THE SCIENCE OF
Air

Breathing Machine

from *The Science of Air Teacher's Guide* and for *Mr. Slaptail's Secret*

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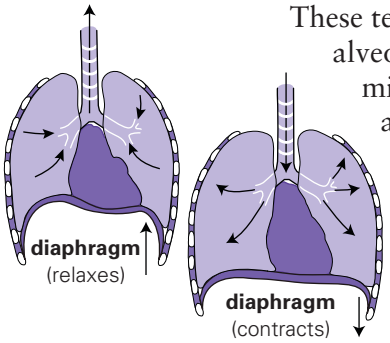
Breathing

Life Science Basics

The cells in our bodies require oxygen to complete the reactions that allow energy to be released from food. The process through which these reactions occur, known as aerobic (from *aeros* for air) respiration, produces carbon dioxide as a waste product.

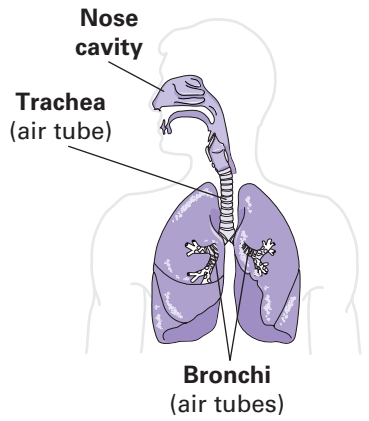
Many large organisms have developed systems to supply cells with oxygen and eliminate carbon dioxide from the body. Fish gills, for example, draw water across thin membranes, thus allowing dissolved oxygen to be transferred into the bloodstream. Insects have a network of small tubes that branch throughout the body and carry air directly to individual cells. Most other land animals use lungs and a blood transport (circulatory) system to take in oxygen and transport it throughout the body, while simultaneously removing carbon dioxide.

The human respiratory system is similar to that of all other mammals. Air enters the nose, where it is warmed and filtered. It passes through the pharynx at the back of the throat and enters the larynx (also called the Adam's apple), or voice box. From there, it passes through the trachea into the chest cavity. The trachea branches into two tubes (plural, bronchi; singular, bronchus), each leading to one of the lungs. Each bronchus branches and rebranches, forming smaller and smaller ducts. These terminate in tiny pockets, called alveoli, which are surrounded by minute blood vessels. Within the alveoli, oxygen moves into the blood stream and carbon dioxide diffuses out.

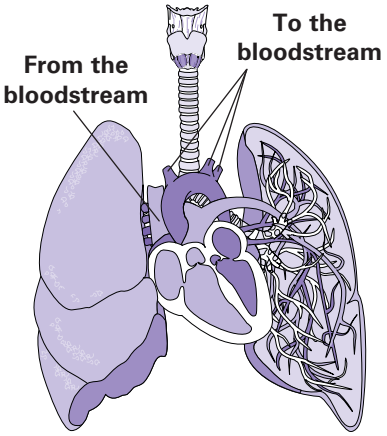


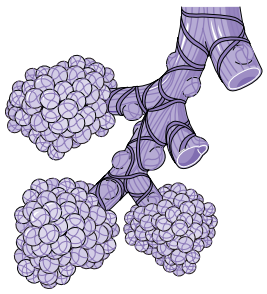
Breathing, the actual process of drawing in and expelling air, is a partially passive process controlled by changes in the volume of the chest cavity. The work of breathing is accomplished by muscles in the walls of the chest and in the diaphragm, a thin layer of muscle at the base of the chest cavity. When these muscles tighten, they increase the size of the space inside the chest. This causes air to rush into the lungs. When the muscles relax, the space becomes smaller and air moves out of the lungs.

When we breathe, all components of air (including pollutants) are drawn into the lungs. Some harmful substances can be expelled from the body by coughing or sneezing. Others are trapped and eliminated in mucus. A few, however, remain in the lungs, where they can cause permanent irritation or damage. Some chemicals in air even are absorbed into the bloodstream through the lungs and are transported to other parts of the body.



Air enters the body through the nose and mouth. When it reaches the lungs, some oxygen is taken into the bloodstream, and carbon dioxide, a waste product, is released.





If you spread out all the tiny pockets in the lungs, they would cover an area the size of a tennis court.

Breathing Machine

Life Science

CONCEPTS

Air moves in and out of the lungs in response to volume changes in the chest cavity.

OVERVIEW

Students will create a model that approximates how the lungs, chest and diaphragm interact during breathing.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Observing
- Modeling
- Drawing conclusions

TIME

Preparation: 20 minutes
Class: 30–45 minutes

MATERIALS

Teacher (see Setup):

- Half-liter water bottles (12 for groups of 2; 6 for groups of 4)
- Clear plastic packaging tape

Each group or student will need:

- 2 balloons, 9-in. round
- Pair of scissors
- Prepared bottle

Each of us breathes about eight to ten times per minute. When we exercise, the rate increases to 15 to 20 times per minute. Surprisingly, our lungs have no muscles of their own. How, then, is the work of breathing done?

The diaphragm and rib muscles of the chest wall work for the lungs. By changing the size of the chest cavity, these muscles control whether air enters or exits the lungs.

Unit Links

Mr. Slaptail's Secret
Story, pp. 18–26

Explorations
Breathtaking Fun! p. 4;
Where Does the Air Go? p. 8

The diaphragm, a broad, thin muscle that stretches across the body between the chest and the abdomen, is responsible for about 75% of the air flow in breathing. At rest, the diaphragm actually bulges upward. When we are about to take a breath of air or inhale, the diaphragm moves downward, thereby increasing the space available (and decreasing total pressure) within the chest. The rib muscles move upward and outward at the same time, increasing the space available for air flow by another 25%. Outside air rushes in to fill this space.

Breathing out, or exhaling, is normally a passive process. As the muscles of the chest and diaphragm relax, the space inside the chest becomes smaller and air moves out of the lungs. When we exhale forcibly, some of these muscles actively help push the air out.

SAFETY

Always follow district and school science laboratory safety procedures. It is good practice to have students wash hands before and after any laboratory activity. Clean work areas with disinfectant.

SETUP

This investigation works best with groups of two to four students, with each group making one "breathing machine." (As an alternative, have each student create his or her own breathing machine.)

One or more days before beginning this activity, ask each group to bring a small to medium-sized clear plastic bottle from home (half-liter water or soft drink bottle, or liquid dishwashing detergent bottle). Cut off and discard the bottom third of each bottle. The remaining top part of the bottle should be about six inches (15 cm) tall. Cover sharp edges with clear plastic packaging tape.

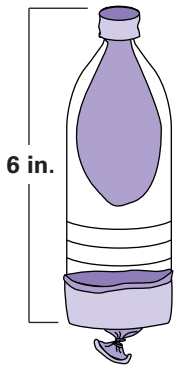


Illustration by M.S. Young © Baylor College of Medicine

Note. Liter-size soft drink bottles are too large to work effectively in this activity.

PROCEDURE

1. Begin by asking each student to notice his or her own breathing. Ask, *How many times are you breathing per minute? How can you tell? Which parts of your body move when you breathe?* Tell students that they will make a simple model to investigate how air moves in and out of the body.
2. Have the Materials Managers pick up prepared plastic bottles and balloons for their groups.
3. One student from each group should slide a balloon into the top of the bottle and roll the open end (mouth) of the balloon over the top edge of the bottle (see illustration, p. 16).
4. Another student should cut off the bottom of the second balloon and tie a knot in the stem (mouth) of the remaining piece. While one student holds the bottle, another should slide the cut end of the balloon around the cut end of the bottle.
5. Ask students to predict what might happen when the bottom balloon is pulled downward. Have students try pulling the bottom balloon gently. Ask, *What happened to the top balloon?* Point out that this is similar to what happens when each of us breathes in.
6. Next, direct the students to squeeze the sides of the bottle gently while pushing the bottom balloon into the space in the bottle. Ask, *What happened?*
7. Using the diagram on page 8 of the Air unit's *Explorations* magazine, help students understand that the balloon inside the model represents our lungs and that the bottom balloon represents our diaphragm. Discuss ways in which their models are similar to and different from the actual respiratory system.
8. Have students stand and take a deep breath. They should be able to notice that their chests expand when they inhale and contract when they exhale.

VARIATIONS

- Challenge your students to make their lung models "cough" or "sneeze." For a more dramatic effect, place 1/2 teaspoon of baking soda or baby powder inside the balloon "lung" before making the model "cough" or "sneeze."

  Safety Note: Be aware of risks to students with respiratory illnesses, such as asthma.
- You may prefer to have students make their breathing machines at home with a family member or friend (see this unit's *Explorations,* p. 4).
- Try making a more accurate model by filling the inside of the breathing machine with water.

ABOUT THE MODEL

The breathing machine model shows students how changes in pressure draw air into the lungs. However, there are several differences between real lungs and the model.

- Humans have two lungs.
- Lungs actually fill the entire space available within the chest.
- Each lung has a spongy appearance inside, instead of being hollow.
- The thin space between the lungs and the chest wall is filled with liquid.
- The chest cavity itself is divided into two spaces, one for each lung.

QUESTIONS FOR STUDENTS TO THINK ABOUT

Tell students that when we breathe in, oxygen is removed from the air in our lungs and carbon dioxide is released. Ask, *What happens to the other things in air when we breathe in? Do we breathe nitrogen and other gases in and out? What about harmful things in air? Do we also breathe them in?*