting your beakers, wax pencil, squirt bottle and the pH meter back at the front of the room. Wipe up any spilled water, and throw away paper towels and the weigh boat.

PROCESSING THE DATA

Calculate the change in pH (ΔpH) for your organisms by subtracting the starting pH from the ending pH. Record your results in Table 1.

You must correct for any changes that occurred to the pH of the water that were NOT the result of photosynthesis or respiration. Do this by subtracting the ΔpH of the control beaker from that of the *Elodea* beaker. Record this "corrected ΔpH" in Table 1.

Divide the corrected ΔpH for the *Elodea* by its weight, and record in Table 1 (Corrected ΔpH/g).

Record your corrected ΔpH/g data on data sheet on the overhead.

Copy class data from the overhead to Table 2.

Calculate the average corrected ΔpH/g for each of the beakers and record in Table 2.

Graph the average corrected ΔpH/g from BOTH light and dark data– the two conditions are “dark” and “light”. USE GRAPH PAPER (or a computer). Be sure to correctly label the x- and y-axes. Attach to this handout.

DATA

Table 1: Data from respiration/photosynthesis experiment with *Elodea*

beaker	treatment	weight (g)	starting pH	ending pH	ΔpH	Corrected ΔpH	Corrected ΔpH / g
"Light-Control"	control						
"Light-Experimental"	**Elodea**						
"Dark-Control"	control						
"Dark-Experimental"	**Elodea**						

Table 2. Corrected ΔpH/g from the different class groups, and average corrected ΔpH/g.

	Corrected ΔpH/g								
Condition	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Average
Elodea-Light									
Elodea-Dark									

INTERPRETING THE DATA AND DRAWING CONCLUSIONS

In the following table (Table 3), you **should have already** filled in the predictions and indicated which is the experimental beaker and which is the control beaker. Now:

- Interpret the class data to support or reject the hypothesis.
- Explain your reasoning. How did you interpret your data to make the conclusion?
- If rejected, write a corrected hypothesis.

Table 3. Hypothesis table about whether respiration rate or photosynthetic rate is greater in the "light" conditions.

Hypothesis 1:
Prediction 1:

Experimental Test Beaker:	Control Test Beaker:	Interpretation (circle one): **support** or **reject**?
Reasoning (for your choice of "support" or "reject")		
If rejected, a corrected hypothesis:		

In the following table (Table 4), you **should have already** filled in the hypothesis, your reasoning for the hypothesis, and the prediction addressing the question of which would be greater, the rate of respiration or the rate of photosynthesis. Now:

- Interpret the class data to support or reject the hypothesis.
- Explain your reasoning. How did you interpret your data to make the conclusion?
- If rejected, write a corrected hypothesis.

Table 4. Hypothesis table about whether respiration rate or photosynthetic rate is greater in the “dark” conditions.

Hypothesis 2:
Reasoning for your hypothesis: Why did you propose the particular hypothesis you did?
Prediction 2:
Interpretation (circle one): **support** or **reject**?

Reasoning (for your choice of "support" or "reject")
If rejected, a corrected hypothesis:

Additional Questions:

1. Determine what the corrected $\Delta pH/g$ would have been if we could have kept the plant from respiring in the “light” conditions (i.e., in the absence of respiration, so that the plant was only photosynthesizing).

2. Why do we divide ΔpH by the weight of the organism?

3. So… do plants both respire and photosynthesize in the light (yes or no)?