

Atmospheric Pressure

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Science Content Standards: Grade 5, 4e *Students know* that the Earth's atmosphere exerts a pressure that decreases with distance above Earth's surface and that at any point it exerts this pressure equally in all directions.

Lesson Concept: High pressure flows towards low pressure.

Conceptual Flow:

Air pressure is the weight of air (a force) pushing on a given square unit area. Air pressure is the force with which the air presses down on things.

- ▶▶ Gravity pulls the air toward the Earth.
- ▶▶ Because of gravity, pressure is greatest near Earth's surface (sea level) and diminishes with increasing height in the atmosphere.
- ▶▶ Because of gravity, the pressure on the bottom of an object is slightly greater than on its top.
- ▶▶ Barometric pressure is pressure of the air at ground level caused by the weight of the air above pressing down. Air pressure is the highest near the Earth's surface where air particles are squeezed close together by the weight of the air above.
 - The greater the altitude, the lower the air pressure.
- ▶▶ Temperature can affect air pressure.
- ▶▶ Differences in air pressure cause changes in weather.
- ▶▶ Air pressure variations across the globe are responsible for the generation of winds.
 - Air flows from regions of high pressure to regions of low pressure.
 - High pressure flows towards low pressure.
 - High pressure areas will cause motion into the areas of low pressure.
- ▶▶ Air pressure readings can help forecast weather conditions.
 - Rising air pressure is an indication that clear weather is likely.
 - Falling air pressure means that clouds and precipitation are likely.

► Students may hold the following misconceptions:

- *Wind has pressure, but not still air.*
- *Pressure is not equal in all directions; pressure is greater pushing downward*
- *Gases “float” and have no weight.*

Teacher Background:

Atmospheric pressure is the weight of air (a force) pushing on a given square unit area (e.g., m² or cm²). Air is invisible, hard to detect by the sense of touch, and difficult to weigh. Thinking of air as being able to exert pressure works against one’s intuition; nonetheless, air has mass and anything with mass is pulled by gravity toward Earth’s center. This principle means that atmospheric pressure is greatest near Earth’s surface at sea level and diminishes with increasing height in the atmosphere. This effect is used by airplane pilots to measure altitude reliably, with barometric pressure at sea level serving as a reference point. The principle also means the pressure exerted on the bottom of an object, such as a balloon, is slightly greater than the pressure on the top. The second part of this standard is a reminder that the direction of the “push” caused by the pressure is the same in all directions—up, down, or sideways. The same principle holds true for pressure in any fluid.

(Excerpted from the *Science Framework for California Public Schools: Kindergarten Through Grade Twelve*.)

Materials Needed for the Lesson:

Teacher Materials

- 2-liter bottle with 4 holes on side and lid (screw top) (see illustration in “Student Handout: Pressure”). If holes are leaking, close them with a strip of masking tape.
- “Air Pressure in Action” (See Additional Teacher Background Information)
From Stop Faking It! Air, Water, and Weather by William C. Robertson; Arlington, Virginia: NSTA Press, 2005; page 15. This book is highly recommended as a resource for teachers.
- Matches

Student Hands-on Materials

For each group of 4 students (see illustration in “Student Handout: Pressure”)

- Aluminum pie plate
- Candle with clay
- A jar (quart size)
- 1-2 cups of water

Student Handouts

- “Pressure”
- “Additional Information for Students: Air Pressure in Action”

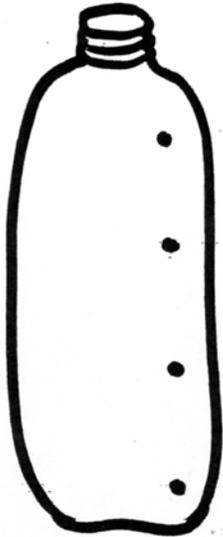
5E Lesson: Atmospheric Pressure

Teacher Does	Student Does	Concept
<p><u>ENGAGE:</u></p> <ul style="list-style-type: none"> ▶ <i>What do you know about air pressure? Raise your hand to share your idea.</i> ▶ <i>We are going to make some observations that have to do with air pressure.</i> <p>Distribute “Student Handout: Pressure.”</p> <ul style="list-style-type: none"> ▶ <i>The first observation is with this 2-liter bottle of water. There are four holes here on the side. What do you think will happen when I take the lid off the bottle? How will the water flow out of these holes? Will all four streams of water be the same? Will the top or bottom stream squirt out further? Talk with your group. Then draw on your “Pressure” sheet on the bottle above “prediction” how you think the water will squirt out of each hole.</i> ▶ <i>Watch carefully and observe what happens.</i> <p>If tape was used, remove tape and then remove the lid from the bottle.</p> <ul style="list-style-type: none"> ▶ <i>Draw how the water is streaming out.</i> ▶ <i>What did you notice about the 4 streams of water coming out the holes?</i> ▶ <i>Why do you think the bottom stream squirts the farthest distance?</i> <ul style="list-style-type: none"> ▶ <i>We will do another activity that should help us to understand what was happening with the water.</i> ▶ <i>In your groups of four, you will gather 8 (eight) books from your desks and place them in one stack. The books will be a model representing Earth’s atmosphere. The desk will be sea level on Earth. You will be taking an imaginary trip up an imaginary mountain. Each book represents 1,000 feet above the Earth. We want to find where air</i> 	<p>Expected Student Response (ESR): Air pressure is what is inside of a basketball; the more air pressure the better the ball will bounce. When I come down from the mountain, my ears pop.</p> <p>ESR: The water will come out the holes. Students observe the water coming out the 4 holes on the side of the bottle. Students talk in groups and then each student draws the streams of water in the prediction illustration.</p> <p>Students draw what they see</p> <p>ESR: The water squirted the farthest out of the bottom hole. The top hole had the shortest distance the water squirted. ESR: There is more pressure at the bottom hole because of all the water on top of it. The top hole does not have that much pressure.</p>	<p>Air pressure is the highest near the Earth’s surface where air particles are squeezed close together by the weight of the air above.</p> <p>Air pressure is the force with which the air presses down on things.</p> <p>The greater the altitude, the lower the air pressure.</p>

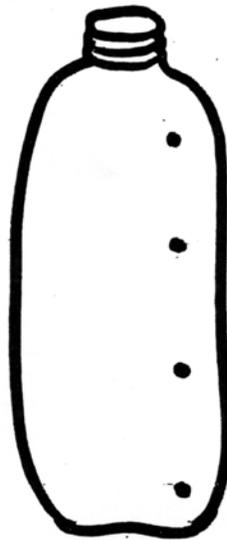
Teacher Does	Student Does	Concept
<p><i>pressure is the greatest and the lowest. Taking turns each of you, one at a time, place your hand at sea level (under all 8 books) and then at 6,000 feet (six books up, or under two books). Record your observations on the back of your "Pressure" sheet.</i></p> <ul style="list-style-type: none"> ▶ <i>Where is the pressure the greatest?</i> ▶ <i>Where is the pressure the lowest?</i> 	<p>Students get out 8 books and stack them. Place hand under all the books and then under 2 books. Record observations.</p> <p>ESR: The pressure was the greatest at the bottom of the books or at sea level; the pressure is the lowest near the top of the mountain.</p>	
<p>EXPLORE:</p> <ul style="list-style-type: none"> ▶ <i>We are now going to observe air pressure in action.</i> <p>Show materials.</p> <ul style="list-style-type: none"> ▶ <i>Each table group will have the following materials: an aluminum pie plate, a candle with clay, and a jar. You will pour about a cup of water in the pie plate so that it is about one inch deep.</i> <p>The water amount needed will vary depending on size of the plate. Show amount. <i>I will light the candle and then put the jar over the candle for each group.</i></p> <ul style="list-style-type: none"> ▶ <i>What do you think will happen when the jar is placed over the burning candle?</i> ▶ <i>Why will the candle go out?</i> ▶ <i>Do you think anything else will happen?</i> <p>Distribute materials.</p> <p>After jars are set up ask:</p> <ul style="list-style-type: none"> ▶ <i>Based on what you already know, what can you say about the amount of pressure on all parts of the apparatus?</i> ▶ <i>Watch what happens to the candle; watch what happens to the water level. Then draw what you saw on your "Pressure" sheet.</i> <p>Light the candles and put the jar over the candle for each group.</p> <ul style="list-style-type: none"> ▶ <i>What causes the water to rise in the bottle?</i> ▶ <i>Can you make a generalization about pressure after seeing the water in the bottle</i> 	<p>ESR: The candle will go out.</p> <p>ESR: Because the oxygen will get used up.</p> <p>ESR: There will be smoke in the jar.</p> <p>Students set up the investigation.</p> <p>ESR: About equal.</p> <p>After teacher puts jar over the candle; students observe and record observations.</p> <p>ESR: Pressure.</p> <p>ESR: High pressure moves towards low pressure.</p>	<p>High pressure flows towards low pressure.</p>

STUDENT HANDOUT

PRESSURE

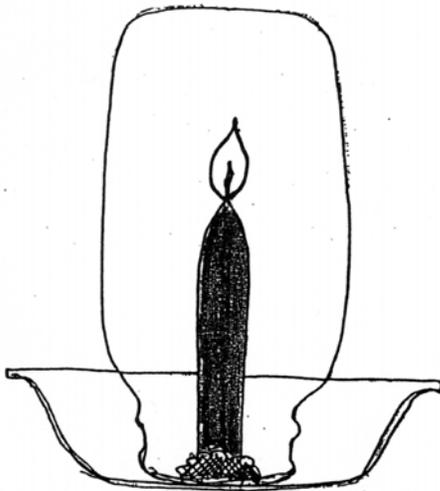


Prediction



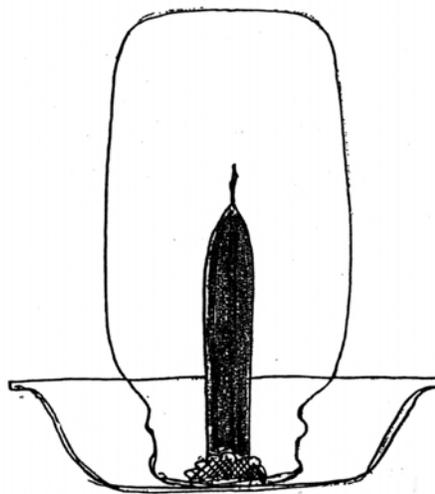
Actual

Why?



Where is the water?

Why?



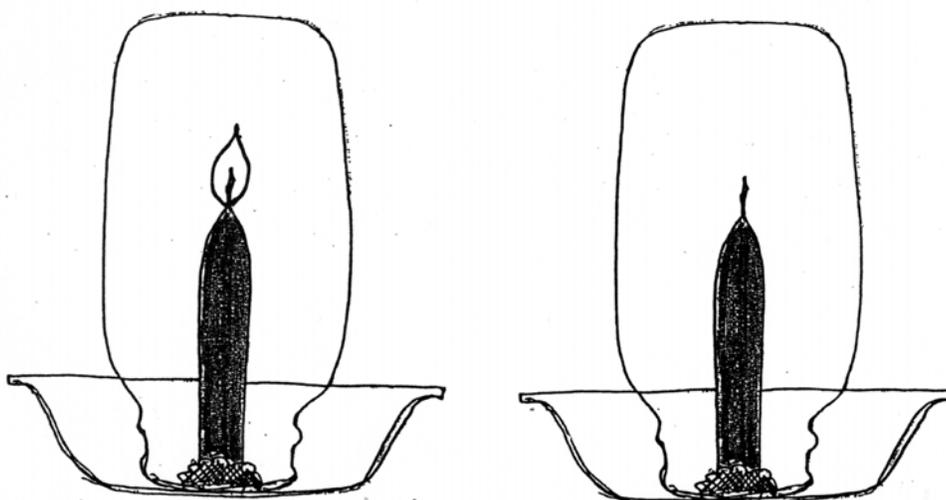
Where is the water?

Why?

Additional Information for Students

Air Pressure in Action

When you first place the jar over the candle, you trap some oxygen in the jar. The air pressure outside the jar is equal to the pressure inside the jar. As the candle burns things are happening. First, a small amount of the oxygen is forced out of the bottom. If you heat a gas it expands (spreads out) so some of the gas will escape out the bottom of the jar. The process of burning also removes some of the oxygen molecules. Because of the heating of the air around the candle and the burning process you have fewer gas molecules inside the glass than before. As the candle burns out the source of heat is gone and the gas molecules that are left move slower and come closer together. This causes the air pressure outside the jar to be greater than inside the jar. This difference in air pressure pushes the water from the pan up into the glass.

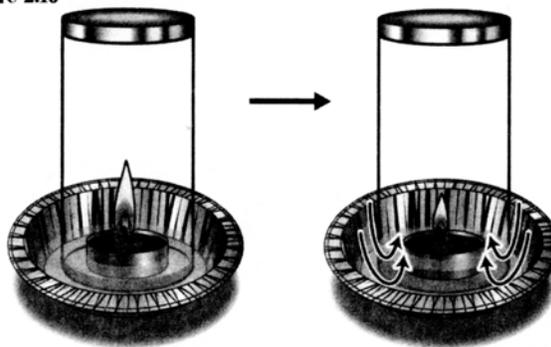


Additional Teacher Background Information

Air Pressure in Action!

While the candle is burning, something else is going on. That something else is that in the process of burning, the candle removes **oxygen** molecules from the air. This is known as **oxidation**. In the process of oxidation, the burning candle removes enough oxygen molecules from the air inside the glass that the pressure inside the glass is significantly reduced⁸ (remember that reducing the number of molecules reduces the air pressure). So, because of the initial heating of the air around the candle and because of the burning process, you have fewer gas molecules inside the glass than you would have otherwise. Once the candle goes out (not enough oxygen for it to keep burning), your source of heat is gone and the gas molecules inside the glass move slower. At this point, the outside air pressure, which is our normal atmospheric pressure, is much greater than the air pressure inside the glass. This difference in air pressure pushes the water from the pan up into the glass. Figure 2.10 provides a summary of the process.

Figure 2.10



While candle is burning, the air pressure inside and outside the glass is equal. Nothing happens.

As the candle burns out, the reduced number of air molecules inside the glass creates a low-pressure area there. The outside air then pushes the water up into the jar.

Once again, before anything starts burning, the air pressures inside and outside the jar are equal.

⁸ In case you want the details of this process, it's the paraffin in the candle that's burning. Paraffin combines with oxygen in the air, giving off carbon dioxide (another gas) and water as a result of the chemical reaction. For every 85 oxygen molecules removed from the air, you get 56 carbon dioxide molecules back in the air, and 58 water molecules. Even though some of those water molecules end up as water vapor, there is still a net reduction in the number of gas molecules inside the glass.