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How Do We Breathe?

An inhalation activity from Science Buddies

BY SCIENCE BUDDIES & SABINE DE BRABANDERE

In and out: Learn how physics plays a role in every breath you take. George Retseck

Biology

Key Concepts

Biology

The body

Lungs

Physics

Air pressure

Introduction

We breathe a lot—roughly 10 times a minute! Have you ever wondered how the process of breathing works so smoothly? Our lungs allow us to inhale the oxygen our body needs, but they do much, much more. They also allow us to get rid of carbon dioxide, the waste product created in the body, and they play a vital role in singing, shouting and even giggling. In this activity you will make a model of a lung and use it to discover how air flows in and out of the lungs with ease.

Background

All cells in our body need oxygen to create energy efficiently. When the cells create energy, however, they make carbon dioxide. We get oxygen by breathing in fresh air, and we remove carbon dioxide from the body by breathing out stale air. But how does the breathing mechanism work?

Air flows in via our mouth or nose. The air then follows the windpipe, which splits first into two bronchi: one for each lung. The bronchi then split into smaller and smaller tubes that have tiny air sacs at their end called alveoli. We have millions of alveoli in our lungs! These sacs have thin walls—so thin that oxygen and carbon dioxide can pass through them and enter or leave our blood. The blood transports oxygen to almost every part of the body. The blood also gives the carbon dioxide a ride back to the lungs.

Lungs take up most of the space in the chest. The 12 pairs of ribs in our ribcage protect the lungs and other organs in our chest cavity, such as our heart.

Relaxed breathing is a reflex; we do not have to think to breathe. During this unforced inhalation our diaphragm—the dome-shaped muscle between the chest and the abdominal cavity—flattens. This expands the chest cavity and as a result air is drawn in. During exhalation the diaphragm relaxes and the lungs naturally recoil, and air is gently pushed out.

We can also breathe more forcefully. When we exercise, sing loudly or otherwise need or want more air or oxygen we can exert force to breathe more deeply. We use various muscles to increase chest volume more dramatically. In the same way as in relaxed breathing the expansion of the chest cavity draws air in so the lungs fill up. The relaxation of the chest cavity pushes air out. Muscles can also force the chest cavity to contract even further, pushing even more air out. Because the expansions and contractions are larger in this case a bigger volume of air flows in and out of our lungs, and our body gets a larger supply of oxygen or we have more air to create sound.

Materials

- Disposable empty transparent bottle (10–16 fluid ounces) made of hard plastic (such as a sports drink bottle)
- Ruler
- Two balloons (8-inch balloons work well)
- Utility knife (have an adult help and use caution when using the knife)
- Adult helper
- Scissors
- Drinking straw (optional)

- Modeling clay (optional)
- Tape (optional)
- Additional balloon (optional)

Preparation

- Ask an adult to cut the plastic bottle. Cut off the bottle's bottom so that when a balloon hangs inside the bottle from the spout there is about 1/3 to 3/4 of an inch of empty space below the balloon.
- Place the cut bottle down on the wide opening. Lower a balloon into the bottle until only part of the balloon's neck sticks out. Fold the neck of the balloon over the top of the bottle. The balloon represents a lung.
- Turn the bottle over (keeping the balloon inside) so the bottle top rests on the table. In the next steps you will create and add the diaphragm to your model.
- Make a knot in the neck of the second balloon. At the opposite side of this balloon cut off about a third of the balloon so you are left with a wide opening.
- Stretch the wide opening of the cut balloon over the wide opening of the bottle. Pull the edges of the balloon far enough up the bottle so the balloon surface is gently stretched. Make sure that the knot is on the outside and located near the middle of the bottle opening.
- Like an inflated balloon our lungs are full of air. We have two lungs, which are enclosed in the ribcage and protected by 24 ribs. When you breathe in, air flows into your lungs. When you breathe out, air flows out of your lungs.

The balloon inside the bottle is like one of your lungs. The bottle is like your ribcage.

Procedure

- Hold the bottle so you can see the balloon inside (representing the lung). Gently pull down on the knot. *What happens to the balloon inside the bottle?*
- Let the knot come back to its neutral position and then gently push it in. *What happens to the balloon inside the bottle now?*
- Repeat these steps a few times. *Does this resemble breathing? Why?*
- *Which part resembles breathing in and which part resembles breathing out?*
- If your model is working well, air will rush into the balloon when you pull the knot outward and flow out when you push the knot inward. *Why do you think this happens?*
- When we breathe in a relaxed way our diaphragm—the muscle that separates the chest cavity from the abdominal cavity—moves to expand and contract the chest cavity. *How is that similar to what you do with your model?*
- Push and pull the knot a few more times. *Using the model can you find which movement of the diaphragmcreates inhalation and which creates exhalation?*
- Feel your ribs and breathe in deeply then exhale. *Can you feel your ribcage expand and fall back?*
- The center of our diaphragm moves more when we take deep breaths: up to four inches! In the model you made, the ribcage (the plastic bottle) is fixed, but you can move the "diaphragm" more by pulling the knot farther and

pushing it in more. Try it out. *How does that change the volume of air that flows in and out of the lung balloon?*

- **Extra**: Add a windpipe to your model. To do this take the balloon out of the bottle and slip its neck over a straw; secure the balloon to the straw with tape. Hang the balloon—and a short section of the straw—in the bottle's neck, and use clay to hold it in place. Make sure the clay makes an airtight seal around the straw and the bottle neck. No change is needed to the second balloon that closes off the bottom of the bottle. *Can you see which part models the windpipe?*

- **Extra**: A cough is the body forcefully expelling air to get rid of something that caused irritation. During a cough you breathe in relatively deeply but instead of air flowing out while the chest cavity contracts, your throat closes, and air builds up in the lungs. When the throat opens the chest contracts even more and air flows out in a forceful way. *Can you mimic a cough with your model?*

- **Extra**: Find a way to create a model that includes a windpipe that splits into two bronchi, each with a lung attached. The model with a windpipe and one lung is a good start. *How can you add a second lung? Can you find a reason why having two lungs is beneficial for us?*

Observations and Results

When you pulled the knot back, the space inside the bottle increased and your balloon probably filled up with air. In the same way, when the diaphragm in our body pulls back, the chest cavity increases and air flows into our lungs, and we inhale.

When you pushed the knot in, the space inside the bottle decreased, and the balloon probably deflated. In the same way, when the diaphragm relaxes the

chest cavity decreases, and air is pushed out of the lungs, and we exhale.

When you pulled and pushed the knot further the balloon inflated and deflated more. This mirrors what happens when a bigger volume of air is displaced when we breathe more deeply.

This dynamic works because of air pressure, a measure of how hard air presses against objects. Air pressure increases when you decrease the amount of space the air has—and decreases when you give air more space. Close a flimsy empty plastic bottle and try to compress it. It is difficult! The air inside pushes back. Open the bottle, and try to compress the bottle again. It is much easier. The air presses back with a much reduced force. Unless something blocks the movement, air will move from areas of high pressure to areas where the pressure is lower, and this is what happens when air rushes in or out of the lungs. When the chest cavity expands there is more space around your lungs. In this condition the lungs can expand, making it a low-pressure area, and air rushes in to balance out the difference in pressure. Then to breathe out the chest cavity and lungs shrink. This raises the air pressure in your lungs, and the air rushes back out.

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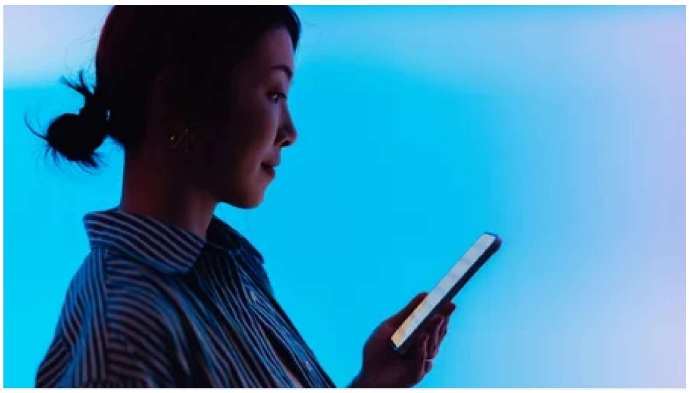

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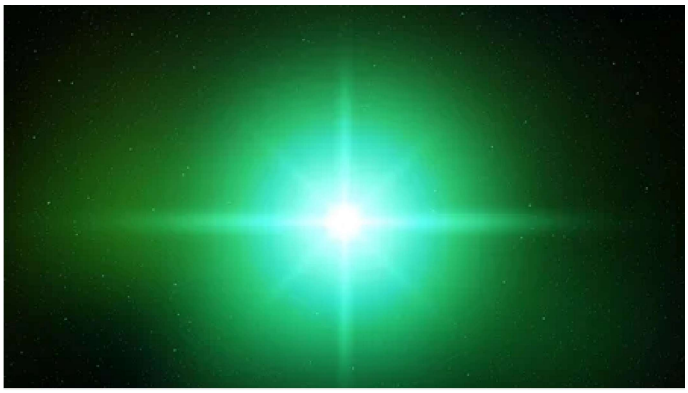

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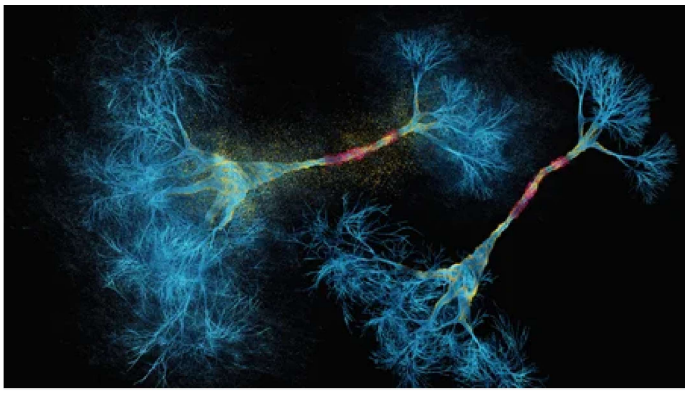

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