Spark Innovations

Science Camp Curriculum Guide

Cool Science

CSI

Investigations

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Physical vs Chemical Change

Experiment: Mentos Geyser - Diet Coke Eruption

Objectives:

Students will be able to:

- **understand the basics of the scientific method and explain them in their own words.**
- **apply the scientific method to answer questions and**
- **formulate and perform their own experiment(s) using the steps of the Scientific Method.**

Key vocabulary

- **Scientific Method**
- **Hypothesis**
- **Theory**
- **Carbon dioxide**
- **Reaction**
- **Physical Reaction**
- **Chemical Reaction**
- **Eruption**
- **Molecules**
- **Nucleation Sites**
- **Liquid**
- **Solution**
- **Ingredients**
- **Gas**
- **Surface Tension**
- **Disrupt**
- **Variables**
- **Consistent vs. Inconsistent**
- **Results**
- **Record**
- **Tests and Trials**
- **Conclusion**
- **Diffuse**

Mentos + Pop = Fun. Words cannot begin to describe the awesome eruption that is created from adding Mentos candies to a 2-liter bottle of soda. The eruption is enormous... and so is the learning if you consider the chemistry.

Materials

A roll or box of Mentos (candy mints) and a 2-liter bottle of diet soda. Either diet or regular soda will work for this experiment, but diet soda is less sticky when you're cleaning it up!

1. This activity is probably best done outside in the middle of an abandoned field, or better yet, on a huge lawn.

2. Carefully open the bottle of soda. Position the bottle on the ground so that it will not tip over.

3. Un-wrap the whole roll of Mentos. The goal is to drop all of the Mentos into the bottle of soda at the same time (which is trickier than it looks). One method for doing this is to roll a piece of paper into a tube just big enough to hold the loose Mentos and tape it. You'll want to be able to position the tube directly over the mouth of the bottle so that all of the candies drop into the bottle at the same time.

4. Don't drop them into the bottle just yet! Warn the students to stand back. Okay, you're going to drop all of the Mentos into the bottle at the same time and then get truckin' (move out of the way... so long... bye- bye... hasta la vista!)

5. It's just like fireworks on the 4th of July. The spectators erupt, of course, in a chorus of ooohs and ahhhs. Someone yells out, "Do it again" and you ask the students what happened.

Lesson: How does it work?

Here's the question of the day... *(ask your students)* Why do Mentos mixed with soda produce this incredible eruption? You should know that there is considerable debate among scientists, over how and why this experiment works.

While we are going to talk about the most probable explanations, we should also understand and admit that other explanations could be possible... and you should share your thoughts.

(Discuss with your students what sugar is made of. What do they think soda is made of. List their ideas on the board. Then read the ingredient label on the sodas. Were they right?) As you probably know, soda pop is basically sugar (or diet sweetener), flavoring, coloring, water and preservatives. *(Ask students what makes soda bubble and fizz)* The thing that makes soda bubbly is invisible carbon dioxide gas, which is pumped into bottles at the bottling factory using

tons of pressure. Until you open the bottle and pour a glass of soda, the gas mostly stays suspended in the liquid and cannot expand (grow larger) to form more bubbles, which gases naturally do if they weren't kept under so much pressure.

But there's more... If you shake the bottle and then open it, *(ask students what happens)* the gas is released from the protective hold of the water molecules and escapes with a whoosh, taking some of the soda along with it. *What other ways can you cause the gas to escape? Have students come up with several ideas and test them.* Just drop something into a glass of soda and notice how bubbles immediately form on the surface of the object.

For example, adding salt to soda causes it to foam up because thousands of little bubbles form on the surface of each grain of salt. *(Demonstrate this for the students or have the students test it themselves)* Many scientists, including Lee Marek, claim that the Mentos phenomenon is a physical reaction, not a chemical one. *(Ask students what the difference is between a physical change or reaction vs. a chemical change or reaction. List their ideas on the board)*

Physical Reaction: A **physical** change in a substance doesn't change what the substance is. Water is still water whether it is frozen, gaseous, or liquid.

Chemical Reaction: In a chemical change where there is a chemical **reaction**, one substance is transformed into another, a new substance is formed. Examples: When you burn something or when metal rusts, those are chemical changes.

Water molecules strongly attract each other, linking together to form a tight mesh around each bubble of carbon dioxide gas in the soda. (*Demonstrate this concept visually for the students by drawing a diagram on the board, using a balloon, etc.)* In order to form a new bubble, or even to expand a bubble that has already formed, water molecules must push away from each other. *(Ex. if the students were all standing in a close group with their arms to their sides, they would have to push against each other to spread apart.)* It takes extra energy to break this "surface tension." In other words, water "resists" the expansion of bubbles in the soda.

(*Just like it takes energy to break the "surface tension" of the balloon or to expand it and the balloon resists the expansion of being blown up.)*

When you drop the Mentos into the soda, the gelatin and gum arabic from the dissolving candy break the surface tension. *(Ask the students what this will help)* This disrupts the water mesh, so that it takes less work to expand and form new bubbles. *(Like blowing up a balloon a little bit will make it easier to blow it up even bigger)* Looking at a piece of Mentos® candy, you may think it is very smooth. But if you were to look under a microscope, you would see tiny bumps coating the entire surface of the candy. *(Ask the students what these pits might do Then have them drop 1 mentos candy into a small amount of soda. What happens?.)* Each tiny bump acts like a nucleation site, a place where this physical reaction can get a kick start. Each tiny nucleation site becomes a place where a bubble of carbon dioxide gas can form and escape the solution. Multiply that by all of the tiny bumps on a Mentos® and you have yourself a geyser!

(Ask the students what happened to the Mentos. Did it float or sink?) Couple the bubble producing nucleation sites with the fact that the Mentos candies are heavy and sink to the bottom of the bottle and you've got a double-whammy. When all this gas is released, it pushes all of the liquid up and out of the bottle in an incredible soda blast. *(Ask students if they've ever seen anything else act like that. Boil over with tons of bubbles…When? Why do they think it happened?)* You can see a similar effect when cooking potatoes or pasta are lowered into a pot of boiling water. The water will sometimes boil over because organic materials that leach out of the cooking potatoes or pasta disrupt the tight mesh of water molecules at the surface of the water, making it easier for bubbles and foam to form.

When a scoop of ice cream is added to root beer, the float foams over for essentially the same reason. The surface tension of the root beer is lowered by gums and proteins from the melting ice cream, and the $CO2$ bubbles expand and release easily, creating a beautiful foam on top.

Next question... *Why should you use diet Coke or diet Pepsi rather than regular soda?* The simple answer is that diet soda just works better than regular soda. Some people think that it has something to do with the artificial sweetener, but no one is sure. *Have the students test it. Does Diet actually work better? Why do they think they got the results they did?*

Also, diet soda does not leave a sticky mess to have to clean up. Hey, that's important.

How to turn a cool science activity into a real science experiment, or a whole bunch of them.

The secret is to focus your students attention away from the flying soda and have them concentrate on setting up an experiment where they isolate a single variable and observe the results. Tests and trials will lead them to more and more questions, which will eventually help them uncover a discovery. The examples below are a good starting place, but you and your students will stumble upon even more questions and ideas once they get started, such as… Can you reuse those Mentos?

Materials

The materials you'll need will change depending on which variables you're testing, but it's safe to say you'll need soda and Mentos® chewy mints. It's very important to use fresh soda for your experiment. Two liter bottles of soda will lose their fizz (carbonation) over time and you'll get poor results. Use fresh soda to get the best results.

How Many MENTOS?

It's a question that everyone who does this project asks. What is the best number of MENTOS to use to make the highest shooting geyser? This is a great topic for a science project, but you'll need lots of soda and MENTOS and a few friends to help record all of the data.

Let's start with one single MENTOS. All of the bottles of soda should be the same and they should also be the same temperature. You'll also need a way to measure how high the soda shoots up into the air. Use a scale attached to the side of a building as one way to measure the height. It's also a good idea to record each launch on video in order to go back and watch the launch in slow motion. Now you know your data will be accurate.

Based on your data, how many MENTOS do you need to make the highest shooting soda geyser?

The Brand Test

You guessed it... it's time to put your favorite soda to the test. Does one brand produce higher flying geysers? How does generic soda stack up again the big name brands? Using the procedure outlined in the previous experiments, it's easy to determine the clear winner. Remember, it's important conduct each test the same way with the same number of MENTOS for each launch. You'll also want to make sure all of the soda is at the same temperature because temperature plays an important role in the reaction.

Just think... your results could help determine the next MENTOS Geyser craze.

Nucleation Goes Nuclear

Test if the number of dimples (nucleation sites) added to a Mentos® candy will change the height of exploding soda. In this experiment, you will see if adding extra, larger nucleation sites to the Mentos® candy will increase the height of the eruption. You will add extra dimples into the surface of the Mentos® candy, and then use them to make Diet Coke® geysers. You can measure the height of the geyser with a wall, a helper, and maybe even a video camera. What will be your highest height?

1. First, you will need to organize your Mentos® candies for the experiment. Each pack of Mentos® comes with 14 candies inside, so if you eat 2 candies you will have enough left for three trials with four candies each (12 total).

2. Each package of Mentos® will be given a different number of dimples. The first package will have no dimples added, so leave the first package alone.

3. The second package will have one small dimple added to each side. Using a sharp, metal skewer or nail, dig into the center of the Mentos® candy to make a small dimple. Flip the candy over and put one on the other side. Repeat with all of the Mentos® in the second package.

4. The third package will have five small dimples added to each side. Using a sharp, metal skewer or nail, dig into the center of the candy to make a small dimple. Then make four more dimples around the center dimple, making a five dot pattern. Flip the candy over and make five more dimples on the other side. Repeat with all of the Mentos® in the third package.

5. Next, you need to make your Mentos® cartridge to hold the Mentos® for you before you drop them into the soda bottle. Take one of the index cards and roll it into a tube, slightly larger than the diameter of a Mentos® candy. Tape the tube together on the side, and now you have a cartridge for holding your stacks of Mentos®. You will use the other index card to place beneath the tube of Mentos®, to keep the Mentos® from dropping into the soda bottle until you are ready.

6. Place your full cartridge on top of the flat index card. When you are ready, quickly remove the flat index card by pulling it, releasing the Mentos® into the bottle. Step back

without tipping the bottle over or disturbing the reaction. When the bottle stops spouting, stop recording.

7. Do your best to estimate the height of the spout (using marks on the wall). Do this for each trial and keep your data in a data table.

Now, try it with a tube full of salt! Do all those little nucleation sits make an even bigger fountain?

The Temperature Test

How does the temperature of the soda affect the height of the geyser? Does a warm soda shoot up higher than a cold soda? The key to keep every launch fair and to make sure the only variable is the temperature of the soda. You'll also need a thermometer to record the temperature of the soda just before you launch it into space.

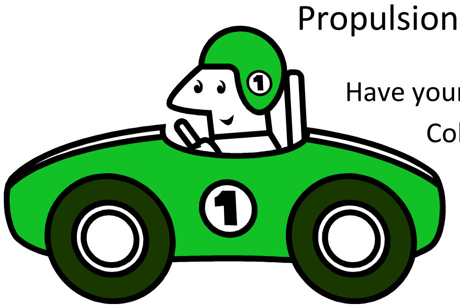
It's best to stick with one brand of soda for the entire test. Let's decide to use Diet Coke. You'll want to purchase three bottles of Diet Coke and several rolls of MENTOS. You're going to set-up three tests: Warm soda, room temperature soda and cold soda. Place one bottle of Diet Coke in the refrigerator and let it sit over night. Place the second bottle in a place where it can reach room temperature over night. There are two safe ways to warm the bottle of soda. The simplest method is to let the unopened bottle sit in the sun for several hours. You can also place the bottle of unopened soda in a bucket of warm water. Never use a stove or microwave to heat a bottle of soda.

It's time to return to your launching site. Check to make sure the scale is in place and the video camera is loaded with tape. Let's start with the bottle of cold Diet Coke. Open the bottle and dip the thermometer down into the soda. Record the temperature on your data table. Attach the Geyser Tube with the trigger pin in place. Load seven MENTOS into the tube and get ready to launch. Pull the pin and record the data. Repeat the same procedure for the soda at room temperature and the warm soda.

Beyond the Fizz

Warm soda tends to fizz much more than cold soda. Why? The answer lies in the solubility of gases in liquids. The warmer the liquid, the less gas can be dissolved in that liquid. The colder the liquid, the more gas can be dissolved in that liquid. This is because as the liquid is heated, the gas within that liquid is also heated, causing the gas molecules to move faster and faster. So, they will diffuse out of the liquid, leaving less gas dissolved in that liquid. In colder liquids the gas molecules are moving very slowly, causing them to diffuse out of solution much more slowly, and more gas tends to stay in solution.

Did you know… At the bottling plant, carbon dioxide is pumped into the cans or bottles when the fluid is very cold—around 35 degrees Fahrenheit. This low temperature allows the maximum amount of carbon dioxide to dissolve in the soda



Propulsion Challenge:

Have your students apply their new knowledge of the Scientific Method and Coke and Mentos physical reactions to build a vehicle (car, rocket,…)whose sole propulsion comes from coke and mentos. Can they do it? How will they design it? Build it. Test it? Have a contest and see how far the vehicles can go!

Tips: Students will discover that they want to make the hole where the soda will exit as constricted as possible. If you take a look at the geyser tube toy http://www.stevespanglerscience.com/product/2072) you will see that the main reason the geyser goes 30 feet in the air is because the hole at the top is so much smaller on the toy than on the standard opening of a soda bottle. One more thing to keep in mind is that warm soda will create a much higher geyser than cold soda.

Student Assessment:

Ask students to write about the Mentos experiments and the Scientific Method in their Science Journals Tell them to list the steps of the Scientific method in order along with descriptions of each; The students could formulate their own experiment using the steps of the Scientific Method. Ask the students to describe/write how they would test their hypothesis.

Scientific Method Song

To the tune of: The Wheels on the Bus

There are six cool steps in the Scientific Method

The Scientific Method

The Scientific Method

There are six cool steps in the Scientific Method

When we do an experiment!

First we need to ask a question

Ask a question

Ask a question

First we need to ask a question

When we do an experiment!

Second we need to predict an outcome

Predict an outcome

Predict an outcome

Second we need to predict an outcome

When we do an experiment!

Third we need to gather materials

Gather materials

Gather materials

Third we need to gather materials

When we do an experiment!

Fourth we need to follow directions

Follow directions

Follow directions

Fourth we need to follow directions

When we do an experiment!

Fifth we need to look at the results

Look at the results

Look at the results

Fifth we need to look at the results

When we do an experiment!

Sixth we need to wrap it all up

Wrap it all up

Wrap it all up

Sixth we need to wrap it all up

When we do an experiment!!!

Experiment: Flying Film Canisters aka Alka-Seltzer Rockets

Objectives:

Students will be able to:

- **Determine and control variables**
- **Identify examples of Newton's laws as they relate to the experiment**
- **Put Newton's third law into their own words and provide examples**
- **Compare conclusions to original hypothesis**

Key Vocabulary:

- **Air pressure**
- **Gas**
- **Motion**
- **Force**
- **Carbon Dioxide**
- **Physical Change**
- **Chemical Reaction/Chemical Change**
- **Cause and Effect**
- **Newton's Third Law**

What happens when you have a build-up of gas? Don't answer that question! The gas in question is carbon dioxide and the explosion is nothing short of fun. Warning: It's impossible to do this activity just once. It is addicting and habit-forming. Proceed at your own risk!

Materials

- Film canister with a snap-on lid. Look for a clear film canister, if possible. (Fuji brand works best)
- Soda

- Alka-Seltzer® tablet
- Empty paper towel roll (the cardboard tube) or a similar size plastic tube
- Duct tape
- Paper towel for clean-up (you already know that this one is going to be good!)
- Water
- Watch or timer
- Notebook
- Adult helper
- Safety glasses

IMPORTANT: This experiment requires you to wear protective safety glasses.

What just happened? Have students use water, Alka-Seltzer tablets

Pre-Flight Testing

1. Put on those safety glasses.
2. Fill the film canister 3/4 full with soda. To avoid a sticky mess, seltzer water can be used, which is simply carbonated, sugarless water.
3. Quickly seal the canister with the lid and shake the thunder out of the canister! Be careful to aim it away from your eyes. If you're lucky, the lid will pop off and fly into the air at warp speed.
4. Ask students what happened? Why did the lid fly off of the film canister? What factors could you change to make the lid fly even farther?

Allow students to test out their ideas:

5. With every trial, students must change the volume of soda you use to produce the biggest POP! For this part of the experiment, have students time each other to try to keep the amount of shaking that they do with each trial the same. In other words, they should only change one variable at a time.

6. After they have determined the best volume of soda for the biggest bang, have students write down their findings in their notebook. Then start experimenting with how much they shake the film can. This time, remember to keep the volume of soda the same on each trial.

7. Discuss what kind of reaction is taking place in their film canisters.

8. Now that they've got the biggest bang possible out of their soda it's time to show students another style of rocket propulsion.

The Amazing Alka-Seltzer Rocket

Perform the Alka-Seltzer Rocket demonstration for students. What happened this time? Was anything different? What did they notice that you did differently? What did they observe happening?

The fizzing you see when I dropped the Alka-Seltzer tablet in water is the same sort of fizzing that you see when you mix baking soda and vinegar. *(mix baking soda and vinegar to demonstrate the similarities)* The acid mixes with the sodium bicarbonate (baking soda), a base, to produce bubbles of carbon dioxide gas. *(Show students the box of Alka-Seltzer)* If you look at the ingredients of Alka-Seltzer, you will find that it contains citric acid and sodium bicarbonate (baking soda). When you drop the tablet in water, the acid and the baking soda react to produce carbon dioxide gas. The gas keeps building up and taking up more and more space, until finally the top pops off.

Ask students what the differences were between the first experiment and the second? In both experiments Carbon dioxide gas builds up so much pressure the lid is forcibly launched. With an Alka-Seltzer tablet, the CO2 is produced as a result of a chemical reaction. With the soda, the CO2 is released as a result of vigorous shaking. This provides a good contrast between a physical and chemical change.

We can thank Sir Isaac Newton for what happens next. When the build up of carbon dioxide gas is too great and the lid pops off, Newton's Third Law explains why the film canister flies across the room - for every action there is an equal and opposite reaction.

Now, what we have to do is figure out what combination of water and Alka-Seltzer make the best "bang." Ask students what variables there are that can be changed and how those variables could be changed.

Ex: Water Level, Top Up or Top down, Size of Tablet, Temperature of Water, Surface Area of Tablet (crushed or whole), Liquid, Weight

Have students work in groups to test one variable at a time and come up with their directions on how to make the biggest bang.

Have students come up with a hypothesis on what they think will make the best bang. Ex. We think that the rocket will go farthest with ½ tablet (crushed) of Alka-Seltzer in a container filled ½ with warm water in the tube. Then have them test all the variables to see if their hypothesis was correct.

Timing the Reaction

1. Put on your safety glasses.
2. Divide the Alka-Seltzer tablet into four equal pieces.
3. Fill one film canister 1/2 full with water.
4. Get ready to time the reaction of Alka-Seltzer and water. Place one of the pieces of Alka-Seltzer tablet in the film canister. What happens?
5. Time the reaction and write the time down. How long does the chemical reaction last? Why does it stop? Empty the liquid in the film canister into the trash can.
6. Repeat the experiment, but this time place the lid on the container. Remember to time the reaction. Write down your observations.

Water Level

Once you've mastered the technique, it's time to measure how far the film canister rocket flies across the room. After each trial, write down the amount of water you used in the film canister, the size of the piece of Alka-Seltzer (this should not change), and the distance the canister traveled. What amount of water mixed with a quarter piece of Alka-Seltzer produces the best rocket fuel?

More or Less Tablet?

This time, keep the water level the same in every trial, but change the size of the tablet in each test. First ¼ tablet, then ½ tablet, then ¾, then a whole tablet.

Tube or No Tube

Start by sealing the end of the cardboard tube with several pieces of duct tape or use a plastic tube with one end sealed. Divide the Alka-Seltzer into four equal pieces. Fill the film canister half full with water. Place one of the pieces of Alka-Seltzer tablet in the film canister and quickly snap the lid on the container. Turn the film canister upside down and slide it (lid first) into the tube. Point the open end of the tube AWAY from yourself and others and wait for the pop. Instead of the lid flying off, the bottom of the film canister shoots out of the tube and flies across the room.

Temperature

After you've determined the best amount of water to use, try changing the temperature of the water. How does temperature affect the speed of the reaction? Does warmer or colder water change the distance the film canister travels?

Surface Area

How does the surface area of the alka seltzer affect the reaction rate (power)? How can you increase the surface area of Alka-seltzer?*(Allow students to come up with several ideas and test them. One method is to crush it)* Which rocket will have more power: the rocket with alka seltzer that's been crushed or the rocket with alka seltzer that has not been crushed? IF the rocket launches faster will it have more power or less power?

Liquid

Will it work as well with another liquid? What about vinegar? Seltzer water?

Weight and Fins

Decorate it like a rocket or an animal or person, then let them fly! Do fins help it fly better? What happens when you add <u>too much</u> weight to the canister?

Observations

Students may need to experiment with several different film canisters before they are successful at building a rocket that launches with a blast. If the lid fits too tightly or too loosely, it won't work.

Post Discussion:

What variables made the largest difference in how the rockets performed? What are each groups results? Were their original hypothesis correct? How did they prove their results? Have everyone follow the directions and final hypothesis from each group. Whose directions resulted in the biggest bang?

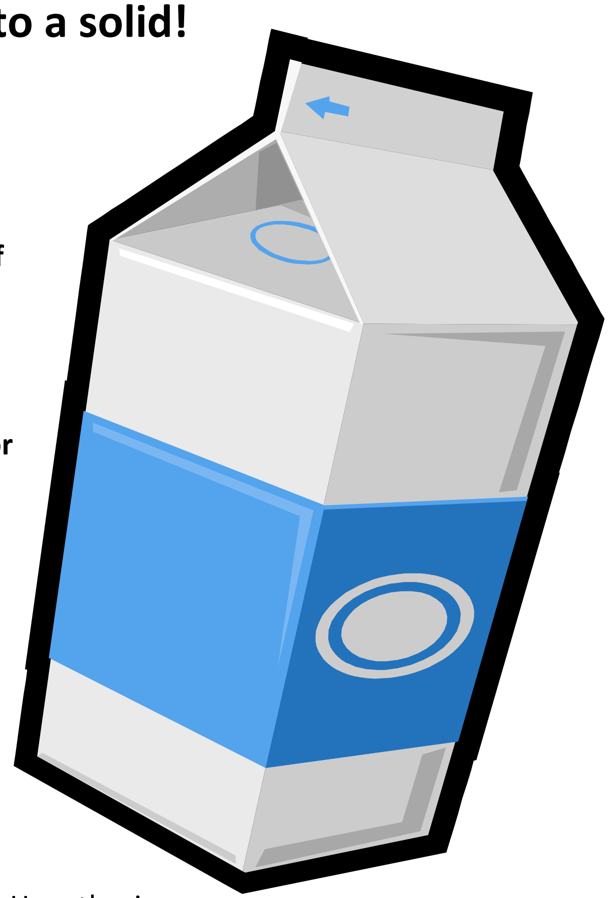
Student Assessment:

During students presentation of their results the students will describe how they tested their hypothesis and give details on how they reached their results using the scientific method and by use of control variables. Students will compare their conclusions with their original hypothesis, identify examples of Newton's laws as they relate to the experiments, put Newton's third law into their own words and provide examples, and compare their conclusions to original hypothesis

WARNING: Sometimes the reaction takes longer than expected. If "rocket" does not explode, place one hand over the canister and use the other hand to pop the top off and release the pressure. Do NOT lean over the canister or severe eye damage could be caused by an unexpected explosion!

Note: Everyone loves a film canister experiment... but in this digital-age, where can you find a film canister? We've been asking ourselves the same thing for a long time, but now, Steve Spangler Science is bringing back film canister science. These super-sturdy film canisters are the best we've ever seen and were specially made for Steve Spangler Science to ensure the biggest pop. And, unlike regular film canisters, their Flying Film Canisters have graduations on the side for accurate scientific explorations. One activity kit includes 10 film canisters, 5 packages of Alka-Seltzer, 1 canister launcher and 1 pair of safety glasses. They also sell them in bulk groups of 10 and 30.

Experiment: Plastic Milk--Turn milk into a solid!



Objectives

Students will be able to:

- **Identify, compare, and describe different states of matter**
- **Recognize that liquids can be made of parts**
- **Understand that plastics can be made of natural or synthetic materials**
- **Apply the scientific method to determine accuracy of hypothesis through experimentation**
- **Compare conclusions to original hypothesis**

Key Terms

- Liquid
- Solid
- Molecules
- Casein
- Curds
- Whey
- Fats
- Proteins
- Scientific Method
- Hypothesis
- Test
- Results
- Conclusion
- Chemical Reaction
- Variables
- Coagulate

Materials Needed

- skim milk

- other milks to test
- lemon juice
- white vinegar
- microwave proof bowl
- strainer
- plastic gloves

Instructions

Ask students how they would turn milk into a solid squishy piece of plastic that can be shaped and painted? Have them list their methods and ideas on the board. Then ask students if they think that they can turn milk into a solid by adding a little vinegar and heat…Have the students make a hypothesis about what will happen when they put 1.5 cups of milk and 4 teaspoons of vinegar together and heat it in the microwave. They should be specific about whether they think that these two liquids will stay separate or come together to form a solid.

Have students add 4 teaspoons of white vinegar to 1 1/2 cups of skim milk.

Microwave the mixture for about a minute. After a minute, the milk and vinegar will be separated into two parts, a liquid and a solid. Have students put on the rubber gloves and wash the lumps in water. You can then press them together into one big blob – they will be squishy and will feel as if they are going to fall apart, but they will stick together after some firm kneading. You can now use your artistic skills to fashion the material into the shapes of their choice Leave the material to dry for a day or two and it will be hard and plastic enough to paint and varnish.

What's Happening?

Here's what happened to the milk. By adding the vinegar, and turning on the heat, you have created a chemical reaction that separated the milk into two parts, and made a whole new substance.

Now, when you stir the milk, the new substance shows up as a "blob." When you strain the liquid off, you can make the blob into one big lump. Let it cool off, and then you can play with it. It feels like rubber.

Plastic? In milk? Well, sort of. Milk is an excellent source of protein. Because proteins have a large molecular structure, they do not dissolve in water. There are two kinds of milk proteins: casein and whey or serum. Casein are approximately 80% of the milk proteins, and whey or serum proteins make up the other 20%.

The casein proteins in milk are combined with some of the minerals in milk and form micelles. Micelles are groups of molecules;.

The light reflected from the micelles makes the milk white. Casein proteins are coagulated by acids. *(Coagulate means to change from a liquid to a thickened or solid state, something that makes a liquid do that is called a coagulant We have coagulants in our blood that help a cut stop bleeding and form a scab.)* If an acid is added to milk, the casein proteins separate from the rest of the liquid forms a solid.

Casein proteins in milk cluster together and work like tiny sponges to hold water in the milk. They can contain and hold as much as 70% water in each protein cluster (see casein protein cluster illustration). Acids, salt, or high heat will cause the casein protein clusters to lose water.

You made a large blob of casein, this occurs when the protein in the milk meets the acid in the vinegar. The protein in the curds is what makes it act like rubber.

The combination of an acid - in this case vinegar, which contains acetic acid - and heat to precipitate casein (a protein) from the milk. The casein in milk does not mix with the acid (it is not soluble in an acid environment) and so it forms blobs, made up of long molecules (made out of fat, minerals and the protein casein) that bend like rubber until they harden.

Casein behaves like the plastics that we see in so many objects around us, such as computer keyboards or phones, because it has a similar molecular form. True plastics, called polymers, are a little different. The plastics in everyday objects are based on long-chain molecules called polymers. These are of high molecular weight and get their strength from the way their billions of interwoven crises-crossing molecules tangle together.

PS: Some forms of cheese-making rely on a similar technique – the name casein comes from caseus, the Latin for cheese. The Indian cheese known as paneer is made in a very similar way to the plastic you have just made, although in this case lemon juice is the acid used rather than vinegar. Afterwards, unlike our plastic milk, it is not dried out and allowed to harden to tooth-breaking consistency, and so remains soft and edible.

A hundred years ago, people took milk and used it like this to make plastic. Can students think of any other liquids they can separate into parts? (ex. blood)

The project above is a **DEMONSTRATION**. To make it a true experiment, students can form hypothesis about these questions (and try to answer some of their own):What works best? Assign students to work in groups and have students work on one of the following Questions (or one of their own), Form a Hypothesis, and Test It Out:

1. Will more vinegar make more casein?
2. Does starting with cold milk work better than hot milk?
3. Will you get the same results with whole milk, soy milk?
4. Do all types of vinegar work the same?
5. Will other acids, such as lemon juice and orange juice work?
6. Does the amount of time the milk mixture stays in the microwave make a difference in the quality of the result? How does a change in the length of time by x amount change the results? What is the optimal amount of time?
7. have the students weigh out each of the liquids and find out how much the produced plastic weighs. With this information you can find out how much liquid is needed to produce a desired amount of plastic.

Post Discussion:

Have students compare their results and write them on the board. What were some of the pitfalls they ran into. If they put all of their results together will they get the best possible "plastic?" Have them test it out. What do their conclusions show?

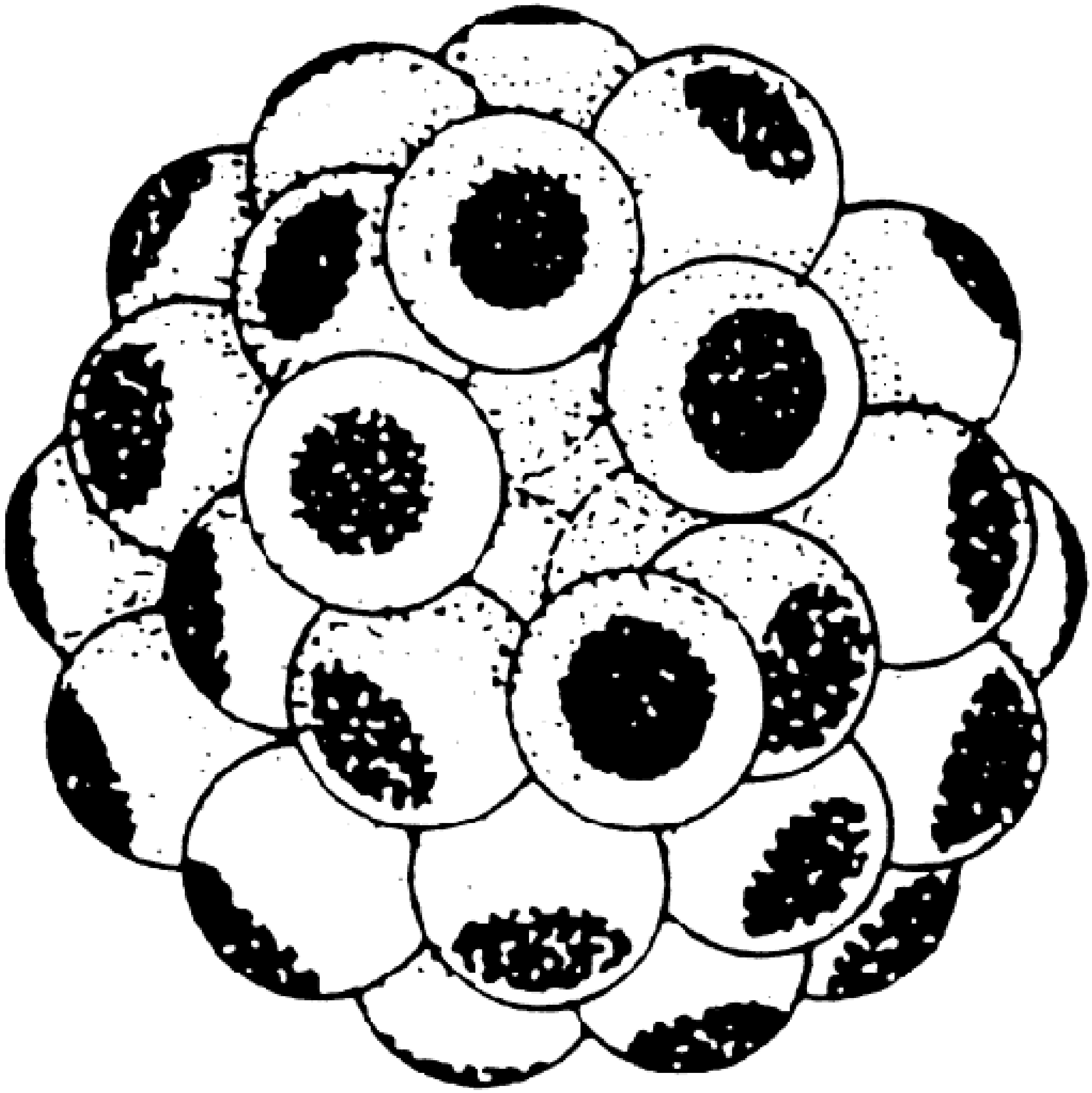
Extension Activity:

Have the students roll their milk plastic into beads, or other shapes, let them dry, and later paint or decorate them.

Student Assessment:

As students to describe in their own words what happened in the experiment in their science journal. Review the results.

CASEIN PROTEIN CLUSTER ILLUSTRATION



Experiment: Homemade Ice Cream in a Bag

Most students enjoy eating ice cream, but not all understand the science that makes it possible. This lesson plan will literally bring three states of matter (gasses, liquid, solids,) in to students hands, spoons and mouths.

Objectives:

Students will:

- **understand how atoms and molecules are organized and move in liquids, solids and gasses.**
- **see and feel a liquid change into a solid state.**
- **learn or review their skills in measuring and working with liquids, dry ingredients, ice, salt and brine as well as taking temperature readings**
- **understand the transfer of energy necessary for a substance to change phase**

Key Terms:

- Freezing Point
- Temperature
- Atoms, Electrons, and Molecules
- Energy
- Matter
- Lower/Decrease
- Raise/Increase
- States of Matter
- Solid
- Liquid
- Gas
- Plasma
- Phase
- Physical Change
- Chemical Change
- Melt
- Freeze
- Boil

Lesson:

Elements and compounds can move in and out of different states of matter when certain physical forces are present. Let's take a short pop quiz on the subject.

Q #1: How many states of matter are there?

Q #2: What condition could change the characteristics of any state of matter?

Q #3: Are changes in matter physical or chemical?

How are you doing so far? Maybe we should explore the subject before taking an exam. Get your pens ready to take down a few notes. Remember, you'll have activities to complete when this lesson is over.

If you answered "three" to the first question in Step 1, you'd be almost right….but not quite. Years ago, it was taught that there were only three states of matter: (ask the students what they are) Solids, liquids, and gases. But now, most scientists recognize a fourth state of matter: Plasma. We're going to look at all four states in this lesson.

First, let's state the definition of matter: simply put, it is anything that has mass and takes up space.

Phase is an interchangeable word for state. When an element or compound changes phases, the change will always be a physical change; it will not be chemical.

Remember that in order for a chemical change to take place, the element would have to become something completely new. When the state, or phase, of matter is changed, the substance remains the same thing, but in a different physical form. For example, if you were to boil a pot of water, *(ask students what they would see*) you would see steam or water vapor over the pot; that steam or vapor is *(ask students what the steam is and what state of matter it is)* water in a gaseous form. When it cools off that same vapor can condense and become drops of water; now we have a liquid phase. *Ask students, what if we collect some of those drops of water and put them in the freezer?* Obviously, they will become ice, but really, all you have is water in a solid form.

Steam, drops of water, and ice are all the same thing—but in different forms or phases. The change was physical, not chemical. A chemical change takes place only when you alter the basic chemical structure of the compound. This does not happen when moving from one state of matter to another.

Probably the most common way a phase changes is when temperature is increased or decreased. Identifying states of matter can be tricky; they are not always absolute. For example, the atomic structure in glass actually looks more like a liquid than a solid, and if you look at a very old sheet of glass you can see that it is thicker at the bottom than at the top, the molecules and atoms have been moving very slowly downward over the years.

Let's look for a moment the four individual states.

Solids are characterized by a fixed volume and shape. That's because atoms and molecules in a solid are closed into a specific place. The atoms still spin and the electrons still move around the nucleus, but the entire atoms don't move around. Normally, solids will use the least amount of energy. Think of it this way: If you're sitting still, you are not exerting much energy. Solids are "sitting still" in a way, while gases and liquids are moving around. Liquids and gases are exerting more energy.

Liquids are characterized by a fixed volume without a fixed shape. What does that mean? You could take a half cup of water and pour it into many different containers. *(Demonstrate this for the students by pouring water into different containers)* If each container has a different shape, the water will take on each specific shape. So, that same amount of water could be the shape of a soda bottle, the shape of a mason jar, and the shape of an old shoe. The liquid will take on the shape of any object into which it is poured.

There is a temperature for every substance that is called the melting point. When a solid reaches the melting point, it becomes a liquid. Likewise, when a liquid reaches what is called the freezing point, it becomes a solid.

Liquids are in the "middle" of gases and solids. Just as a solid can be melted to become a liquid, gases can become liquids as well. Gases have very high-energy atoms, and in order to become a liquid, they must lose some energy. They have to slow down. The best way to turn a gas into a liquid is to lower the surrounding temperature. As the atoms begin to lose energy, they will eventually reach what is called the condensation point, which is the temperature at which a gas becomes a liquid. But the possibilities do not stop here. Liquids can also become gases; one way this can occur is simply through something called evaporation. This can happen to all liquids at room temperature.

The measurable energy of an atom is really just the average energy level. There are always some molecules that have much more energy than the average and it is those molecules that build up enough energy or power to "escape" from the liquid state and become a gas. When that happens, those molecules have evaporated.

Gases are characterized by having neither a fixed volume nor a fixed shape. Gases, like air, are everywhere. As stated before, atoms in solids have the least amount of energy (they are the slowest). Atoms in gases are the most energetic of all. For a liquid to become a gas, energy must be added. An easy example of this is to boil water. You can actually see the energy as the water begins to show signs of movement. Boiling water will put off steam or vapors, which is now gas.

There is one last state of matter that we call plasma. Plasma only exists at very high temperatures or at very low pressures. Unlike the first three phases we examined, the phase of plasma does not happen in our common environment. Scientists consider plasmas to be very unique. They are similar to gases, but are actually very different. The northern lights are one example of plasma. Stars and neon signs are other examples of plasmas. Plasma is also a term used when talking about your blood. Do you know what your blood plasma is?

Now, on to the ice cream!

Legend has it that the Roman emperor, Nero, is credited as the first person to make ice cream. Nero commanded slaves to bring snow down from the mountains, which was then used to freeze the flavored cream mixture. The secret was to lower the freezing point of snow in order to freeze the cream. How? The scientific secret is SALT! Here's a scientific recipe that you can use e to make your own ice cream.

Materials: (per student)

- 2 tablespoons sugar
- 1 cup half and half or whole milk
- 1/2 teaspoon vanilla extract
- 1/2 cup salt (The bigger the granules, the better. Kosher or rock salt works best, but table salt is fine.)
- Ice cubes (enough to fill each gallon-size bag about half full)
- 1 pint-size ziplock bag
- 1 gallon-size ziplock bag
- Temperature probe or thermometer

1. Place 3 cups crushed ice in a gallon-size freezer bag. Take the temperature of the ice in the bag.

2. Add ½ cup rock salt to the ice, and stir for about one minute. Take the temperature again, was there any change?

3. Place 1 cup milk in a quart-size freezer bag with the sugar and vanilla. Make sure it is sealed tightly.

4. Seal the quart-size bag inside the gallon-size bag containing the crushed ice and begin shaking.

5. Continue shaking the bag until the milk turns into a solid. Take the temperature of the ice cream.

6. What processes changed these states of matter? What purpose did the salt have? At what temperature does water freeze? If you used a temperature probe, at what temperature did the milk freeze?

How does it work?

What does the salt do? Just like we use salt on icy roads in the winter, salt mixed with ice in this case also causes the ice to melt. When salt comes into contact with ice, the freezing point of the ice is lowered.

The lowering of the freezing point depends on the amount of salt added. The more salt added, the lower the temperature will have to be before the salt- water solution freezes. For example, water will normally freeze solid at 32 degrees F. A 10% salt solution won't freeze until 20 degrees F, and a 20% solution won't freezes until the temperature drops to 2 degrees F. So, the more the more salt, the colder it gets as the mixture robs the heat or energy it needs from its surroundings. *(Have students test this with a thermometer beakers and a variety of ratios of salt and ice. What is the ratio that gets the coldest temperature?)*

When salt is added to the ice, some of the ice melts because the freezing point is lowered and it pulls the energy it needs to melt from the half and half mixture as well as the air around it, etc. Because the energy is being pulled from the atoms in the half and half mixture they are slowing down (freezing) and turning into a solid. Always remember that heat must be absorbed by the ice for it to melt, the ice has to rob energy from its surroundings. The heat that causes the melting comes from the surroundings (the warmer cream mixture). By lowering the temperature at which ice is frozen, you were able to create an environment where the ice pulls lots of energy from the atoms in the cream mixture and so the cream mixture could freeze at a temperature below 32 degrees F.

Test with different kinds of salt. Do the size of the granules affect the results? What is the best combination to get the ice cream the fastest? What if you put water instead of ice cubes? Does it still work if you don't use sugar?

Student Assessment:

- Ask students to write down a recipe card instructing someone how to make ice cream using the scientific terms and ideas they learned about (listed on the board) Such as: Freezing Point, Temperature, Atoms, Electrons, and Molecules, Energy, Matter, Lower/Decrease, Raise/Increase, Solid, Liquid, Gas, Phase, Physical Change, Chemical Change, Melt, Freeze

Experiment: Magic Milk

It's an explosion of color! Some very unusual things happen when you mix a little milk, food coloring, and a drop of liquid soap. Use the experiment to amaze your students and allow them to uncover the colorful scientific secrets of fats, proteins, and soap.

Objectives:

Students will:

- **Apply the scientific method to determine what is happening in the reaction and what variables determine the results**
- **Understand the differences between hydrophobic and hydrophilic and be able to put them in their own words**
- **Develop and test their own working hypothesis using the scientific method, record, and present their results.**
- **Understand that many liquids (especially milk) are made of parts, i.e. solutions**
- **Understand the role of soap molecules and their interaction with fats**

Key Terms:

- Hypothesis
- Conclusion
- Observation
- Test
- Results
- Solution
- Hydrophobic
- Hydrophilic
- Micelle
- Suspension
- Fats
- Proteins
- Soap
- Chemical Bonds

- Surface Tension

Materials

- Milk (whole or 2%)
- Dinner plate
- Food coloring (red, yellow, green, blue)
- Dish-washing soap (Dawn brand works well)
- Cotton swabs

1. In front of each group place a plate and then pour enough milk in the dinner plate to completely cover the bottom and allow it to settle.

2. Add (or have students add) one drop of each of the four colors of food coloring - red, yellow, blue, and green - to the milk. Keep the drops close together in the center of the plate of milk.

3. Give each student or group a clean cotton swab for the next part of the experiment. Have students predict what they think will happen when they touch the tip of the cotton swab to the center of the milk. It's important not to stir the mix just touch it with the tip of the cotton swab.

4. Then, have students place a drop of liquid dish soap (the Dawn brand works well) on the tip of the cotton swab (optional, place the liquid soap in a small cup and do not tell the students what it is, have them use their senses to decipher what it is). Have students place the soapy end of the cotton swab back in the middle of the milk and hold it there (not stirring!) for 10 to 15 seconds. Look at that burst of color! It's like the 4th of July in a bowl of milk: mini-explosions of color.

5. Have students add another drop of soap to the tip to the cotton swab and try it again. Experiment with placing the cotton swab at different places in the milk. Notice that the colors in the milk continue to move even when the cotton swab is removed. What makes the food coloring in the milk move?

Have students write a hypothesis about why the colors started moving. Was it the fat or proteins in the milk? Was it the soap? After they make a prediction, have students test it out by changing one variable in their procedure at a time. For example, if they think that the experiment works due to the interaction between soap and fat, repeat the experiment once using no soap on the toothpick. Then repeat the experiment a third time, but substitute whole milk with skim milk. Were they right? Be sure they clean their plate well between experiments.

Here are some suggestions (allow students to come up with additional hypothesis and investigations):

- Investigate using more or less soap or different fat content milk in unmarked containers (skim, 1%, 2%, half-and-half, cream, whole milk, or buttermilk). Write the different kinds they are testing up on the board, but have the milks in plain containers marked A, B, C, etc. Divide students into groups and have students test the milks, record the results, and form a theory on which one is which based on their results. Did every group reach the same conclusions? What kind of milk produces the best swirling of color: skim, 1%, 2%, or whole milk? Why?
- Repeat the experiment using water in place of milk. Will you get the same eruption of color? Why or why not? Try it with oil and water.
- Substitute a cotton swab with a wooden toothpick or with a plastic toothpick
- Substitute the liquid detergent with hand soap, a different detergent, or don't use soap at all
- Substitute food coloring with pepper

- Does the temperature of the milk affect the results? Test using cold, room temperature, and hot milk.

How does it work?

Milk is mostly water but it also contains vitamins, minerals, proteins, and tiny droplets of fat suspended in solution. Fats and proteins suspended in the milk (hanging in the milk) are sensitive to changes in the surrounding solution (the milk).

When you add soap, the weak chemical bonds that hold the proteins in solution (to their place inside the milk) are altered. It's a free for all! The molecules of protein and fat bend, roll, twist, and contort in all directions trying to get away from the soap. The food color molecules are bumped and shoved everywhere, providing an easy way to observe all the invisible activity. At the same time, soap molecules combine to form a micelle, or cluster of soap molecules wrapped around fat molecules. The water-loving (hydrophilic) part of the soap molecules points outwards, forming the outer surface of the micelle. The oil-loving (hydrophobic) parts group together on the inside, where they don't come into contact with the water at all. Micelles can trap fats in the center. These micelles distribute the fat in the milk.

This rapidly mixing fat and soap causes swirling and churning where a micelle (cluster of soap) meets a fat droplet. When there are micelles (soap droplets) and fat droplets everywhere the motion stops, but not until after you've enjoyed the show!

There's another reason the colors explode the way they do. Since milk is mostly water, it has surface tension like water. The drops of food coloring floating on the surface tend to stay put. Liquid soap wrecks the surface tension by breaking the bonds that hold water molecules together and allows the colors to zing throughout the milk. What a party!

Additional Info

Detergent, because of its bipolar characteristics (hydrophilic (water-loving) on one end and hydrophobic (water-fearing) on the other), weakens the milk's bonds by attaching to its fat molecules. The detergent's hydrophilic end dissolves in water and its water-fearing end attaches to a fat globule in the milk, shoving it away from the water.

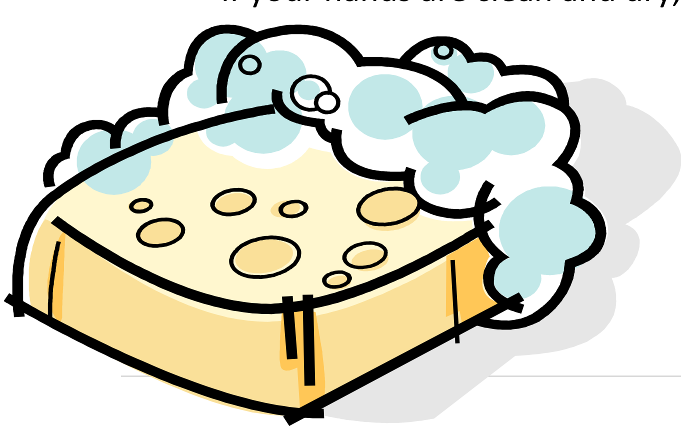
Explanations of terms:

Solutions: Solutions are groups of molecules that are mixed up in a completely even distribution. Hmmm. Not the easiest way to say it. Scientists say that solutions are **homogenous** systems. Other types of mixtures can have a little higher concentration on one side of the liquid when compared to the other side. Solutions have an even concentration throughout the system. An example: Sugar in water vs. Sand in water. Sugar dissolves and is spread throughout the glass of water. The sand sinks to the bottom. The sugar-water could be considered a solution. The sand-water is a mixture.

Micelle: a cluster of molecules

Expansions:

- What about other substances? Try it with very thinned down (with water) Elmers Glue. Does it work? If it does let it dry and you'll have magic art!
- Will soap affect other materials? Clean and rinse a new dish or bowl, fill it with water, then sprinkle a little ordinary black pepper on the surface. It should just sit there floating on the water- nothing interesting yet. Now place a small drop of soap in the center of the dish just like you did before. What happens? Now if your hands are clean and dry, slowly dip the end of your finger into the soap covered surface of water and slowly pull it out again. What did the pepper do now? Why do you think it did that?
- With younger students, this is a great way to teach colors and color mixing.



What colors are first put in, what colors are made when they mix?

- Get a microscope and see: is milk just one thing or made up of parts? Can you see them under the microscope? Have you wondered what *homogenized* means on the side of the milk container? Or what *unhomogenized* means? Homogenization breaks down and blends fat globules in milk. If milk is not homogenized the fat globules are large enough to separate from the milk. An example of this is cream separating and rising to the top of a container.

- **Explanatory Experiment: How is it that soap helps things get clean?** What's so special about it? Here's a simple, fun, experiment to demonstrate. Take two jars (such as baby food jars) and fill them half full of water. Add a drop or two of food coloring and shake. Add plain cooking oil (such as canola) to the jars, leaving some space at the top. (We're going to be shaking these jars.) Add a few squirts of liquid soap to *one* of the jars. Put the lids back on tight and shake them both for about 30 seconds. When you first put them down, there's not much difference between the two jars. The oil and water molecules are all quite well mixed together. But just wait a minute. After only a minute or so, you'll start to see the jar with just oil and water in it start to re-separate. The jar with the soap in it is still mixed together. After several minutes, the oil and water only jar has almost completely separated again, but the jar with the soap is still mixed? WHY??? Soap, water and oil are all made up of molecules. Some molecules are hydrophilic, meaning they are attracted to water, and some molecules are hydrophobic meaning they are repelled by water. Oil and water don't mix right? Well that's where soap comes in. Soap is actually a very long molecule that has one hydrophilic end and one hydrophobic end. The water sticks/bonds with the hydrophilic end and the oil sticks/bonds to the hydrophobic end. Two opposing molecules with the soap in the middle. As the water is rinsed away, the soap sticks to the water, and the oil sticks to the soap. Voila! Clean! That's what's happened in the jar. The jar with just oil and water quickly separates. In the jar with the soap added, however, the oil and water stay mixed together for much longer. (Note: For a more advanced explanation (with diagrams and everything) check out How Does Soap Clean

from About's Guide to Chemistry.
http://chemistry.about.com/library/weekly/aa081301a.htm)

Tips:

- Remember, students need the chance to do things themselves.
- Very young students will love the “magic” while older students need the opportunity to learn how and why things work the way they do.
- Even if an experiment doesn’t work, it’s a learning experience. Thomas Jefferson made over 200 light bulbs before he got one that worked. He didn’t consider himself a failure, he just figured out 200 ways *not* to make a light bulb.

Student Assessment:

Ask students to draw a diagram (in their science journal or outside) of the parts of milk and what happened when the soap interacted with the fat molecules. Have students label their diagrams with the different parts. Ex. Micelles, hydrophobic ends, hydrophilic ends, fat molecules, proteins, food coloring, water, etc

Experiment: Taco Sauce Penny Cleaner

It's one of those things you hear about but wonder if it's true. Can you use taco sauce to clean the tarnish off of a penny? Believe it or not, taco sauce does a great job of cleaning pennies, but how does it work? Which ingredients in the taco sauce really do the cleaning? Have students tackle these questions as part of your science project and they may make a surprising discovery.

Objectives:

Students will:

Learn that not all hypotheses are correct and that sometimes retesting is required

Put the scientific method in action through multiple trials and use of variables and controls

Key Terms:

- Acid
- Hypothesis
- Test/Re-test
- Variable
- Tarnish
- Reaction
- Copper
- Oxygen
- Dissolve
- Copper Oxide
- Tarnish

Materials

- Dirty pennies (try to collect tarnished pennies that all look the same)
- Other materials to clean (tarnished silver, other coins, etc)

- Taco sauce (mild sauce from Taco Bell works well, but bring several kinds)
- Vinegar
- Tomato paste
- Lemon Juice
- Salt
- Water
- Small plates

The tarnish on pennies is actually not tarnish at all. It is simply a reaction between the copper in the penny and the oxygen in the air. When the two elements react with one another, they form copper oxide. To get rid of this dull and often greenish substance we need to dissolve it. And reveal the shiny copper that is there underneath. So, how are we going to do it?

1. Let's start by proving that taco sauce does a good job of cleaning pennies. Place several tarnished pennies on a plate and cover them with taco sauce. Use your fingers to smear the taco sauce all over the surface of the pennies. Remember to wash your hands... and don't lick your fingers (pennies are really dirty and some taco sauces are really spicy!).

2. Allow the taco sauce to sit on the pennies for at least two minutes.
3. Rinse the pennies in the sink and look at the difference between the top side of the pennies that touched the taco sauce and the bottom side. It's no myth... taco sauce does the trick.

So, which ingredients are responsible for the cleaning power of taco sauce? Let's find out...

1. Have students place two or three equally tarnished pennies on each of four plates. Use masking tape or a sticky note to mark each plate with the ingredient they are testing (vinegar, tomato paste, salt, and water).
2. Cover the pennies with the various ingredients and allow them to sit for at least two minutes.
3. Rinse the pennies from each test plate with water. Which ingredient cleaned the pennies the best?

Ask the students, did any of them work? Much to your surprise, none of the ingredients did a good job of cleaning the dirty pennies. In fact, the results are terrible. Ask the students, where did we go wrong?

Tell the students: Even if an experiment doesn't work, it's a learning experience. Thomas Jefferson made over 200 light bulbs before he got one that worked. He didn't consider himself a failure, he just figured out 200 ways not to make a light bulb. We have found several ways not to clean a penny. Now, let's form another hypothesis to possibly help us actually get it clean.

Since one ingredient at a time didn't work, what should we try next? *(Have students share their ideas and test them.)* Maybe two or more of the ingredients work together to react against the dirt and copper oxide on the penny? Lets set up our second test using various combinations of tomato paste, vinegar and salt.

1. Place two or three equally tarnished pennies on each of three plates. Make three signs that say "Tomato Paste + Vinegar", "Salt + Vinegar", and "Tomato Paste + Salt".
2. Cover the pennies with each of the mixtures and give the ingredients at least two minutes to react.
3. Rinse the pennies under water and write down your observations.

Observations

The Taco Sauce Penny Cleaner is a great example of a Science Fair project. First, you ask a question - does taco sauce really clean pennies? You find that it does and then you ask another question - What is it in the taco sauce that causes it to clean pennies? You run multiple tests and isolate one variable at a time to see if the vinegar, the tomato paste, the salt, or the water is the real cleaning agent for the pennies. Guess what... nothing cleans the penny. Now what do you do? You ask another question - Could a combination of ingredients cause the cleaning action? Again, you isolate the variables to eventually reach the conclusion that the combination of the vinegar and salt cleans the pennies. The Taco Sauce Penny Cleaner experiment clearly shows scientific inquiry in motion.

How does it work?



The clear winner is the mixture of vinegar and salt. Neither vinegar nor salt by themselves cleaned the pennies, but when they were mixed together something happened. The chemistry behind the reaction is somewhat complicated but very interesting. Dr. Laurence D. Rosenhein from the Department of Chemistry at Indiana State University published an article in the Journal of Chemical Education in 2001 about this very reaction. According to Dr. Rosenhein, salt (sodium chloride) plays a very important role in making a copper chloride complex. Salt breaks down into sodium ions and chloride ions and it is the chloride ions that form a surprising complex with the copper ions (specifically the Cu+1). By themselves, the salt and weak acid do very little in the way of removing the coating of copper oxide on the penny, but together these ingredients make a great cleaning agent. Now you know the cleaning power of taco sauce!

What about other weak acids? Will they work as well?

Try lemon juice and/or lemon juice and salt. Do they clean as wells was the taco sauce?

Test other materials:

Does taco sauce clean jewelry or quarters as well as it cleans pennies?

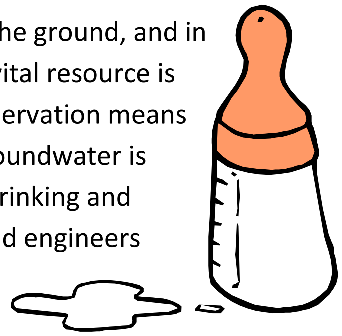
Student Assessment:

Have students write in their science journals what they learned from this experiment. Then have students make a display of their pennies in their science journals. Have students tape, glue, or baggie each penny and label it with the solution used. students label the formulas used on each penny and make notations on the steps used. Students need to use the vocabulary such as acid, tarnish, copper oxide, etc.

For a really dramatic effect, students can take a couple leftover pennies and dip half of each coin in the vinegar and salt solution while leaving the other half as is. This will give them a penny that is half dirty and half clean, which is a pretty cool example of the miracle of chemistry!

Inventions

Experiment: Practical Polymers and helpful Hydrogels



Water is everywhere – in the sky, in the ground, and in our homes. However, caring for this vital resource is often a challenge for each of us. Conservation means using water wisely. Protecting our groundwater is important because it is a source for drinking and irrigation. Consequently, scientists and engineers have developed amazing, superabsorbent polymers, called hydrogels, that can help.

Objectives:

Students will:

- be able to conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy
- Explain how different inventions and technologies impact people and the environment.
- Use the scientific method to determine the limits of and variables that affect the absorbing properties of diaper polymers
- Evaluate an invention that solves a problem and determine the pros and cons of the design.
- Discuss how the unintended consequences of new technologies can impact society.
- Explore technologies that advance health and contribute to improvements in our daily lives.
- Infer that human activities may be helpful or harmful to the environment.

Key Terms:

- Superabsorbent
- Absorb
- Osmosis
- Sodium
- Polymer
- Hydro-gel
- Conservation
- Reusable

- Chain
- Molecules
- Environment
- Environmental Issues
- Water Conservation
- Groundwater
- Contamination
- Agriculture
- Horticulture
- Construction
- Issues
- Soil
- Disposable
- Soil
- Soil Types

In this series of investigations, you will start by looking for a particular polymer at work. Once you discover what this type of polymer can do, you will experiment with other uses for the same polymer. A final step can be taken to consider solutions for water conservation and groundwater contamination.

A polymer is a long chain of molecules. Polymers are all around us, and they make up materials like bicycle helmets, CDs, tires, plastic water bottles, rubber bands, and glue. This experiment focuses on special kinds of polymers that are superabsorbent: hydrogel polymers. Hydrogel polymers are long molecule chains that grab onto water molecules. Some can soak up as much as 500 times their weight in water! This superabsorbent characteristic makes hydrogel polymers useful in water conservation and in solving other environmental issues.

Materials

- 1 Disposable diaper per student
- Water
- Newspaper
- Scissors
- Measuring cup and spoons
- 2 Zipper-lock bags, 3.78 liters (1 gallon) size
- Plastic cup, 266 mL (9 oz)
- 2 Clear plastic bottles with screw-on caps, 355 mL (12 oz)
- 1 Packet (6.2 grams/ 0.22 oz) of unsweetened powdered drink mix, red works the best

- Potting soil (not the "moisture control" type), 475 mL (2 cups)

Demonstration: The following will catch students attention and provides the Gee Whiz! factor, but, be sure to tell the students (after you do it) that that wasn't a science experiment, it was just a fun demonstration. When it becomes a science experiment is when they start asking questions and working to find the answers.

Materials for Demonstration:

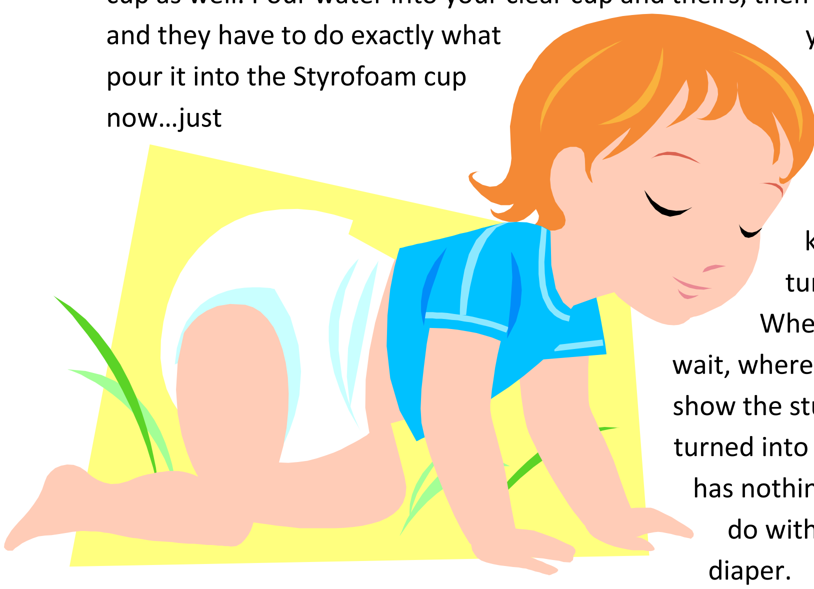
2 Styrofoam cups (with a scoop of water gel powder in them already—without student's knowledge)

Water Gel Powder (or polymer from a diaper)

2 clear cups

Water

Version 1: Ask for a student volunteer to come to the front of the room. Have them stand by one of the two Styrofoam cups and tell them they need some water and have them hold on to the clear cup as well. Pour water into your clear cup and theirs, then tell them that you'll hang on to yours and they have to do exactly what you say. Tell them to take the water and pour it into the Styrofoam cup (3,2,1 Got it!) Tell them, that's perfect, now…just put it over your head. Yes, it's okay, just pour it over your head. Just turn it upside down. It's okay, keep going, keep going. As they turn their cup over turn your cup over your head as well. When they finally do it tell them nice job! But wait, where's their water? Turn the cup over and show the students that the water (Voila!) has been turned into a solid. So, what's the secret? The secret has nothing to with temperature, the secret has to do with a secret ingredient found in a baby diaper.



Or— Version 2: Ask for a student volunteer to come to the front of the room. Have them pick up a Styrofoam cup (with a scoop of water gel powder in them already—without student's knowledge). Tell the student they need some water and ask them to tell you when to stop (stop at the appropriate level no matter when they say). Hold on to the cup and put a card over the top (you can write three directions on the card if you wish and have them face down) and tell them that there are three steps to this experiment and look around like you are trying to find something. Then, ask the student if someone has ever told them to use their head, place the cup upside down on their head and tell them to take responsibility for their own actions and hold onto the cup, put both of their hands on the cup. Say, there's three important steps, and slide the card out from under the cup. Read the card, "Step number three…don't remove this card!" Give a surprised look, Oops! then tell the student you think they are going to be fine…and lift up the cup. Say it looks like the water's gone, but hold out your hand and I'll show you where it went. Pop the gel out into their hand and say it actually turned from a liquid, to a solid. Isn't that kind of cool? When they start asking questions is when the learning begins!

Where are the polymers?

If you've ever changed a diaper and noticed what looked like tiny crystals on the baby's skin, you've uncovered the secret of superabsorbent, disposable diapers. Those tiny crystals actually come from the lining of the diaper and are made out of a safe, non-toxic polymer that absorbs moisture away from the baby's skin.

Have each student collect a sample of hydrogel from the cotton and plastic lining of a disposable diaper.

1. Place a new diaper on the piece of newspaper in front of each student. Carefully cut through the inside lining and remove all the cotton-like material. Put all the stuffing material and plastic lining into a clean, zipper-lock bag.

2. Scoop up any of the powdery material that may have spilled onto the paper and pour it into the bag with the stuffing. Blow a little air into the bag to make it puff up like a pillow, then seal the bag.

3. Shake the bag for a few minutes to remove the powdery hydrogel polymer from the stuffing. Notice how much powder falls to the bottom of the bag.

4. Carefully remove the stuffing and the plastic lining from the bag, and check out the powdery polymer left in the bag. Repeat steps 1-4 with another diaper, if needed, to get 15 mL (1 tbsp) of the hydrogel powder.

5. Now it's time to mix the powder with water to see what happens. Pour 15 mL (1 tbsp) of hydrogel powder into a 266 mL (9 oz) plastic cup. Measure 118 mL (½ cup) of water and pour it into the cup along with the powder.

6. After about 30 seconds, observe that the water has changed — it's no longer a liquid… it's a gooey solid!

Take a closer look at the gel by scooping up some of the gel with your fingers. You can poke holes in it and even tear it into smaller pieces. This hydrogel is safe and non-toxic, so you can touch it, but remember: even safe chemicals never go into your mouth, ears, or nose!

Things to Think About...and Test Out! Experiment with the following (and with additional tests and questions the students come up with.

- How does this water-slurping powder work? Does it only absorb water?
- Do different brands or styles of diaper have different amounts of polymer inside? Which absorbs the most water? The most salt water? Are they really leak proof like some diapers claim? Why or why not?
- What would happen if you let the gel dry out? Is this powder reusable?
- Besides diapers, how else could this powder be used?
- How does the absorbency of the hydrogel compare with other materials that are absorbent: cotton balls, paper towels, sponges?
- How could adding other ingredients (like salt) affect a hydrogel's water-absorbing properties?

Ex: Distilled vs. Salty How much water will the average diaper absorb?

Divide the students into groups and give each group a diaper (all the same kind.) There should be at least one group with distilled water, 1 with tap water and 1 with salt water.

Have each group predict how much water their diaper will hold and record their predictions and hypothesis.

Using the pre-marked plastic cup to measure, students should test their predictions. Have students pour only 100 mL of water at a time into the diapers.

Properly discard all materials (in plastic Ziploc bags).

Have groups share their results and discuss

- Why are there differences?
- Which substance tested is most like urine? What does this tell us about the actual absorbency of the diapers?
- Ask students to discuss the advantages and disadvantages that disposable diapers have over cloth diapers.

What's happening? High School Level:

The absorbent material in disposable diapers is a polymer, sodium polyacrylate. The diaper polymer is really a copolymer (2 polymers linked together), and shaped like a railroad track made of sodium polyacrylate and bis(acrylamide). The sodium polyacrylate strands are the parallel long "rails" of the track, and the bis(acrylamide) makes up the railroad "ties". The polymer contains many groups that can absorb water (by hydrogen bonding.) When water moves into the diaper, one of the main reasons it stays is because of these hydrogen bonds.

The water moves into the diaper because of osmosis, the diffusion of water through a semi permeable membrane. Distilled water on the outside of the diaper contains no sodium ions but the polymer inside has a lot of these. The water will move across the diaper lining to try to equalize the concentration of sodium on both sides of the membrane. Since there is a lot of sodium inside the diaper, the water has a strong tendency to move into the diaper. When the water is inside the diaper, it attaches to the polymer by hydrogen bonding. The result is that the diaper polymer absorbs a lot of water and swells, creating a gel. It is estimated that the diaper polymer can hold 800 time its weight in distilled water. Now that you know how the water moves, how come less salt water is absorbed by the diaper than distilled water?

When salt water is poured onto a diaper instead of distilled water, the tendency of water to move into the diaper is not as great, since there is salt both inside and outside the diaper. As a result the diaper will absorb much less salt water than distilled water. When 5 teaspoons of salt are dissolved in 500 mL distilled water at room temperature, a medium sized diaper can absorb only about 250 mL of the salt water before it begins to "leak" water. What does this say about a diapers ability to absorb urine?

Student Assessment:

Have students write in their science journals about how much distilled water, tap water, and salt water an average diaper can absorb. Then have them explain their results related to the polymer and the affects of salt on the absorption abilities of the polymer and do a diagram of the parts of a diaper. How would they improve the design? What else would they use these polymers for?

Experiment (Continued): Soil Soakers

Can hydrogels help improve the environment?

As you discovered, a hydrogel is a superabsorbent polymer—which can hold up to 500 times its own weight in water. Could hydrogels be used to address water conservation and groundwater contamination? Create an experiment that tests how hydrogels could work in soil.

Have each group of students set up two soil soakers, which are the experimental devices they will use for their experiment.

1. Prepare two Soil Soakers by cutting off the bottoms of the clear plastic bottles. Put one hole in each screw on cap using a 3/16" diameter nail and hammer or use a 3/16" drill bit (see drawing). Think safety — this step might require adult help.
2. Label one bottle as the Control Soil Soaker and the other bottle as the Experimental Soil Soaker.
3. Put 1 cup of potting soil into the Control Soil Soaker and place bottle into tall, narrow drinking glass, lid side down and open side up.
4. Obtain about 1 tablespoon of hydrogel powder (see the Engage activity if you are harvesting hydrogel powder from diapers).
5. Mix 1 cup of potting soil with 1 tablespoon of hydrogel, and place into the Experimental Soil Soaker. Place bottle into tall, narrow drinking glass, cap side down and open side up.
6. Mix 1 packet of unsweetened powdered drink mix into 1 cup of water. This solution represents a water soluble fertilizer application. (Water soluble means "capable of being dissolved in water.")
7. Record your results for the following steps:

- Step 1 - Pour 1/4 cup red solution into EACH of the Soil Soakers. Observe. Does any water drain through the soil into the glasses? For the Control: Yes or No? For the Experimental: Yes or No?
- Step 2 - Add another 1/4 cup red solution into each Soil Soaker. Observe the amount of water that seeps through the soil. Which Soil Soaker allowed the least

amount of water to seep through? Control or Experimental?

- Step 3 - Wait 5 minutes and compare and contrast the solution from each Soil Soaker. Answer the following questions:
- Is there a difference in the amount of water in each glass? Yes or no?
- Is there a difference in color? Yes or no?
- Is there a difference in smell? Use a wafting technique (fanning the air over the glass) to check the smell. Yes or no?

How does it work?

Did the addition of the absorbent hydrogel polymer impact the movement of water through the soil? If yes, how?

If the red solution represented a water-soluble fertilizer or chemical pesticide, what conclusions can be drawn about this contamination entering the groundwater?

If more water is retained in the soil, what conclusions can be drawn about the amount of watering needed to help the plants grow? How might this affect water conservation issues?

FAQs about polymers and other useful information.

What are polymers?
Polymers are one of the classes of materials that we encounter throughout the day. Polymers (commonly known as plastics) are either naturally occurring (rubber, RNA and DNA, proteins, starch, and cellulose) or synthetic (manufactured).

What are hydrogels?

Hydrogel polymers are long molecule chains made up of repeating units that grab onto water molecules. This characteristic makes them a great solution for soaking up water.

How are hydrogels helping the environment?

Many environmental applications for hydrogels have been found for agriculture, as well as the construction and horticulture industries. Hydrogels help reduce water runoff and soil erosion, thus improving the quality of lakes, streams, and rivers. Hydrogels also help with moisture retention and water conservation by helping soil increase water holding capacity, allowing plants to survive during droughts. Erosion control, soil management, and environmental clean-ups are also ways hydrogels can help the environment. Many scientists continue to study the effect of hydrogels on the environment.

Additional Info

Go beyond...how much hydrogel works for you?

Use what you know about the environmental impact of adding hydrogel to soil. Follow the engineering design process to create a better soil for your garden.

Ask 1: How can I conserve water in my garden? How can I prevent contamination of groundwater from fertilizers? Can hydrogel help me accomplish this? Are there different kinds of hydrogels with different properties? Do different soils absorb water at different rates? What is the type of soil in my garden? Can I design a "better soil" that would conserve water and protect the water table from contamination?

Imagine: Designer soil that reduces the number of waterings and, therefore, conserves water. This soil would retain the fertilizer for the plants instead of entering the groundwater and contaminating it.

Create: To craft a designer soil profile, find out about your soil type*: Is it clay, sandy or loamy? Which soil is the most absorbent? Which is the least absorbent? Which one needs more hydrogel? Which needs less hydrogel?**

Test: Using the Soil Soakers experiment, test your own soil with varying amounts of the agricultural version of hydrogel (Polyacrylamide), available in the gardening section of stores. This form of hydrogel is frequently used as a soil conditioner on farmland and construction sites for erosion control, and to protect the water quality of nearby rivers and streams. What is the optimum amount that holds water without "saturating" the soil, making it too soggy for plants? What amount is necessary to retain water and reduce the number of watering times?

Ask 2: What is the optimum amount of hydrogel? Can I use other techniques to improve my soil conditions? What other ways can I conserve water in my garden?

- What are soil types? There are three basic different types of soils: clay soils, loamy soils and sandy soils. Loamy soils are the best; the other two soils present irrigation challenges. But how do you find out which type of soil you have? Here is the simplest way to check your own soil:
- Take a marble-sized chunk of moist soil and roll it between your thumb and finger; try to shape it into a small ball.
- With a clay soil, you can do it and you end up with a ball the size of a marble.
- With a sandy soil, you cannot do it—the ball will fall apart.
- With a loamy soil, you will be able to do it but the ball will fall apart when you quit applying pressure.
- What different kinds of hydrogels are there? The hydrogel polymers found in most disposable diapers are just one kind. Some scientists have found that hydrogels like these don't work well in soil and agricultural use. New, superabsorbent polymers are rapidly becoming one of the most exciting topics in environmental education. Take a trip to your local garden center, and ask the plant specialist if they carry water polymer crystals or water jelly crystals.

- Share your ideas for other applications of hydrogels. For example, hydrogels have been used to preserve and restore a submarine recovered from the Civil War era, and to make "cool ties" that soldiers can tie around their necks to beat the desert heat. What can you find out about these uses? What other ideas do you have?

Experiment: Growing Bacteria in Petri Dishes

This activity will prove that Mom was right, "Wash your hands with soap and warm water!" A Petri dish prepared with nutrient agar (a seaweed derivative with beef nutrients) is an ideal food source for the bacteria you'll be growing. In this experiment, collect samples from items around the classroom - you will not believe what you will find.

Objectives:

Students will:

- Conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy
- Determine effectiveness of different antibacterial agents
- Discover that bacteria (and fungus) are everywhere and that they are usually too small to see unless they are grown in abundance.
- Describe what agar is and pour agar plates.
- Discuss the size of bacteria, give the definition of a colony and tell why they are able to grow to visible proportions in their new environment.
- Discover the diversity of bacteria even in our local setting

Key Vocabulary.

- Agar
- Petri Dish
- Bacteria
- Sanitizer
- Mold
- Sample
- Swab
- Label
- Environment
- Halo
- Kill Zone
- Test

- Conclusion
- Hypothesis
- Test Sites
- Results
- Observations

Materials

- 1 Petri dish (4 inch size)
- Water
- Agar nutrient (5 grams)
- Container to boil water
- Plastic wrap
- Cotton swab
- Hand sanitizer

1. Each student or group will need a clean, microwave-safe container (quart-size bowl works great) to mix and heat the agar with water. These mixing proportions make enough nutrient agar to prepare two halves of the Petri dish. Mix 1/2 teaspoon agar (about 1.2 grams) with 1/4 cup (60 mL) of hot water and stir. Bring this mixture to a boil for one minute to completely dissolve the agar. CAUTION: Adult supervision is required to boil water. If you are using the microwave oven to boil the mixture, be careful not to let the solution boil over. The mixture should be clear " no particles floating around in the solution. Allow the mixture to cool for 3 to 5 minutes before moving onto the next step.

2. Have students separate the Petri dish (there's a top and a bottom) and carefully fill the bottom half of the Petri dish with warm agar nutrient solution. Use the top half of the Petri dish to loosely cover the bottom portion (set the lid ajar to allow moisture to escape) and allow the solution to cool and harden for at least an hour.

3. Each team must discuss and decide upon eight areas. Have students consider all of their options, examples below or come up with their own to collect samples. Students discover on their own where bacteria are lurking. Do not give them too many hints. Often, the dirtiest places have the least and

the clean places have the most. This leads to many teachable moments and much enthusiasm from students.

4. They might want to collect a sample from a computer keyboard for one quadrant of the Petri dish and collect a sample from a door handle for the other quadrant. Bacteria will be gathered from these areas, using Q-tips, gloves, and zip-loc bags. Each Petri dish is divided into four quadrants using permanent marker on the bottom plate. Students must show the list of areas before they leave the room. Look for specificity: Where on the student phone? What button exactly? They must be polite if entering a teacher's room. They cannot swab people without permission. Try to make sure they're not all going to the same places so that we get a wide variety.
5. It's time to collect some bacteria on the end of a cotton swab. The classic test is to roll a clean cotton swab in your mouth and then to lightly draw a squiggle with it on the gelled agar. However, many people like to test something even grosser like the keys on your computer or the television remote control. Unless someone recently cleaned the buttons on the TV remote, you're in for some real YUCK in a few days.

6. Remind them, you must use clean cotton swabs for each sample. In order to get a good sample collection, dampen the end of the cotton swab with water. Be sure to wipe the end of the cotton swab all over the surface to be test “ cover the end of the swab with invisible bacteria! Things that you might want to test Door handles, your hands, under your fingernails, your mouth, the top of a desk, top of the antibacterial pump, computer keyboard, remote control, pencil or a pen, area around a bathroom sink, fax machine, calculator or your favorite toy.

7. For each sample have the students lift the top off the Petri dish and LIGHTLY draw a squiggly line in the agar with the end of the cotton swab. Cover the Petri dish with the top half and use a piece of paper or tape to label the dish with the name of the item you tested. For your protection, place the sealed Petri dish inside a zipper-lock back and seal it closed. For safety reasons, remind students that they do not ever open the zipper-lock bag – they can view the growing bacteria through the clear plastic bag.

8. Experiment: Does Hand Sanitizer Keep Bacteria From Growing? Have students try placing a drop (no more) of hand sanitizing gel in the middle of one of their squiggles. (A different one in each Petri dish can be a test of brand effectiveness) Their hypothesis might be that the antibacterial chemical in hand sanitizer will keep any bacteria from growing. Then see if they're right.

9. Experiment: How Effective is that Cleaner? For instance, compare a still dirty area with a recently cleaned area. Compare efficiency of various cleaners. Students can design their own experiments and variables.
10. Have students place the plates in a warm dark place to grow - not too warm, but anything up to about 98 degrees F (37 degrees C) should be fine. After collecting of the bacteria is complete, the Petri dishes should be taped shut and stored upside-down. Then have students make predictions and make hypotheses on which sample will grow the most bacteria.

11. In a short time, they'll be greeted by an amazing variety of bacteria, molds, and fungi. They should continue to see more and larger colonies for the next few days, but you should not see any growth where the disinfectants (hand sanitizers) are. They might even see a "halo" around each spot where you placed the hand sanitizer. This halo is called the "kill zone" – have students measure and compare the size of the kill zone to determine effectiveness of different antibacterial agents.

12. Remember not to open the zipper-lock bag... ever! When they're finished analyzing your growing bacteria, dispose of the entire bag in the trash.

Golly Mom is right! It is important to wash your hands whenever you can! Remember... Do not open the plates once things begin to grow. You could be culturing a pathogen.

How does it work?

Students are likely to have a huge variety of colors, shapes, and smells in their tiny worlds.

Were their predictions correct? Were they surprised by any of the results?

Have students count the number of colonies on their plates, note the differences in color, shape, and other properties. Getting bacteria to grow can be a little tricky so don't get discouraged if you have to make more than one attempt. Allow enough time for them to grow, too. You need millions of them in one place just to see them at all. They're really tiny! In a lab, you'd use your trusty inoculating loop to pick up a bit of the bacteria in order to create a slide for further study under a microscope.

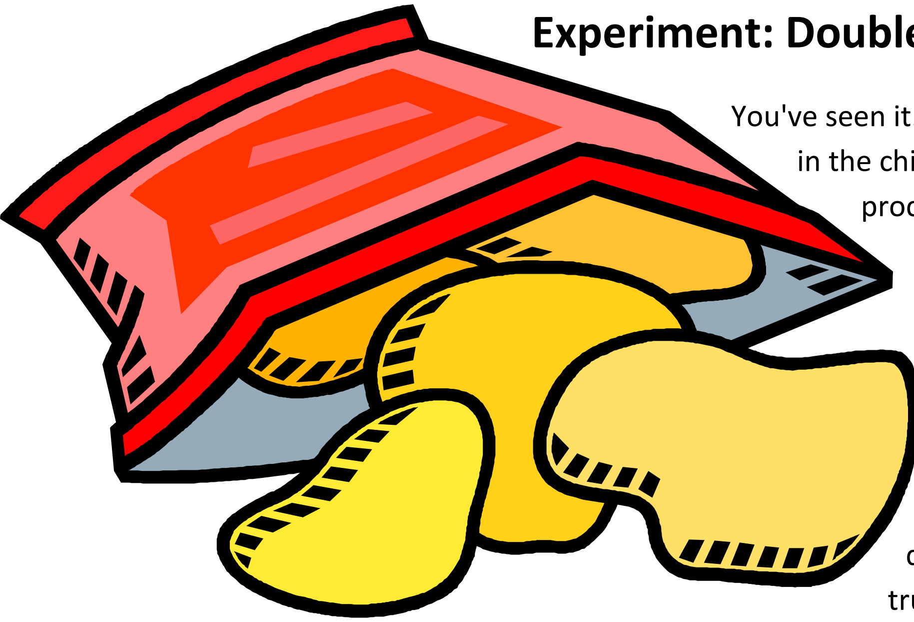
Additional Info

Most bacteria collected in the environment will not be harmful. However, once they multiply into millions of colonies in a Petri dish they become more of a hazard. Be sure to protect open cuts with rubber gloves and never ingest or breathe in growing bacteria. Keep your Petri dishes sealed in the zipper-lock bags for the entire experiment.

Student Assessment:

Have students record their observations and what they learned from the experiment in their science journals. Students write a conclusion in their science journals based on how their ideas about bacteria have changed after this experiment. Which was the most effective antibacterial agent? Which location had the greatest variety of or most bacteria.

Experiment: Double Dip Chip Challenge



You've seen it... someone takes a potato chip, dips it in the chip dip, bites off part of the chip and then proceeds to dip the chip again. Yes, this is the socially unacceptable act of double-dipping. What do you think?

While some people think it's no big deal, others believe the act of double-dipping is the same as putting your whole mouth into the bowl of dip. What do your students think? Is this true or just a myth?

Ask students if they think double dipping is a good thing or a bad thing. Why or why not? Take a vote and put the results up on the board of how many students think each. Here's a test to see who is right, those that don't necessarily see eye-to-eye with the idea that double-dipping is no big deal and those who don't think it's a problem. Leave it to your students armed with Petri dishes, chips, dip and an aversion to double-dipping your chip to uncover the truth.

Are you ready, then get set out to perform your own version of the Double-Dip Chip Challenge.

Objectives:

Students will:

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Discover that bacteria (and fungus) are everywhere and that they are usually too small to see unless they are grown in abundance.
- Describe what agar is and pour agar plates.
- Discuss the size of bacteria, give the definition of a colony and tell why they are able to grow to visible proportions in their new environment.
- Discover the presence of and diversity of bacteria around them.

Key Vocabulary.

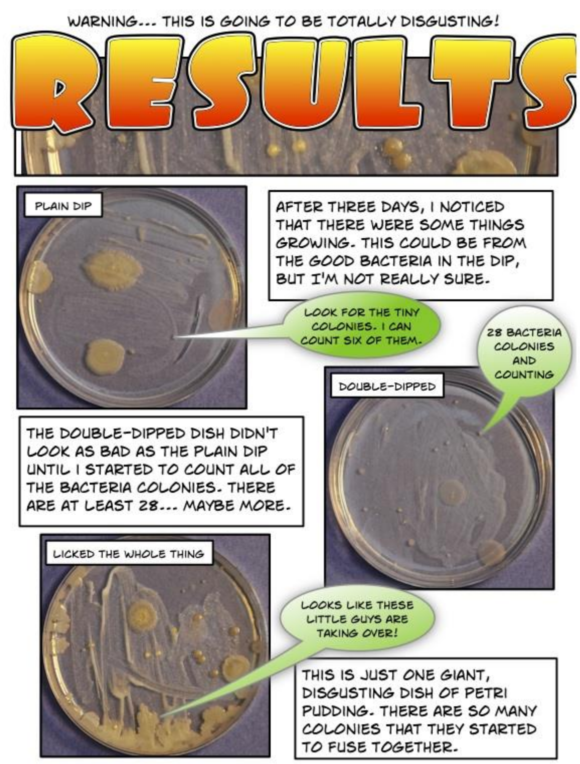
- Agar
- Petri Dish
- Bacteria
- Sample
- Sanitary
- Socially unacceptable
- Manners
- Swab
- Label
- Environment
- Test
- Conclusion
- Hypothesis
- Results
- Observations

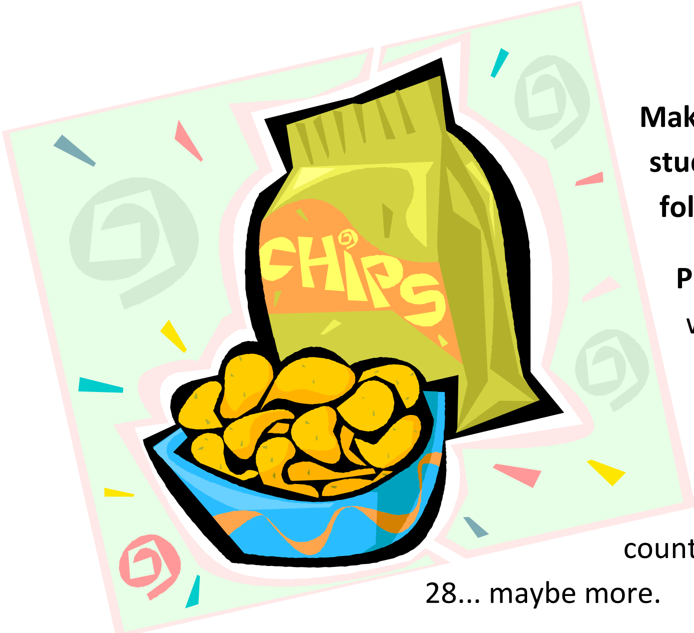
Materials

- Petri Dishes
- Nutrient Agar
- Cotton Swabs
- Potato Chips
- Dip
- Alternate Dips (salsa, etc)
- Bad Manners

1. Purchase a sixteen ounce carton of Ranch dip from the store.
2. Purchase a bag of potato chips.
3. Have students prepare three Petri dishes with nutrient agar. Allow the liquid to harden in the Petri dishes overnight. Keep the Petri dishes cover so that bacteria cannot get into the agar.
4. Divide the Ranch dip equally into three small clean sample bowls for each student.
5. Label the first bowl “plain dip.” Label the second bowl “DOUBLE-DIPPED.” Label the third bowl “LICKED THE WHOLE THING.”

6. Get a large chip and dip it into the “plain dip” sample. Only dip the chip once. this will be the "control."
7. Get a large chip and dip it into the “DOUBLE-DIPPED” bowl and put the chip into their mouth. Bite it in half. Then dip the chip again into the bowl. They have successfully completed the double-dip.
8. Pick up the third bowl labeled “LICKED THE WHOLE THING” and have students do what the label says - lick the whole thing! Students will poke their tongue into every nook and cranny of the bowl. Do lots of licking until you are totally grossed out.
9. Use a clean cotton swab to swab a sample of the “plain dip.” Smear this onto the first Petri dish and label it “plain dip.” (IF you have limited Petri dishes students can either do this activity in groups or divide one large Petri dish into three numbered sections with a marker on the bottom)
10. Use a clean cotton swab to swab a sample of the “DOUBLE-DIPPED” dip. Smear this onto the first Petri dish and label it “DOUBLE-DIPPED.”
11. Use a clean cotton swab to swab a sample of the “LICKED THE WHOLE THING” dip. Smear this onto the first Petri dish and label it “LICKED THE WHOLE THING.”
12. Place the Petri dishes in a place that is between 75oF - 80oF for two days. Watch for the bacteria to grow.
13. Compare the amount bacteria that has grown on each of the samples.





Make Observations: What is happening to your students Petri dishes…Do theirs match the following?

Plain Dip - After three days, I noticed that there were some things growing. this could be from the good bacteria in the dip, but I'm not really sure.

Double-Dipped - the double-dipped dish didn't look as bad as the plain dip until I started to count all of the bacteria colonies. there are at least 28... maybe more.

Licked the Whole Thing - this is just one giant, disgusting dish of Petri pudding. there are so many colonies that they started to fuse together.

How does it work?

The hypothesis was easy to prove - my double-dipped bowl of dip had less bacteria than the "whole mouth" bowl. But I was surprised to see how much bacteria was really in the double-dipped bowl. if you think about it, the chip just touches your mouth for a split second before you plunge back in and get some more dip.

I was really surprised to find how much bacteria there was in the "plain dip" Petri dish. when I read more about bacteria in food, I discovered that there is a lot of good bacteria in food. I wonder if there would have been as much bacteria if I would have used salsa instead of a sour cream kind of dip?

double-dipping your chip is not a good idea. some people would say it's not that big of a deal, but my tests show that the bacteria from my mouth still grew... and it's gross!

Additional Information: Food science students at Clemson University examined the effects of double-dipping using volunteers, wheat crackers and several sample dips. They found that three to six double dips in one bowl transferred about 10,000 bacteria from the eaters' mouths to the remaining dip. That means if you're at a party and three to six people double-dip their chips, any chip you dip may pick up at least 50 to 100 bacteria. The research was published earlier this year online in the Journal of Food Safety.

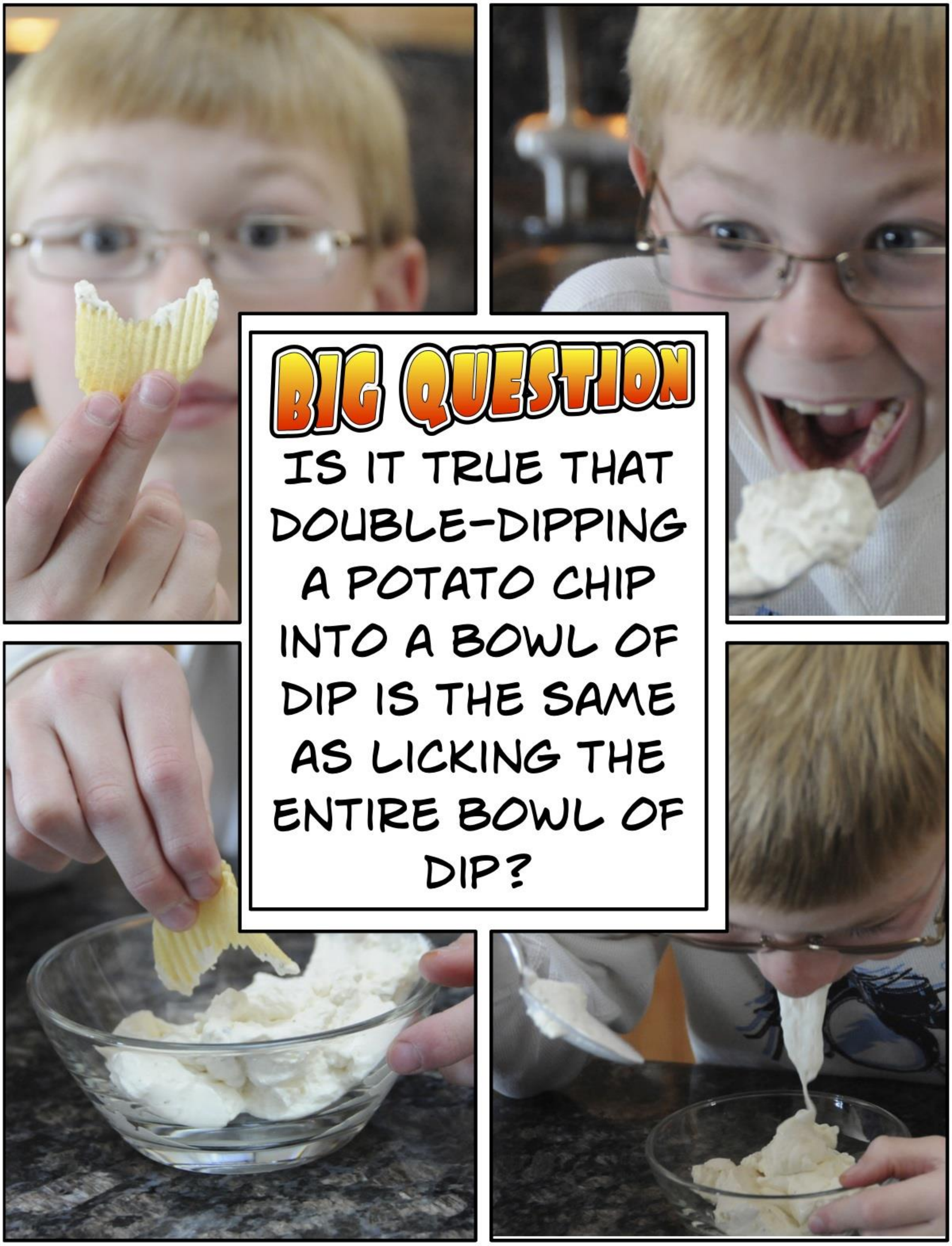
Additional Info

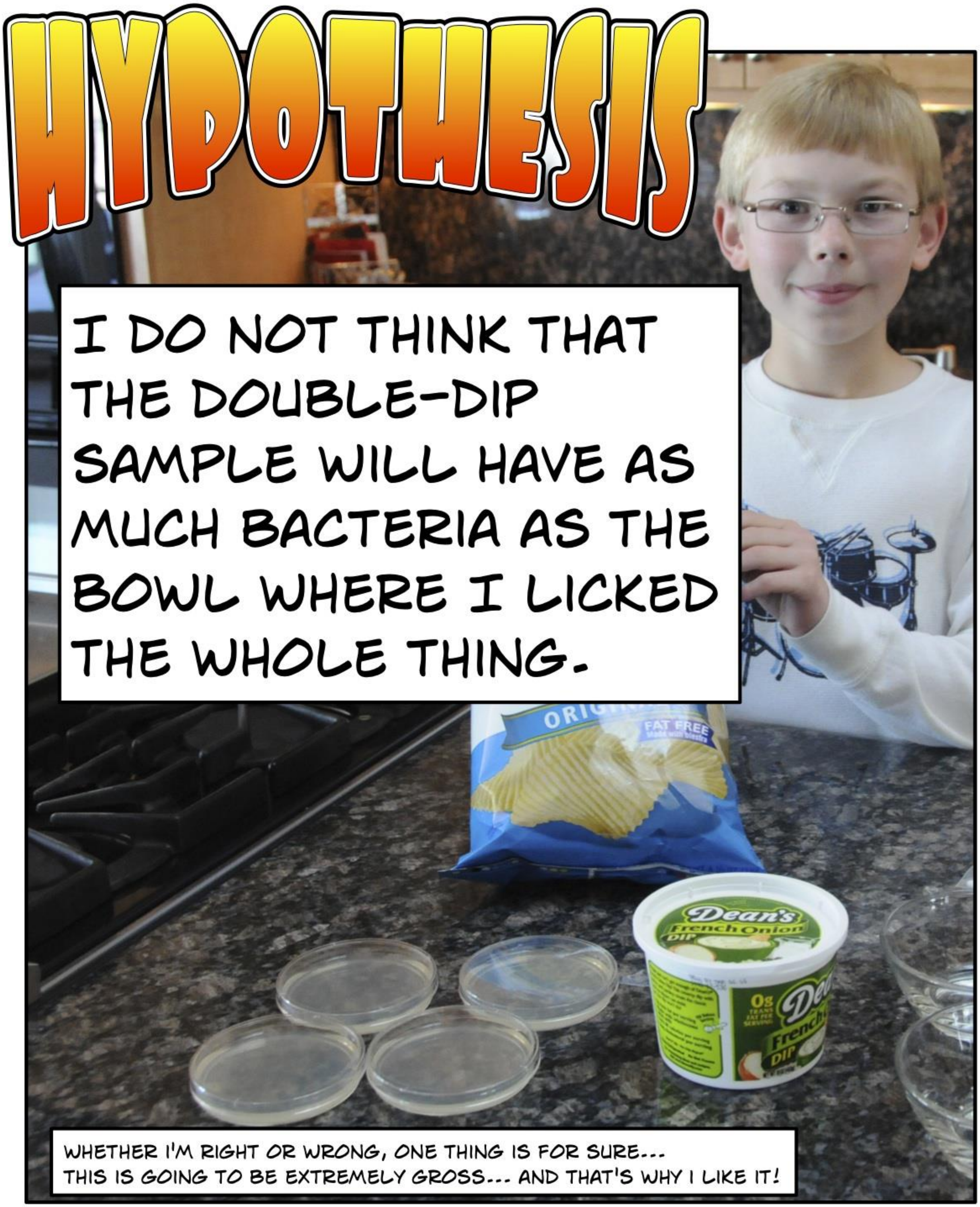
Jack used Comic Life to present his science fair project... see the following and see if your students reached the same conclusion as Jack Spangler.

Additional experiments to try: Would it work the same with a salsa style dip? What about a sweet dip such as a fruit dip with a higher sugar content? Have students come up with their own questions and test them out!

Student Assessment:

Have students record their observations and what they learned from the experiment in their science journals. Students write a conclusion in their science journals based on how their ideas about double dipping have changed after this experiment.


BIG QUESTION
IS IT TRUE THAT DOUBLE-DIPPING A POTATO CHIP INTO A BOWL OF DIP IS THE SAME AS LICKING THE ENTIRE BOWL OF DIP?


HYPOTHESIS
I DO NOT THINK THAT THE DOUBLE-DIP SAMPLE WILL HAVE AS MUCH BACTERIA AS THE BOWL WHERE I LICKED THE WHOLE THING.
FAT FREE
Dean's
French Onion
DIP
WHETHER I'M RIGHT OR WRONG, ONE THING IS FOR SURE...
THIS IS GOING TO BE EXTREMELY GROSS... AND THAT'S WHY I LIKE IT!

EXPERIMENTAL PROCEDURE

JACK SPANGLER

1. PURCHASE A SIXTEEN OUNCE CARTON OF RANCH DIP FROM THE STORE.

2. PURCHASE A BAG OF POTATO CHIPS.

3. PREPARE THREE PETRI DISHES WITH NUTRIENT AGAR (USING THE TECHNIQUE WE LEARNED IN THIRD GRADE). ALLOW THE LIQUID TO HARDEN IN THE PETRI DISHES OVERNIGHT. KEEP THE PETRI DISHES COVER SO THAT BACTERIA CANNOT GET INTO THE AGAR.

4. DIVIDE THE RANCH DIP EQUALLY INTO THREE CLEAN BOWLS.

5. LABEL THE FIRST BOWL "PLAIN DIP." LABEL THE SECOND BOWL "DOUBLE-DIPPED." LABEL THE THIRD BOWL "LICKED THE WHOLE THING."

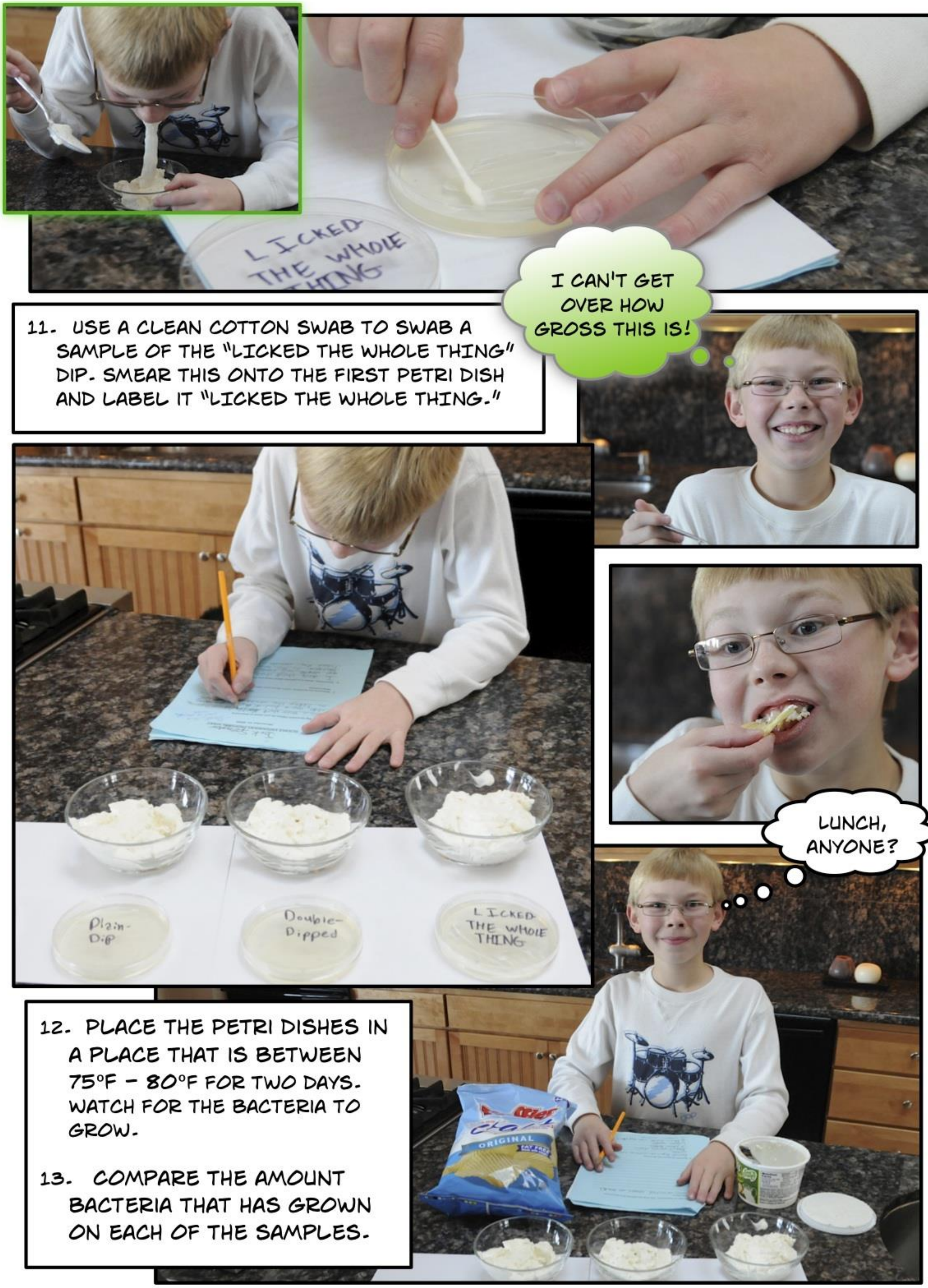
6. GET A LARGE CHIP AND DIP IT INTO THE "PLAIN DIP" BOWL. ONLY DIP THE CHIP ONCE. THIS WILL BE THE "CONTROL."

7. GET A LARGE CHIP AND DIP IT INTO THE "DOUBLE-DIPPED" BOWL AND PUT THE CHIP INTO MY MOUTH. BITE IT IN HALF. THEN DIP THE CHIP AGAIN INTO THE BOWL. I HAVE SUCCESSFULLY COMPLETED THE DOUBLE-DIP.

8. PICK UP THE THIRD BOWL LABELED "LICKED THE WHOLE THING" AND DO WHAT THE LABEL SAYS – LICK THE WHOLE THING! I WILL POKE MY TONGUE INTO EVERY NOOK AND CRANNY OF THE BOWL. DO LOTS OF LICKING UNTIL MY MOM IS TOTALLY GROSSED OUT.

9. USE A CLEAN COTTON SWAB TO SWAB A SAMPLE OF THE "PLAIN DIP." SMEAR THIS ONTO THE FIRST PETRI DISH AND LABEL IT "PLAIN DIP."

10. USE A CLEAN COTTON SWAB TO SWAB A SAMPLE OF THE "DOUBLE-DIPPED" DIP. SMEAR THIS ONTO THE FIRST PETRI DISH AND LABEL IT "DOUBLE-DIPPED."


LICKED THE WHOLE THING
11. USE A CLEAN COTTON SWAB TO SWAB A SAMPLE OF THE "LICKED THE WHOLE THING" DIP. SMEAR THIS ONTO THE FIRST PETRI DISH AND LABEL IT "LICKED THE WHOLE THING."
I CAN'T GET OVER HOW GROSS THIS IS!
Plain-Dip
Double-Dipped
LICKED THE WHOLE THING
LUNCH, ANYONE?
12. PLACE THE PETRI DISHES IN A PLACE THAT IS BETWEEN 75°F – 80°F FOR TWO DAYS. WATCH FOR THE BACTERIA TO GROW.
13. COMPARE THE AMOUNT BACTERIA THAT HAS GROWN ON EACH OF THE SAMPLES.
ORIGINAL

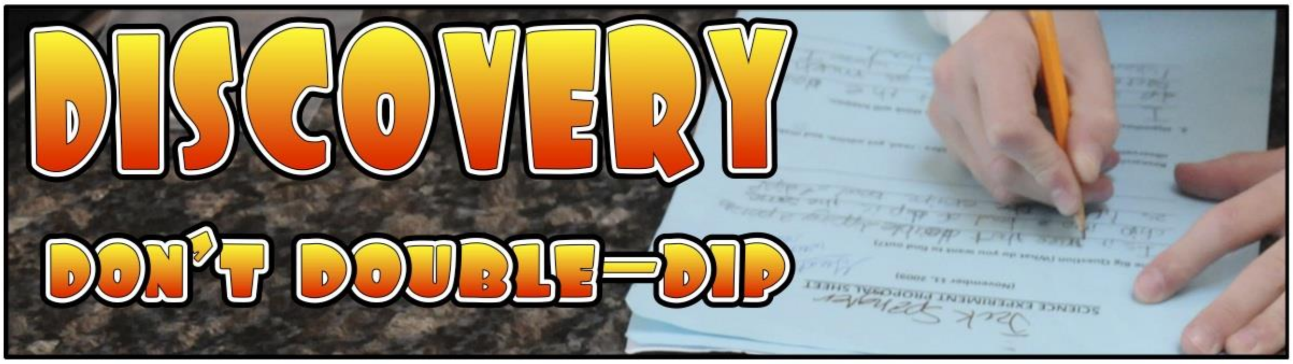
WARNING... THIS IS GOING TO BE TOTALLY DISGUSTING!

RESULTS

AFTER THREE DAYS, I NOTICED THAT THERE WERE SOME THINGS GROWING. THIS COULD BE FROM THE GOOD BACTERIA IN THE DIP, BUT I'M NOT REALLY SURE.

THE DOUBLE-DIPPED DISH DIDN'T LOOK AS BAD AS THE PLAIN DIP UNTIL I STARTED TO COUNT ALL OF THE BACTERIA COLONIES. THERE ARE AT LEAST 28... MAYBE MORE.

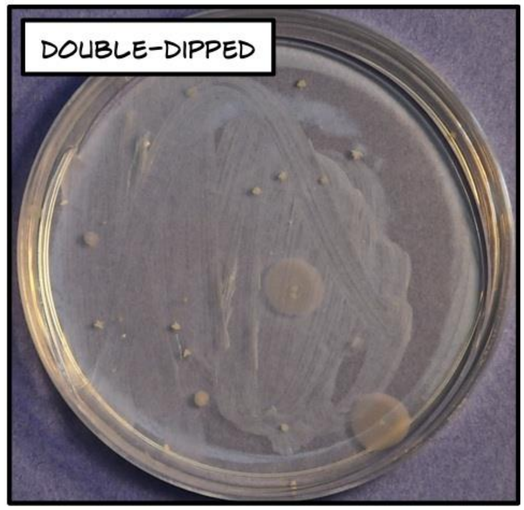
THIS IS JUST ONE GIANT, DISGUSTING DISH OF PETRI PUDDING. THERE ARE SO MANY COLONIES THAT THEY STARTED TO FUSE TOGETHER.

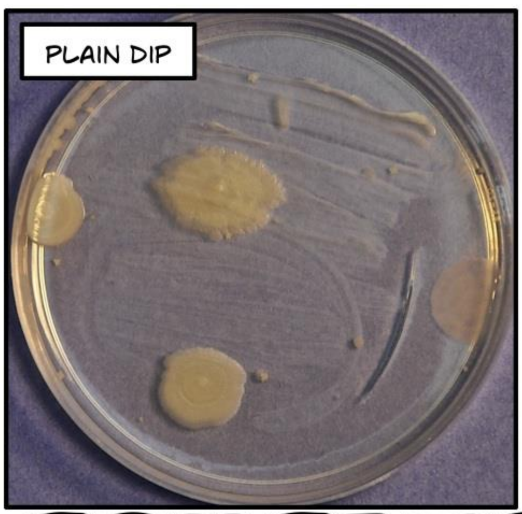


DISCOVERY

DON'T DOUBLE-DIP

THE HYPOTHESIS WAS EASY TO PROVE – MY DOUBLE-DIPPED BOWL OF DIP HAD LESS BACTERIA THAN THE "WHOLE MOUTH" BOWL. BUT I WAS SURPRISED TO SEE HOW MUCH BACTERIA WAS REALLY IN THE DOUBLE-DIPPED BOWL. IF YOU THINK ABOUT IT, THE CHIP JUST TOUCHES YOUR MOUTH FOR A SPLIT SECOND BEFORE YOU PLUNGE BACK IN AND GET SOME MORE DIP.





I WAS REALLY SURPRISED TO FIND HOW MUCH BACTERIA THERE WAS IN THE "PLAIN DIP" PETRI DISH. WHEN I READ MORE ABOUT BACTERIA IN FOOD, I DISCOVERED THAT THERE IS A LOT OF GOOD BACTERIA IN FOOD. I WONDER IF THERE WOULD HAVE BEEN AS MUCH BACTERIA IF I WOULD HAVE USED SALSA INSTEAD OF A SOUR CREAM KIND OF DIP?

CONCLUSION

DOUBLE-DIPPING YOUR CHIP IS NOT A GOOD IDEA. SOME PEOPLE WOULD SAY IT'S NOT THAT BIG OF A DEAL, BUT MY TESTS SHOW THAT THE BACTERIA FROM MY MOUTH STILL GREW... AND IT'S GROSS!

Experiment: Cotton Ball Catapult

F-tWaNg!! ThW-uMP!! The Cotton Ball Catapult leaps into action

"catapult (n) - ancient device used for hurling cats at the enemy. It was later replaced by the rockapult, a much more effective weapon."

But seriously, weapons that once smashed castle and fortress walls are now great lessons in how basic mechanical principles turned simple materials into very useful and effective tools.

Objectives

Students will:

- work in groups to build catapults out of everyday objects; and
- demonstrate their understanding of motion and forces by using the catapults to launch objects.

Key Terms:

- Force
- Motion
- Engineer
- Design
- Modify
- Inertia
- Newton's Laws
- Propel
- Acceleration
- Test
- Hypothesis
- Reference Point

Materials.

There can be many different designs. Cotton balls will be flying all over!

- cotton balls or marshmallows
- plastic spoon

- a ruler
- masking tape
- 2 rubber bands

Explain to students that catapults were often used as weapons of war during the middle ages. Show students some pictures of catapults and discuss how they work, making students understand catapult designs and uses.

Divide students into groups of five or less and give each group the supplies they need to make their catapults. Tell them they can build their catapults how they please, but they can only use the materials you have provided them. Give students time to draw, design, build, and test their catapults as well as name their team. Tell students that after building their catapults, they will compete to see whose catapult can fling a marshmallow the farthest and whose catapult can fling an object closest to a target.

Have students figure out their own designs. But the following are a few basics on catapult construction.

Teacher Background Information:

Stretch a rubber band. Place the ruler on top of it. Loop the two ends of the rubber band to the top of the ruler. Pass one end of the rubber band through the other. Hold the surplus with your finger. Stick the end of a tablespoon through the surplus rubber band. *(figure 5)* Adjust the spoon so that its length is approximately 1/2 way through the rubber band. Tape the ends of the ruler to your tabletop (or to a place mat so you can move it around). The catapult is now complete. **What Objects to Hurl:** Cotton balls, Q-tips, cut up sponge pieces.

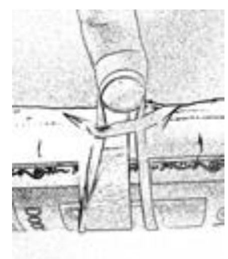


figure 4

How to Hurl Objects: Use three or more fingers. Press down quickly on the handle of the spoon. *(Tip: to hurl objects further, adjust the spoon so that the greater length is to the rounded end of the spoon.)*

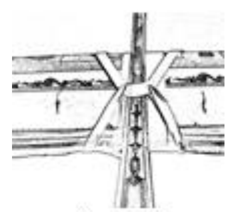


figure 5

Have students test out different variables and make predictions:

Example: They could try a regular cotton ball, a cotton ball with one piece of masking tape on it, a cotton ball covered with masking tape, and a cotton ball with two rubber bands, predicting that adding weight to a cotton ball would make it go farther. In one trial the regular cotton ball went 8 feet on the first try and 9 feet on the second. The cotton ball with one piece of masking tape went 8 and a half feet on the first try and 12 feet on the second. The cotton ball that was covered with masking tape went 18 and a half feet on the first try and 18 feet and 7 and a half inches. The cotton ball with two rubber bands went 10 feet 5 inches on the first try and 10 feet on the second.

What about using a longer spoon? Two spoons?

Games and Activities:

1. Place a bowl 6 to 12 inches away from the catapult. See how many cotton balls in a row you can shoot into the bowl.

2. Same as game one, except this time give each person ten cotton balls. Person who shoots the most into the bowl wins.

3. Make a tower using three rigatoni (log-style) noodles. See how many times it takes to knock down the tower.

(Variation: Launch half a dozen Q-tips at once.)

4. Lay a roll of masking tape its side. That's your target. Now each person flings a cotton ball toward the target. Closest wins a point. (If you make it in the center of the roll you win three points.) First person to ten points wins.

5. Use a marker to make red freckles on three cotton balls, and blue freckles on three others. Again lay the roll of masking tape its side. Your students shoots their three, and you shoot yours. Give a point to the three closest. For example–2 for red and 1 for blue. First person to reach ten points wins.

How Does that Work?

"catapult (n) - ancient device used for hurling cats at the enemy.

It was later replaced by the rockapult, a much more effective weapon."

But seriously -

All varieties of catapults rely on some mechanical scheme to store potential

energy, and then convert it suddenly to kinetic energy to throw a projectile. Energy is stored by pulling the lever back (or winding the ropes on a real catapult) A projectile is loaded, and the trigger releases the arm. The arm is designed in such a way that leverage converts the tremendous stored energy of the coil (or rubber band) into kinetic energy with great speed.

The real monsters of the siege engine world are trebuchets ("trench buckets"). The trebuchet is a long lever, with its fulcrum close to the bottom end. The arm is winched into place with pulleys, locked, and the bottom (counterweight) is loaded with rocks. At the top end of the long arm, the lighter projectile is loaded. This projectile can still be quite large (since the counterweight is tons of rock); common trebuchet loads included boulders, barrels of Greek fire (a primitive form of napalm), and dead livestock (ever seen "Monty Python & the Holy Grail"? Well, that part was for real. It was used to break a siege with disease, or fear of disease, which is often sufficient.). When the arm is released, leverage converts the force of the counterweight's fall into tremendous speed for

the load. Some good references about catapults include:"The Way Things Work", by David Macaulay, "Catapult - Harry & I Build a Siege Weapon", by Jim Paul, and there was also an article in Scientific American in 1979.

Extensions:

1. Wooden Catapult Kit: Weapons that once smashed castle and fortress walls are now great lessons in how basic mechanical principles turned simple materials into very useful and effective tools. The kits are based on historic designs: the Trebuchet is based on the Warwolf from the 13th century and the Catapult on ones used during the Middle Ages. The kits use only wood, rope and leather. Pieces are joined by wooden dowels, not screws or nails. No elastic, rubber, motor or batteries are used to create the movement of these devices swing arms. All pieces are pre-cut and drilled requiring only wood or white glue to assemble. The instructions are detailed and complete with educational notes about the siege engine. When completed, the Catapult stands 15 cm (6") tall x 13 cm (5") wide x 25 cm (10") long and can shoot a ball of soft modeling clay over 15 feet when properly tuned. The mighty Trebuchet is 66 cm (26") long x 46 cm (18") wide x 23 cm (9") tall - it is capable of hurling a ball of soft modeling clay over 6 meters (20 feet)! Ages 10 and up.

2. **What's included?**

3. (Modeling clay is included in the kits.) These kits are suitable for children 10 and older taking an hour or two to complete. Safety instructions are included and children are recommended to use under adult supervision. While these scale models will only be smashing down imaginary castle walls, they are loads of fun to build and use.

For Older Students: Can Students research and design a trebushet? See the following for an example.

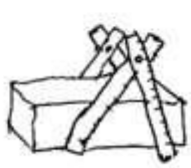
Have you ever wanted build your own trebuchet and fling cows onto unsuspecting Englishmen? Well now you can (assuming that your cows are the size of marbles). Here is how.

First off, you will need a few things:

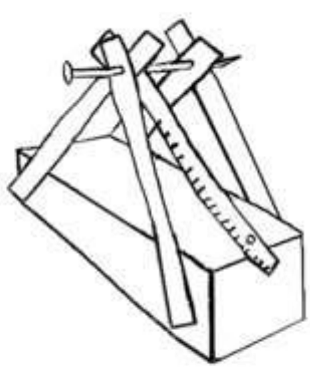
5 rulers with multiple holes in both ends (plastic or wood)
A large nail or bolt (must fit through holes in rulers)
Two very small nails
Some tape (duct tape works well)
Some string
A heavy keychain or something else which can work as a counterweight
A brick or block of wood.

Alright, lets get started!

Attach rulers to brick



Putting the brick or block of wood on its side (drawings do not show this), tape the four rulers to the brick as shown, so that the holes line up, in order to build the support structure. Figure out what angle the rulers should be calibrating them so that the holes on the rulers overlap, and you can line the third hole of your remaining ruler up with these holes while its bottom hole is slightly above the brick. Once its lined up right, tape the four rulers in place.

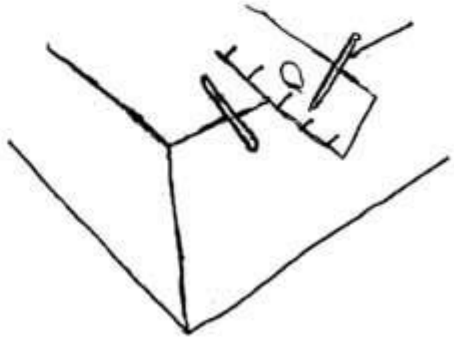


Creating the arm

Put a nail through the hole in the five rulers as shown. Like I said, the hole should be just above the brick.

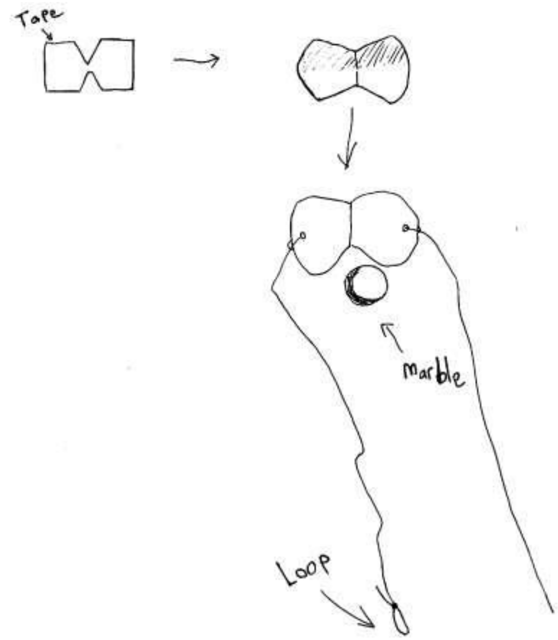
Create release mechanisms

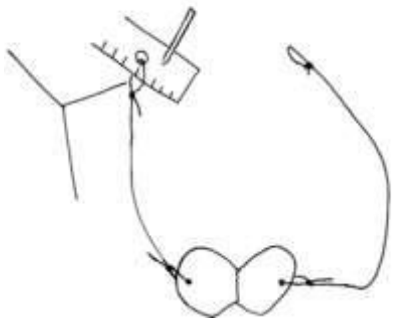
Tape the two little nails to the brick as shown.



Make sling

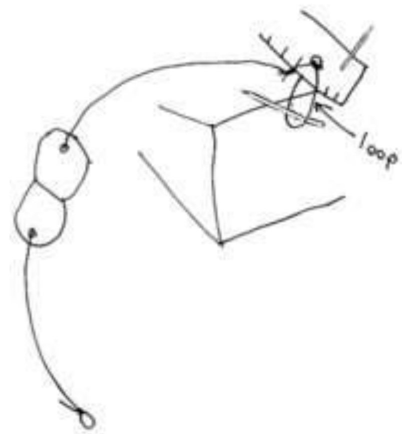
Make sling out of tape and string as shown. Test it out by seeing if you can throw a ball of tape with it.





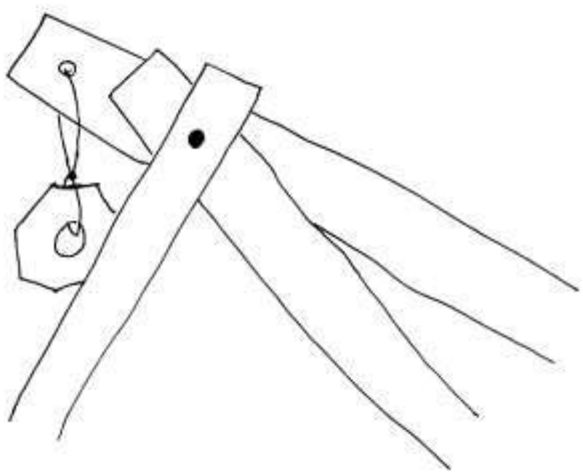
Tie sling to ruler

Tie the loose end of the sling to the ruler as shown.



Create loop

Create a loop of string going through the hole in the ruler. This loop should reach down to the nail and be able to hold the ruler in place.



Add counter weight

Attach the counterweight to the hole on the arm. Should be as heavy as possible, without messing up trebuchet.

Cock and fire!

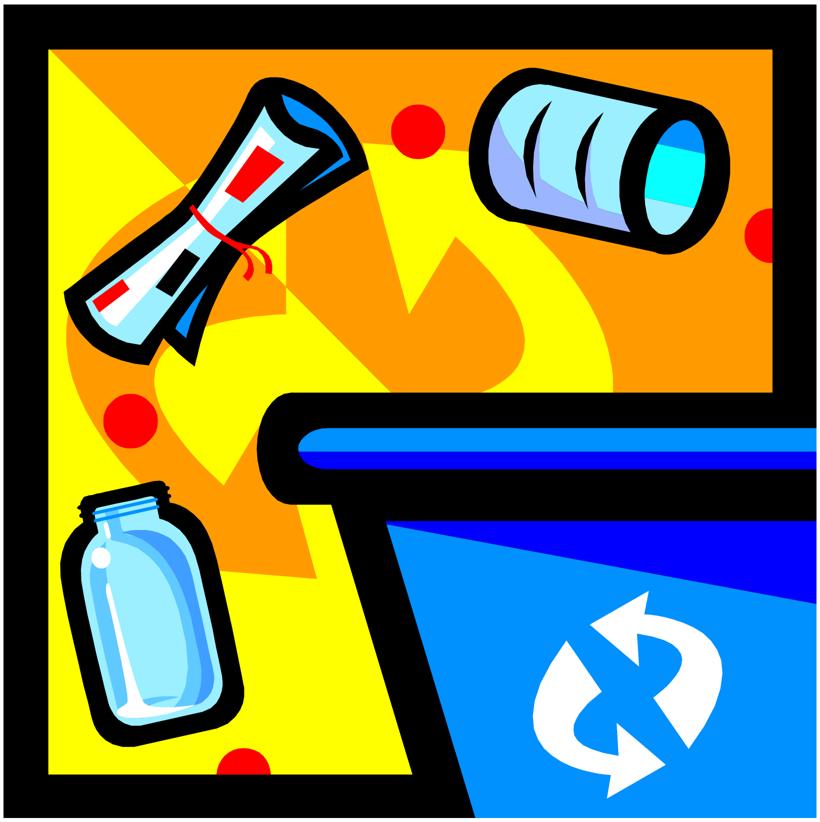
Hook lose end of sling to nail on ruler. Stuff sling under trebuchet, and release string to fire.

Student Assessment:

Students will answer the following questions in their science journals as well as write down their instructions on how to build an accurate long range catapult. What was your group attempting to achieve with its catapult design? How did the catapult set the marshmallow in motion? Which challenge did your catapult meet best, accuracy or distance? What could you have done to make the catapult better? What helped the catapult work as well as it did? What did this activity teach you about motion and forces?

Experiment: Recycling Paper

Students need some paper, but don't have any around. Just old scraps of newspaper. What can they do?



Objectives:

Students will:

- learn how to create their own recycled paper.
- have an appreciation of how companies create new, recycled paper from used paper.
- Discuss the various reasons for recycling

Key Terms:

- Recycle
- Reuse
- Trees
- Pulp
- Scraps
- Garbage
- Environment
- Variables
- Variation

Materials Needed

- 4-5 sheets of newspaper
- glass bowl
- hot water

- cornstarch
- measuring spoons
- aluminum foil
- wooden spoon
- scissors
- sharp pencil
- decorations for your paper, like construction paper scraps, dried flowers, confetti, or glitter

Instructions

Recycling paper is good for the environment. It cuts down on the amount of garbage you throw away and it means fewer trees have to be chopped down to make new paper.

To make your own recycled paper, you need to turn paper into pulp, and then back into new paper. Here's how to do it.

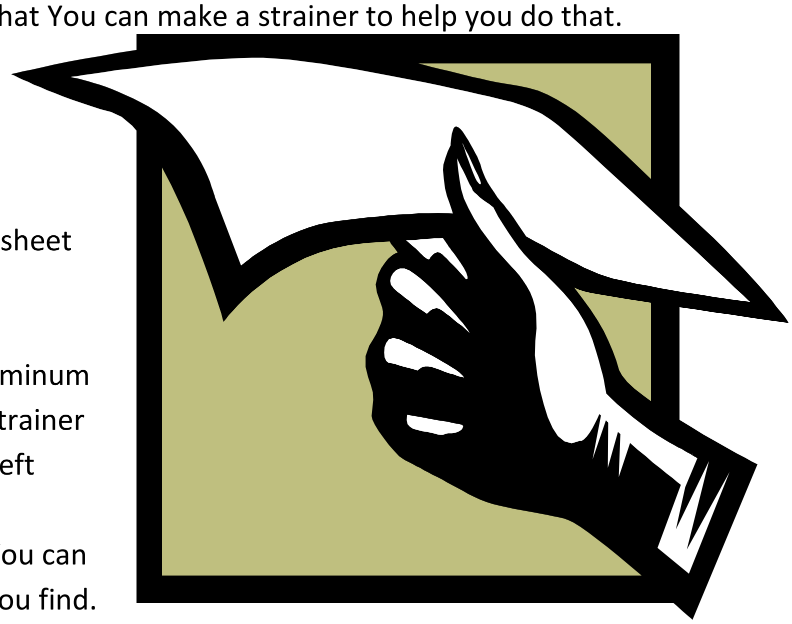
Start by cutting the newspaper into small pieces. About 4 or 5 sheets of newspaper will be enough to make two small pieces of recycled paper.

Put the newspaper scraps into bowl, cover them with hot water and mix it up until all of the paper is wet.

Let the paper sit for a few hours, until it's all mushy. Stir it occasionally. When it looks and feels like oatmeal, you're ready to make new paper.

Add a few tablespoons of cornstarch and a little more hot water. Mix it all up once more.

Now you have a pulpy, watery mess. Pulp is what you need to make paper, but you need to get rid of extra water first. How can you do it? What You can make a strainer to help you do that.



Take a piece of aluminum foil and fold into a square or rectangle about the size of the paper you want to make. Punch holes in the aluminum foil with a sharp pencil.

Now it's time to make the paper. Take a new sheet of aluminum foil and put it on top of extra newspapers.

Then, spoon some pulp on top. When the aluminum foil is covered with a layer of pulp, use your strainer to press out the extra water. The pulp that's left behind will become your new sheet of paper.

Add decorations to your paper, if you want. You can use dried flowers, confetti, or anything else you find.

Pinch together any holes in the paper. You're almost done!

Finally, put aluminum foil and books on top of your paper and press it flat. Then take off the books and the top layer of foil and leave it out overnight so that it can dry.
When it's done, peel the paper from the aluminum foil. You can leave the edges rough or trim them to look like a card you buy in the store

Have students experiment with different methods. Can they make their paper dry faster? Can they color it or make it smoother? How? Have them test their ideas.

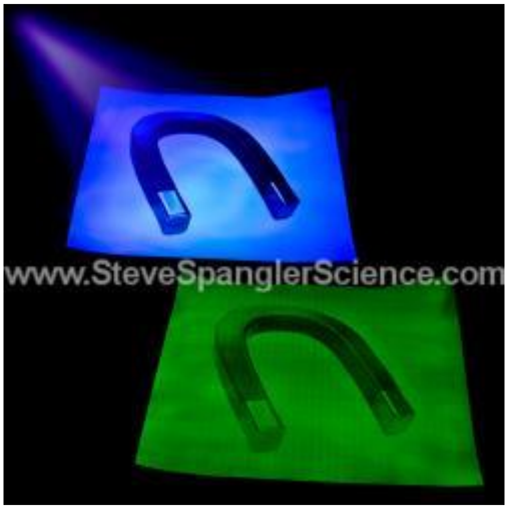
Tree-Free: Not all paper is made from wood. Discuss what other materials could be used to make paper, then test out the theory by trying it.

Ancient Paper: Develop hypothesis on the best ways to make your paper look older. Past ideas have included Mix up some regular, strong black tea and paint the paper with that --- it takes several applications.

Student Assessment:

Students will complete at least one sheet of recycled paper and write directions how to make it in their science journals.

Experiment: Glow in the Dark Paper



Our team of After Dark Scientists know that when the lights go off, the glow in the dark fun begins... and they couldn't stop experimenting with our Glow in the Dark paper. You won't believe your eyes as you write with light, freeze your shadow or even capture a picture with this sticky-back adhesive paper. In fact, even though we call it paper, these glow in the dark sheets are actually, high-quality, super-durable vinyl, that will stick to just about anything and stay there forever. Available in 15 sheet or 30 sheet packs or an all-inclusive activity kit, we'll even give you the mini black lights you need to "energize" your glow in the dark paper. Recommended for children ages 4 and up.

What's included?

Your choice of the following sizes

- 15-pack of Glow in the Dark paper, 2 Mini Black Lights
- 30-pack of Glow in the Dark paper, 2 Mini Black Lights
- 2-pack Activity Kit, 2 sheets of Glow in the Dark Paper, 1 Mini Black Light, 1 pre-printed transparency, 2 blank transparencies

How does it work?

The Glow in the Dark paper actually contains a thin layer of zinc sulfide, or Glow Powder. The zinc sulfide molecules are "energized" by light and let off a bright, green glow.

Experiment: The Science of Clean

Ever wondered if those cleaning products on the infomercials really work? Do stains really disappear like magic? The makers of OxiClean show how stains literally vanish when the "power of oxygen" is used to safely remove the most stubborn of stains. So, what is the secret behind those little white crystals?

Objective:

Students will:

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Compare products and test their claims against their actual effectiveness

Key Terms:

- Oxidation
- Bleach/Bleaching Agent
- Detergent
- Bio-degradable
- Environmentally safe
- By-products
- Stains
- Organic Stains
- Test
- Variable
- Hypothesis
- Results
- Observations

Materials

- OxiClean® powder
- Warm water
- Mixing bowl
- White washcloths
- Stain makers - grape juice, colored drinks, condiments, soy sauce
- Iodine - This featured experiment uses iodine as the stain

The OxiClean® science demonstration presented by Steve Spangler on television (9News) was a version that Steve originally created for the product manufacturers in 1997 as part of a program called the Science of Clean. In Steve's version, the two colorless liquids were mixed together and after a few seconds, the colorless liquid turned jet black! Steve accomplished this by using the classic Landolt Clock Reaction to produce an iodine solution. Iodine was selected as the stain since it shows up well on television and produces a very visual stain on the washcloth.

It's important to remember that this science demonstration was developed specifically to show the amazing oxidation power of OxiClean® (the active ingredient in OxiClean is sodium percarbonate). Sodium percarbonate (C2H6Na4O12) is a great detergent and bleaching agent based on the chemistry of hydrogen peroxide bound with sodium carbonate molecules. Hydrogen peroxide is a strong oxidizing substance which will "bleach" the stains away. Sodium percarbonate is excellent for cleaning and removing organic stains such as coffee, tea, wine, fruit juices, foods, sauces, grass and blood from fabrics and common surfaces made out of porcelain, ceramics, wood and many more. As a cleaning product, OxiClean® is favorable because it's environmentally safe, biodegradable, and leaves no harmful by-products.

Have students come up with additional tests and/or do some of the following

OxiClean Science Experiment Ideas

- Stain ten white washcloths with common materials found around the house such as coffee, tea, soy sauce, grape juice, cranberry juice, soda, wine... you name it... and test the bleaching power of OxiClean on each cloth.
- Isolate a particular stain such as coffee and test the cleaning power of several different products that all claim to use the bleaching power of oxygen!
- Select a stain such as cranberry juice to stain five different carpet samples (found at your local carpet store). Test the stain removing action of OxiClean (or any other product) on those five carpet samples. Is there a type of carpet where the stain is permanent?
- Select one stain, such as grape juice, and test to see if the temperature of the water affects the cleaning action of a selected product.
- Set up a science experiment to test the manufacturer's claims. Does a TIDE® cleaning stick really do a good job of removing ink stains? Does OxiClean® remove red juice stains from a carpet?

Remind Students: The key in any good science experiment is to select one variable to test and to make certain that everything else stays the same. Changing the type of stain *and* the temperature of the water may produce false results since two variables were changed at the same time.

OxiClean® is a registered trademark of OrangeGlo International.

Experiment: Oil Absorbing Polymers

Just imagine if the solution to an oil spill was this simple: Sprinkle a small amount of a non-toxic powder onto the layer of oil and in seconds the powder bonds to the oil, forming a sponge-like material that can be easily removed from the surface of the water. It's more than just a dream... a new form of superabsorbent polymer technology is changing the way environmental scientists approach oil spill and waste management problems. The results are amazing!

Objectives;

Students Will:

- be able to conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy
- Explain how different inventions and technologies impact people and the environment.
- Use the scientific method to determine the limits of and variables that affect the absorbing properties of oil absorbing polymers
- Evaluate an invention that solves a problem and determine the pros and cons of the design as well as applications of it.
- Discuss how the unintended consequences of new technologies can impact society.
- Explore technologies that advance health and contribute to improvements in our daily lives.
- Infer that human activities may be helpful or harmful to the environment.

Key Terms

- Hypothesis
- Test
- Environment
- Oil Spil
- Crude Oil
- Chemical
- Polymer
- Superabsorbent
- Environment
- Environmental Impact
- Invention
- Inventor
- Ocean
- Petroleum
- Trade Secret
- Bonds/Bonding
- Encapsulate

- Absorb
- Contamination
- Pollution
- Hydrophobic
- Hydrophilic
- Formulated
- Encapsulate
- Float
- Density

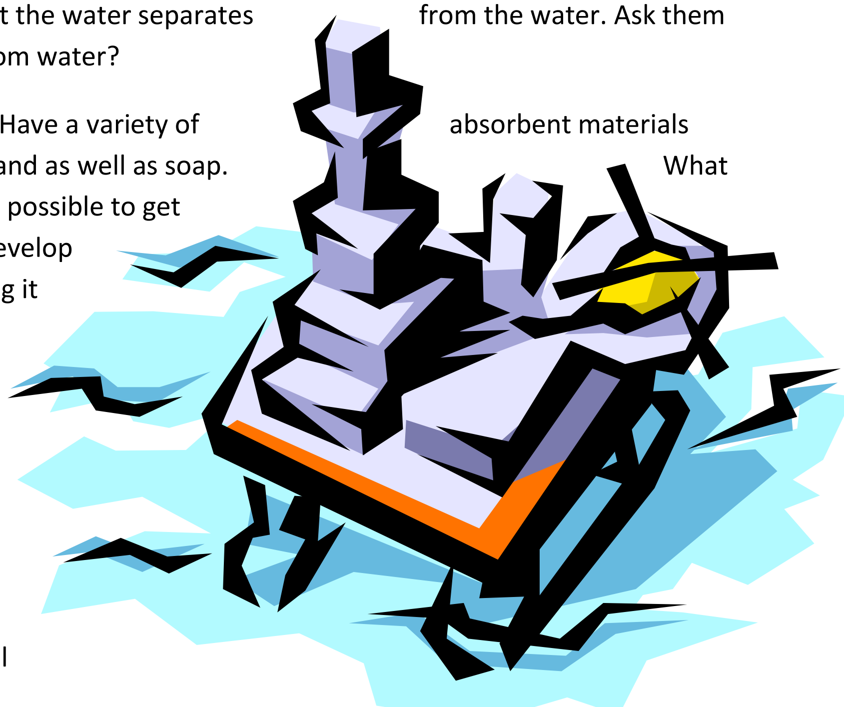
Materials:

- Enviro-Bond 403 Polymer
- Plastic bin
- sand
- motor oil
- hydraulic oil
- vegetable oil
- lamp oil
- jars or beakers
- graduated cylinders
- paper towels
- plastic gloves
- safety goggles

Getting Started:

Make an "oil spill" for students in a plastic bin on water (with a sand base (salt if necessary) and "beach" if possible. Show the students the way that the water separates from the water. Ask them if they remember why the oil separates from water?

What can we use to try to get the oil out? Have a variety of absorbent materials such as sponges, Qtips, paper towels on hand as well as soap. What worked best? Ask students if they think its possible to get the oil out with their hands? Have them develop hypothesis on the best method for cleaning it up and test those methods.



Could there be an easier way?

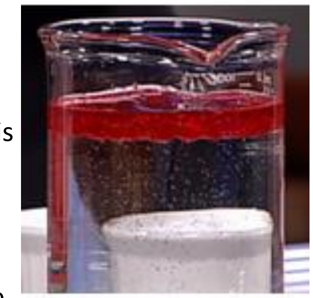
Could someone invent something to "soak up" the **oil**? How might this invention work?

Take the oil absorbing polymer and sprinkle it into the beaker, on top of the oil

Have students watch what happens and now try to remove the oil (and polymer) from the water with their hands. Ask the students what happened? Were they able to remove the oil and polymer now with your hands? Is this an easier way to clean up an oil spill?

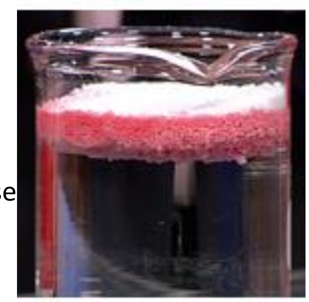
How does it work?

Sprinkle a small amount of this polymer onto the layer of oil and in seconds the polymer bonds to the oil, forming a sponge-like material that can be easily removed from the jar of water. This polymer is specially formulated to bond quickly and safely to many types of liquid hydrocarbons including crude oil, diesel fuel and gasoline. The bonding is so complete that it literally encapsulates the liquid hydrocarbons in just seconds.



The chemical formulation of the polymer is carefully regarded as a trade secret and is under application for patent. However, the inventor agreed to share some limited information about the polymer for educational purposes. The hydrocarbon source (crude oil, diesel fuel, gasoline, etc.) consists of three basic components: Paraffinics, naptinics, and the aromatics. The polymer is specifically formulated to bond to these components. The mechanism is three dimensional with cross-link bonding, and the polymer structures are referred to as die block, triblock, branched, radial, and liner, according to the manufacturer.

When the polymer comes in contact with a liquid hydrocarbon, the free hydrocarbons bond to the polymer forming a solid mass. The hydrophobic properties of the polymer cause it to float on water, but the density of the polymer is great enough to allow it to sink through the hydrocarbon and maximize the bonding potential. There is no need for mixing since the polymer bonds to the free hydrocarbons automatically.



Enviro-Bond 403 Polymer is also used in treating oily sludge, effectively filtering oil drilling fluids, and stabilizing any other spilled or leaked liquid hydrocarbons that pose a threat to the environment.

Have students think of additional hypothesis and tests, example:

Hypothesis: Oil-Absorbing Polymer will absorb all kinds of liquid oil

1. Have students put on their rubber gloves, safety glasses and apron.
2. Prepare two samples of a mixture of motor oil and water and two samples of Hydraulic oil and water (continue with the other kinds of oil you have available). Use the same amounts of water and oil in each of the four samples. Note that the oils and water do not mix since oil is not soluble in water.

3. Label one of each of the samples as a control. Label the other s as motor oil plus water and hydraulic oil plus water.
4. Have students put their controls aside. Add the same amount of the polymer to each of the oil plus water samples as directed on the package.
5. Observe the reactions and record their results.
6. Compare the samples treated with the polymer with the controls.
7. Record the results.

Have students think of other places this technology could be used besides in large oil spills and design a way it could be used effectively.

- What about as filler in oil absorbing mats in auto mechanic garages
- In kitchens for spills.
- To filter oily sludge or oil drilling fluids by making the liquid oil into a solid that can be filtered out. This can allow managers and clean-up crew to get the oil out of the ocean or the water before it seeps into the soil, gets on the sand or covers the rocks.

Additional Info

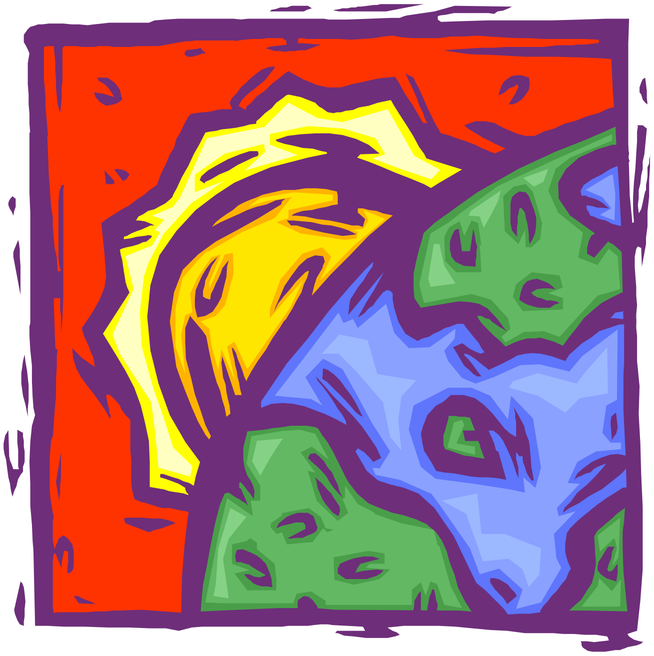
Oil is a major source of ground water contamination and ocean pollution. The vast majority of this oil enters the ocean from oil spills on ships that transport petroleum or from manufacturing operations on land. However, oil can also seep into the ocean naturally from cracks in the sea floor. Oil well and oil tanker accidents at sea account for a small portion of ocean oil pollution. Yet, the lasting effects of these accidental spills can be disastrous.

A personal note from Steve Spangler...

Enviro-Bond 403 Oil Polymer was the invention of a great person in Michigan by the name of Larry Thompson. I first met Larry while researching other kinds of superabsorbent polymers in 1992. I often share the inspirational story of how Larry invented this polymer during my teacher workshops and keynote speeches. Larry was truly passionate about his discoveries and did everything possible to encourage children to better understand the world of chemistry.

Larry Thompson passed away in March of 2004 from a rapid spreading cancer in his liver and pancreas. Up until the last few days of his life, Larry was sending emails and talking with people on the phone about the benefits of his oil absorbing polymers. I recently spoke at the National Honors Society national convention in Florida. After the presentation, a ninth grade girl came up to me and said, "I don't think that I'll ever be as good a scientist as that man who invented the oil polymer, but I can only hope that I make a discovery that helps the world as much as his did.•" I shared this with Larry in our last email correspondence. He will be greatly missed.
-- Steve Spangler

Energy



Experiment: Solar Bag

A Solar Bag is a long plastic bag made from a very thin plastic and colored black to absorb solar energy. The heated air inside the bag provides buoyancy and causes the bag to float. Over the years, it's become a very popular science demo for teachers to share with their students as they explore the properties of air.

Although the Solar Bag looks similar to a regular, black trash bag, the key difference is the thickness of the plastic. But, a great science fair experiment might be testing bags of different thicknesses to see which one floats the highest!

Objectives:

Students will:

- Observe that when air is heated it becomes less dense and rises
- Hypothesize that when air cools it becomes more dense and sinks
- Understand that molecules move more quickly as they receive energy and are heated up
- be able to conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy.
- Explain how different inventions and technologies impact people and the environment.
- Use the scientific method to determine the limits of and variables that affect the solar bag
- Evaluate an invention, determine the pros and cons of the design as well as applications of it.
- Discuss how the unintended consequences of new technologies can impact society.
- Infer that human activities may be helpful or harmful to the environment.

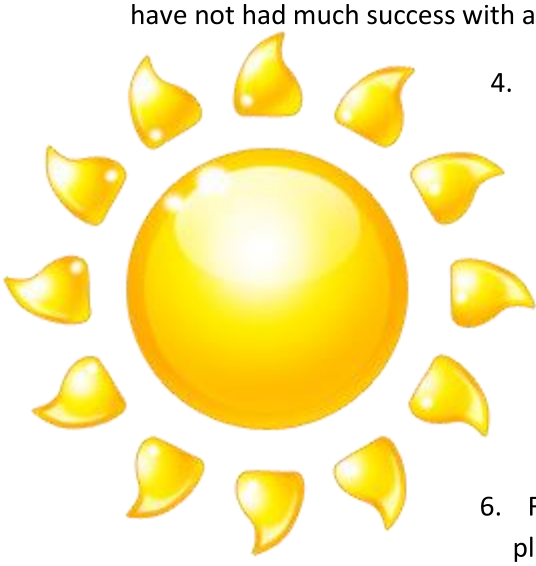
Key Terms:

- Hypothesis
- Observation
- Trial
- Results
- Density
- Heat
- Molecules
- Movement
- Absorption of Energy
- Rise
- Fall
- Solar
- Energy

Materials:

- Solar Bag
- String
- Large Black Trashbags

1. Notice that the bag is made out of a light weight plastic material. Use caution when handling the bag since the plastic will tear easily.
2. Carefully remove the plastic bag from the packaging and locate one of the open ends of the bag. Tie a knot in this end of the bag.
3. The best time for a launch is in the morning when the temperature of the air outside is cool. We have not had much success with a launch attempt in the middle of a hot day.



4. Select an appropriate location for the launch. Find a park or an open field clear of any buildings, trees, and power lines to conduct the launch. Select a day to do the experiment when it's sunny and free of any wind.
5. Unroll the Solar Bag onto a soft surface like grass. Avoid pavement or gravel since the plastic material can easily tear. Have one person hold the bag open as you begin to run around and scoop up air. Believe it or not, you can inflate the bag in just a couple of minutes.
6. Fill the bag with air until approximately 2 feet of deflated plastic remains in your hand. Slide your hand along the plastic to

make sure that the air in the inflated portion of the bag is stretching the plastic tight. Tie a knot in the end of the bag, and tether it to the ground with Solar Bag String.

How does it work?

The remainder of the work is done by the sun. Gather around the giant bag but try not to touch it - sharp fingernails will easily puncture the very thin plastic. Be careful, the outside of the bag also gets very hot to the touch. What is happening to the gas molecules inside the bag? Of course, as the sun warms the air molecules in the bag, their movement begin to speed up. Since the heated air inside the bag is less dense than the cooler air on the outside of the bag, the Solar Bag will float. It's important to remember that it may take as long as ten minutes for the air inside to heat up enough to cause the bag to float.

Testing it Further

Have students hypothesize whether or not a long black trash bag filled with air would work as well as the Solar Bag. Test it.

Is the black color necessary for absorption of solar energy? Will a long white bag work as well? Or another color? Test their theories.

Further Applications:

Discuss with the students what could the solar bags be used for besides teaching about energy and molecules? How would they use it?

Here’s how space scientists put it to use!

scientists from Pioneer Astronautics and Jet Propulsion Laboratory conducted successful tests of its Mars solar balloon inflation system using the Solar Bag. These photos give you a bird's eye view of what a Solar Bag looks like at about 120,000 feet above the Earth! While you can purchase a Solar Bag, you'll need a few million dollars worth of gadgets to get the bag to float 120,000 feet above the Earth.

Scientists have yearned for many years to make use of Mars' thin carbon dioxide atmosphere to enable airborne exploration. Balloon carried instruments would return an amazing bird's eye view of Mars that you could not get through satellites orbiting or surface exploring. However as attractive as such a mission might be, Mars balloon missions have long been stalled by the challenge of inflating a balloon, very long distance, from a descending Mars entry capsule.

Now scientists are working on using solar Bags that would inflate on the way down and heat up due to the sun’s energy. On a recent test mission…they worked perfectly! Now, if only we could use them for air travel on Earth!

Additional Info

Storage and Repair

We store the deflated bag in an old pillow case, which helps prevent accidental punctures or tears when it's not being used. If a small tear is spotted, clear packing tape can be used to repair the damage.

Student Assessment:

Experiment: Radiometer

A radiometer is a large glass bulb or sphere with a mast running up the middle. Four diamond-shaped "sails" balance near the top. As the sunlight hits these flags, they begin to turn. In bright sunlight, they really spin fast! It's an amazing experiment in solar science and the nature of light!

Objectives:

Students will

- observe the particle nature of light
- Discover the relationship behind light, heat, and air pressure
- Understand that molecules move more quickly as they receive energy and are heated up
- Conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy.

Key Terms:

- Vacuum
- Absorb
- Reflect
- Pressure
- Air
- Molecules
- Temperature
- Rise
- Fall

Materials:

- Radiometer
- Shade
- Sunshine

How does it work?

The glass bulb of the radiometer is sealed so that a tiny bit of air is trapped inside. This partial vacuum allows the flags to turn freely, without too much drag. Notice that the flags have one shiny side, and one black side. When the light hits the flags, it is reflected off the shiny sides, but absorbed by the black sides, which raises their temperature. When the black sides of flags heat up, the air near them also heats and the excited air molecules exert a tiny bit of pressure on the flags from one side. This small difference in pressure is enough to make the sails spin!

What does it teach?

Discover the relationship behind light, heat, and air pressure. Learn about the particle nature of light. When the photons strike the surface of the radiometer, they transfer their energy in the form of heat, and the sails spin.

Student Assessment:

Experiment: Solar S'mores

You don't need to build a campfire for your kids to get their fill of gooey marshmallow-and-chocolate s'mores this season. Just tap into the sun, the fuel source that people around the world use to power solar ovens. Here's an easy pizza box model that will let you catch enough backyard rays to cook the coolest s'mores on the block.

Objectives

Students will:

- Observe that when light energy is absorbed by objects it is changed to heat energy.
- Determine dark-colored objects absorb more light and store more heat from sunlight.
- determine the best components to use for and best design for a solar box cooker.
- design and build a box cooker, and test it out to see if it works well enough to make S’mores!

Key Terms:

- Radiant Energy
- Solar energy
- Absorb
- Reflect
- Temperature
- Thermometer

Explain to the students that there is no atmosphere on the Moon, so temperatures fluctuate through a wide range. In the shadowed areas the temperature is –180 oC (or – 300 oF), and in the sunlit areas it is about 100 oC (or 212 oF), which is the boiling point for water! These are serious extremes for human beings! Since there is no atmosphere and thus no clouds on the Moon, there are no cloudy days! During the daytime, it is always sunny! So why not take advantage of all that sunshine, and put the Sun to work? Ask the students to come up with some ideas of how they could use **solar** energy to do some work for them.

Do we use the sun's energy to help us in our lives? Have a discussion about "cooking" outside. Encourage students to think about how we melt marshmallows over a bonfire, heat a hot dog on a stick over a fire, sear and cook the inside of a hamburger on a grill. Then think about what makes the melting, warming, and cooking happen in all of these situations – heat. If we were going to cook outside but couldn't use any kind of fire, what could we use for a heat source? Tell students today we'll build an oven that uses energy from the Sun to cook food. Let's make S'mores!

Show the students three potential set ups and have to discuss among themselves which materials seem to make a better solar cooker1.

- A plain cardboard box, covered with clear plastic sheets
- A cardboard box with black construction paper on the bottom
- A cardboard box made with the following directions

Have students list the materials they want to use, decide upon a design, draw it and then build it using the following materials. Now that the students have their **solar** oven students should Students should record the temperature on the thermometer before placing it in the box.• Students should place a S'more and the thermometer in the box and close the clear plastic lid.• Place the box in direct sunlight (they may have to tilt the box so that there are no shadows inside). If it is a cloudy day, use the goose neck lamp with the 100W . Students should record the temperature on the thermometer every 30 seconds for 10 minutes. At the end of 10 minutes, ask them to report out around the room. Whose cooker got to the highest temperature? Whose cooker melted the marsh mellows and the chocolate?

Discuss the pros and cons of each design with the students.

Have students work in groups to build several of the most effective model of solar ovens.

MATERIALS:

- Large pizza box
- Pencil and ruler
- Craft knife

- Aluminum foil
- Scissors
- Glue stick
- Thermometer
- Black construction paper
- Clear packing tape
- Clear plastic (we used 2 sheet protectors, available at office supply stores)
- Graham crackers, chocolate bars, and marshmallows
- Stick or dowel

Time needed: About 1 to 2 Hours

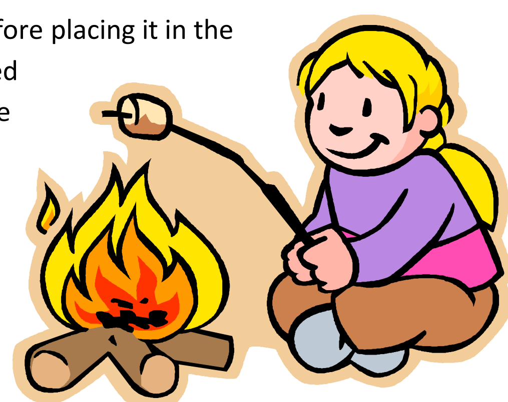
1. On the top of the pizza box, draw a square that is an inch smaller than the lid all the way around. Use the craft knife (adults only) to cut through the cardboard along three sides, as shown, and then fold the cardboard up along the uncut line to form a flap.

2. Glue aluminum foil, shiny side out, to the bottom of the flap, keeping it as wrinkle-free as you can.

3. Glue another piece of foil to the inside bottom of the box, then tape black construction paper on top of the foil.

4. Tape clear plastic to the underside of the lid to seal the opening created by the flap. For the best results, the seal should be as airtight as possible.

5. Students should record the temperature on the thermometer before placing it in the box. Place your oven outdoors in direct sunlight with the flap opened toward the sun. For each s'more, center two graham crackers on the construction paper. Top one with chocolate and the other with a marshmallow. Close the box and then use a stick or dowel to prop the flap open at the angle that reflects the most sunlight into the box (check it periodically to adjust the angle).



6. Within an hour (or sooner if it's a really hot day), the chocolate squares and marshmallows should melt enough to assemble into s'mores.

What's Happening: If you've learned about the greenhouse effect, you may have already guessed how the oven works. The foil flap gathers sunlight and reflects it through the plastic and into the oven, doubling the amount of incoming light. The black paper absorbs the light and converts it to heat, and the clear plastic allows the sun to shine in while keeping all that heat from escaping. (In the greenhouse effect, atmospheric gases allow sunlight to pass through to the earth's surface but keep the heat it generates from escaping back into space.) As more light hits the black paper, more heat is created and trapped. After an hour or so on a sunny day, the oven can be as hot as 275 degrees -- hot enough to melt chocolate and marshmallows.

Student Assessment:

Students will be able to make a diagram of an effective solar oven in their science journals, label the diagram, and explain the role of solar energy and the role each part of the oven plays. Students will record the optimal temperature the oven must reach in order to melt the chocolate and marshmallows.

Experiments: Solar Power!

Materials:

- Sunscreen
- Solar Powered Vehicles

Objectives:

Students will:

- Learn that solar energy is a renewable energy source, and its utilization has numerous benefits for our environment.
- Enumerate the pros and cons of using solar energy as a power source
- Determine that the angle at which a solar cell is positioned in relation to the sun affects its power output.
- Determine the effectiveness of a variety of levels of sunscreen to block the sun's rays

Key terms:

- Solar Power
- Sunlight
- Shade
- Sunscreen
- Energy
- Variable
- Hypothesis
- Results
- Observations

Super Solar Racing Car

This tiny racing car packs a big punch! Watch this little wonder zoom around and you'll hardly believe that he is powered completely by the sun. No tools are required for kids to put together this easy-to-assemble racer. Then, watch their excitement when the car is placed in the sun and zooms away. Now, put the car in the shade and it's like pressing down on the brakes. This Super Solar Racing Car is sure to provide endless hours of entertainment and education about solar power. Recommended for children ages 10 and up.

What's included?

- 11 Pieces needed to build the Super Solar Racing Car

What does it teach?

This super speedy racer teaches all about solar power and allows children to build their fine motor skills putting it together. Teach your students about the importance of sunscreen by rubbing a little on the car… will it still race in the sun? Cover the cell halfway or completely with a variety of different materials, how does it affect it. The possibilities are endless for learning about solar power with the Super Solar Racing Car.

Sunhopper—Solar Grasshopper

This wiggling, jiggling, critter is sure to be the hit of any solar science unit! The Frightened Grasshopper requires no tools to put together and no batteries… he runs by the power of the sun. Kids will love snapping the pieces together to make their own insect creation. Once assembled, just take the Grasshopper outside and watch as he dances his own unmistakable dance, even his antennae sway in the sunlight. The pint-sized Frightened Grasshopper will delight children young and old! Recommended for children ages 10 and up.

What's included?

- 7 Pieces needed to build the Frightened Grasshopper

What does it teach?

Children will build their fine motor skills putting this sun-loving grasshopper together. Then, take the creature out into the sun to learn all about solar energy. Put the Frightened Grasshopper in the sun and watch him wiggle and dance. If you put him in the shade will he still move? How about if he has sunscreen on his back? Explore the endless opportunities of learning about solar power with the RobotiKits Frightened Grasshopper.

Discussion Ideas:

Ask students to discuss what they already know about fuel efficiency in cars. Pose the following questions:

- Which types of cars are the most fuel efficient and why?

- What factors might contribute to a desire for increased fuel efficiency in cars?
- How fuel-efficient are cars today compared to 50 years ago?
- The reasons why we might see changes in the way cars are powered.
- The changes that will occur in car technology in order to accommodate changing attitudes toward fuel efficiency and energy sources.
- What types of alternative energy sources are being developed for future cars? How do these energy sources power the car? What are the advantages and disadvantages of each type of energy source? Which energy sources seem most likely to be commonly used in cars of the future?
- What environmental, political, and cultural factors might contribute to a desire for cars with higher fuel efficiency or cars that use alternative energy sources?
- What factors might detract from creating cars with higher fuel efficiency or cars that use alternative energy sources?

Student Assessment:

Students will record in their science journals what they learned from their experiments and their opinions of the pros and cons of using solar power as an energy source.

Experiment: UV Beads

Materials:

- UV Beads
- Cooking fats
- Olive Oils
- Sun glasses
- Black Light
- Zipper Lock Bags
- Sunscreens (a variety of strengths)
- Cloth, Hats, etc

Objectives:

Students will:

- Understand how solar radiation can be harmful and to recognize preventative measures that can be taken to reduce the risks associated with exposure to sunlight.
- Conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy.
- Understand the meanings of SPF levels and their degree of effectiveness
- Determine effective ways to test the levels of solar energy they are exposed to.

Key terms:

- Solar Energy
- Sunscreen
- UV Rays/UV Energy/UV Radiation
- Ultraviolet Light
- Sunlight
- SPF (Sun Protection Factor)
- Sensitive
- Light

Show students some UV beads and allow them to play with them. Have them take them outside and watch what happens? What happened? Have students form hypotheses and test them to determine what is making the beads turn from white to colored and back again. Guide them towards a discussion of sunlight.

Continue and have students use the Beads to try these experiment ideas, forming hypotheses, recording data, and reaching conclusions.

Experiment: Sun Screen Test -- With all of the SPF (Sun Protection Factor) numbers available, we want to know what SPF lotion really works best at keeping out the sun's harmful UV rays? Start by collecting various strengths of sunscreen (SPF 4, 15 and 50, for example as well as ancient kinds like olive oil and cooking fats). Since the UV Color-Changing Beads are very sensitive to changes in UV energy, you can use the beads to determine the blocking potential of the sunscreen. Place the beads in a zipper-lock bag and apply a layer of sunscreen to the outside of the bag. Use a permanent marker to write the SPF number of the sunscreen you're testing on the outside of the bag. Be sure to set-up one bag without any sunscreen coating for comparison purposes. Expose the beads to direct sunlight for 5 minutes and look for any changes in color.

#2 Tanning Oil Test: Find out if tanning oils block any UV rays when they claim to do so.

#3 Light Test -- Place a handful of UV beads near a fluorescent light. Do any of the beads change color? Can you get a sun burn or a tan by sitting next to a fluorescent light?

#4 Black Light -- "Black light" (long wave ultraviolet light) can also be used to change the color of the beads. You can purchase a black light at many specialty stores or hardware stores that have a large section of light bulbs. Sometimes those high intensity lights (mercury vapor) found in a gymnasium emit just enough UV light to make the beads barely change color.

#5 Cloudy Day -- Test to see if the beads change color on cloudy day. If they change color, then you can see why doctors warn people to wear sunscreen even on a cloudy day. Observe how well the beads change color when exposed to sun light at different times of the day. According to your data, what time of day does the sun give off its most intense UV light?

#6 Sunglasses -- Test the ability of your sunglasses to block out ultraviolet light by covering a few beads with the lens of your sunglasses. If the bead do not change color, your sunglasses block out harmful ultraviolet light from your eyes. If not, you paid too much for that UV coating!

#7 Windshield --Does the glass in your car shield you from UV radiation? Is the glass in the windshield the same as the glass on the side windows?

#8 Different Materials--Experiment which different types of materials, like paper, sandwich bags, cloth, clothing, hats, etc to see what blocks UV and what does not.

 # 9 Make a UV Bead Bracelet - Thread a few beads onto a piece of leather rawhide or string to make a bracelet. Remember to stay away from any door or windows where ultra-violet light could come into the room. When you're finished, cover the bracelet with your hand and walk outside into the sunlight. Don't take your eyes off the beads as you expose them to sunlight. Like magic the beads change from white to a rainbow of colors.

How does it work?

The UV Beads contain different pigments that change color when exposed to ultraviolet light from any source including the sun. The beads are all white in visible light. In UV light, depending on the pigment added to each bead, you will see different colors. Each bead will change color about 50,000 times before the pigment will no longer respond to UV light.

The term "light" is often used as a generic word to describe many different forms of light such as incandescent light, fluorescent light, or sunlight, for instance. However, not all light is made up of the same energy. Using Energy Beads, you will be able to uncover an invisible form of light energy called ultraviolet light. None of the energy in the ultraviolet region of the light spectrum is visible to the naked eye. Just as there are many different colors of wavelengths in the visible spectrum (red, yellow, green, blue...), so are there many wavelengths of ultraviolet light.

First, there is long wave ultraviolet light (300 to 400 nanometers), which most of us recognize as "black light" the light that is often used to make decorations glow in discos and theatrical productions. Long wave UV passes easily through plastic and glass.

Short wave ultraviolet light (100 to 300 nm) is used to kill bacteria, hasten chemical reactions (as a catalyst), and is also valuable in the identification of certain fluorescent minerals. Unlike long wave UV, the short wave UV cannot pass through ordinary glass nor most plastics. The shortest wavelengths cannot even travel very far through the air before being absorbed by oxygen molecules as they are converted into ozone.

UV Beads are the perfect tool for understanding how solar radiation can be harmful and to recognize preventative measures that can be taken to reduce the risks associated with exposure to sunlight. When you expose bare skin to sunlight, your skin will either burn or tan (which doctors warn is still not healthy for your body). UV radiation wavelengths are short enough to break chemical bonds in your skin tissue and with over prolonged exposure, your skin may wrinkle or skin cancer may appear. These responses by your skin are a signal that the cells under your skin are being assaulted by UV radiation.

The beads will always change color regardless of how good the sunscreen blocks UV - the beads are very sensitive! The key is to rate the color of the beads on a scale of 1-5, with 5 showing the most color or "burning" and 1 showing the least color. The bag without any sunscreen is an automatic "5". You can also test the difference between new and old sun screen. Sunscreen manufacturers suggest that you throw away old sun screen because it does not block out harmful UV light. Do your tests support this claim?

Possible Results (from other testers)... SPF 4 did not do well at all (got the worst rating of 5). SPF 15 did a little better with a rating of 3 (still not blocking the harmful UV rays very well). SPF 30 was the best blocker and received the best rating of 1. Our teachers also tested tanning oils (even cooking oil) and all of them did very little to block any UV (rating of 5 on our UV blocker scale). Shortening was rated a 5 and olive oil was rated a 4. SPF 4 doesn't do much at all, while 15 and 30 do about the same. The cooking fats didn't do much at all, which showed us that even though the shortening is thick and opaque, it sure doesn't block UV rays.

Additional Experiments (for after school):

If you are able, take the beads to a tanning parlor and expose them to the UV radiation from the tanning lamps. How does this UV radiation compare to the sun's UV?

If you take a trip into the mountains, take the beads along and see if there is any difference between colors at high altitudes and at sea level.

Student Assessment:

Students will write in their science journals an explanation in their own words how solar radiation can be harmful and will describe preventative measures that can be taken to reduce the risks associated with exposure to sunlight. Students will detail how they would use the UV beads to measure the amount of sunlight they are exposed to and the effectiveness of their protections.

Experiment: Prescription Protection

Don’t throw away your old prescription bottles. Solar science educator, Jim Stryder, recently shared a unique method of demonstrating the "power" of ultraviolet radiation (uv-rays) for K-12 students using our Color Changing UV Beads and a plastic prescription bottle.

Objectives:

Students will:

- Understand how solar radiation can be harmful and to recognize preventative measures that can be taken to reduce the risks to foods and drugs from exposure to sunlight.
- Conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy.
- Understand the purposes of protective plastics and their degree of effectiveness
- Determine effective ways to test the levels of solar energy medicines and foods are exposed to.

Key terms:

- Solar Energy
- Medicines
- Sunscreen
- UV Rays/UV Energy/UV Radiation
- Ultraviolet Light
- Sunlight
- SPF (Sun Protection Factor)
- Sensitive
- Light

Materials:

- Those brownish prescription bottles
- Color Changing UV Beads.
- Extensions: A variety of plastic containers

Solar science educator, Jim Stryder, recently shared a new activity using our Color Changing UV Beads and a plastic prescription bottle. Upon refilling a prescription at his local pharmacy, Jim noticed a marking on his brown prescription bottle that read – “UV BLOCKING PLASTIC”. Being the solar science enthusiast he is, Jim immediately filled an empty prescription bottle with Energy Beads. To his amazement, the bottle blocked out nearly 100% of the UV light! Come to find out that many drugs are sensitive to damaging UV light, so the bottle is specially designed to preserve the life of your prescription.

Jim Stryder suggests testing a variety of plastic bottles and transparent containers to see which ones block out the UV rays the best. Hmmm… this sounds like the making of a great new science fair project! Students can test by comparing various types of common products, like different plastic/glass bottles, even water bottles, because their "thickness" levels do vary with design and will show different levels of uv-exposures."

Consider this: What other products say they give UV protection to protect things you eat? Certain brands of milk say they make their containers yellow to protect against “harmful UV rays.” Do they really? Is it the color or the thickness of the plastic? Have students form a hypothesis and test it out!

Use all the various types and colors of medicine bottles you can find to test the different screening properties of the various bottles. Virtually nine out of ten students have never seen ultraviolet radiation (uv-rays) demonstrated this way! It's a sure bet to put a smile on your students' faces as they learn about ultraviolet rays.

How does it work?

UV Beads have a chemical substance embedded into the plastic that will change color when exposed to UV radiation (sunlight). The beads will remain white indoors as long as they are kept away from windows or doors where UV light can “leak” into the room. Many prescription bottles have a chemical embedded into the brownish plastic that blocks out almost 100% of the UV that might cause damage to the medicine. Using the UV Beads is a great way to test this out!

Student Assessment:

Students will detail in their science journals the results of their experiments and the conclusions they reached purpose for and effectiveness of a variety of plastic containers as well as the variables that are the most effective in blocking the UV rays.

Sunscreen/Tanning Lotions: A History

In the early 1930's, South Australian chemist, HA Milton Blake, experimented to produce a sunburn cream.

The founder of L'Oreal, chemist Eugene Schueller, invented the first sunscreen in 1936.

In 1944, Florida pharmacist, Benjamin Green invented a suntan cream in his kitchen that became "Coppertone Suntan Cream."

In 1980, Coppertone developed the first UVA/UVB sunscreen.

Invention of Sunscreen

While it's tempting to bask in the sun like a French fry under a heat lamp, it's not the best idea – sunburn significantly increases the risk of developing skin cancer.

The ancient Greeks used olive oil as a form of sunscreen, which (unfortunately for them) would have exacerbated the sun's harmful effects. In fact, it was not until the 1940s that an effective sunscreen was invented. Ancient humans desired to avoid sunburn and look attractive. For example, Egyptians considered light skin more beautiful than dark skin. Egypt's sun-drenched environment made it difficult to maintain light, luminous skin. Recently translated papyri scrolls and tomb walls reveal the ingredients of potions used to ward off sunburn and heal damaged skin.

Some of the ingredients used by the Egyptians are also used by modern scientists. For example, the Egyptians used rice bran extracts in some of their sunscreen formulas . Today, gamma oryzanol is extracted from rice bran because of its UV-absorbing properties. The Egyptians also used jasmine, recently shown to heal DNA at the cellular level in the skin, to mend skin damage.

During World War II, many soldiers suffered from serious sunburn, which inspired a pharmacist named Benjamin Greene to invent a solution. Greene concocted a sticky, red substance that he called "red vet pet" (red veterinary petrolatum), a new product so thick that it worked mainly by physically blocking the sun's rays. Greene tried the invention on his own scant hairline and found it to be reasonably effective.

Sunscreen established its roots during WWII when airman and future pharmacist Benjamin Green helped develop a sun protective formula for soldiers. In 1944, Green used his invention as the basis for Coppertone® Suntan Cream - the very first consumer sunscreen product. In fact, this mixture of cocoa butter and jasmine was concocted on his wife's stove and tested on his own bald head.

Sunscreen was first developed to help protect soldiers stationed in the South Pacific during World War II from obtaining severe sunburns.

Coppertone Sunscreen Lotion

A physician from Miami named Dr. Benjamin Green had been giving credit for inventing the United State's first sunscreen along with the help of the military. After the war, Green had taken an interest in the tourists of Miami. They had been using all sorts of different homemade concoctions to tan in the sun. Dr. Green had decided to come up with his own formula while testing the product on his own bald head. In 1944, he had developed a recipe for his Coppertone suntan cream that also contained the essence of jasmine. At the start of its career, Coppertone had a picture of an Indian chief with the slogan "Don't be a Paleface." They had later replaced him with Little Miss Coppertone in 1953.

Coppertone sunscreen lotion is often thought of as having the single purpose of protection from the sun. However, there are a handful of people who have discovered what you can use Coppertone for around the home. With this product, you can:

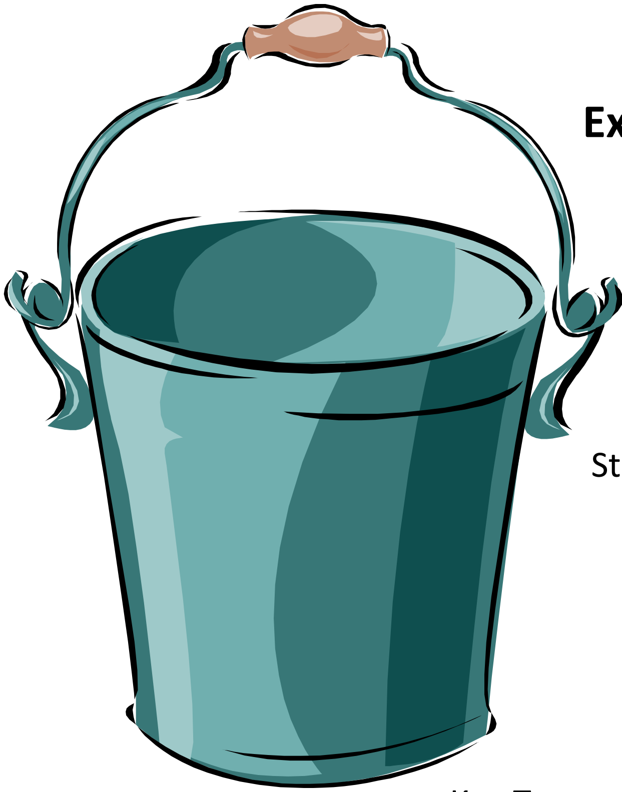
· Prevent chapped lips by replacing lip balm with Coppertone to keep lips moist and healthy.
· Prevent skin damage by using sunscreen whenever you have to be in the sun's rays for prolonged periods of time. Without sunscreen you are increasing the risk of developing cancerous lesions, discoloration, and wrinkling.

· Moisturize your hands by rubbing the sunscreen into the skin. The emollients will rejuvenate dry skin.
· Remove oil and grease from the skin by rubbing Coppertone into the skin and then washing with clean warm water.
· Repel Insects by rubbing Coppertone on to your skin to keep insects away.
· Relieve itching from insect bites by applying Coppertone over the affected area to alleviate the itch.
· Enjoy a massage by substituting massage oil with Coppertone.
· Take a soothing bath by replacing bath oil with two tablespoons of Coppertone to warm bath water.
· Clean grease and dirt by squirting the sunscreen on to a soft cloth and wiping the surfaces clean.
· Remove scuff marks from leather shoes by applying Coppertone to a soft cloth and rubbing gently over the leather.
· Remove tar spots from car finishes by applying Coppertone to a cloth and then rubbing until the tar is removed.
Modern sunscreens have come a long way since then. Formulas of sunscreen designed specifically for athletes, swimmers and children have been invented, and various SPF (Sun Protection Factor) levels are available. :

A: For children six months of age and older, we recommend sunscreens with an SPF 30 or higher. Babies under six months should be kept out of the sun. Adults of all skin types should use a sunscreen with an SPF of at least 15.

A: UVA rays penetrate deeply into the skin and contribute to premature skin aging and skin cancer. Our exposure to UVA is more constant than to UVB - we encounter UVA rays no matter what the season or time of day.

UVB rays are the main cause of sunburn, but they also contribute significantly to premature skin aging and skin cancer. High SPF sunscreen products (those with an SPF higher than 30) are designed primarily to absorb UVB plus the shorter UVA rays.



Experiment: High and Dry

Who can resist the temptation of swinging a pail of water over their head?

Objectives:

Students will:

- Understand the relationships between potential energy, kinetic energy, centrifugal force, gravity, and velocity.
- Conduct a science investigation in which they record, process, and interpret data.
- Make predictions and test their accuracy.

Key Terms:

- Newton's First Law of Motion
- Law of inertia
- Centripetal Force
- Gravity
- Tendency
- Constant
- Friction
- Circular

Materials:

- Bucket
- Water
- Spinning Platform
- Cups

What to Do:

Fill your bucket with water, it is probably best to start with a little rather than a lot.

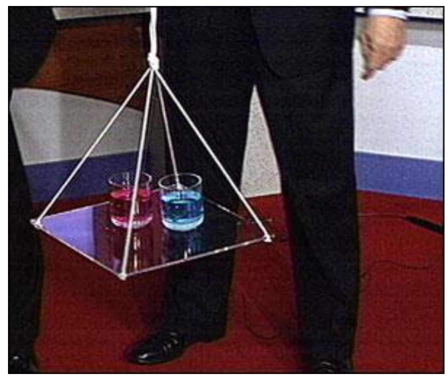
Stand so you can swing the bucket really easily, but make sure that there is no-one and nothing breakable in line with where you are about the swing the bucket (in case you let go or the handle breaks)

Swing the bucket back and forth with bigger and bigger swings.

When you think you will make it swing the bucket all the way over your head in a smooth motion.

Did the water fall out?

Alternate Version:



This demo is a slight modification of the classic swinging pail of water demo. The picture shows the construction of the "spinning platform." The base is made from a square piece of Plexiglass measuring approximately 12 inches. Drill holes in all four corners large enough to accommodate a piece of rope. Attach the ropes to each corner of the platform and join them together in a knot about 2 feet above the platform.

Now that all of the difficult work is finished, it's time to swing the tray and plastic cup (several plastic cups if you're feeling lucky) around in a complete circle without spilling the liquid or flinging the cup around the room. It's the tendency for the plastic cup and its contents to go in a straight line that allows it to seemingly defy gravity. The centripetal force provided by the tension in the cords is large enough to create enough friction to hold the plastic cup(s) in place.

Here's a little advice... practice swinging the tray around without the cups in order to get the feel of a smooth, circular motion. Then add the cup filled half full with water. The liquid adds mass to the cup and helps to keep the cups in place. Some demonstrators even glue a thin piece of rubber to the bottom of the cup to give it a little gripping power (okay, friction) to help the cups stay in place. Shhhh! That's a little secret between you and me.

How does it work? Here's the heavy-duty science for people who really care...

According to Newton's First Law of Motion, objects in motion tend to remain in motion unless acted upon by an external force. In this case, Newton's Law requires the water to continue moving along a tangent to the circle. Thus a force is required to keep it always turning toward the center of the circle, instead of flying out straight. Centripetal force is the force that makes something move in a circular path. According to the law of inertia, in the absence of forces, an object moves in a straight line at a constant speed. An outside force must act on an object to make it move in a curved path. When you whirl a stone around on a string, you must pull on the string to keep the stone from flying off in a straight line. The force the string applies to the object is the centripetal force. The word centripetal is from two Latin words meaning to seek the center.

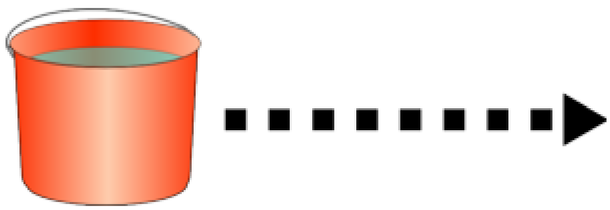
Centripetal force acts in other ways as well. For example, a speeding automobile tends to move in a straight line. Centripetal force must act on the car to make it travel around a curve. This force comes from the friction between the tires and the pavement. If the pavement is wet or icy, this frictional force is reduced. The car may then skid off the road because there is not enough centripetal force to keep it moving in a curved path.Or, another way of saying it… (http://www.thenakedscientists.com/HTML/content/kitchenscience/exp/inverted-bucket/)

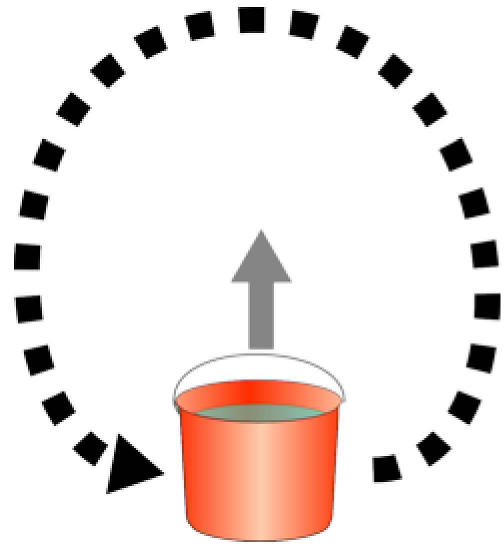
The experiment works due to some very fundamental physics worked out by Isaac Newton. If an object is not pushed by anything it will continue moving at a constant speed and direction, so to make it travel in a circle you have to push or pull it towards the centre of the circle. If you have ever played on a roundabout in a playground this is the force you have to provide my hanging on tight to avoid being thrown off.

This means that you are pulling the bucket downwards while it is over your head. If you are pulling the bucket downwards faster than the water is being pulled down by gravity, the water will get left behind towards the base of the bucket and so, stay inside and not fall out, keeping you nice and dry.

The natural state for an object is to go in a straight line at a constant speed.

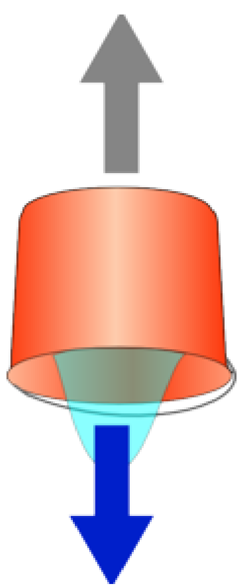
To make it go in a circle you have to pull it towards the centre with a centripetal force.

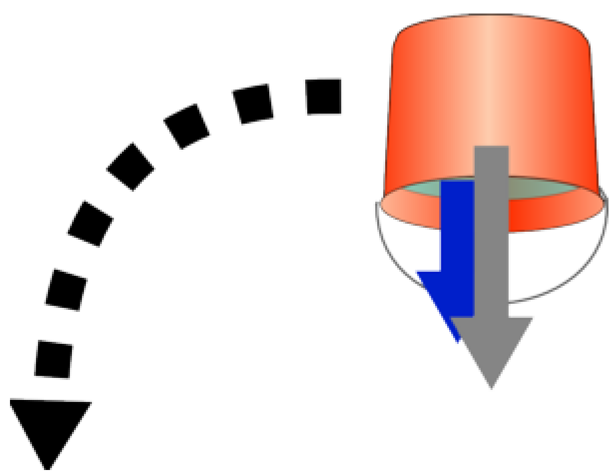




If you just turn a bucket of water upside down you are holding the bucket up, so the water is pulled out from it by gravity.

If it is going in a circle fast enough then you will be pulling the bucket down and around faster than gravity is pulling the water down so the water is left behind in the bucket and doesn't fall out.





A laboratory centrifuge © Magnus Manske

Centrifuges

This centripetal force which is needed to keep something going in a circle increases the faster you spin something, So if you build a machine called a centrifuge that spins incredibly fast the forces can be immense. Astronauts and fighter pilots are trained to be able cope with large accelerations in a centrifuge. They are also used to separate things of different density, as dense things will try harder to keep going in a straight line than less dense things, this means that you can separate red blood cells from plasma, or different isotopes of uranium.

Additional Info

Okay, the lawyers remind us to inform you that twirling, spinning or otherwise throwing cups of water around can be harmful to the walls, furniture, flooring and any living being with a 30 foot radius. It's best to perform this demo outdoors away from all civilization.

Experiment: Egg Drop Experiment

Objectives:

Students will be able to:

- identify Newton's 1st Law of Motion,
- identify and explain the forces that effect how objects move,
- understand that forces are either a push or a pull
- use Newton's First Law to explain the results of the experiments.
- put Newton's First Law into their own words and in scientific terms.
- apply Newton's 1st law in a variety of examples of motion.

Key Terms:

- Inertia
- Gravity
- Motion
- Energy
- Force
- Sir Isaac Newton
- Newton's First Law
- Friction
- Stationary
- Scientific Method

Lesson:

Once upon a time an apple fell from Sir Isaac Newton's tree, and ever since we've heard about Newton's Laws. But did you know that if you just look, you can see Newton's Laws in action everywhere around you? The Egg Drop is a classic science demonstration that illustrates Newton's Laws of Motion, namely inertia. The challenge sounds so simple... just get the egg into the glass of water, but there are a few obstacles. The egg is perched high above the water on a cardboard tube, and a pie plate sits between the tube and the water. Still think it's easy? Sir Isaac Newton does.

Newton's first law of motion: an object at rest will remain at rest unless acted on by a force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by a force. This law is often called, "the law of inertia".

Materials:

- Small ball to practice with, if desired
- Cardboard tube
- Pie pan
- Raw eggs
- Water
- A large drinking glass
- Oh, you might need a few paper towels

Warning: Always wash your hands well with soap and water after handling raw eggs. Some raw eggs contain salmonella bacteria that can make you really sick!

1. Fill the large drinking glass about three-quarters full with water and Invite a student up to be your assistant. Tell the students, Sir Isaac Newton said that an object will stay at rest, won't move at all, until some force acts upon it. We're going to hope that's true with this today. Now the object here is for you (the student) to get the egg in the glass. Have the student pick an egg. *(That's the one I would have picked! Perfect!)* How would they get it in the glass? Just drop it? No.

2. Tell the student if you just let them drop the egg into the glass then gravity would be the winner and we don't want to do that, it's too easy, so that's why the pie pan is here. So the pie pan is going to go in place. Center the pie pan on top of the glass. Place the student's egg in the pie pan and (demonstrate the motion) tell them that when they put their hand there and hit the pie pan they will transfer the energy from their hand, to the pie plate and it will go to the egg and . . .(*what do they think will happen?)* it will pop it up into the air and…well, we want it to go into the glass. So we're going to add in something else to make it even easier.

3. Place the cardboard tube on the plate, positioning it directly over the water. Have the student carefully set the egg (or practice ball) on top of the cardboard tube.

4. Demonstrate for your student, your hand is going to go here, and you'll pull back about this far, and then, you're going to hit the pan, straight in and smack the edge of the pie pan horizontally. Make sure you follow all the way through (tennis, anyone?). It's important that you use a pretty solid hit, so plan on chasing the plate and tube, but don't knock over the glass!
5. Ask the students what they think is going to happen. What will the pie pan do? What about the tube? Tell them, I'm thinking (hoping) the pie pan will knock the tube out of the way and the inertia of the egg (remember, it doesn't really want to move) is going to hold it there for just a second and bam! It will fall right in. Do they agree?
6. Have your student take their shot at the pie plate. Your astonished student and students will watch the egg plop nicely into the water. Clap! Science is so cool!

How does it work?

Credit for this one has to go to Sir Isaac Newton and his First Law of Motion. Who was Newton? Isaac Newton was one of the most famous scientists in the world. He studied many different types of science. He wrote one of the most important science books in history Philosophiæ Naturalis Principia Mathematica, which is Latin for Principals of Mathematics. Published in London, England in 1687 this book contained Newton's Laws of Motion. Newton observed how objects moved. He studied how forces like gravity changed the motion of an object. He found that forces change when the speed or mass of an object changes.

He said that since the egg is not moving while it sits on top of the tube, that's what it wants to do - not move. You applied enough force to the pie pan to cause it to zip out from under the cardboard tube (there's not much friction against the drinking glass). The edge of the pie pan hooked the bottom of the tube, which then sailed off with the pan. Basically, you knocked the support out from under the egg. For a brief nanosecond or two, the egg didn't move because it was already stationary (not moving). But then, as usual, the force of gravity took over and pulled the egg straight down toward the center of the Earth.

Also, according to Mr. Newton's First Law, once the egg was moving, it didn't want to stop. The container of water interrupted the egg's fall, providing a safe place for the egg to stop moving so you could recover it unbroken. The gravity-pushed egg caused the water to splash out. Did someone get wet?

Was it luck or was it skill?

Have students try testing longer tubes, more or less water, different liquids in the glass, different water containers, and heavier or lighter falling objects and multiple eggs at the same time. If one is good, how about five?

Where else can we find the law of inertia?

Have students determine how inertia relates to Newton's first law. Ask students for other examples of Newton's first law in their daily life.

Newton's laws are demonstrated when a goal is scored in soccer, a baseball hit with a bat, or a three point basket is made on the court. Examples of Newton's Laws are found in our machines, work, homes and sports.

Newton's Laws of Motion

Law 1 - An object at rest will remain at rest unless acted on by a force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by a force. This law is often called, "the law of inertia".

Law 2 - Acceleration is produced when a force acts on a mass. The greater the mass - of the object being accelerated - the greater the amount of force needed to accelerate the object. Force = Mass X Acceleration.

Law 3 - For every action there is an equal and opposite re-action.

Student Assessment:

Ask students to write and/or illustrate in their science journals what they did during this activity and what they learned from their participation in the activity.

Experiment: Strong Sand

How can sand be used to stop a speeding bullet? Grains of sand are miniature particles that flow through your fingertips with ease. Put them all together, however, and you'll see that these tiny particles are really quite powerful! Just take the “Strong Sand” challenge and you'll discover an amazing fact about the science of sand.

Objectives:

Students will:

- identify and explain the forces that effect how objects move
- understand that forces are either a push or a pull
- See how compacted materials are stronger than loosely packed materials

Key Terms:

- Sand
- Granules
- Force
- Push
- Compact
- Redistribute

Materials

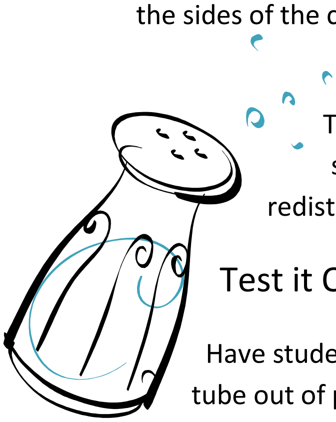
- Cardboard tube from a roll of paper towel
- Sand (salt can be used in place of sand)
- Sheet of tissue paper
- Rubber bands
- Scissors

- Stick - dowel rod approximately 1 foot in length or a drumstick works well

1. Cut a piece of tissue so that it measures approximately 8 inches square.
2. Cover one end of the cardboard tube with the tissue paper and hold it in place tightly with a rubber band.
3. Challenge someone to poke a hole in the piece of tissue paper using the stick. Hey, that's easy! Don't worry… let's try it again.
4. Replace the torn paper with a new piece of tissue paper. Fill the cardboard tube three quarters of the way full with sand. This makes for even a better challenge in the minds of many people because not only will be paper break but the sand will spill out everywhere! Have students form a hypothesis on what will happen when the volunteer pushes through the sand.
5. Instruct your volunteer to push the stick into the sand and keep pushing until the stick breaks through the tissue paper. What's the matter? This time it's not so easy to break through the paper. In fact, it's impossible! How did the tissue paper get to be so strong?

How does it work?

The secret is literally in the sand. As you push the stick into the sand, the granules of sand are pushed away from the stick in all directions. Contrary to what seems logical, the sand pushes against the sides of the cardboard tube instead of the entire force pushing downward against the tissue paper.



This demonstration is a good illustration of why seismic waves move slowly through sand. When the vibrations from seismic waves travel through sand, the sand redistributes the forward energy from the waves and pushes it out in all directions.

Test it Out:

Have students come up with different questions and factors to test. What if you made the tube out of paper? Would that affect it? What if you use salt instead of sand? Sand instead of salt, sugar, flour, even regular soil, or wet sand? Would you get the same results? What other factors can they test? Will a clear tube demonstrate the effect more clearly? What about another kind of paper?

Student Assessment:

- Students will draw labeled diagrams in their science journals illustrating identify and explaining the forces that effect how objects move, show how the force of the stick is a push and demonstrating how compacted materials (due to force) are stronger than loosely packed materials

Experiment: Bounce No Bounce

After you demonstrate have students come up with theories and test them out. Were they right? Guide them towards a discussion of potential and kinetic energy and what happens with both. What do they think is happening with the balls?

Objective:

Students will:

- Define potential and kinetic energy and use those terms in their discussion of the experiment;
- State Newton's Third Law of Motion and explain how it relates to the experiment;
- Understand and apply the Law of Conservation of Energy as it relates to a bouncing ball.

Key Terms:

- Newton's Third Law of Motion
- Potential Energy
- Elastic Potential Energy
- Kinetic Energy
- Absorb
- Transfer
- Conservation of Energy
- Bounce
- Rebound
- Rubber
- Deformation
- Polymer
- Compression
- Molecules
- Observations
- Hypothesis
- Test
- Results
- Characteristics
- Temperature
- Natural Rubber

Materials

•Bounce No Bounce Balls look and feel the same, but one bounces and the other one is completely dead!

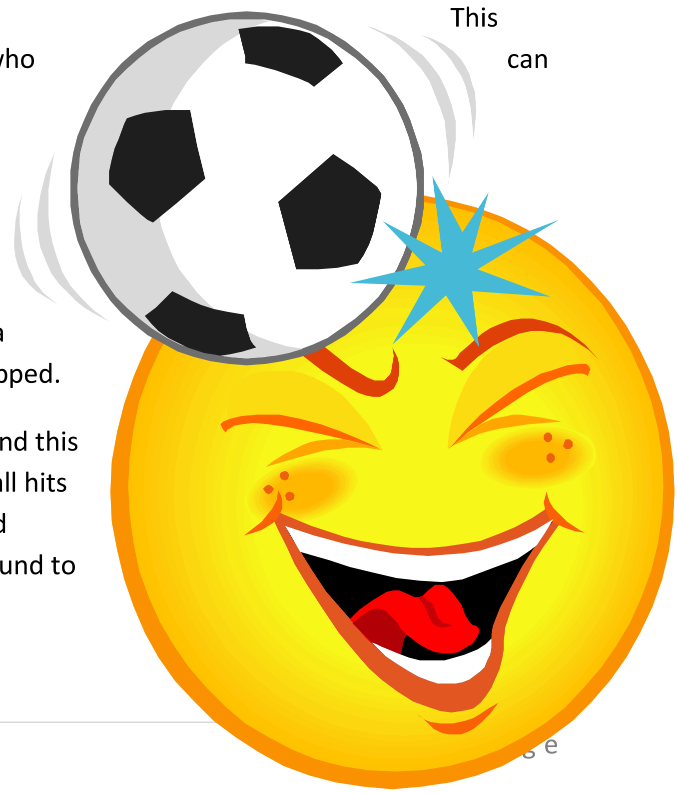
•Poppers can either be made using the instructions below or purchased from your local toy store.

Bounce No Bounce Balls

The black rubber balls look and feel identical in every way except in the way they bounce. One ball bounces like a super ball while the other ball is "dead•." Since the balls look and feel the same, it's easy to cleverly switch the "no bounce"• ball for the one that bounces which results in questions and laughter.

The secret is in the type of material used to make the balls. The ball that bounces is made out of a natural rubber that is highly resilient and very elastic - it's great for bouncing. The "no bounce•" ball is made out of a special type of rubber (usually butyl rubber) that absorbs the kinetic energy of the falling ball instead of changing it into potential energy. This "no bounce•" rubber was considered for use in making car bumpers less resilient in a crash. In running shoes, the superior shock-absorbing ability of the "no bounce"• rubber helps alleviate problems caused by the tremendous pounding suffered by feet, legs and ankles.

Racquet Ball Conserves Energy! This activity requires an adult one who is smart and one who can use sharp objects!



With a sharp knife or razor blade (caution!!!), slice a racquet ball into two halves. Trim each half so that it is slightly smaller than a hemisphere. Turn the he hemisphere inside-out and drop it, bulge-side-up, on a hard surface. The ball will snap and rebound to a height much greater than that from which it was dropped.

Work is required to turn the hemisphere inside-out and this work is stored as potential energy. As the dropped ball hits the hard surface, this potential energy is released and converted to kinetic energy, allowing the ball to rebound to a greater height.

If you don't want to ruin a perfectly good racquet ball use Poppers. They are colorful fun and give you the same effect!

Experiment Ideas:

Bounce and No Bounce Balls behave differently in a variety of situations. They roll down a ramp at different speeds, they emit sound waves at different decibels, and they bounce different heights on different surfaces. They can be compressed dissimilar amounts when the same force is applied and they are different densities, so they sink in different solutions at variable rates.

Allow students to play with the balls for a while and experiment with dropping and rolling the balls to allow them some time to compare and contrast the behavior of the balls and for creative ideas to occur, have students record the phenomenon they observe.

Then have students form hypotheses about the following and then perform the following experiments to see if they were correct in their hypotheses

- Drop each ball simultaneously from 12 inches off the ground. Which one bounces? Now drop the ball that bounces from 12 inches off the ground again. Observe how high the ball bounces each time. Does the height increase, decrease, or remain constant?
- Compare the height the bouncing ball reaches after dropping it from 12 inches, 24 inches, and 36 inches off the ground.
- Carefully throw the bouncing ball at the ground (not too hard, it could hurt someone or knock something over). Does it bounce higher than the height you released it at?
- Mark which ball is the bouncing ball and which one is not. Put both balls in a freezer for 10 minutes. Drop each from 12 inches off the ground. What happens? Does the bouncing ball still bounce?
- Race the balls down a slight incline. Which one wins the race?
- Try dropping the two balls on a soft chair or firm foam surface. Which ball now bounces the highest?

What's Happening:

A ball held in the air has the potential to move when released. This is called potential energy. When the ball is dropped, gravity pulls it towards the center of the earth. The energy of the moving ball is called kinetic energy. When the rubber ball's descent is stopped by the floor, it is slightly flattened as its particles squeeze together. (Imagine dropping a ball of soft clay on the ground. Would it remain a ball or would it spread out on the ground?) Some of the kinetic energy the ball had on the descent becomes elastic potential energy. What happens next is determined by the properties of the ball.

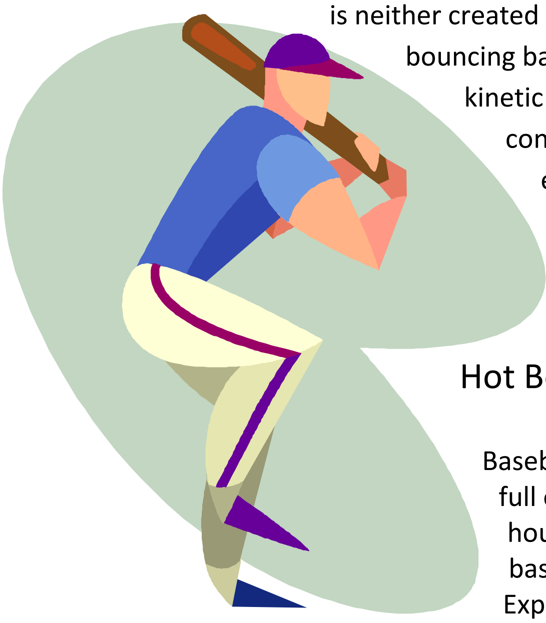
Though they look the same, each ball is made of a different material. The ball that bounces is made of a natural rubber. The natural rubber polymer's molecules are crossed linked by another substance. This prevents the molecules of rubber sliding past each other when a force is applied to the ball. When it makes contact with the ground, the ball flattens momentarily before bouncing back to its original shape. The upward energy created when it returns to its normal shape causes the entire ball to bounce upward again. The process repeats itself until the ball has no more energy and comes to a stop.

The no-bounce ball is made of butyl rubber. It acts just like the bouncing ball, except it absorbs more of the energy. The energy that makes the bounce ball bounce again is absorbed by butyl rubber, so it "dies" almost immediately. This is because there are no cross-links between the butyl rubber. When force is applied, the molecules in the ball slide past one another. The energy goes into deforming the ball. Butyl rubber is used as a shock absorber in materials such as motor mounts and inserts for running shoes.

When frozen, the balls reverse—that is, the ball that is supposed to bounce dies immediately and the ball that isn't supposed to bounce bounces. The cold temperature slows the movement of molecules in each ball, thus reversing the characteristics. Let the balls return to room temperature, and they will behave as expected.

Conservation of Energy:

You should have noticed that the bouncing ball does not bounce higher than it was originally dropped. This is because of Conservation of Energy. This important law of physics states that energy is neither created nor destroyed, it only changes from one form to another. With the bouncing ball, the energy changes from potential energy (before it is dropped) to kinetic energy (while it is moving) to elastic potential energy (while in contact with the ground.) When the ball touches the ground, some of the energy is transferred to the ground. The ball therefore has less energy, and does not bounce as high. When the ball is thrown with some force, however, it gains energy from the floor and is able to bounce higher.



Hot Bounce

Baseball legend tells of managers preparing for the arrival of a visiting team full of home-run hitters by placing baseballs in the freezer for several hours to alter their bounce. You can try this yourself. Take two identical baseballs, freeze one, and then compare the bounciness of the two balls. Experiment with other kinds of balls, comparing a cold ball to a warm one.

We found that frozen baseballs did not bounce as high as warm ones. Continue your research with golf balls or other balls. Are frozen golf balls less bouncy? (If you play golf in the winter, you'll hit the ball farther if you keep it warm in your pocket.) A cold superball bounces less than a warm one. Generally, cold balls are less bouncy than warm ones. That's because cold rubber is generally not as flexible as warm rubber. When a cold ball hits the floor, the deformation that follows the collision is concentrated at the bottom of the ball. This concentrated deformation causes the rubber molecules to collide with each other, producing warmth rather than rebound.

The one exception is the no-bounce ball. A cold no-bounce ball actually bounces better than a room-temperature one. The stiff, cold, norbonene or Butyl rubber polymer does not deform as much to dissipate the energy of the ball

Fun Facts:

- Butyl rubber (as in the no-bounce ball) is used to make running shoes that absorb energy. This keeps the runners' knees and ankles healthy by absorbing the joint-damaging shock of their feet hitting the ground.
- There are many kinds of materials that "remember" their original shape and return to it after being bent. There are metal shape-memory alloys (SMAs), shape-memory polymers (SMPs), and shape-memory ceramics (SMCs).
- SMAs are currently used commercially, particularly in new medical equipment.
- Bounce/No Bounce balls have been used as a magic trick for years.
- Neoprene and Norbonene or butyl rubber have many uses besides bouncy balls. Neoprene is commonly used for wire and cable jacketing, automotive gaskets, seals, hoses and tubes, power transmission belts, foamed wet suits, latex gloves and balloons, as waterproof membranes, and for asphalt modification. Neoprene is flexible in its uses because it resists degradation from the sun, ozone, and weather. It performs well when in contact with oil and chemicals and is useful over a wide temperature range. It also resists burning better than exclusive hydrocarbon rubbers and resists damage caused by flexing and twisting. Doping of the Neoprene polymer allows for more versatility and optimal performance. Norbonene rubber has impact absorption uses. It is used as a damping material in shock absorbers and for the protection of conveyor mechanisms. It is used as a padding material in items such as body armor, helmets, sports gloves and mitts, and in the soles of shoes. It is also widely used as an industrial packing material. Stereo speakers make use of Norbonene to minimize resonance and external vibration.
- Bounce and No-Bounce Balls behave differently in a variety of situations. They roll down a ramp at different speeds, they emit sound waves at different decibels, and they bounce different heights on different surfaces. They can be compressed dissimilar amounts when the same force is applied and they are different densities, so they sink in different solutions at variable rates.

Student Assessment:

- Students will define potential and kinetic energy and use those terms in their discussion of the experiment; put into their own words Newton's Third Law of Motion and explain how it relates to the experiment; and describe the Law of Conservation of Energy as it relates to a bouncing ball.

Experiment: H-Racer Hydrogen Car

The H-Racer is the smallest and coolest hydrogen fuel cell car in the world, and we can't stop playing with it.

This premier energy-friendly resource even includes a fuel tank with a blue light display for hydrogen refueling… just add water and the H-Racer is ready to go. Recommended for ages 10 and up.

Objectives:

Students will:

- Understand the purpose behind, importance of, and functionality of alternative fuel resources.
- Learn about the power of alternative fuel resources
- Build a working model of a hydrogen powered vehicle and test it
- Discuss the pros and cons of alternative fuel technologies

Key Terms:

- Exhaust
- Pollution
- Zero Emission
- Radiant Energy
- Chemical Energy
- Fossil Fuels
- Energy
- Fuel
- Compounds
- Combustion
- Technology
- Produce/Production
- Solution
- Global
- Atmosphere
- Alternative-Fuels
- Fuel cell
- Hydrogen Gas/Hydrogen Fuel
- Element
- Secondary Source of Energy
- Electricity
- Solar Power
- Non-renewable fuel
- Renewable Fuel

The H-racer is the working miniature version of what is being developed in real-size cars of the future. This palm-size fuel cell car contains an on-board hydrogen storage tank, a fuel cell system connected to the car's electric motor, and a hydrogen refueling system linking the car's storage tank to an external hydrogen refueling station.

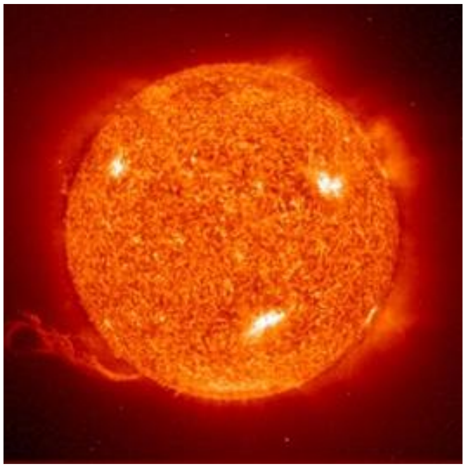
The H-racer is a futuristic model car that contains one of the most exciting and advanced technologies of the 21st century. This car operates on 100% clean fuel produced by a miniature solar-powered hydrogen refueling station that converts water to hydrogen using energy captured from the sun.

Cars running on clean and renewable fuel are the dream of many of today's world leaders, engineers and scientists seeking to eliminate mankind's reliance on fossil fuels in favor of climate-friendly energy resources.

With new advances in technology, hydrogen is on its way to becoming the world's next fuel. Hydrogen offers many important advantages: it is non-toxic, renewable, clean to use, and the most abundant element in our universe. And by using fuel cell technology to convert hydrogen to electricity without any combustion, the technology is a significant solution to many of our global energy and environmental problems.

No combustion occurs inside a fuel cell. The only exhaust resulting from hydrogen fuel cell cars is pure water. Fuel cell cars that use hydrogen as a fuel are also known as "zero emission vehicles." Today, many of the world's automotive companies including Toyota, GM, Ford, Honda, and Daimler-Chrysler, are developing hydrogen fuel cell vehicles with the hope of introducing this technology to the public in the near future.

What's included?
- 1 Hydrogen fuel cell car
- 1 Fuel cell
- 1 Hydrogen filling station.



What does it teach?
The H-Racer is a fun and exciting new way to learn all about the power of alternative fuel resources. Adults and children will marvel at this car powered purely by Hydrogen extracted from regular water.

How Does it Work?

Like electricity, hydrogen is a secondary source of energy. It stores and carries energy produced from other resources (fossil fuels, water, and biomass).

Hydrogen Basics

What Is Hydrogen?

The sun is basically a giant ball of hydrogen gas undergoing fusion into helium gas and giving off vast amounts of energy in the process.

Source: NASA (Public Domain)

Hydrogen is the simplest element. Each atom of hydrogen has only one proton. It is also the most plentiful gas in the universe. Stars like the sun are made primarily of hydrogen.

The sun is basically a giant ball of hydrogen and helium gases. In the sun's core, hydrogen atoms combine to form helium atoms. This process — called fusion — gives off radiant energy.

This **radiant energy** sustains life on Earth. It gives us light and makes plants grow. It makes the wind blow and rain fall. It is stored as chemical energy in fossil fuels. Most of the energy we use today originally came from the sun's radiant energy.

Hydrogen gas is so much lighter than air that it rises fast and is quickly ejected from the atmosphere. This is why hydrogen as a gas (H2) is not found by itself on Earth. It is found only in **compound** form with other elements. Hydrogen combined with oxygen, is water (H2O). Hydrogen combined with carbon forms different compounds, including methane (CH4), coal, and petroleum. Hydrogen is also found in all growing things — for example, biomass. It is also an abundant element in the Earth's crust.

Hydrogen has the highest energy content of any common fuel by weight (about three times more than gasoline), but the lowest energy content by volume (about four times less than gasoline).

Hydrogen Is an Energy Carrier

Energy carriers move energy in a useable form from one place to another. Electricity is the most well-known energy carrier. We use electricity to move the energy in coal, uranium, and other energy sources from power plants to homes and businesses. We also use electricity to move the energy in flowing water from hydropower dams to consumers. For many energy needs, it is much easier to use electricity than the energy sources themselves.

Like electricity, hydrogen is an energy carrier and must be produced from another substance. Hydrogen is not currently widely used, but it has potential as an energy carrier in the future. Hydrogen can be produced from a variety of resources (water, fossil fuels, or biomass) and is a byproduct of other chemical processes.

Hydrogen Fuel Cells Produce Electricity

Hydrogen fuel cells (batteries) make electricity. They are very efficient, but expensive to build. The technology has "the potential to transform the [U.S.] energy industry.

Still, there are problems. Even though there's more hydrogen in the universe than any other element, it's difficult to gather and store.

On Earth, most hydrogen is attached to oxygen (as in water molecules, which contain two atoms of hydrogen for every atom of oxygen) or to other atoms, and energy is required to separate them. That's an issue if the point is to generate energy without the pollution produced by burning gasoline, oil, coal, and other fuels used today, which might be needed to free up hydrogen.

Small fuel cells can power electric cars. Large fuel cells can provide electricity in remote places with no power lines.

Because of the high cost to build fuel cells, large hydrogen power plants won't be built for a while. However, fuel cells are being used in some places as a source of emergency power, from hospitals to wilderness locations.

Portable fuel cells are being sold to provide longer power for laptop computers, cell phones, and military applications.

Hydrogen Use in Vehicles

Today, there are an estimated 200 to 300 hydrogen-fueled working vehicles in the United States. Most of these vehicles are buses and automobiles powered by electric motors. They store hydrogen gas or liquid on board and convert the hydrogen into electricity for the motor using a fuel cell. Only a few of these vehicles burn the hydrogen directly (producing almost no pollution).

The present cost of fuel cell vehicles greatly exceeds that of conventional vehicles in large part due to the expense of producing fuel cells.

From the Laboratory to the Road

Hydrogen vehicles are starting to move from the laboratory to the road. Hydrogen vehicles are in use by a few state agencies and a few private entities.

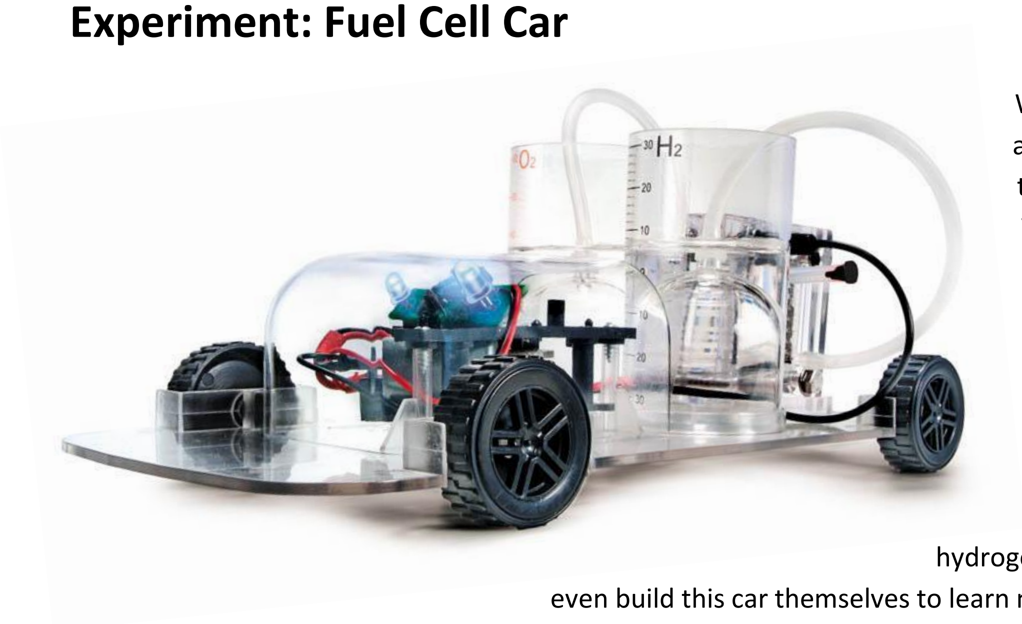
The Refueling Challenge

Currently, there are 63 hydrogen refueling stations in the United States, about half of which are located in California. There are so-called “chicken and egg” questions that hydrogen developers are working hard to solve, including: who will buy hydrogen cars if there are no refueling stations? And who will pay to build a refueling station if there are no cars and customers?

Student Assessment:

Students will create an advertisement for the H-Racer Hydrogen car (as a real car) convincing customers to buy it. Students will the purpose behind, importance of, and functionality of the H-Racer. And the price.

Experiment: Fuel Cell Car



We love the sleek design and hydrogen power of this car of the future. The Fuel Cell Car Science Kit is a great way for kids to learn about the importance of alternative fuel sources. Not only will kids be excited about the car, with onboard hydrogen fuel source, they can even build this car themselves to learn more about the functionality of the hydrogen fuel cells. Children and adults, alike, will be amazed by the power of hydrogen...

Objectives:

Students will:

- Understand the purpose behind, importance of, and functionality of alternative fuel resources.
- Learn about the power of alternative fuel resources
- Build a working model of a hydrogen powered vehicle and test it
- Discuss the pros and cons of alternative fuel technologies

Key Terms:

- Exhaust
- Pollution
- Zero Emission
- Radiant Energy
- Chemical Energy
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- Fuel
- Compounds
- Combustion
- Technology
- Produce/Production
- Solution
- Global
- Atmosphere
- Alternative-Fuels
- Fuel cell
- Hydrogen Gas/Hydrogen Fuel
- Element
- Secondary Source of Energy
- Electricity
- Solar Power
- Non-renewable fuel

- Renewable Fuel

What's included?

- All the pieces needed to build the Hydrogen powered car

What does it teach?

The hydrogen powered Fuel Cell Car teaches about the exciting possibilities that hydrogen technologies provide for the future. Children can build their own car, while learning about the importance of discovering alternative fuel sources.

Around the world today, scientists and researchers are looking to find new ways of meeting our growing energy needs without further damaging our environment and planet. One alternative is hydrogen, which can be created using clean, renewable sources such as wind and solar power.

The Fuel Cell Car Kit is conveniently designed to demonstrate how hydrogen can be stored and utilized for generating power. Using a device called an electrolyzer, water is used to form hydrogen. Fuel cells then converts hydrogen to electrical energy to power anything, from vehicles and homes to electronic devices.

The hydrogen storage tank fills in less than 2 minutes when the fuel cell is running in electrolyzer mode and runs for approximately 10-15 minutes on a full tank when operating in fuel cell mode. Once in operation, the fuel cell car automatically turns when it hits a barrier, reversing away 90 degrees. This fun science kit combines cutting-edge science, education and fun for all!

Air Pressure

Experiment: Bernoulli's Bag

Here's the challenge... How many breaths would it take to blow up a 2 meter (8 ft) long bag? Depending on the size of the person, it may take anywhere from 10 to 50 breaths of air. However, with a little practice... and some scientific knowledge of air... you will be able to inflate the bag using only one breath!

Use the giant Windbags and other experiments to teach the fundamentals: air occupies space, has weight, and exerts pressures.

Objectives:

Students will:

- Gain an understanding of air pressure and Bernoulli's Principle
- Learn air occupies space, has weight, and exerts pressures.
- Investigate air pressure
- Construct a device that demonstrates Bernoulli's Principle

Key Terms

- Air
- Bernoulli's Principle
- Air Pressure
- Air Flow
- Atoms
- Molecules
- Gas
- Mixture
- Gravity
- Weight

Materials

- 2 sheets of paper for each student
- Books (for demonstration)

- The "Windbag" is actually a long plastic bag in the shape of a tube. While you can purchase these bags from toy stores that sell science experiments, you can also make your own long bag using a product called a Diaper Genie refill (only the Original Diaper Genie Refills work). It's part of a diaper system that parents use to dispose of diapers. A Diaper Genie refill is commonly available at any major discount/department store.
- You can also check out colorful Windbags and purchase them in various quantities

Air Pressure, Can I See It?

1. Ask students what they think of when they think of *air,* they might think of emptiness, but air is actually exerting a force – or pushing -- on everything, all the time. This invisible force is called *air pressure*.

2. Ask the students for 3 large notebooks.

3. Ask the students to move the 3 books stacked on top of one another on a table by simply blowing at them. Of course, they can't do it!

4. Place a large plastic bag (or Windbag) on the table, and put the 3 books on top of the bag. Leave the open end of the bag sticking out over the edge of the table.

5. Hold the opening together, leaving a hole as small as possible. Blow into the bag.

6. As you blow air into the bag, the books will rise off the table. They will be supported by the compressed air in the plastic bag.

7. Explain that similarly, there is air all around us exerting pressure.

What is air? Is it nothing? If it is not "nothing", what is it?

Air is not "nothing". Air is something. Air has weight. The more air there is, the more it weighs. You know the earth is covered with air. The air that covers the earth reaches into the sky for several miles. The weight of that air presses down on everything that is on earth, including you and me.

We do not feel as if anything is pressing down against us because the air is pressing against us from all directions. While it is pressing down, it is pressing up. While it is pressing from the outside of us, it is pressing from the inside of us towards the outside.

In outer space, where there is no air, astronauts have to wear pressurized space suits that push against their bodies with the same forces as the air on earth. Without air we could not live. We cannot see it or smell it, but we can feel it when it moves. Just like water, air has many uses. Sailing boats have large sails which catch the wind to push them through the water. Windmills harness the power of the wind to grind wheat into flour or make electricity.

More Air Pressure in Action

1. Pass out a piece of paper to each student. Have each student hold the two corners on one short side, one corner in each hand. That short side should be held up to the mouth, and the other end of the paper should flop down. Demonstrate.

2. What happens when you blow across the flat surface of a piece of paper when holding one corner in each hand? Have the students predict what will happen, and then let them try it. The end of the paper that was drooping down should lift when the student blows across it.

3. This phenomenon is an example of Bernoulli's principle in action. The stream of air over the paper is moving faster than the air underneath the paper. Air that moves more quickly has lower pressure than air that moves more slowly, so the air underneath the paper has a higher pressure than the air above it and pushes the paper up.

4. Pass out another round of paper. Have the students each hold two pieces of paper up by their top (short) edges, one piece in each hand. The pieces of paper should be hanging down. What happens when you blow in between them? The pieces of paper should converge; the air in between the sheets is moving more quickly, so it has a lower pressure than the air on the outsides, which pushes the sheets of paper toward one another.

Time for Windbags!

1. Tie a knot in one end of the bag. Invite a student to blow up the bag, keeping track of the number of breaths it takes. Then, let all of the air out of the bag. Explain to your class that you can blow up the bag in one breath... chances are they won't believe you, but that's all part of the fun!
2. Have your student assist you by holding onto the closed end of the bag. Hold the open end of the bag approximately 10 inches away from your mouth. Using only one breath, blow as hard as you can into the bag. Remember to stay about 10 inches away from the bag when you blow.
3. Quickly seal the bag with your hand so that none of the air escapes. Tie a slip knot in the end of the bag, or let the air out and try again.

Have students come up with their theories and ideas on what is happening and why it works. Then have them test their ideas out. Guide them towards a discussion of airflow.

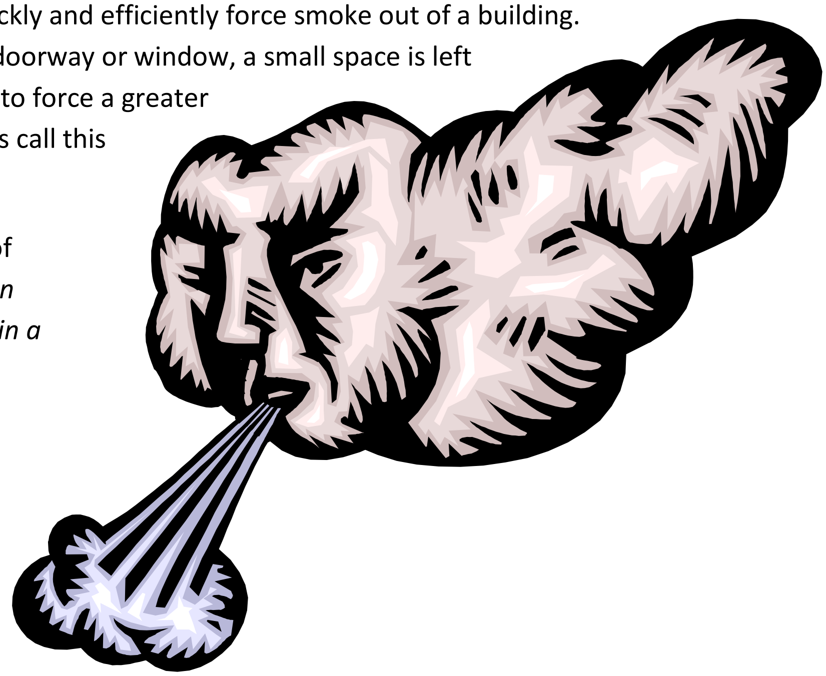
How does it work?

The long bag quickly inflates because air from the atmosphere is drawn into the bag from the sides along with the stream of air from your lungs.

For you science enthusiasts out there - here's the technical explanation... In 1738, Daniel Bernoulli observed that a fast moving stream of air is surrounded by an area of low atmospheric pressure. In fact, the faster the stream of air moves, the more the air pressure drops around the moving air. When you blow into the bag, higher pressure air in the atmosphere forces its way into the area of low pressure created by the stream of air from your lungs. In other words, air in the atmosphere is drawn into the long bag at the same time that you are blowing into the bag.

Additional Info

Firefighters use Bernoulli's principle to quickly and efficiently force smoke out of a building. Instead of placing the fans up against the doorway or window, a small space is left between the opening and the fan in order to force a greater amount of air into the building. Firefighters call this "Positive Air Flow."



What are some other common examples of Bernoulli's principle? *Flags waving, sails, an umbrella that becomes impossible to hold in a strong wind.*

Extensions:

Float on a cushion of air

Lift an entire table with two Windbags

Build Giant Windbag Structures

More Air Pressure Experiments

1. Have one student per group hold two sheets of notebook paper about four inches apart in front of his/her mouth. The sheets should hang down so the pages face each other.

2. Blow between them. Encourage students to try blowing gently at first, and then with more force.

3. Instruct students to observe what happens to the papers.

1. Ask students to explain what happened: Instead of flying apart, the papers come together. The air moving rapidly between the two pieces of paper has less pressure than the air pressing on the outer sides of the paper.

2. Have students compare results. Was the resulting lift better when the students blew gently or when they blew with more force?

Bernoulli's Bag Heads

Another example of Bernoulli's principle can be seen using the paper bag mask. When the student blows through the hole in the paper bag mask and over the curved surface of the "tongue," unequal air pressure will lift the tongue.

1. Place a large paper bag over the head of one student and have a second student carefully draw small dots where the eyes, nose, and mouth are located.

2. Remove the bag from the head and draw a face around the marks made in step 1.

3. Cut out two holes for the eyes and one hole for the mouth

5. To make the tongue, cut a strip of paper, approximately 3 cm wide and 20 cm long.

6. Tape or glue one end of the tongue inside the bag at the bottom of the mask's mouth. Allow the tongue to droop through the mouth on the outside of the bag.

7. Place the bag over the head and blow through the mouth hole. Observe the movement of the tongue.

Why does the tongue move when you blow gently through the mouth? What happens when you blow harder? The *curved surface of the tongue creates unequal air pressure and a lifting action, Blowing harder will cause the tongue to move up and down faster.*

2. Attach a lightweight streamer to a fan or air conditioning vent. Ask the students to observe and describe what happens. How do the streamers relate to this activity? The *same force moves the tongue and streamers. Lift is caused by air moving over a curved surface.*

Have a classmate observe the paper tongue and record what happens. Switch roles.

1. Experiment with different tongue lengths.

2. Encourage the students to be creative with the designs on the bags - faces that say something about who they are, or who they want to be, maybe the face of a friend, relative, or classmate. The designs may also be abstract, or not human; consider holiday themes.

Student Assessment:

Have students draw a diagram of the Windbag and how the air flow fills it up quickly, using Bernoulli's principle. Have students share ideas on how air pressure could be used in other areas. What about lifting up heavy equipment? Or moving people? Have students illustrate their ideas.

Experiment: Marshmallow Masher

You won't believe your eyes! Explore the powerful properties of air as you put marshmallows to the pressure test.

Wind is simply moving air. If there wasn't any wind, weather reports wouldn't be very interesting, as there would be little change in day-today weather. Wind is produced by pressure differences. In this activity, students will produce a region of high pressure and then see how this high pressure causes air to flow to a region of low pressure—they will make the wind blow!

Objectives:

Students will:

- Gain an understanding of air pressure and Bernoulli's Principle
- Learn air occupies space, has weight, and exerts pressures.
- Investigate air pressure
- Produce a region of high pressure and then see how this high pressure causes air to flow to a region of low pressure
- Conduct a science investigation in which they record, process, and interpret data.
- Make predictions and hypotheses and test their accuracy.

Key Terms

- Air
- Air Pressure
- Atmospheric Pressure
- Air Flow
- Atoms
- Molecules
- Gas
- Force
- Net Force
- Pressure/Pressurizing
- Square inch
- Predict
- Sea level
- Weight

Safety Notes: This demonstration requires adult supervision! Use only plastic soda bottles that are in good condition for this experiment. Wear safety glasses just in case something breaks. Don't get carried away with the pumping. Do not over pressurize any container using the pressurizing pump. Too much pressure will result in the breakage of the pump. Do not pump more than 40 strokes (pumps) into the 16 oz. bottle. Apply only enough pressure to allow you to see the shrinking effects. Never leave a soda bottle in the pressurized state. After observing the effects of compression, always release the pressure.

This activity can be performed as a demonstration, but is much more effective if students can see, feel, and hear the experiment while working in small groups.

Prepare your experiment by punching a hole in the side of the 1 liter bottle toward the bottom. Cover the hole with the piece of tape. Fill the bottle with Styrofoam packing peanuts and then put the special Fizz Keeper pump cap on the bottle. If you don't have Styrofoam packing peanuts, mini marshmallows can be used.

Materials

- Small marshmallows
- Pressuring Pump
- Plastic soda bottle - 16 ounce size
- Masking or duct tape

Fill the bottle about half full with marshmallows, and screw on the special pressurizing pump. Begin pumping to increase the pressure within the bottle. As you increase the pressure inside the bottle, notice how the marshmallows seem to become wrinkled and shrink. Do not pump more than 40 times! Release the pressure by unscrewing the cap, but don't take your eyes off the marshmallows. Let's just say the rapid decompression is well worth all of the effort of pumping!

Have students come up with their theories of what is happening and test them. Guide them towards a discussion of air pressure.

Above the earth, an ocean of air surrounds us. The **air pressure** from the air above us produces large forces on all objects. The force of normal atmospheric pressure in Colorado on one side of a typical office door is about 15 tons! But there is an equal force on both sides, meaning the **net force**, or total force, is zero. Now, if the pressure is larger on one side than the other, there will be a force.

In the atmosphere, the pressure isn't constant. This is primarily because the sun heats the earth's surface unevenly. As heat is transferred to the air, we get regions of warm and cool air which can turn into regions of low and high pressure. This difference in pressure makes a force that causes the wind to blow.

On a large scale, the rotation of the earth and other factors can make the source of the pressure differences that drive the wind hard to determine, but on small scales the sources are easier to determine. If you live near the ocean, you have noticed that, in the summer, the land will be warmer than the ocean during the day. Warmed air will rise over the land, leading to a low pressure region; high pressure air over the ocean will cause a wind to blow toward the shore—a welcome sea breeze. At night,

the ocean stays warm longer than the land, so we get the reverse—a land breeze.

On the front range of Colorado, we see a similar effect. In the morning, the eastward-facing foothills

warm first; the air here warms and rises, and the higher-pressure region on the plains causes the wind to

blow toward the foothills. At night, the eastward-facing foothills lose the light first, and so cool down first. The process is reversed, and the wind blows from the mountains. You may have noticed this before; if not, pay attention on your morning and evening commute! It's not always true that the wind blows west in the mornings and east in the evenings, but it's true more often than not.

Doing the Experiment

Hold a brainstorming session with your class to elicit their ideas about the wind and what causes it to blow. Ask them to tell you if they have noticed any trends. What direction is the wind blowing when they walk to school? When they walk home?

Follow this with a brief explanation or review of the differential heating of the earth that leads to pressure differences in the atmosphere, the proceed as follows:

• Tell your students that in this experiment, they will make a high-pressure system that will then flow to an area of low pressure, causing wind to blow. This experiment will also help them see, feel, and hear the effects of air pressure.

• Show students the supplies they have for the experiment and ask them to identify the two main ingredients of the styrofoam peanuts, a plastic foam concoction of plastic and air. (If you are using marshmallows, the main ingredients are sugar and air.)

• Explain that the Fizz Keeper is a special cap that can put more air molecules into the bottle. Ask them not to pump it yet. Have them squeeze the bottle and note how it feels. Then listen as they shake the bottle, and note what they hear. Ask them what they think will happen if they pump a lot of air molecules into the bottle.

• Have one student hold his/her thumb over the taped hole, while another student pumps the cap as much as he/she can. Squeeze the bottle. How does it feel? Has the temperature changed at all? What's happening to the marshmallows? Now carefully shake the bottle, keeping the hole covered.

Does it sound any different then before?

• Have students predict what will happen when they take the tape off the hole at the bottom of the bottle.

• Before removing the tape, tip the bottle horizontally and shake the marshmallows evenly over the surface. • Remove the tape and have them discuss and explain what they observed. (When you add more air molecules to the bottle, the air pressure increases, compressing the air in the styrofoam peanuts. The bottle feels solid, and the peanuts may sound noisy as you shake the bottle. When you release the tape over the hole, the high pressure moves horizontally to an area of lower pressure, creating a wind. The air pressure in the bottle equalizes, and the packing peanuts return to their original size.)

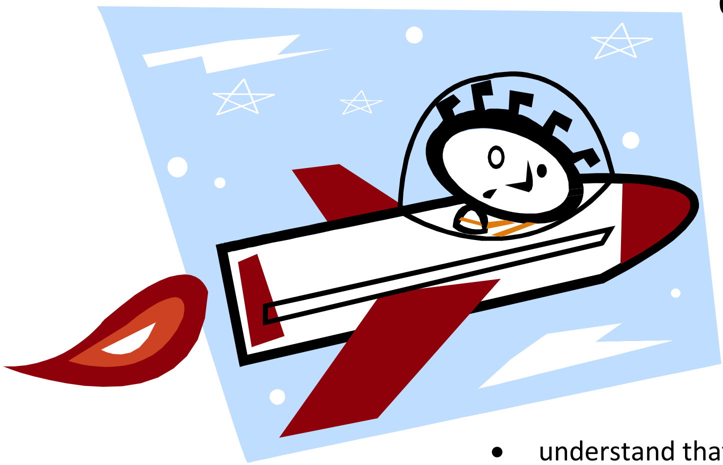
How does it work?

The Fizz Keeper is like a miniature bicycle pump that forces molecules of air into the bottle. The increased pressure, in turn, pushes on the marshmallows. Since marshmallows are just puffy pockets of air, the increased pressure compacts the molecules and the marshmallows shrivel up.

Teacher Notes: Use this demonstration to discuss the effects of atmospheric pressure. We sometimes refer to things as being "light as air," but the truth is that the air surrounding our planet weighs a lot, and exerts considerable pressure on us. The atmospheric pressure at sea level is 14.7 pounds per square inch of surface area at sea level. That's rough the weight of 2 gallons of milk resting on 1 square inch!

A typical regular-size marshmallow has a surface area of about 6 square inches. So, the marshmallow has about 88 pounds of atmospheric pressure being exerted upon it (6 square inches x 14.7 pounds per square inch = 88.2pounds). The marshmallow is really a kind of sugary material that resembles foam rubber. It's full of tiny bubbles of air. The air pressure inside these tiny bubbles is roughly the same as the air pressure pushing on the marshmallow from the outside, so the pressures are equalized and the marshmallow retains its regular shape.

Experiment: Airburst Rockets



Objectives:

Students will:

- Conduct science investigations in which they record, process, and interpret data.
- Make predictions and hypotheses and test their accuracy.
- Become familiar with Sir Isaac Newton's Laws of Motion and how they relate to rocketry.
- understand that forces are either a push or a pull
- Learn air occupies space, has weight, and exerts pressures.
- Investigate air pressure

Key Vocabulary

- Air
- Air Pressure
- Atmospheric Pressure
- Rocket
- Air Flow
- Atoms
- Molecules
- Gas
- Force
- Net Force
- Fuel
- Launch Platform
- Flexible
- Friction/Resistance
- Launch
- Membrane
- Pressure/Pressurize
- Square inch
- Newton's Third Law
- Predict

Materials:

- Air Burst Rocket Launcher
- Air Burst Rockets
- Air Burst Membrane Boosters
- Instruction Guide
- Paper
- Tape
- Scissors
- Measuring Tape
- Bicycle Tire Pump
- Paper Rocket Printouts
- Flexible Plastic Bottles
- Large Straws
- Small Straws
- Modeling Clay

The Air-Burst Rockets are creating quite the buzz around the Spangler Science Office... we just can't believe our eyes every time we launch one of these rockets higher than the roof on our building. The specially designed rocket boosters offer five levels of launching power and use only air pressure to launch... Air Burst Rockets don't require any flames, fire or batteries. Just attach the air tubing to a bike pump, give it a few pumps and your rocket will fly up to 75-305 meters (1,000 ft) in the air. You'll receive 2 rockets, 60 rocket booster membranes for ultimate launching power, a rocket launcher with stand and operating instructions with technical descriptions of why Air Burst Rockets launch higher than any air-powered rocket you've ever seen. Bike pump required but **NOT INCLUDED.** Recommended for children ages 10 and up.

Need more boosters? No problem, check out our refill packs.

What's included?

- 1 Air Burst Rocket Launcher
- 2 Air Burst Rockets
- 60 Air Burst Membrane Boosters
- Instruction Guide

Refill kit includes -

- 60 Air Burst Membrane Boosters

What does it teach?

Teach a lesson in air pressure that your students won't soon forget! These Air Burst rockets build up a lot of pressure and then... boom! The rockets soar up to 5 meters in the air.

Experiment Continuation: Squeeze Bottle Rockets

It's easy to turn a juice bottle into a rocket launcher. How? Grab a few straws, some modeling clay and an empty juice bottle to make a launcher that will send the straw rocket soaring across the room. Ok, you'll learn something about Newton's Third Law of Motion at the same time.

This experiment was designed using the Kool-Aid Bursts juice product. While other flexible juice bottles may work, the Kool-Aid product works very well. The larger of the two straws should fix loosely over the smaller straw. There should be no friction or resistance at all or the straw will not be able to launch. If you're tired of searching for straws, just stop by a fast food restaurant to enjoy a drink and pick up a few straws.

Materials

- Kool-Aid Burst juice bottle (or a similar flexible plastic bottle)
- Modeling clay
- 2 straws - one large and one small. The larger diameter straw must be able to slip over the smaller straw. The large and small straws from Starbucks® work great.

- Drink the juice! Clean and dry the bottle.
- Push the smaller straw into the opening of the bottle. The straw should fit snugly in the hole at the top of the bottle.
- Use modeling clay to seal any possible leaks between the straw and the hole in the bottle. The clay will also make the straw more stable and less likely to wobble.
- Push one end of the bigger straw into another piece of modeling clay. This "plug" will seal the end of the straw. Cover the plugged end with something soft like a Styrofoam packing peanut to keep the straw rocket from hurting anyone in case they accidentally get hit.
- It's time to launch... Place the larger straw over the smaller straw. Ready, aim, squeeze! The larger straw launches off the smaller straw and the room erupts in a chorus of oohs & ahhhs!

How does it work?
While they're having fun launching straws, students are actually learning about Newton's Third Law of Motion. According to Newton, for every action there is an equal and opposite reaction. As they squeeze the bottle, air is forced out of the straw and pushes against the clay plug in the larger straw. The resulting force causes the straw to "launch" through the air.

Additional Info
Remind students to be careful! Never point the straw rocket at anyone. The goal here is to launch the rocket up in the air (not at someone). Be sure to cover the plugged end of the straw with something soft and round to protect someone from accidentally getting hurt by a sharp edge. Be creative! Once you've mastered the simple straw rocket, challenge your friends to a straw rocket design contest. Add a nose cone, some fins, a few decorations, and don't forget to name your straw rocket!

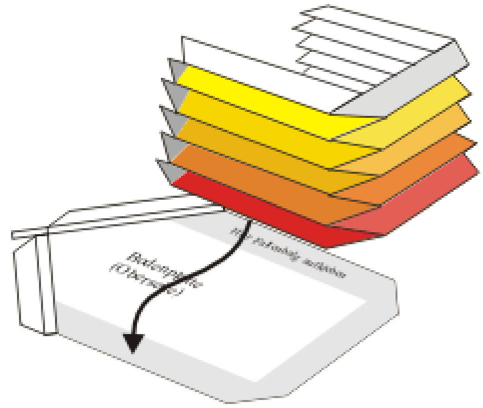
Extensions:

Have students add modifications to the rockets such as fins. Do they fly farther?

Further Air Pressure Rocket Experiments:

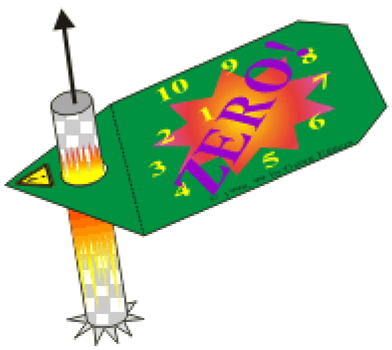
Have students build a rocket and rocket launcher completely out of cardstock: Templates found at **http://www.groeg.de/puzzles/pdf/rocket.pdf**

How to build the rocket :



Building the rocket is rated "tricky". Folding the bellow requires some endurance. The most important thing to observe is that all bellow parts must be air tight! The more precise you work, the higher the rocket will fly.

The most difficult part is the bellow's side wall. Cut it out and carefully scribe the bending lines! Then strictly follow the bending lines:



- - - - - - Outside bend line

— · — · — · — Inside bend line

as described in detail on the Tools and Tips page. The bends must not break! If they do, close the slits with adhesive tape, applied to the back side of the paper.

The folded bellow is then glued to the base plate. Remember: The connection ought to be air tight!

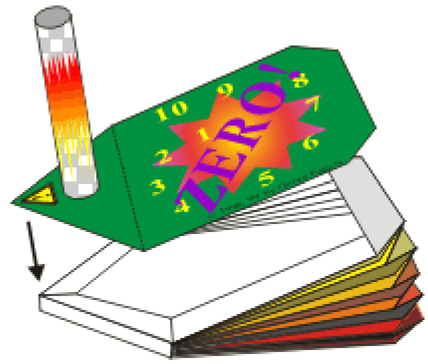
Fold up the flaps at the front of the base plate and glue them to the top side of the folded bellow.

Build the starting tube by coiling the part around a pen or a stick. Slide it up through the top plate as shown on the left and glue it on the back (bottom) side of the top plate.

After the glue of the first connections has dried, mount the top plate on top of the bellow.

Check whether everything is air tight: Close the end of the starting tube with your finger and carefully press the bellow. If you find any escapes for the air, stop them up!

Now build the rocket itself. Once again, the tubular part should be prepared by winding the paper around a stick or a pen. The finished tube must fit over the starting tube and slide easily along it.



Form a cone as the rocket tip and glue it on top of the tube - once again: Air tight, please ...
Build the fins and glue them to the sides of the rocket.

Wait some minutes to allow the glue to dry.

Building Hints

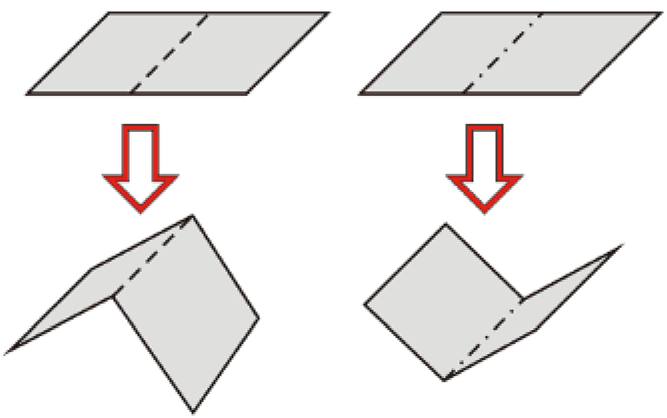
All parts on the sheets are marked with three **different line types**:

Cutting line, marks edges of parts

Outside bend line (see below)

Inside bend line (see below)

All bending lines must be first be scribed or grooved carefully (see the tools section for details). To achieve really perfect bends, inside bend lines should be scribed or grooved on the unprinted back side of the paper. This can be done by marking the ends of the bend line by small cuts and connecting these cuts on the back side.



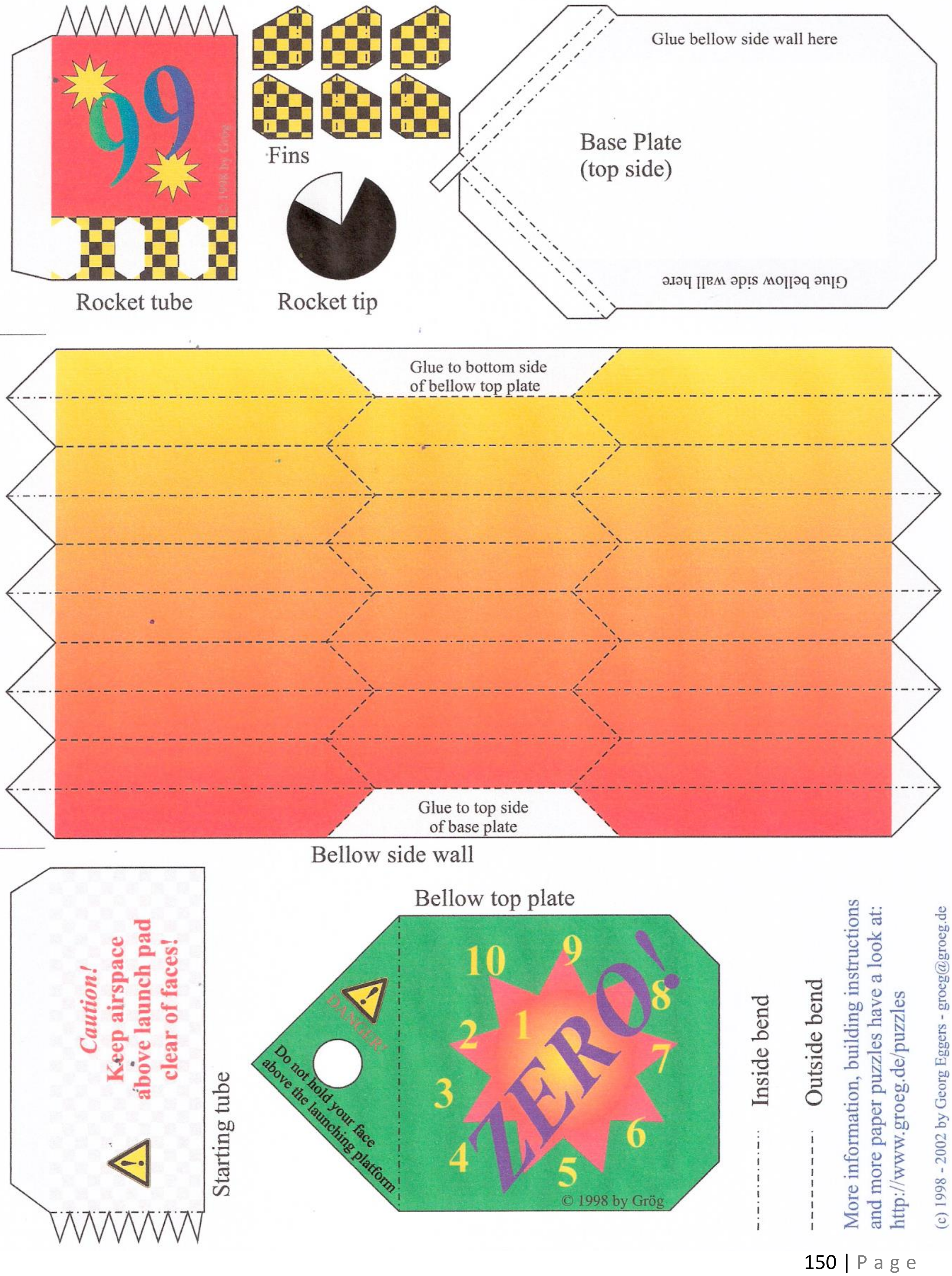
Outside (left) and inside (right) bend lines.

To help finding the right parts, a **part numbering** is used for some of the puzzles:

01 — On some sheets, the parts are marked with numbers like the one shown on the left. These part numbers are then referred to in the building instructions.

01 — The gluing pads are printed grey on all sheets. If the parts are numbered, the corresponding part number is typed into every pad.

Build your own paper rocket



Experiment: Cardboard Boomerang—The Science of Flight

When most of us think of **boomerangs**, we imagine somebody (quite possibly a cartoon character) throwing a banana-shaped stick that eventually turns around and comes right back to the thrower's hand (possibly after hitting another cartoon character in the head). This idea is simply amazing, and as children, our first reaction to such a device was: This stick is obviously possessed with magical powers! Of course, the person or people who discovered the boomerang hadn't actually found a magical stick, but they had come upon an amazing application of some complex laws of physics.

In this lesson, we'll break down the physical principles that make boomerangs work, see what happens as a boomerang flies through the air and find out the proper way to throw a boomerang so that it comes back to you. We'll also delve a little into the history of boomerangs to see how they came about in the first place. Boomeranging is an amazing demonstration of scientific principles as well as a terrific sport you can enjoy all by yourself.

Throw a paper airplane and have the students describe how it flew. Then throw a previously made boomerang (or a Roomerang) and see what it does (You will want to practice before class to perfect your technique). Ask the students why they think the boomerang acts the way it does. Were there any differences between the way the boomerang and planes flew? Have students build their own boomerangs and planes to test their theories.

Objectives:

Students will:

- Gain knowledge of boomerang shapes while engaging in decision making (cognitive critical thinking) as to how they will design their boomerangs up to the finished designed project.
- briefly review boomerangs: their history, their art forms, how they were used then and now and different boomerang shapes
- Conduct science investigations in which they record, process, and interpret data.
- Make predictions and hypotheses and test their accuracy.
- Become familiar with Sir Isaac Newton's Laws of Motion and how they relate to boomerangs.

- understand that forces are either a push or a pull
- Investigate air pressure, lift, and other elements of flight

Key Terms:

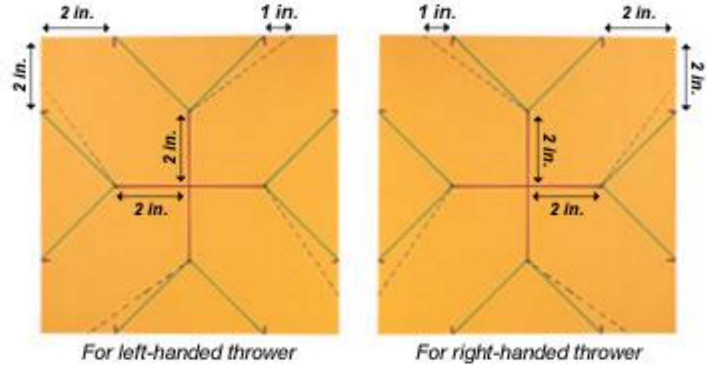
- Inertia
- Center of Gravity
- Lift
- Airfoil
- Air Particles
- Speed
- Motion
- Clockwise
- Counterclockwise
- Pressure
- Velocity
- Force
- Shape
- Surface
- Flight
- Propeller
- Balance
- Axis
- Wing
- Airflow
- Design
- Vertical
- Horizontal
- Physics
- Leading Edge
- Trailing Edge
- Boomerangs vs. Returning Boomerangs

Materials:

- 8-inch square of cardboard cut from a cereal box or poster board (or cardstock)
- Pencil and ruler
- Scissors
- Ballpoint pen
- Decorative stickers or colored markers
- Gyroscope or Top

Time needed: About 1 Hour

1. Depending on whether you are left-handed or right-handed, mark the cardboard square as specified and then cut out the boomerang. It will resemble a chunky X at this stage. Use the scissors to round the ends for safety. Have students make both models and compare their



results. (For the second model have students Trace the master pattern on the card stock and cut it out.)

2. With the ballpoint pen, score along the fold lines (shown as dashes in the diagram) and then fold the cardboard down to create 45-degree flaps. If you like, decorate the boomerang with stickers or colored markers.

3. Have students try out their boomerang on a calm day, standing 20 feet away from people or obstacles (boomerangs are notorious for getting caught in trees or landing on roofs). Hold the boomerang nearly vertical (not horizontal, as you would a flying disk), with the pencil lines visible. Flick your wrist to add spin as you toss it forward and slightly upward. It should start to turn and then flatten out as it coasts back to you. Bend to tune for test flight.

To fly the boomerang, hold the boomerang vertically. Make a fist and hold one blade between your thumb and index finger. Bend your wrist back, so the boomerang nearly touches your forearm. Snap your wrist, spinning the boomerang straight out in front of you and releasing at eye level with your arm fully extended. The boomerang should be vertical, straight out from your body. The easiest way to catch it is to clap it between both hands. Don't be surprised if it takes you a few tries.

5. Have students change the bend of the airfoils and note and record the results.

6. Have students add a 4 cm strip of masking tape to one airfoil. What do they think will happen? Do they note the change in flight path. Continue to add masking tape to another airfoil and note the change in flight path.

What's Happening: There's a lot of physics going on here, with your boomerang acting like a set of wings and a spinning gyroscope.
There are **4** principles of physics that are used to describe the flight of a boomerang or glider.

The principles are:

1. inertia

2. center of gravity, cg (center of mass)

3. gyroscopic principles (primarily used for boomerangs)

4. Bernoulli’s principles (pressure, lifting force, relative velocity, air resistance due to turbulence)

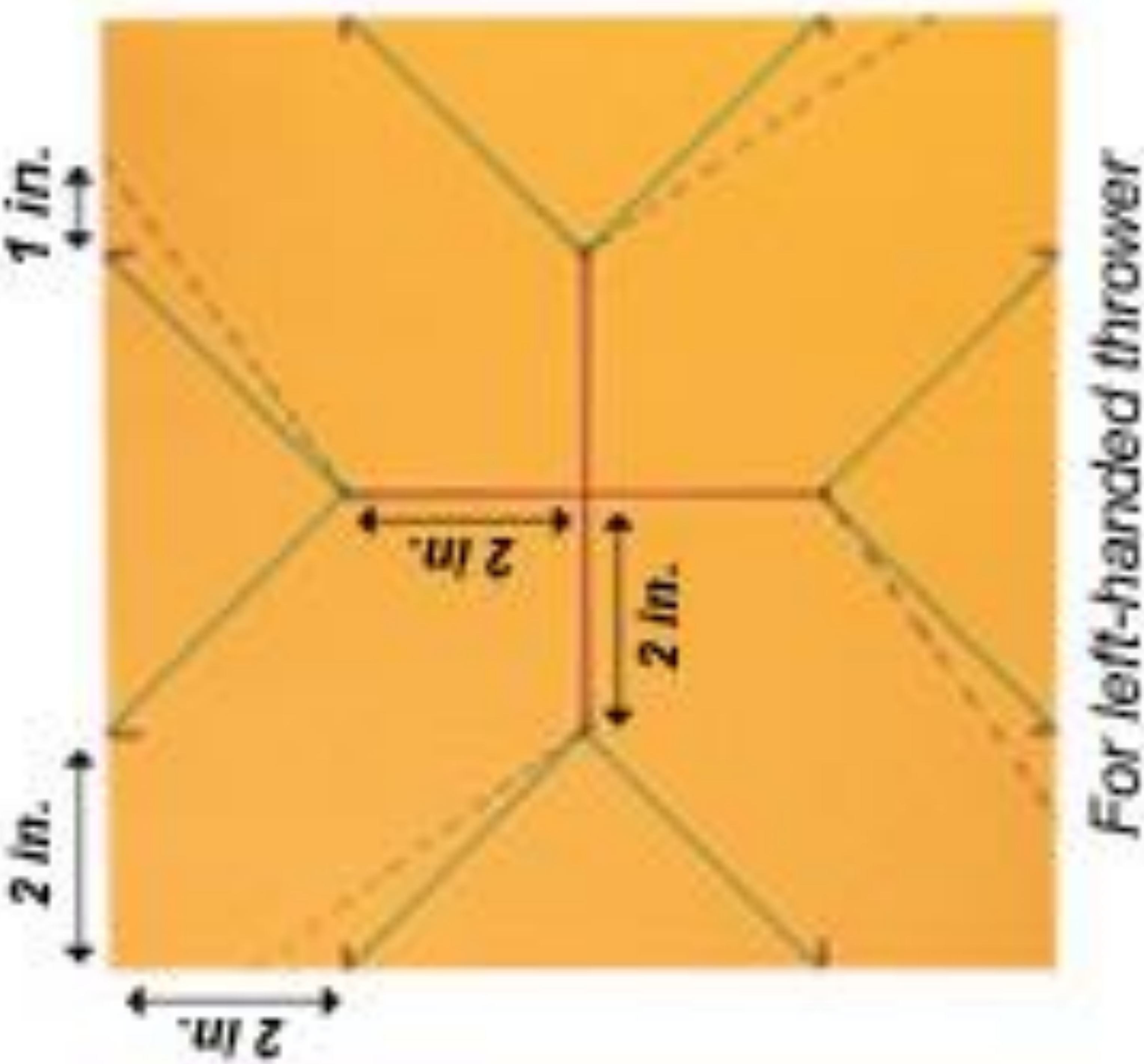
Center of gravity (also called center of mass) is the balance point for **an** object. All applied forces act on or about the center of gravity. Forces that act around the center of gravity creates torque.

Gyroscopic Principles: The gyroscopic principle is perhaps the most important concept if the flight of the boomerang is to be understood. The best **way** to understand the gyroscopic principle is by example.

So, let’s get started, by bending back the edges of the boomerang arms, you turn them into curved wings, like those of an airplane. The curves cause air to move more quickly over the wings' tops than the bottoms, creating lift. That's what keeps the boomerang from falling to the ground.

Each airfoil of the boomerang has a leading and trailing edge. Lift is generated over the entire top surface, but in proportion to the relative air velocity. As it spins, the wing at the top of the rotation has a greater air speed than the airfoil at the bottom of the rotation. These unequal forces result in two actions: the boomerang will shift from vertical to horizontal because of the greater force on the upper airfoil and precession causes the boomerang to move in a circular path. As the boomerang turns to the right or left (right-handed boomerangs travel and spin with counterclockwise rotation and direction and left-handed boomerangs travel and spin with clockwise rotation and direction), the boomerang will move from vertical to horizontal until precession becomes minimal and the boomerang finishes its flight.

The reason the boomerang comes back to you has to do with its spinning motion, similar to the way a gyroscope or top spins in a circle..


1 in.
2 in.
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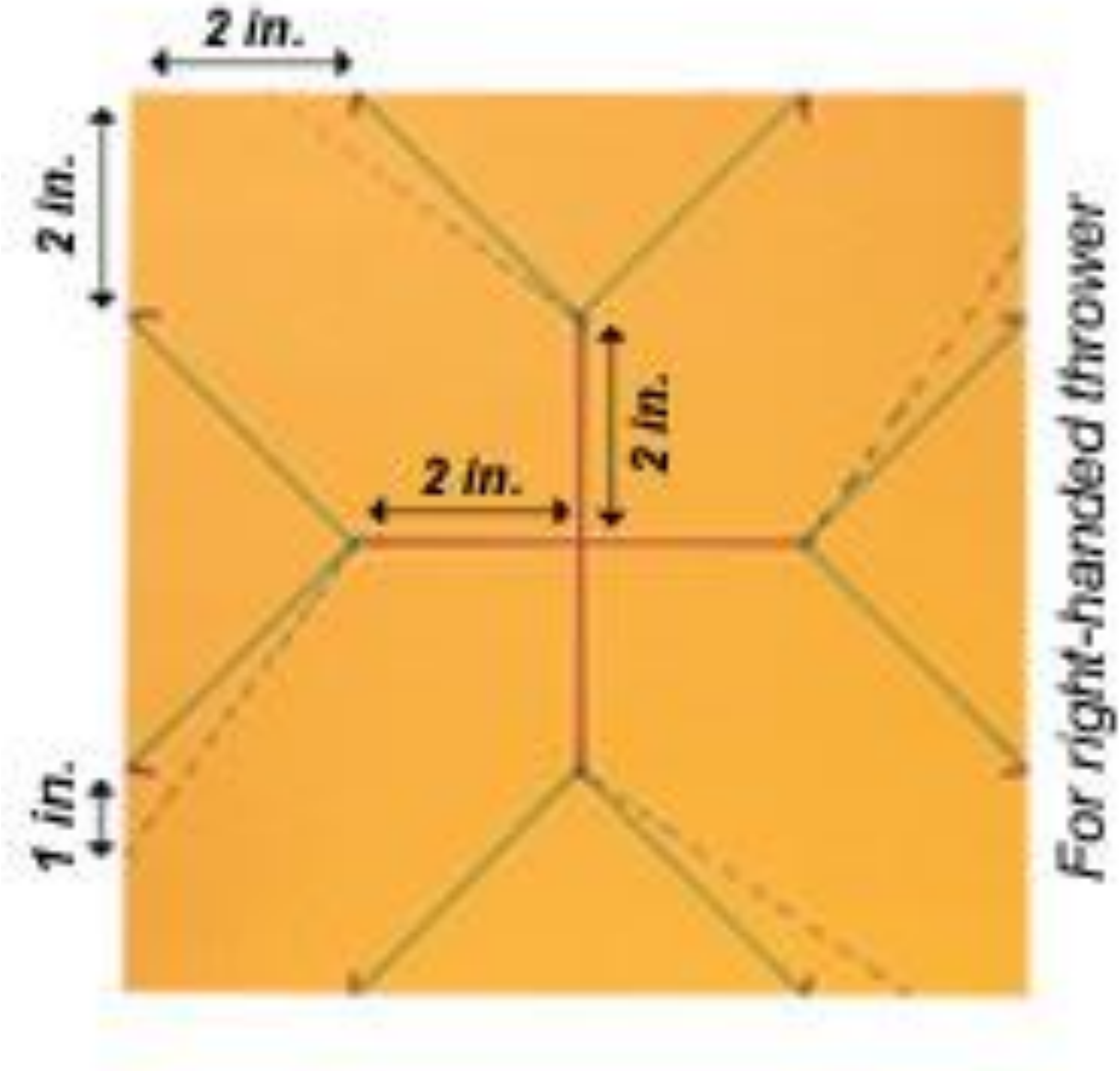
For left-handed thrower


2 in.
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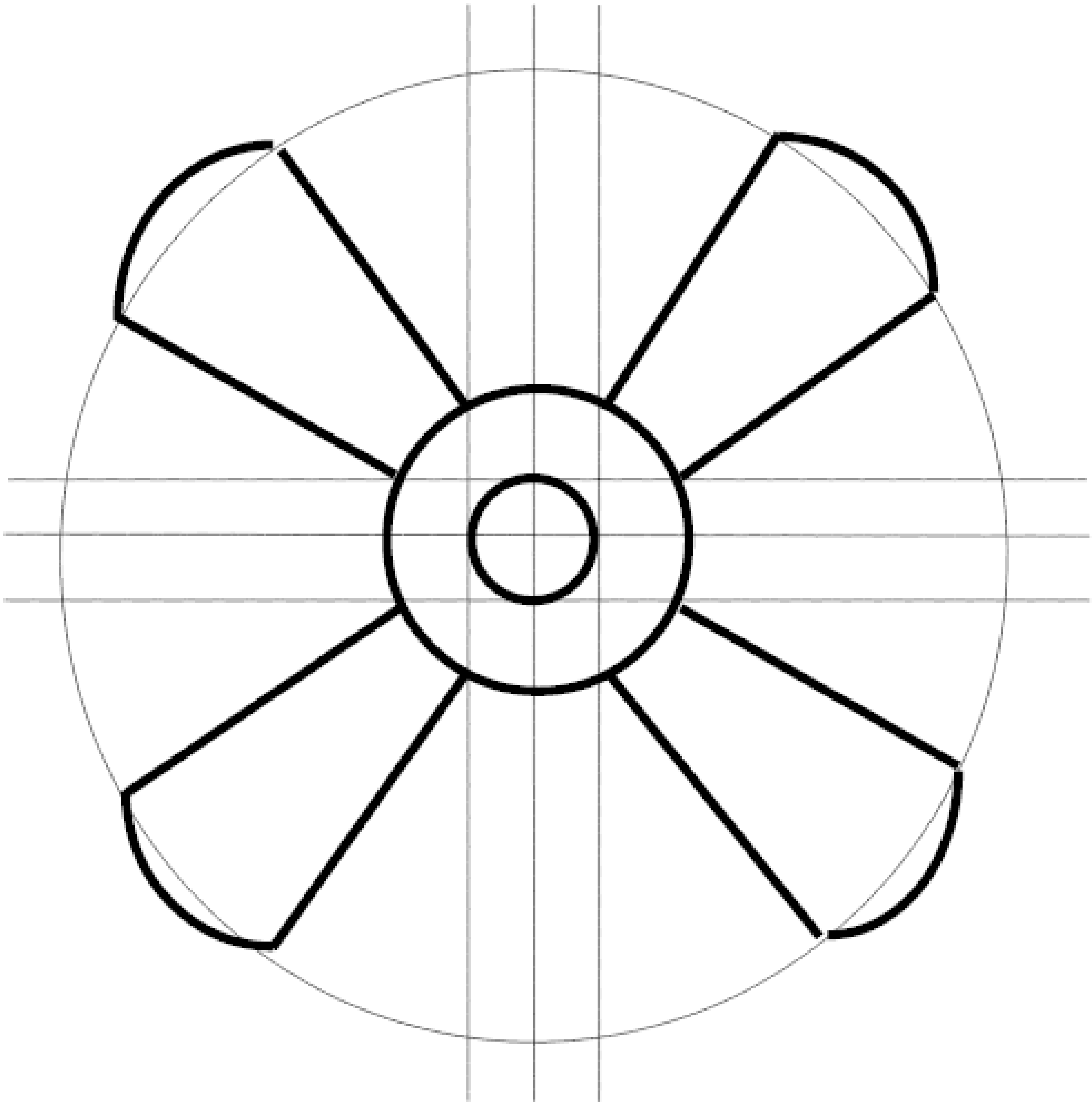
2 in.
2 in.
1 in.
For right-handed thrower



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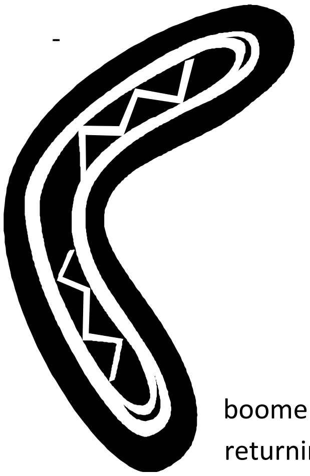
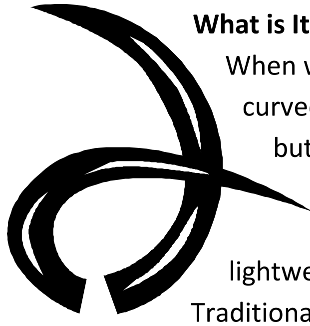




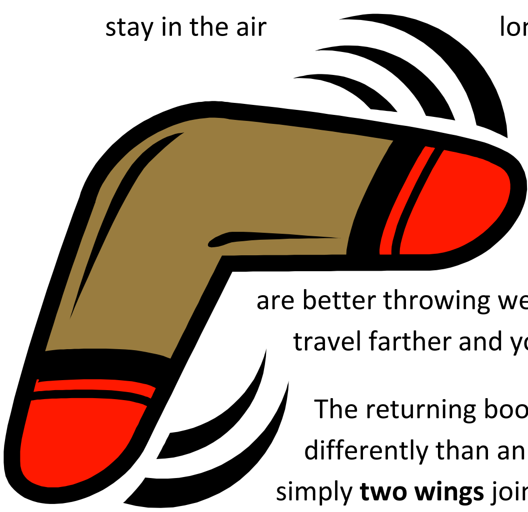
What is It?

When we talk about boomerangs, we usually mean the curved devices that return to you when you throw them, but there are actually two different kinds of boomerangs. The kind we're all familiar with, **returning boomerangs**, are specially crafted, lightweight pieces of wood, plastic or other material. Traditionally, these are basically two wings connected together in one banana-shaped unit, but you can find a number of different boomerang designs available these days, some with three or more wings. Most returning boomerangs measure 1 to 2 feet (30 to 60 cm) across, but there are larger and smaller varieties. When thrown correctly, a returning boomerang flies through the air in a **circular path** and arrives back at its starting point.

Returning boomerangs are not suited for hunting -- they are very hard to aim, and actually hitting a target would stop them from returning to the thrower, pretty much defeating the purpose of the design. Returning boomerangs evolved out of **non-returning boomerangs**. These are also curved pieces of wood, but they are usually heavier and longer, typically 3 feet (1 meter) or more across. Non-returning boomerangs do not have the light weight and special wing design that causes returning boomerangs to travel back to the thrower, but their curved shape does cause them to fly easily through the air. Non-returning boomerangs are effective **hunting weapons** because they are easy to aim and they travel a good distance at a high rate of speed. There is also such a thing as a **battle boomerang**, which is basically a non-returning boomerang used in hand-to-hand combat.

Why Does It Fly?

If you throw a straight piece of wood that's about the same size as a boomerang, *(demonstrate this idea for the students)* it will simply keep going in one direction, turning end over end, until gravity pulls it to the ground. So the question is, why does changing the shape of that piece of wood make it stay in the air longer and travel back to you?

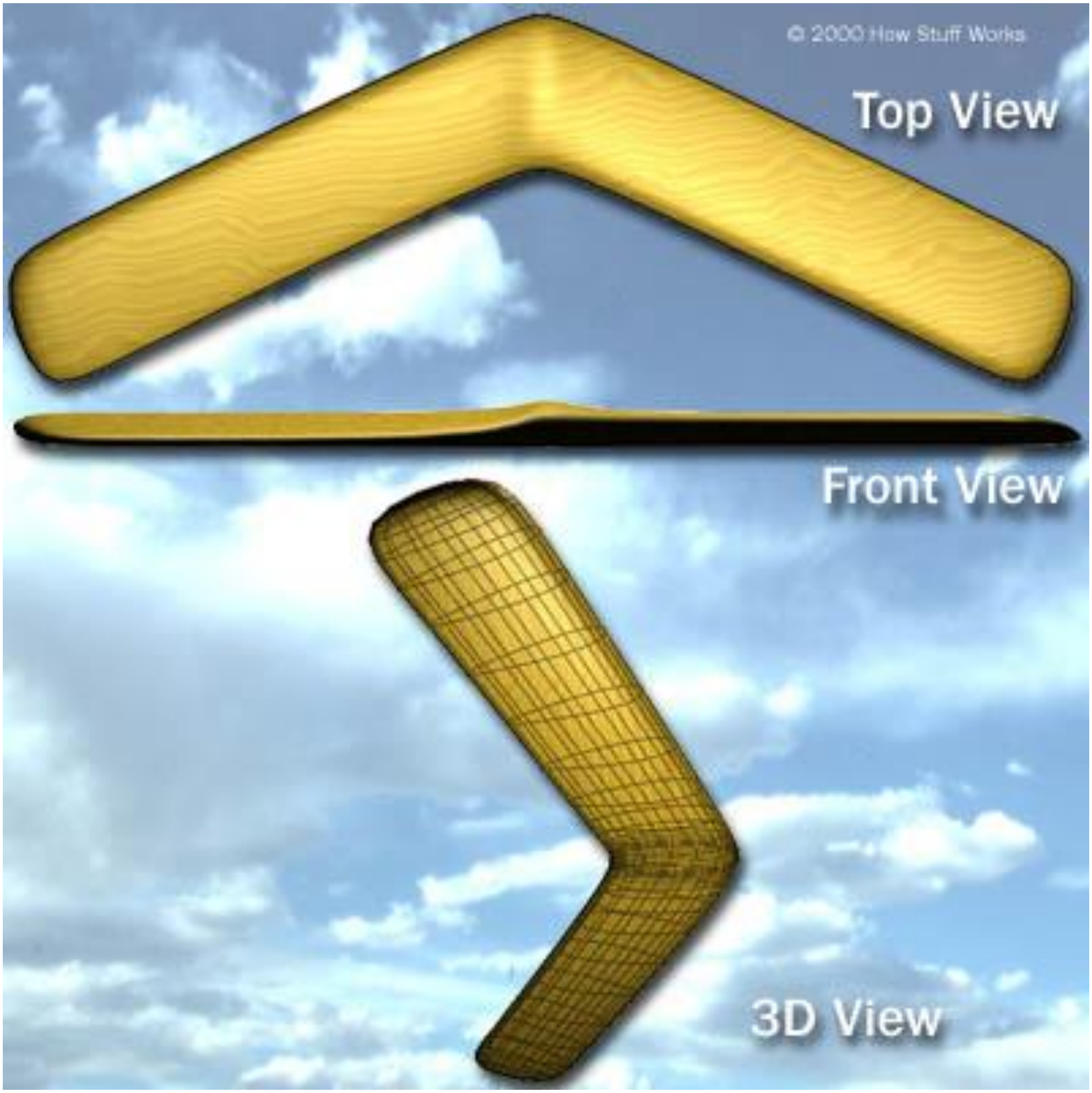


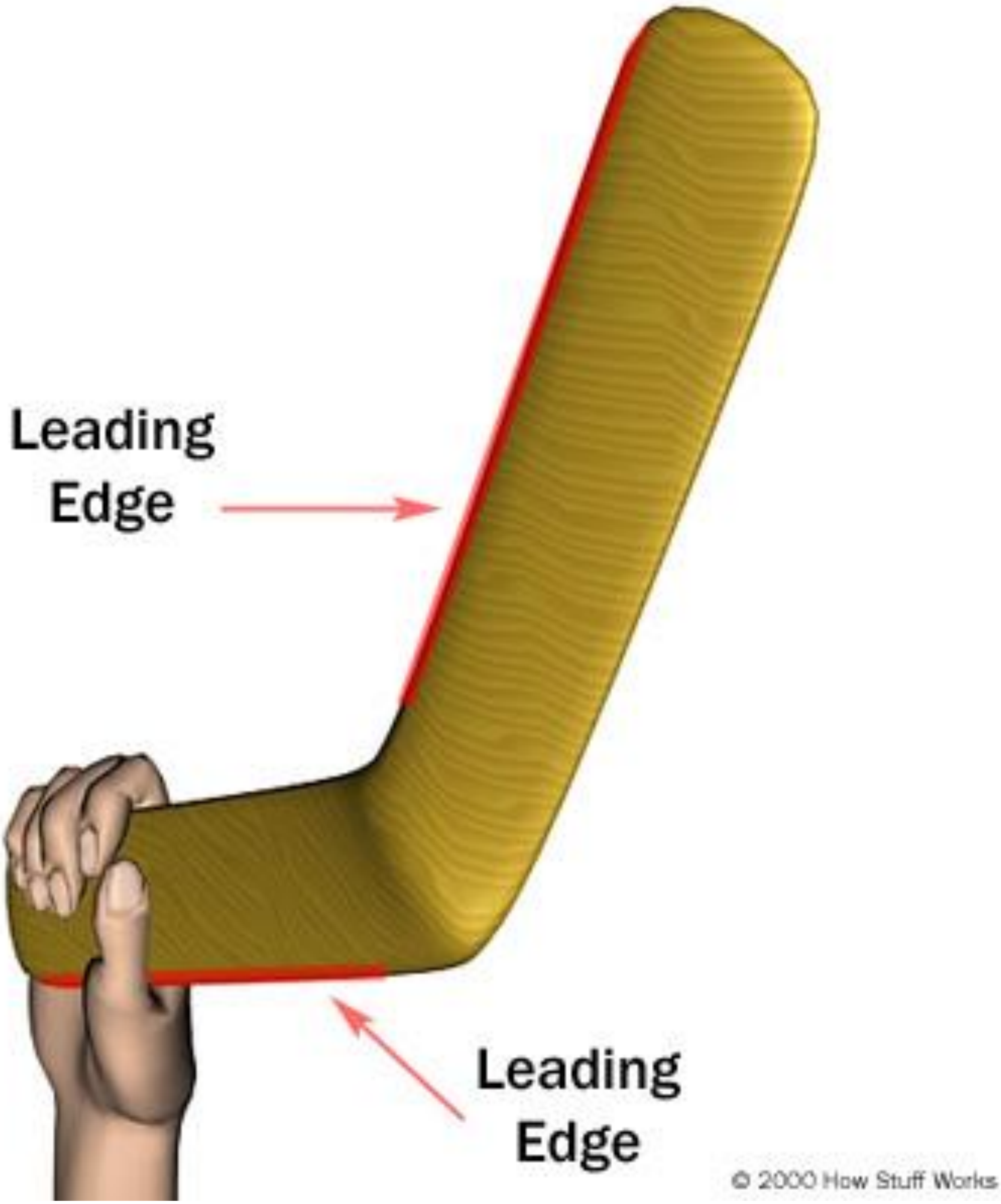
The first thing that makes a boomerang different from a regular piece of wood is that it has at least two component parts, whereas a straight piece of wood is only one unit. This makes the boomerang spin about a **central point**, stabilizing its motion as it travels through the air. Non-returning boomerangs are better throwing weapons than straight sticks because of this stabilizing effect: They travel farther and you can aim them with much greater accuracy.

The returning boomerang has specialized components that make it behave a little differently than an ordinary bent stick. A classic banana-shaped boomerang is simply **two wings** joined together in a single unit. This is the key to its odd flight path.

The wings are set at a slight **tilt** and they have an **airfoil** design -- they are rounded on one side and flat on the other, *(show the students the following picture and ask them what they think it looks like)* just like an airplane wing. this design gives a wing **lift**. The air particles move more quickly over the top of the wing than they do along the bottom of the wing, which creates a difference in air pressure. The wing has lift when it moves because there is greater pressure below it than above it.

A boomerang is two wings combined in one unit.


© 2000 How Stuff Works
Top View
Front View
3D View


Leading
Edge
Leading
Edge
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As you can see in the previous diagram, the two wings are arranged so that the leading edges are facing in the same direction, like the blades of a **propeller**. Basically, a boomerang is just a propeller that isn't attached to anything. Propellers, like the ones on the front of an airplane or the top of a helicopter, create a forward force by spinning the blades, which are just little wings, through the air. This force acts on the **axis**, the central point, of the propeller. To move a vehicle like a plane or helicopter, you just attach it to this axis.

The leading edges of the two wings face in the same direction, like the blades of a propeller.

The classic boomerang's propeller axis is only imaginary, isn't attached to anything, but the propeller itself is moved by the forward force of the wings' lift. It would be reasonable to assume, then, that a boomerang would simply fly off in one direction as it spun, just as a plane with a spinning propeller will move in one direction. If you held it horizontally when you threw it, as you do with a Frisbee, you would assume that the forward motion would be up because that's the direction the axis is pointing -- the boomerang would fly up into the sky like a helicopter taking off, until it stopped spinning and gravity pulled it down again. If you held it **vertically** when you threw it, which is the proper way to throw a boomerang, it seems that it would simply fly off to the right or left. But obviously this isn't what happens.

Let's see why a boomerang turns and comes back to you.

Why Does It Come Back?

Unlike an airplane or helicopter propeller, which starts spinning while the vehicle is completely still, you *throw* the boomerang, so that in addition to its spinning propeller motion, it also has the motion of flying through the air to power it.

Tell students, look at your boomerang and spin it, whichever wing is at the top of the spin at any one time ends up moving in the same direction as the forward motion of the throw, while whichever wing is at the bottom of the spin is moving in the opposite direction of the throw. This means that while the wing at the top is *spinning* at the same speed as the wing at the bottom, it is actually moving through the air at a higher rate of speed.

When a wing moves through the air more quickly, more air passes under it. This makes that wing rise because the wing has to exert more force to push down the increased mass. So, it's as if somebody were constantly giving the blade a push at the top of every spin.

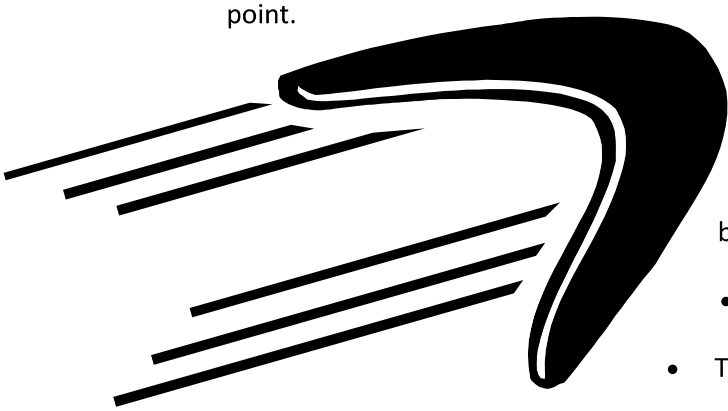
But everybody knows that when you push something from the top, say a chair, you tip the thing over and it falls to the ground. Why doesn't this happen when you push on the top of a spinning boomerang?

*(draw a diagram of the following for the students on the board)*When you push on one point of a spinning object, such as a wheel, airplane propeller or boomerang, the object doesn't react in the way you might expect. When you push a spinning wheel, for example, the wheel reacts to the force as if you pushed it at a point **90 degrees off** from where you actually pushed it. To see this, roll a bicycle wheel along next to you and push on it at the top. The wheel will turn to the left or right, as if there were a force acting on the front of the wheel. This is because with a spinning object, the point you push isn't stationary, it's constantly moving. You applied the force to a point at the top of the wheel, but that point immediately moved around to the front of the wheel while it was still feeling the force you applied. There's a sort of delayed reaction, and the force actually has the strongest effect on the object about 90 degrees off from where it was first applied.

In this scenario, the wheel would quickly straighten out after turning slightly because as the **point of force** rotates around the wheel, it ends up applying force on opposite ends of the wheel, which balances out the effect of the force. But constantly pushing on the top of the wheel would keep a steady force acting on the front of the wheel. This force would be stronger than the **counterbalancing** forces, so the wheel would keep turning, traveling in a circle.

If you've ever steered a bicycle without using the handlebars, you've experienced this effect. You shift your weight on the bicycle so that the top of the wheel moves to the side, but every bicycle rider knows that the bike doesn't tip over as it would if it were standing still, but turns to the right or left instead.

This is the same thing that is happening in a boomerang. The uneven force caused by the difference in speed between the two wings applies a **constant force** at the top of the spinning boomerang, which is actually felt at the leading side of the spin. So, like a leaning bicycle wheel, the boomerang is constantly turning to the left or right, so that it travels in a circle and comes back to its starting point.



How Do I Throw One?

As we've seen, there are several forces acting on a boomerang as it spins through the air. We know that the boomerang is affected by:

- The force of **gravity**
- The force caused by the **propeller motion**
- The force of **your throw**
- The force caused by the **uneven speed of the wings**
- The force of any **wind** in the area

So there are five variables involved in a boomerang flight. For a boomerang to actually travel in a circle and come back to its starting point, all of these forces have to be balanced in just the right way. To accomplish this, you need a well-designed boomerang and a correct throw. In cartoons, the boomerang takes care of all the work and pretty much anyone can get the boomerang to return on the first try. Any boomerang enthusiast will tell you, however, that the only way to consistently make good throws is to practice good technique. In this section, we'll give you the basics so you can get started on perfecting your throw.

1. Your first instinct when you pick up a boomerang may be to throw it like a Frisbee. If you do this, the force of the propeller motion will launch the boomerang up into a vertical arc instead of into a horizontal arc right above the ground. The correct way to hold a boomerang is at a slight angle, say 15 to 20 degrees, from vertical. This will aim the force of the propeller up just enough to balance the force of gravity so that the boomerang isn't pulled to the ground before it can make a complete circle.

2. Hold the boomerang with the V-point, called the **elbow**, pointing toward you, and with the flat side facing out. Hold the boomerang at the end of the bottom wing, with a light pinch-like grip. This boomerang is designed for a right-handed person -- when you hold it correctly with your right hand, the curved edge is on the left and the top wing's leading edge is facing away from you. It probably won't travel back to you if you throw it with your left hand. If you are left-handed, make sure you get a left-handed boomerang -- one that is a mirror image of the boomerang in this illustration. Colorado Boomerangs sells a variety of boomerang styles, and the company says that every model is available in a left-handed version. If you are throwing with your left hand, hold the boomerang so that it is tilted to the left, with the curved side facing to the right. A right-handed boomerang will travel in a counter-clockwise circle and a left-handed boomerang will travel in a clockwise circle.

3. To keep the wind from forcing the boomerang off course, you should aim the boomerang at a point about 45 to 50 degrees to one side from the direction of the wind (stand facing the wind and rotate about 45 degrees clockwise or counter-clockwise). Adjust the position of the boomerang depending on how much wind there is, as shown in the diagram.

4. When you have set your grip on the boomerang and you have oriented yourself in relation to the wind, bring the boomerang back behind you and snap it forward as if you were throwing a baseball. It is very important to snap your wrist as you release the boomerang so that it has a good spin to it. **Spin** is the most important thing in a boomerang throw -- it's what makes the boomerang travel in a curved path.

5. When you throw the boomerang vertically, the uneven force on the top of the spin tilts the axis down gradually, so it should come back to you lying down horizontally, as a Frisbee would. But don't try to catch it with one hand -- the spinning blades could really hurt you. The safe way to catch a returning boomerang is to clap it between your two hands. Always be careful when playing with a boomerang, especially a heavier model. When you throw the boomerang, you must keep your eye on it at all times or it could hit you on the return. If you lose track of its path, duck and cover your head rather than trying to figure out where it is. Boomerangs move quickly, with a lot of force.

Your first attempt will probably end up on the ground, as will your second and third, so don't try to learn with an expensive hand-carved model -- pick up a cheap plastic design at the toy store. Boomeranging is a difficult skill, but it can be a lot of fun to practice. It's certainly a satisfying accomplishment when the boomerang actually comes right back to you and you catch it perfectly!

How Was It Invented?

Boomerangs make perfect sense once you understand all of the physical forces at work, but it doesn't seem like something early man would suddenly come up with out of the blue. So how on earth did this amazing invention come about? Anthropologists believe it was mostly a matter of trial and error.

First let's consider how a primitive hunter might have come up with a non-returning boomerang. We know that at some point people started using the rocks and sticks they found around them as crude tools. One very early invention was the club, which is just a stick that you hit something or somebody with. Hurling a club to hit somebody is just a slight extension of this basic tool, so it's not a stretch to suppose that this was a common use of the club.

A classic boomerang design, hand-crafted by Australian Aborigines

In nature, there are plenty of sticks that are bent in a curve like a boomerang, and people probably threw these sorts of sticks all the time. Because of the stabilizing motion of the two branches of the stick, this sort of stick would have stayed aloft longer and would have been easier to send in the desired direction. People noticed this, and so they started specifically seeking out bent sticks when they wanted to throw a club at their target. Then they started selecting the best curved sticks (thinner, longer ones work better) and were soon customizing sticks so they were especially suited for taking down prey. Non-returning boomerangs have been found all over the world. The oldest known non-returning boomerang, an artifact found in Poland, dates from about 20,000 years ago.

The experts aren't really sure when and where people first developed returning boomerangs, but the Aborigines of Australia are generally credited with the invention. Aborigines used non-returning boomerangs, which they call **kylies**, extensively in hunting, and the theory is that at some point, one or more Aborigines used a kylie with the particular shape of a boomerang and noticed that it traveled in an arc. This might have been pure accident or it might have been the result of design experimentation. One theory is that an Aboriginal hunter fashioned a smaller kylie with a more angled curve because he or she noticed how a bird held its wings in a pronounced V shape while soaring through the air.

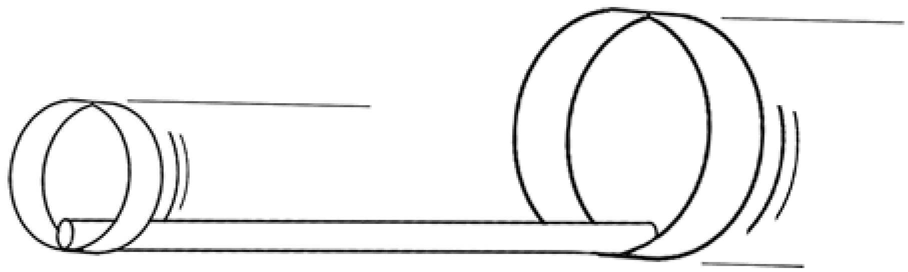
The amazing flight pattern of the new discovery didn't really help out much in taking down prey -- it actually made it harder to aim accurately -- but it was, of course, really cool. Evidently, the Aborigines perfected the boomerang design and throwing technique for the simple pleasure of it, and the boomerang has mostly been used as sports equipment ever since then. The standard game is to see who can throw the boomerang the farthest and still catch it on its return. The boomerang did have some limited use in hunting, however. The Aborigines would set up nets in trees and then throw the boomerang into the air while making a hawk call. This would scare flocks of birds so they would fly down into the nets.

The boomerang is actually the first man-made flying machine, and so it is the direct predecessor of the airplane, helicopter, blimp -- even the space shuttle! It's amazing that a hunk of wood can make such effective use of complex principles of physics -- so amazing that it really seems like magic until you understand what's happening. The boomerang is a great learning tool for anyone interested in physics, and it is certainly one of the most remarkable toys in history!

Experiment: The Incredible Hoop Glider!

Can other strange looking flying objects besides boomerangs fly well too?

Objectives:



Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Design, test and modify a flying object of their own design using the principles of flight they have learned

Key Terms:

- Inertia
- Center of Gravity
- Lift
- Airfoil
- Air Particles
- Speed
- Motion
- Pressure
- Velocity
- Force
- Shape
- Surface
- Flight
- Propeller
- Balance
- Axis
- Wing
- Airflow
- Design
- Vertical
- Horizontal
- Physics
- Leading Edge
- Trailing Edge

Test it out: Have students try the following experiment and then design their own UFO!

•A regular plastic drinking straw

•3 X 5 inch index card or stiff paper

•Tape

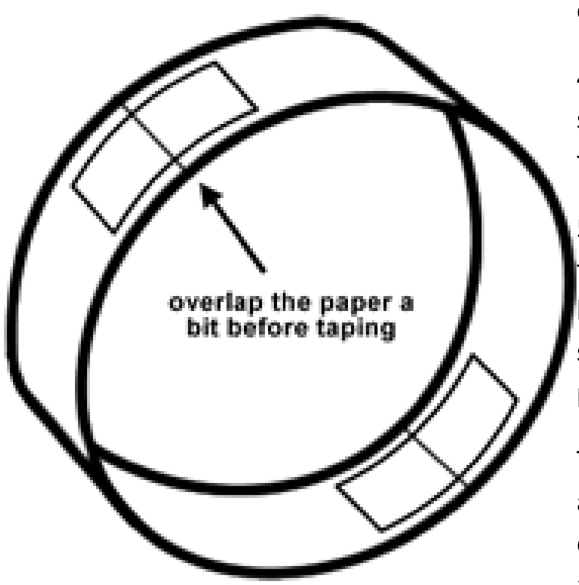
•Scissors

Throw a straw. Ask students what happened, then ask them how they can get a straw to fly. Have students come up with ideas (and test them) Tell students you have an idea. Then draw a diagram of the hoop glider. Have students form a hypothesis whether or not this design will be effective. Have students build the Hoop Glider and test it. Were there hypothesis correct? What do they think is happening?

Can we really call that a plane? It may look weird, but you will discover it flies surprisingly well. The two sizes of hoops help to keep the straw balanced as it flies. The big hoop creates "drag" (or air resistance) which helps keep the straw level while the smaller hoop in at the front keeps your super hooper from turning off course. Some have asked why the plane does not turn over since the hoops are heavier than the straw. Since objects of different weight generally fall at the same speed, the hoop will keep its "upright" position.

1. Cut the index card or stiff paper into 3 separate pieces that measure 1 inch (2.5 cm) by 5 inches (13 cm.)

2. Take 2 of the pieces of paper and tape them together into a hoop as shown. Be sure to overlap the pieces about half an inch (1 cm) so that they keep a nice round shape once taped.



3. Use the last strip of paper to make a smaller hoop, overlapping the edges a bit like before.

4. Tape the paper loops to the ends of the straw as shown below. (notice that the straw is lined up on the inside of the loops)

5. That's it! Now hold the straw in the middle with the hoops on top and throw it in the air similar to how you might throw a dart angled slightly up. With some practice you can get it to go farther than many paper airplanes.

The project above is a DEMONSTRATION. To make it a true experiment, students can try to answer these questions, coming up with their own theories, and additional questions to answer:

1. Have students change their glider so that it flies the longest possible distance. What happens if they make the straw smaller?
2. What happens if you change the size of the hoops?

3. Or, what happens if you add a third hoop?
4. Does the placement of the hoops on the straw affect its flight distance?
5. Does the length of straw affect the flight? (You can cut the straws or attach straws together to test this)
6. Do more hoops help the hoop glider to fly better?
7. Do the hoops have to be lined up in order for the plane to fly well?

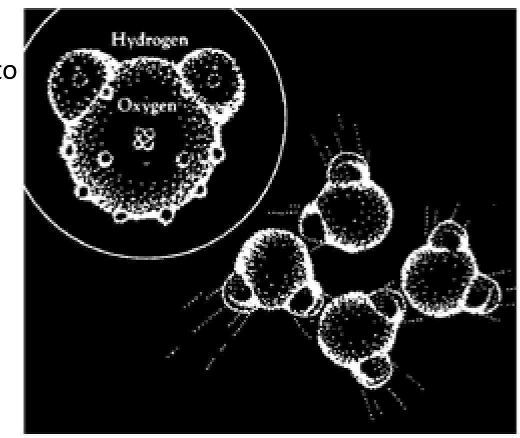
Elements & Molecules

Bubbleology

Helping Students Discover Why Bubbles Are the Way They Are

What is so fascinating about bubbles? Why do we love to chase them and create them and pop them as soon as we can? Is it the precise spherical, round ball, shape, the incredibly fragile nature of the thin soap film, the beautiful colors that swirl and shimmer, or most likely, a combination of all these? Why does a bubble form a sphere at all? Why not a cube, tetrahedron, or other geometrical shape? Let's find out together.

If you could see molecules (the tiny pieces that make up everything) of water and how they act, you would notice that each water molecule attracts or pulls on its neighbors. Each has two hydrogen atoms and one oxygen atom, which is what H20 stands for. The extraordinary stickiness of water, the reason it pulls together, is due to the two hydrogen atoms, which are on one side of the molecule and are attracted to the oxygen atoms of other nearby water molecules. This attraction is called "hydrogen bonding." If the molecules of a liquid did not attract one another, then the constant movement of the molecules would cause the liquid to instantly boil or evaporate and we would never get a drink!

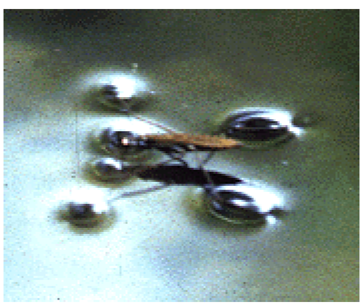


Of course in the liquid form of water, the molecules have too much energy to become locked together permanently; nevertheless, the numerous temporary "hydrogen bonds" between molecules make water an extraordinarily sticky fluid. (The hydrogen atoms are "attached" to one side of the oxygen atom, resulting in a water molecule having a positive charge on the side where the hydrogen atoms are and a negative charge on the other side, where the oxygen atom is. Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky." All these water molecules attracting each other mean they tend to clump together. This is why water drops are, in fact, drops! If it wasn't for some of Earth's forces, such as gravity, a drop of water would be ball shaped -- a perfect sphere.

Within the water, at least a few molecules away from the surface, every molecule is engaged in a game of tug of war with its neighbors on every side. For every "up" pull there is a "down" pull, and for every "left" pull there is a "right" pull, and so on, so that any given molecule feels no net force at all because it is being pulled in every direction at the same time.

At the surface things are different. There is no up pull for every down pull, since of course there is no liquid above the surface; thus the surface molecules tend to be pulled downward, back into the liquid. It takes work to pull a molecule up to the surface. If the surface is stretched - as when you blow up a bubble - it becomes larger in area, and more molecules are dragged from within the liquid to become part of this increased area. This "stretchy skin" effect is called surface tension. Surface tension plays an important role in the way liquids behave. If you fill a glass with water, you will be able to add water above the rim of the glass because of surface tension pulling all the molecules back down so they don't fall over the sides. (Test it out) Or add lots of drops of water to the top of a penny!

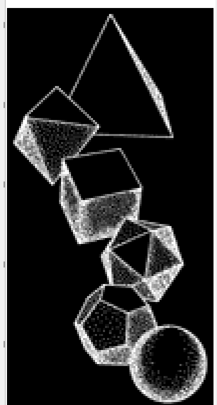
You can float a paper clip on the surface of a glass of water. Before you try this you should know that it helps if the paper clip is a little greasy so the water doesn't stick to it (rub it on your nose or forehead.) Place the paper clip on a fork and lower it slowly into the water. The paper clip is supported by the surface-tension skin of the water.



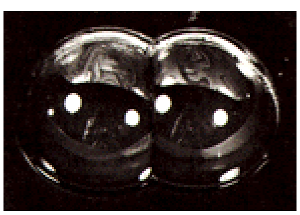
The water strider is an insect that hunts its prey on the surface of still water; it has widely spaced feet. The skin-like surface of the water is pushed down under the water strider's feet.

The Shape of a Bubble

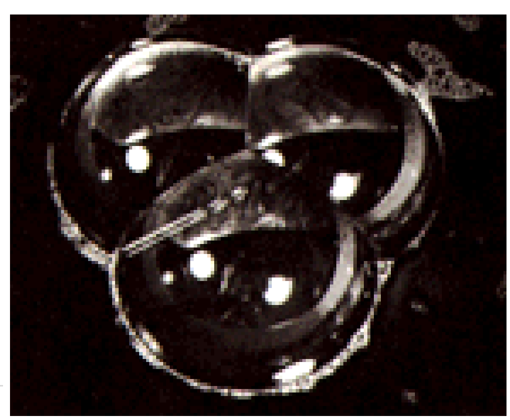
A bubble, like a balloon, is a very thin skin surrounding air. The rubber skin of the balloon is elastic and stretches when inflated. If you let the mouthpiece of the balloon go free, the rubber skin squeezes the air out of the balloon and it deflates as it flies around the room. The same thing happens if you start blowing a bubble and then stop. The liquid skin of the bubble is stretchy and like a balloon it pushes the air out of the bubble, leaving a flat circle of soap in the bubble wand. Unlike a sheet of rubber that loses all tension when you let it go, a bubble always has its "stretch" no matter how small the surface becomes. If you blow a bubble and close the opening by flipping the wand over, the tension in the bubble skin tries to shrink the bubble into a shape with the smallest possible surface area that will hold the amount of air it contains. That shape always happens to be a sphere.

	Shape	# of sides	Volume	Surface Area
	Tetrahedron	4	1 cubic inch	7.21 square inches
	Cube	6	1 cubic inch	6 square inches
	Octahedron	8	1 cubic inch	5.72 square inches
	Dodecahedron	12	1 cubic inch	5.32 square inches
	Icosahedron	20	1 cubic inch	5.15 square inches
	Sphere	infinite	1 cubic inch	4.84 square inches

When Bubble Meets Bubble

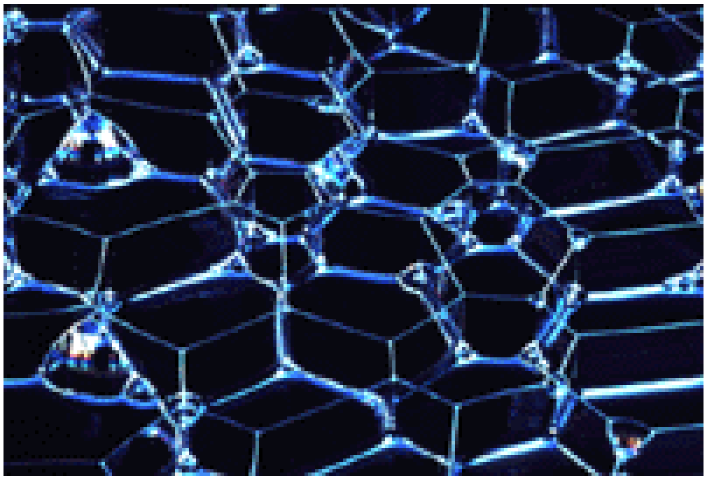


When one bubble meets with another, the resulting union is always one of total sharing and compromise (Human beings could learn a lot from bubbles.) Since bubbles always try to minimize surface area two bubbles will join together and share a common wall. If the bubbles on the right are the same size as the bubbles to the left, this wall will be flat. If the bubbles are different sized, the smaller bubble, which always has a higher internal pressure, will bulge into the larger bubble.



Regardless of their relative sizes, the bubbles will meet the common wall at an angle of 120 degrees. This is easy to see in the bubble picture to the right. All three bubbles meet at the center at an angle of 120 degrees. Although the mathematics to prove this would take more time than we want to spend right now, the 120 degree rule always holds, even with complex bubble collections like foam.

If you take two sheets of clear glass or plastic separated by about one-half inch, soak them in soapy solution and then blow bubbles between the sheets, you will get many bubble walls. If you look closely, you will notice that all of the vertices where three bubble walls meet (and there are always three,) form 120 degree angles. If your bubbles are all the same size, you will notice that the cells form hexagons and start to look much like the cells of a beehive. Bees, like bubbles, try to be as efficient as possible when making the comb. They want to use the minimum possible amount of wax to get the job done. Hexagonal cells are the answer.

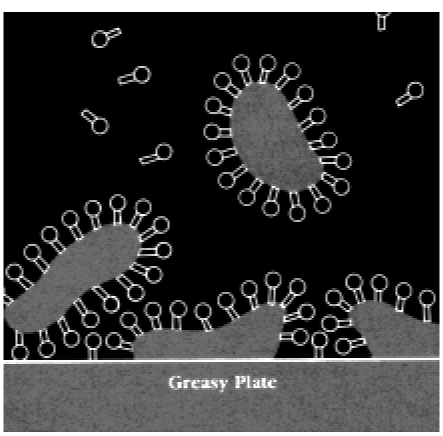


Soap

Have you ever tried to blow a bubble with pure water? It won't work. Try it for yourself. There is a common misconception that water does not have the necessary surface tension to maintain a bubble and that soap increases it, but in fact soap decreases the pull of surface tension - typically to about a third that of plain water. In fact, detergent molecules will cover the surface of a bubble and let it get a lot bigger without breaking. A soap bubble is actually a sandwich with air on the inside: a layer of soap molecules, a layer of water and finally another layer of soap molecules. The inner and outer layers of soap molecules can stretch really far and the water helps hold the bubble together.

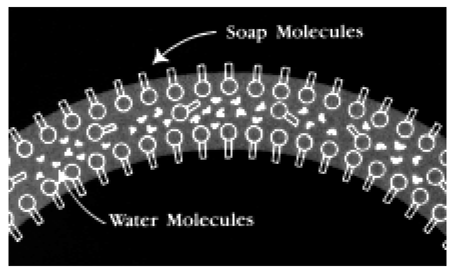
The surface tension (the downward pull of the molecules) in plain water is just too strong for bubbles to last for any length of time. One other problem with pure water bubbles is evaporation: the surface quickly becomes thin,

causing them to pop.



Soap molecules are made of long chains of carbon and hydrogen atoms. At one end of the chain are atoms which like to be in water (hydrophilic—water loving). The other end wants to stay away from water (hydrophobic—afraid of water) but likes grease. In washing, the "greasy" end of the soap molecule attaches itself to the grease on your dirty plate, letting water seep in underneath. The particle of grease is pried loose by the water and surrounded by soap molecules, to be carried off by a flood of water.

In a soap-and-water solution the hydrophobic (greasy) ends of the soap molecule do not want to be in the liquid at all. Those that find their way to the surface squeeze their way between the surface water molecules, pushing their hydrophobic ends out of the water. This separates the water molecules from each other and spreads them apart. This makes the surface tension less because the water molecules are farther apart and can't pull as hard on each other. The water fearing soap molecules decrease the surface tension. If that over-filled cup of water mentioned earlier were lightly touched with a slightly soapy finger, the pile of water would immediately spill over the edge of the cup; the surface tension "skin" is no longer able to support the weight of the water because the soap molecules separated the water molecules, decreasing the pull between them, or in other words, their ability to hold together.



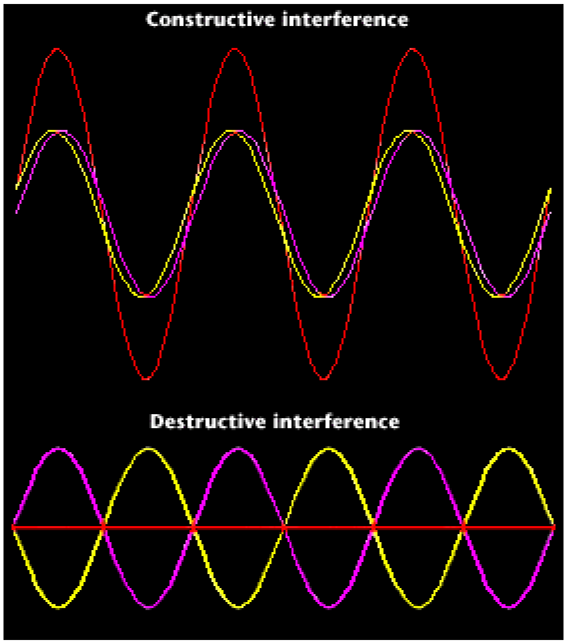
Because the greasy end of the soap molecule sticks out from the surface of the bubble, the soap film is somewhat protected from evaporation (grease doesn't evaporate) which helps the bubble not pop as quickly. A closed container filled with water vapor also slows evaporation and allows bubbles to last even longer. I've blown soap bubbles on a watch glass glued to the bottom of a jar with a large mouth. Once I've sealed the jar the environment will support the bubble for quite a long time. My longest lasting bubble survived for three months! Eiffel Plasterer, a dear departed friend, farmer, educator, and bubble fanatic who lived in Huntington, Indiana blew a bubble that lasted for 342 days!

A Color Full Bubble

Color, one of the most beautiful aspects of bubbles, also provides us with an extremely accurate tool for measuring the thickness of the soap film.

Light waves, like ocean waves, have peaks and valleys, high points and low points, (crests and troughs). Red light has the longest wavelength and violet the shortest.

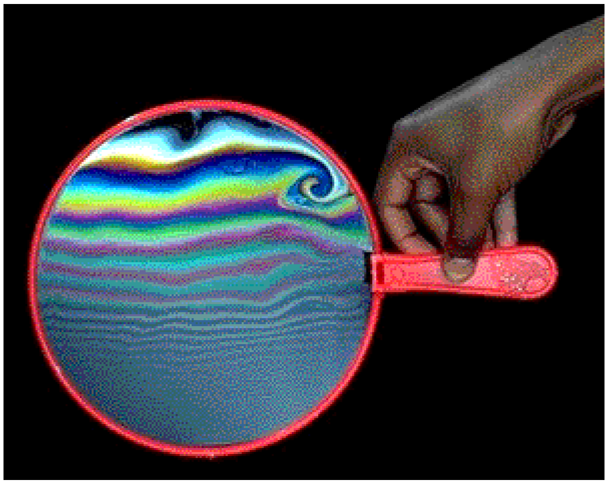
All waves, including light, have a curious property: if two waves combine, the waves can meet each other crest-to-crest, high point to high point, adding up and reinforcing the effect of each other, making the color brighter, or they can meet crest-to-trough, high point to low point, cancelling each other out so that they have no effect, where you won't see that color, but you'll see it's complement on the color wheel. When they meet crest-to-trough, for every "up" vibration in one wave, there is a corresponding "down" vibration in the other wave. This combination of equal ups and downs causes complete cancellation or interference. Interference is responsible for the pearly luster of an abalone shell, the beautiful colors in some bird feathers and insect wings, and the flowing patches of color in an oil slick on the street after a rain shower - and for the color of bubbles.



If the crests of two or more waves are in step (yellow and magenta waves top), or almost in step, they can combine into a larger or more intense effect (red wave top.) This is called "constructive interference." If the crest of one wave meets the valley of another (yellow and magenta waves bottom), they cancel each other out (red wave bottom.) When two light waves cancel each other, the result is darkness and this is called "destructive interference."

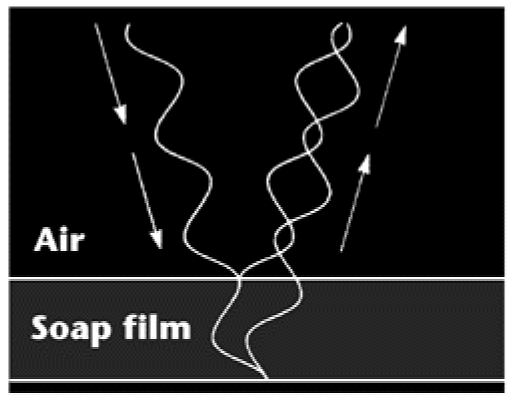
White light is made up of all colors, all wavelengths. If one of these colors is subtracted from white light (by interference, for instance) we see the complementary color. For example, if blue light is subtracted from white light, we see yellow. The skin of a bubble glistens with the complementary colors produced by interference. If we were to look at a highly magnified portion of a soap bubble membrane, we would notice that light reflects off both the front (outside) and rear (inside) surfaces of the bubble, but the ray of light that reflects off the inside surface travels a longer distance than the ray which reflects from the outside surface. When the rays recombine they can get "out of step" with each other and interfere. Given a certain thickness of the bubble wall, a certain wavelength will be cancelled and its complementary color will be seen. Long wavelengths (red) need a thicker bubble wall to get out of step than short wavelengths (violet). When red is cancelled, it leaves a blue-green reflection. As the bubble thins, yellow is cancelled out, leaving blue; then green is cancelled, leaving magenta; and finally blue is cancelled, leaving yellow. Eventually the bubble becomes so thin that cancellation occurs for all wavelengths and the bubble appears black against a black background.

This surprising complete cancellation is due to the different way light reflects from the two surfaces. When light reflects from the outside surface of the bubble (an air-to-water surface) the direction of vibration of the wave is reversed - all "up" vibrations are turned into "down" vibrations and vice versa. (The same thing happens if you send a vibration along a rope tied to a wall; the reflected pulse is upside-down after reflection from the wall.) When light reflects from the inside surface of the bubble (a water-to-air surface) the direction of the vibration is not changed. If the skin of the bubble is very thin, much shorter than the wavelength of visible light, then the two reflected rays of light will always meet crest-to-trough and destructively interfere. There will be no visible reflection, and the bubble looks black. When you see this happening at the top of a soap bubble you know the bubble is only about one millionth of an inch thick and will soon pop.



The alternating bands of light and dark on this soap film are actually bands of color, produced by the reflection and interference of light waves. The colors depend upon the film's thickness. The film shown here is thinnest at the top, becoming thicker toward the bottom. As the film's thickness changes, the colors also change, forming regular bands.

White light is separated into colors as it reflects from the two surfaces of a thin film. Where the two reflections interfere constructively, they produce a band of color. Where they cancel each other, that color is subtracted from the spectrum.



If you let a bubble hang from a bubble wand for awhile, the interference colors begin This soap film is forming horizontal stripes - because the bubble film is thicker at the bottom than at the top, forming a wedge shape. As the bubble drains, the wedge of bubble solution gets thinner and thinner. The black film which then appears at the top of the bubble is a harbinger of an upcoming disaster. The bubble is now so thin only a few moments remain until. . .POP!

Experiment: Bouncing Bubbles

There's something magical about a bubble. It's just a little puff of air trapped in a thin film of soap and water, but its precise spherical shape and beautiful, swirling colors make it a true wonder of science. A bubble's life expectancy is usually measured in seconds unless you know how to make a SUPER BUBBLE!

Objectives:

Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Study the characteristics of bubbles and learn to manipulate them to gain the desired result

Key Vocabulary

- Surface tension
- Grease
- Dirt
- Absorb
- Fragile
- Soap Film
- Bubble
- Color
- Molecules
- Skin/Membrane
- Evaporation
- Light
- Reflective Surface
- Hydrophobic
- Hydrophilic
- Molecules

Materials

- 1 cup of distilled water (240 mL)
- 2 tablespoons of Dawn® dish soap (30 mL)
- 1 tablespoon of Glycerin (15 mL)
- Make up a batch of Bouncing Bubble Solution (see above).
- Purchase a pair of inexpensive children's gloves from your local department store (100% cotton gloves or socks also work well).
- Blow a bubble about the size of a baseball.
- Bounce the bubble off of your gloves or socks. Try bouncing the bubble off of your shirt or pants. As you'll soon see, some fabrics work better than others. Have students discover and test what materials work best after making hypothesis on which ones they think will work best.
- Have students determine what makes bubbles break and why they won't on gloves, etc. What are a bubble's enemies?

About the Ingredients...

Water - The single most important part of the bubble solution is the water. Good quality water that does not contain high levels of iron or minerals is best. If you're uncertain as to the quality of your tap water, invest in a gallon of distilled water from the grocery store.

Soap - When it comes to soap, Dawn® dish soap just seems to work the best for home-made bubble solutions.

Glycerin - Glycerin is the secret additive that gives a bubble its extra strength. Don't be too shocked by the price on a bottle of high quality Glycerin. Contact the pharmacist at your local grocery store for availability. (Note: Some bubble recipes substitute Karo® Syrup for Glycerin due to the expense and availability of Glycerin.)

Bubble Colors - Similar to the way we perceive the colors in a rainbow or an oil slick, we see the colors in a bubble through the reflection and the refraction of light waves off the inner and outer surfaces of the bubble wall. You can't color a bubble since its wall is only a few millionths of an inch thick. A bubble reflects color from its surroundings.

Bouncing Bubbles - Experience tells you that regular bubbles burst when they come in contact with just about anything. Why? A bubble's worst enemies are oil and dirt. A "super" bubble will bounce off of a surface if it is free of oil or dirt particles that would normally breakdown the soap film.

Experiment Extensions: Bubble Mania

Time and again, science has shown us that first impressions can't be trusted. Consider the bubble: At first glance, it looks like the most fragile thing in the world. Yet under the right circumstances, it can be surprisingly difficult, if not impossible, to burst -- as the two tricks here illustrate.

Objectives:

Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Study the characteristics of bubbles and learn to manipulate them to gain the desired result

Key Vocabulary

- Surface tension
- Grease
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- Soap Film
- Bubble
- Color
- Molecules
- Skin/Membrane
- Evaporation
- Light
- Reflective Surface
- Hydrophobic
- Hydrophilic
- Molecules

Materials:

- 8 1/2- by 11-inch sheet of card stock
- Tape
- Scissors
- Bowl and spoon
- 1 cup plus 2 tablespoons water
- 2 tablespoons dishwashing liquid

- 2 tablespoons glycerin (sold at craft and drug stores)
- Plastic drinking straw

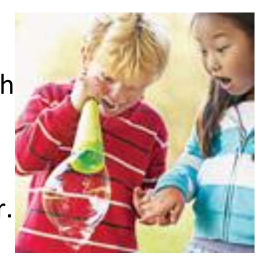
Time needed: Under 1 Hour

1. Make a bubble blower by rolling the card stock into a cone and securing it with tape, as shown. Evenly trim the narrow end so it measures 1/2 inch in diameter. Trim the wide opening to even it too.
2. In the bowl, gently stir together the water, dishwashing liquid, and glycerin, and you're ready to perform the following tricks.
3. **Experiment 1 -- The Unpoppable Bubble:** Dip the wide end of the cone into the bubble solution and hold it there for a few seconds to absorb the mixture. Tap off the excess liquid and then quickly dip the cone again. With the cone pointed toward the ground, gently blow a large bubble. Leave it attached to the end of the cone, using your finger to cover the cone's tip.

4. Now stick the point of the scissors into the bubble. It should pop instantly. Try it again, but this time first dip the scissor points into the bubble solution. They should pass right through the bubble's "delicate" skin without breaking it.
What's Happening: There are two main ways a bubble pops. The first is when its watery wall evaporates (adding some glycerin to the bubble solution slows down this process). The second is when something dry tears a hole in the wall, as when you poke it with the bare points of a pair of scissors. Dipping the blades into the bubble solution beforehand, however, gives them liquid edges, and the bubble wall simply flows around them.

5. **Experiment 2 -- Inside-Out Bubbles:** Blow a large bubble as you did in the first trick.

6. Dip the plastic drinking straw into the liquid (be sure to wet at least 2 inches of it). Insert the end of the straw into the bubble and gently blow to create one or more smaller bubbles inside it.
7. Then watch. The interior bubbles will pass through the skin at the bottom of the large bubble and cling to the outside.



What's Happening: As with the scissors, coating the straw with solution allows you to insert it in the big bubble and blow smaller bubbles inside. But why don't those small bubbles stay in there? Because their proportion of air to liquid is smaller than the bigger bubble's, they are denser. Consequently, they sink and fall through the bottom of the bigger bubble. Still, they don't weigh quite enough to break free completely, so they simply hang in place.

Student Assessment:

Students will write directions in their journals informing another person on how to blow the biggest bubble possible and how to have it last. Students will diagram a bubble and include a description of a Bubble's enemies. Options: Students will work together create a comic about Super Bubble and his enemies (and a possible sidekick) detailing the methods he/she uses to defeat them.

Experiment: Giant Bubbles

Everyone knows that small bubbles are amazing... you can blow them, bounce them, catch them... the fun never ends! But what if you could a make a giant bubble over 1 meter (3 ft) tall? Once you know the secret behind these super bubbles, you can amaze your audience by surrounding them in a human-sized bubble!

Objectives:

Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Apply their knowledge of bubbles to make as large of bubbles as possible

Key Terms:

Key Vocabulary

- Surface tension
- Foam
- Grease
- Dirt
- Absorb
- Fragile
- Soap Film
- Bubble
- Color
- Molecules
- Skin/Membrane
- Evaporation
- Light
- Reflective Surface
- Hydrophobic
- Hydrophilic
- Molecules

Materials

- Pipette or other bubble blowing device
- Dawn dish soap (not anti-bacterial)
- Distilled Water
- Hula Hoops, small and large
- PVC pipe
- String
- Scissors
- Children's swimming pool
- Glycerin (optional)

Bubble Solution Recipe

In the swimming pool mix 19 L (5 gallons) of distilled water with 2.5 L (10 cups) of Dawn® Dish Soap. The best bubble solution ages with time, so allow your mixture to sit overnight before using it. For even stronger bubbles, add 1.2 L (5 cups) of Glycerin to the solution.

Blowing Bubbles with a Pipette

An ordinary plastic eyedropper, called a pipette, makes the perfect bubble blower. Just snip the round end off of the pipette and dip it in the bubble solution. Blow through the skinny end of the pipette and you will get a perfect bubble nearly every time!

Making a Bubble Wall

1. Take two pieces of PVC pipe (available at a hardware store... they will even cut it for you) 30-60 cm (1-2 ft) long.
2. Attach the two pipes with a long loop of string. Thread the string through the top pipe, down into the other pipe and back up to the original pipe. Tie the ends string together. The two pieces of pipe should be hanging about 90 cm (3 ft) apart. Dip the entire contraption into the bubble solution and slowly pull it back out. You will find that the bubble solution is in between the pipes like a bubble wall!
3. If you blow lightly into the wall, a bubble will pop out. Or, try putting your hand in the bubble solution so it is coated with solution. Now, put your hand through the bubble wall.... it goes right through without breaking the wall! Ask students for their ideas on why the bubbles break. Test their ideas out. Guide them in their discussion to discover that when they coated their hand with bubble solution first, the oils on their skin won't break the bubble.
4. You can also try this trick with a small hula hoop. You will have a bubble ring that you can put your hand through or blow out smaller bubbles.
5. Your audience will already be on their feet and you haven't even made it to the grand finale!

GIANT Bubbles

1. Place the larger hula hoop in the bottom of the swimming pool.
2. Ask for one or two brave volunteers to take off their shoes and step into the swimming pool and into the center of the hula hoop.
3. Now, very slowly, and with a steady hand, pull the hula hoop straight out of the pool and to the top of your volunteer(s) head.
4. Before they can say "No way!" Your volunteer is trapped inside a human-sized bubble!
5. Your audience will go wild with applause and you can take your well-deserved bow... after you release your volunteer from their bubble cage!

Have students come up with questions and theories on why bubbles break.

How does it work?

Bubbles form because of the SURFACE TENSION of water. Hydrogen atoms in one water molecule are attracted to oxygen atoms in other water molecules. They like each other so much, they cling together. Normal bubbles enclose the MAXIMUM VOLUME OF AIR with THE MINIMUM AMOUNT OF BUBBLE SOLUTION, so they are always round. When you stretch your bubbles across contraptions like the Bubble Wall or a hula hoop bubbles cling to the sides as you dip into the solution, making the bubbles all sorts of shapes. The surface tension of water, alone, is TOO STRONG to make good bubbles, ADDING SOAP REDUCES THE SURFACE TENSION. It also adds oily film that slows down the evaporation process, so you get longer-lasting bubbles!

Experiment: Rock Candy

Photo by Kaitlan726 ©2010 http://kaitlan726.files.wordpress.com/2008/04/rockcandy1.jpg

Making your own rock candy is a fun and tasty way to grow crystals and see the structure of sugar on a big scale. Sugar crystals in granulated sugar display a monoclinic form, but you can see the shape much better in homegrown large crystals. This experiment is for rock candy that your students can eat, color, and flavor.

Show students rock candy. Ask them what they think it is made of. How do they make it?

Have students assist (younger students) or follow written instructions (older students) for making rock candy under supervision. Have students read the directions and then discuss how they can make the project into an experiment.

Objective:

Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms:

- Hypothesis
- Test
- Variables
- Sugar
- Dissolve
- Heat
- Soluble
- Crystal
- Solution
- Monoclinic
- Granulated
- Flavor
- Dissolve
- Syrup
- Temperature
- Celsius
- Fahrenheit

Make it into an Experiment

- What variables could students change? What if they want larger crystals what could they do? Smaller crystals? Would there be any way to make them form faster? Slower? Is it affected by temperature?
- Squeezing the juice from a lemon, orange, or lime is a way to give the crystals natural flavor, but does the acid and other sugars in the juice slow crystal formation?
- Can they make "rock candy" using salt? How? Does it look the same as the sugar rock candy?

Rock Candy Materials

Basically all you need to make rock candy is sugar and hot water. The color of your crystals will depend on the type of sugar you use (raw sugar is more golden and refined granulated sugar) and whether or not you add coloring. Any food-grade colorant will work.

Materials (per student)

- 3 cups sugar (sucrose)
- 1 cup water
- clean glass jar
- cotton string
- pencil or knife
- food coloring (optional)
- 1/2 tsp to 1 tsp flavoring oil or extract (optional)
- Lifesaver candy (optional)

- pan
- stove or microwave

Make Rock Candy

1. Pour the sugar and water into the pan.
2. Heat the mixture to a boil, stirring constantly. You want the sugar solution to hit boiling, but not get hotter or cook too long. If you overheat the sugar solution you'll make hard candy, which is nice, but not what we're going for here.
3. Stir the solution until all the sugar has dissolved. The liquid will be clear or straw-colored, without any sparkly sugar. If you can get even more sugar to dissolve, that's good, too.
4. If desired, you can add food coloring and flavoring to the solution. Mint, cinnamon, or lemon extract are good flavorings to try.
5. Set the pot of sugar syrup in the refrigerator to cool. You want the liquid to be about 50°F (slightly cooler than room temperature). Sugar becomes less soluble as it cools, so chilling the mixture will make it so there is less chance of accidentally dissolving sugar you are about to coat on your string.
6. While the sugar solution is cooling, prepare your string. You are using cotton string because it is rough and non-toxic. Tie the string to a pencil, knife, or other object that can rest across the top of the jar. You want the string to hang into the jar, but not touch the sides or bottom.
7. You don't want to weight your string with anything toxic, so rather than use a metal object, you can tie a Lifesaver to the bottom of the string.
8. Whether you are using the Lifesaver or not, you want to 'seed' the string with crystals so that the rock candy will form on the string rather than on the sides and bottom of the jar. There are two easy ways to do this. One is to dampen the string with a little of the syrup you just made and dip the string in sugar. Another option is to soak the string in the syrup and then hang it to dry, which will cause crystals to form naturally (this method produces 'chunkier' rock candy crystals).
9. Once your solution has cooled, pour it into the clean jar. Suspend the seeded string in the liquid. Set the jar somewhere quiet. You can cover the jar with a paper towel or coffee filter to keep the solution clean.
10. Check on your crystals, but don't disturb them. You can remove them to dry and eat when you are satisfied with the size of your rock candy. Ideally you want to allow the crystals to grow for 3-7 days.

11. You can help your crystals grow by removing (and eating) any sugar 'crust' that forms on top of the liquid. If you notice a lot of crystals forming on the sides and bottom of the container and not on your string, remove your string and set it aside. Pour the crystallized solution into a saucepan and boil/cool it (just like when you make the solution). Add it to a clean jar and suspend your growing rock candy crystals. You can watch a video tutorial for making rock candy if you would like to see what to expect.

Density

Experiment: Straw Stack of Colors

Messy and fun!

Who would have thought that playing with your food as a kid would lead to a cool science experiment as an adult? Best of all, it will keep the kids occupied for hours. The challenge starts with four different cups of colored water and a clear straw. When you mix red and blue liquid together, you get purple… right? Not so fast. How about a layer of blue liquid sitting on top of the red? Add two more colors and you have four layered liquids in one straw. The secret is density… and a steady hand. Have a competition and the kids might just catch the method faster than you!

Objectives

Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- understand the concept of density
- Apply their knowledge to detect which substance is more dense

Key Terms:

- Salt
- Density
- Matter
- Space
- Molecules
- Salinate/Desalinate

Materials

- clear, plastic cups (12-16 ounces)
- Salt
- Measuring spoons
- Food coloring

- Clear, plastic straws (ex. from fast food restaurants)

1. Fill four of the plastic cups 3/4 full with water
2. Use food coloring to color each cup a different color – blue, red, green and yellow. You'll want the colors to be fairly dark, so add 15-20 drop of food coloring to each cup.
3. Add 1 tablespoon of salt to the blue water and stir.
4. Add 2 tablespoons of salt to the red water and stir.
5. Add 3 tablespoons of salt to the green water and stir.
6. Add 4 tablespoons of salt to the yellow water, and you guessed it, stir the water. Not all of the salt will dissolve immediately… and that's okay. Over time the salt will completely dissolve, but you don't have to wait for that to happen to get started.
7. This last step in preparing the solutions is very important… Add a little water to each cup so that the water level is the same in all four cups.
8. Let's practice the straw-dropper technique using plain water in the fifth cup. Place one end of the straw into the water – about an inch – and place your index finger over the other end of the straw. Pull the straw out of the water and notice how the water stays in the straw. If you release your finger, the water will fall out of the straw. Remember doing this as a kid with your drink? Hey, maybe you're still a kid and you're an expert! Make sure you can do this well before moving onto the next step.
9. It's time to layer some liquids. Place the empty straw into the blue water (about an inch below the surface). Seal the other end of the straw with your index finger and remove the straw. There should be about an inch of blue water in the straw. Keep your finger firmly pressed against the top so the blue water doesn't fall out.

10. Without releasing your finger, lower the straw into the red liquid about an inch lower than the blue liquid in the straw. Slowly release your finger from the top of the straw and the red liquid will push the blue layer up to the level of the water in the blue cup. Press your finger firmly on top of the straw and remove the straw. Look… you have two layers! Don't get so excited that you release your finger from the top of the straw – you'll have to start all over again! Also, be sure to hold the straw straight up and down (vertically) because tilting the straw will cause the

liquids to mix and you'll have to start again.

11. Lower the straw with the two colored layers into the green saltwater solution about an inch lower than the red solution in the straw. Slowly release pressure with your finger and the green solution will push the red and blue layers up about an inch. Seal the top of the straw with your index finger and move onto the yellow solution.

12. Lower the straw into the yellow solution (the suspense is killing you… it feels like your finger is going to fall off… but you continue!). Lower the straw about an inch below the top of the green layer and release your finger. The yellow liquid will push the top layers up. Put your index finger over the top of the straw one last time and remove the straw from the water. To everyone's amazement, you have four layers of colored water in your straw!

13. All good things must come to an end. When it feels like your index finger is going to fall off, release the pressure and your masterpiece will fall into the fifth cup. The crowd yells, "Do it again!" and you can't resist the temptation.

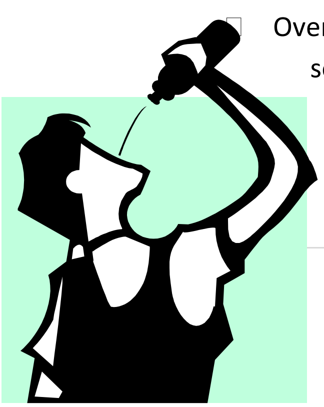
How does it work?

There's really no trick to layering liquids as long as you understand the concept of density. In simplest terms, density is the quantity of something per unit measure (assuming that everything is at the same temperature and pressure). Or in other words, the amount of stuff put into the same amount of space. For example, you added 1 tablespoon of salt to the blue water, but you added 4 tablespoons of salt to the same amount of yellow water. So, the yellow solution has a greater density of salt than the blue water. The density of the yellow solution is greater than the green solution, which is greater than the red, which is greater than the blue. By increasing the amount of salt in each cup of water (and keeping the volume or the amount of water in each cup the same), each liquid had a different density. The solution with the highest density (yellow) (the most "stuff" in the same amount of space) stayed at the bottom of the straw while the solution with the least amount of salt (and the lowest density) remained at the top.

Note: Density is a property of matter that is explored in-depth throughout middle school and high school. However, younger students can begin to understand density by thinking of it in terms of the relationship between weight and volume. For example, a truckload of rocks weighs more than a truckload of feathers. That's because rocks are denser than feathers -- they contain more "stuff" (mass) per unit volume. In the same kind of cup (the same area) a cup of oil would be more dense than a cup of rubbing alcohol. Why? Because more oil molecules are stuffed into the same amount of space than the alcohol molecules, so it's more dense. Ex. A classroom that has 45 students and another classroom that is the same size has 10 students. Which classroom is more "dense?"

Extensions

- Can students add more layers? How would they do it? Would they make those layers more or less dense than the ones they already have? How? What colors could they use to show the order of their density?
- With younger students this is an excellent time to practice recognizing colors, and color mixing. What colors should those two layers make if they mixed? What colors can the students make by mixing the liquids? Are those colors more or less dense than before? Test them.
- Don't tell students which glass has the most salt and which has the least. Hold a challenge and tell students that in order to become "Straw Masters," students have to determine the correct order of four colored salt solutions to make a rainbow straw. Next challenge them to do the same thing in a test tube if you have any available. Finally, students can become "Rainbow Straw Grand Masters" if they successfully layer five colors in a straw.
- Do any high density bodies of water occur naturally? How? What are they? Ex. The Dead Sea, located in the Middle East, between Jordan and Israel, contains some of the saltiest water in the world. It's almost six times as salty as the ocean. (It is about 33% salt) Because of the Dead Sea's high salinity, no plants or animals live there. Since human bodies have a lower density than the water of the Dead Sea, most people can float in it effortlessly. The extremely salty water holds people up instead of letting them sink. Why is it so salty? The Dead Sea receives its water from the Jordan River to the north. Because there is no outlet for the water it sits there and evaporates leaving one of the highest concentrations of salt in any lake in the world.
- What other seas, lakes, or oceans are very salty? Have students research. Can they match the density of these bodies of water in their cups? How much salt would they have to add? (Pure fresh water has a density of 1g/ml or 1kg/L whereas the Dead sea has a density of 1.17 kg/L). The Dead Sea is 33% salt.
- Over 97% of the earth's water is salt water and only about 2-3% is fresh water. What are some ways that humans could turn salt water into fresh water? Have students' research desalination of water. Have students come up with their own theories and test them. Ex experiment: Fill a large bowl with two cups of saltwater. Place a small glass in the center of the bowl. Cover the entire



bowl with plastic wrap. Place a marble on top of the plastic wrap directly over the small glass. The plastic wrap should now slope lower in the center of bowl. Put the bowl in the sun for several hours, which might desalinate the water and drop it into the cup. Remove the plastic wrap and drink the water in the cup. Did it work? Why or why not? How could you improve it?

Experiment: Seven Layer Density Column-- Think of it as a Science burrito…

Everyone knows that vegetable oil floats on water. That's because the two liquids have different densities.

Density is basically how much "stuff" is smashed into a particular area… or a comparison between an object's mass and volume. So, the exact same volume of two liquids may actually have different masses, so they would have different densities. That's why vegetable oil floats on top of water.

But, vegetable oil and water are just one way to explore density. What if you could float seven different liquids in seven different layers? You'll show students how to be amazing and make a seven-layer density column!

Objectives

Students will

- understand the concept of density
- Apply their knowledge to determine the order in which substances should be layered to complete a density column
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms:

- Salt
- Density
- Matter
- Space
- Molecules

Give students the liquids and tell them they need to stack them up according to density. Have students work in groups using clear cups to compare their seven liquids and record their comparisons and their findings on which liquids they believe are more dense than the others due to the results of their tests. When they believe they have the correct order have students put their theories to the test by constructing their seven layer density column. Did everyone get the same results? Have them compare. Do they think they can add another layer? Have them test their theories and questions.

Option: Have the liquids be in unmarked containers and have the students use their senses to tell what each liquid is (without tasting them!).

Materials

- Light Karo Syrup
- Water
- Vegetable Oil
- Dawn dish soap (blue)
- Rubbing alcohol
- Lamp Oil
- Honey
- Graduated cylinder
- Food Coloring or True Color Coloring Tablets
- Food baster
- 9 oz. portion cups

1. Measure 8 ounces of each type of liquid into the 9 oz. portion cups. You may want to start the experiment by coloring each of the liquids to make a more dramatic effect in your column. Light Karo syrup is easier to color than the dark syrup. The only liquids that you may not be able to color are the vegetable oil and the honey.

2. Start your column by pouring the honey into the cylinder. Now, you will pour each liquid SLOWLY into the container, one at a time. Make sure you pour them in the following order.

    a. Honey

    b. Karo syrup

    c. Dish soap

    d. Water

    e. Vegetable oil

    f. Rubbing Alcohol

g. Lamp oil

3.

Note: It is VERY important to pour the liquids slowly and into the center of the cylinder. Make sure that the liquids do not touch the sides of the cylinder while you are pouring. Also, it's okay if the liquids mix a little as you are pouring, the layers will always even themselves out because of the varying densities.

4. As you pour, the liquids will layer on top of one another. After you pour in the liquids you will have a Seven-layer science experiment. Density is too cool!

Observations

We've had lots of teachers and scientists help contribute to this experiment. We inadvertently made an error in verbiage in the very first line of our experiment! It's true, vegetable oil and water are close enough in density that they actually don't mix because of the polarity of their molecules, not because of the slight difference in their densities. Oil molecules are non-polar and water molecules are polar, so the non-polar molecules like to hang out with other non-polar molecules and the polar molecules like to hang out with other polar molecules.

Special thanks to Joe F. and Cathy V. for helping us with the correction to our explanation!

How does it work?

The same amount of two different liquids will have different weights because they have different masses. The liquids that weigh more (have a higher density) will sink below the liquids that weigh less (have a lower density). To test this, you might want to set up a scale and measure each of the liquids that you are pouring into your column. Make sure that you are measuring the weights of equal portions of each liquid. You should find that the weights of the liquids correspond to each different layer of liquid. For example, the honey will weigh more than the Karo syrup, etc. By weighing these liquids, you will find that density and weight are closely related.

Material	Density
Dark Karo syrup or maple syrup	1.37
Light Karo syrup	1.33
Water with food coloring	1.00
Glycerin (colorless)	1.26
Vegetable Oil (yellow)	0.91
Dawn dish washing liquid (blue)	1.03
Rubbing alcohol (colorless)	0.87
Lamp oil	0.80
Honey	1.36
Baby oil	0.82

Here are the densities of the liquids used in the column as well as other common liquids:

Have you found a way to make more than seven layers in your column? Let us know, we would love to hear you success story! Email us at webteam@stevespanglerscience.com

Additional Info

So, we've had the density column sitting in our office for a few days now and have noticed a very interesting change... the layers of vegetable oil and rubbing alcohol have switched places. The rubbing alcohol is now below the vegetable oil, indicating that the density has changed. We are not exactly sure why the change occurred.

Student Assessment:

Students will apply their knowledge of density and complete a correctly layered density column

Experiment: Walking On Water

Extremely messy (and fun!) outdoor only! Works best in a grassy area.

Break the gravity barrier using portions of cornstarch and water, mixed equally by weight.

Mix cornstarch and water in this classroom experiment to form a gooey liquid and solid material that behaves like quicksand. Some people refer to this as the Oobleck recipe, others call it a Non-Newtonian fluid. After watching these video segments, you'll call it a great science lesson as your students learn about the amazing properties of this cornstarch and water mixture.

Objectives:

Students will

- observe the movement of non-Newtonian fluids and be able to relate that movement to that of solids and liquids.
- be able to state the properties of solids and liquids and compare them to the properties of non-Newtonian fluids
- investigate the substance to find out its properties and classify it
- learn how pressure affects non-Newtonian fluid

Key Terms

- Non-Newtonian Fluids
- Colloidal suspension
- Newtonian fluids
- Suspension
- Consistency
- Properties
- Cornstarch
- Solid
- Liquid
- Substance

- Behaviors
- Test

And yes... you will perform the "Cornstarch Walk on Water" on a much smaller scale - using only 100 boxes of cornstarch in a small pool and 10 gallons of water- instead of the 2,500 pounds Steve Spangler used on the Ellen Show.

Photo from http://www.uq.edu.au/news/images/media/5158-050.jpg

Ask students to define Liquid and Solid. What qualities do each of them have?

Liquid:

-assumes the shape of the container which it occupies

-is not easily compressible (little free space between molecules)

-flows easily (the molecules can move/slide past one another)

Solid:

-has a fixed volume and shape 9the molecules are locked into place)

-is not easily compressible (little free space between molecules)

-does not flow easily (the molecules cannot move/slide past one another)

If possible, use a model to demonstrate the molecular difference between solids and liquids. Cheerios work great for liquids – they roll around, take the shape of the container and aren't bound to one another. Several legos stuck together are the perfect solid – they always keep their shape, are hard to the touch, and stick together.

If models are not possible, then simply show the students a variety of solids and liquids and have them note their properties.

Ask the students if it is possible for a substance to have both the properties of a solid and a liquid. If available, read the book Bartholomew and the Oobleck by Dr. Suess.

Ask the students to describe ways in which we can tell solids and liquids apart. Ask the students what is something that is different in every solid and every liquid and how they could test that. They should come up with the following four tests:

1. Push test – can you push into it?
2. Pick up test – if you pick something up, does it all come up?
3. Pour test – does it pour out smoothly, or does it just fall out in a clump?
4. Shape test – does it keep the same shape?

Have the students make a chart of those rules so that they can test any new materials by seeing if they match. These should be written on the board along with in their science journal.

Making Non-Newtonian Cornstarch Goo

1. Pour approximately 1/4 of the box of cornstarch into the mixing bowl and slowly add about 1/2 cup of water. Stir. Sometimes it is easier to mix the cornstarch and water with your bare hands — of course, this only adds to the fun.

2. Continue adding cornstarch and water in small amounts until you get a mixture that has the consistency of honey. It may take a little work to get the consistency just right. As a general rule of thumb, you're looking for a mixture of roughly 10 parts of cornstarch to 1 part water. Notice that the mixture gets thicker or more viscous as you add more cornstarch.

3. Sink your hand into the bowl of cornstarch goo and notice its unusual consistency. Compare what it feels like to move your hand around slowly and then very fast. You can't move your hand around very fast! In fact, the faster you thrash around, the more like a SOLID the gooey stuff becomes. Sink you entire hand into the goo and try to grab the fluid and pull it up. That's the sensation of sinking in quicksand!

Did it act more like a solid or a liquid? Can something be both at once? The students make a list of what they observed and determine what it is, solid, liquid, or Non-Newtonian fluid!

If this is non-Newtonian, what's a Newtonian fluid? A Newtonian fluid is like water. It flows easily from one place to another. When you subject it to pressure, it simply flows out of the way. In a non-Newtonian fluid, the exact opposite happens. When you "shock" it, it suddenly turns solid. The reason for this strange behavior is that it's really two states of matter in one! When you mix the corn starch with the water, the corn starch does not dissolve. Instead, the little particles of starch get suspended in the water and float - making it a very thick liquid. *(Draw a diagram on the board)* When you put sudden pressure on the suspension, most of the water runs out from between the grains leaving the solid corn starch particles to lock up tight. As soon as the pressure is released, the water flows back between the grains, making the mass fluid again.

Colloidal suspensions don't just happen in a lab. You can find them in your kitchen in a ketchup bottle. When people don't want to wait for the ketchup to come out, they usually try hitting the bottom of the bottle. This is the wrong approach because shocking the bottle makes the ketchup turn solid. Instead, simply turn the bottle over and stick a knife inside. The knife blade will give the ketchup a surface to flow along. As long as you don't shake it too hard, it will stay a liquid!

Non-Newtonian fluids change viscosity under strain. Poke, shake, or smash them, and they act like a solid. Let them sit or move them around slowly, and they act like a fluid.

So, these Non-Newtonians fluids are fun, but what can you really do with them? Make it into a bridge? A bed?

A practical application for shear thickening non-Newtonian fluids may be in body armor of the future. Since such fluids are usually flexible, they would allow soldiers to move freely when not under attack. But if confronted with a speeding bullet, they would quickly harder, performing like traditional armor. More research is necessary to see if non-Newtonian fluids are suitable for the military, but until then, it's sure fun to play with.

What other practical applications and not so practical applications can your students come up with for non-Newtonian fluids?

Important – READ THIS!

Ironically, the cornstarch will not stay mixed with the water indefinitely. Over time, the grains of cornstarch will separate from the water and form a solid clump at the bottom of the plastic storage bag. It is for this reason that you must not pour this mixture down the drain. It will clog the pipes and stop up the drain. Pour the mixture into a zipper-lock bag and dispose of it in the garbage.

Student Assessment:

Students will write in their own words an explanation of why the non-Newtonian fluids act the way they do and describe the properties of a non-Newtonian fluid and diagram it in its various states as well as ideas they have for practical and non-practical applications.

Experiment: Gummy Bear Density

What's better than yummy gummy bears? Giant Gummy Bears of course!

Objectives:

Students will:

- Determine what happens to a gummy bear when it is put in water overnight.
- will measure length, volume and mass, and relate the changes in linear dimension to changes in volume.
- Use density data to compare before and after results.
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms

- Density
- Hypothesis
- Test
- Observations
- Results
- Mass
- Volume
- Width
- Length
- Centimeter
- Gram
- milliliter
- Data
- Chart
- Measurement

Materials

- Gummy bears (1 per lab group + extra to feed students)
- Ruler
- Balance
- Beakers
- Water

- Graph Paper

Part A: Choose one gummy bear from the container on your table (Talk to the students about not eating their equipment). Use the equipment available to measure your gummy bear and record the data in the chart for Day 1.

Discuss the definitions of length, height, and width, and different ways to measure volume. 6. Explain the concept of density and why it is an important measurement. . Remind students to measure the gummy bears carefully because they are small. Graduated cylinders can also be used to measure volume via displacement (Archimedes' Principle).

Measurements:

- The length of your gummy bear should be measured from the top of its head to the bottom of its feet to the nearest tenth of a centimeter.
- Measure the width at the widest point across the back of the bear to the nearest tenth of a centimeter.
- Measure the thickness from the front to the back at the thickest point to the nearest tenth of a centimeter.
- Calculate the volume by multiplying the length, width, and thickness. Round to the nearest hundredth.
- Measure the mass using a triple-beam balance or other scale to the nearest tenth of a gram.
- Calculate the density by dividing the mass by the volume. Round answer to the nearest hundredth.

Part B: Put the bear in a cup labeled with your name and class period. Add 50 ml of water to the cup and allow it to sit overnight. On Day 2, remove the gummy bear from the cup of water and use a towel to dry it off to prevent it from dripping all over the place. Repeat the measurements from Part A and record your data in the correct portion of the chart. Determine the amount of change for each measurement and record in the

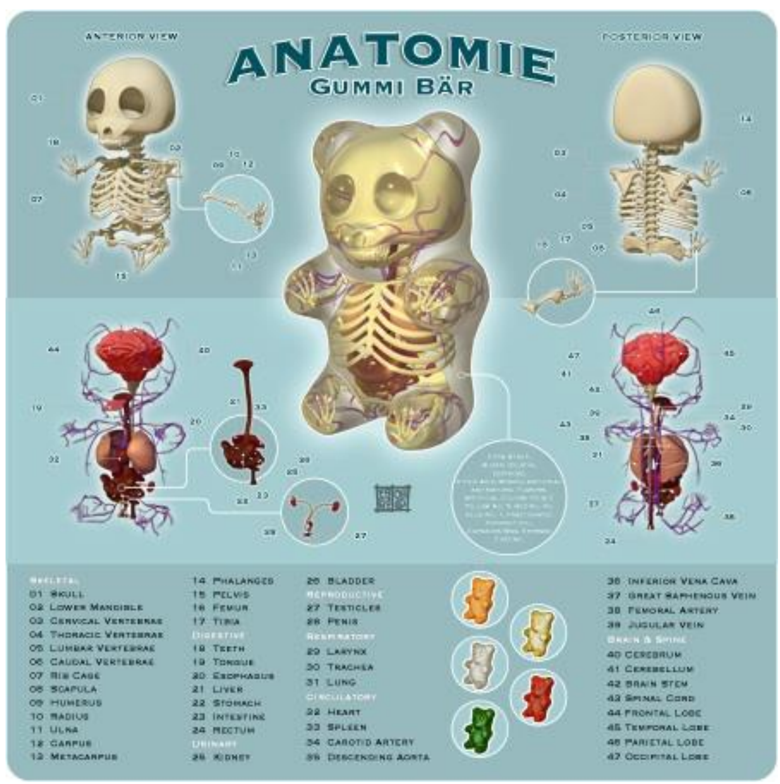


chart.

Questions for each group:

1. Was your hypothesis correct? Why or why not?

2. Which change is greater - volume or mass? Explain.

3. Was there a change in density? Why?

4. How do your results compare to those of your classmates?

Extensions: What factors make the gummy bear change?

Challenge your students to create an experiment with gummy bears. Students have asked if they will "grow" larger if left for another day. Others wondered if the temperature of the water had an effect on the rate of absorption. Some students wanted to experiment with colored water and other liquids to see what would happen to the gummy bears.Would the gummy bear still gain if it was placed in sugar water? Salt water? Orange juice? Would the temperature make a difference in the increase in volume? Does the color make a difference? Do different brands have different results? Does it get even bigger if you leave it in longer? What happens if you put the large bears in a salt solution overnight? What about other gummi candies, do they grow too? Other ideas or questions? Form hypothesis, test them, out and record your results!

Anatomy of a gummy bear from http://zomopro.com/images/gummi_anatomy.jpg

What's Happening?

Gummi bears are a of mixture sugar, glucose syrup, starch, flavoring, food coloring, citric acid, and gelatin.

The gelatin ingredient is the key in this experiment. Gelatin is a polymer that forms large three-dimensional matrices which give structural support to jellies and jams, and lots of other things that you use every day. Specifically, Gummi Bears could be known as a hydrocolloid a special kind of colloid, which is a substance that is neither a solution nor a solid. Through the process of water diffusion, or osmosis, the Gummi bear can reach a size many times larger than its original state. This is because of its colloidal state, its semipermeable membrane allows molecules of certain types (in this case water) to pass through it. The rate of diffusion depends on the membrane, temperatures, molecules being diffused, and many other factors. Eventually the area inside the Gummi bear and the area outside would reach diffusion equilibrium and would discontinue its enlargement. You probably didn't think there was so much behind putting a Gummi bear in a glass of water overnight did you?

Student Assessment:

Students can describe what happened in this experiment and how and why the gummi bears changed. Then students can make a hypothesis about another gummy product and hypothesize whether or not the gummy would change more or less in volume than the gummy bear.

Experiment: Floating Rice Bottles

Although this effect is presented with modern containers like plastic soda bottles, the original magic trick dates back a few thousand years. The science magician shows everybody two identical bottles of rice and two chopsticks. When the performer plunges a chopstick into the bottle of rice and lifts, the rice and bottle seem so light that they float upwards as the chopstick is raised. But, when a spectator is invited to do the same thing with the other bottle of rice and chopstick, it refuses to rise. Nothing changes when the performer and spectator exchange chopsticks – the performer's bottle rises while the spectator's does not. To prove that there is nothing other than rice in the bottles, the performer pours their contents onto a tray, bowl, or dish. It's just rice!

Objectives:

Students will

- understand the concept of density
- Apply their knowledge to determine how the experiment was accomplished
- understand that forces are either a push or a pull
- Be able to explain the terms in their own words and give examples
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms:

- Density
- Matter
- Space
- Molecules
- Compress
- Friction

Materials

- Two identical plastic soda bottles with lids.
- Dry, uncooked rice (You'll need enough to fill both bottles.) Regular rice works better than the instant type.)
- Two chopsticks.
- A tray, bowl, or dish

1. Make a label that reads "Lite Rice" and place it on one of the bottles. Label the other bottle "Regular Rice.".
2. Fill both bottles up to about an inch from the top with rice.
3. Put the lid on the regular rice bottle and shake it to fluff up the rice. It should appear nearly full.
4. Now, we want to put some extra rice into the lite rice bottle. To make room for the extra rice, tap the bottom of the bottle on the table. Or, As you tap, the rice will pack down in the bottle and make room for more. Add some more rice and continue to tap. You may even want to use one of the chopsticks to make a few jabs into the rice to pack it down even better. Pull the chopstick back up and out but don't quite remove it from the rice. Then push it in again. Keep lifting and re-inserting the chopstick at a slow steady rate. If the level of rice in the jar starts to drop, add more rice to fill it back up. The rice starts to compact as the grains fit together more tightly and air gaps shrink.
5. It could take only a few strokes or it could take dozens - but you should feel that it becomes hard work to pull the chopstick out.
6. The important thing is to make both bottles look like they have the same amount of rice in them.
7. Place the bottles and the chopsticks together on your table, and you're ready to perform.

The Performance

1. Hold up the "Lite Rice" bottle and explain to your audience that you have invented a new "Lite Rice" that has so many of the calories removed that now it hardly weighs anything at all. Tell them, "As a matter of fact, this rice is so light that it almost floats. Let me demonstrate the difference between this Regular Rice and my new Lite Rice."

2. Give the Regular Rice bottle and a chopstick to a spectator and ask him to push the chopstick down to the bottom of the bottle. You do the same thing with your Lite Rice bottle and chopstick. It may be easiest to place the bottles back onto the table for support as you push the chopsticks into them.

3. So far, it should appear that you both have done exactly the same thing. But now, as you gently lift your chopstick, it should “stick” to the rice well enough to lift the bottle.

4. The spectator’s Regular Rice bottle will not rise.

5. Offer to exchange chopsticks and repeat the demonstration. Once again, it will work just fine with your bottle of Lite Rice, while the spectator’s bottle will remain on the table.

6. Prove to your students that there’s no secret glue or gripping mechanism in the Lite Rice bottle by pouring the rice out onto the tray or into a dish or bowl. Take a bow.

Have students share their ideas on how it worked and what happened. Have them work in groups and form hypotheses and test their ideas out, using rice and extra bottles. Were their hypotheses correct? Guide the discussion towards density and friction.

How does it work?

If the bottles were filled with water instead of rice, you would see the water level rise in the bottles when the chopsticks were plunged into the water. *(Demonstrate this for the students)* The water has no difficulty creeping up the neck of the bottle to make room for the chopstick. The rice, however, is not a fluid like water *(what is rice? A solid.)* and has great difficulty moving up the neck of the bottle. Instead, the packed rice has very little room to move so it tends to press against the sides of the bottle.

Every time you plunge the chopstick into the rice you are compressing the grains and making them pack more tightly together. The air gaps decrease in size and the rice grains rub against each other more. They can't move as freely, and start to arrange in a pattern that doesn't change. The rice you could previously pour like a liquid becomes solid.

With more grains of rice pressing on the chopstick, and each one of those more tightly packed in, the friction between the knife and the rice increases.

If the friction force between the rice and chopstick equals the combined weight force of the rice and container, then the balance of forces means the chopstick is held in place.

For the jar to lift as well, friction between its inside walls and the rice must also increase. That shows you the rice has moved and compacted even away from where you disturbed it with the chopstick.

The scientific principle that makes this feat work is friction. The chopstick gets wedged between the rice and the sides of the bottle and is stuck due to friction. That’s all there is to it. Friction is the magician.

Extensions:

Do different kinds of rice work the same? Can the experiment be replicated with other dry grains or beans? What about in a larger or smaller container?

Student Assessment:

Students will draw diagrams in their science journals illustrating what happened within the two bottles and why one was “lighter.” Students will label the diagrams explaining the phenomena with the scientific terms and using their own words.

Experiment: Bubbling Density Concoction

This experiment was featured on KUSA-TV in May of 2005 and presented by a group of young scientists from Burlington Elementary in Colorado. The bubbling concoction is a clever mixture of lessons in density and chemistry.

Objectives:

Students will

- understand the concept of density
- Apply their knowledge to detect which substance is more dense
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms:

- Chemical Reaction
- Density
- Matter
- Space
- Molecules

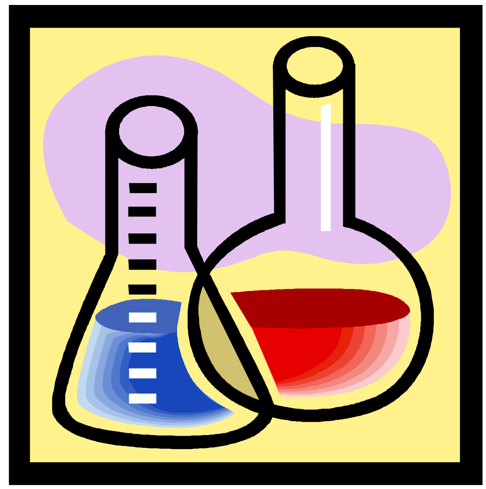
Materials

- clear plastic cups
- light corn syrup
- red and blue food coloring
- mixing spoon
- baking soda
- small measuring spoon
- water
- vegetable oil

- disposable cup
- vinegar
- dropper or pipette

(Be sure to cover your work area before beginning this experiment!)

1. Pour corn syrup into the glass to a depth of about 1 inch (2.5 cm). Mix in several drops of red food coloring and mix well.



2. Sprinkle small measuring spoonfuls of baking soda on top of the corn syrup to a depth of about 1/4 inch (3/4 cm).

3. Gently pour water into the glass to a depth of about 1 inch (2.5 cm).

4. Add the vegetable oil next to a depth of about 1 inch (2.5 cm).

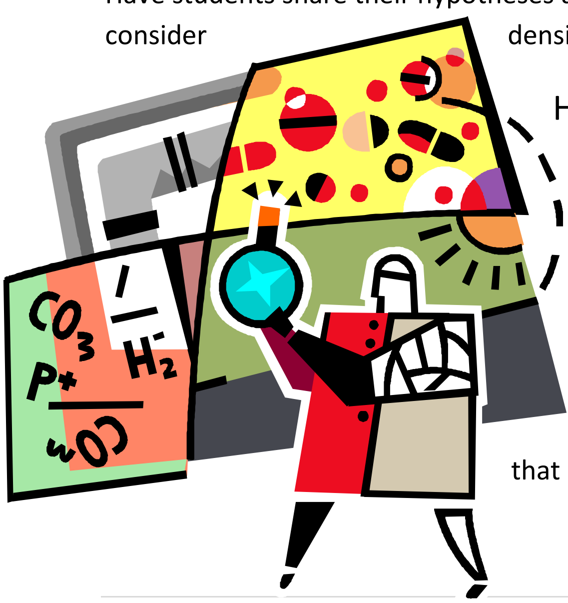
5. In a separate cup, use the blue food coloring to dye the vinegar.

6. Take the dropper and drip the vinegar into the glass. You will notice that blue blobs will slowly add up between the oil and water. Keep adding the vinegar and watch the results.

7. Next, take the dropper filled with vinegar and put it into the glass so that the tip is in the baking soda layer. Release the vinegar and see what happens.

8. Keep adding more vinegar and observe the foaming reaction.

Have students share their hypotheses about what is happening and test them out. Guide them to consider density.



How does it work?

This experiment shows density along with a chemical reaction. Notice that the lighter liquids float on top of the heavier ones which creates the separation in the glass. When you first add the vinegar, it drops through the oil but has trouble breaking through to the layer of water. Because of that, blobs of vinegar pile up at the bottom of the oil layer. When the vinegar is released in the layer of baking soda, a chemical reaction occurs that causes it to foam.

Extension:

Have students consider the different factors and what variables could be changed. Test their ideas. Would another acidic liquid like lemon juice work as well? What if you added water as well? Have students formulate hypotheses, test them, and record their results.

Experiment: The Brazil Nut Effect

Want to shake up a group of physicists? Just show them something that acts in an unexpected way. That's what led to the discovery of a physics principle called the Brazil nut effect. For some time, hungry physicists had noticed that when you shake a jar of mixed nuts, the big, dense Brazil nut moves to the top of the jar. (You'd think it would sink to the bottom.) Check it out by performing the experiment with some mixed nuts of your own, or try this colorful variation.

Objectives

Students will

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms:

- Friction
- Space
- Phenomenon
- Surface
- Layers
- Expectations
- Hypothesis
- Observations

Materials:

•Marble
•An empty transparent plastic jar with a lid
•Cornmeal, salt, or sand (enough to fill the jar 1/2 to 2/3 full)

STEPS:
1. Put the marble in the jar. Add the cornmeal, salt, or sand.
2. Seal the jar, then shake it up and down. It may take a little time, but eventually the marble will rise to the top. You might even hear it pop against the lid before you spot it.

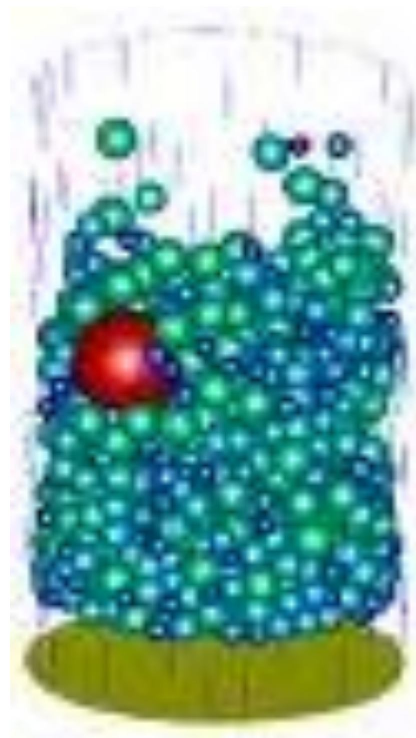
WHAT'S HAPPENING:
You'd expect something denser than cornmeal, salt, or sand to stay at the bottom of the jar. Instead, when you shake the jar, both the cornmeal and the marble move up and down, and a bit of the cornmeal fills the space below the marble before it can fall back to its original position. Once the marble reaches the top of the heap, it gets buffeted around and sometimes falls just below the surface. But keep shaking, and it will resurface.

Extensions--The World Around Us: In Geology there are many reasons for mixed sand grains to separate into groups of similar size, usually with the larger grains at the bottom – opposite to the Brazil nut effect. Why?

Things falling through water and air experience drag (friction). For example a crumpled sheet of paper falls faster than the same sheet of paper cut into little pieces.

When sand, mud and larger rocks start falling at the same time in water, the bigger particles fall faster, forcing their way through the water, sand and mud to reach the bottom first. Next the sand settles out and finally the mud, made of the finest particles, which remain suspended in the water longer.

You can make an ***experiment*** *of this:*
Put some mud in a clear bottle, add water and shake until the mud is fully mixed into the water. Sit the bottle on a flat surface and wait until all the sediments sink to the bottom and the water becomes clear. You should notice that the bigger particles are at the bottom, and the finer at the top.



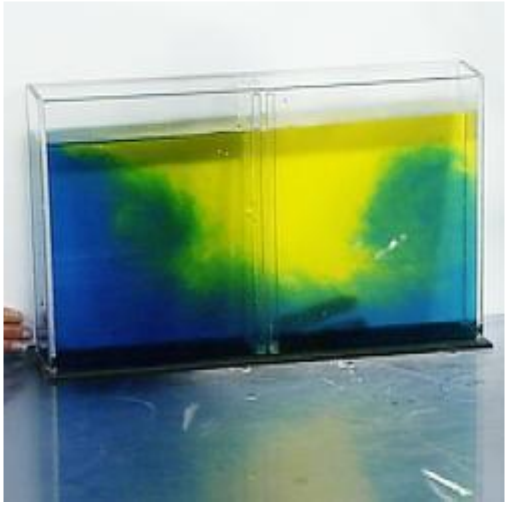
When a volcano explodes, the same phenomenon is observed. The larger particles cannot be supported by the air for as long as the dust, so they fall first. Fine dust from volcanoes can stay in the air for months. The Brazil Nut effect is caused by shaking, which usually makes smaller objects fall beneath larger objects.

Extensions:

Have students test out a variety of small and larger objects in the jar. Do the larger objects always end up on top? Why or why not?

Scientists must learn the characteristics of things in order to be able to separate them into their separate parts. Have students form hypotheses and try sorting other particles:

Salt and Sand
Mix together 25 grams of salt and 25 grams of sand in a small jar.
Now separate them. See how close you can come to getting back 25 g of each.



Experiment: Colorful Convection Currents

Convection is one of those words that we often hear used, but we may not completely understand its meaning. Weather forecasters show how convection currents are formed when warm and cold air masses meet in the atmosphere. Convection currents are responsible for warm water currents that occur in oceans. This activity demonstrates convection currents in a very colorful fashion.

Objectives:

Students will:

- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Gain understanding of the movements of low and high temperature currents in the atmosphere, water, and earth's crust
- Make connections with weather events and the interaction of warm and cool currents

Key terms:

- Density
- Rise
- Fall
- Atmosphere
- Phenomenon
- Convection
- Currents
- Gas
- Mantle
- Earth's crust
- Temperature Inversion

Materials

- Four empty identical bottles (mouth of the bottle should be at least 1 1/2 inches in diameter) or use our Split Demo Tank
- Access to warm and cold water

- Food coloring (yellow and blue) or True Colors Coloring Tablets
- 3 x 5 inch index card or an old playing card

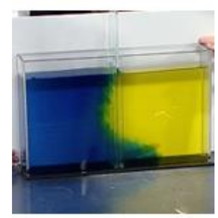
1. Fill two bottles with warm water from the tap and the other two bottles with cold water. Use food coloring or True Colors Coloring Tablets to color the warm water yellow and the cold water blue. Each bottle must be filled to the brim with water.
2. Hot over cold: Place the index card or old playing card over the mouth of one of the warm water bottles. Hold the card in place as you turn the bottle upside down and rest it on top of one of the cold water bottles. The bottles should be positioned so that they are mouth to mouth with the card separating the two liquids. You may want to do this over a sink.

3. Carefully slip the card out from in between the two bottles. Make sure that you are holding onto the top bottle when you remove the card. Observe what happens to the colored liquids in the two bottles.

4. Cold over hot: Repeat steps 2 and 3, but this time place the bottle of cold water on top of the warm water. Observe what happens.

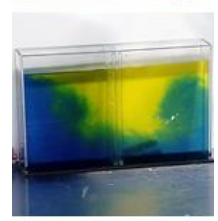
If you are using the Split Demo Tank, follow these directions:

1. Make sure that the tank divider is firmly in place.
2. Fill one side of the tank with warm water and the other side with cold water. Use food coloring or True Color Coloring Tablets to color the warm water yellow and the cold water blue.

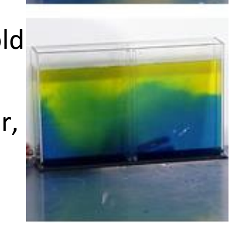


3. Slowly remove the divider from the tank. As you pull out the divider, observe the changes in the tank.

Discuss with students what is happening, their hypothesis, etc. Discuss what the phenomenon mean and when something like this may occur in the world around us. Guide the discussion with the following.



How does it work?



Hot air balloons rise because warm air is lighter than cold air. Similarly, warm water is lighter in weight or less dense than cold water. When the bottle of warm water is placed on top of the cold water, the more dense cold water stays in the bottom bottle and the less dense warm water is confined to the top bottle. However, when the cold water bottle rests on top of the warm water, the less dense warm water rises to the top bottle and the cold water sinks. The movement of water is clearly seen as the yellow and blue food coloring mix, creating a green liquid. Likewise, when the water mixes in the Split Demo Tank, the less dense, cold water stays on the bottom of the tank, and the more dense, warm water moves to the top.

The movement of warm and cold water inside the bottles (or tank) is referred to as the convection current. In our daily life, warm currents can occur in oceans, like the warm Gulf Stream moving up north along the American Eastern Seaboard. Convection currents in the atmosphere are responsible for the formation of thunderstorms as the warm and cold air masses collide.

Although the bottles whose colored liquids mix are more interesting to watch, the other set of warm and cold water bottles helps to illustrate another important phenomenon that occurs in the atmosphere during the winter months. During daylight hours, the sun heats the surface of the earth and the layer of air closest to the earth. This warm air rises and mixes with other atmospheric gases. When the sun goes down, the less dense warm air high up in the atmosphere often blankets the colder air that rests closer to the surface of the earth. Because the colder air is more dense than the warm air, the colder air is trapped close to the earth and the atmospheric gases do not mix. This is commonly referred to as temperature inversion.

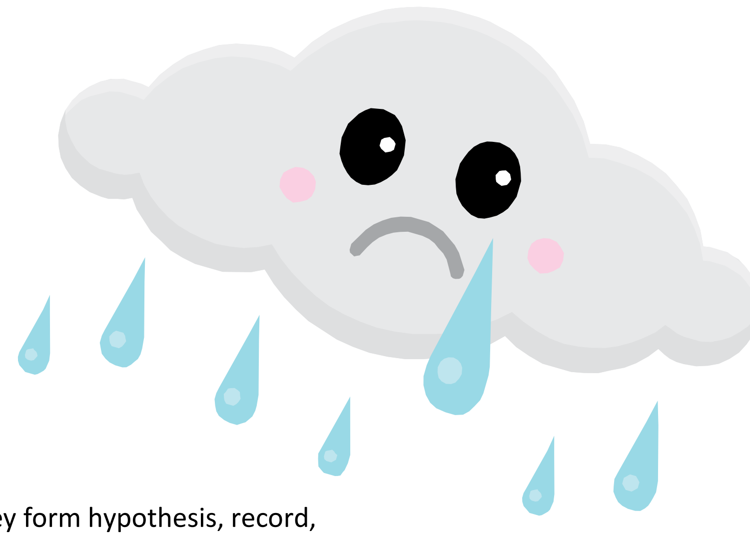
Extension: To be able to more clearly see the movement, you may also add tiny paper dots to the water and watch the movement of the dots through the currents.

Additional Info

What are the results of temperature inversion? Air pollution is more noticeable during a temperature inversion since pollutants such as car exhaust are trapped in the layer of cold air close to the earth. As a result, state agencies in many parts of the country oxygenate automobile fuels during winter months with additives like MTBE in an attempt to reduce the harmful effects of trapped pollution. This trapped pollution is what causes the "brown cloud" effect. Wind or precipitation can help alleviate the brown cloud effect by stirring up and breaking up the layer of warm air that traps the cold air and pollution down near the surface of the earth.

Convection currents don't only affect things above the ground, in the mantle of the earth also drive the motion of Earth's plates, resulting in geological processes that cause volcanoes. Heat in Earth's core powers convection currents inside Earth. Because material close to Earth's surface is cool and heavy, it sinks. When this sinking material gets close to Earth's core, high temperatures heat it up again. This hot material is pushed back up to the surface because heat rises. This cycle of sinking and rising repeats, creating a convection current. Discuss the similarities and differences between convection currents in Earth's mantle and the convection current illustrated by this water and beaker model.

Experiment: Cloud in a Bottle



Objectives:

Students will

- Understand the principles involved in cloud formation.
- Learn how humidity, temperature, and air pressure influence the formation of clouds.
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms

- Evaporation
- Condensation
- High Pressure
- Low Pressure
- Water Vapor
- Particles
- Moisture
- Water
- Molecules
- Heat
- Visible
- Cloud
- Temperature
- Vaporize
- Humidity

Materials

- 1-liter clear plastic bottle with cap
- Foot pump with rubber stopper attached
- Water
- Rubbing alcohol
- Safety glasses

Adult supervision is required!

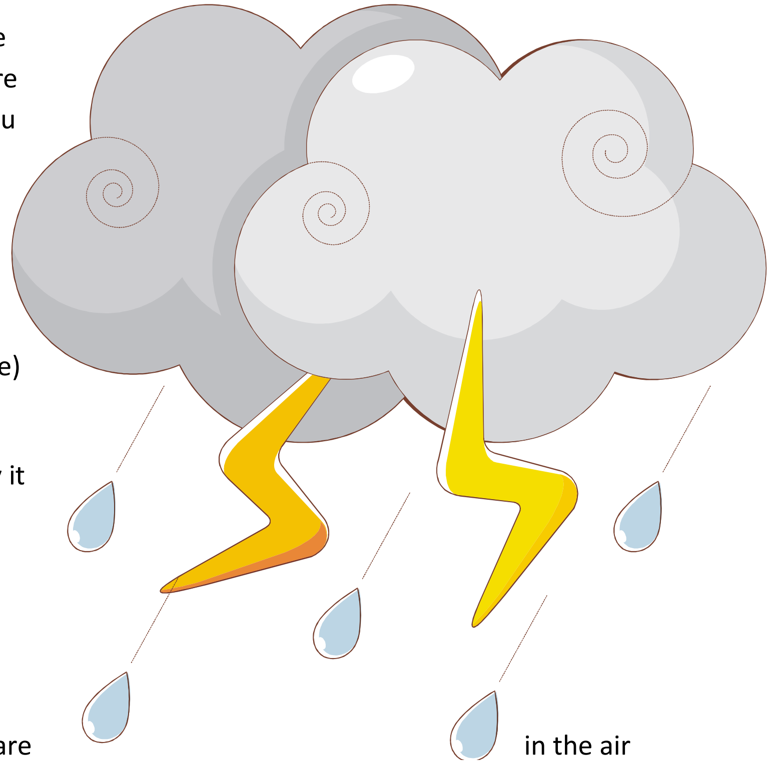
Have You Ever Wondered How Clouds Form? This mind blowing experiment will show how pressure and water vapor in the air compress and expand in a small scale version of what happens in the atmosphere. You'll make your own clouds and learn all about the science behind their formation.

Build anticipation by informing the class that you are now going to make clouds. Ask students what all you will need to make a cloud…

We need water – what for? In order to have a cloud you have to have water that evaporates and goes up into the air, going from high pressure to low pressure, condenses under low pressure on a particle, and all of a sudden you get your cloud.

1. Put on your safety glasses and start by pouring just enough warm water in the bottle to cover the bottom.
2. Swirl the water around and then put the rubber stopper in the bottle. So water, and what else do we need? Oh yes, pressure. So where are we going to get that from?
3. Have a student volunteer come to the front, tell them you're going to work as a cloud team and they're going to add the pressure. Have them pump the foot pump five times while you hold the stopper in the bottle. You will notice that as you start to pump, the rubber stopper will want to pop right out. Hold it in the bottle tightly, being very careful not to let it fly out of the bottle. Ask the students what you are adding to the bottle, what will that do? Tell them they are creating an area of high pressure and the high pressure is causing the water molecules to start to heat up.
4. After five pumps, ask the students what will happen when you pull the stopper out of the bottle. You'll likely see a very faint "poof" of a cloud. There wasn't enough pressure in the bottle to make a good cloud, but now you are starting to get the feel of the foot pump.
5. Repeat the experiment again, but instead of five pumps, have the student pump the foot pump ten times. Have students predict what will happen. You'll notice that the more they pump, the harder it is to keep the stopper in the bottle. Just remember to hold it in there tightly. When you are done pumping, pull out the stopper. They should see a slightly more visible cloud this time.
6. Tell students now that they have a good feel for how the experiment works, fill the bottom of the bottle again and pump the foot pump 15-20 times. You want to put about 9 kg (20 lbs) of pressure in the bottle.

7. When you remove the rubber stopper, you should see a good cloud.



Okay, tell students now that we have mastered the technique of adding air pressure and releasing it are they ready for an even better cloud? Make sure you are still wearing your safety glasses. Place just a few drops of rubbing alcohol in the bottom of the 1-liter bottle. Swirl the alcohol around in the bottle, making sure to coat the sides. Then put the rubber stopper in the bottle. Follow steps 3-7 above to make a more visible (and more impressive) cloud. 3,2,1...Instant Cloud!! Isn't that amazing?

Discuss with the students what happened and why it happened. Allow students to put their ideas to the test and guide the discussion towards air pressure and the following.

How does it work?

Even though we don't see them, water molecules are in the air all around us. These airborne water molecules are called water vapor. When the molecules are bouncing around in the atmosphere, they don't normally stick together.

Pumping the bottle forces the molecules to squeeze together or compress. Releasing the pressure allows the air to expand, and in doing so, the temperature of the air becomes cooler. This cooling process allows the molecules to stick together - or condense - more easily, forming tiny droplets. Clouds are nothing more than groups of tiny water droplets!

The reason the rubbing alcohol forms a more visible cloud is because alcohol evaporates more quickly than water. Alcohol molecules have weaker bonds than water molecules, so they let go of each other more easily. Since there are more evaporated alcohol molecules in the bottle, there are also more molecules able to condense. This is why you can see the alcohol cloud more clearly than the water cloud.

Clouds on Earth form when warm air rises and its pressure is reduced. The air expands and cools, and clouds form as the temperature drops below the dew point. Invisible particles in the air in the form of pollution, smoke, dust or even tiny particles of dirt help form a nucleus on which the water molecules can attach.

Allow students to ask questions, form hypotheses and test them out! What if you add a high pressure front back into the bottle? What will happen to your cool temp cloud condensation when the pressure rises?

Student Assessment:

Students will write a “recipe” for making clouds in their science journals. What parts do they need to make their clouds? What forces will help them?

Sound

Experiment: Screaming Cups

You've never heard a sound quite like this coming out of an ordinary cup!

Objectives:

Students will:

- Learn that sound is transmitted through the air by vibrations.
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Describe what happens when a sound is transmitted in their own words

Key Terms

- Hypothesis
- Observation
- Hear
- Test
- Stick and Slide Effect
- Phenomenon
- Molecules
- Air
- Vibration
- Amplify
- Transmit
- Sound
- Sound waves

Materials

- Large plastic cup
- Piece of string (24")
- Water
- Violin rosin (optional)

1. Start by poking a hole in the bottom of the cup just large enough to thread the piece of string. 2. Thread the string through the hole and tie a knot or two at the end of the string to hold the string in place. 3. Wet the string or coat the string with violin rosin. 4. Holding the cup in one

hand, pinch the string between your thumb and forefinger. Squeeze tight on the string as you slide your thumb and forefinger down the string. With practice and a little patience, the string will "stick and slide" between your fingers causes a "screaming" sound. Oh, you'll know when you've got it down to a science!

2. What do the students think is happening? How is the sound being made? Why is it so loud?

How does it work?
Sound is transmitted through the air by vibrations. As your fingers slide across the string, vibrations occur in the string. The violin rosin makes the string more sticky and increases the "stick and slide" effect. The vibrations caused by "stick and slide" cause the cup to vibrate, which results in the amplification of sound. In other words, the cup produces an incredibly eerie scream!

Extensions:

Have students form hypothesis to answer the following questions (or those that they come up with) and test them.

How can you make the sound louder? What kind of sticky material works best? Try differently shaped and/or different sized cups and determine what this change does to the sound. What happens if you try the experiment without the string tied to the cup? Different sized cups? Multiple strings? Different types of string? Have students form hypotheses and ask questions then test out their ideas to see if they were correct!

Student Assessment:

Students will write

Experiment: Whirly: The Singing Tube

You wouldn't think twirling a hose over your head could make music, but you'd be surprised what you can discover at the hardware store! You might get a few strange stares, but who cares - it's all in the name of science.

Objectives:

Students will:

- Learn that sound is transmitted through the air by vibrations.
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy
- Explore the properties of energy and matter by manipulating vibration.
- Describe what happens when a sound is transmitted through a corrugated tube in their own words
- Form a conceptual understanding that the faster the air flows through the tube, the higher the frequency of the sound
- Understand that different ways of changing pressure of air all lead to sounds
- Determine that as they twirl the tube, the speed of the twirl affects the frequency and pitch as air molecules are launched out of the other end.

Key Terms

- Corrugated
- Ridge
- Eardrum
- Pitch
- Molecules
- Movement
- Vortex
- Frequency
- High/Low Frequencies
- Speed
- Airflow
- Air

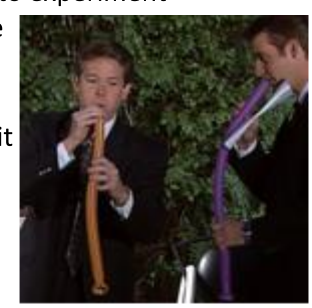
- Vibration
- Amplify
- Transmit
- Sound
- Sound waves

Materials

- The “Singing Tube” is a popular and inexpensive item in toy stores. There is really nothing to it - a corrugated plastic tube measuring about 3 feet long and 2 inches in diameter.
- If you can't find the official "Singing Tube" just use a piece of irrigation tubing from the hardware store.
- Plastic bag (garbage bag or shopping bag)
- Rubber band

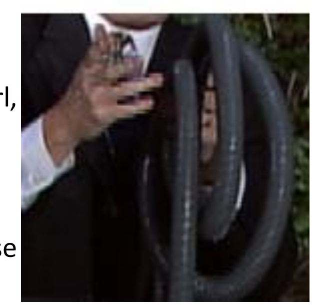
1. Hold one end of the tube and twirl the other end in a circle over your head.
2. Spin the tube faster and notice how the pitch of the note goes up. Fast twirling creates high pitch notes and slower twirling creates lower notes. Amazing!
3. Attach the plastic bag to the end of your Sound Hose with tape or a rubber band.
4. With your mouth a few millimeters from the Sound Hose, blow into the open end. The bag will inflate with just a few big breaths.
5. Once the bag is inflated, twirl your Sound Hose. As the "music" plays from the hose, watch the bag deflate!

In Search of More Tubes... While the toy store “Twirly” is fun, students will soon want to experiment with different size tubes (long, short, fat, skinny) to see how the size and shape change the sound.



Blow across the end of the whirly to show it would not sing, then blow into it to make it sing.

How does it work?



Imagine that the tube is filled with tiny pebbles. Twirling the tube overhead would shoot the rocks out of the tube. The same thing happens with the molecules of air. As you twirl the tube, air molecules are launched out of the other end. The faster the twirl, the faster the molecules come flying out.

The bag part of the experiment creates a stunning effect. The plastic bag allows you to see the movement of the molecules when you watch the bag deflate as the Sound Hose is "played."

Not all plastic tubes sing. The tube must be corrugated on the inside. Why? Aerodynamics researchers in Japan put a whirly in a wind tunnel and used very tiny hot wire anemometers to measure the airflow near the corrugations. As the air flows first over one ridge then over a second it tumbles into a vortex. The faster the air flows through the tube, the higher the frequency of the sound produced by the vortex. When the frequency of the vortex matches one of the natural resonant frequencies of the tube, it is amplified.

Notice how the inside of your vacuum cleaner hose is NOT corrugated! Otherwise, your vacuum cleaner would play music (maybe a poor choice of words) whenever you cleaned the house. That would be one way to get out of doing your chores!

Extensions:

How can you make different sounds? Will longer whirlies play lower frequencies? (The whirlies only sing sound waves which fit in them exactly, longer tubes mean longer soundwaves which have lower pitch.)

The whirly cannot be made to sing by air flowing across the end, or can it? Blow through the tube. Hold your mouth a few inches from the end and blow, will it sing?. Blow faster, do the notes increase in pitch?

While playing the whirly:
1. Cover the stationary end with your hand. Notice that the sound stops immediately.
2. Hold the stationary end of the whirly near a pile of confetti, or other small paper pieces. Notice that when the whirly is signing a note the paper pieces flow into the whirly and are sprayed around.

Can you make it sing two notes at once? Make a longer whirly, perhaps 3 meters long. Play it. Notice that it sometimes sings two adjacent notes at once.

Student Assessment:

Acids & Bases

Experiment: Goldenrod Paper

Objectives:

Students will

- Learn about the difference between acid and alkaline substances.
- Become familiar with the pH scale
- Determine if substances are either acids or bases through experimentation and recording of results
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms

- Goldenrod
- Acid
- Acidic
- Base
- Basic
- Neutral
- Indicator
- pH
- pH Scale
- Carbon Dioxide
- Acid Rain
- Alkaline
- Litmus Paper
- Dye
- Solutions
- Ammonia
- Liquid
- Substance
- Properties
- Neutralization
- Hydrogen
- Hydroxide
- Solid
- Hypothesis
- Test
- Observations
- Color-Changing

The term goldenrod is typically used to describe a color of paper - golden yellow. Certain brands of goldenrod paper contain a special dye that turns bright red in solutions that are basic like ammonia water or washing soda. The paper turns back yellow with an acid like vinegar or lemon juice. Learn how to use this special color-changing paper to develop a hidden message.

1. Place a piece of Goldenrod Paper on a clean, dry surface.
2. Away from the paper, spray your hand with "magic water" (the ammonia-water solution).
3. Tell your audience that when you touch the paper you can make it bleed.

4. Gently slap your hand down on the Goldenrod Paper... oh no! It's a bleeding hand print!
5. Your audience won't believe their eyes when you hold up the Goldenrod Paper, dripping with your "bloody" hand print.
6. Option: Make secret messages with a wax candle before you spray.

Have your students develop hypotheses about what is happening on the paper. Then give them a variety of liquids to test. Have students record what happens when they test each liquid. What are their conclusions? Were their hypotheses correct?

How does it work?
The ammonia on the cotton ball is a base and causes the dye in the special goldenrod paper to change color. You probably noticed that the red color fades over time and the paper eventually changes back to its original yellow color. Why? The carbon dioxide gas that is in the air we breathe is slightly on the acidic side of the pH scale. The carbon dioxide reacts with the ammonia on the paper to produce ammonium carbonate, which changes the pH of the paper to neutral (roughly a pH of 7) and the dye changes back yellow. If you use a stronger base like washing soda, the red message will not disappear with just the carbon dioxide in the air. You will need to use a stronger acid like lemon juice or vinegar to change it from red to yellow. You can also use goldenrod paper as inexpensive pH paper to classify safe household products as being either acidic or basic.

Extensions:

What about other juices, liquids, and household cleaners. Is Windex an acid or a base?

Dip it in base so it turns red, then dry it out. This gives you an acid-indicating paper which starts out red ...and turns yellow in acid.

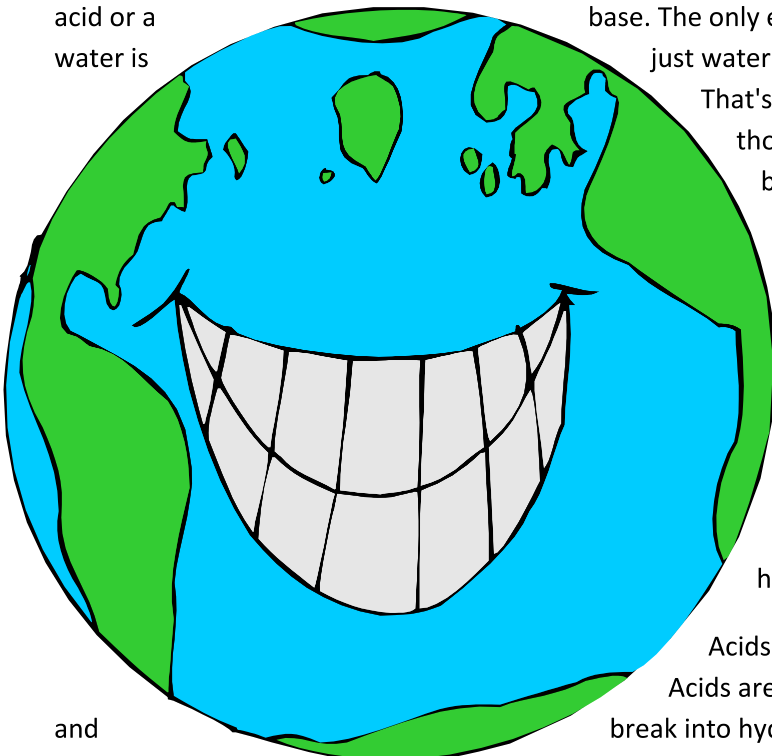
Paint an invisible picture with vinegar on yellow goldenrod, let it dry, then spray it with baking soda solution. It turns red everywhere except the places having vinegar.

Wet a strip of previously-reddened goldenrod, then lower the strip into a half-full glass of carbonated beverage. Don't let the strip touch the liquid. The strip turns orange as the transparent pool of carbon dioxide forms carbonic acid in the wet paper. This lets you "see" the invisible pool of CO2 gas which fills the cup. (Only works in a draft-free room, where the CO2 gas remains atop the cola.)

ACID RAIN DEMO: Wet the inside of a glass jar. Light a match, blow it out, then collect the smoke inside the upside-down jar. After awhile the drops of water collect nasty combustion products from the smoke and become acidic. Touch the drops to previously reddened goldenrod paper, and it turns yellow, indicating acid. Instant acid rain! And might you think twice about smoking cigarettes and putting acid in your lungs?

Acids and Bases: Why do we care?

One of the most important things scientists need to know about the water on Earth is, "What's the pH?" Knowing the pH of a substance helps determine whether the substance is an acid or a base. People , plants, and animals can't live well in a world that is too acid or too base or drink water that is acidic or too base.

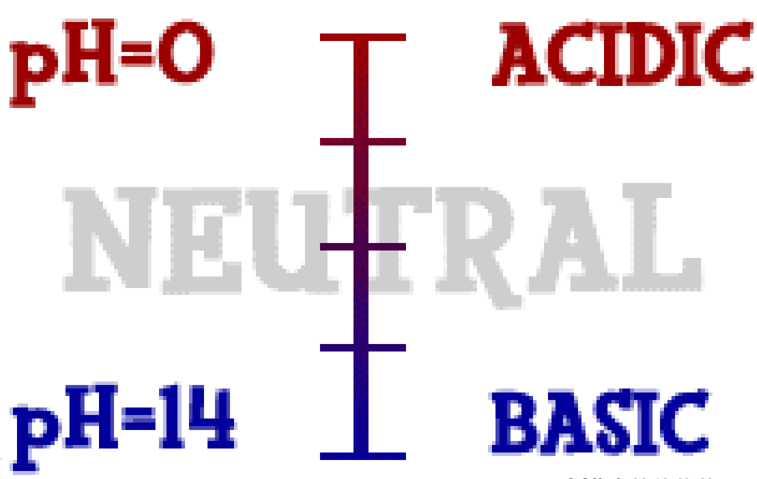


Acids and bases are everywhere. Look around you and every liquid you see will probably be either an acid or a base. The only exception would be distilled water. Distilled water is just water. It is neutral, (neither an acid nor a base). That's it. Most water you drink has ions in it . It is those ions which make something acidic or basic.

As a matter of fact, acids and bases play a big part in your everyday lives. You probably just don't realize it. Examples of substances that are acids are vinegar and lemon juice. Examples of bases (also called alkalis) are baking soda and ammonia (a very strong cleaning substance). There are actually acids in the human body which help digest food.

Acids and bases each have certain properties. Acids are ionic compounds which have a sour taste and break into hydrogen (H+) ions, and another compound when placed in a water/liquid solution. Bases are ionic compounds which have a bitter taste and break up into Hydroxide (OH-) ions, and another compound when placed in an aqueous solution. (Tell students they should never taste chemicals! It's dangerous and unnecessary.)

The really cool thing is that when an acid mixes with a base, a neutral substance (a substance that is neither an acid nor a base) + water is the result. This process is called neutralization. Did you ever see those commercials on TV about relief of acid indigestion? So, how do you spell relief? R-O-L-A-I-D-S!! You can also spell it T-U-M-S! Why do you think these products can get rid of ACID indigestion? I'll give you a hint. It has to do with neutralization. If you said that Tums and Rolaids are bases, you'd be correct. When the base in the Tums mixes with the acid in the stomach, a neutral substance + water is produced and like magic, the acid indigestion is gone.



(Show this to the students with some Rolaids or Tums and an acidic liquid)

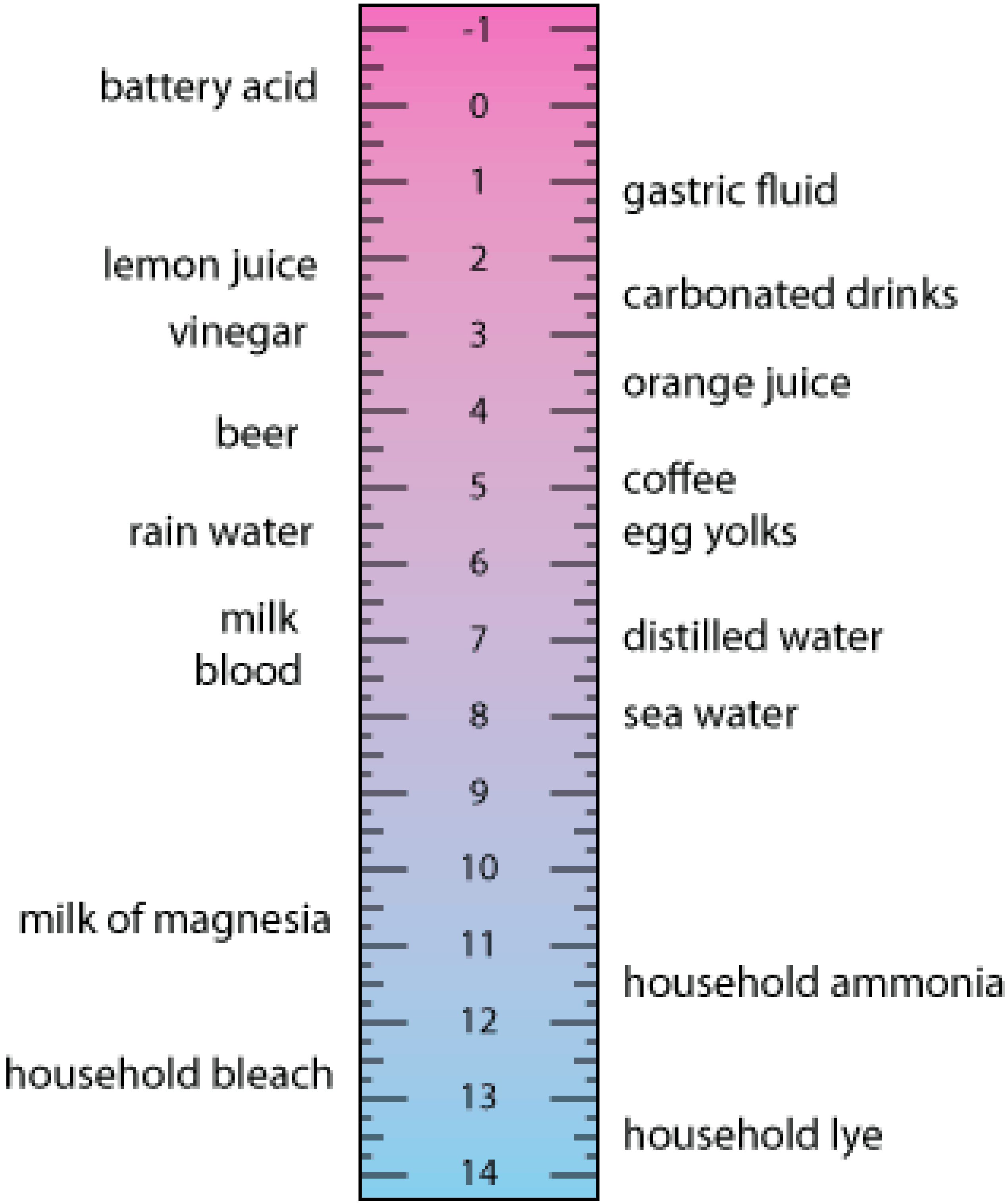
The pH scale goes from "0" to "14". Distilled water is 7 (right in the middle). Acids are found between "0" and "7". The stronger the acid the lower the pH. Bases are from "7" to "14". The stronger the base, the higher the pH. Most of the liquids you find every day have a pH near "7", either a little below, or a little above. Those substances are very mild acids and bases. If you ever go into a chemistry lab, you could find solutions with a pH of "1" and others with a pH of "14". Those chemicals are very dangerous. The closer you get to the middle of the scale the weaker the acids and bases. The farther away you get from the middle of the scale the stronger the acids and bases and the more dangerous.

So how do scientists use the scale? How do they determine if the pH of a substance is 3 or 7? They use indicators. Inidcators are substances that change color in acids and bases. There are different kinds of indicators like litmus paper, goldenrod paper, a liquid called phenylphthalein, and even cabbage juice. If you have seen swimming pool you know they have chlorine in them. To test whether or not the pool had enough chlorine they probably used a kind of litmus paper or liquid litmus (that big long 'p' word), to see if they needed to add chlorine to the water. When you dip the paper in the pool or add the litmus drops to a water sample it changes color. You compare the color to a chart that comes with the litmus to determine if chlorine is needed. Well, scientists do basically the same thing.

Definitions you should know...

<u>pH</u> : A measure of the amount of hydrogen ions in a substance - A low pH indicates lots of hydrogen ions (strong acid). A high pH indicates few hydrogen ions (strong base).
<u>INDICATOR</u>: Substance which changes color in acids and bases. They are used to determine pH.
<u>ION</u>: An atom that has either gained or lost an electron. Ions have a '+' or a '-' after the symbol (Ex: H+ or OH-)
<u>ACID</u>: A solution that has an excess of H+ ions. It comes from the Latin word "acidus" which means "sharp".
<u>BASE</u>: A solution that has an excess of OH- ions. Another word for base is ALKALI.
<u>AQUEOUS</u>: A solution which is mainly water. Think about the word aquarium. AQUA means water.
<u>STRONG ACID</u>: An acid which has lots of Hydrogen ions and very low pH (0-4).
<u>STRONG BASE</u>: A base which has lots of Hydroxide ions and very high pH (10-14).
<u>WEAK ACID</u>: An acid that only partially ionizes in an aqueous solution. That means not every molecule breaks apart so not that many hydrogen ions are formed. They usually have a pH close to 7 (3-6).
<u>WEAK BASE</u>: A base that only partially ionizes in an aqueous solution. That means not every molecule breaks apart so not that many hydroxide ions are formed. They usually have a pH close to 7 (8-10).
<u>NEUTRAL</u>: A solution which has a pH of 7. It is neither acidic nor basic.
<u>NEUTRALIZATION</u>: When an acid mixes with a base to form a neutral substance (salt) and water

This diagram of the pH scale shows the pH values of several common chemicals.



Experiment: Magic Color Changing Flowers

Although the flowers in this kit seem to be normal white carnations, they will soon have you believing in the science of magic. These carnations use the principals of pH (acids and bases) to change color right before your eyes. Using a special combination of indicators, acids, and bases, you'll be asked "How'd you do that?" in no time. They even come with their own vase to showcase your magical abilities.

Objectives:

Students will

- Learn about the difference between acid and alkaline substances.
- Become familiar with the pH scale and acid/base indicators and their purposes
- Determine if substances are either acids or bases through experimentation, observation, and recording of results
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

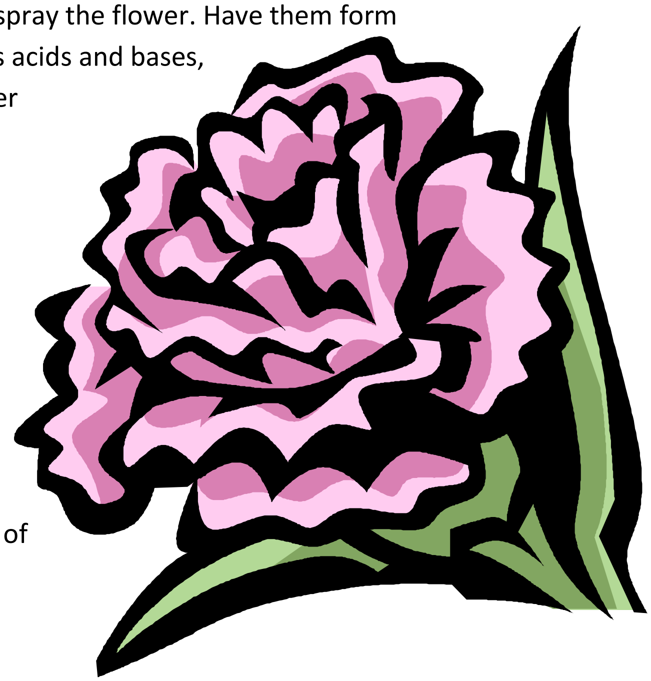
Key Terms

- Acid
- Acidic
- Base
- Basic
- Neutral
- Indicator
- pH
- phenolphthalein (fee-nol-fthay-leen)
- pH Scale
- Carbon Dioxide
- Alkaline
- Litmus Paper
- Dye
- Solutions
- Ammonia
- Liquid
- Substance
- Properties
- Neutralization
- Hydrogen
- Hydroxide
- Solid
- Hypothesis
- Test
- Observations
- Color-Changing

What's included?

- 2 white carnations
- Glass display vase
- Ammonia (4 oz.)
- Phenolphthalein (4 oz.)
- Safety glasses

Ask the students what they think is happening when you spray the flower. Have them form hypotheses and test them. Guide their discussion towards acids and bases, indicators, and pH. Have them test other flowers and other substances. Does it work the same? Why or why not?



How does it work?

Magic Flowers use the principals of the pH indicator phenolphthalein to change color. When phenolphthalein interacts with a base such as ammonia, the results are incredibly colorful.

What does it teach?

Magic Flowers are a great tool for learning the properties of acids, bases, indicators, and pH.

Experiment: Red Cabbage Magic

Some of the earliest recorded "magic" was actually nothing more than a few simple science experiments using chemistry. Just imagine how amazed your friends would be if you could change crystal clear water into grape juice... and then into lemonade. Shhhh! Don't tell anyone that it's not really grape juice or lemonade. It's chemical magic and the ingredients are in your kitchen.

Objectives:

Students will

- Learn about the difference between acid and alkaline substances.
- Become familiar with the pH scale and acid/base indicators and their purposes
- Determine if substances are either acids or bases through experimentation, observation, and recording of results
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms

- Acid
- Acidic
- Base
- Basic
- Neutral
- Indicator
- pH
- pH Scale
- Carbon Dioxide
- Alkaline
- Litmus Paper
- Dye
- Solutions
- Ammonia
- Liquid
- Substance
- Properties
- Neutralization
- Hydrogen
- Hydroxide
- Solid
- Hypothesis
- Test
- Observations
- Color-Changing

Materials

- Red cabbage

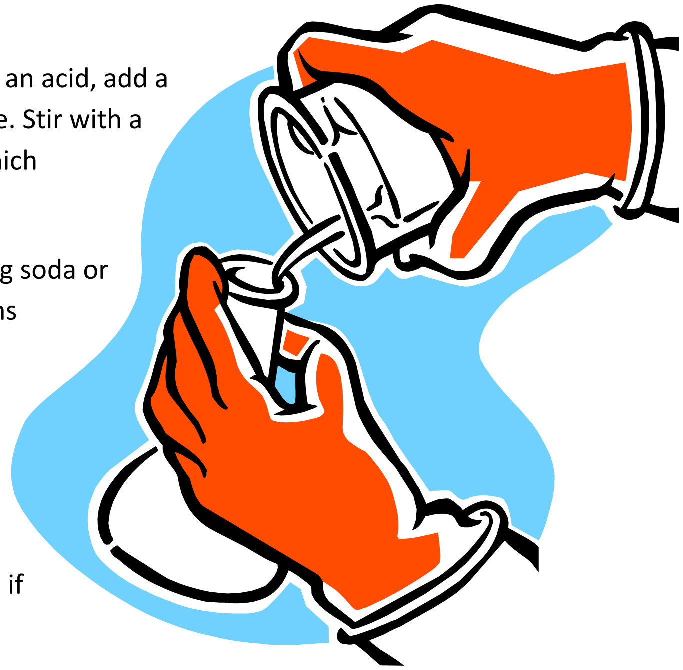
- Blender
- Strainer
- Clear drinking glasses
- White paper
- Apron or lab coat (cabbage juice can leave nasty stains!)
- Test chemicals: Vinegar, Baking soda, Lemon juice, Washing soda, Laundry detergent, Soda pop, Alka-Seltzer

** You can use a new product called Red Cabbage Jiffy Juice which is best described as a red cabbage concentrate that eliminates all of the mess and awful smell associated with making red cabbage indicator.

1. Peel off six big cabbage leaves and put them in a blender filled half full with water. Liquify!
2. Pour the purplish cabbage liquid through a strainer to filter out all of the big chunks of cabbage. Doesn't cabbage juice smell great? Save the liquid for the experiments to follow.
3. **Regardless of which method you used to make your "indicator" solution, try this...**

   Set out three glasses, side by side against a white piece of paper. Fill each glass half full with cabbage juice. Since you know that vinegar is an example of an acid, add a little vinegar to the first glass of cabbage juice. Stir with a spoon and notice the color change to red, which indicates that vinegar is classified as an acid. In the second glass add a teaspoon of washing soda or laundry detergent. Notice how the liquid turns green which indicates this chemical is a base. Keep these two glasses of red and green liquid for future reference.
4. Have students try adding their own "test" substances to a small amount of cabbage juice and note the color change to determine if something is an acid or a base.

5. Set out three glasses, side by side against a white piece of paper. Fill each glass half full with cabbage juice.



6. Since you know that vinegar is an example of an acid, add a little vinegar to the first glass of cabbage juice. Stir with a spoon and notice the color change to red, which indicates that vinegar is classified as an acid.

7. In the second glass add a teaspoon of washing soda or laundry detergent. Notice how the liquid turns green, indicating that this chemical is a base. Keep these two glasses of red and green liquid for future reference.

8. Try adding each of the other “test chemicals" to a small amount of cabbage juice and note the color change to determine if the chemical is an acid or a base.

Use your cabbage juice indicator to test the acid or base properties of other common substances. You might want to try orange juice, lemonade, milk, salt, ammonia, or soap.

Try soaking some filter paper in concentrated cabbage juice. Remove the paper from the cabbage juice and hang it up by a clothespin to dry. Cut the dried paper into thin strips. Dip the strips into various liquids to test their pH. The redder the strip turns, the more acidic the liquid is. The greener the strip turns, the more basic the liquid is.

How does it work?

Some substances are classified as either an acid or a base. Think of acids and bases as opposites - acids and bases are on opposite sides of a teeter-totter. Scientists can tell if a substance is an acid or a base by means of an indicator. An indicator is typically a chemical that changes color if it comes in contact with an acid or a base.

As you can see, the purple cabbage juice turns red when it is mixed with something acidic (an acid), or green when it mixes with something basic (a base). In the previous experiment, the vinegar was the acid and the laundry detergent was the base. Remember that an acid is the opposite of a base. Red cabbage juice is considered to be an indicator because it shows us something about the chemical composition of other substances. This is just one of many indicators that are available to scientists. Some indicators start out colorless and turn blue or pink, for example, when they mix with a base. There are hundreds of different types of indicators available to scientists depending on the type of substance that they are testing. If there is no color change at all, the substance that you are testing is probably neutral, just like water.

Have students use the cabbage juice indicator to test the acid or base properties of other common substances: Orange juice, lemonade, milk, salt, ammonia, or soap are some suggestions. You may have heard about how acid rain is destroying the environment. Have students collect a sample of rain water and test its acidity using their cabbage indicator.

What is it about cabbage that causes this to happen? Red cabbage contains a water-soluble pigment called *anthocyanin* that changes color when it is mixed with an acid or a base. The pigment turns red in acidic environments with a pH less than 7 and the pigment turns bluish-green in alkaline (basic) environments with a pH greater than 7.

Red cabbage is just one of many indicators that are available to scientists. Some indicators start out colorless and turn blue or pink, for example, when they mix with a base. If there is no color change at all, the substance that you are testing is probably neutral, just like water. Can students find a neutral substance besides water?

What other things can students use to tell if something is an acid or a base? (pH paper, cabbage juice, phenolphthalein, beets, turmeric powder)

Lay a variety of materials out (including some that look similar to the real acid/base indicators) and have students hypothesize which are acid/base indicators and which are not. Have students create tests to check their theories and record their results.

Beet Juice Indicator Solution #1

Wash and slice a fresh beet. Place about four slices of beet into a pan containing one cup of water. Heat until boiling and continue boiling for about five minutes. Remove the beet slices and allow the red liquid to cool. Store juice in dropper bottles. Beet juice is red in acidic solutions and blue in basic solutions. Beets contain a pigment known as anthocyanin that will change from red to yellow somewhere between pH 11 and 12.

Phenolphthalein Indicator Solution #2

Purchase any laxative that contains phenolphthalein. With the back of a spoon, mash four to six tablets in a saucer. Pour the powder into a small cup. Add about ten milliliters of rubbing alcohol. Let this mixture stand for fifteen minutes. Pour off the liquid and store in a dropper bottle. Phenolphthalein is purple in very basic solutions and colorless in acidic solutions.

Turmeric Indicator Solution #3

Obtain a package of turmeric form the spice section of the grocery store. Add 1/4 teaspoon of turmeric to four tablespoons of rubbing alcohol. Stir to mix. Store in dropper bottle. Turmeric solution stays yellow in the presence of acids and changes to purple-brown in the presence of bases. Turmeric solution can also be made into indicator paper (see Cabbage Paper). Dry turmeric paper is bright yellow and changes to red in the presence of bases.

Red Cabbage Juice Indicator Solution #4

Red cabbage juice indicator is red in acid solutions, purple in neutral solutions, and greenish-yellow in basic solutions. Red cabbage contains a pigment molecule called flavin (an anthocyanin). This water-soluble pigment is also found in apple skin, plums, poppies, cornflowers, and grapes. Red cabbage juice will function over a wide pH range, from as low as pH 1 up to pH 12.

Cabbage Indicator Paper (optional)

Pour one cup of cabbage indicator (above) into a bowl. Dip one or two coffee filters into the indicator. Place the wet filter paper on a cookie sheet or flat pan. Continue to soak the paper until saturated. Allow the paper to dry (this will take more time than your class time, so use it the next day or for another activity). The paper will be pale blue. Cut the dry papers into strips about 1.25 by 7.5 centimeters (0.5 by 3 inches). Store the strips in a zip-lock plastic bag. Cabbage paper turns green in the presence of bases and pink to red in the presence of acids. NOTE: Beetroot indicator paper can be made in the same way.

Procedure (Part B) – Testing the Natural Indicators:

Unknown A: Ammonia

Unknown B: Vinegar

1. Label two dropper bottles with UNKNOWN A on one and UNKNOWN B on the other.
2. Fill each labeled dropper bottle with the correct unknown. These solutions will be used to test the indicators students made.
3. Obtain 8 small, clear plastic cups. Label these **1A -4A** and **1B – 4B** for the **indicator** solutions students made.
4. Correctly place a small amount of each **indicator** in the bottom of each labeled cup using the following table as a guide.

1A	2A	3A	4A	1B	2B	3B	4B
Beet juice	**phenolphthalein**	**Tumeric solution**	**Cabbage juice**	**Beet juice**	**phenolphthalein**	**Tumeric solution**	**Cabbage juice**

5. Record the name of the **indicator** and its initial color on the data table.
6. Have students add **one drop at a time** of UNKNOWN A to the **indicator** in **cup 1A**. **Record** the unknown being used on the data table --- A or B.
7. Stir with a toothpick or carefully swirl the cup after each drop.
8. Continue **adding one drop at a time** followed by stirring until the color changes from the original color.
9. **Discard the toothpick** and use a new toothpick for each **indicator** solution.
10. **Record** the color change (final color) in the data table.
11. Repeat steps 5 - 10 with each of the **other indicators 2A – 4A**.
12. Using the color change information found in the recipe for the **indicator**, place a check mark in the **Acid OR Base** column on the data table for each of the color changes you found.
13. Repeat steps 6 – 11 with cups 1B – 4B using UNKNOWN B.

Data and Results:

INDICATING ACIDS & BASES						
Cup #	**Unknown # A or B?**	**Indicator Solution**	**Initial Color**	**Final Color**	**Acid?**	**Base?**
1						
2						
3						
4						
5						
6						
7						
8						

Discuss the following with the students.

1. When an **acid** and **base** combined what reaction results?
2. What ion found in a solution would make it acidic?
3. What scale is used to determine whether a solution is acidic or basic?
4. A PH of less than 7 indicates the solution is a/an ____________________.
5. A PH greater than 7 would indicate the solution was a/an __________________.
6. A neutral Solution has a PH of _____.
7. We found out that a beet juice **indicator** solution will be red in a/an_______?
8. So, then beet juice **indicator** solution will be blue in a/an_________?
9. Cabbage **indicator** solution will turn what color in the presence of bases
10. Phenolphthalein **indicator** solution will turn what color in the presence of bases?

11. Phenolphthalein **indicator** solution will turn what color in the presence of acids?
12. **Turmeric indicator** solution stays yellow in the presence of acids and turns what color in the presence of bases?

What acid/base indicators do students prefer? Why? Which gives the clearest indication of acids and bases? Which one gives results that look the most like the acid/base chart?

Experiment: Naked Egg

Did it come from a naked chicken?

This experiment answers the age-old question, "Which came first, the rubber egg or the rubber chicken?" It's easy to make a rubber egg if you understand the chemistry of removing the eggshell with an acid (vinegar.) What you're left with is a totally embarrassed naked egg and a cool piece of science.

Objectives

Students will:

- Study how liquids can pass through a membrane
- Learn about the strengths and behaviors of acid and alkaline substances.
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms

- Membrane
- Osmosis
- Concentration
- Equalize
- Vinegar
- Calcium
- Shell
- Dissolve
- Durable

- Acetic Acid
- Permeate
- Semi-permeable membrane
- Carbon Dioxide
- Interact

Materials

- Raw eggs
- Graduated cylinder or tall glasses
- Vinegar
- Corn Syrup
- Cardboard
- Patience

1. Place the egg in a graduated cylinder or tall glass and cover the egg with vinegar.
2. Have students develop hypotheses on what is going to happen over the next 2 days.
3. Fill the jar half full of vinegar. Draw two different faces (happy, sad) on opposite sides of each egg. Place the eggs in the jar. Cover the jar with the cardboard.
4. Bubbles will begin to show on the surface of the eggs after a few hours.
5. After one day, the shells have softened and begun to disappear. Can you still see the faces?
6. Change the vinegar on the second day. Be careful—since the eggshell has been dissolving, the egg membrane may be the only thing holding the egg together. The membrane is not as durable as the shell. Carefully pour the old vinegar down the drain and cover the egg with fresh vinegar. Place the glass with the vinegar and egg in a safe cool place. Don't disturb the egg but pay close attention to the bubbles forming on the surface of the shell (or what's left of it).
7. After two days, most of the calcium will have dissolved and you can see the thin membranes that are between the shell of each egg and its contents.
8. Remove the eggs from the vinegar and carefully rub any remaining shell off under cold running water.
9. Several days to One week later, pour off the vinegar and carefully rinse the egg with water. The egg looks translucent because the outside shell is gone! The only thing that remains is the delicate membrane of the egg. You've successfully made an egg without a shell. Okay, you didn't really make the egg - the chicken made the egg - you just stripped away the chemical that gives the egg its strength.

Continuing the Experiment:

1. Place one egg in the corn syrup so that the syrup covers it completely. After a few days, you will notice that the egg is much smaller.

What will happen if we put a "naked" egg into plain water? List hypotheses.

2. Place a second egg in plain water so that it is covered. After a few days, they will notice that this egg is larger. The third egg can be used for a control. They can keep it in a plastic bag to prevent dehydration.

Challenge: You might try reversing the experiment. Note what the egg in the corn syrup looks like after a few days and then put it in the water. Put the egg from the water into the corn syrup. Are you able to reverse the activity?

Hint: In handling during this activity, it is easy to break the membrane of the egg and delay the experiment. Three eggs are suggested so that if one breaks, you still have two to use for the lesson.

Further Hypothesis Questions to Test

Do organic or free-range eggs have an eggshell that is stronger or weaker than generic eggs? Have students conduct their own tests on several different kinds of eggs all at the same time to observe any differences in the time required for the vinegar to dissolve the shell.

Try using concentrated vinegar instead of traditional vinegar. Does it make a difference?

How does it work?

Let's start with the bubbles you saw forming on the shell. The bubbles are carbon dioxide gas. Vinegar is an acid called acetic acid - CH3COOH - and white vinegar from the grocery store is usually about 5% acetic acid and 95% water. Egg shells are made up of calcium carbonate. The vinegar reacts with the calcium carbonate by breaking the chemical into its calcium and carbonate parts (in simplest terms). The calcium part floats around in the solution while the carbonate part reacts to form the carbon dioxide bubbles that you see.

Some of the vinegar will also sneak through, or permeate, the egg's membrane and cause the egg to get a little bigger. This flow of a liquid from one solution through a semi-permeable membrane and into another less concentrated solution is called *osmosis*. That's why the egg is even more delicate if you handle it. If you shake the egg, you can see the yolk sloshing around in the egg white. If the membrane breaks, the egg's insides will spill out into the vinegar. Yes, you've made a pickled egg! Allowing the egg to react with the carbon dioxide in the air will cause the egg to harden again. Amazing!

Quick Summary: When you submerge an egg in vinegar, the shell dissolves. Vinegar contains acetic acid, which breaks apart the solid calcium carbonate crystals that make up the eggshell into their calcium and carbonate parts. The calcium ions (ions are atoms that are missing electrons) float free, while the carbonate goes to make carbon dioxide—the bubbles that you see.

Naked Egg in Corn Syrup, What Happened?

The liquid inside the egg is not as concentrated as the sugar water corn syrup. Chemically, the liquid wants to go where there is a high concentration of matter and equalize the concentration. After two days, you will have only a membrane around an egg yolk because the water from the egg white has moved out of the egg.

Naked Egg in Water, What Happened?

The liquid inside the egg is more concentrated than the plain water in the container. The water goes into the egg to equalize the concentration. After two days, you will have an egg that is nearly the size of a tennis ball.

Egg Definitions

• Air Cell - an empty space located at the large end of the egg; it is between the inner and outer shell membranes.

• Chalaza - a spiral, rope-like strand that anchors the yolk in the thick egg white. There are two chalazae anchoring each yolk; one on the top and one on the bottom. (The plural of chalaza is chalazae.)

• Germinal Disc or Blastodisc - a small, circular, white spot (2-3 mm across) on the surface of the yolk; it is where the sperm enters the egg. The nucleus of the egg is in the blastodisc.

• Inner Shell Membrane - the thin membrane located between the outer shell membrane and the albumin.

• Outer Shell Membrane - the thin membrane located just inside the shell.

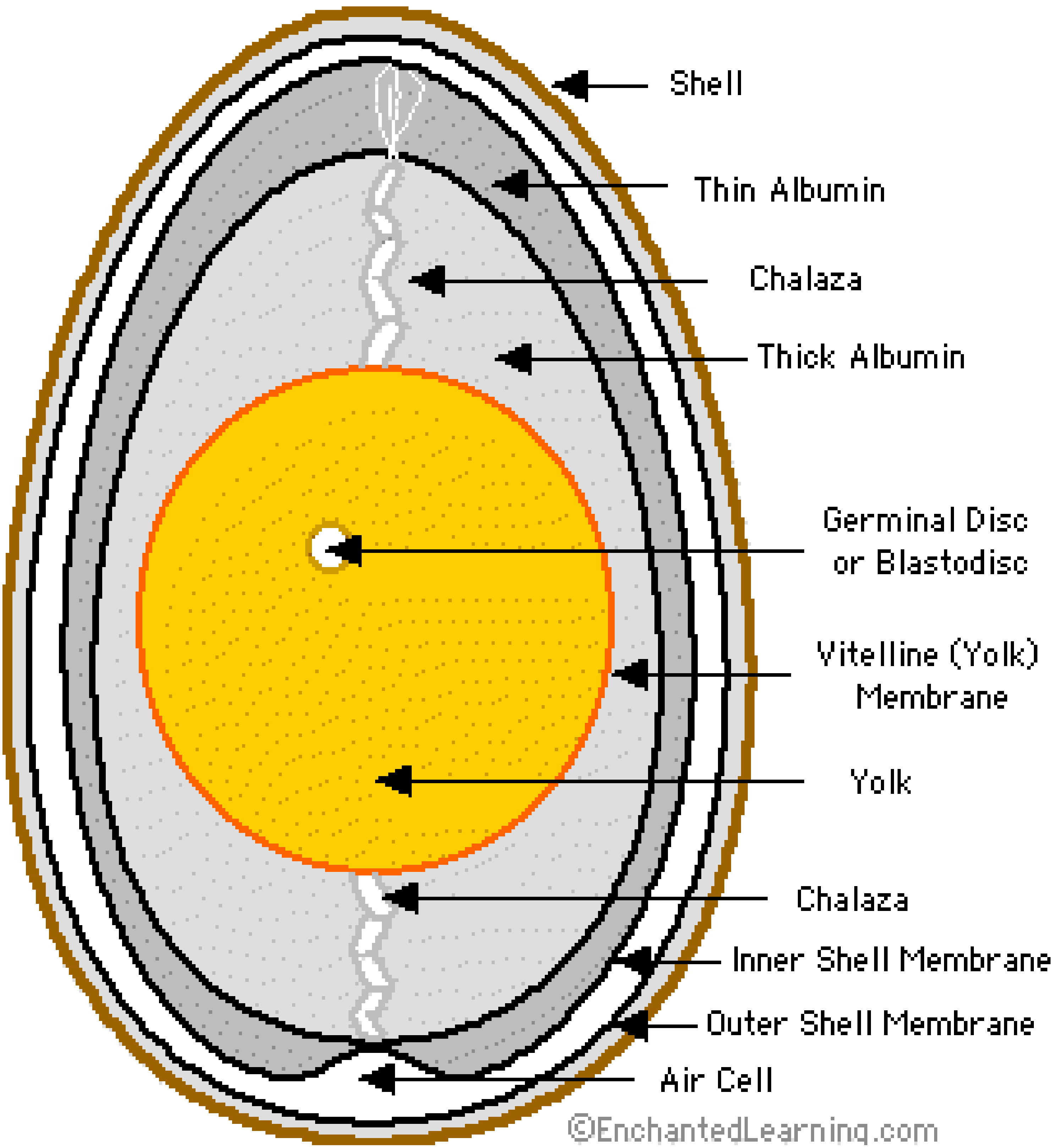
• Shell - the hard, protective coating of the egg. It is semi-permeable; it lets gas exchange occur, but keeps other substances from entering the egg. The shell is made of calcium carbonate.

• Thick Albumin - the stringy part of the egg white (albumin) located nearest the yolk.

• Thin Albumin - the watery part of the egg white (albumin) located farthest from the yolk.

• Vitelline (yolk) Membrane - the membrane that surrounds the yolk.

• Yolk - the yellow, inner part of the egg where the embryo will form. The yolk contains the food that will nourish the embryo as it grows.


Shell
Thin Albumin
Chalaza
Thick Albumin
Germinal Disc
or Blastodisc
Vitelline (Yolk)
Membrane
Yolk
Chalaza
Inner Shell Membrane
Outer Shell Membrane
Air Cell
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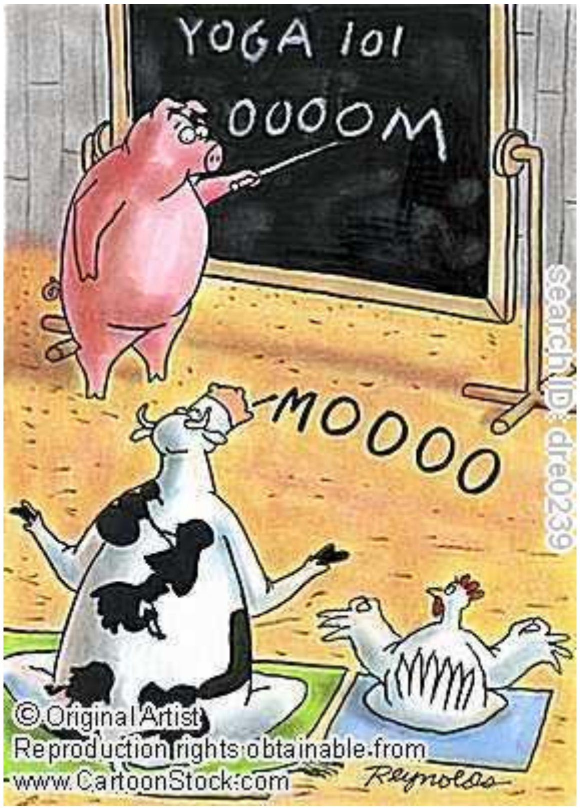


Experiment: Folding Egg

Objectives

Students will:

- Study how liquids can pass through a membrane
- Learn about the strength and abilities of acid and alkaline substances.
- Conduct a science investigation in which they form hypothesis, record, process, and interpret data.
- Make predictions and test their accuracy

Key Terms

- Membrane
- Osmosis
- Concentration
- Equalize
- Vinegar
- Calcium
- Shell
- Dissolve
- Durable
- Acetic Acid
- Permeate
- Semi-permeable membrane
- Carbon Dioxide
- Interact

Materials:

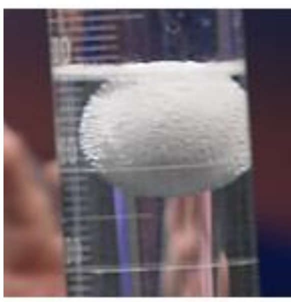
- Eggs
- Thumbtack
- Egg blower

- Vinegar
- Plastic coffee stirrer

The first step is the trickiest and requires a little practice. You'll need to blow out the inside of the egg without damaging the egg (too much!). Use a sharp pin, a thumb tack or the tip of a sharp knife to poke a small hole in both ends of the egg for your students . The hole should be about an 1/8 of an inch in diameter. Don't be frustrated if you crack a few eggs before you get the hang of it.

The next step is to scramble the inside of the egg to break the yellow yolk and to blow the liquid out through one of the holes. The best way to break the yolk is to poke a long needle or something similar (like a plastic coffee stirrer) through the hole and to carefully poke around inside the egg.

Once the yolk is broken and the egg is "scrambled," it's time to blow all of the liquid out of the egg. One method is to clean off one end of the egg, cover the hole with your mouth and blow the egg liquid out the other hole. Of course, it's best to hold the egg over the sink as you're doing this. People who are concerned about using their mouth may experiment with other methods or may elect not to try the activity.



Place the hollow egg in a tall glass or jar and cover the egg with vinegar. You want the egg to be completely submerged in the vinegar, which means that you may need to place something on top of the egg to push it down or to try to fill the inside of the egg with vinegar to weigh it down.

Leave the egg in the vinegar for up to 10 days or until all of the shell has dissolved. Some eggshells will take longer to dissolve than others because every egg is unique. For the first few days, bubbles of carbon dioxide gas will form on the shell. The vinegar is dissolving the calcium carbonate in the shell and producing bubbles of carbon dioxide at the same time. When the bubbles stop forming, it's a good indication that the eggshell is completely dissolved. (In the video Steve uses 3 M HCl to speed up the process.)

Once the bubbles have stopped forming (again, this could be up to 10 days so be patient!) pour off the vinegar and carefully rinse the egg with water. The egg looks translucent because the outside shell is gone! The only thing that remains is the delicate membrane of the egg. You've successfully made an egg without a shell. Okay, you didn't really make the egg. The chicken made the egg. You just stripped away the chemical that gives the egg its strength.

Carefully squeeze out all of the water from the egg membrane. Gently blow a little air into one end of the egg and the egg will puff up. Hey, it looks like a real egg! Slowly squeeze the egg in your hand and it will look like you crushed the egg. Just carefully toss and bounce the "folded egg" in your hand to allow the air to slowly work its way back into the egg. The egg magically restores its shape.

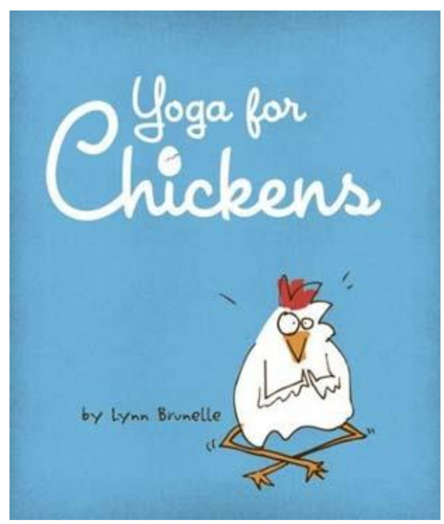
Dust the egg membrane with some baby powder (sometimes called Talcum powder). Try to get some of the powder inside the egg as well. The powder will help keep the egg membrane from drying out and cracking - and it makes the egg look even more real.

How does it work?

The acetic acid in the vinegar breaks down the calcium carbonate in the eggshell, and the bubbles that form on the surface of the egg are carbon dioxide gas. Eventually the hard shell of the egg disappears entirely and all that remains is the egg membrane. Because you have already blown out the contents of the egg, the membrane is just full of air. You can fold it up and the air will sneak out the tiny hole in the membrane you used to blow out the egg. The membrane will compress down into practically nothing. As you gently shake the "folded egg," the air will re-enter the membrane, expanding back into its original shape and volume.

Additional Info

A Little Magician's Secret - The Folding Egg is a classic science magic trick dating back to the early 1900's. To perform the illusion, the magician would place the inflated egg in an egg carton along with several real eggs. He carefully removed the "special" egg and proceeded to squeeze the egg in his hand. With a little slight of hand, the egg magically seemed to vanish. The magician then showed his audience a clear, empty glass. While showing the glass, he secretly dropped the crumpled up egg membrane into the glass being careful to cover the bottom of the glass with his other hand. "I'll make the egg magically appear by simply shaking the glass." With a little shaking and lots of showmanship, the audience watched as the egg magically reappeared in the glass. Ta da!



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- Magic Milk
- Taco Sauce Penny Cleaner
- Growing Creatures
- Practical Polymers and helpful Hydrogels
- Soil Soakers
- Growing Bacteria
- Double Dip Chip Challenge
- Glow in the Dark Paper
- The Science of Cleaning Products
- Oil Absorbing Polymers
- Solar bag
- Radiometer
- Solar S'mores
- Solar Power! Solar Powered Robots, Bugs, Racing Cars
- UV Beads
- Prescription Protection
- High and Dry: Spinning Bucket
- Egg Drop Experiment
- Strong Sand
- Bounce No Bounce Ball
- H-Racer Hydrogen Car
- Fuel Cell Science Car Kit
- Bernoulli's Bag
- Marshmallow Masher
- Air Burst Rocket
- Bouncing Bubbles
- Giant Bubble
- Straw Stack of Color
- Seven Layer Density Column
- Walk on Water Cornstarch Goo
- Gummy Bear Density
- Floating Rice Bottles
- Bubbling Density Concoction
- Colorful Convection Currents
- Cloud in a Bottle
- Screaming Cup
- Whirly—the Twirling Sound Hose
- Goldenrod Color-Changing Paper
- Magic Color Changing Flower
- Red Cabbage Magic
- Naked Egg Experiment
- Folding Eggs

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