Season 1 Ep. 4 (#104)

Balloon in a Bottle

Description:
There's a secret to blowing up a balloon in a bottle.

Materials:
1 liter plastic bottle
Balloon
Nail
Hammer
Container of water (for variation)

Procedure:
1) Place a latex balloon inside the bottle and stretch the balloon over the outside mouth of the bottle
2) Attempt to blow up the balloon inside the bottle
3) Remove the balloon and fill the bottle with water, then cap the bottle
4) Pierce a single hole in the side of the bottle near the bottom with a nail and a hammer (a drill can also be substituted for a slightly larger hole, but the hole should be small enough to cover with a finger or thumb)
5) Take off the cap and pour out the water.
6) Insert the balloon again and blow up the balloon inside the bottle
7) Cover the hole with a finger and stop blowing
8) The balloon should remain inflated

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Season 1 Ep. 4 (#104)

(Part 2)

Balloon in a Bottle

My Results:

Explanation:
Because the seemingly empty bottle still has air in it, more air will not fit inside. Matter takes up space and cannot occupy the same space. However, when the hole is added to the bottle, it is possible to force the air out of the bottle and fill up that volume with additional air inside the balloon. By closing the whole it holds the air in the balloon from the air pressure in the bottle (exerting a force of 14.7 pounds per square inch, 1 kilogram per centimeter). Removing your finger will permit the air in the room to reenter when the latex balloon squeezes the air back out and deflates. Tying off the balloon inside the balloon is a bit tricky, but does make for a perplexing visual.

There are two variations to try. First, state that you will attempt to blow up a balloon by inhaling. Insert the balloon once again into the bottle. This time place your mouth over the hole and take short sucking breaths to draw the air out of the bottle. As you do, the balloon will inflate from the outside air pressure, which will be higher than the lower inside air pressure. High pressure will always move toward lower pressure systems.

For the second variation, blow up the balloon again, and hold your finger over the hole. This time fill the balloon with water. When you remove your finger, the water will erupt out of the bottle. Encourage friends to experiment with different hole sizes and note their effects.

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The Curiosity Guide

Subject: Gases (Matter)

Investigation: 02

Season 1 Ep. 4 (#104)

Funnel in a Bottle

Description:
Did you ever think you could make a tornado?

Materials:
3 plastic bottles
3 funnels
Colored water
Rubber stopper (or clay)
Tornado tube connector

Procedure:
1) Using two bottles that are the same size, fill one and connect them with a tornado tube (be sure to notice that there is a hole in the center)
2) Quickly invert the bottle so that the full bottle is on top. The water will not fall
3) While the you reflect on this phenomenon, set up a bottle with a funnel in the top
4) Be sure to run the funnel through a rubber stopper or seal the opening with clay so that there are no air leaks
5) Pour colored water into the funnel and observe that the water does not go into the bottle
6) Challenge friends to determine how to make the water enter the bottle

My Results:

Explanation:
The water will not fall in either the tornado tube bottle or the funnel because air is in the way and matter cannot occupy the same space. By squeezing (applying extra force) to the air in the bottom bottles, the air exits and makes room for the water to replace it.

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Season 1 Ep. 4 (#104)

Dry Tissue

Description:
Submerged, but still dry!

Materials:
Clear cup
Ping pong ball
Double sided tape
Tissue
Large clear container to hold water
Water

Procedure:
1) Begin by filling the tank to hold enough water that the cup can be submerged
2) Place the ping pong ball in the water so the students note that it floats
3) Invert a plastic cup placing it over the ball and gently push it underwater
4) Observe that the ball remains at the bottom of the cup no matter how deep the cup is pushed
5) Hypothesize as to why
6) Next, take the cup and place a small piece of two-sided tape in the bottom
7) Roll up a tissue and stick it to the tape
8) Invert the cup and fully submerge
9) Notice that the tissue is still dry

My Results:

Explanation:
Because there was air in the "empty" cup the air kept its space and would not permit the water in the cup. The ping-pong ball stayed at the bottom of the cup because it was heavier than the air but floated on the surface of the water and the tissue stayed dry because the air filled up all of the space around it. It is worth noting that some water will enter the cup as the air above it is compressed, but then the compressed air offers too much resistance for the water to go any further.
Follow up with "Pouring Air Underwater"

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Season 1 Ep. 4 (#104)

Pouring Air Underwater

Description:
If you pour air underwater, it goes up.

Materials:
2 cups (or jars)
Water tank
Water

Procedure:
1) Submerge two cups underwater, one right side up and the other upside down
2) The upside down cup will trap air while the other will fill up with water
3) Push the cup with air to the base of the tank and invert the cup filled with water so that it is over and slightly to the side of the cup willed with air
4) Slowly tilt the cup with air and capture the rising air bubbles in the cup full of water

My Results:

Explanation:
The air, which is less dense than the water, floats up into the second cup and displaces the water that is there. Matter cannot occupy the same space and so the air replaces the water in the cup. It can be helpful to describe one cup as being full of air and the one with water being empty of air.

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Season 1 Ep. 4 (#104)

Toroidal Vortex Cannon

Description:
Make an air blaster

Materials:
5-gallon pail
Drill
4-inch hole cutter
Plastic
Scissors
Duct tape
An assortment of paper cups
Length of rope

Procedure
1) Cut a 4 inch hole in the bottom center of a 5-gallon pail
2) Place the plastic on the floor and cut a circle tow inches larger than the top of the pail
3) Cut out the plastic with scissors
4) Using duct tape secure the plastic to the top of the pail so that the excess drapes into the pail and that the entire circumference is well secured
5) To strengthen the striking membrane, run strips of duct tape across the plastic and cover it fully
6) Tear off a 4 inch long piece of duct tape and tape it to the center of the membrane so that it forms a small pull-back handle
7) Set up a pyramid of paper cups, hold the cannon under one arm aiming the small opening toward the cups, pull back the handle, and strike the membrane with a flat hand
8) Practice knocking down the cups from different distances
*Smaller versions can be made with a cylindrical oatmeal container

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Subject: Gases (Matter)

Investigation: 05

Season 1 Ep. 4 (#104)

(Part 2)

Toroidal Vortex Cannon

My Results:

Explanation:
This demonstration illustrates that air does in fact exist because we can see its effects as it knocks down the cups and that air takes up space. Interestingly, the air that exits the cannon is in the shape of a doughnut (torus), which results from the centered hole and the air being abruptly forced out. The part of the air in contact with the hole opening is dragged more than the air in the center and it causes the air to spin on itself. Adding smoke further clarifies this phenomenon as well as Bernoulli's Principle—the moving air has speed (which causes lower air pressure) and therefore the Toroidal vortex stays together in a traveling ring because the air around it has a higher air pressure.

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Season 1 Ep. 4 (#104)

Building a Lung Model

Description:
Here's how your lungs work.

Materials:
1 liter plastic bottle
Scissors
Two latex balloons
Clear packing tape (duct tape)

Procedure:
1) Using scissors, carefully cut out the bottom of the plastic bottle
2) Carefully add tape around the bottom edge of the cut bottle to capture the sharp edge (duct tape works well for this)
3) Insert one balloon through the neck of the balloon and stretch the opening of the balloon over the outside neck of the bottle
4) Tie the remaining balloon closed in a knot and then cut open the opposite end of the balloon with scissors
5) Stretch the cut balloon over the base of the bottle and securely tape so that it is air tight
6) Gently pull down on the knot and observe the balloon inflate and deflate when you press up
* One variation is to make the model with a straw representing the trachea and splitting to bronchi and lungs done with two balloons.

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(Part 2)

Building a Lung Model

My Results:

Explanation:
During this task it is helpful to use proper anatomical terms, particularly with respect to the diaphragm. The task of breathing is the result of the diaphragm muscle flattening out to create space in our chest cavity, which results in a partial vacuum. This lower pressure will immediately be filled with air in the room because of outward air pressure pressing in on us at 14.7 pounds per square inch and the balance of forces. Gas particles in the air will fill up every void that is accessible because of the vast amount of air pressure pressing down. The flexing of the diaphragm is therefore responsible for the inhalation of air. When the muscle relaxes up, the air is pushed out of the lungs because there is no more space for it. In this model when the lower balloon is drawn down it creates a partial vacuum and outside air pressure enters to balance the internal and external forces on the bottle. The expandable "lung" balloon inflates from that outside pressure.

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Season 1 Ep. 4 (#104)

Bubbles Take up Space

Description:
Ever blow a bubble inside of a bubble?

Materials:
Pitcher
4 cups water
1 cup dishwashing liquid
4 tsp. of glycerin (to prevent the water from evaporating so quickly)
Mixing spoon
Straw (one for each person)
Spray bottle filled with water
Measuring tape

Procedure:
1) Combine 4 cups water with 1 cup dishwashing soap in a pitcher
2) Add 4 tsp glycerin
3) Stir with a mixing spoon
4) Dip straw into mixture and gently blow into the straw
5) Use the spray bottle and thoroughly spray down the table surface
6) Dip the straw in the mixture, set it on the table, and blow a bubble onto the table surface
7) When the bubble pops, it will leave a ring so you can measure the diameter
*Variation-blowing bubbles inside one another

My Results:

Explanation:
The bubble will expand when air form our lungs is blown into it. So long as the bubble does not touch anything dry it will not pop. By wetting the straw, the straw can pass through a formed bubble without breaking it and a new bubble can be blown inside of the first. When doing so be sure to notice that the exterior bubble grows as well because of the increasing gas within the overall space.

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Curious Crew
Season 1 Ep. 4 (#104)

Making a Spirometer

Description:
Build this and see how much air is in your lungs

Materials:
2 liter bottle (one per group—we included a 3 liter bottle for older students)
Flexible plastic tubing sections (about 40 cm long for each person)
Masking tape
Marker
Measuring Cups
Basin
Water
Graduated cylinder
Object to drop in the graduated cylinder

Procedure:
1) Fill a graduated cylinder partially full of water and note the water level
2) Drop in an object and note the change in water level
3) Briefly discuss the concept of displacement to determine the volume of something
4) Then introduce the challenge of finding out the volume of our own lungs
5) Attach a piece of masking tape vertically up the side of the bottle
6) Measure out 60 ml of water in the measuring cup and pour it in the bottle
7) Using the marker draw a line on the tape where the water line is
8) Repeat with another 60 ml until the bottle is full and there are lines all the way up the bottle
9) Fill the basin so that it is at least 5 cm deep (the deeper the water, the easier it is to start the test, but the risk of overflows is greater)
10) Fill the bottle to the very top with water
11) Screw on the cap and invert it so that the mouth of the bottle is underwater
12) Carefully remove the cap keeping the mouth of the bottle underwater
13) Feed one end of the tube into the bottle
14) Take a deep breath and blow out as much air as possible
15) Measure the volume of each person's lungs
16) Discuss the implications for this device and how lung capacity might change

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Season 1 Ep. 4 (#104)

(part 2)

Making a Spirometer

My Results:

Explanation:
Spirometry is the measuring of breath, so a spirometer is a tool that can do just that by measuring a person's lung capacity. This is based on the principle of displacement so that when a student blows into the bottle the air displaces the water. The volume of water displaced is measurable with the spirometer and directly equals the volume of lung capacity of the person. Lung capacity increases as a person grows and can also be improved with exercise. It may be worth relating this to Archimedes' discovery in which he was hired by King Hieron II of Syracuse to figure out if the gold crown he had made was of pure gold or not. While bathing, Archimedes thought of an appropriate test when he reclined in the bath displacing the water all over the floor. As legend goes, that is when he jumped out of the bath shouting "Eureka" which translates as "I've found it!" in Greek. He went on to measure the crown through displacement to determine its volume. That volume, when divided into its weight would reveal its density. The formula would be Density = mass/volume. He repeated the experiment with a block of gold and a block of silver to determine their density only to discover that the crown was a combination of both gold and silver and that the goldsmith had cheated the king.

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