Air Apparent: A Program About Air and Air Pressure
Presented by the Sciencenter in Ithaca, NY

Program Overview

Air Apparent introduces students to air, focusing on the key properties of air as a kind of matter. The program is designed for classes or home-school groups of up to 24 students in grades K-5. Each program runs approximately 50 minutes, and is held in the Sciencenter classroom.

The program begins with several demonstrations that capture students' interest in the subject of air. Students then try out a variety of hands-on activities that introduce and reinforce the properties of air. *(For background information and air basics, see page 3.)*

Although there are a number of learning objectives, students may not grasp them all during the program. Post-program activities will reinforce their learning and help broaden their understanding.

Learning Objectives:

Students will be able to:

- Explain that air takes up space and has weight and is therefore a form of matter.
- Explain that air exerts approximately 15 pounds of pressure per square inch.
- Describe how air pressure and density change at different temperatures.
- Explain that moving air is at lower pressure than still air.
- Explain that air always moves from areas of high pressure to areas of low pressure and recognize that this rule is known to scientists as the *Bernoulli principle*.

Students will practice the following process skills:

- Scientific observation
- Interpreting data
- Drawing conclusions.

New York State Math, Science and Technology Curriculum Standards:

Standard 1—Analysis, Inquiry and Design

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing creative process.
2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Standard 4—Science

The Physical Setting

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.
4. Energy exists in many forms, and when these forms change energy is conserved.

Standard 6—Interconnectedness: Common Themes

Equilibrium and Stability

4. Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Background Information

On planet Earth, we live below a vast layer of air extending 500 miles above us. This atmosphere is essential to human life. We depend on air to protect our planet and create an environment we can survive in. Without our atmosphere, Earth would be burning hot during the day where the sun hits it directly, and freezing cold at night where it is exposed to the cold of outer space. Fortunately, the air in our atmosphere protects us by absorbing many of the sun's rays so that only a small number hit the Earth and warm it up during the day. Then at night, the air in the atmosphere acts as a blanket, holding in that warmth so we don't freeze.

To a scientist, air is a form of matter that has several characteristic properties. Although we often aren't aware of it, air takes of space. An empty bottle isn't really empty. It's full of air. Air that is warmer takes up more space than the equivalent amount of air when it is colder. This is because when air molecules are warmer, they move more quickly and across a greater area. When they are cooler, they move more slowly and across a smaller area. This means that the same number of air molecules will take up more space when they are warm than when they are cool.

In addition to taking up space, air has weight and exerts pressure. We're so used to the weight and pressure of air that we rarely notice it, but we are actually bearing approximately 15 pounds of air pressure on each square inch of our bodies at all time.

Air circulates according to a rule known as the Bernoulli principle: moving air has lower pressure than still air; and air always moves from higher pressure areas to lower pressure areas. The Bernoulli principle seems straightforward, but you and your students will find some surprising results when you experiment with it!

Resources

Websites

The following websites have a number of activities and lesson plans related to air, states of matter, and properties of matter (as well as many other science topics):

www.teach-nology.com/teachers/lesson_plans/science/chemistry/matter/
http://www.physics.rutgers.edu/hex/visit/lesson/lesson_links5.html

The Smithsonian website has a lesson plan on how aircraft fly:

http://www.smithsonianeducation.org/educators/lesson_plans/how_things_fly/lesson2_main.html

Books

Best of WonderScience, vols. I and II. Wadsworth Publishing, 2000.

Ontario Science Centre. *Scienceworks: 65 Experiments that Introduce the Fun and Wonder of Science.* Addison-Wesley, 1986.

Richards, Roy. *101 Science Tricks: Fun Experiments with Everyday Materials.* Sterling Publishing, 1990.

Usborne's Science Activities. *Science of Air.* E.D.C. Publishing, 1992.

VanCleave, Janice. *203 Icy, Freezing, Frosty, Cool & Wild Experiments.* John Wiley & Sons, 1999.

Classroom Activities

KWL Chart

A great way to build excitement for your *Air Apparent* program at the Sciencenter is to create a "KWL" chart with your students. This activity is effective as a whole-class discussion, or as an individual assignment.

Air

K: What I **know**	**W**: What I **want** to know	**L**: What I **learned**

Before your field trip, fill in the "K" and "W" columns. After the field trip, fill in the "L" column. You may want to review the program objectives, so that you can help students remember the most important things that they learned.

Catch Some Air

Demonstrate that air takes up space and exerts pressure and that air is lighter than water.

<u>Materials</u>

- Large container of water (a plastic storage bin works well)
- Two plastic cups
- Small strainer or sieve (a small one with a handle is best)

<u>Procedure</u>

1. Push a plastic cup straight down into the tub of water, so you capture the air inside the cup. Tilt the cup and observe how the air bubble escapes and rises to the surface. Ask students whether the air bubble is taking up space in the container or not.
2. Let the students try capturing and releasing an air bubble under water. Challenge them to pour their air bubble from one cup to another. Can they do it if the second cup is full of water? What about air?
3. What will happen if you try to catch the air bubble in the strainer. Will the air escape through the holes, or will the strainer hold the air? Test your hypothesis.

<u>Explanation</u>

By trapping the air underwater, you can see that air takes up space. Because air is lighter than water, the trapped air bubble will rise to the surface as soon as it is released. It can be caught again by a second cup full of water because it exerts enough pressure to push the water out of the cup—but it cannot push its way into a cup that's already full of air.

The strainer will catch the bubble, because the bubble is too big to fit through its holes. If you shake the bubble inside the strainer, you may be able to create smaller bubbles that will fit through the holes.

Bubbling Up
See that air expands as warms and contracts as it cools.

Materials
- Water bottle or other bottle with a small mouth (pint-sized works well)
- Soap bubble solution in a saucer or shallow bowl.
- Bowl of hot water (big enough to hold the bottle)
- Bowl of cold water (big enough to hold the bottle)

Procedure
1. Dip the mouth of the bottle into the bubble solution. Carefully lift and tilt the bottle as you pull it out so that a film of bubble solution covers the opening of the bottle.
2. Place the empty bottle in the bowl of hot water. What happens to the soap film?
3. Place the bottle in the bowl of cold water. Now what happens?

Explanation
When you place the bottle into the bowl of hot water, the air inside the bottle warms up. As it warms, it expands and pushes against the mouth of the bottle—creating a bubble. When you move the bottle into the bowl of cold water, the air inside the bottle contracts as it cools and the bubble shrinks.

Sinking Like a Cork?
Demonstrate that air exerts pressure.

Materials
- Medium-sized bowl of water
- Small cup that fits inside the bowl
- Small cork that fits inside the cup

Procedure
1. Fill the bowl about two-thirds full with water, and float the cork in the water.
2. Turn the cup upside down and push it into the water, capturing the cork inside it. (Practice this ahead of time, so you can demonstrate the proper motion to your students.)
3. Ask students to explain what happens!

Explanation
The air inside the cup pushes the water and cork down to the bottom of the bowl.

Balancing Balloons
Prove that air has weight.

Materials
- Two balloons
- Yardstick or meter stick
- Two rubber bands
- Paper milk carton or other narrow edge to use as a balancing point

Procedure

1. Attach a deflated balloon to each end of the stick with a rubber band.
2. Balance the stick on the top edge of the milk carton.
3. Mark the exact place on the stick where it balances.
4. Now blow up one of the balloons and reattach it to the yardstick using the rubber band. Try to balance the yardstick on the same spot.
5. Ask the students to explain what happens.

Explanation

The inflated balloon is heavier than the deflated balloon, pulling that end of the yardstick down. This demonstrates that the air inside the balloon has weight.

Paper Bridge

Surprise yourself with a vivid demonstration of the Bernoulli principle.

Materials

- Two large books
- Sheet of notebook paper

Procedure

1. Place two large books about four inches (10 centimeters) apart on a table.
2. Lay a sheet of paper across the books to form a bridge.
3. Predict what will happen to the paper bridge when you blow underneath it.
4. Test your prediction by blowing a stream of air that is parallel to the table below the paper, not directly on the paper.

Explanation

When you blow underneath the bridge, you are creating a stream of low pressure air. Because air always moves from areas of higher pressure to areas of lower pressure, air on the upper side of the bridge moves downward toward the low pressure area, pushing the paper bridge with it.

Funny Funnel

A deceptively simple challenge that demonstrates the Bernoulli principle.

Materials

- Ping-pong ball
- Funnel (clean, and big enough to hold the ping-pong ball)

Procedure

1. Put the ping-pong ball in the funnel. Ask students if they think they can blow the ping-pong ball out of the funnel.
2. Challenge them to try it! Explain that they must keep the funnel upright, blowing into it from below.

Explanation

When you blow through the funnel, the air below and around the ball is moving fast and so has low pressure. In comparison, the still air on top of the ball has more pressure and pushes the ball down into the funnel. The harder you blow, the harder the ball is pushed back into the funnel.

Balloon Rocket Races

This activity demonstrates the Bernoulli principle.

Note: This activity works best with older students who are adept enough to set up their rockets on the raceway. For younger students, you will need additional adult help.

Materials

- Balloons
- Straws, paper towel tubes, or toilet paper tubes
- Smooth string
- Furniture to anchor the string
- Tape
- Markers, stickers, paper, or other materials to decorate the rockets (optional)

Procedure

1. Blow up a balloon, and ask students what they think will happen if you let go of the end. Test their hypotheses by letting the balloon go.
2. Tell the students that in this activity, they are going to use the pushing power of air to power their own toy rockets.
3. Have the students make toy rockets from the straws or tubes and optional decorating materials. Instruct them to leave *both* ends of the rocket body open.
4. Set up at least two rocket runs by tying one end of a string to a chair, table leg, or other stable furniture.
5. Thread a rocket body through the loose end of the string. Blow up a balloon and tape it to the rocket body, being careful to hold the open end of the balloon tight so the air doesn't escape. This is best accomplished by teaming two or even three students. One student can hold the string in one hand and the rocket body in the other, and one or two others can hold the balloon and tape it to the rocket.
6. When two or more balloons are side by side on the strings, they're ready to race! Make sure the student holding the string keeps it very taut.
7. Students can count down to a "blastoff." When the student holding the balloon lets go of the end, the balloon will shoot forward, propelling the rocket along the string.
8. Let students try their rockets several times, experimenting with the placement of the balloon on the rocket body and other variables.

Explanation

When you blow up a balloon, you create greater air pressure inside the balloon than there is outside the balloon. When the air is allowed to escape, it rushes out of the high-pressure environment of the balloon to the relatively low pressure surrounding it. If you don't hold onto the balloon, the movement of the air pushes the balloon forward in an equal and opposite reaction.