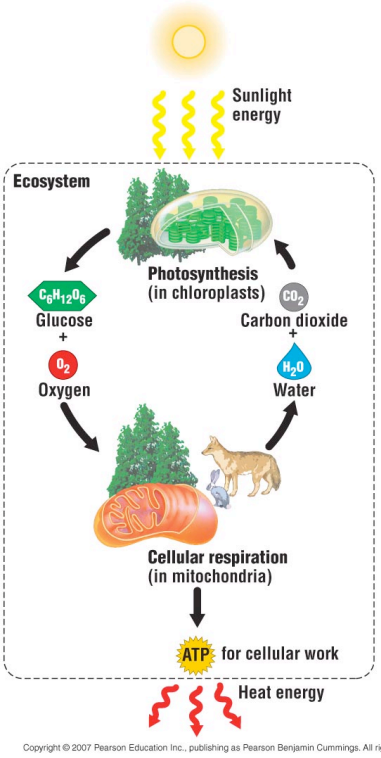
# Photosynthesis and Respiration

## Introduction

All living organisms require energy for growth, movement, reproduction, and metabolism. Photosynthesis is the process by which **photoautotrophs** convert inorganic compounds (like carbon dioxide) to high-energy organic compounds (like glucose) using light energy.

Cellular aerobic respiration is carried out within the cells of most organisms. Using oxygen, high-energy organic compounds (like glucose) are broken down and the energy is captured in a form that can be used by the cell. While **autotrophs** produce their own glucose, **heterotrophs** are organisms that must get their energy by consuming high-energy compounds.





Examine the two equations below. The 1st equation represents photosynthesis and the 2nd equation represents aerobic respiration. Notice that the end products of one reaction are the reactants for the other. Only cells containing chlorophyll can perform photosynthesis, while aerobic respiration can take place in most cells. Many plants perform photosynthesis and aerobic respiration simultaneously.
($C_6H_{12}O_6$ = glucose)

**Photosynthesis**:

$$6CO_2 + 6H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6O_2$$

**Respiration**:

$$C_6H_{12}O_6 + 6O_2 \Rightarrow 6CO_2 + 6H_2O + ATP$$

In this lab experiment, you will examine the dual nature of photosynthesis and respiration. In the presence of light, high-energy organic molecules and oxygen will be produced by photosynthesis, and $CO_2$ will be used up. Aerobic respiration occurs in the presence or absence of light, and $CO_2$ will be produced as a by-product.

*Elodea* is a green aquatic plant. Its cells contain chloroplasts. Would you expect this plant carry out photosynthesis? _____ Would you expect this plant carry out aerobic respiration? _____

Seeds are a dormant phase of a plant life cycle. They contain cells that feed a plant embryo before the plant germinates and is capable of photosynthesis. Would you expect a seed carry out photosynthesis? _____ Would you expect a seed carry out aerobic respiration? _____

To determine whether photosynthesis or aerobic respiration have taken place, we'll note **pH changes**. Examine the following equation:

$$CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + CO_3^-$$

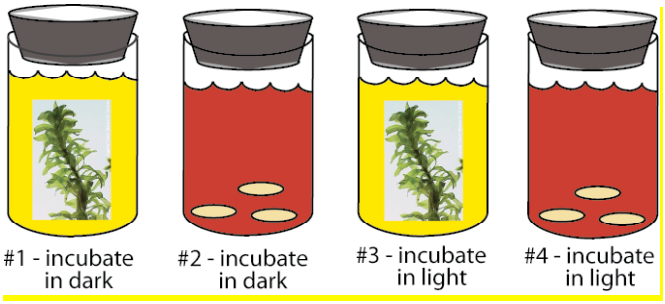
As you can see, when $CO_2$ mixes with $H_2O$, a weak acid ($H_2CO_3$) is produced. This equation is reversible, so as $CO_2$ is added to a solution (via aerobic respiration) the pH decreases. As $CO_2$ is removed from a solution (via photosynthesis), the pH increases.

In this laboratory experiment, we will look for changes in acidity as $CO_2$ is added to a solution (via aerobic respiration) or removed from a solution (via photosynthesis). We'll use **phenol red** as a pH indicator. It is red at a basic pH (above pH 8.0) and yellow at an acidic pH (below pH 6.6).

**Procedure**

**I. Test photosynthesis and respiration**

1. Set up 4 test tubes. Each tube should contain: 20 ml of tap water and 10 drops of phenol red, a pH indicator.




2. To prepare tubes #1 and #3, add $CO_2$ by blowing gently into the tube with a straw. Be careful not to suck any of the liquid into your mouth. Blow until the *solution turns yellow*. What caused the color change? _____

Tube #1 – *Elodea* sprig
- Add $CO_2$ by blowing gently into the tube with a straw. Be careful not to suck any of the liquid into your mouth. Stop blowing as soon as the liquid turns yellow.
- Place a 10 cm **leafy** sprig of *Elodea* in the tube, pressing it down so that it is completely submerged. Seal the test tube with a rubber stopper.
- Place the test tube in a dark place.

Tube #2 – 3 bean seeds (red)
- Place 3 seeds in the tube; make sure they are completely submerged. Seal the test tube with a rubber stopper.
- Place the test tube in a dark place.

Tube #3 – *Elodea* sprig (yellow)
- Add $CO_2$ by blowing gently into the tube with a straw. Be careful not to suck any of the liquid into your mouth.
- Place a 10 cm **leafy** sprig of *Elodea* in the tube, pressing it down so that it is completely submerged. Seal the test tube with a rubber stopper.
- Place the test tube in a light place.

Tube #4 – 3 bean seeds (red)
- Place 3 seeds in the tube; make sure they are completely submerged. Seal the test tube with a rubber stopper.
- Place the test tube in a light place.

3. Incubate your test tubes for 1 hour

4. Look for a color change in each tube and record your results in Table 1.

**II. Design your own experiment**

1. Using the materials available, design an experiment to determine the number of seeds required to produce enough $CO_2$ to balance amount of $CO_2$ used by *Elodea* during photosynthesis. Your experiment should answer the question: *How many seeds produced the same amount of $CO_2$ used by the* Elodea?
2. Discuss your procedure with your group and check with your instructor before you begin.
3. This experiment should not be started until after your previous experiment is finished, since you will want to see the results of the first experiment. However, you can start planning this experiment while you wait.

Be sure to check your instructor's website for extra credit questions and announcements.

Name _____

# Photosynthesis and Respiration

**Results and Data Analysis**

**Test photosynthesis and respiration** - Indicate the solution starting and ending color.

| Test Tube | Starting Color | Ending Color |
|---|---|---|
| #1 – *Elodea* in the dark | *yellow* | |
| #2 – Seeds in the dark | *red* | |
| #3 – *Elodea* in the light | | |
| #4 – Seeds in the light | | |

1. Which tubes changed color?

2. Do your results indicate that light is necessary for photosynthesis? Explain your answer using *your results*.

3. Do your results indicate that light is necessary for aerobic respiration? Explain your answer using *your results*.

**II. Design your own experiment**

1. Briefly describe the procedure you used to determine the amount of seeds needed to produce the same amount of CO2 as the *Elodea* consumed. You may include a labeled diagram as part of your explanation.

2. Create a table to present the results of your experiment. You may use the space below or attach a separate sheet.

3. What can you conclude from your data? *How many seeds produced the same amount of $CO_2$ used by the* Elodea? How could you tell?

4. As seen in the graph below, $CO_2$ levels have been increasing since the industrial revolution. Increasing $CO_2$ levels correlate with increasing global temperatures. Many environmental groups advocate planting trees and other vegetation solve the problem. Based on your results from today's experiments, how will this help solve the problem of global climate change?