The Science of Air

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Center for
Educational Outreach

Baylor College of Medicine

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The Science of Air
Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets and answer keys, can be found in *The Science of Air Teacher's Guide*, which is available free-of-charge at http://www.bioedonline.org/lessons-and-more/teacher-guides/air/.

Activities found in the Air unit are organized into the following sections.

- Physical Science (air, gases, air composition, air movement and temperature)
- Life Science (air in the body, vital lung capacity, exercise and breathing rate)
- Environmental Science and Health (air particles and concentrations, dust, mold, indoor air pollution, allergies)

Reference
Moreno, N., Tharp, B., and Dresden, J. (2011) *The Science of Air Teacher's Guide*. Baylor College of Medicine: Houston. ISBN: 978-1-888997-74-3

Image Reference
Photo courtesy of NASA Earth Observatory. http://earthobservatory.nasa.gov/

Key Words
air, air molecules, air currents, air quality, air pollution, allergy, allergies, argon,

asthma, breath, breathing, carbon dioxide, carbon monoxide, chemicals, cigarette smoke, concentrations, dander, diaphragm, dispersion, dust, dust mites, fungi, fungus, gas, gases, heart, heartbeat, heart rate, indoor air pollution, lungs, mold, nitrogen, oxygen, pesticides, pollen, pulse, radon, respiration, second hand smoke, smoke, smoking, tobacco smoke, ventilation,

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What is Air?

- The air we breathe is a mixture of several colorless, odorless gases, one of which is oxygen. It is necessary for functions within cells.

- Another gas, carbon dioxide, is produced as waste by most living things. It also is required for photosynthesis.
- Other substances in air, such as pollen, dust or smoke, can lead to allergies or asthma in some people.

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What Is Air? (pre-assessment)
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Background
Air surrounds us, yet we rarely think about its composition or why it is important. It is a mixture of colorless, odorless gases, one of which, oxygen, is necessary for functions within cells. Another gas, carbon dioxide, is produced as waste by most living things and also is required for photosynthesis.

Gas molecules are in constant motion. Because heat makes the movement of gas molecules more pronounced, warm air rises and cool air sinks. Many tiny substances can be suspended in air. Some, such as pollen, dust or smoke, can lead to allergies or asthma in some people. Other substances in air, such as chemicals, can be toxic to everyone.

Most people think of air pollution as being outdoors. But frequently, pollutants can become more concentrated in indoor environments because of limited fresh air circulation. Fortunately, there are many ways to improve the indoor air quality of homes, schools or offices.

This unit uses indoor air pollution as a unifying, real-world theme to teach students important physical and life science concepts about gases, air and the respiratory system. It also presents important environmental health concepts related to air quality and indoor spaces.

Procedure

1.Ask students to think about the question, *What questions do you have about air?* Record students' questions on a sheet of chart paper to be displayed in the classroom. Allow opportunities for students to answer their own questions as they complete this unit.

2.Have students complete the pre-assessment individually; then collect and save each student's form. Students will refer back to their pre-assessment answers at the conclusion of this unit.

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Image Reference

Photo courtesy of The Gateway to Astronaut Photography of Earth. http://eol.jsc.nasa.gov/

Key Words

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Indoor Air Quality

Second-hand smoke is one source of indoor air pollution.

- Air pollution can happen indoors as well as outside.
- Without fresh air, many substances can become concentrated inside of buildings.
- Indoor air pollution can make some people sick.
- What are some sources of indoor air pollution?

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Indoor Air Quality

Background (cont.)
Sources of indoor air pollution include mold, pollen, dust, tiny animal particles, tobacco smoke, cleaning products, pesticides, gases (carbon monoxide, radon), and materials used in building construction (asbestos, formaldehyde and lead).

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Image Reference
Photo by Giovanni Dall'Orto, released to Public Domain, Wikimedia Commons. http://commons.wikimedia.org/wiki/File:Stefano,_smoking_3_-_Foto_Giovanni_Dall%27Orto,_August_2007.jpg

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Gases Matter

- Gases are one of the three basic states of matter.
- Gases will keep expanding if they are not in a container.

- Even though we cannot see or smell many gases, we can observe them in other ways.
- It is easy to detect the pressure caused by a gas on the walls of a balloon, bicycle tire or swimming pool floats.

Gases Matter – Physical Science

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Background

Gases are one of the three basic states of matter (the other two are liquids and solids). Unlike liquids or solids, gases will expand indefinitely if they are not in a container. Even though we cannot see or smell many gases, it is possible to observe them in other ways. For example, it is relatively easy to detect the pressure exerted by a gas on the walls of a balloon or an inflatable tire.

About the Image

Research scientists setting up one of NASA's long-duration balloon missions.

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Image Reference

Photo courtesy of NASA Wallops Flight FacilityMatt Truch.

http://stratocat.com.ar/fichas-e/2011/MCM-20110109.htm

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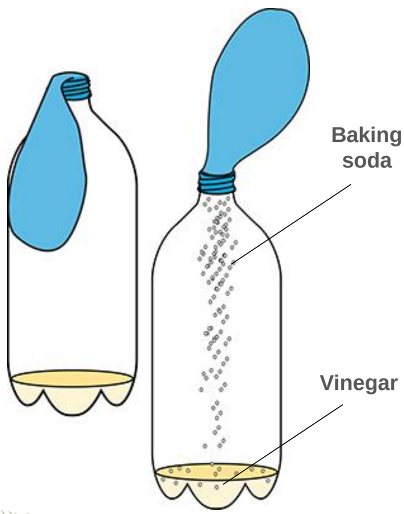
Detecting Carbon Dioxide



- Carbon dioxide is one of the gases found in air.
- We cannot see or smell it.
- Carbon dioxide can be produced by mixing baking soda with vinegar.
- How can we tell that carbon dioxide is being produced?

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Detecting Carbon Dioxide

Background (cont.)
The air we breathe is a mixture of several gases. One of these, carbon dioxide, is produced as a waste product by most living cells. Carbon dioxide also can be produced by a number of other means, including the mixing of a weak acid (vinegar) with sodium bicarbonate (baking soda).

Procedure
1.In front of your students, inflate a large balloon. Ask them if there is anything inside the balloon. Stimulate a discussion about the contents of the balloon, leading them to the conclusion that the balloon contains air.

1.Tell students, *Air consists of gases we cannot see or smell. However, we can tell gases are present in the balloon because they place pressure on the sides of the balloon and make it expand.* Let the students feel the sides of the balloon.

1.Ask the students to observe as you place a few tablespoons of vinegar into the soft drink bottle. Next, using a note card that you have creased down the center, slide about one teaspoonful of baking soda inside the second balloon. Fasten the balloon over the mouth of the bottle, without letting the baking soda fall into the bottle.

1. Gently lift the balloon upward and let the baking soda fall into the vinegar at the bottom of the bottle. As carbon dioxide is produced inside the bottle, the balloon gradually will inflate. Challenge students to think about what might be causing the balloon to expand. Lead them to understand that mixing the two compounds produced a gas, known as carbon dioxide, which also is released from our bodies when we breathe out.

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About Air

- Air is a mixture made up of several gases.
- There are different amounts of each gas found in air.
- We can use popcorn to model how much of each gas is in air.

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About Air – Physical Science
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Background
About 78% of the volume of dry air is nitrogen gas (N_2). Oxygen (O_2), the component of air required by our bodies, comprises less than one fourth of dry air. Argon, a non-reactive gas, makes up slightly less than 1% of dry air. Carbon dioxide (CO_2), a gas released from our bodies when we exhale, is present in even smaller quantities (less than one part per 1,000). Very minute amounts of many other naturally-occurring gases (such as neon, helium, methane and ammonia), as well as gases resulting from pollution, are present in air. Water vapor, when present, can occupy up to 5% of the total volume of air. When we breathe, nitrogen, oxygen and all the other components of air enter and exit our lungs.

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Image Reference

Photo courtesy of the National Cancer Institute.
https://visualsonline.cancer.gov/details.cfm?imageid=2439

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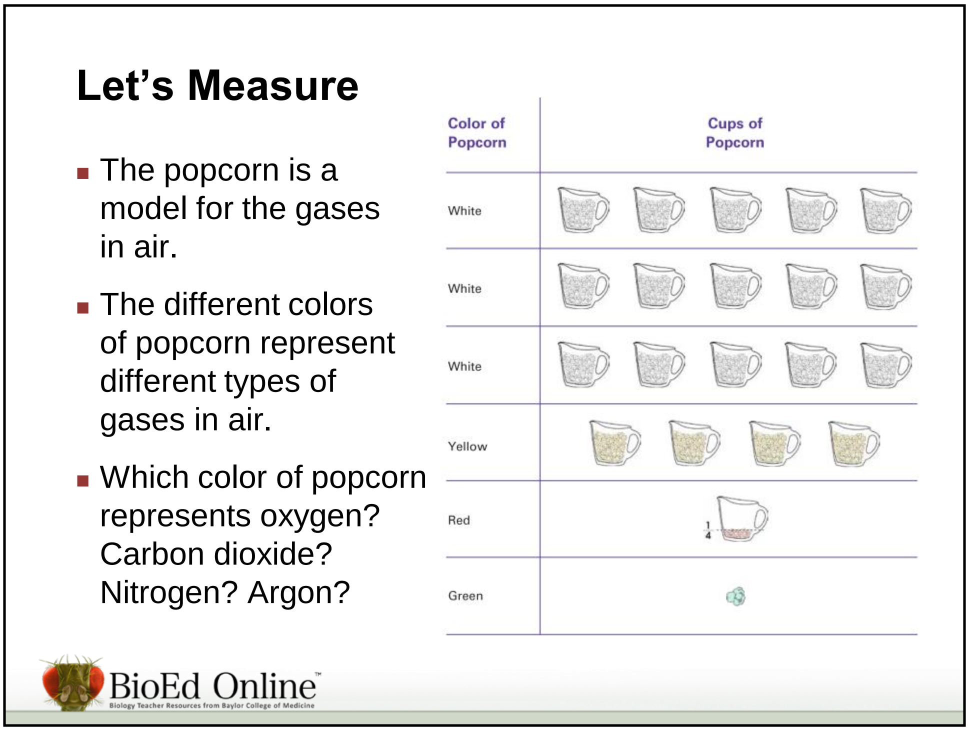

Let’s Measure

Background

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Components of Dry Air

Atmospheric air may contain 0.1% to 5% water vapor (H_2O) by volume.

- Nitrogen gas (N2) 78%
- Oxygen gas (O2) 20%
- Argon 0.9%
- Carbon dioxide (CO2) 0.03%

•Minute amounts of: Neon Krypton Helium Xenon

•Other substances, including pollutants

Procedure

1.Divide the students into six small groups. (If your students are very young, you may prefer to conduct the activity as a discovery lesson with the entire class.)

2.Have the Materials Manager from each group collect a measuring cup and a sealable plastic bag. Give three groups approximately 7 cups of white popcorn each. Give 1 bag of colored popcorn to each of the remaining three groups.

3.Project the “Let’s Measure” student sheet while you explain that each group with white popcorn will measure 5 cups of popcorn into its bag; the group with yellow popcorn will measure 4 cups; the group with red popcorn will measure 1/4 cup; and the group with green popcorn will place only one kernel in its bag.

4.When the students have finished measuring, ask one student from each group to empty the popcorn from the group’s bag into the large, clear plastic bag (which you will hold in a central location).

5.Shake the large plastic bag. Ask, *What do you think I’m doing?* Lead the students to understand that the popcorn is being mixed. Ask, *Are the colors of popcorn arranged in a special way in the bag?* Students should note that the colors are mixed randomly.

6.Have the students identify which color of popcorn is represented by the most kernels in the bag, by the second-most kernels and so on, until you mention the single kernel of green popcorn. Follow by asking students to name other kinds of mixtures (e.g., fruit salad, crayons of different colors in a container, etc.).

7.Explain that air also is a mixture, made up of different kinds of gases. The different colors of popcorn in the large bag are present in the same proportions as the different gases in air. (Some students already will know that oxygen and carbon dioxide are involved in breathing. If the class is not familiar with this information, point out that the gas we take out of air when we breathe in is known as oxygen, and the gas we release when we breathe out is carbon dioxide.) Ask students to guess which color of popcorn represents oxygen molecules (yellow) and carbon dioxide molecules (green) in air.

8.Finally, point out that air is mostly nitrogen, represented by the white popcorn. The red popcorn corresponds to argon, gases present in air, but not absorbed by the body during breathing.

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Image Reference

Illustrations by M.S. Young © Baylor College of Medicine. http://www.bcm.edu

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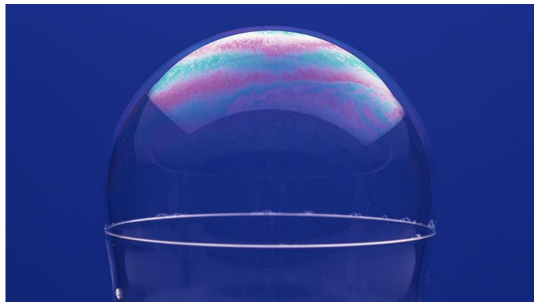
Moving Air



- Molecules in air are constantly in motion.
- Temperature can affect how air molecules behave.
- Do you think air will sink or rise if it is warmed?

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Moving Air – Physical Science
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Background
The molecules in air (and in all gases) are constantly moving, but the amount of movement depends on temperature. At higher temperatures, molecules are more active. They bounce off one another and off the sides of a container with more energy. At lower temperatures, molecules move less and bounce with less energy. A given number of gas molecules will take up more space when warm (because of more energetic "bouncing") than the same number of molecules at a lower temperature. These characteristics account for much of the air movement that we can observe, both indoors and outdoors. Air currents develop when there are differences in temperatures, because higher-energy ("bouncier") warm air molecules rise and lower-energy cool air molecules sink.

Procedure
1.Challenge your students to predict whether warm air and cold air behave differently. Ask, *Do you think air will sink or rise if it is warmed?* Write students' predictions on the board or have each group make its own prediction.

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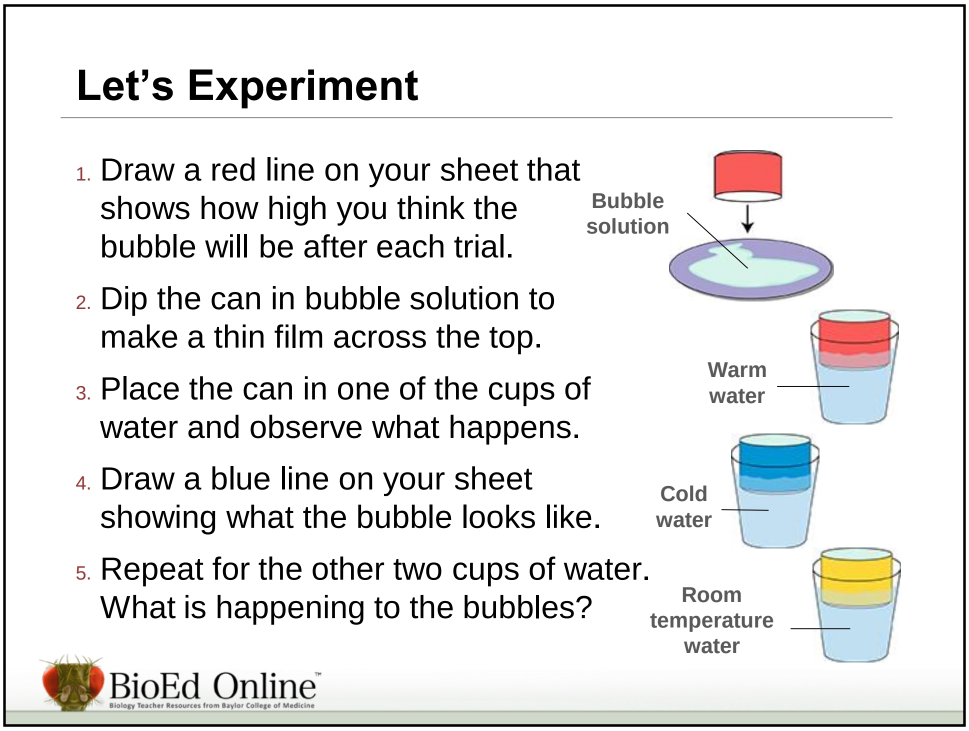

Let’s Experiment

Procedure (cont.)

2.Set up a station from which the Materials Managers can pick up the following supplies for their groups: one prepared can, one shallow dish or bowl with bubble solution, one cup half-filled with warm tap water, one cup half-filled with ice water (include a few ice cubes), and one cup half-filled with room temperature water.

3.Demonstrate how to tip the open end of a can in the bubble solution to create a thin film. Have students predict what might happen to bubble film when the can is placed in room temperature, warm and cold water. They should draw their predictions on their student sheets. Have students dip the open ends of their cans into bubble solution. A film of solution will be visible across the top of the can. Direct each group to place its can in one of the cups (cold water, warm water or room temperature water). Let students observe the bubble film for about a minute. Ask, *What is happening to the bubble? What does this tell us about the air inside the can?*

4.Have students record their observations on the “My Observations” sheet.

2.Then have each group make a new bubble film and place its can in one of the other cups. Have students record their results before placing and observing the can in the third cup.

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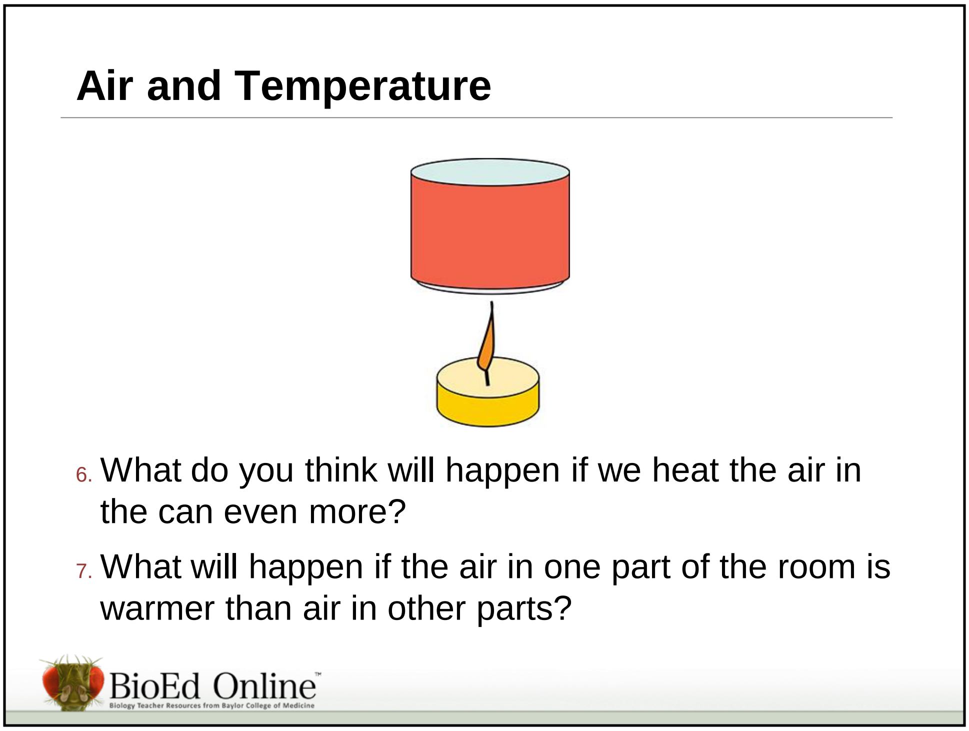

Air and Temperature

Procedure (cont.)
6.Discuss students' predictions about the behavior of warm and cool air, in light of their observations. Ask, *What do you think will happen if we heat the air in the can even more?* In a demonstration area, dip another can in bubble solution; then heat it using a lighted candle, hotplate, warm towel, etc. (The bubble will bulge much more dramatically than students saw in their previous trials.)

7.Discuss the students' discoveries about air movement and encourage them to think about what might be happening with the air inside the classroom. Ask, *What happened to the air inside the can when it was placed in cold water? In warm water?* Follow by encouraging a general discussion. Ask, *Where are the sources of different air temperatures in the room? What will happen if the air in one part of the room is warmer than air in other parts?*

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Breathing Machine

- Each of us breathes about 8–10 times per minute.
- When we exercise, we breathe about 15–20 times per minute.
- Breathing occurs when the diaphragm and chest muscles move to open up the chest area.
- Outside air rushes in to fill this space.
- When we breathe out, some of the muscles help push the air out.

A bag valve mask can be used to help people breathe.

Breathing Machine – Life Science

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Background

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.

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.

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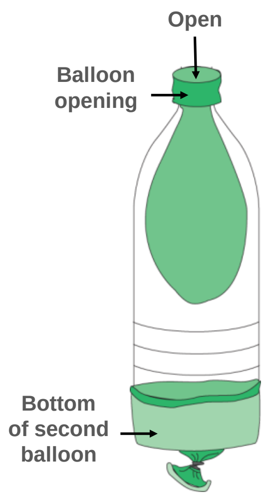
Modeling the Lungs



1. Slide one balloon into the top of the bottle. Pull the open end of the balloon through the mouth of the bottle. Roll the top of the balloon over the outside of the bottle, as shown.
2. Tie the open end of another balloon. Cut it in half. Place the second balloon over the bottom of the bottle.
3. Pull the bottom balloon downward. What happened to the top of the balloon?
4. Gently squeeze the sides of the bottle while pushing the bottom balloon up into the bottle. What happened?

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Modeling the Lungs

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.

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.

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.

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Lungometer

- When you inhale, air from outside is pulled into your lungs.
- When you exhale, air is pushed out of your lungs.

- People differ in the amount of air that they can blow out of their lungs.
- The largest amount of air that can be blown out of the lungs after taking a deep breath is called vital lung capacity.

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Lungometer– Life Science
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Background
When we breathe inward (inhale), air from outside enters our airways and lungs. As demonstrated in the activity, "Breathing Machine," breathing is a mechanical process, driven by changes in the volume of the chest cavity. The air taken in with a normal breath represents only part of the total amount of air the lungs can hold. Likewise, the amount of air normally breathed outward (exhaled) represents just a portion of the total amount of air that can be expelled.

The maximum amount of air that can be blown out of the lungs after taking a deep breath is known as vital lung capacity. But some air always remains in the lungs and airways.

Diseases of the respiratory system affect lung volumes and capacities in many different ways. Some diseases reduce the lungs' vital capacity. Others cause changes in the amount of air held in the lungs after air is blown out forcefully.

Note: A spirometer is an apparatus for measuring the volume of air inhaled and expelled by the lungs. It is used to rule out different respiratory diseases and can help find the cause of shortness of breath, effects of contaminants on lung functions, effects of medication, and progress for disease treatment.

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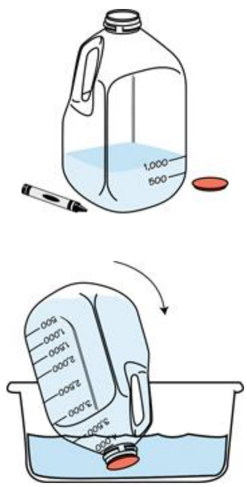
Make a Lungometer



1. Pour 500 mL of water into a one-gallon plastic jug. Use a crayon to draw a line on the jug to mark the water level. Label the line 500.
2. Add another 500 mL of water into the jug. Draw a line on the jug at the new water level. Label the line 1,000.
3. Repeat until the jug is filled with water.
4. Fill a plastic tub halfway with water.
5. Put a cap on the jug, turn it upside down and lower it into the tub. Hold it in place and carefully remove the cap.

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Make a Lungometer

Procedure
Session 1: Making Lungometers

1.Make a lungometer and demonstrate your vital lung capacity to the class. Tell students they will be able to measure their own vital lung capacities using lungometers that they will build. If students have read *Mr. Slaptail's Secret*, mention that they will be making a lungometer just like the one that Riff built. Ask students to predict how much air they will be able to blow out of their lungs.

2.Have the Materials Manager from each group pick up a clean plastic gallon milk container and lid, a plastic dishpan, one piece of plastic tubing and a crayon from a central area.

3.Fill each group's tub (or have the students fill their tubs) about halfway with water.

4.Have each group calibrate the volume of its plastic jug by adding water, 500 mL at a time. One student should pour and another should label each level (500 mL, 1,000 mL, 1,500 mL, etc.) using a crayon. When the jug is filled, put on the lid.

5.Instruct two students from each group to turn the milk jug upside down and lower it into the tub, submerging the top under water.

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Key Words

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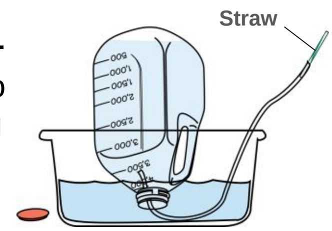
Measuring Vital Lung Capacity



6. Continue to hold the jug in place.
7. Put one end of a plastic tube into the jug. Insert a piece of drinking straw (a mouthpiece) into the other end of the tube. Take a deep breath and blow into the straw. Blow out as much air as you can with one breath.
8. Put the cap back on, turn the jug over, and measure the amount of water left in the jug.
9. Write this number on your data sheet.
10. Using a clean straw for each team member, repeat until all members have measured their vital lung capacities.

Measuring Vital Lung Capacity

Procedure (cont.)
Session 1: Making Lungometers
6.While those two students continue to hold the jug in place, a third student should carefully remove the lid and slide one end of the tubing up into the submerged mouth of the jug. The lungometer is now ready for testing.

7.Before each student uses the lungometer, he or she should insert his or her own clean mouthpiece into the plastic tubing.

8.To measure vital lung capacity, each student will inhale deeply and then blow out all the air he or she can through the tubing into the jug. Then, the students holding the jug should put the lid back on and carefully turn the jug upright. This will enable them to determine the amount of water remaining. Have each student record this value on his/her “Lungometer Data Sheet.”

9.Have younger students measure their vital lung capacities once. Older students may try three times and determine the average.

10.Allow students to calculate their vital lung capacities as shown on the “Lungometer Data Sheet.” (Total volume of jug will equal approximately 4,000 mL with a standard gallon milk jug.)

Session 2: Looking at Results

1.With younger students, draw a large graph on the board. Label the X axis "Students." Number the Y axis from 0 to 4,000 mL, using 500 mL intervals. Have the students write their names and lung capacity measurements on "sticky" notes. Help each student place his/her "sticky" at the appropriate level on the graph.

2.Older students should obtain the average value for their vital lung capacities, as shown on the "Lungometer Data Sheet." After students have completed their calculations, have them graph their average vital lung capacities as illustrated above.

3.Discuss the class results represented on the graph. Ask, *Which was the highest vital lung capacity? Which was the lowest? What range of values did we find? How could we find the average vital lung capacity for the class?*

4.Elicit a discussion of factors that might limit vital lung capacity. Ask questions such as, *What might account for differences in vital lung capacity? Do large people have larger vital lung capacities? How does exercise affect vital lung capacity? How might the vital lung capacity of a smoker compare to that of a non-smoker?*

5.Have students group their data (for example, by student height or by amounts of daily exercise) to investigate some of the questions raised during their classroom discussion.

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Heart and Lungs

- Your heart and lungs work together to supply your body with oxygen and other materials.
- When you exercise, your lungs and heart need more air to help your body work faster and harder.
- We can measure heart rates (or heartbeats), and breathing rates.

Heart and Lungs – Life Science
Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets and answer keys, can be found in *The Science of Air Teacher's Guide*, which is available free-of-charge at http://www.bioedonline.org/lessons-and-more/teacher-guides/air/.

Background
The heart and lungs work together to supply all the tissues in the body with oxygen and other materials, and to carry away waste products, such as carbon dioxide. All the cells in our bodies need oxygen to carry out the reactions that release energy. Carbon dioxide, a waste product of this process, is manufactured inside cells when energy is released from sugars and other molecules.

Usually, when parts of the body require more oxygen (as during exercise), the lungs and heart respond by working faster. The lungs also take in more air, so that more oxygen can be absorbed into the blood stream and transported to hard-working tissues.

We often measure heart rate by feeling the surge of blood after each heart beat at places on the body where arteries are near the surface of the skin (the wrist, for example). This recurrent surge is known as the pulse. The number of pulses per minute usually is referred to as pulse rate (heart beats per minute). The average pulse rate for a child ranges from 60 and 120 beats per minute.

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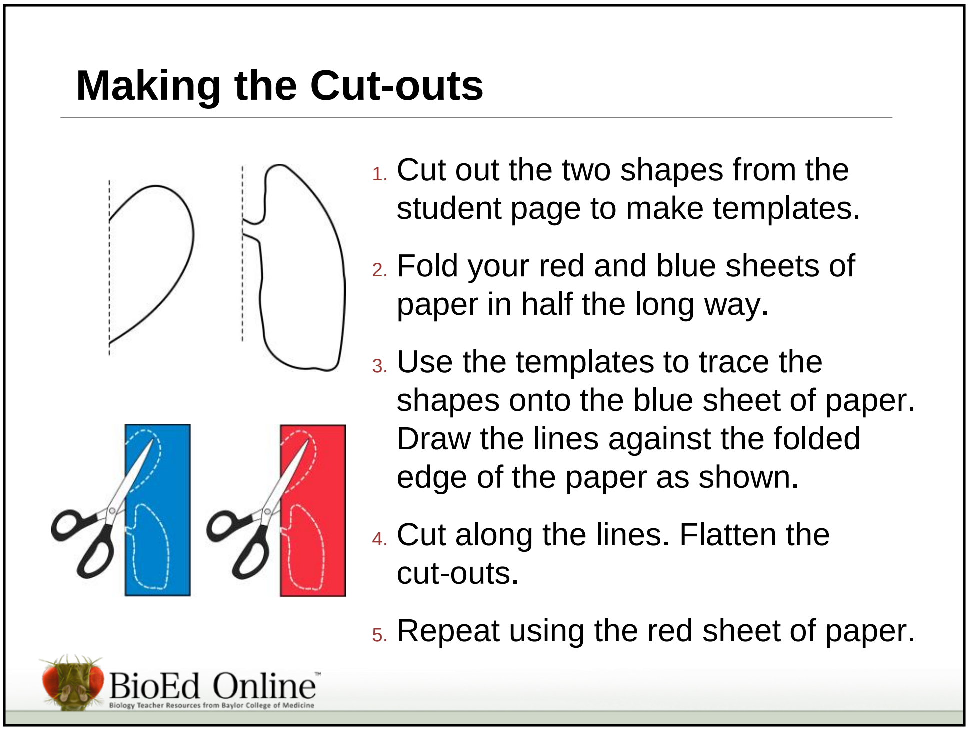

Making the Cut-outs

Procedure

Part 1

1.Give each student one sheet each of blue and red construction paper. Direct students to cut out a set of lungs and a heart from each sheet, using the templates on the "Heart and Lungs Cut-Outs" student sheet. (This can be integrated into a mathematics or art lesson as a symmetry activity.)

2.Have students follow the directions on the student sheet to make the cut-outs (steps 1-5 above).

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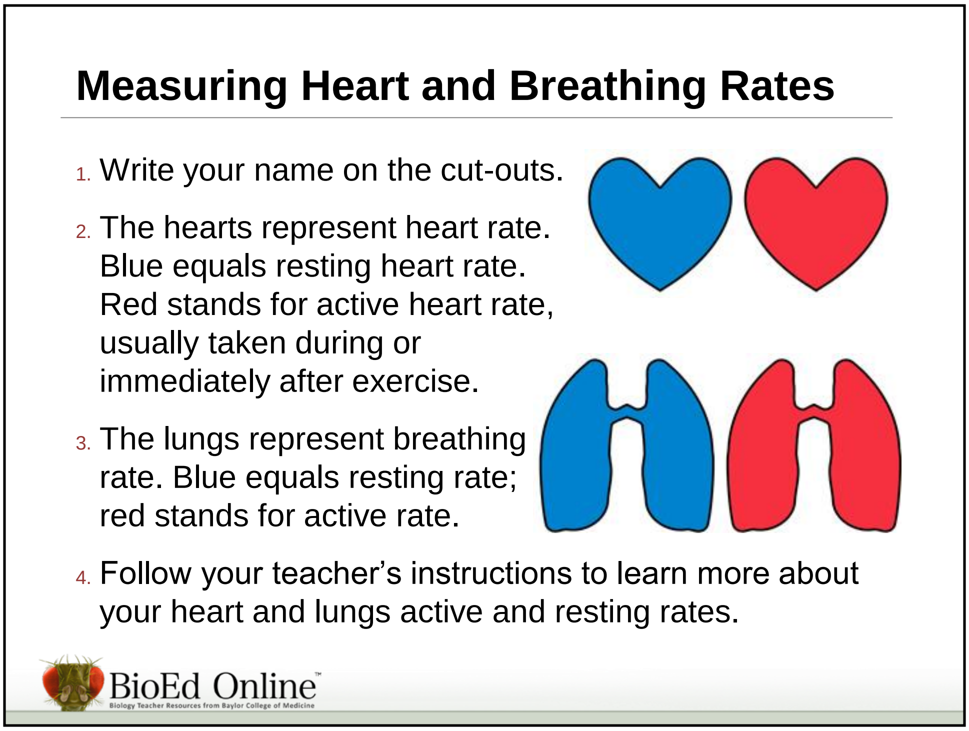

Measuring Heart and Breathing Rates

Safety Issue (see next slide for illustration)
Do not have students use the carotid artery in the neck to find their pulse. Applying too much pressure there could stimulate a reflex mechanism that can slow down the heart.

The safest and most common site to check pulse is on the thumb side of the wrist (radial pulse). Use the middle finger and ring finger together to apply slight pressure at the location shown. This is the pulse site recommended for the general public by the National Heart, Lung, and Blood Institute, National Institutes of Health.

Procedure (cont.)
Part 2. Gathering Data
1.Explain to students that they will be investigating their breathing and heart rates. Make sure they understand that a "rate" is a measure of "how fast" or "how slow" something is happening.

2.Group the students into pairs. Ask them to sit quietly and breathe normally. Have one student count the number of times his/her partner inhales (breathes in) in one minute, and record the results on the "Heart and Lungs Data Sheet." Older students can time themselves, using a wristwatch or stopwatch. If a student has difficulty observing the breathing of his/her partner, instruct the student being observed to dangle a strip of tissue in front of his/her nose. Have students repeat the measurements at least three times to calculate an average. Then instruct the students to switch jobs.

3.With younger students, conduct this procedure as a whole class activity. You can either time them or direct the timing, while students take turns counting and recording their partners' breathing rates.

4.Prepare the students to measure their pulse rates (heart beats per minute) by demonstrating the safest way to locate a pulse point (see **"Safety Issue,"** above and the following slide). Give students time to locate their pulse points and practice counting beats.

5.Have students measure their heartbeats by counting the number of times they feel a tiny surge at their pulse points, while their partners time them for 15 seconds. Older students should enter this value on their worksheets and multiply by four to obtain the number of beats per minute. They should take three readings. Younger students may add this value four times to find beats per minute. Have the students switch jobs and repeat the process. Again, with younger students, you probably will want to direct the activity and measure the time.

6.Next, tell the students that they are going to investigate their breathing and pulse (or heart) rates after physical activity. Ask, *What do you think will happen to your heart rate when you exercise? What about your breathing rate?* Have one member of each team run in place for one minute and sit down. Have their partners determine their breathing rates again. Older students should repeat this procedure three times. Then, let the students switch jobs and repeat the process. This step should be teacher-directed for younger students.

7.To investigate pulse rate after activity, have the students repeat the process described in steps 3 and 4 after running in place for one minute.

Part 3. Graphing

1.Draw two large grids for class graphs on chart paper or on the board. Label one grid "Heartbeats Per Minute" and the other "Breaths Per Minute." Lines on the vertical axis should be 6 cm apart. Lines on the horizontal axis should be approximately 12 cm apart. Make sure students understand that they were able to quantify their heart rates by counting the tiny surges of blood moving through an artery.

2.Using blue for resting rate and red for active rate, have students write their names and rates on the appropriate cut-outs. Tape students' cut-outs on the appropriate class graphs OR help each student position his or her cut-outs on the graphs.

3.Ask, *Where are most of the blue hearts on the graph? How about the red hearts? Where are the blue lungs? The red lungs? How does exercise affect a person's breathing rate? Heart rate?* Help students notice that heart and breathing rates change together.

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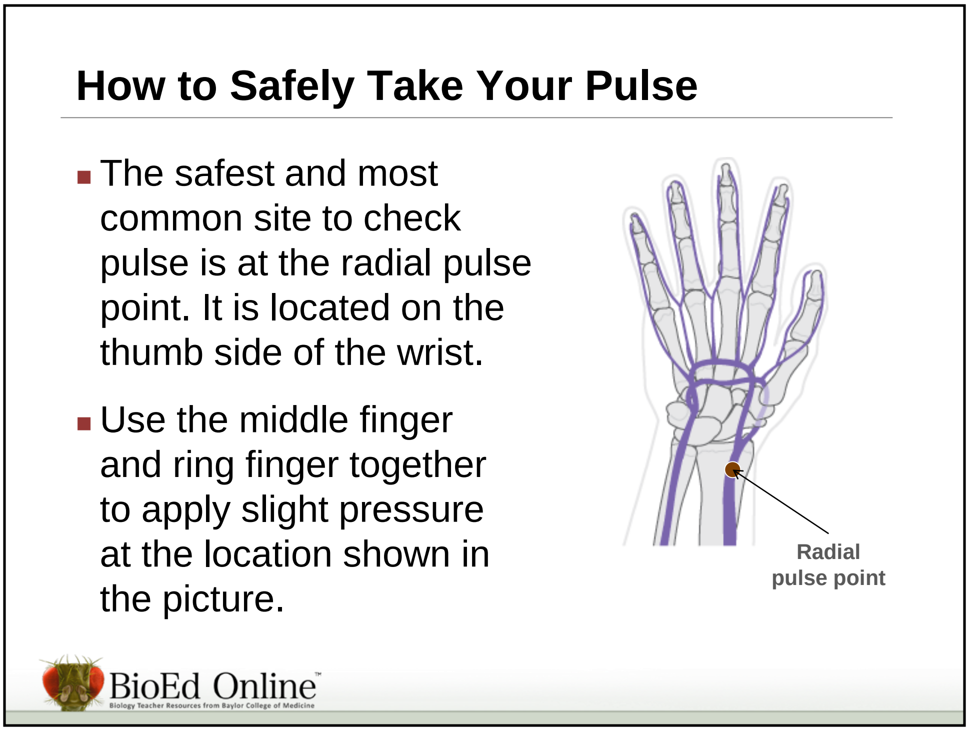

How to Safely Take Your Pulse

Safety Issue

Do not have students use the carotid artery in the neck to find their pulse. Applying too much pressure there could stimulate a reflex mechanism that can slow down the heart.

The safest and most common site to check pulse is on the thumb side of the wrist (radial pulse). Use the middle finger and ring finger together to apply slight pressure at the location shown. This is the pulse site recommended for the general public by the National Heart, Lung, and Blood Institute, National Institutes of Health.

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Dust Catchers

- Dust and other particles come from many different sources, and may include the items listed below.
  - Cigarette smoke
  - Animal dander
  - Insect parts
  - Mold spores
  - Fibers
  - Dust mites

- Indoor dust can cause health problems for people with asthma or who have allergies.

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Dust Catchers – Environmental Science and Health
Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets and answer keys, can be found in *The Science of Air Teacher's Guide*, which is available free-of-charge at http://www.bioedonline.org/lessons-and-more/teacher-guides/air/.

Background
Dust and other particles found indoors can come from a variety of sources and may include cigarette smoke, animal dander (flakes of dead skin), insect parts, mold spores, fibers, and/or dust mites and their droppings.

Indoor dust can pose a significant health problem to individuals who are allergic to any one of the particles it contains. Animal dander, mold spores and dust mites are especially common indoor allergens (allergy-causing agents). They can cause simple allergies of the upper respiratory system ("hay fever" symptoms). Dust mites also have been linked to allergic diseases of the airways, such as asthma.

Several measures can help to control dust in indoor environments. Filters remove larger particles from the air. Keeping living areas dry and well ventilated also helps to limit the growth of molds (and dust mites that can feed on molds), which prefer damp places. Eliminating curtains and other materials that hold dust may be necessary, in some cases, to control allergies in susceptible individuals.

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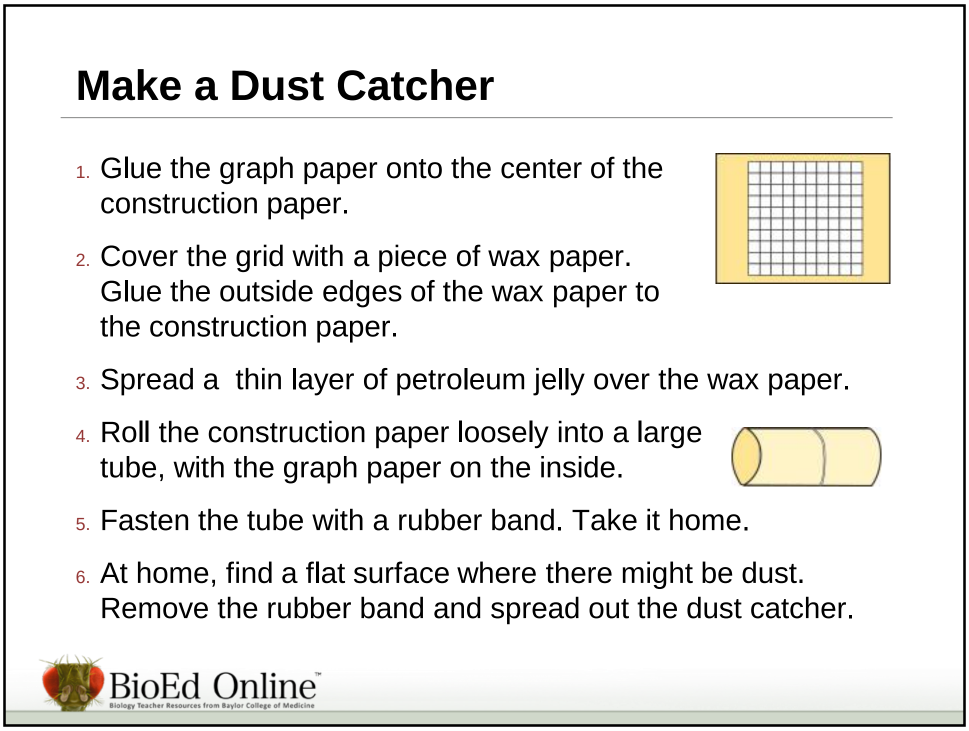

Make A Dust Catcher

Procedure
Session 1

1.Create a small cloud by shaking a cotton ball dipped in baking soda (or cornstarch or baby powder, or use a dusty eraser; see PDF Safety note). Shine a flashlight through the dust cloud. Ask, *What are we seeing? Do you think this always is in air? How could we find out?*

2.Show students the dust catcher that you have made and explain that they each will make a similar one to take home. They will place the dust catchers in areas of their homes they predict will have the most air pollution. After one or two weeks, they will bring the dust catchers back to school and examine them for particles.

3.Guide students as they construct their dust catchers, following steps described on the "Make a Dust Catcher" student sheet (steps 1-6 above)

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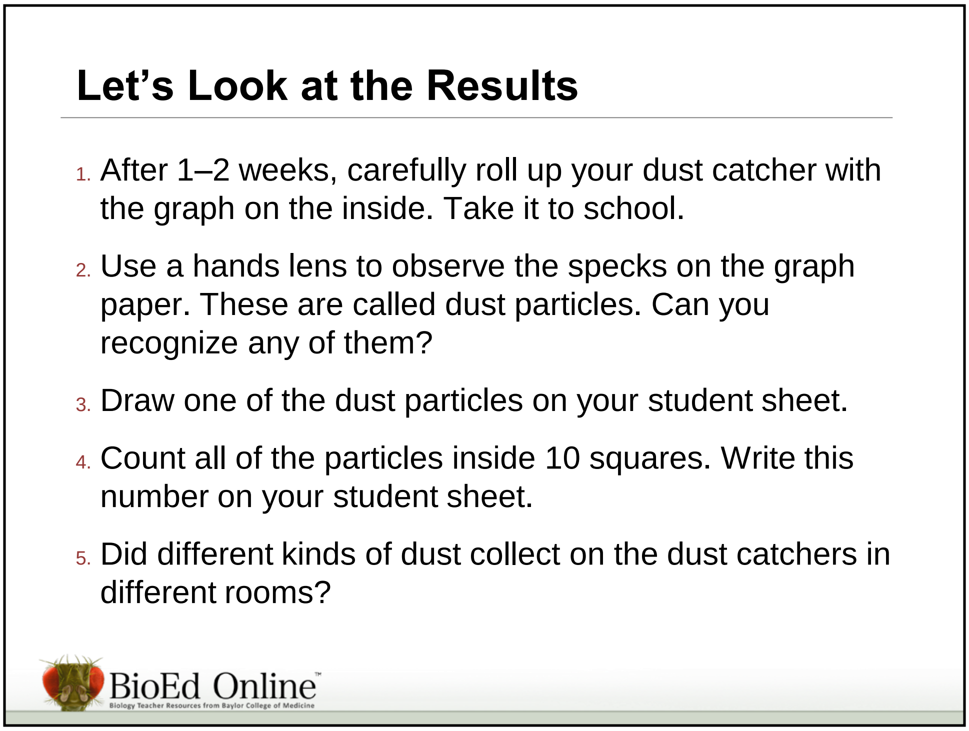

Let’s Look at the Results

Procedure (cont.)
Session 2

1.When all students have brought their dust catchers back to school, open a general discussion about the appearance of the dust catchers. (Some will have a visible sprinkling or layer of particles; others will have few or no visible particles.)

2.Have the Materials Managers collect enough hand lenses for their groups. Each student should examine the overall appearance of the dust on his or her dust catcher and, if time permits, on the dust catchers of other members of the group.

3.Have each student use a magnifier to count the number of particles in 10 squares chosen randomly on the grid. (You may need to vary the number of squares counted, depending on the type of graph paper used. Paper with a grid size of approximately 1 cm works well.)

4.Have each student record the number of particles he or she counted in the appropriate place on the “Make a Dust Catcher” sheet (if you have made a copy for each student), or have students write the number in their journals or notebooks.

5.If you have one or more microscopes available, help students to examine their grids under higher magnification. You may want to trim the construction paper around the graph paper square to help it fit under the microscope.

6.Ask, *What kinds of particles did you capture?* Students are likely to find small hairs, tiny pieces of ash, crumbs and bits of thread or lint. With the aid of microscopes, students also may see pollen grains, pieces of molds and very small insect parts. Have them draw some of the particles they have observed.

7.For further discussion, refer students to the various sources of household dust pictured on the front cover of the Air unit's *Explorations* magazine.

Session 3

1.Conduct a brief survey of the values that students obtained for their dust counts. Create a chart on the board similar to the one on the right, taking into consideration the range of counts reported by the students.

2.Help each student place a dot or "sticky note," labeled with the type of room tested, on the appropriate place on the graph.

3.Discuss the survey results with the class. Ask students to identify areas in their homes that have more or less dust. Also ask, *Did different kinds of dust collect on dust catchers in different rooms?* Talk about ways in which dust can be reduced or eliminated.

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Fungus Among Us

- Fungi are an essential part of life on Earth. Some are helpful, while others can be harmful.
- Fungi that grow on damp surfaces are called mold.
- Fungi and mold spread by producing tiny spores that are released into air.
- These spores can and trigger allergic reactions and cause health problems in some people.

Fungus Among Us – Environmental Science and Health
Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets and answer keys, can be found in *The Science of Air Teacher's Guide*, which is available free-of-charge at http://www.bioedonline.org/lessons-and-more/teacher-guides/air/.

Background

The old saying, "There's a fungus among us," contains an element of truth. There are at least 100,000 different fungus species, and members of the fungus kingdom (collectively known as fungi) are found almost everywhere. Fungi, along with some bacteria and other organisms, are the decomposers of our world. They break down the remains of dead plants, animals and other living things and, in the process, obtain the energy they need to grow and reproduce.

Fungi are essential for the continued recycling of nutrients into the soil and the release of carbon dioxide into the air. However, fungi also can be a nuisance to humans. For example, fungi do not discriminate between fruits in a natural setting (such as those that have fallen on the ground) and fruits in the refrigerator. Many fungi attack living organisms and are sources of disease in both plants and animals. Fungi grow especially well in damp places and can attack cloth, paint, paper, leather, cable insulation and even photographic film. The various fuzzy-looking fungi that grow on damp surfaces often are called molds.

Fungi spread by producing spores—tiny particles that can remain suspended in the air for long periods of time. The powdery appearance and bright colors of many kinds of molds actually are caused by the spores they have produced. Some fungi, such as yeasts, are one-celled organisms. Most, however, consist of mats of slender tubes or hyphae (singular, hypha). In some fungi, the hyphae are loosely packed and easy to see. In others, the hyphae are packed so densely that the structure appears solid. Mushrooms, the spore-producing parts of some fungi, are good examples of structures composed of these tightly packed filaments.

Inside buildings, fungi can grow in damp places, such as basements, shower curtains, food storage areas and window air-conditioning units. The spores produced by molds can contribute significantly to indoor air pollution and can trigger allergic reactions in some individuals. Fortunately, indoor air pollution from mold spores can be controlled by keeping humidity levels low (below 30%), by improving ventilation, and by keeping damp areas clean.

Bread mold (*Rhizopus stolonifer*) is a common fungus that is easy to grow and observe. In this activity, students also may see greenish colonies of *Penicillium* (the fungus that produces the antibiotic, Penicillin) and other related fungi.

Image Notes

Rhizopus stolonifer on plum tomatoes. This fungus grows quickly on bread and fruit.

Reference

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Image Reference

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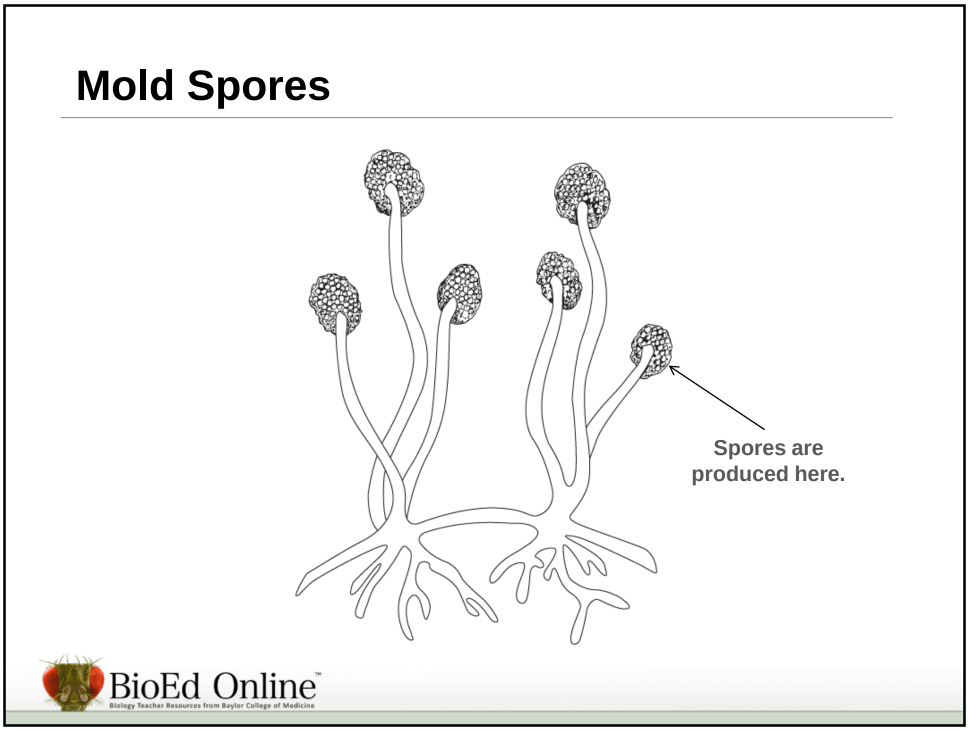

Mold Spores

Procedure

Part 1. Getting started

1.Hold up a piece of bread and ask the students if they know who or what might use it for food. Prompt them to consider all the possibilities. Follow by asking if they ever have seen a rotten apple, moldy slice of bread, etc. Point out that when something is rotting, other living things are using that object for food. Ask, *How do you think these living things spread from place to place?* Remind the students of the particles they observed in the “Make a Dust Catcher” activity. Mention that some of the tiniest particles in dust are produced by organisms as a means of spreading to other places. Tell students they will be able to observe some living things that spread in this way.

2.Have Materials Managers pick up materials for all members of their groups. Have each student label a container with a piece of tape on which the student has written his/her name.

3.Direct the students to examine their bread samples with a magnifying glass, and draw or describe what they predict will happen to the bread in the first space on the “Bread Mold Observations” sheet. In the second space, have students draw or describe the bread as it appears at the beginning of the investigation.

4.Each student should place the bread in his/her container and add a few drops of water. Store the containers in a dark corner or cupboard.

Part 2. Observations

1.For the next 3–7 days, have students observe their cultures (with and without a hand lens) at one- or two-day intervals. Do not allow students to open the containers in which molds are growing. Some breads may grow mold in as little as 24 hours; others may require seven days or more.

2.Have students record their observations on their data sheets.

Part 3. Final observations

1.When all or most cultures (some breads treated with preservatives may not grow mold within the time allotted) have visible molds, instruct students to make their final observations.

2.As a class, decide how many different kinds of molds are present on the bread samples. Have students make a list of the characteristics they use to distinguish one mold from another. Prompt them to think about whether some molds seem to grow on certain types of bread. Ask, *How did the mold get to the bread?* (Spores were present in the air and landed on the bread.)

3.One fungus that will be present is bread mold. It consists of dark gray threads forming a loose, tangled mat that may reach a centimeter in thickness. Find several samples of bread mold from the class's cultures, and give a container with bread mold to each group.

4.Have students observe the bread mold inside their containers with their magnifying glasses. They will be able to see the individual threads with small dark dots at the ends. The dots are the spore-producing parts of the fungus. (The actual spores are very tiny.) If you have access to microscopes, place a few strands of the bread mold (using forceps or tweezers) under microscopes for students to observe. Students will be able to see the tubular structure of the filaments (hyphae), the round, dark heads that produce spores and, depending on the magnification, some of the tiny, round spores. Project the "Common Bread Mold" page to help students spot the different parts.

5.Conclude by leading a class discussion of the role of molds in causing indoor air pollution. You may wish to refer to the story, *Mr. Slaptail's Secret*, in which Rosie, one of the characters, is allergic to mold spores.

Image Notes

Rhizopus stolonifer on plum tomatoes. This fungus grows quickly on bread and fruit.

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There’s Something in the Air

- Many kinds of gases, particles and chemicals travel through, and become dispersed in air.
- Substances in air become concentrated in enclosed spaces.

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There’s Something in the Air – Environmental Science and Health
Complete instructions for conducting activities in this slide set, including materials needed, setup instructions, student sheets and answer keys, can be found in *The Science of Air Teacher’s Guide*, which is available free-of-charge at http://www.bioedonline.org/lessons-and-more/teacher-guides/air/.

Background

Indoor air pollution can occur in many ways. Some indoor pollutants are produced when something burns. These include gases, such as carbon monoxide, as well as particles, like those in soot. Tobacco smoke introduces these pollutants and many other chemicals into the air. Other indoor pollutants, such as pollen, spores, insect parts and droppings, and dust mites come from biological sources. Formaldehyde, a poisonous chemical, can be given off by particle board, carpeting, insulating foam, some cleaners, permanent-press fabrics and tobacco smoke. These and many other sources (such as solvents and cleaners, paints, glues and dry-cleaning fluids) add potentially harmful chemicals to the air.

The concentration of such compounds is much higher indoors than outdoors, in part because many modern, energy-efficient buildings are designed to prevent air leaks or the introduction of outside air into heating or cooling systems. With inadequate ventilation, chemicals and other substances become concentrated in these closed environments.

To reduce indoor air contamination, heating and cooling systems should by serviced regularly. Humidifiers and air conditioners should be cleaned frequently to reduce places where molds and bacteria can multiply. New buildings should be ventilated thoroughly before being occupied. Other measures that can reduce the build-up of harmful indoor pollutants are given on page 3 of the Air unit's *Explorations* magazine.

Reference

Moreno, N., Tharp, B., and Dresden, J. (2011) *The Science of Air Teacher's Guide*. Baylor College of Medicine: Houston. ISBN: 978-1-888997-74-3

Image Reference

Key Words

lesson, slides, air, air pollution, indoor air pollution, dispersion, chemicals, odors, concentrations, ventilation,

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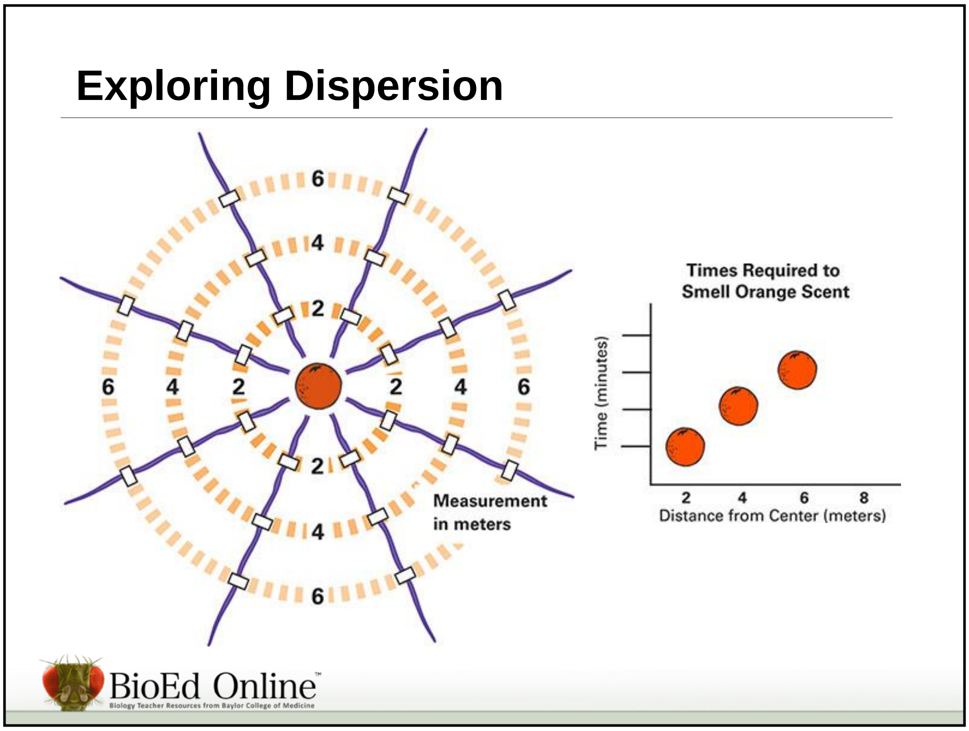

Exploring Dispersion

Procedure

Part 1: Indoors

1.Arrange the pieces of string on the floor like spokes of a wheel around a central point in the room (see PDF for illustration). Divide the class into three groups. Tell the members of one group to sit on the 2-meter marks on the various pieces of yarn. Tell the second group to sit on the 4-meter marks, and the third group to sit on the 6-meter marks.

2.Stand in the center of the “wheel” holding the orange. Before you proceed, tell the students that they should raise their hands as soon as they smell the scent from the orange.

3.Begin to peel the orange, hold it in your hand and turn around slowly. Record (or have one or more students observe and record) the times when approximately three-fourths of the students at each distance have raised their hands.

4.On the board, create a graph showing the time it took for the group at each distance to smell the orange. (Leave the graph on the board until after you have conducted the outdoor portion of the activity.)

5.Use the graph to talk about odors traveling through the air. Ask questions such as, *Which group smelled the orange first? Which one smelled it last? Why do you think that happened?*

Part 2: Outdoors

1.Ask students, *What do you think will happen if we peel the orange outside? Will you smell it more quickly or more slowly?* Have students record their predictions.

2.Repeat steps 1 through 3 from Part 1 in an outdoor location.

3.After returning to the classroom, make a second graph, using the same scale as on the first, to show the time required for odors to travel outdoors. Compare the two graphs, and discuss differences. Ask, *In which environment did you smell the odor more quickly? Was the odor stronger in either place? Could everyone smell the scent in both locations? Why do you think that happened?* (In most cases, the scent will be noticed more quickly indoors. However, air currents indoors and breezes outdoors may affect the results. Discuss these variations with the class.)

Part 3: Compare and Contrast

In a class discussion, relate this experiment to the movement of particles through air (see the activity, "Moving Air"), and lead students to understand how pollutants can become concentrated in indoor environments. Ask, *What do you think an odor is?* (It can be a gas or tiny particles of liquid floating in the air. Explain that many gases and particles float in air all the time.) Ask, *What happens when things floating in air get trapped inside a room? What if it were a harmful gas? How could pollutants in air enter our bodies?*

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Healthy Homes

- Indoor air can be polluted by many sources.
- How can we keep the air inside our homes clean and safe to breathe?

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Healthy Homes (post-assessment)
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Background

We tend to forget that environmental problems are not restricted to outside habitats (natural or urban). Most people's homes, offices and schools are the "environments" in which we spend most of the day and night. Since we spend so much time inside, the quality of our indoor environments is very important.

Indoor air can be polluted by many sources. Some indoor air pollutants are so irritating that they can bother anyone who breathes them. These include paints, asbestos fibers, smoke, cleaners, insect sprays and chemicals used on fabrics. Other pollutants can cause more problems for some people than for others. For example, some people are allergic to dust. When they breathe dusty air, people with dust allergies may start to sneeze, or experience runny noses and itchy eyes. Once in a while, dusty air can cause serious breathing problems, such as those associated with asthma.

How can we keep the air inside our homes and other buildings clean and safe to breathe? A little common sense goes a long way. We can be careful about using chemical cleaners, paints, glues and pesticides. Even better, we can use products that don't pollute. We can reduce the amount of dust in the air by regularly changing the filters in our home heating and cooling systems. We can eliminate some sources of indoor air pollution, such as tobacco smoke, completely.

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Image Reference

Photo courtesy of the CDC/11408/Dawn Arlotta.
http://phil.cdc.gov/phil/home.asp

Key Words

lessons, air, air molecules, air currents, air quality, air pollution, allergy, allergies, argon, asthma, breath, breathing, carbon dioxide, carbon monoxide, chemicals, cigarette smoke, concentrations, dander, diaphragm, dispersion, dust, dust mites, fungi, fungus, gas, gases, heart, heartbeat, heart rate, indoor air pollution, lungs, mold, nitrogen, oxygen, pesticides, pollen, pulse, radon, respiration, second hand smoke, smoke, smoking, tobacco smoke, ventilation,

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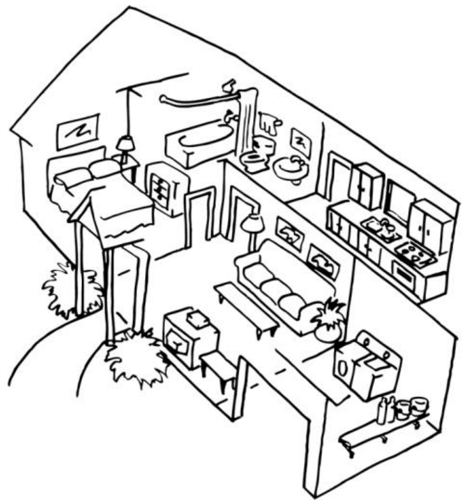
Healthy Home Survey



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Healthy Homes Survey

Procedure

Part 1. Getting started

1.Ask students to mention some things they have learned about indoor air. If you have used the Air unit's *Explorations* magazine and/or read the story, *Mr. Slaptail's Secret,* one or the other might serve as a basis for beginning a discussion. Otherwise, initiate a class review of different sources of indoor air pollution.

2.Mention that we can do many things to improve the quality of the air we breathe at home. Stress that before trying to solve problems of this type, we must look for possible sources of indoor air pollution. After those sources are identified, we can decide which actions are needed to make improvements.

3.Give each student a copy of the "Healthy Home Survey" student page. Ask students to take their pages home and use them to conduct a survey of possible air pollutants inside their homes. Stress that an older family member or friend should help them conduct the survey. Students should circle or color different areas on their sheets in which they have found potential sources of indoor air pollution. Encourage them to draw any additional pollutants that they encounter during their surveys.

Part 2. Looking at results

1.Invite students to share their survey results with the class. Create a list on the board of different home air quality hazards identified, or make a transparency of the "Healthy Home Survey" sheet and make annotations while you project it as an overhead.

2.After the list is complete, have students suggest ways in which hazards can be decreased or eliminated. Do this as a whole-class discussion, or ask each student to write a paragraph about ways to improve indoor air quality.

3.Refer students to pages 28–29 of the storybook, *Mr. Slaptail's Secret*. Ask them to find the different ways Mr. Slaptail's neighbors were able to eliminate air pollution inside his house.

4.Display the students' surveys.

Part 3. Post-assessment

1.Hand out students' pre-assessments, completed at the beginning of the unit. Ask students if there are any questions that they would answer differently now.

2.Have students use a different color ink to circle any new responses. On a separate sheet of paper, have students explain the reasoning behind their changes. Discuss students' new responses as a group.

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