

## Teacher Preparation Notes for Breathing and Holding Your Breath

by Dr. Ingrid Waldron and Jennifer Doherty, Department of Biology, University of Pennsylvania, 2008<sup>1</sup>

### Supplies

- stopwatches or watches to time 1 minute intervals (1 or 2 per group of 4 students)
- 13 gallon plastic bags (tall kitchen trash bags; 1 per student)
- graph paper (1 per student + extras available as needed).
- red and blue chips can be cut as 1 cm x 1 cm squares from construction paper to represent oxygen and carbon dioxide respectively in using the diagram of the circulation; some students find it useful to have O<sub>2</sub> printed on each red chip and CO<sub>2</sub> printed on each blue chip

### Supplies and Instructions for lung model construction

(to demonstrate inhalation and exhalation on the bottom of page 2)

- 4 oz baby bottle; clear, preferably cylindrical, without a wide mouth (1 per group)
- size 7 one-hole rubber test tube stopper (1 per group) [www.onlinesciencemall.com](http://www.onlinesciencemall.com) \$0.98/each
- drinking straw (1 per group)
- balloons (2 per group)
- electric stencil cutter or soldering iron to melt the bottom of the baby bottle off (can be found at any craft store such as Michael's or JOANN's)
- rubber bands (1 per group) and tape

Lung models can be purchased from both Fisher Scientific and Carolina Biological for between \$60-70. For just a few dollars, however, you can create your own model that works just as well. There are many websites with instructions for creating home-made lung models but we feel that using a rigid plastic bottle such as a baby bottle and a rubber test tube stopper greatly increases the model's effectiveness.

To create the model: melt off the bottom of the baby bottle with an electric stencil cutter. Cut the neck off one balloon and stretch it over the bottom of the baby bottle; secure it with a rubber band. This will function as the diaphragm. To construct the lung portion of the model cut a 3 inch piece of straw and put it through the hole in the rubber stopper so there is 1 inch sticking out the top. With tape attach the second balloon to the piece of straw sticking out of the bottom of the rubber stopper. Insert the rubber stopper with balloon into the baby bottle and push down until the rubber stopper is secure. To inflate the lung balloon pull down on the diaphragm balloon; to deflate simply release the diaphragm balloon. The model can be expanded to two lungs by using a y shaped connector tube ([www.homesciencetools.com](http://www.homesciencetools.com) Product #CE-TUBEY \$1.95/each) instead of a drinking straw and attaching a balloon to both tips of the Y.

### Suggestions for Discussion and Implementation

If your students are unfamiliar with the concept that a fire requires oxygen as well as fuel, you may want to incorporate the demonstration with a candle in a sealed vs. unsealed jar.

The relaxed diaphragm (during exhalation) is pulled into a dome shape by the elasticity of the lung, due in part to surface tension (which also keeps the diaphragm adjacent to the bottom of the lung).

You may find it helpful to distinguish between coma, brain death, vegetative state, and minimally conscious state. In coma, the patient is unresponsive, cannot be aroused, and has no awareness. This is usually a temporary state resulting from injury or lack of oxygen. Brain death is a permanent state with no electrical activity in the brain and with no consciousness, awareness or reflexes. This is generally accepted as equivalent to death of the individual. A person in a vegetative state can be aroused and can have reflexes, but shows no evidence of awareness or thought. A vegetative state can be caused by diffuse traumatic brain injuries or lack of oxygen, resulting in widespread, severe damage to both cerebral

---

<sup>1</sup>These teacher preparation notes and the related student handout are available at [http://serendip.brynmawr.edu/sci\\_edu/waldron](http://serendip.brynmawr.edu/sci_edu/waldron).

hemispheres, but with significant function in the brain stem. A person in a minimally conscious state has occasional periods of awareness and may sometimes reach for objects, respond to commands, e.g. by blinking, and even smile at jokes.

In the Holding Your Breath experiment, unexpected results may be observed unless students make a maximum effort to hold their breath as long as possible, both before and after breathing into the bag, so students should be encouraged to hold their breath as long as they can. On the other hand, it is also important to prevent "cheating", by making sure that each student holds his or her nose, and neither breathes in nor out while holding their breath. Furthermore, special techniques such as hyperventilating and "buccal pumping" immediately before holding your breath can increase the duration of breath holding<sup>2</sup>, so students should be encouraged to breathe normally before each breath-holding attempt.

We have found that we need to remind students to label axes and units in the graph.

### **Possible Additional Activity**

The experiment described demonstrates the importance of low levels of oxygen and/or high levels of carbon dioxide in stimulating resumption of breathing, but does not allow students to distinguish the relative importance of these two factors. In order to make this distinction, you may want to add the following activity.

"Breathe into a plastic bag that contains a small bowl with KOH (which absorbs carbon dioxide), and then hold your breath for as long as you can. **You need to be very cautious in handling KOH since it is caustic.** The specific procedures are as follows:

- Put a piece of filter paper in the bottom of a finger bowl, and use a spatula to put approximately 6-7 pieces of KOH in the finger bowl.
- Moisten the filter paper with a few scattered drops of water (KOH has to be moist in order to absorb carbon dioxide).
- Cut a piece of cheesecloth a few layers thick and big enough to surround the finger bowl; use a rubber band to close the cheesecloth above the finger bowl.
- Place the finger bowl in a 13 gallon plastic bag which has been filled with air.
- Breathe into the bag for a minute or as close to a minute as you can.
- Immediately after breathing into the bag, take a deep breath of the air from the bag and hold your breath as long as you can while someone in your group times you.
- Dispose of the KOH in the jar provided.

Compare the length of time you could hold your breath after breathing into the bag with KOH to the length of time you could hold your breath after breathing into the bag without KOH. How do you interpret your results?"

### **Teaching Points**

- All parts of our body need oxygen and need to get rid of carbon dioxide.
- Oxygen is inhaled into the lungs and then circulates in the blood to the rest of the body.
- Carbon dioxide moves through the blood to the lungs where it is exhaled.
- Contraction of the diaphragm expands the lungs and air is sucked in, resulting in inhalation.
- Relaxation of the diaphragm allows the elastic lungs to become smaller and squeeze air out, resulting in exhalation.
- The brain sends signals which stimulate the rhythmic contractions of the diaphragm.
- We can voluntarily stop breathing, but only for a limited period. Low levels of oxygen and/or high levels of carbon dioxide in our body stimulate resumption of breathing and faster, deeper breathing.

---

<sup>2</sup> Muth et al. (2005) Physiological and clinical aspects of apnea diving. Clin. Chest Med. 26:381-94