LABORATORY #6 -- BIOL 111
Photosynthesis and Respiration

There are two great processes that make the world of life go 'round: **photosynthesis** and **respiration**. One is about converting solar energy into chemical energy (to make the sugar, glucose); the other is about converting this chemical energy into a useful form (to convert glucose into ATP) to drive everything living organisms do. One seems to be the opposite of the other, and when you consider where the "first" process begins and where the other ends, then these two processes indeed form a circle. If there is actually a "circle of life" this is it. All cells (and thus all organisms) perform respiration. In eukaryotes respiration takes place in an organelle called the mitochondria. Not every organism can perform photosynthesis. Organisms that have a specific organelle called a chloroplast carry out photosynthesis. Those organisms that are capable of photosynthesis are known as **producers**, and all the remaining organisms are called **consumers**. But as you will soon see, photosynthetic, producers, must also consume the glucose they make in the process of respiration.

Photosynthesis can be defined as the transfer and storage of solar energy to a chemical form called **glucose**. Glucose (and other kinds of sugar) is an arrangement of atoms of carbon (C), hydrogen (H) and oxygen (O). Much like a battery stores energy used to power your cell phone, glucose is designed to be a temporary holder for some of the energy that arrives from the sun. From the standpoint of chemistry, photosynthesis is written like this:

solar energy

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

Carbon dioxide comes from the air and is dissolved in water, the water comes from the soil or the surrounding environment, the glucose is either used (in photosynthesis) by the plant or gets stored (we eat the stored stuff), and the oxygen gets released into the air. This reaction requires energy input (the sun provides this) and can be called **endergonic**. The numbers simply balance the reaction, showing matter is not lost or gained.

Respiration can be defined as the release of the stored energy from glucose; this stored energy is transferred to a molecule called ATP that is used to drive any process in your cells that needs energy input. (Recall the many "coupled" reactions we have seen).

$$2C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 12H_2O + \text{ATP (energy)}$$

Because this reaction releases energy, it can be called **exergonic**. Note how the number of atoms on each side of the equation is balanced. This is important in chemical reactions.

An example of this reaction occurs during intense physical exertion. While contracting muscles, you need lots of ATP. This is because your muscles need ATP to do what they are supposed to do (i.e., contract and release, contract and release). Where does this ATP come from? You obtain it by retrieving sugars that are stored in your liver (they got there by digesting more complex foods in your digestive tract) and carrying them via your bloodstream to your muscles where respiration occurs to move the energy from glucose (that began as energy in the sun) to ATP which make your muscle cells work.

Note that the balance sheet is even. The only discrepancy is the energy budget. A lot more solar energy is available than gets stored as glucose, and more energy is available in the glucose than gets transferred to ATP. All the energy that is not stored is “lost” as heat. Have you ever noticed that you warm up during intense physical exertion?

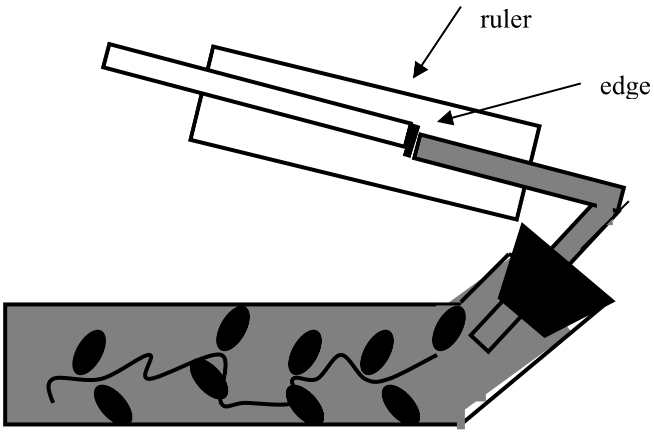
In an earlier lab, you learned about osmosis and diffusion, two pervasive chemical processes. These processes are free; they require no energy because stuff is moving from a high concentration to a low concentration. However, life often requires that we move stuff the opposite way: from a low concentration to a high concentration. It also requires that this movement happens in an organized fashion. This takes energy. In short, life needs energy. ATP is this energy.

In this lab you will perform a simple procedure that will allow you to measure photosynthesis and respiration indirectly by noting production and consumption of 0_2 in an aquatic plant you have used before---*Elodea*.

Procedure

1. Place an *Elodea* sprig in a test tube that is equipped with a rubber stopper and a bent glass tube. Before capping the tube, fill the tube with $NaHCO_3$ (sodium bicarbonate) solution. Add enough solution so that when the stopper is inserted into the tube, the solution comes to rest at about one-fourth the length of the bent glass tubing. Your instructor will help you adjust the position of your ruler.

($NaHCO_3$ provides an abundant source of dissolved CO_2. When the edge of the water in the chamber tube moves forward or backwards, it indicates if O_2 is being released by the plant or used by the plant. (Keep in mind the CO_2 in the system does not behave this way—it becomes immediately dissolved in the water and does not move the edge).



Formation of O_2 bubbles displaces the $NaHCO_3$ solution and moves the edge to the left in this diagram. Consumption of O_2 makes the edge move to the right in this picture. The distance moved is directly proportional to the amount of O_2 produced or consumed.

2. Place the tube near a light source on the lab bench.

3. Record the position , according to your ruler, of the solution "edge." As soon as the edge of the solution in the thin glass tube begins to move away from the *Elodea*, time the reaction for 10 minutes. At the end of the 10 minutes, record the new position of the edge of the solution in the tube. **Record in millimeters [mm]--how far the edge moved.**

4. During this time, answer questions 1 and 2 on your requirements page

5. After the 10 minute "light reaction" wrap the test tube in aluminum foil to mimic a period of darkness. Wait for the bubble to stop moving forward. This might take a while (10-15 min.). Once it has stopped moving forward, begin a 10 minute trial "in the dark", and measure the distance and direction the edge moves.

6. Replace the *Elodea* and $NaHCO_3$ solution and clean and dry the equipment and lab area.

Note: always pay attention to the direction that the fluid is moving. Moving in opposite directions must mean that something is either being consumed or produced. Be sure to record direction of movement with '+' or '-'.

Name________________________

Requirements Lab 6

1. Refer to the chemical reactions you have studied above, and explain your understanding of production or consumption of O_2 during photosynthesis and respiration. (*4pts*)

2. Based on production or consumption of O_2 in each process (photosynthesis and respiration), provide a hypothesis regarding how the edge will move in the light and dark parts of your experiment. For example, will the edge move <u>toward or away</u> from the test tube in each experiment? *(4pts)*

A. Light experiment

B. Dark experiment

3. (2 pts) Data collection: How far (in mm) did the bubble move in the "light"? How far (in mm) did the bubble move during the "dark" ?

<u>LIGHT</u>	**<u>DARK</u>**
Initial_________	Initial_________
Final__________	Final__________
+ or - Distance moved____________	+ or – Distance moved___________

4. (2 pts) Remember, the *Elodea* does both photosynthesis and respiration.

a. Assuming the Elodea did not have any spare ATP, when did photosynthesis occur? (light and/or dark?)

b. When did respiration occur (light and/or dark?)

5. (3 pts.) If the *Elodea* had not been respiring during photosynthesis, how far would the edge have moved? (**Tell exactly how far, i.e., a number in mm.**) Please show your math and check to see whether it makes sense!