4TH GRADE
AIR AND AIR PRESSURE

Summary: Students experiment with air by finding that it has mass and pressure. Warm air is less dense than cool air and this is tested using a balance. Students experiment with a bottle barometer and use their 'hot' hands to increase the volume of air. Finally, students further experiment with air pressure and observe what happens after a candle burns out under a mason jar.

Intended Learning Outcomes for 4th grade:
1c. Make simple predictions and inferences based upon observations.
1d. Compare things and events.
1f. Conduct a simple investigation when given directions.
1h. Use observations to construct a reasonable explanation.
3a. Know science information specified for their grade level.
3c. Explain science concepts and principles using their own words and explanations.
4b. Report observations with pictures, sentences, and models.
4c. Use scientific language appropriate to grade level in oral and written communication.

Utah State Core Curriculum Tie:
Standard 2 Objective 1:
c. Investigate evidence that air is a substance.

Preparation time: 1 hour initially then 30 minutes after bottle barometers are assembled.
Lesson time: 1 hour
Small group size: Works best with one adult for 5 students**.**

Materials: 6 sets of supplies works well for a class of 30; if you have much smaller classes you don't need as many sets of supplies.
1. packing bags of air
2. 6 - 1-pint mason jars with lids
3. 6 index cards
4. 6 equal arm balances (If you only have one you can do this experiment as a demo.)
5. 2 balloons
6. colored ice made with food coloring
7. 12 – 16 oz. paper cups
8. 6 - 500 ml Wheaton Boston Rounds bottles with caps. Carolina.com 715755, $24.20 for case of 12
9. 6 - black one hole rubber stoppers size # 2. Carolina.com 712433, $12.25 for one pound of stoppers, about 50

10. 6 - 18 inch length of glass tubing size 5mm, Carolina.com 711145, comes in 4ft lengths and they will need to be cut down to 18 inches.
11. matches
12. 6 birthday candles
13. 6 foam dinner plates
14. 6 tea light candles

Alternative to purchasing Wheaton Boston Round Bottles: Use a glass bottle from a liquid such as Apple Cider Vinegar. Check that it's top opening diameter is approximately ¾ inch and it holds about 500 ml and it should work.

Preparation:
1. To make the barometer jars: cut the glass tubing with a file into 18-inch segments. Instructions for cutting the glass tubing can be found at: *dev.nsta.org/ssc/pdf/v4-TS_01.pdf* If the ends are sharp, you can fire them smooth using a flame. Insert the glass tubing into the rubber stopper using oil for lubrication if necessary. The bottom of the tubing should be long enough to reach about ¾ of the way down into the glass bottle.
2. To make the cups that hang on the equal arm balance: use thread and make a loop on the bottom outside of the cup. This will allow the cups to hang over the arms of the equal arm balance.

Background information:

Air is mostly empty space filled with particles of oxygen, nitrogen, carbon dioxide, water, and other gases. These particles are moving at very fast speeds and darting all around us. As the particles are moving they are colliding with each other and the objects around them. The warmer the temperature the faster the particles are moving; the cooler the temperature the slower the particles are moving.

Air has mass. Air particles are pulled towards earth by gravity. The atmosphere is a thick layer of air that surrounds our world. As the particles in our atmosphere are pulled towards earth by gravity they create atmospheric pressure. These air molecules exert about 15 pounds of pressure per square inch of surface at sea level. Because there are less molecules of air above the mountaintops than above the sea, atmospheric pressure is lower in the mountains. Because it's a gas, air not only pushes down, but also upwards and sideways. This atmospheric pressure is the same at all angles in a particular location.

Air has different densities at different temperatures. Warm air has molecules moving faster and its collisions are greater. This causes the air to take up more volume. Since you have the same mass but a greater volume the density is less. Cold air has molecules moving more slowly with the collisions being smaller. This causes the air to take up less volume. Since you have the same mass but a smaller volume the density is higher. Therefore, warm air rises

and cold air sinks. Think of a hot air balloon. This principle of warm and cold density differences also applies to liquids like water.

Changes in air pressure also cause changes in weather. Low pressure areas usually produce cloudy, stormy weather. When a low pressure area is over a region, the air in the atmosphere rises because it is lighter or less dense. As air rises it cools and produces clouds and precipitation. High pressure areas usually produce fair weather. In high pressure, the air is sinking because it is more dense or heavier. This usually doesn't make clouds and without clouds precipitation can't form.

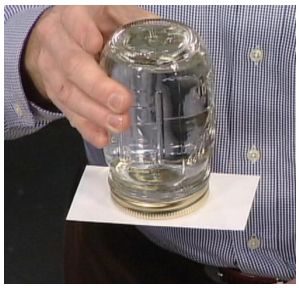
Pre-lab discussion: Have the students cup their hands and grab some air. Ask them if their hands are empty. Discuss that air is not empty space but molecules bouncing around inside your hands. Explain the properties of air and gasses found in the background information section of the lab.

Instructional procedure: Have students answer the questions on the student sheet as they perform the following experiments.

I. What is air? Have students squeeze the packing bags of air and feel the pressure. This demonstrates that even though you can't see the air particles they are moving and bumping into the sides of the bag, which holds the bag out. What happens if you pop the packing bag? (You can do this with one of the bags.) It collapses.

II. Does air have pressure? Fill a mason jar to the top with water. Place a damp index card over the jar. Hold the jar over a bucket, your hand over the index card and turn it over. Carefully remove your hand from the index card and see that the index card stays on the jar and the water doesn't flow out.

What is happening? When you remove your hand, the pressure of the air pushing on the index card is higher than the pressure of the water on the index card and the index card does not fall down.



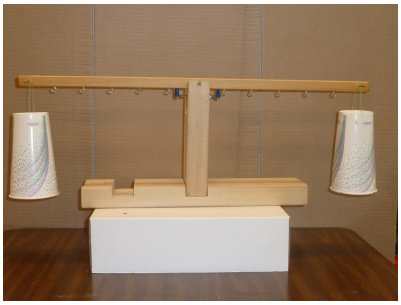
III. Does air have mass? Put one empty balloon on each side of a balance. See that they have equal mass. Blow one balloon up as much as you can and tie

a knot. Now see if the balloon with air and the balloon that is empty have the same mass. The balloon with air is heavier.

IV. Can water have different masses at different temperatures? Wipe off a colored ice cube and place it very gently into a slightly warm cup of water. Observe the ice cube for a few moments and see that as the ice cube melts the colored water makes a stream towards the bottom of the glass. The freezing cold water has higher density than the room temperature water in the glass and it sinks. This principle applies to gasses as well.

V. Is hot air more or less dense than cool air?

1. Place the balance on a box to raise it off the table. Make sure the beam of the equal arm balance is horizontal.
2. Loop the string attached to the bottoms of the cups over the two ends of the balance and again make sure the beam is horizontal.
3. Place a piece of aluminum foil under each cup to capture any wax that drips.
4. Light the birthday candle and place it briefly under one of the inverted cups. (Do not leave the match for more than a few seconds or the cups can ignite.)
5. Now place the candle under the other cup.



What is happening? When the gas is heated up under the cup, the gas molecules increase in energy and speed. As the molecules are bouncing around the container more of them escape from the bottom of the cup. This means that there are less molecules in the cup that is heated than in the cup that is not. Therefore, the cup with air that is heated has less mass. Hot air rises and is less dense than cool air. When air particles heat up they move faster and take up more space. In our atmosphere – hot air rises and cool air sinks. This movement of air up and down in our atmosphere causes changes in our weather.

VI. What happens when a mass of air is heated?

1. Have the bottle barometers assembled with about 1/3 of the bottle filled with colored water. Make sure the bottom of the glass tube is about 1-cm below the surface of the water.
2. Notice the height of the water in the tube.

3. Have the students take turns placing their warm hands around the top of the bottle over the gas, not the water. Caution: Do not push down on the glass tube it can break and cut you. Also, be very careful to not dislodge the rubber stopper from the top of the bottle in the experiment, which will release the gas and destroy the experiment.
4. Students can see how high they can make the water rise up the tube.
5. Finally, students can take ice and place it around the gas in the jar. Keep applying the ice until air is pulled down through the glass tube and bubbles occur.

What is happening? The water rises up the tube because as you warm up the air in the jar the molecules move faster and take up more space. The gas expands. When the gas expands it pushes down on the water and forces the water up the tube. The gas can't escape the bottle but the water can. When you cool the gas in the jar the gas contracts and the water moves down the tube. If you keep cooling the gas it contracts to a space smaller than when you started the experiment. Air is sucked into the jar through the glass tube to replace and bubbles occur.

VII. Another example of changes in heat causing gas expansion and contraction.

1. Pour water into a flat pan or foam pie plate to a depth of about 1 cm.
2. Place the lid of the Mason jar in the center of the pan with the rubber ring side down.
3. Place a tea light candle on the jar lid. Light the candle.
4. Have the students predict what will happen when the mason jar is placed over the candle.
6. Once the candle is burning steadily, turn the Mason jar over and quickly place it over the burning candle. The jar should be far enough to one side of the lid so water can go between the edge of the jar and the lid. This allows water to be sucked in and fill the jar.
7. After the candle goes out, wait a moment and notice the water filling the bottom of the Mason jar.

What is happening? The students may predict that the candle goes out because the candle uses up the oxygen. When the candle has burned up the oxygen, water comes in to replace the lack of oxygen. This is only slightly true. The oxygen does get partially consumed which causes the flame to go out. However, it is not that the oxygen is all used up but more so that the carbon dioxide that is produced smothers the flame. What is really happening is that when the air inside the jar is heated by the candle it expands and pushes the little bit of water at the bottom of the jar out. Once the flame expires the air begins to cool. The cooling gas inside the bottle contracts to create a partial vacuum. The pressure in the bottle lowers and this sucks water into the bottle. There is actually a lot going on here to bring the water up into the Mason jar!