# RESPIRATION AND PHOTOSYNTHESIS - THEY'RE A GAS!!

Respiration and photosynthesis -- what could be more essential? Photosynthesis is the basis for life on earth since it harnesses energy from the sun and converts it into a usable form….respiration breaks down food (ultimately from plants) and converts that into energy that powers all living things.

These fundamental processes can be confusing! Here are some guidelines for open-ended explorations to help students explore these concepts.

**Materials**

- Bromothymol blue (btb) indicator (0.04% aqueous) *available through biological supply companies; e.g. Ward's: http://wardsci.com/product.asp?pn=IG0015113&bhcd2=1236049867 944V7004; 100 ml $3.50*
- Many small baby-food sized jars or containers
- Small vials or test tubes
- Germinated radish seedlings (about 4 days old, germinated on moist paper towels; should be able to see roots and root hairs
- Elodea water plant
- Small aquatic snails (that will fit in the tubes or vials)
- Clay
- Straws
- Large bottles for storage of indicator
- Light source
- Rubber bands
- Unlined (one side at least) index cards
- Droppers
- Dry ice (optional)
- Colored pencils (optional)
- pH paper in 0.5 pH units (optional)

Prepare diluted indicator by adding 3 ml 0.04% btb into 250 ml tap water. If it is not blue, add *a few specks* of baking soda and stir.

**To Do and Notice**

*Indicator*

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1. Pour some of the blue btb diluted indicator into a beaker or jar. Observe the color. Get a straw and slowly blow into the indicator. Keep blowing for about 30 seconds. What happens?

2. Get three fresh beakers of the dilute indicator. Leave one blue, then blow into the other two to change one to green and one to yellow. Why do you think this happens?

3. (optional). Test each of the three colors of indicator with pH paper. IMPORTANT! Leave the pH paper in the solutions for at least one minute prior to reading (unbuffered solutions, as these are, react more slowly with the dye in the pH strips). How much do the pH's differ?

4. (optional) Begin with a flask of blue indicator. Add a tiny chunk of dry ice to the indicator. What happens? You may try the same experiment with gas produced by yeast (yeast +sugar +water in a test tube in warm water bath; test tube is stoppered, with aquarium tubing transporting the gas produced from the test tube to a jar of indicator). You may also want to try this same experiment by adding lemon juice.

5. What do these explorations tell you about the nature of the btb indicator?

*The Living Stuff Explored*

*A. Guided*

1. Prepare some of the btb indicator so that it is green.

2. Fill, nearly to the top, 3 small vials with the green indicator.

3. Take 4-5 radish seedlings. Place the roots in the fluid in one vial. Support the seedlings, and seal off the fluid from the air, by putting clay around the top of the vial and seedlings.

4. Take 4-5 radish seedlings and prepare as above, but put the leaves in the fluid, and the roots sticking into the air. Do nothing to the third vial (this is

your control). You may wish to record the original color with colored pencils in your notebook.

5. Rubber band the vials together, and place all of the vials under a light.

6. Predict what will happen to the colors of the indicator. Why do you make that prediction?

7. Let the vials alone for 15-20 minutes, then observe. Placing the vials on a white index card, and placing one behind them, will help reveal the true colors of the fluid. What happened? How do the results compare to your predictions? You may wish to quantify your results by using pH paper, or recording the colors with colored pencils.

*B. Open Exploring*

Design your own experiments! Materials available include those we've used above, as well as Elodea and snails. Always make sure that you predict what will happen, and why you think so, before the experiment gets underway.

**What's Going On?**

*Indicator*

Bromothymol blue dissociates at its transition point of (indicator dissociation constant) of pH 7. Below 7 it's yellow, above 7 it's blue and right at 7 it's a mix, so appears greenish. When starting with a green solution, addition of acid turns it yellow, removal of acid (addition of base) turns it blue.

Carbon dioxide reacts with water to form acid in the reversible reaction:

$H_2O + CO_2 \rightarrow H_2CO_3$

Addition of carbon dioxide will turn the indicator yellow, removal will turn it blue.

***** Careful!** Water from different taps will yield different colors with btb; you can adjust with breath or a tiny pinch of baking soda (careful!!! Use very little because it is a buffer and more than a speck will make it difficult to change the pH of the indicator). Distilled water will be yellow, because it contains a lot of carbon dioxide. You can gradually change it to blue also by letting it sit open to the air -- the extra carbon dioxide will diffuse out into the atmosphere, neutralizing the pH.

*Living Stuff*

Under light, green plants will photosynthesis, using carbon dioxide and producing oxygen.

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

This should increase the pH of the indicator.

When organisms break down food while using oxygen to produce usable energy, they produce CO2 lowing the pH. The chemical equation is essentially the reverse of photosynthesis.

A surprise you may find are that respiration and photosynthesis can occur simultaneously.

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