



Air Has Weight and Temperature Affects It?

LESSON THEME

This lesson has two activities that develop a basic understanding about the weight of air and its basic importance to understanding meteorology and to determine that a change in temperature of air affects its vertical movement.

OBJECTIVES

Students will

- Experiment with the change in the position of a bar balancing a balloon inflated with air on one end and a noninflated balloon on the other end and the cause for this change
- Write a procedure for investigating a research question
- Identify factors affecting the dynamics of air in motion

NASA SUMMER OF INNOVATION

UNIT

Earth and Space Science—Weather

GRADE LEVELS

4 – 6 Earth Science

CONNECTION TO CURRICULUM

Science

TEACHER PREPARATION TIME

1 1/2 hours

LESSON TIME NEEDED

2 hours

Complexity: Basic

NATIONAL STANDARDS

National Science Education Standards (NSTA)

Science as Inquiry

- Understanding of scientific concepts
- The dispositions to use the skills, abilities, and attitudes associated with science

MANAGEMENT

Activity 1—A complicated factor that needs to be explored is that air usually becomes cooler (more dense) at higher elevations. See Appendix V of the full teacher guide for more information on boiling point and Content Research notes below.

Activity 2—This activity requires patience and skill to balance two paper bags. It is important that the paper bags are balanced before the light is turned on and directed toward one of the bags. Younger learners might experience difficulty in balancing the two bags. A lamp with a 100-watt or higher wattage bulb works best to warm the air inside the bag. Caution should be exerted not to set the light too close to the paper bag because the heat could cause a fire.

It should be noted that due to the small mass of air in each bag, the scale might tip only slightly in the direction of the nonheated bag. In a Guided-Inquiry Activity, the learner is given the question to investigate but he/she must design an appropriate procedure to carry out the investigation.

The challenge is to aid the student in constructing his/her own design without too much external directing. Naturally, there are many procedures that can lead to a valid resolution of the presented question. The illustrations (Figures 8–2 and 8–3) should not be shared with the learner, because in a Guided-Inquiry Activity, the learner constructs the procedure. The figures should assist the teacher in guiding the learner toward an appropriate design. Encourage the learner to be creative in the procedure design. For example, the experiment

could be repeated more than once and results compared. Another variation could be to switch the light from one of the bags to the other to see if this makes a difference. In Figure 8–2, the two bags are balanced. In Figure 8–3, the bag receiving the direct light has risen slightly.

CONTENT RESEARCH

Atmospheric Structure: The vertical distribution of temperature, pressure, density, and composition of the atmosphere constitutes atmospheric structure. These quantities also vary with season and location in latitude and longitude, as well as from night to day; however under the topic of atmospheric structure, the focus is on the average variations with height above sea level. Although it is impossible to define an absolute depth of the atmosphere, most of the atmosphere is confined to a narrow shell around the planet, with the pressure and density of air decreasing rapidly with altitude and gradually merging into the emptiness of space.

Boiling Point: The two principal factors that affect boiling are the pressure and the temperature. Under one atmosphere of pressure, pure water boils at 100 °C. If the pressure changes, then the temperature will also change. More pressure means that the water vapor has to push harder on the air above it and less pressure means that there is less air to push out of the way. When altitude is increased, generally there is an accompanying decrease in atmospheric pressure; changing altitude can change a boiling point. At the South Pole the barometric air pressure is about 20 percent less than expected for an elevation of 2,835 meters. This is the result of the general weather pattern that persists at the Pole and the effect of cooling the air over the Pole. This extra "thinning" of the atmosphere combined with the calm weather pattern and the fact that air is extremely dry makes the South Pole an excellent place for astronomy.

LESSON ACTIVITIES

Activity 1—Does air have weight? How do you know?

The purpose of the following activity is to verify that air has weight and that this fact can be concretely illustrated. This activity originated from *Meteorology: An Educator's Resource for Inquiry-Based Learning for Grades 5–9*.

http://www.nasa.gov/centers/langley/pdf/245899main_MeteorologyTeacherRes-Ch8.r3.pdf

Activity 2—Can you show that the temperature of air has an effect on its weight and its direction of vertical movement?

This activity has two important purposes: To challenge the learner to develop a procedure for investigating a research question and to learn more about factors affecting the dynamics of air in motion.

http://www.nasa.gov/centers/langley/pdf/245898main_MeteorologyTeacherRes-Ch7.r3.pdf

ADDITIONAL RESOURCES

What is atmospheric pressure?

This NASA video segment explores atmospheric pressure and why humans must wear specialized suits in space. Viewers learn that atmospheric pressure is the force exerted by air molecules. One reason that astronauts must wear space suits is to maintain a normal air pressure on their bodies, because space is a vacuum.

http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/What_is_Atmospheric_Pressure.html

Comments from guest blogger and International Space Station Associate Scientist Tara Ruttle, Ph.D., as she reflects on the physical science of boiling in space.

http://blogs.nasa.gov/cm/blog/ISS%20Science%20Blog/posts/post_1301433765536.html

Boiling Point of Water in Space

At this site you can find questions submitted by users of the Web site "From Stargazers to Starships" and the answers given to them (e.g., At what temperature would water boil at in Outer Space?)

<http://www-istp.gsfc.nasa.gov/stargaze/StarFAQ15.htm#q255>

NASA SCI Files—The Case of the Phenomenal Weather

Files segment explains how air pressure affects weather.

http://nasa.ibiblio.org/selection_page_new.php?view=combo&action=search&start=0&query=weather&gra=3-5

DISCUSSION QUESTIONS

Activity 1—Does air have weight? How do you know?

- What is the boiling point of water? Can this question be answered with a short answer? Why? Why not?
The boiling point of water differs with elevation; however, at 100 °C pure water will boil.
- What way do you view the weight of air influencing the understanding of meteorology? *Answers will vary.*
- Why is it important to bring the two deflated balloons to a balance before proceeding with the next steps of this investigation? *To have an accurate assessment.*

Activity 2—Can you show that the temperature of air has an effect on its weight and its direction of vertical movement?

- Have you ever seen leaves on trees turn upward during a summer afternoon breeze? *Answers will vary.*
- What do you think might cause this to happen? *Answers will vary*
- Do you think it might have something to do with change in the density (weight) of the air? *Answers will vary*

ASSESSMENT ACTIVITIES

Activity 1—Does air have weight? How do you know?

Below are the assessment questions provided in the activity.

-After conducting this investigation, what did you conclude about air having weight?
Answers will vary; however, students should clearly see that air does in fact have weight.

-What data (observation) enabled you to arrive at this conclusion?
At the beginning of the experiment both bags were balanced; however, after heating one bag, the scale became unbalanced and the bag that was heated moved up. There must be something in the bag that changed.

-What is the most important factor in verifying this conclusion for you? *Answers will vary.*

-Can you suggest additional investigations that could be used to further verify that air has weight? *Answers will vary.*

Activity 2—Can you show that the temperature of air has an effect on its weight and its direction of vertical movement?

The activity is the assessment.

ENRICHMENT

Activity 1—Does air have weight? How do you know?

Pose the following questions to students and have them carry out their suggestions.

- Can you suggest additional investigations that could be used to further verify that air has weight?
- How could you determine if cooler liquids weigh more than warmer liquids?

Activity 2—Can you show that the temperature of air has an effect on its weight and its direction of vertical movement?

The Mysterious Snake

Decorate the spiral snake below. Cut out the circle, and then carefully cut along the spiral line. Poke a small hole in the center of the snake's head and tie a piece of thread through it. Hang the snake over a lamp that is turned off. Observe what happens. Next turn on the lamp and observe what happens.

What do you observe happening?

The snake that hung over the lamp that is not turned on probably stayed motionless. When the lamp is turned on, the snake will probably spin.

Can you explain why this happened?

When the lamp was turned on, it heated the air above it. The hot air, being less dense, rose. This rising air rushed against and flowed over the underside of the snake causing it to spin.

