Lab 4: Respiration and Photosynthesis in Plants

OBJECTIVES

• In this laboratory exploration, you will
• Use an O₂ probe to measure the concentration of dissolved oxygen in water.
• Use the O₂ probe measurements to make inferences on the amount of O₂ dissolved in water.
• Use the inferences about the amount of oxygen in the water to make conclusions about whether plants consume or produce oxygen in the light.
• Use the inferences about the amount of oxygen 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

—we can measure rates of respiration—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 or consumption of oxygen.

To perform the necessary tests, you will need to determine the presence of dissolved oxygen in the water. We will make use of the fact that when aquatic organisms respire in the water they consume oxygen from the water and the amount of dissolved oxygen in the water will decrease. 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:
  
  \[ 6 \text{H}_2\text{O} + 6 \text{CO}_2 (g) + \text{sunlight energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2(g) \]

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 appearance of oxygen.

To perform the necessary tests, you will need to determine the presence of oxygen. We will make use of the fact that when aquatic organisms photosynthesize in water they release oxygen into the water. As in the respiration experiment, we have a direct measure of the amount of oxygen in the water. An O₂ probe can be used to monitor O₂ and thus measure how much oxygen 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 O₂ 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 the amount of dissolved O₂ 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.
Lab 3 Worksheet

a. Do plants respire in light? ________
b. Do you expect that plants 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 be 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)**

- 2 Experiment Jars
- 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 O$_2$ probe

**PROCEDURE**

1. Work in groups of 5 or 6. To work efficiently, split up the work!

2. Obtain and label 2 experiment jars, and label one of them Light and the other Dark with a wax pencil. Be certain to include your group name on your jars using the wax pencil.

3. Obtain an O$_2$ probe, read and follow the instructions provided on how to properly use the O$_2$ probe.

4. Fill each jar approximately one-half full 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. Remove the cap on the O$_2$ probe. Rinse the probe thoroughly with distilled water (you may rinse into a sink or the 400-ml beaker).

7. Place the probe into each jar and gently swirl briefly to allow water to move past the probe’s tip. When the O$_2$ probe reading stabilizes, or after 2 minutes, record the O$_2$ value in Table 1; do not wait longer than 2 minutes. These readings will be your initial amounts of dissolved oxygen.

8. When all readings have been taken, rinse the O$_2$ probe with distilled water, replace the cap, and turn off the meter.

9. Put a sprig of *Elodea* into the light jar and place it under light conditions in the light rack in the back of the room. Leave the jar for 40 minutes.

10. Put a sprig of *Elodea* into the dark jar and place it into a dark cabinet as soon as possible. Leave the jar for 40 minutes.

11. After 40 minutes, remove the sprigs of *Elodea* from each jar and measure the amount of dissolved oxygen in each jar (using the O$_2$ probe) for each of the 2 jars. Record the data in Table 1 below.

12. 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

1. Calculate the change in dissolved oxygen \( (\Delta O_2) \) for your organisms by subtracting the starting amount of dissolved oxygen from the ending amount of dissolved oxygen. Record your results in Table 1.

2. Divide the change in dissolved oxygen for each experimental condition of *Elodea* by its weight, and record in Table 1 (Corrected \( \frac{\Delta O_2}{g} \)).

3. Record your corrected \( \frac{\Delta O_2}{g} \) data on data sheet on the overhead.

4. Copy class data from the overhead to Table 2.

5. Calculate the average corrected \( \frac{\Delta O_2}{g} \) for each of the beakers and record in Table 2.

DATA

<table>
<thead>
<tr>
<th>JAR</th>
<th>weight (g)</th>
<th>starting O(_2)</th>
<th>ending O(_2)</th>
<th>( \Delta O_2 )</th>
<th>( \frac{\text{change O}_2}{\text{weight (g)}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Corrected \( \frac{\Delta O_2}{g} \) from the different class groups, and average corrected \( \frac{\Delta O_2}{g} \).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
<th>Group 7</th>
<th>Group 8</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Elodea</em> - Light</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Elodea</em> - Dark</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Graph the corrected \( \frac{\Delta O_2}{g} \) from BOTH light and dark data from each group – one line for the “dark” condition and one line for the “light” condition. USE GRAPH PAPER (or a computer). Be sure to correctly label the x- and y-axes. Attach to this handout.
**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.

<table>
<thead>
<tr>
<th>Hypothesis 1:</th>
<th>Prediction 1:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Test Beaker:</td>
<td>Control Test Beaker:</td>
</tr>
<tr>
<td>Reasoning (for your choice of &quot;support&quot; or &quot;reject&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Hypothesis 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasoning for your hypothesis: Why did you propose the particular hypothesis you did?</td>
</tr>
<tr>
<td>Prediction 2:</td>
</tr>
<tr>
<td>Interpretation (circle one): support or reject?</td>
</tr>
<tr>
<td>Reasoning (for your choice of &quot;support&quot; or &quot;reject&quot;)</td>
</tr>
<tr>
<td>If rejected, a corrected hypothesis:</td>
</tr>
</tbody>
</table>
Additional Questions:

1. Calculate what the corrected $\Delta O_2/g$ 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 $\Delta O_2$ by the weight of the organism?

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