EXERCISE 8

Photosynthesis

LEARNING OBJECTIVES:

- Understand the components of the equation for photosynthesis.
- Observe evidence of plants taking up carbon dioxide.
- Observe the relationship between the presence of pigments for photosynthesis and the presence of carbohydrate product (starch).
- Observe evidence of plants producing oxygen.
- Demonstrate that light is necessary for photosynthesis.
- Observe the presence of stomata in the epidermis of plant leaves.

Answer these questions before you come to lab:

1. Define:
   autotrophic_____

   Heterotrophic_____

2. During photosynthesis plants convert _____ energy to _____ energy in the form of _____.

3. List the factors necessary for photosynthesis.

_____

4. Which of these factor(s) are used in the light reactions?

_____

5. Which are used in the light-independent reactions (Calvin cycle)?

_____

6. What are the products of the light reactions?

_____

7. What are they used for in the Calvin cycle?

_____

_____

8. What are the products of the Calvin cycle?

_____

9. Write the general equation for the process of photosynthesis.

_____

EXERCISE 1: To show that carbon dioxide is taken up during photosynthesis.

Introduction

Plants require CO_2 to produce glucose during the light-independent reactions (also called the _____) of photosynthesis. Therefore if CO_2 disappears, there is evidence that photosynthesis is occurring. A **pH indicator** solution can be used to detect the uptake of CO_2 by a plant. An indicator is a molecule that changes color depending on pH. Today you will be using **phenol red** solution. Phenol red solution turns **yellow** in acidic solutions (pH <7.0) and is red to neutral to basic solutions (pH >7.0).

In order to see this color change take place, you will breathe CO_2 from your lungs into a solution of phenol red. The phenol red solution will begin basic (red) and become acidic (yellow) as you add CO_2. This is due to the following chemical reaction between water and carbon dioxide.

$$\underset{\text{water}}{H_2O} + \underset{\substack{\text{carbon}\\\text{dioxide}}}{CO_2} \longrightarrow \underset{\substack{\text{carbonic}\\\text{acid}}}{H_2CO_3}$$

If a plant is added to an acidic solution it can "fix" (or take up) the carbon dioxide. Removing CO_2 from the solution raises the pH (becomes more basic). This causes a yellow solution to turn red.

IMPORTANT NOTE: Wear gloves.

Dispose of Phenol Red and Lugol's Iodine in appropriate waste jar.

Procedure

1. In a beaker, mix 50 ml of water with 10 drops of phenol red indicator.

2. Mark two test tubes with your initials. Fill one tube half-full with the phenol

red-water mixture. You will have phenol red-water mixture remaining in the beaker.

3. Using a straw, gently blow into the beaker, being careful to avoid splashing. Stop blowing ***as soon as*** your solution turns yellow. Otherwise, the experiment will take longer because of the additional carbonic acid formed.

4. Fill the second labeled test tube half-full with this yellow solution (phenol red-water rich in CO_2).

5. Add two pieces (about 3 cm each) of *Elodea* stem (with leaves) to each test tube.

6. Pour off any excess phenol red-water solution so that the solution just covers the *Elodea.*

7. Place both test tubes under the bright light for 30-60 minutes (this will insure that the plant has adequate supplies of ATP and NADPH necessary for the light-dependent reactions).

8. Observe the solutions every 10 minutes and record the time and color changes you observe in Table 1.

Table 1. Record of time and solution color

Time	Color

Has the color in either test tube changed? If so, why?

_____

_____

_____

EXERCISE 2: To demonstrate that chlorophyll is required for photosynthesis.

Explain what chlorophyll is used for during photosynthesis.

_____

_____

Procedure

A variegated leaf is one is which pigments are not evenly distributed.

1. Sketch this leaf in the "before" section of Figure 1, making sure to indicate the location of the pigments (the parts that are white and those that are green)

Before	**After**

Figure 1. Student sketch of leaf before and after staining

2. Bring half a beaker of water to boil.

3. Boil the leaf in water for 1 minute. This kills the leaf.

4. Carefully remove the leaf from the water.

5. Half fill a test tube with 95% ethanol, and place the killed leaf in it.

6. Place the test tube in the beaker of boiling water and boil for about or until all of the pigment is removed.

7. Place the leaf into cool tap water for 30 seconds or until it becomes soft. The alcohol make it hard)

8. Carefully spread the leaf out on a Petri dish and stain it with iodine. Wait 5 minutes and then make a sketch of the stained leaf in the 'after' section of Figure 1. Indicate the areas that are black.

How is the presence of starch related to the process of photosynthesis?

_____

_____

_____

Why would dark brown/black staining be absent if the portion of the leaf was originally white?

_____

_____

_____

Describe how carbon dioxide is used in photosynthesis.

_____

_____

_____

_____

EXERCISE 3. To show that light is necessary for photosynthesis.

Procedure

1. Obtain a leaf from a plant kept in the light and one kept in the dark.

2. Using two separate test tubes and the method described in Exercise 2, test both leaves for starch.

What does boiling the leaf in water do? In alcohol?

_____

_____

_____

Was there starch formation in the leaf from the plant kept in the dark? If so, was this what *you* expected?

_____

_____

_____

Why do plants store starch?

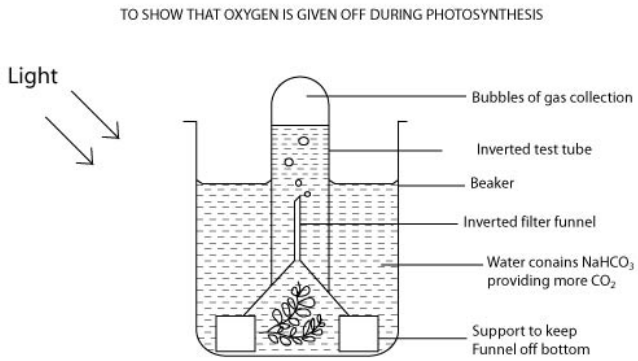
_____

_____

EXERCISE 4. To demonstrate that oxygen is produced during photoysnthesis.

During the light-dependent reaction of photosynthesis, water is split to produce the hydrogen needed for the reduction of carbon dioxide during the light-independent reaction (or Calvin cycle). This splitting of water also produces oxygen, which is released as a gas (O_2), a by-product. The production of oxygen can be observed using the aquatic plant, ***Elodea***.

This demonstration has been set up so that molecules of oxygen produced during photosynthesis are trapped in a test tube attached to the narrow end of a funnel. Several fresh sprouts of aquatic plant are placed under the funnel and the entire system is submerged in water taking care to ensure that the oxygen produced will be trapped in the test tube rather than escaping into the air. Since tap water does not contain much carbon dioxide, sodium bicarbonate is added to release carbon dioxide into the water.



Observe the demonstration periodically during your lab period to observe formation of oxygen as the level of water in the test tube is displaced. You may also see that oxygen is being produced by observing the bubbles as they travel from the aquatic plant to the test tube.

What would happen if this system was only allowed green light? Explain your answer.

_____

_____

Why is the system submerged in a solution of sodium bicarbonate rather than pure water?

_____

_____

Exercise 5: Observing stomata on the epidermis of the leaf

Procedure

1. Paint a small area about the size of a dime with clear nail polish on the underside of the leaf.
2. Allow the nail polish to dry completely.
3. Tape a piece of clear tape onto the dried nail polish.
4. Peel the nail polish **(*BE GENTLE*!)** by pulling on the tape.
5. Gently press the tape with your leaf impression onto a clean slide.
6. Examine under the microscope 40X.
7. Draw a few of the stomata you observe in the space below.

Lab Report

Exercise 1

1. What is phenol red?

_____

2. What was the purpose of blowing into the water solution of phenol red?

_____

3. What caused the color to change to yellow?

_____

4. Explain why the color changed from yellow back to pink after leaving the *Elodea* in it for an hour.

_____

5. What was the purpose of the other tube (without the plant)?

_____

_____

Exercises 2 and 3

6. What does boiling the leaf in water do?

_____

7. Why is the leaf then boiled in alcohol?

_____

8. Which area of the variegated leaf contained chlorophyll?

_____

9. What does a blue-black color with iodine indicate?

_____

10. Which areas of the leaf stained blue-black?

_____

11. Explain why only those areas stained blue-black?

_____

_____

12. Was there any starch in the leaf that had been left in the dark? Explain your answer.

_____

_____

Exercise 4

13. Why was the plant submerged in a solution of sodium bicarbonate instead of pure water?

_____

14. What would have happened if green light were used instead? Explain your answer.

_____

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