Unity and Diversity of Respiration
"Do all living things give off CO_2?"

TEACHER GUIDE

Instructional Goals
This lab takes us back to the overarching theme of unity and diversity in the curriculum. We've come to recognize that we get our energy through the reaction of cellular respiration. This reaction of glucose with oxygen yields a lot of energy in the cell in the form of ATP, an energy "carrier molecule" or "taxi" that moves energy about the cell. One of the products of the reaction is CO_2 and so we get rid of this "waste" product as we exhale. But do all living things give off CO_2? If they do, we might suspect that cellular respiration is a universal chemical reaction we can add to our list of unifying features of life.

It's important to frame this lab as a return to unity and diversity with your students. There are a few tasks that may help you to accomplish this:

1. Revisit the Unity and Diversity Part 1 list of things that all life has in common. Some classes may have already generated ideas about cellular respiration (or at least oxygen and carbon dioxide) all the way back at the beginning.
2. Connect the use of radish seeds, insects, and yeast in this lab to an intent to test a sampling of diversity. Each represents a different major group (plants, animals, fungi).
3. Be willing to do some of your own research as questions arise. We counter-point the conclusion of this lab (yes! everything respires in this way!) with a follow-up discussion of fermentation and anaerobic conditions. But there are other examples of diversity out there, including organisms that use sulfur as a reactant instead of oxygen. The commonality, in truth, is that all organisms must somehow obtain the energy they need. Cellular respiration just turns out to be a pretty darn good way to do that which may explain its ubiquity among living things. (And yes, many bacteria do something much like cellular respiration without having mitochondria!)

Lab Setup and General Instructions

<u>TWO DAYS BEFORE LAB:</u>
Soak (overnight) enough radish seeds to provide 25 per pair of students.
(If seeds are old you may want to 3 days ahead of time so they can germinate for 2 days)

<u>DAY BEFORE LAB</u>

<u>For each lab table:</u>
2 pairs scissors, paper towels, 2 petri dishes, 600ml beaker of water, dish with enough pre-soaked radish seeds to provide 25 per pair of students and a spoon to scoop out the seeds.

Instructions for Radish Seed Preparation
(These are also provided in a couple of PowerPoint slides which you can project during the lab.)

1. Obtain one petri dish (top and bottom) per lab station.
2. Cut 6 circles of paper towel to just fit bottom of petri dish.
3. Label one circle with student #'s (use pencil or waterproof ink).
4. Dunk all circles in water. Allow excess to drip off.
5. Place 3 circles in bottom of petri dish.
6. Spread out exactly 25 radish seeds.
7. Cover with remaining 3 circles (labeled one on top).
8. Put lid on petri dish.

DAY OF LAB

Per 2 students:

- 1 test tube rack with small enough bottom holes to keep small test tubes from falling through (http://www.carolina.com/lab-tubes-tubing/test-tube-rack-economy-plastic/731880.pr?catId=10268&mCat=10216&sCat=10255&ssCat=&trail=4016:Rack)
- 6 very small (12x75) test tubes - plastic is best (http://www.globescientific.com/12x75-c-30_488_491.html)
- 6 corks or lids for small test tubes
- 3 medium test tubes (14x125) – glass ok.
- 6 screws (Flats, #10 x 3/4")
- 100 ml beaker to hold screws and corks
- 1 dropper bottle phenol red.
- 1 forceps
- 1 petri dish, top and bottom.

(The last two items are to help students manage their live insect. If there is an insect station, students bring their test tube to the station to obtain insect and place in test tube, this eliminates the last 2 items, though it is important to have a pair of forceps at the insect station.)

Per lab table (shared by two pairs):

- 1 dropper bottle club soda (label it "CO_2 water")
- 150 ml beaker with precut strips of paper towel ≈ 1.5"x 2.5" (each pair will need two)
- A dish with dry radish seeds (enough for 25/pair) and spoon.

For whole class:

2 - 150 ml beakers of unboiled yeast solution, in trays with a couple of pairs of forceps.
2 - 150ml beakers of boiled yeast solution, " "
Drinking straws (1 per pair of 2 students)
1 test tube rack, 1 test tube, 1 screw, 1 cork, plus one VERY dead, but not decomposing, insect (for test tube 10)

MIXING SOLUTIONS:

Phenol Red: Stock solution: .1g water-soluble phenol red powder/1 liter distilled H_2O.
For lab, dilute it: 7 parts tap H_2O: 1 part stock solution. Solution should be a purplish-pink in color.

Yeast: Prepare the morning of the lab. Dissolve 1 envelope of yeast + ≈ 1t of sugar in ≈ 300ml of tap water. Boil half of it for 10 minutes. Divide the unboiled and boiled each into two beakers so you can set up two stations for students to obtain each. (This can be prepared a day ahead of time and refrigerated.)

TIPS:

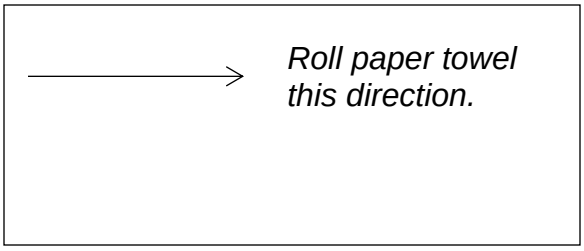
1. Posting the lab instructions on a PowerPoint slide is key!
   Example here… but see the PowerPoint slides and modify them as appropriate for your classroom.

   Part B:
   1. Set up 6 test tubes of Part B first. Allow as much time as possible with corks on. Be patient! Do Part A while you wait.
   2. Count: 6 corks, 6 screws. Be sure to leave the same in beaker when done.
   3. Stir yeast before using. Squeeze out excess – no dripping.
   4. Use ALL of your seeds that sprouted. Use an equal # of dry seeds.
   5. Put all solid waste in garbage. Only liquids in sink.

   Part A:
   1. Do this part while you're waiting for part b to change.
   2. Blow GENTLY through straw. (one per pair).

   Clean up:
   1. Rinse and dry petri dish. Put top & bottom together and place in box.
   2. Rinse screws & dry. Return to beaker in tray.
   3. Empty solid contents of test tubes 4-10 in trash. (Careful – don't throw out screws!!). Place the test tubes in plastic tub.
   4. Rinse test tubes 1-3 well. Invert and leave in test tube rack to dry.

2. Demonstrate to students how to tightly roll paper towel strip lengthwise, dunk in yeast solution and squeeze out all excess. If any yeast (or any other material) touches the phenol red it will change its color.



3. Very important that students prepare for the lab by doing the prelab questions and making the data table ahead of time. They should fill out the first three columns on the data table before starting the lab too. This ensures they have some idea of what they're supposed to be doing when they set up the lab.

a. Make sure students understand before starting the lab that yeast is a living thing…and think about what effect boiling would have on it.

b. If you haven't already covered it earlier in the year discuss "controls" and the need for them.

4. Before the students write their conclusions have them share and discuss their data. As with any lab (especially those with living things) error happens and it's important that the students have a clear understanding that only the active living organisms gave off CO_2.