Breathing and Holding Your Breath
Teacher Preparation Notes

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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 helpful to have O_2 printed on each red chip and CO_2 printed on each blue chip

Supplies and Instructions for Construction of Diaphragm/Lung Model

-- 4 oz baby bottle; clear, preferably cylindrical (1 per group)
-- a one-hole rubber stopper to fit the mouth of the bottle (1 per group):
    -- size #7 one-hole rubber stopper (30-37 mm in diameter) www.onlinesciencemall.com $0.98/each or www.widgetco.com $0.99/each
    -- or size #10 one-hole rubber stopper (42-50 mm in diameter) www.onlinesciencemall.com $1.75/each or www.widgetco.com $2.25/each
    -- or see reference chart http://101science.com/Rubberstopper.htm
-- drinking straw (1 per group)
-- balloons (2 per group)
-- electric stencil cutter or soldering iron or hacksaw plus file or sandpaper to melt/cut the bottom of the baby bottle off (the melting devices 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 have found 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: Use a electric stencil cutter or soldering iron or hacksaw to melt/cut the bottom of the baby bottle and remove the bottom piece. If you are using a hacksaw, you will want to sand or file off the rough edges of the cut bottle. 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 a second balloon to the piece of the straw which is sticking out of the bottom of the rubber stopper. (The model will work best if you can find a very small balloon, such as a water balloon, to use as this lung balloon.) 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 connecting tube (711833, 3/16" diameter, www.carolina.com $1.65/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 a 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, each of which may be a result of traumatic brain injury or lack of oxygen (e.g. due to a stroke). In coma, the patient is unresponsive, cannot be aroused, and has no awareness. This is usually

[1] These teacher preparation notes and the related student handout are available at http://serendip.brynmawr.edu/sci_edu/waldron.

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 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. Some recent medical findings concerning prognosis and possible treatments for individuals in a vegetative or minimally conscious state are summarized in "Impossible Awakenings", New Scientist, Vol. 194, Issue 2611, pp. 40-3, 2007 and "Conditional Consciousness", Scientific American, News, September 20, 2009.

In the Holding Your Breath experiment, aberrant results can occur if students do not make a maximum effort to hold their breath as long as possible, both before and after breathing into the bag. One possible way to motivate maximum duration breath-holding is to stimulate a little competition by comparing duration of breath-holding observed in the first try before the students begin their experiment. On the other hand, it is also important to prevent "cheating", by making sure that all students hold their nose, and neither breathe in nor out while holding their breath.

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.