

# **NE STEM 4U**

## **Lesson Plans and Activities: Hands-On, Active Learning Strategies for K-8 Youth**

# Introduction

Enclosed in these pages are lessons brought to you by the University of Nebraska at Omaha out-of-school time program, NE STEM 4U, and its extension sites. These lessons have been delivered to thousands of elementary and middle school-aged students (K-8) in the Omaha Public Schools system. These lessons provide students with STEM concepts in a fun, engaging manner that embraces the Next Generation Science Standards of the target audience. Each lesson has the cognizant NGSS standard, as well as suggestions on where to find more information for longer lessons (such as vetted web-based resources or videos).

Below are the overarching categories of lessons within this booklet:

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**NOTE:** Safety is of the utmost importance. Please carry out each lesson with “being a scientist” in mind! Wear proper attire and all necessary safety materials suggested by the lesson.



## Catalysts and Chemical Reactions

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|-----------------------------|---|
| <b>NGSS</b>                 | MS-PS1-2  |
| <b>Student Objective</b>    | Students will be able to define a catalyst as a substance that increases the rate of a chemical reaction but is not incorporated into the products of the reaction.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- Basic processes of a decomposition and redox reaction.</li> <li>- The role of catalysts in chemical reactions</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Conduct experiments to observe the effects of catalysts on chemical reactions.</li> <li>- Observe chemical processes and determine when a chemical reaction is and is not occurring.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Chemical reaction:</b> a process that involves rearrangement of the molecular or ionic structure of a substance</p> <p><b>Catalyst:</b> a substance that causes or accelerates a chemical reaction without itself being affected by the reaction. In other words, catalysts are always reformed after catalyzing the reaction.</p> <p><b>Reactant:</b> a substance that takes part in and undergoes change during a reaction.</p> <p><b>Product:</b> a substance that is formed from reactants during a chemical reaction.</p> <p><b>Decomposition:</b> separation of a chemical compound into elements or simpler compounds</p> <p><b>Precipitate:</b> A precipitate is an insoluble solid that emerges from a liquid solution. The emergence of the insoluble solid from solution is called precipitation.</p> <p><b>Oxidation:</b> loss of electrons</p> <p><b>Reduction:</b> gain of electrons</p> <p><b>Redox reaction:</b> a chemical reaction in which electrons are exchanged but atoms are not.</p> <p><b>Exothermic:</b> a reaction that releases energy (in the form of heat) into the surroundings.</p> |
| <b>Materials</b>            | <p>- Teacher Guide Sheet</p> <p><b>Elephant Toothpaste Demonstration (yeast catalyst)</b><br/>Material for each group (expect groups of 2-3)</p> <ul style="list-style-type: none"> <li>- Small soda bottle (5)</li> <li>- Hydrogen peroxide (3%)</li> <li>- Yeast (1 pack per school)</li> <li>- Red Solo Cup</li> <li>- Clear plastic cups (5)</li> <li>- Pie tin (to catch the bubbles)</li> </ul>   |

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|                  | <ul style="list-style-type: none"> <li>- Assorted food coloring</li> <li>- Spoon</li> <li>- Liquid dish soap</li> <li>- Water</li> <li>- Funnels (5)</li> <li>- Student Activity Sheet</li> </ul> <p><b>Copper (II) Sulfate &amp; Aluminum Demonstration (salt catalyst)</b><br/> Materials for each group (expect groups of 2-3)</p> <ul style="list-style-type: none"> <li>- Copper solution (in a plastic cup)</li> <li>- Clear plastic cup (5)</li> <li>- Aluminum foil (enough to cover bottom of empty clear plastic cup, ~ 5 cm x 5 cm)</li> <li>- Spoon</li> <li>- Salt</li> <li>- Thermometer</li> <li>- Student Activity Sheet</li> </ul> <p><u>PREPARE AHEAD OF TIME or PREPARE ON SITE WITH STUDENTS</u></p> <ul style="list-style-type: none"> <li>- Copper Solution: Fill Mason Jar <math>\frac{3}{4}</math> with water, add 2 spoonful of copper (II) sulfate and 2 spoonful of salt</li> </ul> <p><b>Copper (II) Chloride &amp; Hydrogen Peroxide Demonstration</b></p> <ul style="list-style-type: none"> <li>- Plastic cup</li> <li>- <math>H_2O_2</math></li> <li>- Copper (II) chloride salt</li> <li>- Spoon</li> </ul> |
| <b>Procedure</b> | <ol style="list-style-type: none"> <li>1) Icebreaker Activity</li> <li>2) Introduce topic</li> <li>3) <b>Elephant Toothpaste Demonstration</b> <ol style="list-style-type: none"> <li>a. In this experiment, we will see if another substance (Yeast) can catalyze the decomposition of hydrogen peroxide into water and oxygen gas.</li> <li>b. Split the students into groups and give each group: <ol style="list-style-type: none"> <li>i. 1 soda bottle</li> <li>ii. 1 pie tin</li> </ol> </li> <li>c. Start off the experiment by making a yeast/water mixture that will be divided among the groups of students. <ol style="list-style-type: none"> <li>i. Make the mixture by filling the red solo cup <math>\frac{3}{4}</math> of the way with WARM water.</li> <li>ii. Add the whole pack of yeast and stir until there are no more big clumps of yeast</li> <li>iii. Divide that mixture up evenly into 5 clear plastic cups, one for each group.</li> <li>iv. Put these off to the side, we will be using them later.</li> </ol> </li> </ol> </li> </ol>   |

- d. Go around to each group and put about an inch of hydrogen peroxide to their soda bottles. Make sure their soda bottles are sitting in the pie tin, because this is going to get messy!
- e. Have the students add food color to the soda bottle, 3-4 drops are enough.
- f. Next, add about 1 tablespoon of soap to the soda bottle. (You can just eyeball it, but it's about a two or three-second-long pour)
- g. GENTLY swirl the hydrogen peroxide, food color, and soap mixture.
- h. Ask the students: Are there bubbles forming?
  - i. Explain to the students that the detergent is added only to make bubbles if any gas is produced. Since the breakdown of hydrogen peroxide produces oxygen gas, bubbling shows that the hydrogen peroxide is breaking down. The lack of bubbling shows that not much oxygen gas is being produced.
- i. To make the reaction happen: Give each group a cup of the yeast/water mixture and have them use the funnels to pour the mixture into the soda bottle.
- j. Have them TOUCH (**not pick up!**) the bottle to see if there is a change in temperature.
  - i. **EXPECTED RESULTS:** Before the yeast is added, there is only a tiny bit of bubbling because of the swirling. After the yeast is added, bubbling will cause foam to move up the soda bottle. Also, the soda bottle should feel a little warmer because the decomposition of hydrogen peroxide releases energy.

#### 4) **Copper (II) Sulfate & Aluminum Demonstration**

- a. Keep the students in their groups
- b. Give each group one plastic cup and one small piece of aluminum foil. Have them pack the foil into the bottom of the cup so that it is flat.
- c. Split the copper solution into 5 empty plastic cups and give one cup to each group.
- d. Have the students pour the solution into the cup with the foil in it
  - i. **BE CAREFUL WITH THIS PART.** The reaction will happen very fast and the reaction causes the cup to get **very hot**. Do not let the students hold the cup during this

|                          |  |
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|                          | <p>experiment, make sure it is on the table before they pour in the copper solution.</p> <ul style="list-style-type: none"> <li>ii. Place a thermometer in the cups to see the temperature change.</li> <li>iii. Expected results: Explain to the students that the copper solution has salt (the catalyst) in it, and the reaction would not occur if the salt was not present.</li> </ul> <p><b>5)Copper II Chloride &amp; Hydrogen Peroxide Demonstration</b></p> <ul style="list-style-type: none"> <li>a. To do another experiment to learn about decomposition reactions, you can pour <math>\text{H}_2\text{O}_2</math> into a cup. Ask students if a chemical reaction is occurring? (No, at least not a detectable one. Is there a temperature change? No. Is gas being produced? No. etc.) BUT, you can use Copper II chloride as a catalyst.</li> <li>b. Drop some <math>\text{CuCl}_2</math> into the <math>\text{H}_2\text{O}_2</math> and observe the bubbles forming. Now, you know a chemical reaction is occurring.</li> </ul> <p>6)Clean up!</p> <p>***When using hydrogen peroxide, follow all warnings on the label. After students have conducted the activity with the copper II sulfate solution and aluminum foil, allow the contents of the cup to evaporate. Put the small amount of solid in a paper towel and dispose in the trash or use a disposal method required by local regulations.</p> |
| <b>Guiding Questions</b> | <p>What is a chemical reaction? Do all chemical reactions occur rapidly? What can speed reactions up? Why might it be important to speed up a reaction? Are there catalysts in the human body? What chemical reactions can you think of that occur in your daily life? What is the difference between a chemical reaction and a physical change? What are some ways to tell that a chemical reaction is occurring?</p>   |
| <b>Background</b>        | <p>In general, catalysts work by providing a place where reactants can come together to react. Explain to students that cells in yeast and other organisms contain a catalyst called catalase. Through normal cell processes, living things produce hydrogen peroxide in their cells. But hydrogen peroxide is a poison so the cells need a way to break it down very quickly. Cells contain catalase, which breaks down hydrogen peroxide at a very fast rate. A single molecule of catalase can catalyze the breakdown of millions of hydrogen peroxide molecules every second.</p> <p>We also observe in this experiment, a reaction between copper II sulfate and aluminum. The copper is called "copper II" because copper can make different types of ions. It can lose one electron and be just <math>\text{Cu}^+</math> or it can</p>  |



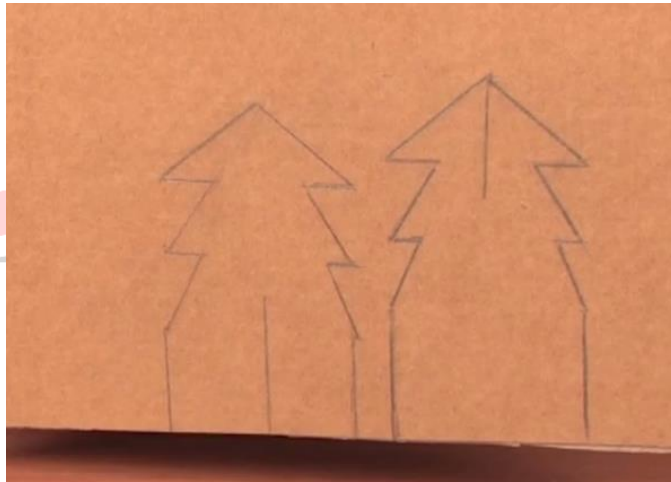
|                                  |   |
|----------------------------------|---|
|                                  | <p>lose two electrons and be <math>\text{Cu}^{2+}</math>. This type of copper ion is called copper II. Also, the “sulfate” in copper II sulfate is also an ion. This ion is made up of more than one atom. The sulfate ion is made up of a sulfur atom bonded to four oxygen atoms and is treated as one ion (<math>\text{SO}_4^{2-}</math>).</p> <p>There are several interesting aspects of the reaction between copper II sulfate and aluminum, but it is different from the other reaction students have seen so far. In this reaction, the movement of electrons, rather than entire atoms, ions, or molecules, causes the reaction to occur. This type of reaction is called an oxidation/reduction reaction. This particular reaction is fun to do because it is exothermic, generates a gas, and copper metal appears as aluminum metal disappears.</p> <p>Salt can be considered a catalyst in the reaction but has a different role than most catalysts. Copper II sulfate and aluminum react very slowly because aluminum is coated with a very thin layer of tarnish (aluminum oxide). This reaction can be sped up if the layer of aluminum oxide is removed or compromised. Adding salt does this and allows electrons from the aluminum to react with the copper ions in the solution, causing them to become copper metal.</p> <p>You know that a chemical reaction occurs when a piece of aluminum foil and sodium chloride is placed in copper II sulfate solution because of bubbling, a color change, an increase in temperature, and a different solid was formed. Tell students that the blue solution contains copper ions (<math>\text{Cu}^{2+}</math>). Adding salt to the solution helps remove a layer of tarnish from the piece of aluminum that was in the solution. This exposes some aluminum and allows electrons from the aluminum to react with the copper ions. These negative electrons are attracted to the positive copper ions. When the electrons join with the copper ions, the ions become neutral copper atoms and look like copper metal in the solution. As the aluminum loses its electrons, it becomes aluminum ions and goes into the solution and seems to disappear.</p> <p>You can refer to the Teacher Guide Sheet as well.</p> |
| <b>Career/Future Application</b> | Chemical reactions are incredibly important. Biochemistry, culinary arts, inorganic and organic chemistry, industry, and so much more!  |
| <b>Sources</b>                   | <p><a href="http://www.pbs.org/parents/adventures-in-learning/2013/10/the-great-elephant-toothpaste-experiment/">http://www.pbs.org/parents/adventures-in-learning/2013/10/the-great-elephant-toothpaste-experiment/</a></p> <p><a href="http://imaginationstationtoledo.org/educator/activities/elephant-toothpaste">http://imaginationstationtoledo.org/educator/activities/elephant-toothpaste</a></p> <p><a href="http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson5">http://www.middleschoolchemistry.com/lessonplans/chapter6/lesson5</a></p> <p><a href="http://www.middleschoolchemistry.com/multimedia/chapter6/lesson5#genie_bottle">http://www.middleschoolchemistry.com/multimedia/chapter6/lesson5#genie_bottle</a></p> <p>(Genie in a bottle and Elephant toothpaste video)</p>  |

## Crystallization Tree

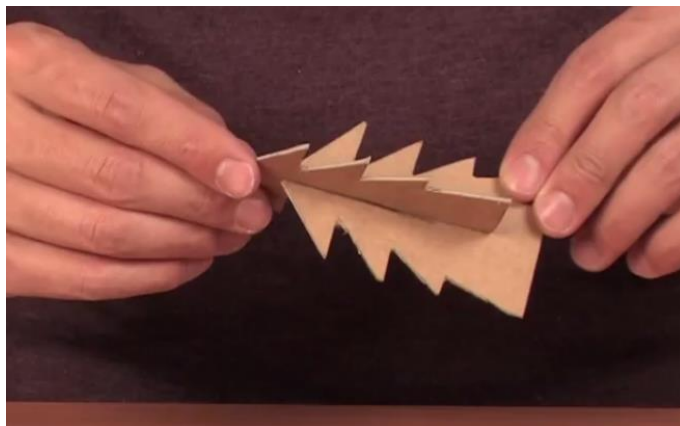
|                             |   |
|-----------------------------|---|
| <b>NGSS</b>                 | 2-PS1-4; MS-PS1-2; MS-PS1-6   |
| <b>Student Objective</b>    | In this experiment, students will be introduced to the concepts of capillary action, evaporation, crystallization and saturation in the course of preparing a neat cardboard tree that will crystallize overnight.  |
| <b>NE STEM 4U Objective</b> | <p><b>I. Main Concept to be learned</b></p> <p><b>1. Capillary Action</b></p> <p>i. The solution in the bowl moves up the cardboard tree using a process similar to the one which enables plants and trees to uptake water and nutrients from the soil.</p> <p><b>2. Evaporation and Recrystallization</b></p> <p>i. As the liquid solution moves up the cardboard tree, the ammonia and water begin to evaporate. The bluing and salt that were initially dissolved in the ammonia and water are left behind as a solid crystalline residue.</p> |
| <b>Vocabulary</b>           | <p><b>a. Capillary Action</b> - the tendency of a liquid to rise into narrow tubes or spaces</p> <p><b>b. Saturation</b> - the point at which a solution of a substance can dissolve no more of that substance and additional amounts of it will appear as a separate phase</p> <p><b>c. Evaporation</b> - the changing of a liquid to its gaseous state</p>  |
| <b>Materials</b>            | <p><b>a. For trees:</b></p> <p>i. Sturdy Cardstock (enough for each student to trace two trees)</p> <p>ii. Tree Pattern (for each student)</p> <p>iii. Scissors (enough for each student)</p> <p>iv. Food Coloring</p> <p>v. Plastic bowl (for each student)</p> <p><b>b. For the Crystallization:</b></p> <p>i. one polystyrene bowl and plastic spoon per student</p> <p>ii. tablespoon to measure</p> <p>iii. 1 TB salt per student</p> <p>iv. 1 TB bluing per student</p> <p>v. 1/2 TB ammonia per student</p>                                |

## Procedure

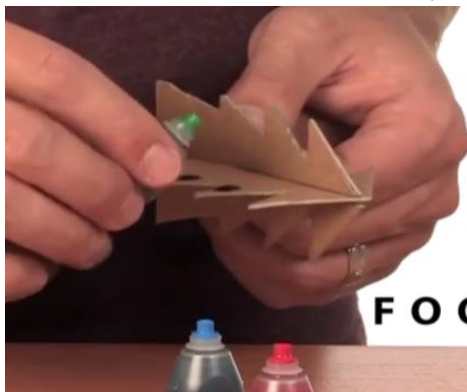
- a. Administer Quiz/ Play Quiz Game
- b. Necessary Explanations- Introduce the concepts of capillary action, solutions, saturation and super-saturation, and re-crystallization. Bring along a completed tree to pique students' interest.
- c. Start the experiment
  - a. Have each child trace two trees onto the cardboard, and then cut them out.



- b. Starting at the top and stopping in the middle, cut a slot down one of the trees.
- c. On the other tree, cut a slot beginning at the bottom and stopping in the middle.
- d. Slide the two slots together; creating a three-dimensional structure that can stand on its own.



- e. Add drops of food coloring to the edges of the cardboard- these will color the crystals later.



- f. Distribute a polystyrene bowl to each student, and have them mix the following with a spoon:

- i. 1 tablespoon water
- ii. 1 tablespoon bluing
- iii. 1 tablespoon salt
- iv.  $\frac{1}{2}$  tablespoon ammonia

- g. Stand the cardboard tree in the middle of the bowl. Explain to the students that crystals will develop over the next 10 - 12 hours. Reshow the example tree you've brought along, and review the concepts of saturation, super saturation and evaporation.

This would also a great place to explain capillary action to the students, expressing that the rise in in the fluid from root to tip up the tree will extend the color and salts out the upper edges of the tree forming crystals. This is similar to a process that trees have moving water from their roots through an inner tube called the xylem to their outer leaves.

- d. Final Quiz/Game

- e. All students should participate in cleaning up the room.

**Tips for Home:**

When the students take their trees home advise them to keep them in a warm place to keep the crystals growing at a fast rate. This should take 10-12 hours to complete so advise the students that they will have to wait for the finished product. Also allow ample air circulation as ammonia is very odiferous furthermore increased circulation will allow for increased evaporation and faster crystal growth.

|                                  |  |
|----------------------------------|--|
| <b>Guiding Questions</b>         |  |
| <b>Background</b>                | <p>The solution mixed in the bowl at the beginning of this experiment is supersaturated with bluing and salt. When the cardboard tree is placed in it, the liquid begins moving up the cutouts as a result of capillary action. This continues to occur until the cardboard is saturated with liquid solution. Over time, the water and ammonia in the solution will evaporate and only the bluing and salt will remain, visible as a crystalline precipitate...or magic tree!</p> |
| <b>Career/Future Application</b> | <p>Crystallization is a major topic in chemistry. Students who really enjoy the process of creating and precipitating a solution are likely to have an aptitude for chemistry, and may consider a career thus oriented. Besides their obvious roles in academic settings, chemists are an integral part of such diverse fields as food processing and development, pharmaceutical development, materials manufacturing, energy science and environmental ecology.</p>              |
| <b>Sources</b>                   | <p><a href="http://www.stevespanglerscience.com/lab/experiments/magic-crystal-tree">http://www.stevespanglerscience.com/lab/experiments/magic-crystal-tree</a><br/> <a href="http://youngzeus.blogspot.com/2010/03/grow.html">http://youngzeus.blogspot.com/2010/03/grow.html</a></p>  |



## The Biology of Taste

|                             |   |
|-----------------------------|---|
| <b>NGSS</b>                 | 4-LS1-2; MS-LS1-1   |
| <b>Student Objective</b>    | Through a series of experiments and activities, students will learn about the biology of taste.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- Basic biology of taste and gustation.</li> <li>- Anatomy of the tongue</li> <li>- Evolutionary significance of taste</li> <li>- Scientific method and experimentation.</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Explain the concepts above.</li> <li>- Conduct tasting experiments.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Gustation:</b> The action of or ability to taste.</p> <p><b>Olfaction:</b> The action of or the ability to smell.</p> <p><b>Fungiform Papillae:</b> Mushroom shaped projections on the tongue that contain taste buds.</p> <p><b>Umami:</b> most recently discovered basic taste. It relies on glutamate receptors and gives a savory taste.</p> <p><b>Gene:</b> a unit of heredity that is transferred from a parent to offspring and is held to determine some characteristic of the offspring</p> <p><b>Allele:</b> one of two or more alternative forms of a gene that arise by mutation and are found at the same place on a chromosome.</p>   |
| <b>Materials</b>            | <p><b>Activity 1: You and Your Tongue!</b></p> <ul style="list-style-type: none"> <li>- Magnifying glasses - Link: (<a href="https://www.amazon.com/Fun-Express-Magnificent-Magnifying-Glasses/dp/B0074MIQ9E/ref=sr_1_1?ie=UTF8&amp;qid=1474756890&amp;sr=8-1&amp;keywords=magnifying+glass+bulk">https://www.amazon.com/Fun-Express-Magnificent-Magnifying-Glasses/dp/B0074MIQ9E/ref=sr_1_1?ie=UTF8&amp;qid=1474756890&amp;sr=8-1&amp;keywords=magnifying+glass+bulk</a>)</li> <li>- Blue food coloring</li> <li>- Dixie cups</li> <li>- Mirrors – Link: ( <a href="https://www.amazon.com/Circles-Projects-Traveling-Decoration-Super/dp/B01BXFHYWW/ref=sr_1_1?ie=UTF8&amp;qid=1474649820&amp;sr=8-1&amp;keywords=small+mirror+bulk">https://www.amazon.com/Circles-Projects-Traveling-Decoration-Super/dp/B01BXFHYWW/ref=sr_1_1?ie=UTF8&amp;qid=1474649820&amp;sr=8-1&amp;keywords=small+mirror+bulk</a>)</li> </ul> <p><b>Activity 2: The Basic Tastes</b></p> <ul style="list-style-type: none"> <li>- Q-tips (5 per student)</li> </ul> |

|                         |  |
|-------------------------|--|
|                         | <ul style="list-style-type: none"> <li>- Sharpie Markers</li> <li>- Disposable gloves (optional)</li> <li>- Dixie cups (5 per student)</li> <li>- Water Jug</li> <li>- Lemon juice</li> <li>- Sugar</li> <li>- Grapefruit juice</li> <li>- Monosodium Glutamate (MSG)</li> <li>- Tongue Diagram Handout</li> <li>- Mirrors (1 per student)</li> <li>- Colored pencils</li> </ul> <p><b>NOTE:</b> Sour (lemon juice + water), Sweet (sugar water), Bitter (grapefruit juice + water), Salty (salt water), Umami (MSG water) tasting solutions can be made by mentors ahead of time or on site. They should be made up at a relatively weak concentration. Prepare in clean cups / bottles, as students will be tasting these solutions.</p> <p><b>Activity 3: Taste vs Flavor (the importance of smell)</b></p> <ul style="list-style-type: none"> <li>- Assorted Jelly Beans AND/OR Parma Violets</li> <li>- Dixie cups</li> </ul> <p><b>Activity 4: Are you a super taster?</b><br/> <a href="https://www.amazon.com/QUALITY-Super-Taster-Strips-Test/dp/B019MACBOG/ref=sr_1_8?s=industrial&amp;ie=UTF8&amp;qid=1474657271&amp;sr=1-8&amp;keywords=Genetic+taste+testing">https://www.amazon.com/QUALITY-Super-Taster-Strips-Test/dp/B019MACBOG/ref=sr_1_8?s=industrial&amp;ie=UTF8&amp;qid=1474657271&amp;sr=1-8&amp;keywords=Genetic+taste+testing</a></p> <ul style="list-style-type: none"> <li>- Control strips</li> <li>- PTC strips</li> <li>- Thiourea strips</li> <li>- Sodium Benzoate strips</li> <li>- Plastic cup for water</li> <li>- Peppermints</li> <li>- Supertaster handout</li> </ul> |
| <p><b>Procedure</b></p> | <p><b>Introduce topic</b></p> <ol style="list-style-type: none"> <li>Get into the activities quickly. There is a lot to get through. You can talk about the science background info while you are setting up/working on the activity.</li> </ol> <p><b>1) Activity 1: You and Your Tongue!</b></p> <ol style="list-style-type: none"> <li>Hand out the following items             <ol style="list-style-type: none"> <li>Dixie cup filled with one sip's worth of water</li> <li>Mirror</li> <li>Magnifying glass (if not enough, students can share)</li> </ol> </li> <li>Do the following demonstration with your mentoring partner             <ol style="list-style-type: none"> <li>Place ONE drop of blue food coloring on the tip of the tongue.</li> <li>The person with blue food coloring on their tongue will take a small sip of water, swish the water around in his or her</li> </ol> </li> </ol>   |



mouth for 15 seconds, and then spit it out carefully back into the Dixie cup.

III. Now that their tongue is stained blue, have them use the mirror to look at their papillae (which contain taste buds).

The papillae are the non-stained bumps on the tongue.

- c. Now that the students have seen a demonstration, go around the room placing one drop of blue food coloring on each of their tongues. Be careful not to touch the bottle of food coloring to their tongues.
- d. While the students are completing the activity, be sure to engage them in discussion about papillae, taste buds, and gustation. You can introduce the topic of super tasters, but this will be explored more later. Use background section.

## 2) Activity 2: The Basic Tastes

- a. Hand out the following items:
  - I. Q-tips (5x student)
  - II. 5 Dixie cups (labeled Salty, Sweet, Bitter, Sour, Umami)
  - III. Plastic water cup (1x student to cleanse the palate between tastes)
  - IV. Mirror (1x student)
  - V. Tongue Diagram Handout (1x student)
- b. Talk to the students about the 5 basic tastes.
  - I. See if they know what they are?
  - II. What might be the evolutionary benefits of having these tastes
- c. Talk to the students about the tongue map. See if they believe it is true.
  - I. The tongue map is a MYTH! It has been disproven by science. However, many people still believe it to be true. During this activity, have students taste each solution in all areas of the tongue seen on the diagram to prove that taste is not regionally localized. They will record their observations on the handout.
- d. Instruct students to dip a Q-tip into each solution and, holding the mirror in front to see their tongue, place the Q-tip on various regions of the tongue as directed by the tongue map. Record which tastes could be experienced on which areas of the tongue using the handout. Rinse with water between each trial.

## 3) Activity 3: Taste vs Flavor (importance of smell)

- a. Ask questions about the connection between smell and taste. Use the background section to spur conversation.
- b. Hand out assorted Jelly Beans and/or Parma Violets to each student.
- c. Do the parma violet or jelly bean test. Ask the student to hold their nose and start to suck the parma violet or chew the jelly bean. Ask if they can tell what flavor it is and what they can taste. They will probably only say it is something sweet, which is the sugar taste in the parma violet or jelly bean. Now tell them to let go of their nose

and they will get a sudden rush of the flavor and be able to tell you what it is. This demonstrates that it is smell which gives it flavor. Just like when you have a cold you cannot “taste” your food properly.

**4) Activity 4: Are you a supertaster?**

- a. Introduce the topic of genetics and taste. Use the background information to lead conversation. Tell the students they will conduct a scientific experiment and collect data to determine who among them are non-tasters, tasters, and supertasters.
- b. Hand out the following items to each student:
  - I. 4 labeled Dixie cups (Control, PTC, Thiourea, Sodium Benzoate) with one of each designated strip in the cups.
  - II. Dixie up with peppermint or some other universally loved candy (to be eaten at the end of the activity).
  - III. Plastic water cup (for rinsing between each trial)
  - IV. Supertaster handout
- c. Instruct students to conduct their experiment and record their data.
- d. **BE SURE TO TELL THE STUDENTS;**
  - I. None of these chemicals are dangerous. Some of them might taste bad to you, but please do not make a scene. If someone makes a scene, it will influence the rest of the class and bias the data.
  - II. Also, it is worth mentioning that being deemed a non-taster, taster, or supertaster during this experiment is not necessarily accurate, nor does it have any bearing on their lives. This is just a simple activity to explore genetic differences between individuals.
- e. Once the students are finished collecting their data, have all the students stand up.
  - I. **FIRST**, do the control strip.
    - Sit down if you did not taste anything but plain old paper.
    - Everyone should sit down. The control strip is used to make sure students understand what a plain strip tastes like, that way they don't confuse it with one of the chemicals in the other strips.
    - If you like, you can explain the importance of using a negative control during experiments at this time.
  - II. Do the “Stand up / sit down” activity for the rest of the strips. Here is an example for the PTC strips.
    - Sit down if you did not taste the PTC. This means you are a non-taster. You do not have the gene to taste PTC. Talk about the advantages / disadvantages of being a non-taster.
    - Sit down if you were able to taste PTC and rated the taste anywhere from 1-3. These are the tasters, but not supertasters. They have the gene to taste PTC,

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|                          | <p>but it is not expressed as much as it is for supertasters.</p> <ul style="list-style-type: none"> <li>Those that are still standing are supertasters. They have the gene to taste PTC with high expression. Talk about the advantages / disadvantages of being a super taster.</li> </ul> <p>Students can have peppermints or whatever other candy that we give them to finish the lesson.</p>  |
| <b>Guiding Questions</b> | <p>1) How do we taste?</p> <p>2) What are the evolutionary benefits for having different types of taste</p> <p>3) We crave certain tastes, like salty and sweet, why might this be?</p> <p>4) Are there medical conditions that make tasting food impossible? How about gustatory and olfactory hallucinations?</p>  |
| <b>Background</b>        | <p><b>Activity 1:</b> Basic tastes are detected by taste receptor cells or 'Taste Buds' on your tongue, throughout your mouth. The <u>taste buds</u> are clustered in papillae, and each taste bud has 50-150 taste receptors sensitive to certain chemicals. When these chemicals dissolve in the saliva in your mouth, a signal is sent straight to your brain. The sense of taste is termed gustation.</p> <p>Taste buds can be seen as non-staining regions on the tongue when food coloring is added. The non-staining regions are called <u>papillae</u> and they are the structures on your tongue that hold your taste buds. <u>Non- and medium-tasters</u> look as though they have polka dots on their tongues. <u>Supertasters</u> have a tiled effect on theirs, and the papillae will be edge to edge on the tip of the tongue.</p> <p><b>Activity 2:</b> The basic tastes are the commonly recognized tastes including <u>bitter, salty, sour, sweet</u>, and a fifth taste termed <u>umami</u>. Taste is detected by sensory organs called taste buds, found on the upper surface of the tongue and other parts of the mouth. Receptors that recognize a large number of specific chemicals have been identified. The specific chemicals that can be detected include sodium, potassium, chloride, glutamate and adenosine. <b>Salt</b> - the taste of salt is due to sodium chloride (and to a lesser degree other salts); <b>Sour</b> - the taste of sour is due to acids like vinegar, lemon juice or malic acid found in 'sour sweets'; <b>Sweet</b> - the sensation of sweetness is produced by sugars, sugar substitutes and some proteins. Aldehydes and ketones are also often found to be sweet; <b>Bitter</b> - Bitter tastes are initially unpleasant and often require a period of exposure to 'acquire a taste' for foods that are very bitter such as beer, coffee or quinine found in tonic water. Bitter tastes may indicate toxins or spoiled food. Most</p> |

toxic plants and many poisons taste bitter and evolutionary biologists think that a dislike of bitter tastes evolved as a defense against accidental poisoning; **Savouriness or Umami** - The taste of savoury foods is the 'fifth' taste and is produced by free glutamates (forms of the glutamic amino acid). These glutamates are often found in protein rich foods such as meats and mushrooms as well as fermented and aged products such as soy sauce and parmesan. Umami has only recently been found to have its own taste receptors.

The tongue map is a MYTH! It has been disproven by science. However, many people still believe it to be true. During this activity, have students taste each solution in all areas of the tongue seen on the diagram to prove that taste is not regionally localized.

**Activity 3:** The *flavour* of food depends more on its *smell*, than on its *taste*, and we can recognize a very large number of different odours indeed. What you think of as taste, is more likely to be aroma. That's why food seems so tasteless when you have a cold. When you have food in your mouth, as you breathe molecules of the food that come off into the air (volatile chemicals) pass over a part of your nose called the *olfactory epithelium*. Your olfactory epithelium is the super star of food flavour sensation!

You have about 350 different types of odour receptor, each one works like a lock and key to detect a particular set of scent molecules. The individual receptors work together in combinations to produce the sensation of smell. It is like the letters of a giant alphabet and the smells we perceive are the words made up from a 350 letter alphabet. Your memory recognizes the smell and tells you what it is.

The olfactory bulb can detect around 3,000 compounds, which when combined together with the 5 tastes will make between 10,000 and 100,000 recognizable flavors. Sensations other than taste that contribute to our sense of flavour are termed chemesthesis.

**Activity 4:** There is a single gene that codes for a protein (receptor) found in our taste buds known as taste receptors, type 2 (TAS2R38). If a person has this protein receptor then they are able to detect the bitter taste of a chemical called phenylthiocarbamide (PTC). PTC can bind to the receptor and the person will be able to taste the chemical. If the individual does not have the gene, and hence the protein is not present, PTC cannot bind to the taste buds and the person cannot taste it.

PTC can taste very bitter to some people, but are virtually tasteless to others. Among the tasters, some are so-called "supertasters" to whom PTC

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|                                  | <p>is extremely bitter. The variation in the ability to taste substances amongst people has been determined to be a genetic trait. This has led to great interest from geneticists and anthropologists investigating diverse groups around the world. It is also of interest to evolutionary biologists and nutritionists since many naturally bitter compounds also happen to be toxic but so too are foods high in antioxidants such as broccoli or coffee. Those individuals with the ability to taste PTC may have acquired this trait through an evolutionary protective mechanism that now puts them off healthy foods such as green vegetables. Tasters are more likely to avoid bitter foods such as green vegetables, coffee and tea as well as smoking.</p> <p>Being able to taste PTC is a dominant trait. About 2/3 to 3/4 of people in western cultures are able to taste it, while 1/3 to 1/4 will not. Individuals who are homozygotes for the dominant allele are commonly described as “supertasters”. Having two copies of the gene means that they produce more proteins or more binding sites for PTC. The proportions of tasters and ‘non-tasters’ varies in different parts of the world. It has been reported that 100% of Native Americans, about 70% of westerners, and 50% of Aboriginal peoples are tasters and supertasters are more likely to be African-American, Asian or female.</p> <p>A wide variety of responses to PTC have been described and may elicit tastes such as sour, sweet, salty and occasionally more obscure tastes. Phenylthiourea papers taste bitter to seven out of ten people. A different pair of alleles determines the ability to taste Sodium Benzoate, so taste results are different from PTC. Sodium benzoate papers taste sweet, salty, bitter, or tasteless to different people. Thiourea is another bitter tasting compound that is chemically similar to PTC. The ability to taste PTC and Thiourea are genetically linked, but it doesn’t mean you will have the same reaction to both.</p> |
| <b>Career/Future Application</b> | Gustation is an important scientific concept, relating to biological sciences, culinary arts, food industry, psychology and more!   |
| <b>Sources</b>                   | <a href="http://www.ifr.ac.uk/media/cms_page_media/85/ForTeachers.pdf">http://www.ifr.ac.uk/media/cms_page_media/85/ForTeachers.pdf</a><br><a href="https://preclaboratories.com/are-you-a-supertaster/">https://preclaboratories.com/are-you-a-supertaster/</a>  |

## Fruit DNA Extraction

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| <b>NGSS</b>                 | MS-LS3-1; MS-LS4-5   |
| <b>Student Objective</b>    | The purpose of this lesson is to teach the students that, like us, fruits and all plants have DNA as well! Students will extract DNA from strawberries and bananas to learn that DNA is similar in all living organisms.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>-Every cell in each plant and animal has DNA!</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>-Somewhat understand and explain what DNA is.</li> <li>-DNA is the genetic material that provides the blueprint, or genetic instructions, for how an organism will develop and function.</li> <li>-Each cell has the exact same copy of DNA housed in the nucleus.</li> <li>-This DNA is turned into protein, which then performs a specific function.</li> </ul>   |
| <b>Vocabulary</b>           | <p><b>DNA/Deoxyribonucleotide:</b> The genetic instructions for an organism</p> <p><b>Genome:</b> An organism's genetic material encoded by DNA</p> <p><b>Chromosome:</b> Structure composed of DNA, RNA, and protein that carry genetic material in the form of genes.</p> <p><b>Phospholipid bilayer:</b> Amphipathic bi layer that makes up the cell membrane.</p>  |
| <b>Materials</b>            | <p><b>Supplies per Student Group</b></p> <ul style="list-style-type: none"> <li>Strawberries (1 per student)</li> <li>Bananas (1/2 or 1/3 per student)</li> <li>Isopropyl alcohol (keep chilled)</li> <li>Distilled water (regular water should work)</li> <li>Dish soap</li> <li>Salt</li> <li>Quart sized Zip lock bags (1 per student)</li> <li>Plastic cup (2 per student)</li> <li>Spoons (1 per student)</li> <li>Plastic pipettes (1 per student)</li> <li>Coffee filters (1 per student)</li> <li>Measuring spoons</li> <li>Rubber bands (1 per student)</li> <li>Micro centrifuge tubes and string.</li> <li>Colored gum drops / dots / mini-marshmallows (all that matters is that there are at least 4 different colors) (2 boxes per school)</li> <li>Box of toothpicks.</li> <li>Twizzlers</li> <li>1 paper plate per student</li> <li>Pens or Pencils</li> <li>DNA Handout (1x student)</li> </ul> |

## Procedure

### 1) Introduce the Topic

- a. go over concepts and background.

### 2) Start the experiment

- a. Have the students split up into two groups. One group will do the extraction with a strawberry and the other a banana.
  - I. This is so the students can compare afterwards and see that everything has a genetic makeup and that it looks the same!
- b. Within each group, students will work individually to extract DNA from their fruit.
- c. Pass out to each student
  - I.  $\frac{1}{4}$  cup of distilled  $H_2O$
  - II. 2 plastic cups
  - III. Rubber band
  - IV. Spoon
  - V. Pinch of table salt
  - VI. Coffee filter paper
  - VII. Plastic pipette
- d. **NOTE:** When you conduct each step of the extraction procedure, be sure to explain the scientific reason for each step using the information in the background section of the lesson. (Soap to break cells open, salt to bind DNA, etc.)

#### **Strawberry Group:**

1. Give 1 strawberry per student along with one zip lock baggie.
2. Have students place strawberry (without the leaves) in the baggie.
3. Next have the students add  $\frac{1}{4}$  cup of distilled  $H_2O$  to the baggie.
4. Have the students mash up the strawberries so there are no large chunks left.
5. Have them place this aside and in one cup mix together the following:
  - a. Fill the cup 1 centimeter high with soap
  - b. 3 second count dump of salt
  - c.  $\frac{1}{4}$  cup of distilled  $H_2O$
  - d. Lastly, add all of the crushed up strawberry solution in the ziplock bag to the cup.
  - e. Have them stir this for about 5 minutes.
    - i. Have them stir slowly as to not produce too many bubbles.
6. After the five minutes they will strain the contents of this cup through the coffee filter into another clean cup.
  - f. Make sure coffee filter is resting on the top of the cup. Also, the filter paper should not be too tight over the top of the cup... you do not want the paper to rip when you filter the solution. Use rubber band to secure the filter.
7. Once all of the strawberry mix has been filtered into a new cup, slowly pour cold isopropyl alcohol down the side and into the cup (add about  $\frac{1}{2}$  inch of isopropyl into the cup). This should precipitate the DNA and make it float to the top.



8. Gather the precipitated DNA at the surface of the fluid using the plastic pipette. You can put the DNA in the micro-centrifuge tubes and take home. You can even make a necklace out of it if you brought string.

**Banana Group:** (same procedure as strawberry group)

1. Give  $\frac{1}{2}$  or  $\frac{1}{3}$  banana per student along with one zip lock baggie.
2. Have students place a peeled banana in the baggie.
3. Next have the students add  $\frac{1}{4}$  cup of Distilled H<sub>2</sub>O to the baggie.
4. Then have the students mash up the bananas so there are no large chunks left.
5. Have them place this aside and in one cup mix together the following:
  - a. Fill the cup 1 centimeter high with soap
  - b. 3 second count dump of salt
  - c.  $\frac{1}{4}$  cup of distilled H<sub>2</sub>O
  - d. Lastly, add all of the crushed-up banana solution in the ziplock bag to the cup.
  - e. Have them stir this for about 5 minutes.
    - i. Have them stir slowly as to not produce too many bubbles.
6. After the five minutes they will strain the contents of this cup into another clean cup.
  - g. Make sure coffee filter is resting on the top of the cup. Also, the filter paper should not be too tight over the top of the cup... you do not want the paper to rip when you filter the banana solution. Use rubber band to secure the filter.
7. Once all of the banana mix has been filtered into a new cup, slowly pour cold isopropyl alcohol down the side and into the cup (add about  $\frac{1}{2}$  of isopropyl into the cup). This should precipitate the DNA and make it float to the top.
8. Gather the precipitated DNA at the surface of the fluid using the plastic pipette. You can put the DNA in the micro-centrifuge tubes and take home. You can even make a necklace out of it if you brought string.

**Both groups:**

1. Have students compare their results
  - a. Does the DNA from the banana look different from that of the strawberry? Have them explain why or why not.
  - b. The students should be able to observe that aside from a slight difference in color both DNA extractions look like white snot!

**3) Build Candy DNA Model:**

- a. Each student building a candy DNA model will need the following:
  - I. 2 Twizzlers (Sugar/Phosphate backbone)
  - II. ~10-12 toothpicks
  - III. Dots / gumdrops / mini-marshmallows (~20 total, but in a mixture of 4 different colors)
    - i. Each different color will represent a nucleotide base (A,T,G,C)



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|                                  | <p>IV. DNA Handout</p> <p>b. Each student will decide which color of candy represents each base. On their DNA handout, they must indicate their choices. When they build their model, the bases must pair properly (A-T &amp; C-G)</p> <p><b>4) Cleanup:</b></p> <p>a. Finally have the students assist with cleanup.</p> <p>b. Let one of the students pass out paper for the post-test.</p> <p>c. Administer post-test.</p>   |
| <b>Guiding Questions</b>         | <ol style="list-style-type: none"> <li>Which of the following contains DNA? <ol style="list-style-type: none"> <li>Banana</li> <li>Human</li> <li>Fly</li> <li>All of the above</li> </ol> </li> <li>Does every cell within an organism contain the exact same DNA sequences?</li> <li>Which pair of organisms shares the same DNA? <ol style="list-style-type: none"> <li>Banana and a strawberry</li> <li>Identical twins</li> <li>Mother and child</li> <li>Snake and cat</li> </ol> </li> <li>What is the name of an organism's complete set of genes or genetic material encoded by DNA?</li> <li>What is a nucleotide? Give an example:</li> </ol>  |
| <b>Background</b>                | <p>All plants and animals have DNA, and today this experiment will demonstrate that all living things have DNA. The students will be divided into two groups and at the end will compare their experiments. We can extract the strawberries and bananas genomes and even sequence them if we want. Strawberries are a convenient fruit to use because they have large genomes that are easily visible when extracted. Strawberries are octoploids, which means that have 8 chromosomes in each cell.</p> <p>To get to the genetic material, a detergent is needed to disrupt the phospholipid bilayer of cell membranes and organelles. Detergents, such as soap, have a head that is attracted to water (hydrophilic) and a tail that is attracted to grease (hydrophobic). This makes it possible to disrupt the hydrophobic and hydrophilic regions of phospholipid bilayers.</p> <p>To release the DNA strands, we then use salt to break up the protein chains that bind around the nucleic acids.</p> <p>Because DNA is not soluble in isopropyl alcohol it will precipitate, and then the DNA can be scooped up.</p> |
| <b>Career/Future Application</b> | <p>DNA can help to identify people, even better than a fingerprint! Crazy right? Being able to extract DNA helps a lot of professionals. It helps the forensic scientist that is trying to catch a criminal. Doctors use DNA to help diagnose genetic illnesses. But it can also be used by genetic engineers that study the mechanisms of DNA</p>  |

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|                | replication; there are people that even research our food!  |
| <b>Sources</b> | <a href="https://www.youtube.com/watch?v=23jSj-B18gM">https://www.youtube.com/watch?v=23jSj-B18gM</a><br><a href="https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_biomed/cub_biomed_lesson09_activity2.xml">https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_biomed/cub_biomed_lesson09_activity2.xml</a><br><a href="http://www.stevespanglerscience.com/lab/experiments/strawberry-dna">http://www.stevespanglerscience.com/lab/experiments/strawberry-dna</a> |



## Honey Purity Test

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| <b>NGSS</b>                 | MS-LS1-7; MS-PS1-2; MS-PS1-3  |
| <b>Student Objective</b>    | Following today's experiment, students will be able to identify and explain the visual and chemical differences between natural or synthetic honey.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-The chemical makeup of natural and synthetic honey.</p> <p><b>The student will be able to:</b><br/>-Perform a test on distinct honey brands.<br/>-Distinguish the synthetic from real honey.</p>  |
| <b>Vocabulary</b>           | <p><b>Synthetic:</b> made by chemical synthesis, imitates a natural product.</p> <p><b>Adulterate:</b> to lower the quality of something by adding another substance.</p> <p><b>Enzymes:</b> catalyst which accelerates chemical reactions.</p> <p><b>Antioxidants:</b> compounds produced in the body, found in foods, defends one's cells from damage caused by harmful molecules.</p> <p><b>Soluble:</b> can be dissolved, specifically in water</p>   |
| <b>Materials</b>            | <p>2 Brands of pure honey<br/>2 Brands of artificial honey (synthetic)<br/>4 Spoons<br/>4 Bowls (per group)<br/>Bring snacks to eat with honey for fun! (i.e. pretzels, bread)</p>  |
| <b>Procedure</b>            | <p><b>Water Test</b></p> <ol style="list-style-type: none"> <li>1. Fill a bowl with water</li> <li>2. Add a spoonful of honey into the bowl (keep bottles unmarked so that the students can guess which bottles are the artificial honey)</li> <li>3. Stir for 5 seconds</li> <li>4. Observe results</li> <li>5. Repeat for each brand of honey (4 total)</li> <li>6. Artificial honey will begin to dissolve quickly and break apart in the water because it has been adulterated with additives, particularly sugar, which is soluble in water.</li> <li>7. Raw honey will not dissolve, or dissolve very slowly, due to the fact that honey has low to zero water content. Pure honey little to no water because water promotes the growth of fungi, which is undesirable to bees. To incorporate it into the liquid, real honey needs to be stirred for a longer period of time.</li> </ol> |
| <b>Guiding Questions</b>    | <p>1) What do you think will happen when honey is mixed with water? Natural versus synthetic?</p> <p>2) Why does natural honey not dissolve quickly in water? Why does synthetic honey dissolve?</p>  |

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| <b>Background</b>                | <p>Honey is a product loved by millions of people. Not only is natural honey delicious, many studies have linked its antioxidants with many health benefits. If one is attempting to buy real, natural honey rather than synthetic honey, it can be challenging to find one's preferred product amongst an eclectic mix of honey brands in stores, due to the fact that almost 3 out of 4 brands of honey on the market is synthetic honey. Honey consists primarily of fructose and glucose, with water, sucrose, maltose, trisaccharides, vitamins, and minerals listed as the remaining elements. During the processing system, the once natural honey has been altered and stripped of natural components, such as enzymes, pollen, nutrients, and vitamins, which leaves the "honey" as just sweetened syrup. Additionally, in pursuit of lower production costs, some companies add ingredients, such as corn syrup, artificial sweeteners, and other contaminants to adulterate the honey. Utilizing this experiment, one can perform a test which involves water, which home variety honey brands are synthetic, and which are natural.</p> |
| <b>Career/Future Application</b> | Nutritional Therapist, Food Process Engineer, Agricultural Food Scientist, Horticulture Research, Apiarist  |
| <b>Sources</b>                   | <p><a href="http://jimmymacfarm.com/farm-journal/2014/7/12/the-truth-about-raw-honey">http://jimmymacfarm.com/farm-journal/2014/7/12/the-truth-about-raw-honey</a></p> <p><a href="https://www.mybeeline.co/en/p/how-can-we-differentiate-100-pure-honey-and-adulterated-honey">https://www.mybeeline.co/en/p/how-can-we-differentiate-100-pure-honey-and-adulterated-honey</a></p>   |

## Human DNA Extraction

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| <b>Average Lesson Cost (class of 15)</b> | \$150   |
| <b>NGSS</b>                              | MS-LS1-1  |
| <b>Student Objective</b>                 | The purpose of this lesson is to teach the students about the DNA that makes up their bodies and the structure of DNA. Students will extract DNA from their cheek cells.  |
| <b>NE STEM 4U Objective</b>              | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- Their cheek (and all other) cells have DNA</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Somewhat understand and explain what DNA is</li> <li>- Extract genetic material from their own cells</li> </ul>   |
| <b>Vocabulary</b>                        | <p><b>DNA/Deoxyribonucleic acid</b> – The genetic instructions for an organism</p> <p><b>Genome</b> – The whole collection of an organism's genetic material, composed of DNA</p> <p><b>Double Helix</b> – The twisting shape of DNA composed of nucleotides in two long chains that twist around each other.</p> <p><b>Genes</b> – Carry the information that determines the features or characteristics that are inherited from your parents.</p>   |
| <b>Materials</b>                         | <p>Writing utensils</p> <p><b>Human DNA Extraction Demonstration</b></p> <ul style="list-style-type: none"> <li>- Clear cups (2 per student)</li> <li>- Large cup (Used to pre-mix salt and water)</li> <li>- Coffee stirrers (1 per student)</li> <li>- Isopropyl alcohol (keep chilled)</li> <li>- Distilled water</li> <li>- Dish soap</li> <li>- Salt</li> <li>- Food coloring</li> <li>- Spoons (1 per student)</li> <li>- Plastic pipettes (1 per student)</li> <li>- Micro centrifuge tubes and string (1 per student)</li> </ul> <p><b>Origami DNA Model Demonstration</b></p> <ul style="list-style-type: none"> <li>- DNA Origami Template (1 per student)</li> <li>- DNA Origami Instructions (1 per group)</li> </ul> |

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| <p><b>Procedure</b></p>         | <p><b>2. Introduce topic</b></p> <p><b>3. Safety Precautions</b></p> <ul style="list-style-type: none"> <li>a. Do not let students handle alcohol.</li> </ul> <p><b>4. Human DNA Extraction Demonstration</b></p> <ul style="list-style-type: none"> <li>a. Give each student two clear cups.</li> <li>b. In one large cup fill with water and add salt until the solution is saturated (no more salt dissolves).</li> <li>c. Transfer approximately 3 tablespoons into each students' first clear cup.</li> <li>d. Gargle the second cup of salt water for 1 minute.</li> <li>e. Spit the water back into their first cup. This salt solution will contain suspended cheek cells.</li> <li>f. Dip a coffee stirrer into the dish soap, take a medium-sized drop of soap, add to the second cup, and gently stir while avoiding bubbles as much as possible.</li> <li>g. In each students' second clear cup, fill <math>\frac{1}{4}</math> full of isopropyl alcohol and add 3 drops of food coloring.</li> <li>h. Tilt the first cup containing the student's DNA and add the second cup slowly to it. A layer will form on top.</li> <li>i. In approximately 3 minutes, the students will start to see white snot like stuff, this is the DNA that has been extracted.</li> </ul> <p><b>5. Origami DNA Model Demonstration</b></p> <ul style="list-style-type: none"> <li>a. Fold paper in half lengthwise. <b>Make all creases as firm as possible.</b></li> <li>b. Hold the paper so that the thick lines are diagonal and the thin lines are horizontal. Fold the top segment down and then unfold.</li> <li>c. Fold the top two segments down along the next horizontal line. Unfold.</li> <li>d. Repeat for all segments.</li> <li>e. Turn paper over.</li> <li>f. Fold along the first diagonal line. Unfold and fold along the second diagonal line. Repeat for all diagonal lines</li> <li>g. Fold the white edge without letters up.</li> <li>h. Fold the other edge away from you. Partly unfold both edges.</li> <li>i. You can now see how the model is starting to twist.</li> <li>j. Twist and turn the paper while pushing the ends towards each other</li> <li>k. Now let go.</li> </ul> <p>Clean up the room!</p> |
| <p><b>Guiding Questions</b></p> | <p>1) What types of living organisms contain DNA?</p> <p>2) Does every cell within an organism contain the exact same DNA sequences?</p>   |

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|                                  | <p>3) Which pair of organisms shares the same DNA?</p> <p>A. Banana and a strawberry<br/>B. Identical twins<br/>C. Mother and child<br/>D. Snake and cat</p> <p>4) What is the name of an organism's complete set of genes or genetic material encoded by DNA?</p> <p>5) What is a nucleotide? Give an example</p>  |
| <b>Background</b>                | <p>DNA is a record of instructions telling the cell what its job is going to be. A good analogy for DNA is a set of blueprints for the cell, or computer code telling a PC what to do. It is written in a special alphabet that is only four letters long! Unlike a book or computer screen, DNA isn't flat and boring - it is a beautiful curved ladder. We call this shape a double helix. The letters of the DNA alphabet (called bases) make up the rungs, special sugars and other atoms make up the handrail.</p> <p>The rungs are very special. Each one has a name, but they prefer to be called by their initials: A, T, C and G. They don't like to be by themselves so always pair up with a friend. But they are very choosy about their friends:</p> <p style="padding-left: 40px;">A and T are best friends and always hang out together<br/>G and C are best friends and always hang out together</p> <p>Another way of looking at it is that A, T, G and C are like jigsaw pieces. A and T fit together, C and G fit together - you cannot force a jigsaw piece to fit in the wrong place - just like in the picture!</p> <p>Think of all the words you can spell. I bet there are loads. But each word is made using the same selection of letters. Yes, sometimes we leave letters out, sometimes we repeat letters, but we always have the same selection of letters. Depending on how we arrange the letters of the alphabet we can make new words. The same is true in the four-letter alphabet of DNA</p> |
| <b>Career/Future Application</b> | <p>NA can help to identify people, even better than a fingerprint! Crazy, right? Being able to extract DNA helps a lot of professionals. Biomedical researchers use DNA all the time as a tool for discovering new things about diseases – their discoveries help develop new and better treatments and cures for diseases. It helps the forensic scientist that is trying to catch a criminal. Doctors use DNA to help diagnose genetic illnesses. But it can also be used by genetic engineers that study the mechanisms of DNA replication; there are people that even research our food!</p>  |
| <b>Sources</b>                   | <p><a href="https://www.youtube.com/watch?v=DaaRrR-ZHP4">https://www.youtube.com/watch?v=DaaRrR-ZHP4</a><br/> <a href="http://www.yourgenome.org/activities/origami-dna">http://www.yourgenome.org/activities/origami-dna</a><br/> <a href="http://www.chem4kids.com/files/bio_dna.html">http://www.chem4kids.com/files/bio_dna.html</a><br/> <a href="http://learn.genetics.utah.edu/content/labs/extraction/howto/faq.html">http://learn.genetics.utah.edu/content/labs/extraction/howto/faq.html</a><br/> <a href="ftp://ftp.sanger.ac.uk/pub/yourgenome/downloads/activities/origami-dna/dnaorigamitempcoloured.pdf">ftp://ftp.sanger.ac.uk/pub/yourgenome/downloads/activities/origami-dna/dnaorigamitempcoloured.pdf</a><br/> <a href="https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_biomed/cub_biomed_lesson09_activity2.xml">https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_biomed/cub_biomed_lesson09_activity2.xml</a></p>   |





# Model Cell


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| <b>NGSS</b>                 | MS-LS1-2  |
| <b>Student Objective</b>    | Create a model of an animal cell  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-The basic components of a cell</p> <p><b>The student will be able to:</b><br/>-Identify basic components of a cell</p>  |
| <b>Vocabulary</b>           | <p><b>Cell</b> - Smallest structural and functional unit of an organism/life</p> <p><b>Nucleus</b> (candy brains) - The brain of the cell. Contains DNA and RNA that is responsible for growth and reproduction</p> <p><b>Plasma Membrane</b> (nerds rope) - Thin layer of proteins and fats that surrounds the cell. It is semipermeable (some substances can pass, others cannot)<br/>Gatekeeper!</p> <p><b>Cytoplasm</b> - Jellylike material outside of the cell nucleus in which other organelles are located</p> <p><b>Endoplasmic Reticulum</b> (air head extremes) - Helps transport materials around the cell</p> <p><b>Lysosome</b> (shark candy) - The trash can of the cell, will “eat” particles in the cell</p> <p><b>Ribosome</b> (sprinkles) - Helpers inside a cell to make different products (DNA and proteins)</p> <p><b>Golgi Apparatus</b> (gummy worms) - Near the nucleus, provides a membrane for lysosomes that can be exported from the cell</p> <p><b>Vacuoles</b> (gushers) - Storage “bubbles”, contain nutrients and food for the cell</p> <p><b>Mitochondria</b> (mike and ike’s) - POWERHOUSE, creates energy for the cell</p> <p><b>Tissue</b> - Mass of like cells that form specific organs, which then form systems, which then form organisms</p> |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>- Toothpicks, pens, and masking tape for labeling</li> <li>- 15 paper plates to put the cell model on</li> <li>- 15 spoons to spread out the frosting/cytoplasm</li> <li>- Jar of frosting (cytoplasm)</li> <li>- 15 gummy brains (nucleus)</li> <li>- 15 nerds ropes (Plasma membrane)</li> <li>- 15 air heads extreme (ER)</li> <li>- 15 Shark Candies (Lysosomes)</li> <li>- Sprinkles (Ribosomes)</li> <li>- 15 Gummy Worms (Golgi Apparatus)</li> </ul>   |

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|                                  | <ul style="list-style-type: none"> <li>- 5 packs of gushers (vacuoles)</li> </ul> Bag of Mike and Ikes (pick a color for the mitochondria)   |
| <b>Procedure</b>                 | <p><b>1) Introduce the concept</b></p> <ol style="list-style-type: none"> <li>SUGGESTION- It will probably be best to talk about each part of the cell as you go on. You know your students – you can decide!</li> <li>Pass out Toothpicks and masking tape. They will need 9 toothpicks, and the masking tape will be folded over one end of the toothpick and written on as a label.</li> <li>You can either have them write everything out at the beginning, or go organelle by organelle.</li> <li>Explain what each part of the cell does as you go along and ask questions!!</li> </ol> <p>This lesson is pretty self-explanatory. After all discussion they can eat their cell!</p> |
| <b>Guiding Questions</b>         | <p>1) Why would we choose a shark to be the lysosome?</p> <p>2) Why is the nucleus the brain?</p>  |
| <b>Background</b>                | <p>If you are unsure of what any part of the cell does – refer to the vocabulary section. This lesson is often paired with DNA extraction, so depending on what the schedule looks like, you can ask the students if they ever remember extracting DNA from a strawberry – DNA is located in the nucleus. Etc....</p>  |
| <b>Career/Future Application</b> | <p>Biologists, Doctors, Researchers.. the possibilities are endless!</p>   |
| <b>Sources</b>                   | <p>Cell Biology Book (CITE IT)</p>   |

## Stethoscopes and Heart Rate

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| <b>NGSS</b>                 | MS-LS1-1   |
| <b>Student Objective</b>    | To determine how our heart rate changes in response to physical activity or other stimuli (stress) and to listen to body sounds using a stethoscope.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- The heart rate is the measure of how many times the heart beats in one minute (bpm)</li> <li>- Oxygen is not the only thing the heart pumps to the rest of the body</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Take heart rate and use a stethoscope to listen to heart beat, lungs, and bowel sounds.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Pulse</b> – rhythmic throbbing of arteries as blood is being pumped through them</p> <p><b>Heart rate</b> – Number of heart beats per minute (bpm)</p> <p><b>Red Blood Cell</b> – cell located in the blood that transports oxygen and carbon dioxide to and from the tissues</p> <p><b>White Blood Cell</b> – defenders of your body and make up your immune system</p> <p><b>Platelets</b> – colorless blood cells that help blood clot</p> <p><b>Plasma</b> – liquid component of blood that holds the blood cells in whole blood suspension</p> <p><b>Stethoscope</b> – a medical instrument used to listen to a person's heart</p>  |
| <b>Materials</b>            | <p>Heart Rate &amp; Blood Component worksheet (1 per student)</p> <p><b>Candy Blood Vessel Demonstration</b></p> <ul style="list-style-type: none"> <li>- Red Hots (or a red candy) (10 per student)</li> <li>- Certs (or a white candy) (2 per student)</li> <li>- Salt (1 pinch per student)</li> <li>- Candy sprinkles (1 pinch per student)</li> <li>- Light corn syrup</li> <li>- Red food dye</li> <li>- Ziploc sandwich bags (1 per student)</li> <li>- Plastic spoons (for mixing) (1 per group)</li> </ul> <p><b>Pulse Demonstration</b></p> <ul style="list-style-type: none"> <li>- Clock with second hand (in classroom)</li> </ul> <p><b>Stethoscope Demonstration</b></p> <ul style="list-style-type: none"> <li>- 1 large funnel (per group)</li> <li>- 1 small funnel (per group)</li> <li>- 1 hose, cut into 18-inch pieces (per group)</li> <li>- Duct tape</li> </ul> |

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|                  | - 1 stethoscope (per group)  |
| <b>Procedure</b> | <p><b>1) Blood Vessel Demonstration</b></p> <ol style="list-style-type: none"> <li>Hand out candy, bags, salt             <ol style="list-style-type: none"> <li>Red candy – red blood cells</li> <li>White candy – white blood cells</li> <li>Salt – ions in blood</li> <li>Sprinkles – platelets</li> <li>Corn syrup - plasma</li> </ol> </li> <li>Fill bags ½ way full with the corn syrup, and add candy, salt, and food dye. Mix well.</li> <li>Close the bags tightly and then roll the bags into a cylinder.</li> <li>Explain the functions of the various components in this blood vessel.</li> </ol> <p><b>2) Pulse Demonstration</b></p> <ol style="list-style-type: none"> <li>There are different areas on the body where the pulse can be taken. The two most common are on the radial artery (wrist) and the carotid artery (side of neck).</li> </ol> <div data-bbox="550 879 927 1163" data-label="Image"> </div> <div data-bbox="959 879 1313 1184" data-label="Image"> </div> <ol style="list-style-type: none"> <li>Teach the students how to test their heart rate. Use the 30-second method (count beats in a 30-second span and multiply by 2 to get bpm).</li> <li>Have the students record their resting heart rates.</li> <li>Have students do jumping jacks until they do ~50 reps             <ol style="list-style-type: none"> <li>Immediately record heart rate at the 0 minutes mark</li> <li>Record every minute after for 3 minutes</li> </ol> </li> <li>Have students hold their breath for 30 seconds and record heart rate while holding breath.</li> </ol> <p><b>3) Stethoscope Demonstration</b></p> <ol style="list-style-type: none"> <li>Have the students to pair up, and have a volunteer group pass out a large and small funnel and one hose piece to each group.</li> <li>Ask another student to hand out 2 8-inch pieces of duct tape to each group.</li> </ol> |

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|                          | <p>c. Instruct the students to attach a funnel to either end of the hose piece with the duct tape. It should look like the figure below.</p>  <p>d. Allow the students to attempt to listen to both their own and their partner's heart with their stethoscope and with the regular stethoscope.</p> <p>e. Have them listen to someone's lung sounds by placing stethoscopes on backs and instructing their partner to "deep breathe". Then have students listen while that person wheezes. (They will have to fake the wheezing).</p> <p>f. Have them try to listen to bowel sounds by placing stethoscopes onto abdomens. If they just ate they may have good luck.</p> <p>Clean up the room!</p>   |
| <b>Guiding Questions</b> | <p>1) Why does our heart beat?</p> <p>2) What is the purpose of blood in the body?</p> <p>3) Who uses stethoscopes? (Good opportunity to talk about health careers)</p>   |
| <b>Background</b>        | <p>The heart is the organ responsible for pumping oxygenated blood into the tissues and deoxygenated blood into the lungs for re-oxygenation. (Think of the veins as tunnels and blood cells as mailmen: they pick up oxygen in the lungs and deliver them to the heart and other areas of the body). The heart is about the size of your fist and weighs about the same amount as a lemon. <b>(At this point you can ask the students to place their palms at the center of their chest and hold their breath, they should be able to feel or "hear" their heart beating.)</b> The heart also pumps nutrients into the tissues by contracting and relaxing (same concept as before: it's a delivery system!).</p> <p>The rate at which our heart pumps blood into the periphery is directly related to how much oxygen our bodies need at that time. For example, when we are sleeping, we are not burning a ton of calories, so we do not require that much oxygen, and our heart rate slows. When we are exercising, however, our tissues develop a massive need for oxygen, and our heart rate increases accordingly. As a person begins to exert physical activity, there is a higher demand for oxygen in the brain and muscles. To sufficiently supply to body with oxygen, the heart rate will increase as needed. (Average resting pulse is about 60-100 bpm) In this exercise, we will have students determine their resting heart rate by measuring their pulse (neck or wrist) for 30 seconds.</p> <p>If you have time this 6-minute video does an excellent job of explaining the heart: <a href="http://www.aboutkidshealth.ca/en/justforkids/body/pages/heart.aspx">http://www.aboutkidshealth.ca/en/justforkids/body/pages/heart.aspx</a></p> |
| <b>Career/Future</b>     | Any job in a healthcare setting (physician, nurse, PA, phlebotomist, medic,   |

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| <b>Application</b> | paramedic, etc.) must understand how and why blood circulates to the peripheral tissues and how stethoscopes work. Stress that healthy heart rate is instrumental to a long healthy life, which we all want to live! Aerobic exercise can decrease the risk of heart disease by 20 to 60 percent, depending on the exertion level, duration and frequency.   |
| <b>Sources</b>     | <a href="http://health.howstuffworks.com/diseases-conditions/cardiovascular/heart/exercise-important-for-heart-health1.htm">http://health.howstuffworks.com/diseases-conditions/cardiovascular/heart/exercise-important-for-heart-health1.htm</a><br><a href="http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBio_p033.shtml?from=Pinterest#procedure">http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBio_p033.shtml?from=Pinterest#procedure</a> |

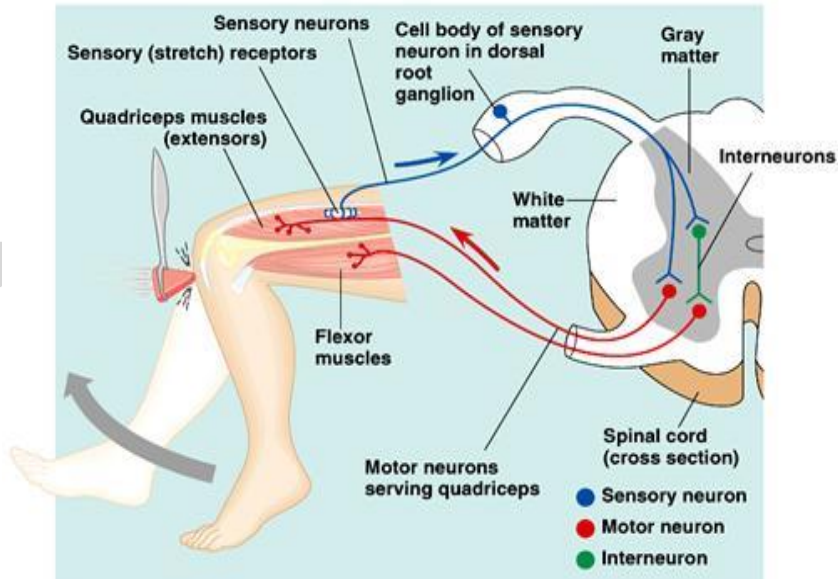


## Testing Reflexes

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| <b>NGSS</b>                 | MS-LS1-3; MS-LS1-8  |
| <b>Student Objective</b>    | Reflexes are an important part of the human body. During this lesson we will be exploring a few of the many reflexes that are present in our bodies.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b> Reflexes are involuntary reactions of the body to a stimulus. It results from the impulse of a sensory neuron that triggers a motor neuron.</p> <p><b>The student will be able to:</b> Identify places on their body where reflexes can be triggered.</p>  |
| <b>Vocabulary</b>           | <p><b>Reflex:</b> An action or movement of the body that happens automatically as a reaction to something.</p> <p><b>Stimulus:</b> Something that causes a change or a reaction.</p> <p><b>Neuron:</b> A cell that carries messages between the brain and other parts of the body. It is the basic unit of the nervous system.</p>  |
| <b>Materials</b>            | <p>“How to Test Reflexes” Handout</p> <p>Reflex Hammers</p>   |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>1. <b>Introduce topic</b></li> <li>2. <b>Activity 1: Slam!</b> <ol style="list-style-type: none"> <li>a. Begin by introducing the splinter scenario (in the Background Information). When you get to the part that explains what a reflex is, discretely slide a book (or a pile of notebooks) from the table so it/they land on the floor with a loud slam.</li> <li>b. Query the students for their responses: How many jumped, how many moved their heads, how many screamed, how many blinked their eyes, how many put their hands up?</li> <li>c. Tally the results on the board.</li> <li>d. Explain that these are all reflexes to a stimulus—in this case, the loud noise that the book made.</li> <li>e. Now that they’re familiar with reflexes, explain that they will be doing a series of one or more experiments to explore reflexes.</li> </ol> </li> <li>3. <b>Knee Jerk Reflex/Other Reflexes</b> <ol style="list-style-type: none"> <li>a. Place students into teams. Distribute the reflex hammers and demonstrate the correct way to use one. Gently tap the bottom edge of</li> </ol> </li> </ol> |

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|                          | <p>a seated student's kneecap (patella) with the small end of the hammer. (If you don't have the hammers, use the side of your hand. <b>Do NOT use a carpenter's hammer.</b>)</p> <p>b. Have students take turns testing their patellar (knee) reflexes. Tell students to relax the legs and watch the hammer strike below the knee.</p> <p>c. Explain that they will now repeat the reflex test, but this time they will not watch the hammer. Have them make a prediction: <i>will the reflex response be faster, slower, or the same speed when they don't watch?</i> Once students make a prediction, have them test it.</p> <p>d. Using the "How to Test for Reflexes" Handout, the students can test a variety of different reflexes, depending on the amount of time left.</p> <p><b>4. Pupil Test</b></p> <p>a. Have the students' pair up and face one another. Explain that you will be turning out the lights in the room for 30 seconds.</p> <p>b. When you turn the lights back on, each student is to look into his or her partner's eyes and watch what happens.</p> <p>c. Turn out the lights in the room.</p> <p>d. After 30 seconds, turn the lights on while students watch each other's eyes.</p> <p>e. Wrap up and close lesson</p> <p>f. All students should participate in cleaning up the room.</p> |
| <b>Guiding Questions</b> | <p>1) An example of your body using reflexes is:</p> <p>A. You are running and you get a muscle cramp in your leg.</p> <p>B. You touch a hot stove and immediately pull your hand away.</p> <p>C. Someone says a funny joke and you laugh.</p> <p>D. You watch a sad movie and start to cry.</p> <p>2) What does the word "stimulus" mean?</p> <p>3) When your body feels a stimulus, which neuron carries the first signal to the spinal cord?</p> <p>A. Motor neuron</p> <p>B. Pain neuron</p> <p>C. Sensory neuron</p> <p>D. Dormant neuron</p> <p>4) Fill in the blank: Reflexes are _____ (options: <i>faster, slower, the same</i>) when you are paying attention to the stimulus versus when you are not paying attention.</p>   |



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|   | <p>5) In the human body, there are a variety of different nerves that have labels corresponding to the different segments of the vertebral column (i.e. L4, S3, T1). Name one common name for <u>one</u> of these nerves (<i>the students would have seen this on the “Reflex handout” if they were paying careful attention</i>).</p>  |
| <p><b>Background</b></p>                | <p>Imagine you’re working in your yard and you decide to pick up a wooden stick. The stick jabs you with a splinter. Without thinking, you drop the stick. What happened?</p> <p>You had a simple reflex response. When the nerves in your finger sensed the splinter, an impulse traveled along a sensory neuron (a nerve cell that senses sensations) to your spinal cord. <b>(They can think of this as text message or mail being sent)</b> There, the impulse passed to a motor neuron (a nerve cell that initiates movement), which carried the impulse back to the muscles in your fingers. The impulse made the muscles contract, and your fingers let go of the stick. At no time did the impulse travel to your brain for processing in order to make your fingers respond. Eventually your brain did receive an impulse. The sensory neuron carrying the original impulse also sent an auxiliary impulse to the brain. When it got there, your brain probably made you say “Ouch!” But by the time your brain registered the splinter, your fingers had already dropped the stick. That’s the beauty of a reflex—it’s fast. And you don’t even have to pay attention. <u><i>Reflexes are no faster when you’re paying attention than when you’re not.</i></u></p>  <p>The diagram illustrates the neural pathway of a reflex. On the left, a person's leg is shown with a splinter in the quadriceps muscle. Sensory (stretch) receptors in the muscle detect the stimulus. A blue line representing the sensory neuron carries the impulse to the cell body in the dorsal root ganglion. The impulse then enters the spinal cord through the dorsal root. Inside the spinal cord, the impulse passes through interneurons (green dots) in the gray matter. A red line representing the motor neuron carries the impulse out through the ventral root to the motor neurons serving the quadriceps, causing them to contract. A cross-section of the spinal cord is shown on the right, highlighting the gray matter (containing the cell bodies of neurons) and white matter. A legend indicates: Blue dot = Sensory neuron, Red dot = Motor neuron, Green dot = Interneuron.</p> |
| <p><b>Career/Future Application</b></p> | <p>The human body is beyond fascinating! Introducing the students to the idea of reflexes is just one way to show how complex the human body really is. Interest in science begins with a spark, and perhaps these experiments will provide a spark of interest in these students. Reiterate to the students that many careers in the health field study reflexes and other intricacies of the body. For this lesson, incorporate awe and wonder into the background and the experiment. If the students sense that we are enthralled with what we are teaching, they will be more likely to</p>  |

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|                | become captivated themselves. Stay golden, NE STEM mentors, you are doing an incredible job.   |
| <b>Sources</b> | <b><i>Brain: The World Inside Your Head, 2001</i></b><br><a href="http://www.evergreenexhibitions.com/exhibits/brain/">http://www.evergreenexhibitions.com/exhibits/brain/</a> |





## Balloon Rocket and Balloon Car

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| <b>NGSS</b>                 | 5-PS1-1; 5-PS1-2  |
| <b>Student Objective</b>    | To learn how to make a balloon rocket and balloon car.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- How thrust, weight, and drag impact their car's performance</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Build a functional balloon-powered car and rocket</li> </ul>   |
| <b>Vocabulary</b>           | <p><b>Thrust</b> – is the force that propels a flying machine in the direction of motion. Engines produce thrust.</p> <p><b>Weight</b> – is the force of gravity. It acts in a downward direction—toward the center of the Earth.</p> <p><b>Drag</b> – is the force that acts opposite to the direction of motion. Drag is caused by friction and differences in air pressure.</p> <p><b>Lift</b> – is the force that acts at a right angle to the direction of motion through the air. Lift is created by differences in air pressure.</p>   |
| <b>Materials</b>            | <p><b>Balloon Rocket Demonstration</b></p> <ul style="list-style-type: none"> <li>- 1 Balloon (per group of 2-3)</li> <li>- 1 Drinking straw (per group of 2-3)</li> <li>- Scotch tape</li> <li>- String (10-25 feet)</li> </ul> <p><b>Car Rocket Demonstration</b></p> <ul style="list-style-type: none"> <li>- 1 Balloon (per group of 2-3)</li> <li>- 3 Drinking straws (per group of 2-3, 1 for the balloon and 2 for axle holders)</li> <li>- Piece of cardboard for the body</li> <li>- Items for wheels (can have students make their own wheels, like from excess cardboard, or you can give them already circular supplies like photo film canisters)</li> <li>- Skinny wooden dowels (must be smaller in diameter than a drinking straw)</li> </ul> |
| <b>Procedure</b>            | <p>Anticipatory Set of Questions</p> <p>What if I told you I could make a balloon powered race car! What do you think it would look like? Can you think of any forces in our world that may help or hinder my car's progress?</p> <p>1) Icebreaker</p>  |

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|                                 | <p>2) Introduce topic</p> <p>3) <b>Balloon Rocket Demonstration</b></p> <ol style="list-style-type: none"> <li>a. Create a “track” for the rocket balloon to run on.             <ol style="list-style-type: none"> <li>i. Begin by identifying two stationary objects (tree, post, chair) that will serve as the start and end of the path for your rocket balloon.</li> <li>ii. Slide the string through the drinking straw and tie the end to one stationary object.</li> <li>iii. Have other student holding string tights so the string is taut and walk to the other stationary object.</li> <li>iv. Cut the string and tie it (try to make sure the string is tied at about the same height on each stationary post so that it is horizontal).</li> <li>v. Move the straw to one end of the string.</li> </ol> </li> <li>b. Inflate the balloon. Pinch the neck to keep it full.</li> <li>c. Using two pieces of scotch tape, attach the inflated balloon to the straw. The mouth of the balloon should point away from the second post.</li> <li>d. Release the balloon and watch it go!</li> </ol> <p>4) <b>Car Rocket Demonstration</b></p> <ol style="list-style-type: none"> <li>a. Insert a straw into the balloon and tape the mouth of the balloon around the straw so it is airtight. This is a very important step and the only criteria.</li> <li>b. Give each group of students their own slab of cardboard to design a body to their car.</li> <li>c. Give each of the groups whichever materials for wheels that are provided.</li> <li>d. Give each group time to design and create their own balloon car.</li> <li>e. The car is now complete, let's take it for a test drive! Let the students then race their cars and see whose car goes the furthest.</li> </ol> <p>5) Clean up the room!</p> |
| <p><b>Guiding Questions</b></p> | <p>What forces do think hurt your car's progress? How about help?</p> <p>What can you change that might make your car go faster? What conclusions can you draw?</p> <p>How could you use this in a career? What types of careers can you think of?</p>   |

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| <b>Background</b>                | <p>In a real rocket, thrust is created by burning rocket fuel- as the engines blast down, the rocket goes up. The balloon, which is made of an elastic material, contracts on the air within the balloon. When the mouth of the balloon is held (or tied) closed, the air has nowhere to go, so it pushes back to retain the balloon's shape. However, since the mouth is open, the air has somewhere to go. The air pushes out the mouth of the balloon and a force is exerted. In congruence with Newton's third law of motion an equal force is generated in the opposite direction.</p> <p>This follows both Newton's Third Law of Motion ("for every action there's an equal and opposite reaction") and the law of conservation of momentum (the rocket and car will move when the air is pushed out of the balloon). More specifically, this force causing the motion of the balloon is called thrust, which is a critical concept when discussing the propulsive force of aircraft (NASA).</p> <p>For the rocket, there is friction between the string and the straw, but the straw is made of material with a low coefficient of friction (because it's smooth) and the weight of the balloon and straw is light, so the overall frictional force is effectively negligible. For the car, the balloon does not propel it as fast as the straw. This makes sense since the car has more mass and there is more friction between the wheels and the ground than the straw and the string. As a result, more thrust is needed.</p> <p>This is essentially the same principle upon which rockets work. They burn fuel to propel matter out the back generating a force in the direction of the ground. The rocket moves due to the opposite force pushing back on the rocket. Since a rocket typically weighs much more than a balloon, of course, it takes more propellant to get it moving.</p> |
| <b>Career/Future Application</b> | <p>Students with great enjoyment of this experiment most likely would take interest in aerospace/aeronautics engineering, which focuses on the research, design, construction and testing of both aircraft and spacecraft. They may also take an interest in becoming a testing or airline pilot.</p>  |
| <b>Sources</b>                   | <p><a href="http://www.kidspot.com.au/kids-activities-and-games/science-experiments+10/balloon-rocket-experiment+11976.htm">http://www.kidspot.com.au/kids-activities-and-games/science-experiments+10/balloon-rocket-experiment+11976.htm</a><br/> <a href="http://findtimeforfun.com/rocket-balloon-a-balloon-that-flies-like-a-rocket/">http://findtimeforfun.com/rocket-balloon-a-balloon-that-flies-like-a-rocket/</a><br/> <a href="http://www.esa.int/Education/Rocket_Balloon_Experiments_for_University_Students">http://www.esa.int/Education/Rocket_Balloon_Experiments_for_University_Students</a><br/> <a href="http://themetapicture.com">themetapicture.com</a><br/> <a href="http://www.bajiroo.com">www.bajiroo.com</a></p>   |

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|  | <a href="http://www.esa.int/Education/Rocket_Balloon_Experiments_for_University_Students">http://www.esa.int/Education/Rocket_Balloon_Experiments_for_University_Students</a><br><a href="http://www.ted.com/talks/steve_jurvetson_on_model_rocketry.html">http://www.ted.com/talks/steve_jurvetson_on_model_rocketry.html</a> |
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## Build a Catapult

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| <b>NGSS</b>                 | 4-PS3-3; 5-PS2-1  |
| <b>Student Objective</b>    | In this activity, students reinforce their understanding of compound machines by building a catapult. This compound machine consists of a lever and a wheel-and-axel. Catapults have been designed by engineers for a variety of purposes — from lifting boulders into the air for warfare to human beings for entertainment; Given the building materials, students design and build their catapult to launch marshmallows   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Use the engineering design process to create a compound machine – the catapult.</li> <li>- Describe the interrelationship of the simple machines within a compound machine.</li> <li>- Describe the constraints of their model in the context of engineering.</li> </ul>   |
| <b>Vocabulary</b>           | <p><b>Simple Machine:</b> The fundamental parts of any machine. Simple machines can exist on their own and are also sometimes hidden in the mechanical devices around you; a device which performs work by increasing or changing the direction of force, making work easier for people to do.</p> <p><b>Compound Machine:</b> Consists of two or more simple machines and allows for work to be done easier.</p> <p><b>Structural Engineering:</b> The branch of civil engineering that is responsible for the design of structures.</p>   |
| <b>Materials</b>            | <p>Per Group:</p> <p>The idea here is to have a ton of different useful supplies so that students can brainstorm and design their own original catapults. <b>MENTORS MUST CONSTRUCT AT LEAST 1-2 SAMPLE CATAPULTS BEFORE GOING TO THE SCHOOL.</b></p> <p>For catapults:</p> <ul style="list-style-type: none"> <li>- Newspapers</li> <li>- Popsicle sticks (thick and thin)</li> <li>- Plastic spoons</li> <li>- Dixie cups</li> <li>- Rubber bands (various sizes)</li> <li>- Soup cans</li> <li>- Cans of Pop</li> <li>- Bottle caps</li> <li>- Scissors</li> <li>- Tape (masking or duct)</li> <li>- Measuring Tape or Meter Sticks</li> <li>- Paper &amp; Pencil</li> </ul> |



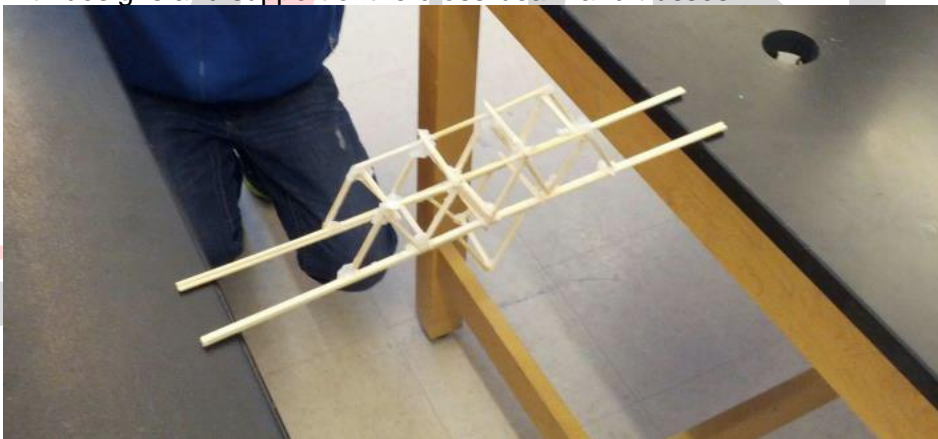
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|                  | <p>NOTE: Materials can be added or taken away from this list. This is just a few ideas / essentials to be included.</p> <p>For the Angry Birds game:</p> <ul style="list-style-type: none"> <li>- Large Marshmallows</li> <li>- Small Marshmallows</li> <li>- 1-2 decks of cards</li> <li>- Printouts of Angry Birds pigs. (Cut out and taped to empty soda bottles)</li> <li>- Empty soda bottles</li> <li>- Material to stack bottles on top of (cereal boxes, shoe boxes, etc.)</li> </ul>   |
| <b>Procedure</b> | <ol style="list-style-type: none"> <li>1. Introduce the topic using background information and thinking prompts/guiding questions.</li> <li>2. Split students into groups of two (if necessary).</li> <li>3. Lay out all of the available supplies for building the catapult. Show examples of catapult designs.</li> <li>4. You can make all materials available to students or incorporate budgeting by adding a price tag to each supply.</li> <li>5. Have students sketch a rough design for their catapult based on available supplies.</li> <li>6. Once students have made their preliminary drawing, they can gather or “purchase” their supplies.</li> <li>7. Allow students time to design, build, test, redesign, rebuild, retest their catapults.</li> <li>8. Once students are happy with their catapult, move on to Angry Birds competition.</li> <li>9. Set up one or two Angry Birds stations (depending on available supplies)             <ol style="list-style-type: none"> <li>a. Tape green pigs onto plastic bottles</li> <li>b. Build structures using cereal boxes (or any other available supplies) and incorporate the pig bottles.                 <ol style="list-style-type: none"> <li>i. Students should help build these structures.</li> </ol> </li> <li>c. Think Angry Birds. If you don’t know what this is, Google it.</li> </ol> </li> <li>10. The deck of cards is used to determine how many marshmallows and which kinds of marshmallows each student can launch.             <ol style="list-style-type: none"> <li>a. The student will pull a card from a shuffled deck.</li> <li>b. Remove Jacks, Queens, and Kings.                 <ol style="list-style-type: none"> <li>i. If the card is an Ace – 5, they get that number of large marshmallows (note: aces are low and represent 1)</li> <li>ii. If the card is a 6 – 10, they get to use that number of small marshmallows.</li> <li>iii. If the card is a Joker, they get to draw two cards and get the combined number of marshmallows</li> </ol> </li> <li>c. The student then gets to use all their marshmallows and their catapult to try to knock all of the pig bottles down to the floor.                 <ol style="list-style-type: none"> <li>i. If a student does not knock all of the pig bottles down to the floor...                     <ol style="list-style-type: none"> <li>1. Pull two more cards.</li> </ol> </li> </ol> </li> </ol> </li></ol> |

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|                          | <p>2. Take the difference between the two numbers.<br/>3. Use that number of small marshmallows.</p> <p>11. Students will take turns during the Angry Birds activity. Shuffle the deck between each student. Replace cards immediately after pulling them out of the deck.<br/>Clean up room together.</p> <p><b>Differentiation</b><br/>Use budgeting component for building the catapults or place limits on supplies.</p> <p>Change the rules for the Angry Birds game to increase difficulty.<br/>- Change the card / marshmallow rules.<br/>- Make a point system for the bottles. For example: If bottles are worth different points, students can keep track of their points after knocking bottles down.</p>   |
| <b>Guiding Questions</b> | <p>- What does a catapult look like? (Discuss where the students get their ideas. Perhaps from a film.)<br/>- Does anyone have an idea on how to build one? Have a student come up and draw one on the board based off the available supplies.<br/>- Ask the students what simple machines are found in the catapult they are building? (Answer: The arm is a lever and the straw around the dowel forms a wheel-and-axel.)</p>  |
| <b>Background</b>        | <p>Compound machines are two or more simple machines interacting with one another to do work. We can find them all around us in everyday items, including a can opener, a pencil sharpener, a wheelbarrow, a pair of scissors and a piano. Compound machines are dependent on each of its simple machines. If just one of the simple machines in a compound machine is removed, the compound machine will not function nearly as well. Engineers use their knowledge of simple machines to create many of the compound machines we use every day.</p> <p>Engineering firms do work for people in a variety of ways. A structural engineering firm, for instance, may one time help build a skyscraper for people to work in, the next time build a bridge that connects people with one another, and the next design the devices used in a circus performance to entertain people. A structural engineer is one who designs the structures, or the "built things" around us. Like the buildings towering above us, devices used in entertainment acts must be structurally engineered for, above all, safety. These devices in entertainment include the chains and supports of a swing holding intertwined trapeze artists and the web of metal giving form to the main tent, or big top. During our activity today, we are going to imagine that we are structural engineers.</p> <p>To make a projectile cover the most horizontal distance possible, it should be launched from a <math>45^\circ</math> angle. Remember this fact because you will need to apply it to the construction of your catapults in the upcoming activity. If a</p> |

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|                                  | <p>projectile is launched from an angle greater than <math>45^\circ</math>, where will it go? (Answer: It will go higher, but not cover as much horizontal distance.) If the same projectile is launched from an angle less than <math>45^\circ</math>, where will it go? (Answer: It will not go as high and therefore is pulled to the ground more quickly by gravitational force, and thus, falls short.)</p>   |
| <b>Career/Future Application</b> | <p>Simple machines and compound machines are the foundation of many modern conveniences. Engineers use a combination of levers, wedges, screws, wheels-and-axels, pulleys and inclined planes to develop simple tools such as a pencil sharpener to complex machines such as an elevator or airplane. Compound machines are everywhere. Engineers usually design machines for a specific function, as specified by their clients. Engineers also have to design within certain constraints, including time, money and human resources.</p>   |
| <b>Sources</b>                   | <p> <a href="http://pbskids.org/designsquad/build/pop-fly/">http://pbskids.org/designsquad/build/pop-fly/</a><br/> <a href="https://www.scientificamerican.com/article/build-a-mini-trebuchet/">https://www.scientificamerican.com/article/build-a-mini-trebuchet/</a><br/> <a href="https://www.teachengineering.org/activities/view/cub_simp_machines_less_on04_activity1">https://www.teachengineering.org/activities/view/cub_simp_machines_less_on04_activity1</a><br/> <a href="http://www.vivifysystem.com/blog/2014/12/23/catapult-challenge">http://www.vivifysystem.com/blog/2014/12/23/catapult-challenge</a><br/> <a href="https://www.youtube.com/watch?v=kRz_PRoCCgg">https://www.youtube.com/watch?v=kRz_PRoCCgg</a> </p> |

## Building Bridges

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| <b>NGSS</b>                 | 3-5-ETS1-2; 3-5-ETS1-3   |
| <b>Student Objective</b>    | To determine the basic engineering components needed to build a bridge.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-Basic physics terminology and the engineering process.</p> <p><b>The student will be able to:</b><br/>-How to build supporting structures and the terms used in building bridges.<br/>-Concept of engineering.</p>   |
| <b>Vocabulary</b>           | <p><b>Engineering</b> – Engineers apply scientific and mathematics knowledge to create solutions for various technical problems. There are different disciplines that include chemical, civil, electrical, and mechanical.</p> <p><b>Truss</b> – A framework, typically consisting of rafters, posts, and struts to support a roof, bridge, or other structure.</p> <p><b>Cross-beam</b> – A horizontal or transverse beam, especially a structural beam resting on two supports.</p>  |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>-Skewers</li> <li>-3ft of tape per person</li> <li>-Scissors</li> <li>-Construction paper (2 purposes: road across the bottom of the bridge)</li> <li>-Weights (varying amounts)</li> <li>-Hot wheels car</li> <li>-Scale</li> </ul>  |
| <b>Procedure</b>            | <p><b>1) Introduce Topic</b></p> <ol style="list-style-type: none"> <li>a. Necessary Explanations</li> <li>b. Opener: See what they already know about bridges and talk to them a little. Share knowledge and don't drag it out.</li> </ol> <p><b>2) Start the experiment:</b></p> <ol style="list-style-type: none"> <li>a. Split them into groups of two or three depending on class size.</li> <li>b. Give them the challenge: Build the strongest bridge you can.               <ol style="list-style-type: none"> <li>I. It has to cover the foot distance (Variable)</li> <li>II. Must be able to transport my hot wheels car though it, and we will put weight on it until it breaks</li> <li>III. You can also change rules if you like i.e. longer distance, if it is two lanes get a bonus, can't weight more than X, you can be creative.</li> <li>IV. Need to test it to know what will be optimal.</li> </ol> </li> </ol> |

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|                                  | <p><b>3) Check bridges:</b></p> <ol style="list-style-type: none"> <li>Run the car through</li> <li>Add weights slowly until each one breaks. Do it more ceremonially so everyone gets to watch everything break. It's the best part of this whole thing obviously.</li> </ol> <p><b>4) Discussion:</b></p> <ol style="list-style-type: none"> <li>Talk to them about what worked and what didn't work. Be specific.</li> <li>Ask why certain designs are inherently weaker than others.</li> <li>What forces allow the most successful bridges able to hold the most weight?</li> </ol>   |
| <b>Guiding Questions</b>         | NEED SOME  |
| <b>Background</b>                | <p>Bridges are important. They shouldn't break. We need them for stuff. They are largely used for transporting things, goods, and people over various obstacles. Can be simple or very large and ornate. They are able to hold with designs and support of the cross-beam and trusses.</p>    |
| <b>Career/Future Application</b> | <p>Team work and problem solving as part of every job. EVERY JOB. You will have to work with people your entire life to get things done, come up with solutions, and be cooperative. This can be a good team-building exercise as well as an experience for students to learn from each other.</p> <p>Engineering is cool. They take many of the advances in the sciences and use them to create more useful products and machines. Examples: building rockets, buildings, cars, particle accelerators, etc... We are constantly designing things to be stronger, better, and more aesthetically pleasing. It is not limited to bridges. Architecture and engineering are involved in almost every aspect of our day-to-day lives in the 21st century.</p> |
| <b>Sources</b>                   | <p><b>References</b></p> <p><a href="http://www.phlf.org/downloads/education/Edu_WabashBridgeDesign.pdf">http://www.phlf.org/downloads/education/Edu_WabashBridgeDesign.pdf</a></p>  |

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|  | <a href="http://www.sciencekids.co.nz/sciencefacts/careers/engineer.html">http://www.sciencekids.co.nz/sciencefacts/careers/engineer.html</a><br><a href="http://www.oxforddictionaries.com/us/definition/american_english/truss">http://www.oxforddictionaries.com/us/definition/american_english/truss</a><br><a href="http://www.thefreedictionary.com/crossbeam">http://www.thefreedictionary.com/crossbeam</a><br><a href="http://eadventures.com">http://eadventures.com</a> |
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## Creating a Heat Engine

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| <b>NGSS</b>                 | 5-PS1-4; MS-PS1-6; MS-PS3   |
| <b>Student Objective</b>    | Following today's experiment, students will be able to describe heat engines using a model and concepts from thermal physics.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <p>- During this experiment, students will learn about thermal expansion and how it relates to work and heat. Students will work together in small groups to build a simple heat engine that utilizes thermal expansion in rubber bands to turn thermal energy into mechanical work.</p> <p><b>The student will be able to:</b></p> <p>-</p>   |
| <b>Vocabulary</b>           | <p><b>Contraction:</b> To shorten by increasing tension</p> <p><b>Thermal Energy:</b> A type of energy from motion; the motion in thermal energy is moving particles and is measured by temperature</p> <p><b>Thermal Expansion:</b> When matter changes shape due to a change in temperature</p> <p><b>Work:</b> A transfer of energy, such as heat</p>  |
| <b>Materials</b>            | <p>Per Group:</p> <ol style="list-style-type: none"> <li>1 rubber band, size 24 (or about 5 inches long and 1/16 inches wide)</li> <li>3oz of flour or sugar in a resealable sandwich bag</li> <li>1 pencil</li> <li>1 sheet of graph paper</li> <li>1 hand warmer</li> <li>Writing utensil</li> <li>Desk or table</li> <li>Ruler</li> </ol> <p>Clock or stopwatch</p>  |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>1. Prepare hand warmer following the package's instructions and set aside.</li> <li>2. As a group, record initial observations about the rubber band; color, temperature, and measured length.</li> <li>3. Using both hands, have a group member lightly stretch the rubber band. Record observations for the stretched rubber band; color, temperature, and measured length. Has the temperature of the rubber band changed?</li> <li>4. Tape a sheet of graph paper to the edge of the table, so it is hanging freely.</li> <li>5. Pinching the rubber band with two fingers, tie or wrap the other end of the rubber band to the sandwich bag containing flour/sugar.</li> <li>6. Test that the rubber band can support the weight of the bag without the bag falling off; retie if necessary.</li> <li>7. Lay the pencil flat on the table with the eraser-end hanging over the</li> </ol> |

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|                                  | <p>graph paper and a group member holding the opposite end in position.</p> <ol style="list-style-type: none"> <li>Place the rubber band over the pencil so the bag is freely hanging over the graph paper.</li> <li>With a writing utensil, mark on the graph paper where the bottom of the bag reaches.</li> <li>With the bag still hanging, hold the hand warmer to the rubber band for 5 seconds.</li> <li>Remove the hand warmer and, with a writing utensil, mark on the graph paper where the bottom of the bag reaches.</li> </ol> <p>Time how long it takes the bag to return to its original position. What is the temperature of the rubber band now?</p>  |
| <b>Guiding Questions</b>         | <p>Is the mark after using the hand warmer higher, lower, or the same as the first?</p> <p>What would happen if you used an ice cube on the rubber band instead of a hand warmer?</p> <p>Does it take longer for the rubber band to heat up or cool down? Is there any way to make it faster?</p>   |
| <b>Background</b>                | <p>When an object has an increase in temperature, the object is experiencing an increase in thermal energy. This means the molecules are moving faster and collide more often.</p> <p>The molecules of a rubber band are arranged in a chain-like structure, resulting in them becoming shorter and tighter the faster they move. This causes the rubber band to contract when exposed to a higher temperature. The reverse is also true; when the rubber band is stretched, it will produce heat. This is due to a principle called LeChatelier's principle; it states that a change in temperature of a system (like a rubber band being stretched) results in a predictable, opposing change (producing heat to contract back to the original size).</p> <p>The heat transferred from the hand warmer causes the contraction of the rubber band, lifting the weight. This is an example of a simple heat engine; it turns heat into mechanical work.</p> |
| <b>Career/Future Application</b> | Civil Engineer, Chemist, Chef, Mechanic   |
| <b>Sources</b>                   | <p>Heating A Rubber Band:<br/> <a href="https://depts.washington.edu/chem/facilserv/lecturedemo/EntropyofRubber-UWDept.ofChemistry.html">https://depts.washington.edu/chem/facilserv/lecturedemo/EntropyofRubber-UWDept.ofChemistry.html</a></p> <p>Rubber Bands and Engines:<br/> <a href="https://www.scientificamerican.com/article/bring-science-home-rubber-band-heat/">https://www.scientificamerican.com/article/bring-science-home-rubber-band-heat/</a></p>  |





## Balloon Jousting

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| <b>NGSS</b>                 | 3-PS2-1; MS-PS2-1   |
| <b>Student Objective</b>    | Students will learn Newtonian physics concepts and utilize the engineering design process to design balloon jousters.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- Some of the basic physics of racketeering.</li> <li>- the basics of the engineering design process</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- use the engineering design process to meet a challenge.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Force:</b> strength or energy as an attribute of physical action or movement</p> <p><b>Thrust:</b> the propulsive force of a jet or rocket engine. This is explained by Newton's Third Law of Motion.</p> <p><b>Newton's Third Law of Motion:</b> For every action, there is an equal and opposite reaction. The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object.</p> <p><b>Pressure:</b> force per unit area.</p> <p><b>Potential Energy</b> - the energy possessed by a body by virtue of its position</p> <p><b>Kinetic Energy</b> - energy that a body possesses by virtue of being in motion.</p> <p><b>Engineering Design Process:</b> is a series of steps that <b>engineering</b> teams use to guide them as they solve problems. The <b>design process</b> is cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way.</p> |
| <b>Materials</b>            | <p><b>*** Students will be in groups of 2-3 depending on class size. No more than 5 groups allowed.</b></p> <p>26 large balloons.. at least 12 inches (5 per group limit, 1 for demonstration)</p> <p>25 straight drinking straws (5 per group limit)</p> <p>~30 feet of string (Make two ~15 ft strings... smooth line, like fishing line, strong thread, or kite string)</p> <p>10 Barbeque skewers (limit 1 per jouster)</p> <p>Duct tape</p> <p>Clear tape or masking tape</p> <p>10 Styrofoam cups (2 per group limit)</p> <p>10 Plastic cups (2 per group limit)</p> <p>25 popsicle sticks (5 per group limit)</p>  |

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|                  | <p>5 Scissors (1 per group)<br/> Assorted color sharpies<br/> 25 pieces of white printer paper (5 per group)<br/> Pencils (1 per student)</p> <p><b>Note:</b> More supplies can be added, but this is a good start. Anything that a student could use to design a better jousting. Supplies to use for protection, stability, etc. Get creative here.</p>  |
| <b>Procedure</b> | <ol style="list-style-type: none"> <li>1. Introduce the topic and the scientific concepts related to balloon rockets.</li> <li>2. <b>Balloon Rocket Demonstration</b></li> <li>3. Slip a straw onto the string. Blow up a balloon and tape it to the straw. Two NE STEM mentors (or student volunteers) should hold the string up tight between them and release the balloon so it rockets over to the other side. Talk about the physics concepts at work here. (Newton's 3<sup>rd</sup> Law, Thrust, Kinetic and Potential Energy, etc)</li> <li>4. <b>Balloon Jousting</b></li> <li>5. Split students into groups of 2-3 (no more than 5 groups)</li> <li>6. Tell the students that they will design and build balloon jousting and then compete against other groups. <ol style="list-style-type: none"> <li>a. You can show this video to the students, but MENTORS SHOULD WATCH IT REGARDLESS. (Google: Balloon Jousting Design Squad) <a href="https://www.youtube.com/watch?v=JyCTydQOxsA">https://www.youtube.com/watch?v=JyCTydQOxsA</a></li> </ol> </li> <li>7. <b>IMPORTANT:</b> There needs to be some sort of limitations on supplies. You can give students a budget and assign prices to each material, or you can just put flat limitations on each item (refer to the "materials" section). <ol style="list-style-type: none"> <li>a. There are no limitations on how each supply is used. Materials can be used for protection, extension, stability, increased attacking abilities.... Anything the students can imagine. You are advised to only allow one BBQ skewer per balloon, but if you want to change that go right ahead.</li> </ol> </li> <li>8. <b>IMPORTANT:</b> When you tie the ~15 ft string to something stable (chairs, tables, etc.) it must be below eye level. We need to be careful that no one pokes his or her eyes out with the flying BBQ skewer.</li> <li>9. <b><u>BRAINSTORM &amp; DESIGN (~5 min)</u></b> <ol style="list-style-type: none"> <li>a. Have all of the materials laid out on a table and have each group come up one at a time to look at the available materials.</li> <li>b. Each group must then draw up a blueprint design and materials list for their first jousting.</li> </ol> </li> <li>10. <b><u>BUILD, TEST, EVALUATE, and REDESIGN (~40 min)</u></b></li> </ol> |

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|                          | <ul style="list-style-type: none"> <li>a. Each group will build their first balloon joust and then challenge another group.</li> <li>b. Mentors keep track of wins and losses for each group. You could even make a bracket if you wanted to!</li> <li>c. After each round, groups can redesign, rebuild, and compete again. Groups are limited to 5 balloons, so they will get at least 5 attempts.</li> <li>d. Using your smart phone, try filming the jousts in slow motion so students can see why their balloon won or lost in more detail.</li> </ul> <p><b>11. <u>DISCUSS WHAT HAPPENED (~5 min)</u></b></p> <ul style="list-style-type: none"> <li>a. Between each round and at the end of the lesson, take some time to talk about which designs worked and why. Come back to the basic physics concepts involved in the lesson.</li> </ul> <p>Clean up as a group. Save and return as many of the supplies as possible.</p> <p>This should be plenty to keep the students busy. However, here are some additional activities.</p> <p><b>Darts:</b> Make a “dart” by attaching a balloon, skewer, and straw together, just like in the balloon joust. Make a target by inflating a second balloon, but tie this one closed, and tape it at one end of the string. Launch the dart balloon at the target. You could also use a bulls-eye on a piece of paper.</p> <p><b>Push over:</b> Put two straw-balloon combos on a single line, aimed at each other (NO SKEWERS). Put a marker, such as a pencil, on the floor at the string’s center-point. Launch the balloons. The winning balloon is the one that pushes the other one beyond the centerline.</p> <p><b>Race:</b> Set up two long lines, side by side. Race the two balloons. Whose travels the farthest? Whose crosses the finish line first.</p> |
| <b>Guiding Questions</b> | What makes a rocket ship move? Explain the transfer of energy (i.e. kinetic & potential). Explain the value of the engineering design process.   |
| <b>Background</b>        | <p>Sir Isaac Newton first presented his three <a href="#">laws of motion</a> in the "Principia Mathematica Philosophiae Naturalis" in 1686. His third law states that for every action (force) in nature there is an equal and opposite reaction. In other words, if object A exerts a force on object B, then object B also exerts an equal and opposite force on object A. Notice that the forces are exerted on different objects.</p> <p>In aerospace engineering, the principal of action and reaction is very important. Newton's third law explains the generation of <a href="#">thrust</a> by a rocket engine. In a rocket engine, hot exhaust gas is produced through the</p>  |

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|                                  | <p><a href="#">combustion</a> of a fuel with an oxidizer. The hot exhaust gas flows through the rocket <a href="#">nozzle</a> and is accelerated to the rear of the rocket. In re-action, a thrusting force is produced on the engine mount. The thrust accelerates the rocket as described by Newton's <a href="#">second law</a> of motion.</p> |
| <b>Career/Future Application</b> | The engineering design process is a valuable model for daily and occupational life.   |
| <b>Sources</b>                   | <a href="http://pbskids.org/designsquad/build/balloon-joust/">http://pbskids.org/designsquad/build/balloon-joust/</a><br>Wikipedia  |



## Balloon Popping

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| <b>NGSS</b>                 | 4-PS3-2; 4-PS4-1; 5-PS1-4   |
| <b>Student Objective</b>    | Following today's experiment, students will be able to identify and explain the behavior of light in different scenarios.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>During today's activity, students will explore how light interacts with matter. Students will utilize sunlight and lenses on several different materials to observe how wavelength relates to light and its conversion to heat energy.</p> <p><b>The student will be able to:</b></p>  |
| <b>Vocabulary</b>           | <p><b>Wavelength:</b> The distance between peaks of a wave</p> <p><b>Absorption:</b> To take in/immerse</p> <p><b>Convex Lens:</b> A lens that is thicker in the middle; these lenses focus light waves</p> <p><b>Heat:</b> A transfer of energy; caused by objects near each other having different temperatures</p>   |
| <b>Materials</b>            | <p>Per Group:</p> <ol style="list-style-type: none"> <li>1 magnifying lens</li> <li>1 transparent balloon</li> <li>1 black balloon</li> </ol> <p>Sunlight</p>   |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>Partially inflate the transparent balloon. Do not fill it completely or tie off the end.</li> <li>Insert the deflated black balloon into the opening of the clear balloon. Make sure the black balloon's end is hanging out.</li> <li>Inflate the black balloon and tie off both ends.</li> <li>In direct sunlight, position the magnifying lens to focus on the center of the balloons.<br/>Observe. Did any balloons pop?</li> </ol>   |
| <b>Guiding Questions</b>    | <p>What makes the balloons different so that one pops and the other doesn't?</p> <p>Do you think this experiment would work with another transparent balloon inside the first?</p>  |
| <b>Background</b>           | <p>Light is a type of energy, made of waves and particles called photons. Different wavelengths of light have different energies. Of the wavelengths that make up visible light, for example, red light has less energy than green light, which has less than violet. When we see an object's color, we're actually seeing the wavelength that the material reflects. White light is made up of all the different wavelengths of light.</p> <p>Black objects are black because they absorb almost all wavelengths of light and converts it into heat energy.</p> <p>When the magnifying glass is aimed at the balloons, the black balloon absorbs the white light while the transparent balloon reflects it. This causes the black balloon to pop while still inside the transparent balloon.</p> |

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| <b>Career/Future Application</b> | Optometrist, Photographer, Thin-film Engineer  |
| <b>Sources</b>                   | <p>Dark Colors Absorbing Light:<br/> <a href="https://scienceline.ucsb.edu/getkey.php?key=3873">https://scienceline.ucsb.edu/getkey.php?key=3873</a></p> <p>Wavelength and Color:<br/> <a href="https://www.sciencelearn.org.nz/resources/47-colours-of-light">https://www.sciencelearn.org.nz/resources/47-colours-of-light</a></p> |



## Cartesian Density Divers

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| <b>NGSS</b>                 | 3-PS2-1; MS-PS2-2  |
| <b>Student Objective</b>    | To learn about the scientific concepts of density, buoyancy, pressure, and states of matter through several fun activities and demonstrations using Cartesian Divers.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- The basic concepts of density, buoyancy, pressure, and states of matter.</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Conduct experiments and manipulate variables in order to learn more about density, buoyancy, pressure, and states of matter.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Buoyant/Buoyancy:</b> an upward force exerted by a fluid that opposes the <b>weight</b> of an immersed object.</p> <p><b>Density:</b> mass of a substance per unit volume. More simply, the weight of something compared to how much space it takes up. (Density = Mass / Volume)</p> <p><b>Mass:</b> the quantity of matter that a body contains, as measured by its acceleration under a given force or by the force exerted on it by a gravitational field. It is an intrinsic property of matter.</p> <p><b>Volume:</b> the amount of space that a substance or object occupies</p> <p><b>Pressure:</b> is the ratio of <b>force</b> to the <b>area</b> over which that force is distributed.</p>  |
| <b>Materials</b>            | <p>NOTE: the same supplies are reused in most of the activities.</p> <p><b>Diver Demo</b></p> <ul style="list-style-type: none"> <li>- 1 or 2 liter clear soda bottle (with cap)</li> <li>- 10mL plastic pipette (make sure the pipettes have skinny necks... like these <a href="https://www.amazon.com/Plastic-Transfer-Pipettes-Graduated-Pack/dp/B005CD2I50/ref=sr_1_1?ie=UTF8&amp;qid=1475177695&amp;sr=8-1&amp;keywords=1+ml+plastic+pipettes">https://www.amazon.com/Plastic-Transfer-Pipettes-Graduated-Pack/dp/B005CD2I50/ref=sr_1_1?ie=UTF8&amp;qid=1475177695&amp;sr=8-1&amp;keywords=1+ml+plastic+pipettes</a> )</li> <li>- Hex nut</li> <li>- Clear plastic cup</li> <li>- Scissors</li> <li>- Water</li> </ul> <p><b>Gas and Liquid Compression Demo</b></p> <ul style="list-style-type: none"> <li>- Two 100mL plastic syringes with caps</li> <li>- Duct tape (to make sure cap stays on)</li> </ul> <p><b>4 Diver Challenge</b><br/>(per group / per student)</p> <ul style="list-style-type: none"> <li>- 1 or 2 liter clear soda bottle (with cap)</li> </ul> |



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|                  | <ul style="list-style-type: none"> <li>- 10mL plastic pipette (4x)</li> <li>- Hex nut (4x)</li> <li>- Clear plastic cup</li> <li>- Sharpie</li> <li>- Scissors</li> <li>- Water</li> </ul> <p><b>Hook the Diver Challenge</b><br/>(per group / per student)</p> <ul style="list-style-type: none"> <li>- 1 or 2 liter clear soda bottle (with cap)</li> <li>- 10 mL plastic pipette (2x)</li> <li>- Hex nut 2x</li> <li>- Coated wire or pipe cleaner (~20 inches total per student to make a ~10 inch piece &amp; a ~6 inch piece)</li> <li>- Clear plastic cup</li> <li>- Water</li> </ul> <p><b>Bottles</b> <a href="http://www.freundcontainer.com/">http://www.freundcontainer.com/</a> or <a href="https://www.teachersource.com/product/2013/chemistry?gclid=CKrAlOmSts8CFQGpaQodT0wBAQ">https://www.teachersource.com/product/2013/chemistry?gclid=CKrAlOmSts8CFQGpaQodT0wBAQ</a> or</p> <p><b>Pipettes:</b> <a href="https://www.amazon.com/Plastic-Transfer-Pipettes-Graduated-Pack/dp/B005CD2I50/ref=sr_1_1?ie=UTF8&amp;qid=1475177695&amp;sr=8-1&amp;keywords=1+ml+plastic+pipettes">https://www.amazon.com/Plastic-Transfer-Pipettes-Graduated-Pack/dp/B005CD2I50/ref=sr_1_1?ie=UTF8&amp;qid=1475177695&amp;sr=8-1&amp;keywords=1+ml+plastic+pipettes</a></p> <p><b>Syringes:</b> <a href="https://www.amazon.com/VivReal®-Nutrient-Measuring-Reusable-Hydroponics/dp/B00COGVXNQ">https://www.amazon.com/VivReal®-Nutrient-Measuring-Reusable-Hydroponics/dp/B00COGVXNQ</a></p> |
| <b>Procedure</b> | <p><b>YOU MUST WATCH THIS VIDEO WHILE PREPARING FOR THE LESSON:</b><br/><a href="https://www.youtube.com/watch?v=A-xUp3R0OAA">https://www.youtube.com/watch?v=A-xUp3R0OAA</a></p> <ol style="list-style-type: none"> <li>1) Introduce topic – Density = Mass/Volume, states of matter (gases and liquids), buoyancy, etc.</li> <li>2) <b>Diver Demo</b> <ol style="list-style-type: none"> <li>a. Find a spot in the classroom so that all the students can clearly see your demonstration.</li> <li>b. Fill the clear plastic cup <math>\frac{3}{4}</math> with water</li> <li>c. Push / screw a hex nut onto the 10mL pipette so that it rests just below the bulb.</li> <li>d. Cut the neck of the pipette below the hex nut so that only a centimeter or two of plastic remains below the hex nut. You have now made your Cartesian Diver!</li> <li>e. Ask students if they think that the Diver will sink or float, and why?               <ol style="list-style-type: none"> <li>i. Drop the Diver into the cup of water (it will float because it is less dense than the water).</li> </ol> </li> <li>f. Draw up water into the Diver so that it just barely floats at the surface of the water (will probably work if about 40% of the bulb is filled with water)</li> </ol> </li> </ol>   |

- i. Ask students why it is not floating as well (it has become more dense because water has been added to the bulb and water is more dense than the air that it replaced)
- g. Draw up some more water so that the Diver sinks to the bottom.
  - i. Again, ask students why it sinks (the Diver is now more dense than the fluid it is immersed in).
- h. Squeeze out some water so that it barely floats again (~40% full)
- i. Now, fill up the 1 or 2 liter bottle with water so that the only air remaining is in the neck of the bottle.
- j. Place the Diver in the bottle and close the lid. It should be floating at the top.
- k. Ask the students for a drum roll, and then squeeze the sides of the bottle.
  - i. Once you squeeze the bottle, the Diver will sink to the bottom. When you release the bottle, it will float back up.
  - ii. Do this a few times and have students come up in small groups to look very closely at the Diver as you squeeze the bottle.
    - 1. Squeeze the bottle slowly so they can see the air inside the diver get compressed. The water level slowly rises in the Diver until it sinks.
    - 2. When the Diver is at the bottom, as you slowly release the bottle the air will again expand, the water level in the diver will decrease, and the Diver will float back to the top.
    - 3. WHY IS THIS HAPPENING?!? Move onto the next demo.

### 3) Gas and Liquid Compression Demo

- a. Pull out your two pre-prepared capped 100mL syringes, one filled with 30mL of air and the other with 30mL of water.
- b. Give one student volunteer the syringe with water
- c. Count to three, and on three both of you try to compress the syringe.
  - i. The student will not be able to compress the syringe, but you will because air (gas) is compressible while water (liquid) is not.
    - 1. Explain why gases are compressible and liquids are not (answer: the atoms and molecules in gases are really spread out and can thus be pushed closer together. The atoms and molecules in liquids are already touching one another, so they cannot be compressed any further. Same goes for solids. Use can use your fists as molecules to demonstrate.
- d. Now ask, how does this relate to the Diver demonstration?
  - i. When you squeeze the bottle, the air inside the Diver gets compressed, but the water does not. When the air compresses, the Diver becomes denser because the

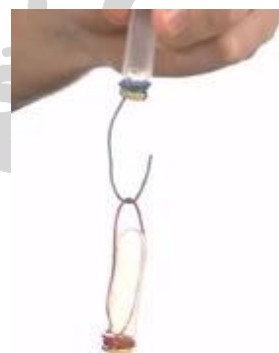
volume of air inside the diver has decreased (Density = Mass / Volume). As the Diver becomes denser, it sinks.

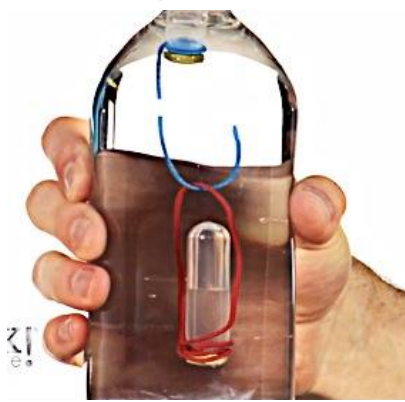
#### 4) 4 Diver Challenge

- a. Depending on how many students you have, you can either split them into small groups (of 2 or 3) or you can have them work alone.
- b. Here is the challenge: "We are going to give you five Divers (numbered 1-4), a cup, and a bottle. Your challenge is to figure out how to make the Divers sink in sequential order (1-4) when you squeeze the bottle.
- c. Hand out all the supplies and let the students experiment until they figure it out. Let them struggle with this while you continue to reinforce the topics discussed in the first two demonstrations.
- d. Solution:
  - i. Fill each of the 4 pipettes with water from the clear plastic cup so that they barely float in the cup.
  - ii. Take pipette 1 and place it in the bottle filled with water
  - iii. Take pipette 2 and squeeze ~3 drops back into the cup, then place it in the bottle.
  - iv. Take pipette 3 and squeeze ~6 drops back into the cup, then place it in the bottle.
  - v. Take pipette 4 and squeeze ~9 drops back into the cup, then place it in the bottle.
    1. TIP: If the divers don't drop, there is not enough water in them. You may need to play around with the amount of water in each Diver.

#### 5) Hook the Diver Challenge

- a. Once the kids have figured out the 4 Diver challenge, hand out the wire or pipe cleaner and tell them to make a hook on one Diver and a loop on the other, as seen in this image.
- b. Using the "looped" Diver, suck in water until the Diver barely sinks to the bottom of the plastic cup.
- c. Using the "hooked" Diver, suck in water until the Diver barely floats (like in the previous activities)



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|                                  | <p>d. Place the Divers in the bottle and close the cap.</p> <p>e. Squeeze the bottle and try to hook the Diver.</p> <p>Finish</p>   |
| <b>Guiding Questions</b>         | <p>Why do some things float and others sink? What is density? What is the formula for density? How does changing the volume or mass of an object affect its density? What are major differences between gas and liquids? What does it mean to say that liquids are not compressible but gases are?</p>   |
| <b>Background</b>                | <p>The Cartesian Diver experiment is set up by placing a "diver"—a small, rigid tube, open at one end in a larger container with some flexible component. The larger container is completely filled with water and must be made airtight when closed.</p> <p>The "diver" is partially filled with a small amount of water, just enough to allow it to contain enough air so that it is nearly <b>neutrally buoyant</b>, but still buoyant enough that it floats at the top while being almost completely submerged. There is just enough <b>air</b> in the diver to make it positively <b>buoyant</b>. Therefore, the diver floats at the water's surface.</p> <p>As a result of <b>Pascal's law</b>, squeezing the airtight container increases the pressure of the air, part of which pressure is exerted against the water that constitutes one "wall" of the airtight container. This water in turn exerts additional pressure on the air bubble inside the diver; because the air inside the diver is compressible but the water is an incompressible fluid, the air's volume is decreased but the water's volume does not expand, such that the pressure external to the diver forces the water already in the diver further inward and drives water from outside the diver into the diver. Once the air bubble becomes smaller and more water enters the diver, the diver <b>displaces</b> a weight of water that is less than its own weight, so it becomes negatively buoyant and sinks in accordance with <b>Archimedes' principle</b>. When the pressure on the container is released, the air expands again, increasing the weight of water displaced and the diver again becomes positively buoyant and floats.</p> |
| <b>Career/Future Application</b> | <p>Density is a crucially important concept across many fields of science. Understanding density, buoyancy, and different states of matter is important for engineers, chemists, physicists, and many more careers.</p>  |
| <b>Sources</b>                   | <p><a href="http://www.sciencekids.co.nz/videos/physics/archimedesprinciple.html">http://www.sciencekids.co.nz/videos/physics/archimedesprinciple.html</a></p> <p><a href="https://www.youtube.com/watch?v=A-xUp3R0OAA">https://www.youtube.com/watch?v=A-xUp3R0OAA</a></p>  |

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|  | <a href="http://www.hellokids.com/c_31710/videos-for-kids/kids-science-experiments/archimedes-principle">http://www.hellokids.com/c_31710/videos-for-kids/kids-science-experiments/archimedes-principle</a><br><a href="https://www.youtube.com/watch?v=s5eIRjmor1w">https://www.youtube.com/watch?v=s5eIRjmor1w</a><br><a href="https://www.youtube.com/watch?v=LTlbuNUQpdg">https://www.youtube.com/watch?v=LTlbuNUQpdg</a><br><a href="https://www.youtube.com/watch?v=qxtpC4KDASY">https://www.youtube.com/watch?v=qxtpC4KDASY</a> |
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# Electromagnetism

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| <b>NGSS</b>                 | 5-PS1-3; MS-PS2-3   |
| <b>Student Objective</b>    | Understanding how the magnetic field of the Earth drives the compass needle to North and how this can be manipulated with magnets. Electromagnet motors with combine this understanding of the magnetic field and how magnetism drives an electrical current.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>basics of electromagnetism and magnetic fields.</p> <p><b>The student will be able to:</b><br/>Build a functional compass.</p>   |
| <b>Vocabulary</b>           | <ul style="list-style-type: none"> <li>• Electron</li> <li>• Charges</li> <li>• North and South Pole</li> <li>• Electromagnetism</li> </ul>   |
| <b>Materials</b>            | <p>Compass</p> <ul style="list-style-type: none"> <li>• Magnets</li> <li>• Needle</li> <li>• Styrofoam</li> <li>• Pie plate</li> </ul> <p>Motor</p> <ul style="list-style-type: none"> <li>• D cell Battery (make sure their fresh)</li> <li>• Something to cut Copper wire</li> <li>• Heavy rubber bands (that fit snugly around the battery)</li> <li>• Safety pins</li> </ul> <p>HW: need to add this lesson <a href="https://sciencebob.com/make-an-electromagnet/">https://sciencebob.com/make-an-electromagnet/</a></p> <p>A large iron nail (about 3 inches)</p> <p>About 3 feet of THIN COATED copper wire</p> <p>A fresh D size battery</p> <p>Some paper clips or other small magnetic objects</p> <p>Electrical tape</p> |
| <b>Procedure</b>            | <p><b>Compass</b></p> <ol style="list-style-type: none"> <li>1. Run a magnet along the needle in the same direction 10 or 20 times</li> <li>2. Fill pie plate with water</li> <li>3. Cut out bottom of Styrofoam cup and place needle on it</li> <li>4. Place the bottom of the cup and needle on top of the water so that it floats.</li> <li>5. The needle will line up along the North South line.</li> </ol>  |

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|                                  | <p><b>Motor</b></p> <ol style="list-style-type: none"> <li>1. Make the copper wire into the ring as shown in the above video</li> <li>2. Rubber band the magnet to the middle of the battery</li> <li>3. Rubber band the safety pins to the charged ends of the battery</li> <li>4. Give the copper ring a push and away it goes!</li> <li>5. Do the experiment with different shapes of the copper wire and use batteries to manipulate the speed of the copper wire</li> </ol>  |
| <b>Guiding Questions</b>         | <p>What else can be affected by magnetic fields?</p> <p>Is there anything else you can think of that would emit or require magnetism to work?</p> <p>Do you think magnetic fields can intersect?</p>  |
| <b>Background</b>                | <p><b>COMPASS:</b> By running the magnet along the needle you give it magnetic dipole. By moving the magnet in one direction along the needle, you are in a sense “organizing” the electrons so that their charges (spins) are aligned to opposing negative and positive ends. The negatively charged electrons are then oriented toward the positive pull of the North Pole. The North Pole is positive because the earth has a strong magnetic field. This is generated by the spinning of the iron core of our planet. The magnetized needle aligns itself along the magnetic pole of the earth.</p> <p><b>MOTOR:</b> The battery runs current through the copper (which is non-magnetic material)causing the copper loop to generate a magnetic field perpendicular to the current (see figures below for the right hand rule to explain this phenomenon. The first shows the simple rule with emphasis on the direction of the forces. The second shows how the field rotates around the current). With a little nudge, the opposing magnetic field of the copper wire reacts with the magnetic field of the magnet. This drives the copper wire around because its different poles are being simultaneously attracted and repelled by the magnet.</p> |
| <b>Career/Future Application</b> | <p>Engineering process and finding direction.</p>   |
| <b>Sources</b>                   | <p>a. <a href="http://adventure.howstuffworks.com/outdoor-activities/hiking/compass2.htm">http://adventure.howstuffworks.com/outdoor-activities/hiking/compass2.htm</a></p> <p>b. <a href="https://www.youtube.com/watch?v=vSPFwibREUg">https://www.youtube.com/watch?v=vSPFwibREUg</a></p> <p>c. <a href="http://www.livescience.com/21668-why-earth-magnetic-field-wonky.html">http://www.livescience.com/21668-why-earth-magnetic-field-wonky.html</a></p> <p>e. <a href="http://www.education.com/science-fair/article/effect-magnet-electron-beam-right/why-earth-magnetic-field-wonky.html">http://www.education.com/science-fair/article/effect-magnet-electron-beam-right/why-earth-magnetic-field-wonky.html</a></p>   |

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|  | <p>d. <a href="http://kids.britannica.com/comptons/art-53602/When-the-right-hand-thumb-points-in-the-direction-of-e">http://kids.britannica.com/comptons/art-53602/When-the-right-hand-thumb-points-in-the-direction-of-e</a>. <a href="http://www.education.com/science-fair/article/effect-magnet-electron-beam-right/">http://www.education.com/science-fair/article/effect-magnet-electron-beam-right/</a></p> |
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## Kinetic and Thermal Energy

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| <b>NGSS</b>                 | 5-PS1-4; MS-PS1; MS-PS3-4   |
| <b>Student Objective</b>    | Following today's experiment, students will be able to use various models along with new vocabulary to describe how particles in different states of matter behave.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <p>During this experiment, students will learn about kinetic and thermal energy and its relationship with matter. Working in small groups, students will first create a model and observe how temperature relates to the movement of particles. Students will then conduct an experiment to simulate molecules in a gas to test how changing the speed of the molecules impacts the object's temperature and pressure. <b>The student will be able to:</b></p>   |
| <b>Vocabulary</b>           | <p><b>Volume:</b> The amount of space an object takes up</p> <p><b>Kinetic Energy:</b> The energy of an object has due to its motion</p> <p><b>Thermal Energy:</b> A type of kinetic energy where the moving objects are particles; it is measured by temperature</p> <p><b>Molecules:</b> A group of atoms bonded together; bonding is a result of atoms sharing or exchanging their electrons</p> <p><b>Pressure:</b> A force that a gas uses to push against the walls of its container</p>  |
| <b>Materials</b>            | <ol style="list-style-type: none"> <li>Per Group (For Observation Portion): <ul style="list-style-type: none"> <li>2 transparent containers</li> <li>250mL of cold water</li> <li>250mL of warm or room temperature water</li> <li>2 bottles of liquid food coloring (can be the same color)</li> <li>2 pieces of tape and a writing utensil for labeling</li> <li>A clock or stopwatch</li> </ul> </li> <li>For Simulation Portion: <ul style="list-style-type: none"> <li>Per Group: 1 cup/large handful of beads, marbles, or similarly sized spherical objects</li> </ul> </li> </ol> <p>Per student: 1 plastic cup</p>   |
| <b>Procedure</b>            | <p><b>Molecule Observation:</b></p> <ol style="list-style-type: none"> <li>Using tape and a writing utensil, label the 2 transparent containers; one being "Cold" and the other "Warm".</li> <li>While a groupmate holds the "Cold" container steady, pour in 250mL of cold water and set aside.</li> <li>While a groupmate holds the "Warm" container steady, pour in 250mL of warm or room temperature water and set aside.</li> <li>Place the two containers approximately one foot apart from each other with the labels visible.</li> <li>Choose one group member to be in charge of timing the experiment.</li> <li>Choose two different group members to prepare the food coloring; one student will need food coloring for the "Cold" container and one student with food coloring for the "Warm" container.</li> </ol> |

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|                          | <ol style="list-style-type: none"> <li>When the group's time keeper is ready, both students will simultaneously put 1-3 drops of food coloring into their own container.</li> <li>Observe for 1 minute. While watching the food coloring, be careful not to stir or move the container. Which container is moving the food coloring faster?</li> </ol> <p><b>Molecule Simulation:</b></p> <ol style="list-style-type: none"> <li>Each student will need 1 plastic cup.</li> <li>Place 1 single bead/marble in the cup.</li> <li>Cover the opening with the opposite hand that is not holding the cup.</li> <li>Start by moving the cup slowly. Listen to how often the bead/marble makes contact with the sides of the cup.</li> <li>Begin shaking the cup more quickly. How hard do you have to shake the cup to feel the bead/marble collide with your hand that is covering the opening?</li> <li>Uncover the cup and place more beads/marbles inside. Repeat steps 3 through 5.</li> </ol> <p>Compare and contrast results: In which scenario were the beads/marbles hitting your hand more often? How did the speed of the beads/marbles inside impact the collisions?</p> |
| <b>Guiding Questions</b> | <p><b>Molecule Observation:</b></p> <p>Which temperature of liquid moved the food coloring faster, the cold or warm water?</p> <p>Why do particles that move faster, like in warm water, carry food coloring better?</p> <p><b>Molecule Simulation:</b></p> <p>Is there a connection between the shaking speed of the beads/marbles and the number of collisions? Does this apply to the water and food coloring activity?</p> <p>How would the experiment change if you used a balloon instead of a cup?</p>   |
| <b>Background</b>        | <p>Thermal energy is kinetic energy at the molecular level. The faster molecules move, the more energy the molecule has and the more often molecules bump into each other.</p> <p>The way thermal energy is measured is by temperature. Temperature does not measure heat; heat is energy being transferred. Temperature is defined as the average kinetic energy of the particles in an object. It's the 'average' energy because it is extremely difficult to know the exact speed of every particle, but it can be measured that a cup of liquid at 80°C has more fast-moving particles on average than a cup of liquid at 20°C.</p> <p>During the molecule observation activity, the container holding the warmer water will spread the food coloring noticeably faster. This is because the molecules in the warm water are moving faster than the molecules in the cold water. When particles are moving faster, they collide more often. The molecules in the warm water are moving faster and bumping into the food coloring particles more often. This results in the food coloring mixing faster in the water with the higher temperature.</p>                        |

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|                                  | <p>The average kinetic energy of particles in a gas depends only on the temperature of the gas, because the temperature describes the particle's energy. This also increases the pressure, because particles with more energy exert a larger force when they bump into the walls of their container. This also increases the volume of the container if the container is flexible, like in a balloon. Temperature, pressure, volume, and even the number of molecules in a gas are all directly related by the Ideal Gas Law. In the molecule simulation, students should notice that more collisions happen when the "molecules" (i.e. beads/marbles), are moving faster. The collisions happen even more when the number of molecules increases. When the frequency or energy of the molecule collisions (i.e. temperature), the pressure increases.</p> |
| <b>Career/Future Application</b> | Chemist, Thermodynamics Engineer, Aerospace Engineer   |
| <b>Sources</b>                   | <p>Heat and Moving Particles:<br/> <a href="http://www.chemistryexplained.com/Ge-Hy/Heat.html">http://www.chemistryexplained.com/Ge-Hy/Heat.html</a><br/>           Kinetic Molecular Theory and Ideal Gas Law:<br/> <a href="http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch4/kinetic4.html">http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch4/kinetic4.html</a></p>   |

## Life Jackets and Buoyancy

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| <b>NGSS</b>                 | 5-PS1-1  |
| <b>Student Objective</b>    | To build a life jacket and test its buoyancy when strapped to a soup can.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- Buoyancy and its application in life jackets.</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Build a functional personal floatation device from unorthodox materials.</li> </ul>   |
| <b>Vocabulary</b>           | <p><b>Buoyancy</b> - the ability or tendency to float in water or air or some other fluid.</p> <p><b>Life Jacket</b> - a device designed to help keep a person or animal afloat -- whether they are conscious or not.</p> <p><b>Patent</b> - A form of intellectual property.</p>  |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>- Resource handout</li> </ul> <p><b>Soup Can Demonstration (Assortment of supplies listed for the whole class)</b></p> <ul style="list-style-type: none"> <li>- Identical soup or vegetable cans (1 per group)</li> <li>- Paper cups</li> <li>- Straws</li> <li>- Paper towels</li> <li>- Rubber bands</li> <li>- Paper clips</li> <li>- Tape</li> <li>- Balloons</li> <li>- Plastic bags or lunch bags</li> <li>- Glue</li> <li>- Corks</li> <li>- Foam pieces</li> <li>- String</li> <li>- Foil</li> <li>- Hose or tubes</li> <li>- Small containers</li> <li>- Paper towels</li> <li>- Bucket</li> </ul> |
| <b>Procedure</b>            | <p>1) Introduce topic</p> <p>Today we will learn about buoyancy. Who has ever worn a life jacket? Has anyone you know ever been saved by one? We will be making life jackets which can keep a soup can afloat.</p> <p>2) <b>Soup Can Demonstration</b></p> <ol style="list-style-type: none"> <li>Discuss the rules of the life jacket building             <ol style="list-style-type: none"> <li>The device must be in one attached piece</li> </ol> </li> </ol>   |

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|                                  | <ul style="list-style-type: none"> <li>ii. It must be affixed to the can within a 20 second period (so students cannot just add foam or balloons to it for an hour)</li> <li>iii. Some portion of the can must touch the water and get wet.</li> </ul> <ul style="list-style-type: none"> <li>b. Put students into teams of 2-3 and allow them 10-15 minutes to plan their design. They should have a list of materials and drawing when done.</li> <li>c. Have students build their life jackets and test them.</li> </ul> <p>3) Clean up the room!</p>   |
| <b>Guiding Questions</b>         | <p>Why is buoyancy important when building a life jacket? What are some of the best materials for a life jacket?</p> <p>What conclusions can you draw?</p> <p>What types of careers can you think of?</p>  |
| <b>Background</b>                | <p>A personal flotation device (abbreviated as PFD; also referred to as, life jacket, life preserver, life vest, life saver, cork jacket, buoyancy aid, flotation suit, etc.) is a device designed to help keep a person or animal afloat - whether they are conscious or not.</p> <p>In most of the world, life jackets or life vests are now mandatory on airplanes that travel over water. These usually consist of a pair of air cells or bladders that can be inflated by triggering the release of carbon dioxide gas from a canister - or can be inflated by blowing into a tube with a one-way valve to seal in the air.</p> <p>Life jackets are also provided on both recreational and commercial seafaring vessels - so all crew and passengers can wear one in an emergency. Not only people wear personal flotation devices; some are available for dogs and other animals to wear.</p> <p>Most people are familiar with the story of the Titanic, which struck an iceberg a century ago - many know there were not enough lifeboats on board to rescue all the people, but interestingly, there were enough life jackets (see example on the right) for all the people aboard, and most everyone was wearing one. Of course, in the frigid water of the North Atlantic, the life vests alone were not enough to save many people.</p> <p>Simple flotation devices are used by many children learning to swim, and can be a vest or arm "bubbles."</p> |
| <b>Career/Future Application</b> | <p>PFD's are used in many maritime and military careers. The problem solving and teamwork are used in every STEM field. Buoyancy is especially important in some engineering project such as boat design or oil rigs.</p>  |

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| <b>Sources</b> | <a href="http://tryengineering.org/lesson-plans/life-vest-challenge">http://tryengineering.org/lesson-plans/life-vest-challenge</a><br><a href="http://tryengineering.org/sites/default/files/lessons/lifevest.pdf">http://tryengineering.org/sites/default/files/lessons/lifevest.pdf</a> |
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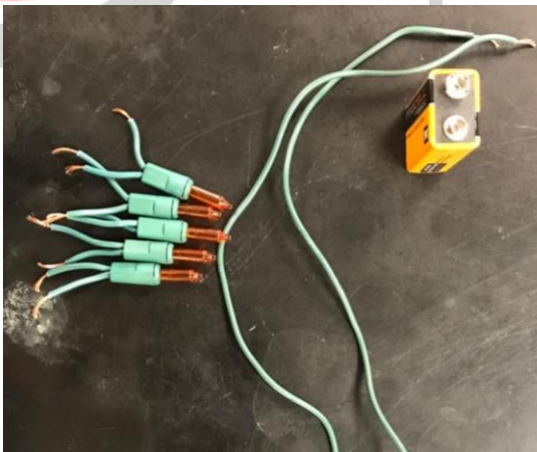


## Simple Circuits

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|-----------------------------|--|
| <b>NGSS</b>                 | 4-PS3-4; MS-PS3-2  |
| <b>Student Objective</b>    | Become familiar with simple circuits and electrical quantifiers.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>• The difference between series and parallel circuits.</li> <li>• How different circuit set-ups change the power through a circuit.</li> </ul> <p><b>The student will be able to:</b><br/>Build simple circuits</p>  |
| <b>Vocabulary</b>           | <p><b>Overview:</b> Mentors should have a basic understanding of parallel and series circuits, and how the current, voltage, and power, of various circuit components changes with different setups.</p> <p><b>Resistance:</b> Resistance quantifies the <i>resistance to the flow of electrical charge</i> through an electrical component and is measured in ohms (<math>\Omega</math>). Resistors can be thought of as any component that has resistance. The only components used in these experiments are light bulbs (cut from a strand of holiday lights) and batteries. For the sake of these experiments, batteries have no resistance and lightbulbs have resistance. We do not count wires as components because their effect on the actual functioning of the circuit is negligible. In other words, the only purpose of wires is to connect the significant components.</p> <p><b>Power:</b> Electrical power is really the product of voltage and current. Power, in general, is the amount of energy that is consumed per unit of time. It's probably best to explain power to the students as simply the rate of flowing electricity. The amount of power that is consumed by a circuit is inversely proportional to the resistance of that circuit, assuming constant voltage. If resistance is high, it will take longer to flow the charge through the circuit therefore less power is dissipated. If resistance is low, more electricity will be able to flow in a shorter amount of time, and power is increased.</p> <p><b>Circuits:</b> For the sake of this lesson, circuits are defined as being composed of a current-source (battery) that has at least one complete path from the positive terminal to the negative.</p> |

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|           | <p>The path or paths can travel through wires and various components that conduct electricity (light bulbs).</p> <p>A circuit that has one end of the battery connected to a light bulb, but nothing connected to the other end of the battery is not a complete circuit because there is not a complete path from the positive terminal of the battery to the negative.</p> <p>A circuit that has one end of the battery connected to a light bulb and the other end connected to the same lightbulb is a circuit because there is a complete path (albeit through the lightbulb) connecting both sides of the battery.</p> <p><b>You can use the analogy of a track around a football field and an airport runway as an example. The track is a circuit because there is a complete path connecting both ends. The runway is not a circuit because the ends are not connected.</b></p> |
| Series:   | <p>Series circuits are arranged in such a way that multiple resistors are hooked together in a chain and form a complete loop with the battery. The total resistance of series circuits is the sum of all of the resistances of all of the resistors. This is so because there is only one path for electricity to travel; therefore, <b>the electricity gets slowed down like heavy traffic through a narrow street.</b></p>  |
| Parallel: | <p>Parallel circuits are arranged in such a way that multiple resistors, each having an A and B side, are hooked together such that all of the A sides are hooked together, and all of the B sides are hooked together. The A and B sides are then hooked to opposite ends of the battery. The total resistance of parallel circuits is less than the resistance of any one resistor used in the circuit. By adding multiple resistors, one effectively creates more paths for electricity to flow, <b>so instead of all the traffic being forced down one narrow street, the traffic can be split between 1, 2, 3, 4, ... streets and, therefore, moves much faster.</b></p>  |



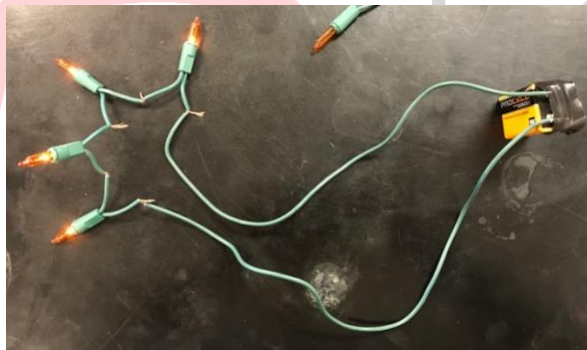
|                  |  |
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|                  | <p><b>Batteries:</b> Batteries create a flow of electricity because they have a difference in potential between the terminals. <b>You can explain this to the effect that someone has taken a bunch of electricity and stuffed it into one end of the battery and that the electricity really wants to get to the other side. The only way it can get there is by traveling through a complete circuit to the other end. You can also explain that the more resistance that is in the circuit, the slower the electricity will travel to the other end.</b></p> <p><b>Light Bulbs:</b> Lightbulbs have a small filament (thin piece of wire) that connects one end of the lightbulb to the other inside the glass. They have resistance because the filament does not let electricity pass as easily as the other connecting wires. When electricity is passed through the filament it gets very hot and glows brightly. The more electricity we put through the light bulb, the brighter it shines.</p> |
| <b>Materials</b> | <ul style="list-style-type: none"> <li>• 9-volt battery</li> <li>• 2-5 Christmas Lights (Lights can be cut from a strand. Make sure leads are long enough to work with and that the insulation is trimmed at least half an inch.)</li> <li>• 2 longer wires for connecting the circuit.</li> <li>• Strip of Electrical Tape</li> </ul>    |
| <b>Procedure</b> | <p>Electrical connections to the battery can be made by sandwiching the each of the two leads between a battery post and a piece of electrical tape as pictured.</p> <p>Connections among lightbulbs can be made by twisting the exposed copper together.</p>  |

### Activity 1 (Complete the Circuit):

Instruct the students on the characteristics of a **complete circuit**. They should experiment with connecting the lights to the batteries in different ways. You should point out that when there is not a traceable path from one end of the battery to the other and through a light bulb, the light bulbs will not shine.

### Activity 2 (Series and Parallel):

Instruct the students to first make a series circuit with their lights and battery. You can draw a diagram on the board or make up an example to help them out. Tell the students to take note of how bright the bulbs are.

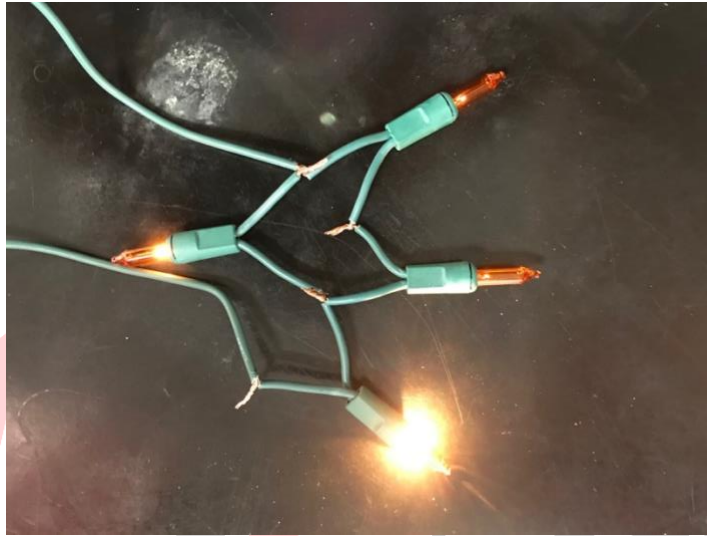


Next, have the students make a parallel circuit. The lights should be much brighter in the parallel circuit than the series circuit. Ask them why?



Activity 3 (Combination Circuits):

Instruct the students to make up their own circuits with varying amounts of bulbs and to observe how some of the lights have different brightness's. If the students are having trouble getting creative, you can demonstrate some different circuits pictured below.



Activity 4 (Large groups / class activates):

Students can pool their materials to make larger circuits with multiple batteries. If larger circuits are assembled with many lightbulbs, you can point out how adding batteries in series makes the bulbs brighter. If batteries are added in series, they should be added + to -, otherwise they will not conduct electricity.

It is not recommended that batteries be connected in parallel (+ to +, - to -) because doing so is not likely to have any noticeable effect on the brightness of the bulbs. However, if this is done, make sure the batteries are not connected (+ to -, - to +) otherwise the batteries could overheat.

**Guiding Questions**

Always be asking the Students why the circuit is behaving the way it is. Lead them to answer questions about how electricity flows in series and parallel circuits.

Have you done a similar experiment or used these concepts in another experiment?

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|                                  | How did you modify the experiment? Do you think scientists or engineers use similar creativity? |
| <b>Background</b>                |   |
| <b>Career/Future Application</b> | Electrical engineering, Electrical Contracting, Computer Science                                |
| <b>Sources</b>                   |   |



## Terrible Tower of Newton

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| <b>NGSS</b>                 | 5-PS2-1; MS-PS2-1   |
| <b>Student Objective</b>    | To learn Newton's first and third laws of motion in a fun way!  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b> two of the three laws of motions. They will be able to explain how the egg is experiencing both Newton's first and third law.</p> <p><b>The student will be able to:</b> demonstrate Newton's first and third law by explaining all of the forces actin on all the materials.</p>  |
| <b>Vocabulary</b>           | <p><u>Force</u>- A push or pull upon an object resulting from the objects interaction with another object</p> <p><u>Inertia</u>- the resistance of any physical object to any change in speed, direction or state of rest</p> <p><u>Newton's first law</u>- An object at rest will remain at rest and an object in motion will remain in motion unless acted upon by an external force.</p> <p><u>Newton's third law</u>- For every action there is an equal and opposite reaction.</p>   |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>• Item needed per school</li> <li>• 2-3 Pie pans</li> <li>• 2-3 Glass cup or beaker</li> <li>• 2-3 Toilet paper tube</li> <li>• 2-3 Hardboiled egg</li> <li>• Water (to go into glass cup or beaker)</li> <li>• Newspaper and paper towels in case someone spills water.</li> </ul> <p>Small bag of marbles of varying sizes</p>   |
| <b>Procedure</b>            | <p><a href="http://www.youtube.com/watch?v=STQRUzaIH2M">http://www.youtube.com/watch?v=STQRUzaIH2M</a> (WATCH THIS BEFORE DOING EXPERIMENT)</p> <p><b>Experiment 1: Terrible tower</b></p> <ol style="list-style-type: none"> <li>1) Hand out pre tests</li> <li>2) Do a whole- group demonstration and then have the kids set up the experiment at each group. (For the demonstrations follow steps 4-9)</li> <li>3) Fill three fourths of a clear glass cup (or beaker) with water</li> <li>4) Place a pie pan on top of the glass cup</li> <li>5) Place a toilet paper roll in the middle of the pie pan</li> <li>6) Place a hardboiled egg on top of the toilet paper tube</li> <li>7) Slap the pie pan only!! (Not the egg)</li> <li>8) Watch in amazement as the egg drops into the cup of water, even though the pie pan and toilet paper tube shoot off of the glass cup!</li> <li>9) As you proceed through the experiment, relate what you are doing to Newton's Laws</li> <li>10) Now have the students try slapping the pan out without making a mess!</li> </ol> |

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|                          | <p><b>Experiment 2: Marble collisions</b></p> <ol style="list-style-type: none"> <li>1) The following steps should be done at a constant velocity: therefore, we can relate this to inertia</li> <li>2) Place a stationary marble on the floor, then roll another marble of the same size to collide with it. What happens?</li> <li>3) Place a big stationary marble on the floor, then roll a small marble to collide with it.</li> <li>4) Place a small stationary marble on the floor, then roll a big marble to collide with it.</li> <li>5) In which instance did the stationary marble move the most? Why? Which marble had more inertia?</li> <li>6) Have students try out different setting with the marbles (example: line two stationary marbles up and have a larger marble collide into it)</li> <li>7) Have students make observations and discuss the results.</li> <li>8) Final Quiz/Game</li> <li>9) All students should participate in cleaning up the room</li> </ol> <p><b>Differentiation</b></p> <ul style="list-style-type: none"> <li>• Have the students lead the experiment after you have done the main one. Let them explore different setups such as: stacking two toilet paper tubes, using two pie pans instead of one, hitting the pie pan slower versus faster. Instead of an egg, use a ball of paper or other small objects. What happens to them?</li> </ul> <p>If time permits, take some time to play with marbles and explore how their movements change when colliding them with one another (kind of like playing pool). You can explain how Newton's laws have an effect when marbles collide with one another.</p> |
| <b>Guiding Questions</b> | <p>What will happen when we strike a stationary marble with a moving marble? What will happen when we strike two identical moving marbles rolling towards each other? Let's change the size of one of the marbles: what happens now? Does one have more inertia than the other?</p>   |
| <b>Background</b>        | <p>While at rest the egg/roll/pan complex is experiencing the force of gravity and the normal force. The force of gravity pulls it downwards while the normal force pushes up. By striking the pie pan the horizontal force is transferred to the pie dish but not the egg. The only force acting on the egg is the force of gravity, which pulls it into the cup. The water then exerts buoyant force upon the egg, allowing it to rest safely in the cup.</p> <p>The marbles are stationary on the floor (or table) until an outside force acts on them. The outside force will be another marble striking them. Notice that when one marble strikes a stationary marble, they bounce off of each other and they are both in motion. Why is it that the marbles stop moving on their own if we don't see an outside force stopping them? Because of the friction between the marble and the floor. In a frictionless world, the marbles would continue on their trajectory until acted on by an external force.</p>   |

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|                                  | <p>When two moving marbles strike each other head on, there is an equal and opposite reaction between them (if they are the same mass and traveling at the same speed). Changing the mass or speed of one of the marbles will have different effects on its inertia. Generally, an object with a larger mass and a greater velocity will have more inertia compared to an object with a smaller mass and a lower velocity. Experiment with these changes and observe the results; try to relate it back to Newton's Laws of motion.</p> |
| <b>Career/Future Application</b> | <p>Understanding all potential forces in a system is critical for designing structures. Physics is therefore highly relevant to engineering, construction, architecture, etc. Ask the students if any of these careers interest them! Emphasize that careers like this involve lots of hard work in your high school and college classes.</p>   |
| <b>Sources</b>                   | <p> <a href="http://www.physicsclassroom.com/class/newtlaws/u2l2a.cfm">http://www.physicsclassroom.com/class/newtlaws/u2l2a.cfm</a><br/> <a href="http://dictionary.kids.net.au/word/inertia">http://dictionary.kids.net.au/word/inertia</a><br/> <a href="http://www.youtube.com/watch?v=STQRUzalH2M">http://www.youtube.com/watch?v=STQRUzalH2M</a> (WATCH THIS BEFORE DOING EXPERIMENT) </p>   |

## The Incredible Egg

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| <b>NGSS</b>                 | 5-PS1-2  |
| <b>Student Objective</b>    | To build a life jacket and test its buoyancy when strapped to a soup can.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>a. - Pressure change caused by temperature change.</li> <li>b. Weight distribution of eggs and structures allowed by the shape and angles of the object.</li> <li>c. Change in pressure to allow for equilibrium.</li> </ul> <p><b>The student will be able to:</b></p> <p>-</p>   |
| <b>Vocabulary</b>           | <p><b>Pressure</b> - A measure of the force applied over an area.</p> <p><b>Weight distribution</b> - The way in which weight is spread over an area.</p> <p><b>Equilibrium</b> - When something is in balance.</p>  |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>a. For Demo <ul style="list-style-type: none"> <li>i. Peeled hard-boiled egg</li> <li>ii. Flask or jar with opening slightly smaller than the diameter of the egg</li> <li>iii. Paper and lighter <i>or</i> very hot water <i>or</i> very cold liquid</li> </ul> </li> <li>b. Experiment One: Weight Distribution <ul style="list-style-type: none"> <li>i. 1 raw egg for each student</li> <li>ii. 1 plastic bag</li> <li>iii. 1 carton of eggs (without cracks)</li> <li>iv. Student handout of dome-shaped buildings and bridges</li> <li>v. Bare feet</li> </ul> </li> <li>c. Experiment Two: Creating a Vacuum using a Plastic Bottle <ul style="list-style-type: none"> <li>i. 1 Plastic Bottle per student</li> <li>ii. 1 Egg (from experiment one)</li> <li>iii. 1 Paper Plate per student</li> <li>iv. 1 tarp (recommended)</li> </ul> </li> </ul> |
| <b>Procedure</b>            | <p><b>II. Procedure:</b></p> <ul style="list-style-type: none"> <li>1. Open</li> </ul>   |



2. Administer Quiz/ Play Quiz Game
3. Necessary Explanations
4. Start the experiment

a. **Demo**

i. **- How to Get the Egg In**

1. *Method 1:*

- a. Set a piece of paper on fire and drop it into the bottle.
- b. Set the egg on top of the bottle (small side pointed downward).
- c. When the flame goes out, the egg will get pushed into the bottle.

2. *Method 2:*

- a. Set the egg on the bottle.
- b. Run the bottle under very hot tap water.
- c. Warmed air will escape around the egg.
- d. Set the bottle on the counter.
- e. As it cools, the egg will be pushed into the bottle.

3. *Method 3:*

- a. Set the egg on the bottle.
- b. Immerse the bottle in a very cold liquid.
- c. I have heard of this being done using liquid nitrogen, but that sounds dangerous (could shatter the glass).
- d. Recommend trying ice water.
- e. The egg is pushed in as the air inside the bottle is chilled.

ii. **How to Get the Egg Out**

1. You can get the egg out by increasing the pressure inside the bottle so that it is higher than the pressure of the air outside of the bottle.

2. Roll the egg around so it is situated with the small end resting in the mouth of the bottle.
3. Tilt the bottle just enough so you can blow air inside the bottle. Roll the egg over the opening before you take your mouth away.
4. Hold the bottle upside down and watch the egg 'fall' out of the bottle.
5. Alternatively, you can apply negative pressure to the bottle by sucking the air out, but then you risk choking on an egg, so that's not a good plan.

**b. Experiment One**

i. Egg Crush

1. Place one raw egg in a plastic bag and give one to each student.
2. Have the students place the egg horizontally in the palm of their hands (no rings on fingers!), and then have them squeeze the egg as hard as they can. The egg will not break!
3. \*\*\*Tell the students not to break their eggs intentionally, as they will be used in the final experiment.\*\*\*

ii. Egg Stomp

1. Ask for one student volunteer who is willing to take his/her shoes and socks off.
2. Place two cartons of raw eggs on the floor with the top cover of each egg carton off (exposing the eggs).
3. Ask the student to gently step onto the eggs flat-footed.
4. Watch as the eggs do not break!

**c. Experiment Two**\*\*Demonstrate how to do this before letting the students do it\*\*

- i. Have each student bring their egg in the plastic bag from experiment two, and crack it onto their paper plate.
- ii. They will then squeeze their empty water bottle to create increased pressure in the bottle.

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|                          | <ul style="list-style-type: none"> <li>iii. Have them place the opening of the water bottle over the yellow egg yolk, and then slowly release their tight squeeze on the water bottle.</li> <li>iv. Doing so will suck the egg yolk into the bottle- an example of equilibrium.</li> <li>v. This can be done as a race, to see which group of kids can get the egg yolk into their bottles first.</li> </ul> <ul style="list-style-type: none"> <li>5. Have the students write observations in their scientific journals. Collect the notebooks at the end.</li> <li>6. Final Quiz/Game</li> <li>7. All students should participate in cleaning up the room.</li> </ul>   |
| <b>Guiding Questions</b> |   |
| <b>Background</b>        | <p>When you change the temperature of the air inside the bottle, you change the pressure of the air inside the bottle. If you have a constant volume of air and heat it, the pressure of the air increases. If you cool the air, the pressure decreases. If you can lower the pressure inside the bottle enough, the air pressure outside the bottle will push the egg into the container.</p> <p>Eggshells get some of their strength from their unique mix of hard crystals (calcium carbonate) that are held together by flexible organic material (called a protein matrix). But much of the strength of the egg comes from the shape itself.</p> <ul style="list-style-type: none"> <li>i. When a heavy weight presses down on an arch or dome, the force moves uniformly down the sides toward the base. The lack of angles or corners means that no one spot must handle the whole load. This is why hens can sit on their eggs with the arched end pointed up because the weight gets distributed evenly. In addition, people can walk across eggs, if they walk flat-footed, which equally distributes the weight across the eggs.</li> <li>ii. For this reason, arches and domes pack an architectural punch. They can enclose a great deal of space without needing internal supports, and they can span large distances without collapsing under the strain.</li> </ul> <p>Air wants to be at equilibrium; therefore, if there is an increase or decrease in pressure, air will be brought one way to create equilibrium. The</p> |

students will squeeze their empty water bottle to create increased pressure in the bottle. Doing so will suck the egg yolk into the bottle, an example of equilibrium. The bottle's increased internal pressure wants to be equal to that of the outside pressure, so the bottle brings in air to equalize the pressure. This bringing in of air is what causes the egg yolk to be sucked up.



**Career/Future  
Application**

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|----------------|---|
| <b>Sources</b> | <a href="http://cocopreme.hubpages.com/hub/Egg-tremelyFunandEasyEggExperiments">http://cocopreme.hubpages.com/hub/Egg-tremelyFunandEasyEggExperiments</a><br><a href="http://chemistry.about.com/b/2013/02/10/egg-in-a-bottle-demonstration.htm">http://chemistry.about.com/b/2013/02/10/egg-in-a-bottle-demonstration.htm</a><br><a href="http://www.answersingenesis.org/articles/am/v6/n3/eggshells">http://www.answersingenesis.org/articles/am/v6/n3/eggshells</a><br><a href="http://chemistry.about.com/od/chemistryglossary/a/pressuredef.htm">http://chemistry.about.com/od/chemistryglossary/a/pressuredef.htm</a><br><a href="http://dictionary.reference.com/browse/equilibrium">http://dictionary.reference.com/browse/equilibrium</a> |
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## Aquifers and Artesian Wells

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| <b>NGSS</b>                 | 5-ESS2; MS-ESS3  |
| <b>Student Objective</b>    | After today's lesson students will understand how artesian wells and aquifers work.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-What artesian wells are</p> <p><b>The student will be able to:</b><br/>-Apply new knowledge of aquifers<br/>-Identify an aquifer.</p>  |
| <b>Vocabulary</b>           | <p><b>Aquifer:</b> An underground lake in which groundwater is contained in permeable rock.</p> <p><b>Artesian Well:</b> A well drilled into an aquifer, underneath the water table where the natural water pressure pushes the water out.</p> <p><b>Water Table:</b> The line between the unsaturated and saturated zone; the top of the aquifer.</p> <p><b>Permeable Rock:</b> Rock that allows air and liquid to pass through due to tiny holes throughout the entire rock.</p>     |
| <b>Materials</b>            | <p><b>For each group (2-3 students):</b></p> <ul style="list-style-type: none"> <li>-Plastic cups</li> <li>-Small pebbles or rocks</li> <li>-Straws or small plastic tubing</li> <li>-Water</li> <li>-Napkins or paper towels</li> <li>-Marker</li> <li>-Tin foil, plastic wrap, or a plastic lid for artesian well models.</li> <li>-Piece of paper and writing utensil</li> </ul>  |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>1. Beforehand create a model that the kids can follow; it's okay if the model doesn't work because the students try to figure out how to create a better model that works.</li> <li>2. Have the students write out their hypothesis and the steps of their experiment.</li> <li>3. Then have the students create their artesian well models and test them. Have them share with the class whether or not their hypothesis came true.</li> </ol> |

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| <p><b>Guiding Questions</b></p>         | <ol style="list-style-type: none"> <li>1) What do you already know about aquifers?</li> <li>2) What do you already know about artesian wells?</li> <li>3) What is your understanding of the scientific method?</li> <li>4) How can the scientific method help us with day to day activities?</li> </ol>  |
| <p><b>Background</b></p>                | <p>The scientific method is a multi-step method to help people do research by providing the steps normally needed to do research. The first steps normally are to create a question or objective, find background information/ do research into understanding the topic more, and then construct a hypothesis. Then one goes on to test the hypothesis, figure out if the test backed up their hypothesis or not, and then analyze the data one got from their test and draw conclusion on why their hypothesis was supported or not. If wanted other steps can be added such as troubleshooting, or adding on more experiments or research into why the experiment did not backup one's hypothesis.</p> <p>Aquifers are a large area under the ground where water is stored inside permeable rock. The permeable rock is in-between layers of non-permeable rock, which is how the water is able to stay within the layer of permeable rock until acted on by an outside force (such as the digging of a well or formation of a spring). The layer within the aquifer is called the saturated zone, because the rocks are saturated with water, the area above the aquifer is called the unsaturated zone because there is either no water or very little water within this area. Between the saturated and unsaturated zones is the water table, this is the very top of the saturated zone.</p> <p>Artesian wells are wells that are dug into an aquifer below the water table that do not require extra force do to the natural water pressure. The water will naturally want to rise from the bottom to the water table due to pressure, and when the pressure is great enough it will rise past the water table and come out of the top of the well.</p> |
| <p><b>Career/Future Application</b></p> | <p>Geologist, Geographer</p>   |
| <p><b>Sources</b></p>                   | <p><a href="https://www.usgs.gov/special-topic/water-science-school/science/artesian-water-and-artesian-wells?qt-science_center_objects=0#qt-science_center_objects">https://www.usgs.gov/special-topic/water-science-school/science/artesian-water-and-artesian-wells?qt-science_center_objects=0#qt-science_center_objects</a></p>   |



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|  | <p><a href="https://www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater/qt-science_center_objects=0#qt-science_center_objects">https://www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects</a></p> <p><a href="https://www.sciencebuddies.org/science-fair-projects/science-fair/steps-of-the-scientific-method">https://www.sciencebuddies.org/science-fair-projects/science-fair/steps-of-the-scientific-method</a></p> |
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## The Center of the Earth

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| <b>NGSS</b>                 | 5-ESS2; MS-ESS3   |
| <b>Student Objective</b>    | After today's activity, students will understand the dynamic properties of the Earth's core.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>-Earth's layers and what they are made of</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>-Label the three layers of the Earth and what the layers consist of (in terms of general properties).</li> <li>-Create a model of the earth.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Inner Core:</b> The core of the Earth; a large iron ball.</p> <p><b>Outer Core:</b> Fast moving magma.</p> <p><b>Lower Mantle:</b> Slower moving rock that moves due to pressure.</p> <p><b>Upper Mantle:</b> Tectonic plates.</p> <p><b>Crust:</b> The part we live right on top of. Consists of soil, rocks, and the sea floor.</p>   |
| <b>Materials</b>            | <p><b>For each group (2-3 students):</b></p> <ul style="list-style-type: none"> <li>-A plastic cup</li> <li>-Tin foil</li> <li>-Red food dye (three drops per cup)</li> <li>-Aloe Vera</li> <li>-Foam sheets</li> <li>-Popsicle sticks</li> <li>-Sprinkles</li> <li>-Napkins or paper towels.</li> </ul>  |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>4. Lay napkins or paper towels on the table or desk and place materials on top of it.</li> <li>5. Crumple up tin foil into a ball and place it in the plastic cup.</li> <li>6. Pour the aloe Vera on top of the tin (about <math>\frac{3}{4}</math> full)</li> <li>7. Put three drops of the red food dye on the aloe Vera and mix with popsicle sticks until it is a clear red.</li> <li>8. Then lay foam sheets on top of the aloe Vera, make sure parts of them overlap.</li> </ol> |

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|                                  | 9. Put sprinkles on top of foam sheets.   |
| <b>Guiding Questions</b>         | <p>1) What part do you think the foam sheets will be/what do you think the different materials will be?</p> <p>2) What have you learned about the inside of the earth before?</p> <p>3)What metal is the core made out of?</p> <p>Optional Question:</p> <p>4) Why do the foam sheets not sink through the aloe Vera? (Density)</p>   |
| <b>Background</b>                | <p>The interior of the Earth consists of three basic parts: the crust, mantle, and core. The core and mantle are then cut into two parts each: the upper and lower mantle and the outer and inner core. The Crust is what we live on top of: it's the soil, rocks, and seabed underneath us. The upper mantle underneath that is where the tectonic plates are, these are what the cause earth quakes, mountains, and volcanos. The lower mantle is made up of slow-moving rocks that move due to heat and pressure. The outer core is a faster moving magma that can cool and form igneous rocks that will join the lower mantle. The inner core is an iron ball that rotates very slowly and is responsible for our magnetic field.</p> |
| <b>Career/Future Application</b> | Environmental Scientist, Geologist, Geographer  |
| <b>Sources</b>                   | <a href="https://pubs.usgs.gov/gip/interior/">https://pubs.usgs.gov/gip/interior/</a>   |

## Mapping and Geographic Information Sciences

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| <b>NGSS</b>                 | 5-ESS2-1; 4-ESS1-1  |
| <b>Student Objective</b>    | After today's lesson students will understand the principles of reading and using maps.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>-How to apply new knowledge to create a map</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>-Read a map</li> <li>-Explain key components of a map.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>GIS:</b> Geographic Information Systems (or Science)</p> <p><b>Latitude:</b> Lines that run East to West on a map.</p> <p><b>Longitude:</b> Lines that run North to South on a map.</p> <p><b>Cartography:</b> The making of a map.</p> <p><b>Key:</b> Tells us what different symbols on a map mean.</p>   |
| <b>Materials</b>            | <p><b>For each group (2-3 students):</b></p> <ul style="list-style-type: none"> <li>-Piece of paper</li> <li>-Pencil or pen</li> <li>-Ruler</li> <li>-Clipboard</li> <li>-Google map print outs of the area of the school</li> </ul>  |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>10. Print out the area of the school for google maps to figure out coordinates</li> <li>11. Then using a pencil and ruler draw longitude and latitude lines on the piece of paper, with the middle of the paper being the coordinates found on google maps.</li> <li>12. If weather permits have the students choose two landmarks to walk between to figure out distance between landmarks.</li> <li>13. Then have them draw a smaller version of the area based on how much detail and distance they want to have.</li> <li>14. They can then create a part of the area (such as roads and buildings) and create symbols to represent those parts.</li> <li>15. Then have them create a key to show what those symbols mean.</li> <li>16. If wanted possibly create a scale and figure out how many centimeters</li> </ol> |

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|                                  | or inches on the piece of paper would represent in real life (again based on distance that the student wants to create).  |
| <b>Guiding Questions</b>         | <p>1) Does anyone know what cartography is?</p> <p>2) Can anyone name the different types of maps?</p> <p>3) Does anyone know where the prime meridian is?</p> <p>4) Does anyone know where the equator is?</p> <p>5) Can someone explain what latitude and longitude are?</p> <p>6) What is scaling up or scaling down in relation to a map?</p>   |
| <b>Background</b>                | <p>Geographic Information Sciences (GIS for short) is creating and using maps for all sorts of purposes. We use maps and GIS for city planning, farming, disaster relief, and transportation services. Some fundamental ideas involved with map making is longitude, latitude, coordinates, and the equator and prime meridian. Longitude (going north to south) and latitude (going east to west) are the lines on a map that give us coordinates. Coordinates are given in degrees or “minutes”; latitude is always listed first and longitude is always listed second. Coordinates show us where on a map we are, and we can also use maps (like google earth) that show us where we are to find our coordinates. The Equator is a latitude line (so it runs east to west) and it splits the earth between north and south. The Prime Meridian is a longitude line (so it runs north to south) and it splits the earth between east and west. Other important key factors for creating a map are the key and scale. The map key tells us what the symbols on the map mean and the map scale shows us an amount of space on a map covers an amount of space on earth.</p> |
| <b>Career/Future Application</b> | Cartographer, City Planner, Geographer, Civic Engineer  |
| <b>Sources</b>                   | The Complete Book of Maps and Geography for Grades 3 through 6 by Carson Dellosa  |

## Seismology and Earthquakes

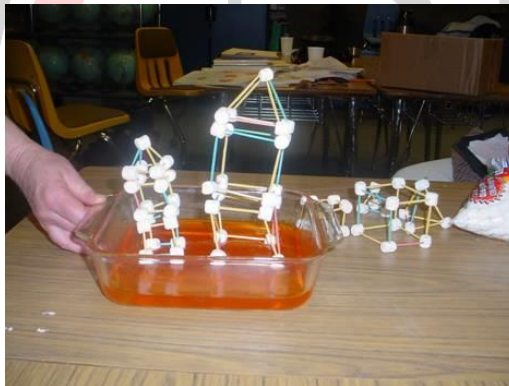
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| <b>NGSS</b>                 | 2-ESS2-2; 4-ESS3-2   |
| <b>Student Objective</b>    | Today we will be talking about earthquakes! We will be building marshmallow and toothpick structures and putting them to the test! Also, we will be testing out our seismograph.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>-Seismology and how earthquakes affect the people as well as the world around them</li> <li>-The importance of good engineering will play a big role in showing how structures take on the forces of earthquakes.</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>-Explain the differences between seismic waves</li> <li>-Describe the two scales earthquakes are measured on</li> <li>-Build/replicate earthquake effects on marshmallow buildings all while working as a team!</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Epicenter</b> – The point on the Earth's crust directly above the origin of the earthquake.</p> <p><b>S Waves (Secondary Waves)</b> – Slower secondary body waves, which cause side-to-side movement.</p> <p><b>P Waves (Primary Waves)</b> – Primary body waves, which cause compression. Occur from the focus (origin) of the earthquake.</p> <p><b>Aftershock</b> – Shocks or tremors that occur after an earthquake.</p> <p><b>Compression Waves</b> – Waves that travel by compressing molecules.</p> <p><b>Body Wave</b> – Waves from an earthquake that travel in the ground.</p> <p><b>Surface wave</b> – Waves from an earthquake that travel along the surface of the Earth</p> <p><b>Seismograph</b> – Instrument that records how powerful an earthquake is by recording how much the ground shakes.</p> <p><b>Seismogram</b> – Record of an earthquake</p> <p><b>Richter Scale</b> – Measurement of the power of an earthquake, from 1 to 9</p> <p><b>Mercalli Scale</b> – Measurement of the damage an earthquake caused, from I to XII.</p> |
| <b>Materials</b>            | <p><b>For each group (2-3 students):</b></p> <p><b>Marshmallow Building: For each school</b></p>   |

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|                         | <ul style="list-style-type: none"> <li>• 1 box Toothpicks</li> <li>• 1 bag mini marshmallows</li> <li>• 2 Baking pans with jello</li> </ul> <p><b>Seismograph Building: For each group (2 groups per school)</b></p> <ul style="list-style-type: none"> <li>• 2 foot long rulers with four holes in them</li> <li>• 2 fine line markers (sharpies will work)</li> <li>• 1 roll of adding machine paper</li> <li>• 1 small box approximately 6" L x 3" W x 2" H to fit the adding machine paper roll (Use the small blue boxes provided)</li> <li>• Several rubber bands</li> <li>• Strip of tag board or cardboard (about 1.5" by 3")</li> <li>• Cork or square eraser</li> <li>• 2 pencils or a thin wood dowel that can fit through the holes in the rulers</li> </ul> <p><b>For the class</b></p> <ul style="list-style-type: none"> <li>• 4-6 large, heavy books (find at school or bring your own)</li> <li>• Masking, duct, or transparent tape</li> </ul> <p>-Scissors</p>   |
| <p><b>Procedure</b></p> | <p><b>1) Introduce the Topic</b></p> <ol style="list-style-type: none"> <li>Before handing out experiment materials explain that the students will be pretending to be engineers by building marshmallow structures.</li> <li>Show the students an example of marshmallow building blocks: cubes, triangles, pyramid like the photo below.             <ol style="list-style-type: none"> <li>Give them any building restrictions that may increase the difficulty or excitement level. Base any restriction on grade level.</li> </ol> </li> </ol> <p><b>2) Jell-O Earthquakes</b></p> <ol style="list-style-type: none"> <li>Pass out 30 toothpicks and 30 marshmallows to each student and limit them to one large structure or two smaller ones. Keep in mind that every student should have space on the pie pans for their structures.</li> <li>Once the students have completed their structures, place them in the jello. If you decide to only test a few student's structures at a time make sure that the jello is still useable.</li> <li>Test each structure with different types of forces such as: shaking from side to side, shaking it forwards and backwards, tapping the pie pan from below, wave like motions, etc. Try to relate some of the forces to the vocabulary above.</li> <li>Allow students to re-engineer and test their own structures again if there is time.</li> </ol> <p><b>3) Seismograph</b></p> <ol style="list-style-type: none"> <li>See picture below to see how it's supposed to look like!</li> <li>Place paper roll on the end of the table with a pen or pencil through it. Have a student hold on to it when running the seismograph.</li> </ol> |

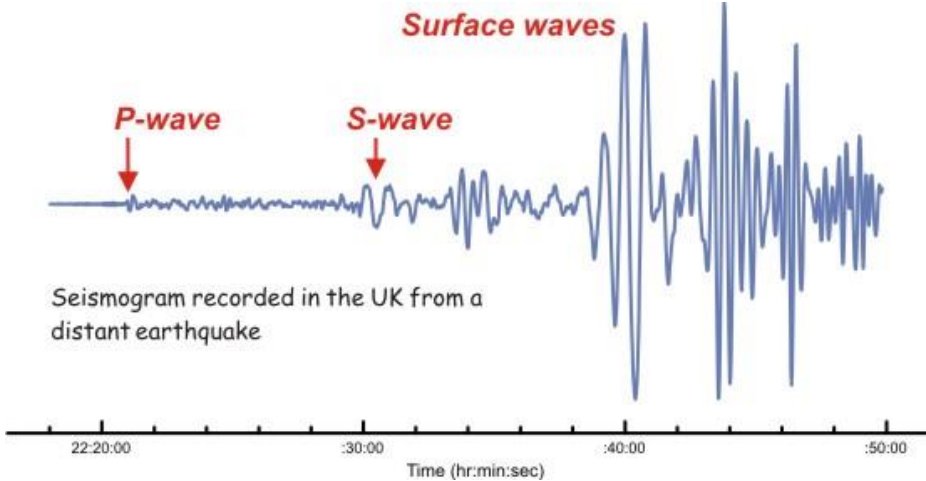
- c. Place a cork in between two rulers at the 6"-mark and tape it in place.
- d. Wrap a rubber band around the 1" of the rulers.
- e. Place a marker/sharpie just passed the rubber bands so that it is at the very end of the rulers.
- f. At the opposite end of the rulers (away from the marker), wedge a pencil into each ruler hole so that the tips of the pencils touch (erasers facing away from the rulers).
- g. Suspend the seismograph using 6-8 textbooks 8 inches apart similar to the figure below.
- h. Tape a paper strip to the table on top of the roll of paper so that the paper strip can act as a guide for the machine paper.
- i. After the apparatus has been prepared, have one student hold the seismograph in place by adding pressure on the books and have one student intermittently shake the paper roll as you pull the end.
  - l. Make sure to explain what this experiment is simulating and see if they can relate the seismograph readings to the jello earthquake experiment.
- j. Final Quiz/Game

If there is still time left, have the students go through another round of building using the same materials to see if they can improve their buildings.

All students should participate in cleaning up the room.





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|                          |  <p>Seismogram recorded in the UK from a distant earthquake</p>  |
| <b>Guiding Questions</b> | <ol style="list-style-type: none"> <li>1) What kinds of shapes can you make with the materials to withstand an earthquake?</li> <li>2) Can you make your building better? How?</li> <li>3) What do the lines on the seismograph represent? Why are some larger than others and what does the size of the peaks on the seismograph mean? (Look at picture above)</li> </ol>   |
| <b>Background</b>        | <p>Earthquakes happen around tectonic plates for the most part. However, some manmade structures can cause them also. For example, the Hoover dam caused so much pressure (with the water behind it), that it created an earthquake. When an earthquake causes waves, there are two main types. Surface waves travel along the surface of the earth and body waves travel below the surface and cause major damage. You also get P waves (primary waves) and S waves (secondary waves) (Image 1). P waves are the first waves to show up, and are fast. These waves are compression waves (like sound), which can be demonstrated by a slinky. When the slinky is pulled far apart, it wants to spring back into place. The energy travels along the rings of the outstretched slinky. S waves are slower, but cause the most damage. S waves travel back and forth in a sheering motion. This can be demonstrated by a rope on the ground, and moving it like a snake. After the earthquake is over with, you can still get aftershocks. These aftershocks can occur for days after the earthquake has passed. In the first demonstration you will be able to see how these waves affect a building. The toothpicks and marshmallows are a student's building. When you tap on the pan, the vibrations travel through the jello, and into the buildings. Depending on how well the buildings are constructed, they may just shake, or they could fall over.</p> <p>To measure how strong an earthquake is scientists created seismology. Seismology records the vibrations created by an earthquake, and puts them into a scale of strength. This instrument is called a seismograph. The first one was invented in 132 A.D. in China. This was called a seismoscope,</p> |

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|                                  | <p>and was a vase with either dragon heads holding a bronze ball. When an earthquake occurred, the waves would dislodge the bronze ball, and it would fall into the mouth of a toad positioned below. This allowed people to estimate which direction the wave came from, and allowed them to find the epicenter of an earthquake. Today, earthquakes are measured and put onto a Richter scale. The Richter scale goes from 1 (pounds) of movement, to 9 (tons) of movement. While a 1 or 2 cannot be detected by humans, a seismograph can still pick them up. Each value on the Richter scale represents a 10 fold increase in strength. Earthquakes are also measured using the Mercalli scale. This scale goes from I (not felt at all) to XII (nearly total damage caused). In the second demonstration you will build a seismograph. A pen will be held lightly in a ruler and on a piece of paper. When vibrations occur, the pen will move and leave marks on the paper. This piece of paper is called a seismogram, and is a record of an earthquake.</p>             |
| <b>Career/Future Application</b> | <p>Civil, structural, mechanical and materials engineers make sure the structures we rely upon are built strong enough to keep us safe. To reduce the number of human injuries and casualties, they research and test new and improved techniques and materials that help structures withstand the tremendous earthquake forces. For example, engineers have developed shock absorbers and structure sliders—techniques that isolate the foundation of a building from the ground so the building and the earth move independently. They also create monitoring equipment to predict and measure earthquakes and warn surrounding communities.</p>  |
| <b>Sources</b>                   | <p><a href="https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson03.xml">https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson03.xml</a><br/> <a href="https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03_activity1.xml">https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03_activity1.xml</a><br/> <a href="https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03_activity2.xml">https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_natdis/cub_natdis_lesson03_activity2.xml</a><br/> <a href="http://earthscience.stackexchange.com/questions/352/how-to-distinguish-p-s-love-and-rayleigh-waves-in-a-seismogram">http://earthscience.stackexchange.com/questions/352/how-to-distinguish-p-s-love-and-rayleigh-waves-in-a-seismogram</a></p> |

# Volcanoes

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| <b>NGSS</b>                 | 4-ESS2; 5-ESS2  |
| <b>Student Objective</b>    | After today's lesson students will know the main parts of a volcano.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>-The makeup of a volcano</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>-Create a model of a volcano</li> <li>-Recognize the main parts of a volcano</li> </ul>   |
| <b>Vocabulary</b>           | <p><b>Magma Chamber:</b> The chamber at the very bottom of the volcano where the magma is stored.</p> <p><b>Conduit:</b> The pipe the magma travels through to reach the top of the volcano.</p> <p><b>Vent:</b> The opening at the top of the volcano where magma comes out.</p> <p><b>Crater:</b> The top of the volcano that surrounds the vent; normally will look like a large dent.</p> <p><b>Magma:</b> Rock that has been melted.</p> <p><b>Lava:</b> Magma that has reached the top of the vent.</p> |
| <b>Materials</b>            | <p><b>For each group (2-3 students):</b></p> <ul style="list-style-type: none"> <li>-Markers and white boards.</li> <li>-Materials to create volcano models.</li> </ul>   |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>17. After the students discuss the main parts of the volcanos they will draw or write out how they will create a model with the materials they have been given on the white board.</li> <li>18. The students will then create their own volcano models with given materials.</li> <li>19. The students will share their models.</li> <li>20. The students will vote on who created the best volcano model.</li> </ol>  |
| <b>Guiding Questions</b>    | <ol style="list-style-type: none"> <li>1) What do you already know about volcanos?</li> <li>2) If you could choose your materials to create a model what materials would you choose for each part?</li> </ol>   |

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|                                  | <p>3) Have you heard of Hawaii, what do you know about it?</p> <p>4) Do you know of any volcanos?</p>   |
| <b>Background</b>                | <p>There are 4 main parts to a volcano: the magma chamber, conduit, vent, and crater. The magma chamber is where magma is stored underneath the volcano, the conduit is the pipe where the magma moves to the top, and the vent is the opening at the top of a volcano where magma will come out. The crater is a crater at the top of volcano where the vent is. Magma is molten rock or rock that has been melted, and is stored in the earth's crust as well as makes up the lower mantle. Lava is magma that has reached the surface of the earth. There are 4 types of volcanos: cinder cone, lava dome, shield, and composite. The biggest difference between these volcanos is shape, size, and how explosive they are. Cinder cones are the most explosive but are very small whereas lava domes tend to become violent over time where at first the lava seeps out and cools and dries around the vent, but once the magma builds up pressure they will explode sending the cooled lava flying. Shield volcanos are very wide and large volcanos but they tend to be none-explosive where the lava will simply flow out like water. Composite volcanos tend to be very tall and skinny and are known to explode violently.</p> |
| <b>Career/Future Application</b> | Geologist, Geographer, Volcanologist  |
| <b>Sources</b>                   | <a href="https://volcanoes.usgs.gov/vhp/about_volcanoes.html">https://volcanoes.usgs.gov/vhp/about_volcanoes.html</a>   |



## Die Hard Challenge

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| <b>NGSS</b>                 | 5-PS1-3   |
| <b>Student Objective</b>    | To develop problem solving and skills in mathematics.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-How precision and accuracy are related, but different.</p> <p><b>The student will be able to:</b><br/>-Develop skills in measurement and volume, all while using problem solving and teamwork!</p>  |
| <b>Vocabulary</b>           | <p><b>Volume</b> – The amount of space occupied by a substance, and can be measured in <math>\text{cm}^3</math> or mL.</p> <p><b>Accuracy</b> – How close a measured value is the actual value.</p> <p><b>Precision</b> – How close measured values are to each other.</p> <p><b>Density</b>– Mass per unit volume – how much matter is occupying a given amount of space (e.g. g/mL).</p>  |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>-1 “3 unit” cup per group (5 total)</li> <li>-1 “4 unit” cup per group (5 total)</li> <li>-2 “5 unit” cups per group (10 total)</li> <li>-1 tub per group that can hold around 15 units of water (5 total)</li> <li>-Extra 1, 2, 3, 4, and 5 units cups to measure volume at the end</li> <li>-Laptop/iPad/iPhone with internet to show the Video that goes along (references)</li> </ul>  |
| <b>Procedure</b>            | <p><b>Introduce the Topic</b></p> <ol style="list-style-type: none"> <li>a. Explain the vocabulary terms using student-led methods. Introductions and vocab should take around <u>10 minutes</u>.</li> <li>b. Split the students into groups no larger than 3 people and explain the following challenges as time permits.</li> </ol> <p><b>1) Challenge 1:</b></p> <ol style="list-style-type: none"> <li>a. Play the first minute of the video – OR explain what their goal is if you cannot have video at your school. With that being said, make sure you watch the video in references before you go!</li> <li>b. They must use one 5-unit container and one 3-unit container to measure 4 units of water precisely.</li> <li>c. Once they get their answer in groups – you will have the “4-unit” container that they can measure accuracy with!</li> </ol> |

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|                                  | <p><b>2) Challenge 2:</b></p> <ol style="list-style-type: none"> <li>Give them one 3-unit container, one 4-unit container, and two 5-unit containers.</li> <li>They must create amounts of exactly 1, 2, and 3-unit amounts of water.</li> </ol> <p><b>3) Challenge 3:</b></p> <ol style="list-style-type: none"> <li>Give them one 3-unit container, one 4-unit container and two 5-unit containers.</li> <li>They must fill these containers with 2, 3, 4, and 5 units of water.</li> </ol> <p>Close the day with future applications – do pre-/post-test if necessary!</p>   |
| <b>Guiding Questions</b>         | 1) If you currently have 1 unit in this container and we need 4 total, how will we get 3 more?  |
| <b>Background</b>                | <p>Solutions:</p> <p><b>Challenge 1:</b></p> <ol style="list-style-type: none"> <li>Fill the five-unit jug. Pour 3 units from 5 into 3. (There are now 2 units in the 5)</li> <li>Empty the 3-unit jug. Pour 2 units from 5 into the 3-unit jug.</li> <li>Fill 5-unit jug completely. Pour 1 unit into the 3-unit jug.</li> <li>You now have 4 units in the 5-unit container.</li> </ol> <p><b>Challenge 2:</b></p> <ol style="list-style-type: none"> <li>Fill the 5-unit container and pour it into the 4-unit jug</li> <li>Empty the 4-unit jug and pour the 1 unit from the 5 –unit jug into the 4-unit jug</li> <li>Fill the 5 and pour 3 units into the 3 unit</li> <li>You now have 2 units in the 5, 1 unit in the 4, and 3 units in the 3 unit</li> </ol> <p><b>Challenge 3:</b></p> <ol style="list-style-type: none"> <li>Same as challenge 2, but you can fill up the four and 5 (if you start the students from fresh, it will feel like a brand-new challenge and they might even have a different way of figuring this out!</li> </ol> |
| <b>Career/Future Application</b> | Problem solving and teamwork are always important. In any job, you will have to work together with teammates to solve a problem. Learning to think outside the box and trying out new ideas that are never guaranteed to work are utilized in STEM fields every day.  |
| <b>Sources</b>                   | <p>FIRST minute contains problem, last 30 seconds has the answer for challenge 1!</p> <p><a href="https://www.youtube.com/watch?v=BVtQNK_ZUJg">https://www.youtube.com/watch?v=BVtQNK_ZUJg</a></p>  |

# Hexaflexagons

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| <b>NGSS</b>                 | TBD   |
| <b>Student Objective</b>    | Today you are going to learn how to build a hexaflexagon!   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-What a hexaflexagon and equilateral triangles are</p> <p><b>The student will be able to:</b><br/>-Build a hexaflexagon</p>  |
| <b>Vocabulary</b>           | <p><b>Hexaflexagon:</b> A folded paper construction that can be flexed along its folds to reveal and conceal its faces alternately.</p> <p><b>Geometry:</b> The area of mathematics that deals with points, lines, shapes and space.</p> <p><b>Equilateral Triangle:</b> A triangle with all three sides and all three angles equal</p> <p><b>Mobius Strip:</b> A two dimensional, non-orientable object that has only one side and one edge</p> <p><b>Hexagon:</b> A six sided geometric shape made up of triangles</p>  |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>-Markers</li> <li>-Pens</li> <li>-Scissors</li> <li>-Hexaflexagon handouts</li> <li>-Tape/Glue</li> <li>-iPad or computer</li> </ul>   |
| <b>Procedure</b>            | <p><b>1) Introduce the Topic:</b></p> <ol style="list-style-type: none"> <li>a. Have students talk about what a Mobius Strip is.</li> <li>b. Ask them whether they think it is true it only has one side and one edge.</li> </ol> <p><b>2) Start the Experiment:</b></p> <ol style="list-style-type: none"> <li>a. Have them build a Mobious Strip and test it by tracing the edge and side</li> <li>b. Watch the video<br/>(<a href="https://www.youtube.com/watch?v=VIVlegSt81k&amp;feature=youtu.be">https://www.youtube.com/watch?v=VIVlegSt81k&amp;feature=youtu.be</a>)</li> <li>c. Hand out the hexaflexagon sheets with no instructions to each student</li> <li>d. Walk them through using your handout how to build a hexaflexagon</li> <li>e. Allow students to color in the sides as the surface</li> </ol> |



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|                                  | <p>f. Discuss vocabulary terms as they are working</p> <p>l. If time permits, show this video<br/>(<a href="https://www.khanacademy.org/math/math-for-fun-and-glory/vi-hart/hexaflexagons/v/flex-mex">https://www.khanacademy.org/math/math-for-fun-and-glory/vi-hart/hexaflexagons/v/flex-mex</a>)</p> <p><b>3) Further Discoveries:</b></p> <p>a. See if students can find another way to fold a hexaflexagon</p> <p>b. See if students can make another flexagon shape</p>  |
| <b>Guiding Questions</b>         | <p>1) How many sides does a hexaflexagon have?</p> <p>2) How about a hexagon?</p> <p>3) How many sides and edges does a Mobious Strip have and why?</p>  |
| <b>Background</b>                | <p>What is a flexagon, you ask? At first glance it looks innocuous enough, like a folded hexagon or square, a child's fortune teller or cootie catcher, or a piece of origami. But look closely and you'll see hidden layers lurking between the front and back. When you fold or pinch corners together, the flexagon "flexes," meaning a formerly hidden layer will come to light as the top layer folds underneath. It all sounds complicated but is really pretty simple when you see an actual flexagon in action.</p> <p>Mathematicians refer to flexagons as "mathematical oddities." That's because flexagons have very complex mathematical structures. As the flexagon is flexed, sections shift position to create an almost kaleidoscopic effect, and different faces come into view, in cyclic order. Mathematicians enjoy analyzing the structure and dynamic behavior of flexagons. Laypeople just enjoy playing with them.</p> |
| <b>Career/Future Application</b> | <p>Any career involving puzzles will be appealing to students interested by especially those in math and engineering.</p>  |
| <b>Sources</b>                   | <ul style="list-style-type: none"> <li>• <a href="http://www.wikihow.com/Fold-a-Hexaflexagon">http://www.wikihow.com/Fold-a-Hexaflexagon</a></li> <li>• <a href="http://mathequalslove.blogspot.com/2012/12/hexaflexagon-love.html">http://mathequalslove.blogspot.com/2012/12/hexaflexagon-love.html</a></li> <li>• <a href="http://www.puzzles.com/hexaflexagon/img/instructions_for_folding_trihexaflexagon.pdf">http://www.puzzles.com/hexaflexagon/img/instructions_for_folding_trihexaflexagon.pdf</a></li> <li>• <a href="http://www.puzzles.com/hexaflexagon/img/blank_trihexaflexagon_template.pdf">http://www.puzzles.com/hexaflexagon/img/blank_trihexaflexagon_template.pdf</a></li> </ul> <p><a href="https://www.khanacademy.org/math/math-for-fun-and-glory/vi-hart/hexaflexagons/v/flex-mex">https://www.khanacademy.org/math/math-for-fun-and-glory/vi-hart/hexaflexagons/v/flex-mex</a></p>                                  |

## Skittles Math

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| <b>NGSS</b>                 |   |
| <b>Student Objective</b>    | Students will compile data on Skittles, create a graph, then eat the Skittles!  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-How to investigate basic probability and graphing</p> <p><b>The student will be able to:</b><br/>-Calculate theoretical and experimental probabilities and create graphs</p>  |
| <b>Vocabulary</b>           | <p><b>Sample Space</b> – the set of all possible outcomes of an experiment</p> <p><b>Experimental Probability</b> – probability of an event is the ratio of the number of times the event occurs to the total number of trials</p> <p><b>Theoretical Probability</b> – the likeliness of an event happening based on all the possible outcomes</p>  |
| <b>Materials</b>            | <p><b>For each student:</b></p> <ul style="list-style-type: none"> <li>-Pack of skittles</li> <li>-Skittles Handouts</li> <li>-Pencil</li> <li>-Colored Pencils or markers</li> <li>-Cup</li> </ul>   |
| <b>Procedure</b>            | <p><b>1) Anticipatory Questions</b></p> <ol style="list-style-type: none"> <li>a. How many skittles are in a bag?</li> <li>b. Can you think of a way to predict which color you might pull out without looking?</li> <li>c. Discuss the vocabulary words. Use the anticipatory set to try to get a discussion going with the kids</li> </ol> <p><b>2) Start the experiments</b></p> <ol style="list-style-type: none"> <li>a. Have students answer the questions on page one of the handout (This can be done individually, in pairs, or as a group.)</li> <li>b. Have students now pour out skittles and count them and fill in page 2</li> <li>c. Have students create their graph</li> <li>d. Have students complete their theoretical calculations and then complete their trials and record them</li> <li>e. Now compare your two results</li> <li>f. If time permits, complete all the group comparisons</li> </ol> <p>Ask the students about jobs and how this might be useful</p> |
| <b>Guiding</b>              | 1) Why do theoretical and experimental probability differ?  |

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| <b>Questions</b>     | <p>2) How could you use this to impress your friends?</p> <p>3) What conclusions can you draw?</p> <p>4) How could you use this in a career?</p> <p>5) What types of careers can you think of that would use this?</p>   |
| <b>Background</b>    | <p>Probability is the numerical measure of the likelihood of occurrence of an event. The value of probability lies between 0 and 1.<br/>If all outcomes of an experiment are equally likely, then the probability is given by:</p> $\text{Probability} = \frac{\text{\# of Favorable Outcomes}}{\text{\# of Possible Outcomes}}$ <p>From Quiz:</p> <ol style="list-style-type: none"> <li>How many colors of Skittles are there in a normal bag? <ol style="list-style-type: none"> <li>3</li> <li><b>5 ← answer</b></li> <li>6</li> <li>4</li> </ol> </li> <li>If there are equal numbers of each color what are my chances of pulling a purple skittle out of the bag (without looking)?<br/><b>1/5</b></li> <li>What is the most common color of Skittle? <ol style="list-style-type: none"> <li>Red</li> <li>Green</li> <li><b>Yellow ← answer</b></li> <li>Purple</li> </ol> </li> <li>What color of Skittle are we <b>actually</b> most likely to pull out of our bag?<br/><b>Yellow</b></li> <li>If I have 3 red skittles, 4 green skittles, 2 purple skittles, and 6 yellow skittles all in a cup, what are my chances of pulling out two red skittles out without looking?<br/><b>(3/15)*(2/14)=(1/35)</b></li> </ol> |
| <b>Career/Future</b> | <p>Probability is used not only in math but in the sciences for experiment</p>   |

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| <b>Application</b> | prediction, population estimation, and business planning.   |
| <b>Sources</b>     | <a href="http://www.icoachmath.com/math_dictionary">http://www.icoachmath.com/math_dictionary</a><br>Skittles Math Handouts |



## Toothpick Puzzle

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| <b>NGSS</b>                 | <b>NONE</b>  |
| <b>Student Objective</b>    | To introduce the students to spatial reasoning.  |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>- The heart rate is the measure of how many times the heart beats in one minute (bpm)</li> <li>- Oxygen is not the only thing the heart pumps to the rest of the body</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>- Take heart rate and use a stethoscope to listen to heart beat, lungs, and bowel sounds.</li> </ul>  |
| <b>Vocabulary</b>           | <p><b>Polygon</b> – A closed figure for which all sides are line segments.</p> <p><b>Line</b> – the straight path connecting two points and extending beyond the points in both directions.</p> <p><b>Square</b> – A rectangle where all the sides are the same</p> <p><b>Quadrilateral</b> - A polygon with four sides.</p> <p><b>Triangle</b> - A polygon with three sides.</p>  |
| <b>Materials</b>            | <ul style="list-style-type: none"> <li>-A copy of the toothpick puzzles</li> <li>-24 toothpicks</li> <li>-A coin</li> </ul>  |
| <b>Procedure</b>            | <p><b>III. Main Concept to be learned</b></p> <p>1. <b>Main Idea</b> – Thinking spatially</p> <p>i. Spatial thinking- finds meaning in the shape, size, orientation, location, direction or trajectory, of objects, processes or phenomena, or the relative positions in space of multiple objects, processes or phenomena. Spatial thinking uses the properties of space as a vehicle for structuring problems, for finding answers, and for expressing solutions (National Research Council, 2006). In this exercise the student will use puzzles to initiate this type of thought and to think geometrically.</p> |

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| <b>Guiding Questions</b>         | <p>1) Did you brainstorm with other students to figure out these puzzles?</p> <p>2) How do you think working in a group helps to solve problems?</p>   |
| <b>Background</b>                |  |
| <b>Career/Future Application</b> | <p>Every career uses spatial reasoning in some way and you use it in your daily life. Say you move into a new house or apartment, you use spatial reasoning to make sure everything fits. If you are an engineer you use spatial reasoning to plan out a project. A hairdresser uses spatial reasoning to make sure someone's hair cut looks good.</p> |
| <b>Sources</b>                   | <p><a href="http://serc.carleton.edu/research_on_learning/synthesis/spatial.html">http://serc.carleton.edu/research_on_learning/synthesis/spatial.html</a></p> <p><a href="http://www.education.com/activity/article/Toothpick_Math/">http://www.education.com/activity/article/Toothpick_Math/</a></p>  |





## Cloud Formation

|                             |  |
|-----------------------------|--|
| <b>NGSS</b>                 | 4-ESS2; MS-ESS2  |
| <b>Student Objective</b>    | After today's lesson students will understand how clouds are formed.   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b><br/>-How clouds are formed</p> <p><b>The student will be able to:</b><br/>-Compare and contrast how cold and warm temperatures affect clouds.</p>   |
| <b>Vocabulary</b>           | <p><b>High Pressure System:</b> A mass of air with a high amount of pressure.</p> <p><b>Low Pressure System:</b> A mass of air with a low amount of pressure.</p> <p><b>Water Vapor:</b> Water's gas form.</p> <p><b>Warm Front:</b> A mass of warm air.</p> <p><b>Cold Front:</b> A mass of cold air.</p>   |
| <b>Materials</b>            | <p><b>For each group (2-3 students):</b></p> <ul style="list-style-type: none"> <li>-Empty large bottle</li> <li>-Air pump</li> <li>-Rubber stopper with hole</li> <li>-Rubbing alcohol</li> </ul>   |
| <b>Procedure</b>            | <ol style="list-style-type: none"> <li>1. Put a small amount of rubbing alcohol in the bottle and coat the entire inside of the bottle by moving it around.</li> <li>2. Put the rubber stopper in the top of the bottle, putting it on tightly.</li> <li>3. Put the tip of the air pump in the hole in the rubber stopper, again make sure it is secured tightly.</li> <li>4. Start pushing air into the bottle, and keep pushing air for 30 to 45 seconds, this may become difficult and the students may need help.</li> <li>5. Pull the rubber stopper with the air pump out of the top of the bottle. A cloud should form in the bottle, if not repeat steps 3 through 5.</li> </ol> |
| <b>Guiding Questions</b>    | <p>1) What different types of clouds do you know of?</p> <p>2) What kind of clouds have you seen?</p> <p>3) Do you think we are going through a cold front or warm front right now?</p>  |

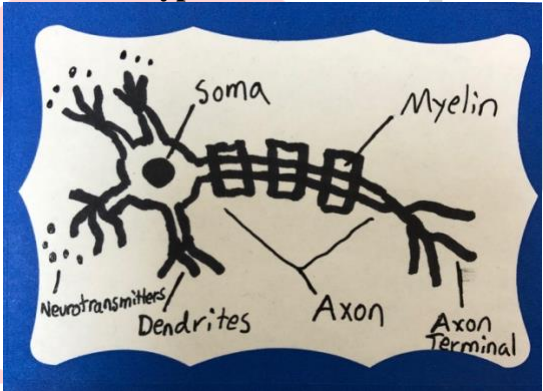


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|                                  | 4) Do you know why we get fog?   |
| <b>Background</b>                | <p>Clouds are made up of tiny droplets of water or ice crystals. These droplets of water or ice crystals form from water vapor, the gas form that water takes on. Clouds form when water vapor is pushed upward from a high-pressure system where there are a lot of air molecules tightly packed together with the water vapor to a low-pressure system where there is more room for the water vapor and air to move around.</p> <p>With low- and high-pressure systems comes warm fronts and cold fronts. Fronts are large masses of air that are warm or cold (i.e. warm front and cold front). As the air warms it rises and as it rises it will cool causes water vapor to cool down to form either ice or water. A great way to think about this is boiling a pot of water and how it forms steam. When the steam touches a cold surface, it will form water droplets.</p> |
| <b>Career/Future Application</b> | Meteorologist, Environmentalist  |
| <b>Sources</b>                   | <a href="https://scied.ucar.edu/shortcontent/how-clouds-form">https://scied.ucar.edu/shortcontent/how-clouds-form</a><br><a href="https://www.youtube.com/watch?v=msSVQ903T8k">https://www.youtube.com/watch?v=msSVQ903T8k</a>   |

## Nervous About Neurons?!

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|-----------------------------|---|
| <b>NGSS</b>                 | MS-LS1-1; MS-LS1-2; MS-LS1-3  |
| <b>Student Objective</b>    | Students will be able to define what a neuron is and the basic components of a neuron in addition to using their scientific skills of observation   |
| <b>NE STEM 4U Objective</b> | <p><b>The student will know:</b></p> <ul style="list-style-type: none"> <li>-Basic components of a neuron</li> <li>-How a neuron works</li> </ul> <p><b>The student will be able to:</b></p> <ul style="list-style-type: none"> <li>-Build and explain the key components of their own beaded neuron</li> <li>-Strengthen their observation skills</li> </ul>   |
| <b>Vocabulary</b>           | <p><b>Neuron:</b> Nerve cell and primary functional unit of the nervous system. Comes in all shapes and sizes.</p> <p><b>Dendrites:</b> Area where neurons receive most of their information and look a bit like tree branches. There are receptors on dendrites designed to pick up signals from other neurons that come in the form of neurotransmitters.</p> <p><b>Cell body (soma):</b> Electrical changes in neuron interpreted in this area. Contains the DNA or genetic material of the cell and takes all the information from the dendrites and puts it into the axon hillock.</p> <p><b>Axon:</b> If the signal from the dendrites is strong enough, then the signal travels to the axon. Signal called action potential at this point.</p> <p><b>Axon Terminal:</b> The last step in the action potential. When the signal reaches this point, it can cause the release of neurotransmitters, which will interact with dendrites of another nerve cell to continue the signal.</p> |
| <b>Materials</b>            | <p><b>Large Group:</b></p> <ul style="list-style-type: none"> <li>-Rope</li> <li>-Plastic containers</li> <li>-Pool noodle</li> <li>-Plastic Balls</li> <li>-Plastic Cups</li> </ul> <p><b>Per Group (work in pairs):</b></p> <ul style="list-style-type: none"> <li>-Flexible wire</li> <li>-Three assorted colors of beads</li> </ul>   |
| <b>Procedure</b>            |   |

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|                          | <p><b>Group Activity</b></p> <ol style="list-style-type: none"> <li>1. Two large groups will build a large neuron.</li> <li>2. Each group must assign roles of axon, axon terminal, dendrites, cell body, and neurotransmitters</li> <li>3. The students will work together to build and then act out the job of a neuron</li> <li>4. Both groups will work together to demonstrate how a signal transfers from one neuron to the next.</li> </ol> <p><i>Note: The plastic container can act as the soma of the neuron, with rope portions coming off to be the dendrites. Holes in plastic cups are made and attached to the rope, which acts as a “receptor” point. Then the pool noodle threaded through rope is the axon (enclosed in a myelin sheath) that is then connected to more pieces of rope tied to the pool noodle, functioning as axon terminals. The plastic balls are used as neurotransmitter chemicals.</i></p> <p><b>Partner Activity</b></p> <ol style="list-style-type: none"> <li>1. Provide a sheet of paper for partner teams to plan out their design for a neuron. Partner teams can design a neuron like the cards or be creative for a neuron that they claim would be for a new species... The neuron <b>must have the essential parts</b> (dendrites, soma, axon, and axon terminal).</li> <li>2. Partners will build their own neuron using supplies available at the front table.</li> <li>3. Partner teams will then be provided an opportunity to showcase their designs. All designs placed on a table and each partner team will describe the parts of their neuron.</li> </ol> <p><b>Review of what was learned for the day and their thoughts on the activity</b></p> |
| <b>Guiding Questions</b> | <p>Why is the myelin sheath important for a neuron signal?</p> <p>What would happen if neurotransmitters were not released?</p> <p>When people are paralyzed, describe how that relates to their neurons for lack of movement or inability to feel.</p> <p>Do people with quick reflexes have neurons that fire quicker? Why?</p>  |
| <b>Background</b>        | <p>The brain of a mammal is said to contain approximately 100 billion neurons. Neurons are the fundamental functional unit in the nervous system, specifically playing a role in action potential of a signal and transferring information. This information transfer can be to other nerve cells, muscle cells, or even gland cells. Key components of a neuron include the dendrites, the soma or cell body, the axon, and the synaptic terminal.</p> <p>Dendrites extend from the neuron cell body and look often like “tree branches.” They have contact points that allow for communication with another neuron, receiving a signal from a chemical called a neurotransmitter.</p>  |

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|                                  | <p>The sending and receiving of messages by neurons is accomplished through electrical impulses along the axon of the neuron. This axon is covered with a myelin sheath that acts as insulator material to prevent the signal from degradation. It also functions in speeding up the signal.</p> <p>After traveling down the axon, the signal reaches the axon terminal that with a strong enough signal will release neurotransmitters to alert the next nerve cell of the communication signal via the synaptic cleft (interaction point between two nerve cells).</p> <p><b>Example:</b><br/>         You touch a hot cookie sheet that was just pulled out of the oven. In this moment you feel immense pain because the skin and muscle cells that were injured communicated with nerve cells that created a signal cascade, reaching the nerve cells in your brain that indicated the painful event of burning your hand on the cookie sheet.</p> <p><b>Photo of a typical Neuron</b></p>  |
| <b>Career/Future Application</b> | Neurology, neuroscience, everything we do is based off of neurons  |
| <b>Sources</b>                   | <a href="https://www.brainfacts.org/brain-anatomy-and-function/anatomy/2012/the-neuron">https://www.brainfacts.org/brain-anatomy-and-function/anatomy/2012/the-neuron</a><br><a href="https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/overview-of-neuron-structure-and-function">https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/overview-of-neuron-structure-and-function</a><br>Institute of Neuroscience—University of Oregon   |