Chapter 7

Respiration and Photosynthesis

7-1 Laboratory Investigation

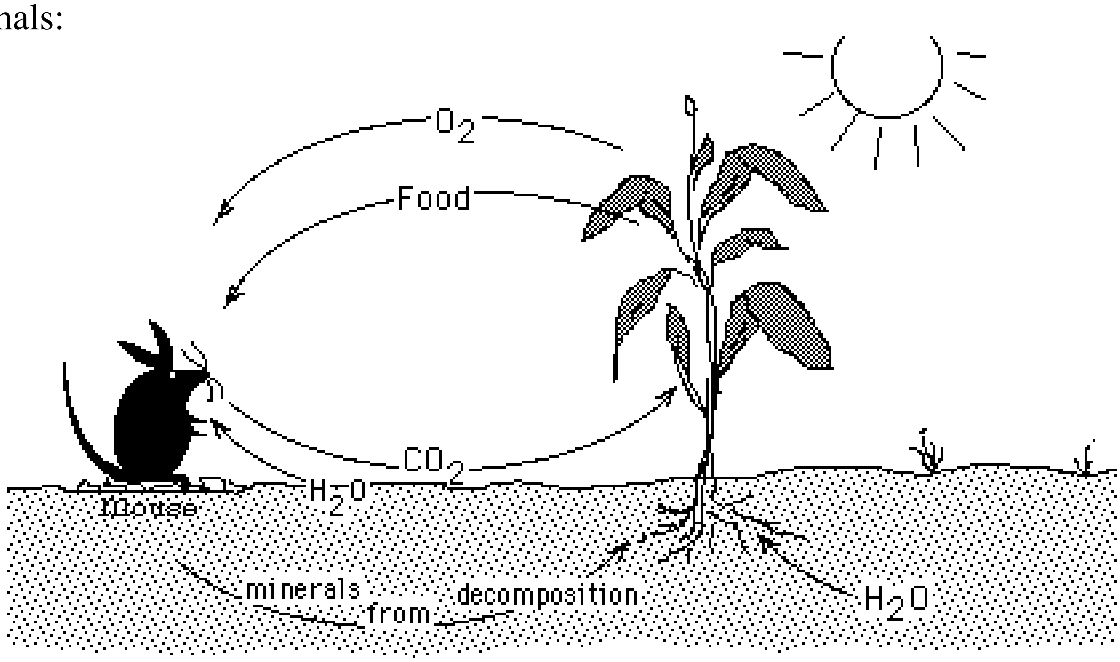
Can You Design an Experiment
to Test a Hypothesis?

Objective

You will be expected to design and conduct a series of experiments to determine the relationship between a pond snail and the aquatic plant, *Elodea.*

INTRODUCTION:

Examine the following diagram that shows an interdependence between plants and animals:



1. Do you think that this diagram would apply to <u>every</u> plant and <u>every</u> animal? (Give the reason for your answer.)

<u>MATERIALS AVAILABLE FOR THE EXPERIMENTS THAT FOLLOW:</u>

Glass vials with screw cap lids
pond or aquarium water
2 - 3 pond snails
labeling tape
.01 N NaOH solution
Bromthymol blue indicator
straw
2 - 3 pieces of *Elodea* (pond plant)

In this lab activity you will be designing your own original experiments to determine if the relationships in the drawing above apply to a pond snail and pond plant (*Elodea*). Then you will conduct your experiments as planned and collect and interpret the data. Finally, you will indicate your conclusion about whether the hypothesis is supported by the data or not.

PRE-LAB
In this investigation, you will use a chemical indicator called **bromthymol blue.** To discover its properties, perform the following brief procedure:

a. Fill a small beaker or similar container about 1/3 full of tap water. [___]
b. Add about 7 drops of bromthymol blue indicator. [___]

2. What color is the resulting solution?

If the solution is not blue, add 1 drop of .01 N NaOH solution and stir. ***<u>Caution:</u> Sodium hydroxide is corrosive. Avoid contact with the skin. If sodium hydroxide gets on the skin, flush the area with water and notify your teacher.*** Add drops until the solution is blue. Do not add beyond this point. When bromthymol blue indicator is blue, this indicates that no carbon dioxide is present in the solution. Human breath contains carbon dioxide. Use a straw to gently blow your breath through the bromthymol blue solution in the beaker until no more change takes place. [___]

3. What color did the solution finally become as you blew through the straw?

4. What other colors did you observe as the solution was turning to its final color?

5. What color is bromthymol blue indicator when carbon dioxide is present in a

solution?

NaOH removes carbon dioxide from a solution. While stirring, slowly add enough drops of .01 NaOH to the solution containing carbon dioxide to turn it back to blue. Once the solution is blue, it contains no carbon dioxide. [___]

6. Copy the following into your report and complete each sentence:
   When bromthymol blue is **blue**, it means _____
   When bromthymol blue is **yellow**, it means _____
   When bromthymol blue is **green**, it means _____

If the relationships in the drawing on page 1 are suspected as being true for the snail and *Elodea*, then one hypothesis could be written as follows:

<u>HYPOTHESIS 1</u>: Snails give off CO_2. 

Copy this hypothesis into your lab report and label the statement as "**HYPOTHESIS 1**". [___] Label the next section of your report as "EXPERIMENTAL DESIGN FOR HYPOTHESIS 1" [___] Under this title, draw two boxes as follows:

EXPERIMENTAL DESIGN:

Experimental set-up	**Control set-up**
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

In the boxes on your paper, <u>draw</u> how you will set-up an experiment using the materials listed on page 1, to test hypothesis 1. You don't need to use all the materials listed. Take time to think through what would be needed. Be sure to include what needs to be set-up as a control. Add any written description on the lines below each box. [___]

PREDICTION OF RESULTS:

Next add the label heading “PREDICTION OF RESULTS” to your report just below the two experimental design boxes. [___] Now write what results you would “expect” **if** hypothesis 1 were true. Write the expected results for the experimental set-up and the control set-up. [___]

LEAVE ABOUT THREE BLANK LINES IN YOUR REPORT AT THIS POINT FOR TABULATING THE RESULTS OF THE EXPERIMENT THAT YOU WILL OBTAIN IN A DAY OR TWO. [___]

HYPOTHESIS 2: ***Elodea* take in CO_2.**

Now copy the above heading and hypothesis into your report after the spaces left for the results for hypothesis 1. [___]

Go through the same steps for hypothesis 2 as you did for hypothesis 1 and use the same headings as before.
Experimental Design: (With the 2 boxes)
Prediction of Results:
Space for Results: [___]

READ THE FOLLOWING HYPOTHESES, WHICH WERE WRITTEN BY EXAMINING THE DRAWING ON PAGE 92:

Hypothesis 3: *Elodea* use CO_2 snails give off.
Hypothesis 4: Snails give off CO_2 in the dark.
Hypothesis 5: *Elodea* take in CO_2 in the dark.
Hypothesis 6: *Elodea* use CO_2 that snails give off in the dark.
Hypothesis 7: *Elodea* give off CO_2 in the dark.

Continue copying each hypothesis, and then design experiments to test each one. Use the following steps for each of the 7 hypotheses:

Copy the hypothesis:
Experimental Design: (With the 2 boxes)
Prediction of Results:

Space for results, interpretation and conclusion: **[___]**

DAY 2:

CONDUCT THE EXPERIMENT AS PLANNED:

Your teacher may assign certain hypotheses for your table to test while others set up experiments for the other hypotheses. Follow the directions you wrote for your experimental designs. **Set up the experiments and controls for the hypothesis assigned to you. [___]** Have your teacher check all vials for your table before you place them in the designated light or dark cabinets. [___] Your teacher will announce the locations of the light and dark areas where you will place the vials to remain overnight. All caps should be left loose. All vials should be filled to within a half-inch of the top. [___] Whenever a snail or *Elodea* is required, use only one. The *Elodea* piece should be the length of the vial. [___] Place a **label** on each vial with the following: Name, hypothesis number. [___]

DAY 3

RECORDING THE EXPERIMENTAL RESULTS:

After you have set up the experiments and let them set overnight, examine your tubes and record the results under the report heading **Experimental Results.** Record the results for each experiment that was done at your table. Only record the colors obtained. [___] Also visit a table next to you to obtain results of any experiments that your table did not set up. [___] Be sure to record the color for each control and any other observations about the snails or Elodea. [___]
You should have the results for experiments for hypotheses 1 through 7. [___]

Clean up the vials only when all students have had a chance to obtain the data. To clean up the tubes, place the snails and *Elodea* in the containers set up to receive them. Remove the labels from the vials and wash and rinse them. Return the clean vials and lids to your tray. [___]

INTERPRETATION OF RESULTS:

For each hypothesis, add the title **Interpretation,** in the blank space below the results. [___] Interpret the results for each hypothesis by writing a statement about what the data means in each experiment. Statements about CO_2 use or production are appropriate. [___]

CONCLUDING STATEMENTS ABOUT THE HYPOTHESES:

For each hypotheses, add the title, "**Conclusion",** in the blank space below the interpretation. [___] Now insert your concluding statement about each hypothesis according to the data you obtained. Select one of the following for each hypothesis: **hypothesis supported, hypothesis contradicted or hypothesis not supported. [___]**

ANALYSIS AND CONCLUSIONS

How does the use and production of carbon dioxide by snails differ in the dark and in the light? How is it different for the *Elodea?*

Teacher's information begins on the next page. >

Teacher Information for:
CAN YOU DESIGN AN EXPERIMENT TO TEST A HYPOTHESIS?
Lab Activity 7-1

I. Concepts taught
A. Content objectives:
As a result of class analysis of the experiments, students will conclude that: Snails produce carbon dioxide in light or dark. Elodea produces carbon dioxide in the dark. Elodea uses carbon dioxide in the light. Elodea uses carbon dioxide in that snails give off in the light.
B. Inquiry process objective:
Experimental design, role of the control group, experimenting, observation and data recording, interpreting data and conclusion about hypotheses

II. Prerequisite knowledge:

This inquiry should only be attempted after students have been exposed to 3-4 other inquiry activities of less difficulty. Significant review and mastery of the steps in the scientific process is essential before students can be successful in this activity. Also review the following three alternative conclusions that can be used with respect to any hypothesis:

1) **Hypotheses supported.** (Hypothesis "seems" to be true and the data is what would occur if the hypothesis were true.)
2) **Hypothesis contradicted.** (Hypothesis "seems" to be false according to the data.)
3) **Hypothesis not supported.** (The hypothesis "seems" to be neither contradicted nor supported by the data.)

Note: Distinction between two and three is difficult for students.

III. Time requirements and teaching strategies:
Day 1: Do the pre-lab and begin to design the experiments. Have them design an experiment for hypothesis 1 and then discuss it. Do the same for hypothesis 2. Then see if they can design the rest independently. Complete at home.

Day 2: Review designs (about 15 minutes), then set up the experiments (about 30-40 minutes more). You might have each table test only 3-4 of the hypotheses. Otherwise an extra day will be needed. One table can set up hypotheses 1-3 (in light), the next table hypotheses 4-7 (in dark) and alternate around the room. If you determine that it is easier for your students to do one experiment per day, do so.

Day 3: Collect data and draw conclusions. (About 45 minutes)

When this lab is completed it would be a very appropriate time to introduce how a hypothesis can be written in an "IF - THEN" form. An example of this could be taken from the lab.   For Example:
If snails give off CO_2 , **then** a vial containing a snail and blue BTB will turn yellow & the control will not. (The phrase following the "If" is the simple hypothesis. The phrase following the "then," is the experimental design and results expected if the "if" part is supported.)

V. Materials needed and set-up instructions:

Set out one tray for each table (8)

In each tray place:
1 dropper bottle of Bromthymol blue
Prepare BTB as follows:
0.4 g BTB powder
6.4 ml 0.01 N NaOH solution (see appendix if needed)
993 ml tap water
Makes 1 liter.   Mark bottle as "stock solution" and dispense to labeled dropper bottles. (Adjust amount of .01 NaOH if you live in an area with very basic or acidic water.)

1 dropper bottle of 0.01 N NaOH solution
Prepare as follows:
Place .4 g. of NaOH crystals in 1000 mL of tap water.
Distribute to labeled dropper bottles. **CAUTION: TEACHERS ONLY SHOULD PREPARE NaOH** (Sodium hydroxide) Use gloves, apron and goggles. Caution students to avoid contact with the body and face. .01 N is an extremely weak concentration and not nearly as harmful as stronger solutions.)

1 beaker or container of water and 3-4 small living pond snails plus 4-5 sprigs of Elodea about 3-4 inches long.
2 plastic or paper straws
5-6 vials with screw caps or similar containers to contain snails, water and Elodea. (Other containers can be substituted)
An area in the lab lit for 24 hours (preferably with plant grow-bulbs, otherwise use a well-lighted window) and an area shielded from all light like a closed cabinet. 1 extra container of water.

A total of about 20 snails will be required per class. (Most will survive unharmed.)
A total of about 20 elodea sprigs will be required per class. Snails and elodea can be

ordered from Carolina Biological Supply in NC.

INTRODUCING THE LAB ACTIVITY (Class introduction)

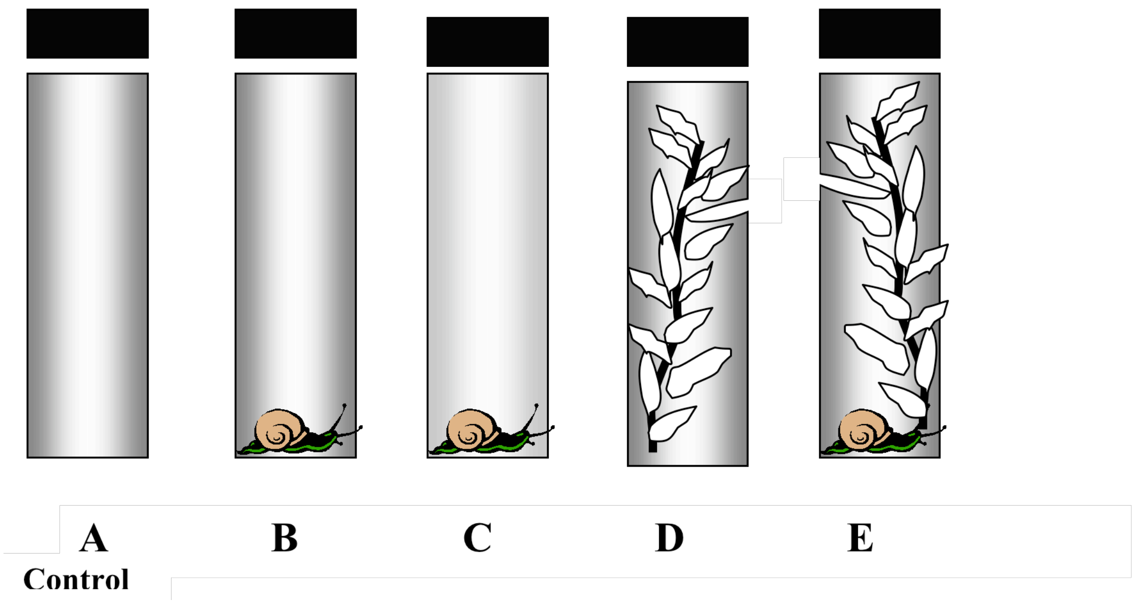
Have students examine the drawing on the first page of this lab and write an answer to question 1. Then have 3-4 students give their answers and reasons. Lead them to understand that the diagram does not apply to all plants and animals. There are exceptions. Then pose the general question, "Is this diagram accurate for a pond snail and the pond plant elodea?" Point out that this lab activity is designed to determine the answer to this question. Show the students the materials listed on page 1 of the lab and have them go into the lab to do the pre-lab only. Return to the classroom and begin working on designing experiments for hypotheses 1 - 3 only. Students should attempt to design the experiments needed for this activity independently. If students work in a group and cooperatively design experiments, the group will usually accept the first reasonable idea voiced and this deprives the others from doing their own creative thinking. It's advisable to circulate among the students as they work on designing the experiments to help steer them on the right track. Announce to the students that there is more than one way to design these experiments. You might want to review the designs for the first three experiments with the entire class before assigning the others. Hypotheses 4 through 7 could be done at home if you run out of class time. This will depend on the ability of the class.

Design for hypothesis 1 and 4: (Snails give off CO2)

Refer to the drawings that follow for diagrams showing how to set up experiments for each hypothesis.

In both cases set up 2 vials with water and a few drops of BTB to produce an obvious pale blue color. Add a snail to 1 vial. The set-up will look like "A" and "B" below, with "A" as the control. For hypothesis 1, the two vials go in the light. The light should be on the entire 24 hours. For hypothesis 4, the vials go in the dark. Vial "C" along with a control like "A" need to be put in a dark cabinet or box. Good results are obtained in 24 hours. All vials should start out blue, showing no CO_2 present. On the 2nd day, the vials containing the snails should be yellow, showing the production of CO_2. The controls should remain blue. In every experiment for each hypothesis, the controls are expected to retain the starting color.

Some students might suggest that the BTB test be made on a portion of the water before it is placed in the vial and then tested again after the 24-hour period. That way, no BTB will come into contact with the snail. This is an acceptable alternative. This alternative might be suggested for all of the hypotheses. Caps should be loose and about one-fourth inch of air space left at the top of each vial.



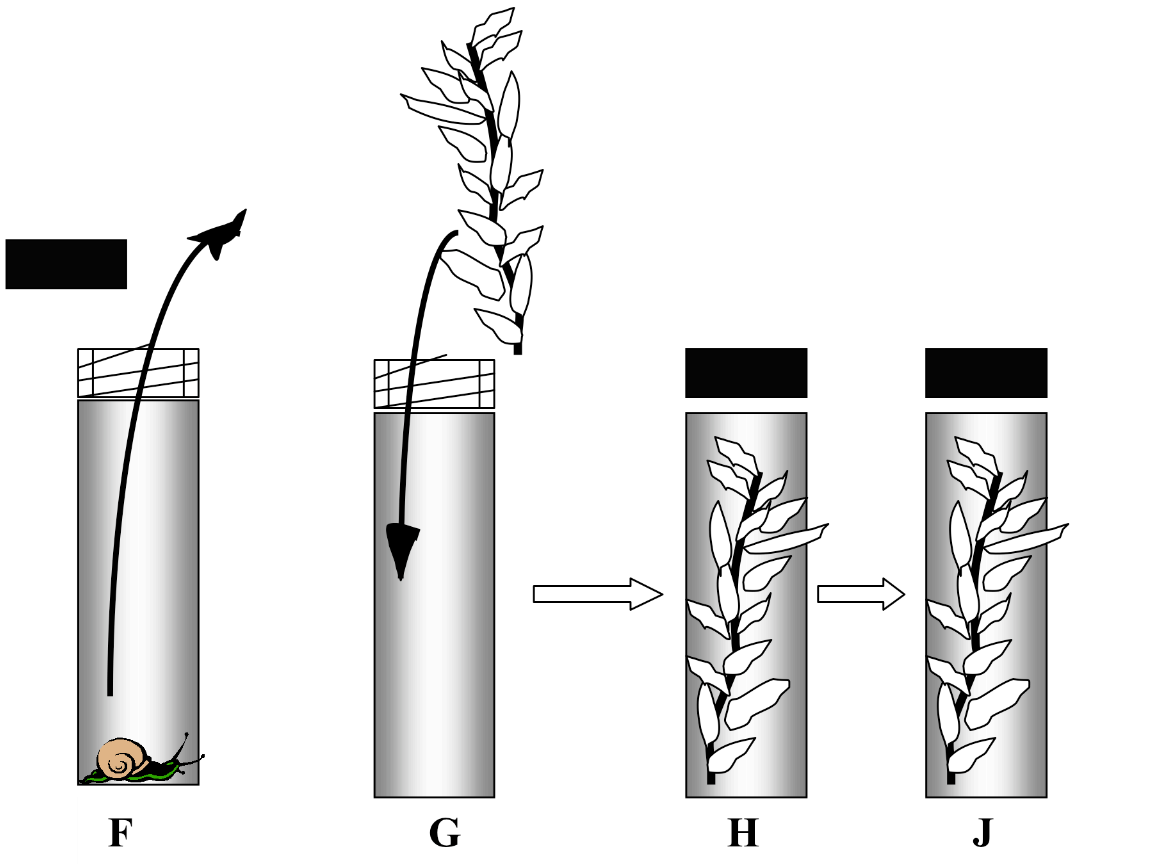
Hypothesis 2: (Elodea take in CO2 in the light)

Set up vials "A" and "D" in the light. Both should start out yellow. Add the CO_2 by blowing one's breath into the solution with a straw. "D" will turn blue by 24 hours since elodea does take in CO_2 in the light.

Hypothesis 3 and 6: (Elodea use CO2 that snails give off.)

The best way to set up this experiment involves a two-day sequence shown in vials "F" through "J" in the drawings that follow. Place a snail in blue BTB and allow it to stand overnight in the light for hypothesis 3 and in the dark for hypothesis 6. A control like tube "A" should accompany each set-up. The next day, the BTB should be yellow for the vial containing the snail. On the 2nd day, the snail should be removed and exchanged for elodea as shown in vials "F" and "G". Leave the vial, now looking like "H," overnight. This vial should turn back to blue in the light ("J") since elodea do use CO_2 that snails give off. Hypothesis 3 is supported by the results. The set-up left in the dark for hypothesis 6 should remain yellow, since **elodea do NOT use CO2 that snails give off** in the dark. In fact, hypothesis 4 showed that elodea gave off CO_2 in the dark.

Some students will design experiments for hypotheses 3 and 6 that will have both the snail and elodea in one vial like vial "E". This is not as good as the preceding design but students can be allowed to set up this vial and they can later discuss the pros and cons of each design. Rational can also be provided for setting up vial "E" with vials "A" and "B" as controls.



Hypothesis 5: (Elodea take in CO2 in the dark.)

Set up vial "D" with yellow BTB made yellow by blowing breath into the solution with a straw. Set the vial along with a yellow control like "A" in the dark. The elodea will not turn the BTB blue since elodea does not take in CO2 in the dark. They produce CO2 in the dark.

Hypothesis 7: (Elodea give off CO2 in the dark.)

Set up a vial like "D" in the dark. Be sure the BTB is blue in both the control and the experimental vials. After 24 hours in the dark, the experimental vial will be yellow and the control blue. In all of the above experiments, students should be able to interpret the data observed. In this case the interpretation is that the elodea gave off CO2 in the dark. Hypothesis 7 is supported by the data.

In discussing the interpretations of the data obtained for these experiments, no attempt is being made to discuss the fact that plants carry out both respiration and photosynthesis both in the light and only respiration in the dark. In this activity, it is expected that students will provide interpretations only for which there is data.

Computer Data Collection Option:

Have all students design and perform this experiment using BTB as described above. Then demonstrate how technology can be applied to gather data for these experiments. If you have pH-sensing computer probes, you can perform each of these experiments by inserting the probes into the experimental and control containers for each experimental set-up. Do not use bromthymol blue in these set-ups. If you only have one probe, test each set-up separately. As carbon dioxide is produced, the pH will drop. As carbon dioxide is used up, pH will rise. Be sure each set-up is either in the dark or light, as the experimental design requires.

Set up the software according to the manufacture's instructions for gathering pH data. Run each experiment for 24 hours.

Most teachers that use this option have students first perform the experiments by depending upon the bromthymol blue results alone and then demonstrate how the computer can be used to gather the data as well.

The necessary probes and interface are available from *Vernier Software* in Portland. OR (Do an Google search for Vernier.)