**Lab Activity No. 5**

 **Photosynthesis**

**Bio 100 Lab**

**A. Objectives:** Upon completion of this lab activity, you should be able to:

1. Define/explain each of the following terms: photosynthesis, chloroplasts, chlorophyll, starch, electromagnetic spectrum, wavelength, endothermic, condensation (dehydration synthesis) reactions, autotrophs, and heterotrophs.

2. Write a balanced chemical equation for photosynthesis and identify the reactants and products.

3. Describe the general method used to determine the rate of photosynthesis of leaf discs.

4. Use the scientific method to determine the effects of each of two variables (light intensity and light source color) on the rate of photosynthesis in leaf discs.

5. Interpret data to determine the effect of temperature on the rate of photosynthesis in leaf discs.

6. Use appropriate and specific terminology as part of all explanations.

7. Graph data obtained from experiments in this activity.

**B. Introduction:** In lecture, we have/will discuss(ed) photosynthesis. We can define photosynthesis as “the process by which light energy is used to convert inorganic compounds (ie. carbon dioxide and water) to sugar (i.e. monosaccharides) and oxygen”. We can also recognize that photosynthesis is regarded as an “energy-acquiring” (i.e. overall endergonic) process**.**

 The process of photosynthesis can be chemically summarized using the following chemical equation:

 **light energy**

 **12 H2O + 6 CO2 -------------------------> C6H12O6 + 6 O2 + 6 H2O**

 **chlorophyll**

 **enzymes**

 It is important to remember that the glucose produced by photosynthesis can be converted to starch, which is the storage form of extra glucose in plants, or cellulose. Starch and cellulose are made of many molecules of glucose joined together by condensation reactions**.**

 We have also discussed the fundamental importance of photosynthesis to food chains and webs. Plants are classified as “producers”(autotrophs) because of their ability to carry out photosynthesis. These photosynthetic producers are important to “consumers”(heterotrophs), such as ourselves, because we can’t capture light energy and use it to create organic molecules from inorganic reactants. Not only are photosynthetic organisms important because of their position as the base of all food webs, but they also release elemental oxygen (O2) as a byproduct. This oxygen is necessary for maintaining life on earth as we know it.

 The purpose of today’s lab activities is to introduce you to photosynthesis and several factors that influence it, while at the same time continuing to develop your use of the scientific method.

**C.**  **Influence of Light Intensity on Rate of Photosynthesis** (Adapted from Perry and Morton (1995) Laboratory Manual)

As a class, we will evaluate the influence of light intensity on the rate of photosynthesis by testing three different light intensities: 25W, 75W, and 200 W. Each group will be assigned one light intensity to test. **CAUTION: Do not touch the hot light bulbs**. Give them time to cool before changing to another bulb. Also, make certain that your lamp is not shining on another group’s syringes or directly in someone’s face!

Materials:

 • 25W, 75W, and 200W light bulbs and lamp

 • Large test tubes and rack

 • Photosynthesis chambers

 • Fish aquariums

 • Spinach

 • Soda straws

 • 1.5% sodium bicarbonate solution

**Hypothesis:**

How do you expect light intensity to influence the rate of photosynthesis? Write a testable hypothesis:

1. Obtain three (3) clean 10-ml syringes (with the same dimensions) and check to make certain that they can

create and maintain a vacuum (This procedure will be demonstrated in lab.). The syringes will act as miniature photosynthesis chambers. The following directions will be described for a single syringe. Simply repeat the directions for the second and third one.

2. Remove the plunger from the body of the syringe.

3. Use a soda straw to cut 6 leaf discs from the provided leaves.

**Note: Use a new leaf for each experiment that your group will subsequently perform.** Dehydrated leaves will potentially affect your results. Also, don’t take the samples from the “veins” of the leaf.

4. Use tweezers to **gently** remove the 6 leaf discs from the straw and place them into the body of the syringe.

Replace the plunger and be careful not to damage the leaf discs when you depress the plunger.

5. Draw approximately 9.0 ml of the 1.5 % sodium bicarbonate (NaHCO3) solution into the syringe as

demonstrated. The leaf discs should be floating in the solution towards the tip of the syringe. If the discs are on the bottom or sides of the syringe chamber, tap the sides to dislodge them.

6. Invert the syringe (so the tip is pointing to the ceiling) and expel the air in the syringe by pushing gently

on the plunger.

7. Using your index finger, seal the tip of the chamber and pull back on the plunger to create a partial

vacuum within the chamber. You should see air bubbles coming from the edges of the leaf discs.

**Note:** Do NOT pull too far back or the plunger will come out and you will have a mess!

8. Simultaneously, release your index finger and the plunger (You should hear a “pop” sound).

9. Repeat steps 7 and 8 until all (or at least 5) of the leaf discs sink to the bottom. It may help to lightly tap

the chamber on the edge of your hand or repeatedly invert it to help remove trapped air bubbles.

10. Adjust the final volume in the syringe to 8 ml by gently pushing out any excess solution.

11. Obtain a fish bowl (i.e. the “heat absorber unit”) and fill it with **cold** tap water.

12. Obtain a lamp and place it on one side of the fish bowl approximately 2” from the glass. **Note:** If the lamp is too tall compared to the height of the fish bowl, place the bowl on top of a test tube rack.

13. Place three large glass test tubes into a test tube rack and position the rack on the side of the fish bowl

opposite to the lamp (i.e. the fish bowl will separate the lamp from the test tubes).

14. Invert the three syringes so that the plunger is pointing towards the floor and place one syringe in each

 of the glass test tubes. The plunger should fit into the tube, but the barrel should not. The purpose of the test tubes is to keep the syringes from falling over during the experiments.

15. Position the barrels of the syringes so they are next to, but not touching, the sides of the fish bowl. Also, make certain that the syringes are equally centered with respect to the light source. As photosynthesis proceeds, oxygen will accumulate in the intercellular spaces of the leaf, causing it to float. **Therefore, the number of floating discs can be used to quantify the rate of photosynthesis (i.e. the greater the number of floating, leaf discs, the greater the rate of photosynthesis).** You first removed this intercellular air (including oxygen) by creating the vacuum. As photosynthesis takes place again, oxygen will be produced and the leaf discs should rise.

16. After initiating your experimental conditions, record the **total number** of floating leaf discs every 2 min.

for 20 min. Keep a cumulative total of the number of leaf discs at the top of each syringe. **Once all the leaf discs in each of the syringes have floated to the top, you can terminate the experiment.** **Note:** Gently tap the syringes at regular intervals (i.e. every 2 min.) to free any discs that have become trapped at the bottom of the barrel. When you tap the syringes, make sure you rotate them 180 degrees to help ensure that all leaf discs have an opportunity to be exposed to the light.

**Data Tables:**

Enter total number of discs floating after each time period.

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| Time | 2 min. | 4 min. | 6 min. | 8 min. | 10 min. | 12 min. | 14 min. | 16 min. | 18 min. | 20 min. |
| Watt:Syringe 1 |  |  |  |  |  |  |  |  |  |  |
| Syringe 2 |  |  |  |  |  |  |  |  |  |  |
| Syringe 3 |  |  |  |  |  |  |  |  |  |  |
| Average |  |  |  |  |  |  |  |  |  |  |

Class Averages

|  |  |  |  |  |  |  |  |  |  |  |
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| Averages | 2 min. | 4 min. | 6 min. | 8 min. | 10 min. | 12 min. | 14 min. | 16 min. | 18 min. | 20 min. |
| Watt:25 W |  |  |  |  |  |  |  |  |  |  |
| 75 W |  |  |  |  |  |  |  |  |  |  |
| 200W |  |  |  |  |  |  |  |  |  |  |

**Graph of the Light Intensity Data:**

Create a LINE graph that shows the changes (over the 20 min. testing period) in the **overall class averages** of floating leaf discs for each of the three light intensities.

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**Questions:**

Reflect on the design of this experiment. Come up with one specific change you would make if starting over again. Make certain you explain how the changes will result in an improved design.

Improvement:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**D. Influence of Light Source Color on Rate of Photosynthesis**

1. As a class, we will evaluate three different light color sources: clear, red, and green. **Each group will evaluate one syringe of each color (3 syringes total). Use the 100W bulb for this experiment.**

2. Prepare three syringes as previously described.

3. Adjust the color of the light reaching the leaf discs in the photosynthesis chamber by

wrapping cellophane around the body of the chamber (**AFTER** the leaf discs are at the bottom) and securing it with transparent tape. Make certain that you use enough paper to wrap the complete syringe barrel **two times** (No more or less). Use just enough transparent tape to secure the cellophane. Orient the syringes so that the tape is oriented away from the light source.

4. Once the syringes are prepared, conduct the experiment in a similar manner to the first one.

1. Data Table

Enter total number of discs floating after each time period.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time | 2 min. | 4 min. | 6 min. | 8 min. | 10 min. | 12 min. | 14 min. | 16 min. | 18 min. | 20 min. |
| GreenSyringe |  |  |  |  |  |  |  |  |  |  |
| RedSyringe |  |  |  |  |  |  |  |  |  |  |
| ClearSyringe |  |  |  |  |  |  |  |  |  |  |

**Graph of the Results:** Make a graph to show the results of your experiment.

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**Questions:**

Reflect on the **design** of this experiment. Write one specific change you would make if starting over again. Make certain you explain how the changes will result in an improved design.

Improvement:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Consider the following data collected from an experiment to determine the effects of temperature on rate of photosynthesis. For this experiment, the syringes were submerged in a designated temperature water bath.

**Overall Class Average Percentages of Floating Leaf Discs in Photosynthetic**

**Chambers Exposed to Three Different Temperatures**

|  |  |  |  |
| --- | --- | --- | --- |
| **Temperature****Time (Min.)** | **Ice Water (3 C)****AVE.** | **Room** **Temperature (22 C)****AVE.** | **Warmer** **Temperature (35 C)****AVE.** |
| **0** | 0 | 0 | 0 |
| **2** | 0 | 0 | 0 |
| **4** | 0 | 0 | 15 |
| **6** | 0 | 10 | 25 |
| **8** | 0 | 15 | 25 |
| **10** | 0 | 15 | 30 |
| **12** | 0 | 25 | 35 |
| **14** | 0 | 25 | 35 |
| **16** | 0 | 35 | 45 |
| **18** | 0 | 40 | 60 |
| **20** | 0 | 45 | 65 |

1. Based on the data presented in the table, summarize the influence of temperature on the rate of photosynthesis. Describe the parts of the cell that are involved in this process as part of your answer.

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2. What will happen to the rate of photosynthesis if the leaf discs are **boiled** in water prior to exposing them to the light source? Why?

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3. What color of light would you use to encourage growth in your house plants? Explain your response using data from your experiment.

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 **E. Review Questions**

 1. In what organelle does photosynthesis occur?

 2. What is chlorophyll and where is it located in plant cells?

 3. What is the specific function of chlorophyll in photosynthesis?

 4. Describe the visible light spectrum and how it is used by plants.

 5. What are the reactants and products of photosynthesis?

 6. Is photosynthesis an overall endergonic or exergonic reaction? Explain your response.

 7. Why did the leaf discs sink to the bottom of the syringe?

 8. Explain how the # of floating leaf discs can be used as an indicator of the rate of photosynthesis.

 9. Explain, using the class data, the influence of light intensity on the rate of photosynthesis.

 10. Explain, using your group data, the influence of light source color on the rate of photosynthesis.