

“What’s going on with plants and CO₂?”

Elodea (anacharis)

TEACHER GUIDE

Instructional Goals

Students likely already have some ideas about photosynthesis coming into high school biology classrooms, but there is usually a lot of confusion about whether plants take up, give off or take up AND give off carbon dioxide. There is usually parallel confusion about oxygen. Here we test ideas about CO₂ output and uptake under both light and dark conditions using BTB solution to measure associated changes in the pH of the surrounding environment.

The lab gives students an opportunity to design their own investigation (refer to the NGSS Science and Engineering Practices or SEPs) into the role of CO₂ and plants. Your role is to press them to consider how their experimental design addresses their questions or does not. It’s OK for some student groups to “fail” to design a complete investigation with proper controls, etc.: the class will eventually work together to build some model ideas around the process of photosynthesis and the role of carbon dioxide. Be sure to review the ensuing activities so that you have a sense of what conversations to foster following the review of the results.



Lab Setup and General Instructions

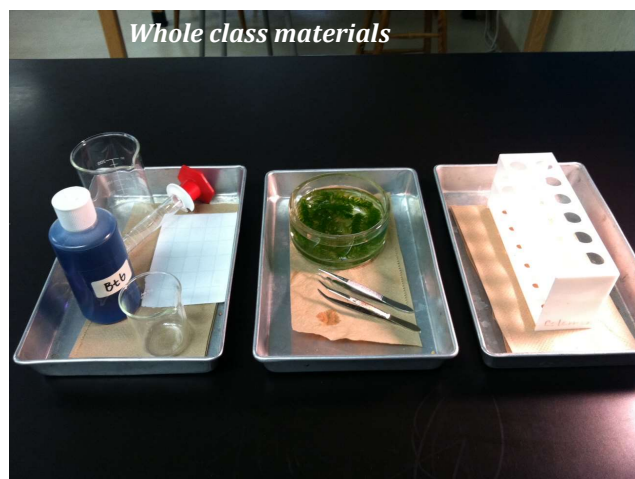
MATERIALS

1. test tube rack
2. 4-8 standard test tubes but approx. 14mm x 125mm (big enough for *Elodea*) with screw tops, corks or stoppers
3. *Elodea* – in finger bowl or beaker of water with 4 or 5 2”-3” pre-cut sprigs per class
(Sold by Carolina Biological or at sold at pet stores as “ANACHARIS”. You’ll need about 4-5 bunches per class depending on quality.)
4. large dropper bottle Bromothymol Blue
(Dilute stock solution 1:10 with distilled H₂O then further dilute 2 parts tap H₂O: 1 part BTB.) Need approx. 1 liter per class (assuming 8-9 groups/class).
5. 2 forceps
6. labels - 1 sheet (or masking tape works too!)
7. 100ml beaker (for bubbling CO₂ into BTB)
8. 10ml or 25ml graduated cylinder
9. goose neck lamp or plant light banks in classroom

Per Lab Group



Whole class materials



Whole Class

For “DARK” conditions:

1. lockers or drawers for students to store sealed tubes overnight, or aluminum foil cut into approx. 5x5” squares (about 2/group) to cover test tubes tightly.
2. straw

For demo of BTB properties:

1. CO₂ water in a dropper bottle
2. dilute NaOH in dropper bottle (to demonstrate reversibility of BTB)
3. test tube rack and 3-4 test tubes



DAY BEFORE THE LAB

1. Demonstrate the properties of Btb. Important that students see: 1) that it is blue out of the bottle, 2) turns 1st green then yellow with increasing amounts of CO₂ water added (explain that this is because CO₂ is an acid), 3) that it is reversible – turns back to blue if CO₂ is removed (or neutralized with a base but removing CO₂ would have the same effect). Have students take notes on these demonstrations.
2. Give students time in class or have them do as homework: read the lab carefully and think about what they would need to put in test tubes to get answers to the experimental questions. Have them color the test tubes on the lab handout to show how they will set them up. Have them do this individually first – they will share their ideas with group members the next day.
3. Emphasize the importance of recording everything they do and labeling test tubes carefully.
4. For HW: students do “prelab” 1) make and explain overall hypotheses, 2) Write out the procedure they did in their group, 3) create their data table and fill in the 1st five columns based on how they set up their lab.

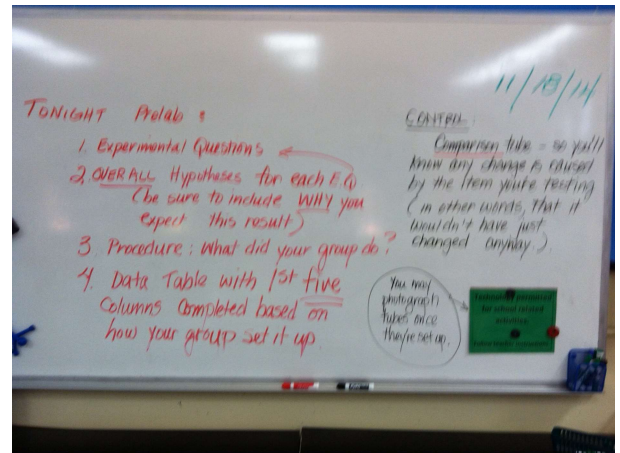
DAY 1 OF THE LAB

1. Using talking sticks, have the students begin by sharing their ideas about how to set up the experiment, discussing, and coming to a consensus. Give each group a copy of the “LIGHT test tubes” and “DARK test tubes” pages. Color the “Start” test tubes to show how they decided to set them up. They will color the “End” rows tomorrow, then glue these on to the poster they will make.
2. Have all materials easily accessible. Once groups have decided on how they want to proceed they go ahead and set up their test tubes.
 - a. If you are short on test tubes tell students that any test tubes, they wish to set up without plants you will set up for them for them. The whole class will share these.
 - b. If you haven’t gone over it before, establish what a “control” is and why controls are needed. It is ok if some groups don’t set up proper controls – they will see the problem with their design at the end. However you do want at least some groups to have them so that you will have those results to discuss so you may have to “seed” a few groups. Circulate and gently question if they do not seem to be getting the idea. “So how will you know if the color changes that it was the plant that changed it?” etc.

DAY 2 OF THE LAB

1. Record final indicator colors for all test tubes.
2. Clean up materials.
3. Groups color "End" test tubes to show what the test tubes look like today.
4. Discuss in groups "Interpretation" column of data table and work together on Discussion Questions but each student write own answers.
5. Conclusion of labs can be done as homework or you can have them make a group poster of results and answers to the experimental questions. **This is highly recommended!** If they are doing posters, start by gluing the "Light" and "Dark" test tube pages onto the poster.

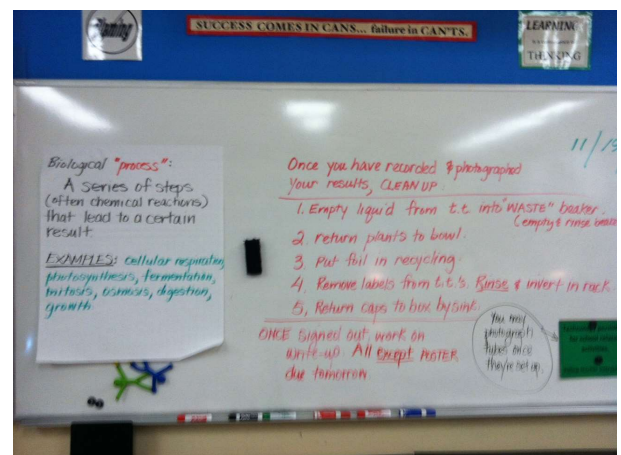
Front board outlining Pre-lab work and HW



Control tubes set up by teacher per student instructions



Sample board showing clean-up instructions



AFTER POSTERS ARE COMPLETED:

1. Do gallery walk or some other method to get students to look at and analyze the conclusions (posters) of other groups.
2. All class discussion of conclusions. Be sure to establish what processes are responsible for the results.
3. To uncover student thinking about when photosynthesis and cellular respiration occur have students respond to “Light and Dark” formative assessment individually.
 - a. Next students go to the corner with the name of the person with whom they agree.
 - b. Once in their corner students discuss their reasons for their choice and choose a spokesperson to justify their choice to the rest of the class
 - c. After all 4 corners have been heard, the students can decide to move to another corner or stay
 - d. Many students will conclude that the data from the lab shows that photosynthesis happens in the light and respiration happens in the dark. Hopefully some will think that a cell always needs energy (ATP), even in the light, and will argue that position. You will have to guide the discussion to that final conclusion. One way to help the students think about this is to ask: “How long can you survive without oxygen?”

Further discussions will help the students make sense of the idea that plants photosynthesize only in the light because the light is a source of energy that allows them to convert CO₂ and H₂O to glucose but are always undergoing cellular respiration due to the need for ATP (energy) to carry on life processes.

Support Materials

PowerPoint Slides

Photosynthesis Lab

Light and Dark Four Corners Handout