EXPLORING NORTH CAROLINA

Pressure on the Mountain

STANDARD COURSE OF STUDY CORRELATIONS:

Science, Grade 7, Goal 3: The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of the atmosphere.

3.01 Explain the composition, properties and structure of the atmosphere.

3.05 Examine evidence that atmospheric properties can be studied to predict atmospheric conditions and weather hazards.

INTRODUCTION TO LESSON: Students will conduct experiments to learn about air pressure and barometers. They will develop an understanding of how air pressure changes with altitude and how barometers can be used to measure heights.

MATERIALS

- Scrap pieces of printer paper (1 per pair of students)
- Sheets of newspaper (1 per pair of students)
- Ruler (1 per pair of students)
- Straws (1 per student)
- Small cups (1 per student)
- Access to drinking water

For demonstration:

- Hot plate
- Skillet
- Tongs
- Shallow dish (such as a pie pan or casserole dish)
- Empty aluminum cans (soda cans work fine; for a super-impressive result, use a large, new gas can).

PREPARATION

- You might want to practice the "Elaborate" demonstration a few times before presenting it to the class.
- You will need two pieces of climate data for the "Evaluate" section. Go to the State Climate Office of North Carolina Web site and note the current barometric pressure reading for Mount Mitchell (http://www.ncclimate.ncsu.edu/cronos/?station=MITC). Use the menu bar on the same page to find the barometric pressure reading for a locale that is near your school.

BACKGROUND FOR TEACHER: When Elijah Mitchell was challenged to measure the height of North Carolina's Black Mountains, he used a barometer as his tool. Barometers measure changes in air pressure and are frequently associated with meteorology.

Italian scientist Evangelista Torricelli developed the first barometer in 1643 while trying to understand the principles of vacuum and air pressure. Galileo, a contemporary of Torricelli, had worked on a water vacuum apparatus to develop the vacuum principle. This work inspired Torricelli to set up a 35-foot-tall tube of water that protruded from the top of his house. He noticed that the level of the water in the tube varied in response to changes in air pressure. Torricelli placed a dummy on top of the column of water, and passersby could see it moving up and down as the pressure changed. During this time in human history, there was a lot of conflict between scientists and the churches. Some people believed that Torricelli was participating in some type of witchcraft, so he realized that he needed to find a way to do his experiments outside of the public eye. Based on his previous work with Galileo, he decided that he could use a shorter tube and substitute mercury for water. Because mercury is 14 times denser than water, he needed only a 32-inch container to measure air pressure. Even today, air pressure is still measured in "inches of mercury."

The first publicly marketed barometers for home use appeared about 1670. Many were embellished and made with decorative cabinetry. Owning one became a symbol of great achievement. Thomas Jefferson used one to measure air pressure at his home, Monticello. Using a table published in London in 1725, he was able to turn the measurements into heights. The first mechanical barometers, which use a metal vacuum disc and a pointer, appeared about 1840. These were much less expensive and easier to transport.

engage > Have pairs of students place a ruler flat on their desktop with about half its length extending over the edge of the desk. Have them place a piece of paper on top of the ruler and smooth it down to eliminate any air pockets. Ask them to take turns pushing down gently on the end of the ruler, using it as a lever to try to lift the paper off the desk. They will discover that it is somewhat difficult to do. Have them try again, this time using a sheet of newspaper. It should be even more difficult to lift the newspaper. Ask them to brainstorm why it was hard to lift the paper and why it was even more challenging to lift the newspaper.

For a follow-along viewing guide for students, see Viewing Guide 6.

Antique barometer photograph from istockphoto.com.

Next, give each student a straw and small cup of water. Ask them to sip some of the water into the straw. Challenge them to figure out how to keep the water in the straw without sealing the bottom. *(Putting one finger, or the tip of the tongue, over the top opening will cause the water to stay in the straw.)* Ask them to brainstorm why the water remained suspended in the straw.

explore Ask students if they have ever experienced the sensation of having their ears "pop" while driving in the mountains or while riding in an elevator or plane. Have them offer explanations for this phenomenon. *(Traveling upward in the atmosphere reduces the air pressure on eardrums. The sensation of having one's ears "pop" is the result of them equalizing pressure. This phenomenon is most noticeable during a rapid change in pressure, as often happens in a moving car, plane or elevator.)*
Show Chapter 3 of the video.

explain After showing the video, share that the reason the paper stayed on the table and that the water stayed in the straw was because of air pressure. When they tried to lift the paper off the table, it met resistance from the force of air pressing down on it. The surface area of the newspaper is greater, which made it even more difficult to lift. By covering the top of the straw with a finger, they prevented the air from entering from above and pushing the water out of the straw.

Share with students that the word *barometer* derives from the Greek words *baros*, meaning weight, and *metron*, meaning measure. Barometers measure the weight of the air. The video explained that there is more air pushing down in the Piedmont and less air pushing down in the Mountains. Elijah Mitchell used this concept to help him determine the height of Mount Mitchell.

elaborate Set up a final demonstration of air pressure in front of the class.

Soda can option:
Fill a shallow dish with about 1/4 inch of cold water. Put a small amount of water in the empty aluminum can (just enough to cover the bottom) and place it in the skillet. Turn the hot plate on and let it heat up until the water in the can starts to boil. Use the tongs to pick up the can and invert it into the shallow dish of water, sealing the hole in the top. Immediately there will be a loud crack, and the sides of the can will collapse.

Ask the students what they think happened. (*Heating the can made the air inside of it expand, changing the air pressure and forcing some of the air out. Inverting the can into the dish of water sealed the entrance, and air could not get back in. The air in the can cooled quickly, and the pressure decreased; because more air couldn't get in, the sides of the can collapsed.)*

Gas can option:
Remove the lid of the can and set aside. Pour a small amount of water into the can. Set it on the hot plate and let the water come to a boil. Remove the can and quickly seal it with the cap. As the water inside cools, the sides of the can will collapse.

evaluate On the board, post the barometric pressure readings from Mount Mitchell and the locale nearest you. Ask the students to write a brief explanation of why the two numbers might be different. (If your school is in a region with high elevation, there should not be much difference). Answers should demonstrate an understanding of these three concepts: 1) air has weight, 2) barometers measure air pressure, and 3) there is less air pressure at the top of a mountain.

Teacher's Notes:

BEYOND THE CLASSROOM

- Arrange a field trip to a local television station to meet a meteorologist and learn about how air pressure and weather patterns are related.
- Take a field trip to one of North Carolina's mountain parks, e.g., Mount Mitchell State Park, Grandfather Mountain, Pilot Mountain State Park. For more information, visit http://www.ncparks.gov/.

Additional Resources:

Silver, Timothy. 2003. *Mount Mitchell and the Black Mountains: An Environmental History of the Highest Peaks in Eastern America.* Chapel Hill: University of North Carolina Press.

"Make Your Own Barometer" activities:
http://www.srh.noaa.gov/jetstream/atmos/ll_pressure.htm (wet barometer)

http://www.srh.noaa.gov/jetstream/atmos/ll_pressure2.htm (dry barometer)