2022

Hands-On with NE STEM 4U: For budding STEMers in grades 4-8

NE STEM 4U Program

HANDS-ON WITH NE STEM 4U

For budding STEMers in grades 4-8

The NE STEM 4U program is a result of the creativity and hard work of many. This book is a culmination of effort from many participants, mentors, and partners. Therefore, we would like to thank the many contributions of the NE STEM 4U undergraduate and graduate mentors, and faculty advisors for lesson development within the program. Especially, we would like to acknowledge the following individuals for their contributions to this book: *Christine Cutucache, Neal Grandgenett, William Tapprich, Nikolaus Stevenson, Hayley Jurek, Amanda Shultz, Maggie Kehler, Nithya Rajagopalan, Javier Rodriguez-Flores, Harim Won, Bejan Mahmud, Jacob Robinson, Breanna Strunc, Madelyn Won, Danilo Sanchez Aquino, Carolanne Albers, Alec Lerner, Heather Leas and Dena Lund.* Further, the NE STEM 4U program acknowledges the many mentors, youth participants, and evaluators who have helped prepare these activities.

The Worlds of Connections Project, an NE STEM 4U extension program, would like to thank the following individuals for their involvement in the development of the Network Science-specific activities: *Kim Gocchi Carrasco, Meghan Leadabrand, Grecia Macias, Shayla McNear, Julia McQuillan, Luke Novack, Wendy Smith, Amy Spiegel, and Patricia Wonch Hill, Chika Akwani, Amjad Awlad-Thani, Lisa Clapper, Sarah Gergen, Nestor Hernandez, Mary Herrington, Molly Hoffmann, Aditi Jain, Amy Klar, Alvaro Moreno Lozano, Nancy Nguyen, Lindsey Sample, and Grace Stallworth.*

The information throughout this book is a result of the collective efforts of the authors through the NE STEM 4U program over the last eight years. These activities have been developed and tested in the out-of-school time / afterschool space for K-8 learners, primarily in grades 5 through 8.

While this resource is meant to serve as a workbook for youth, groups ranging from afterschool programs, formal school day, homeschoolers, community learning centers, and libraries may find utilization in the packaged lesson plans. Our goal is to help youth become scientists by learning what scientists do by simply immersing themselves in the processes and wonder. We hope that you enjoy these engaging, hands-on, inquiry-based learning activities.

FIRST EDITION

Designed by the NE STEM 4U Program

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Need Help? Contact Us!

Send an email to

nestem4u@unomaha.edu

Our book uses QR codes!

QR codes let you quickly scan a code with your phone, and transport you to a link.

Here is how it works:

Step 1: Open Camera App

on your Smartphone (Andriod users may need to download seperate app)

Step 2: Hover over QR code

(you may need to tap to focus it) and follow the on screen instructions.

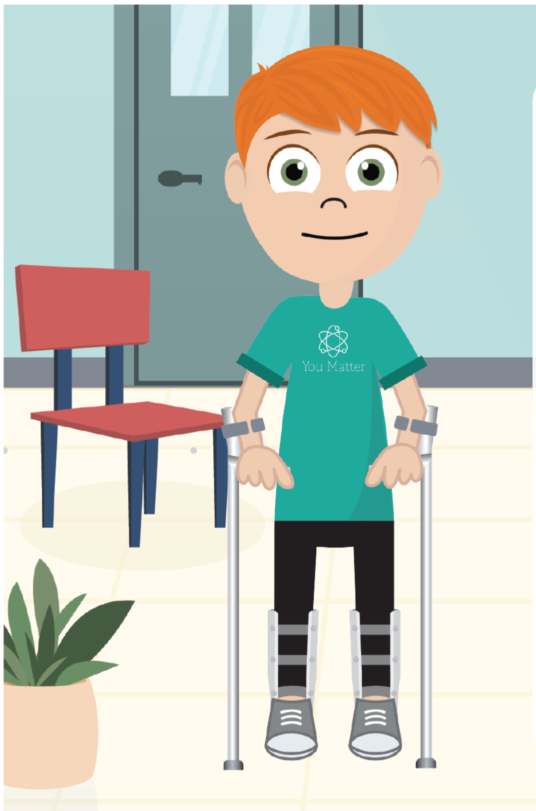
Test it out!

Hi, I'm Ari! My friends tell me I'm kind and I love spending time with them. But I'm struggling in class. Sometimes I have trouble focusing. I can't sit still and often I find myself thinking about drawing or painting. I really like computers, but I have a hard time just sitting at the computer and doing anything meaningful. Recently, I found some programs like Bricklayer®, Minecraft®, Adobe Creative Suite® that help me use computers to create designs. I have to admit that I get in trouble at school sometimes for not listening to what the teacher has to say. Then, sometimes when I go to the principal's office, I can't remember why I got kicked out of the classroom to begin with!

I'm Dominick and I am a math nerd—especially when I can show off my fast, mental gymnastics with math while at the store with my family. At the store, I help my little sister calculate tax on the toy she wants to buy, and I like to make sure anyone standing in front of AND behind us hears that I know my stuff! I spend a lot of time daydreaming and looking at patterns. Fractals are one of my favorite mathematical phenomena!

I'm Tiana! I've always considered myself a builder. Since I was 2, I was always putting blocks together to build elaborate cities. Now, I spend lots of time building with LEGO®, foam blocks, and within Minecraft®. I love anything with building! One day, I want to be an architect—or maybe an engineer. My favorite thing to do is build towers as tall as possible and share on social media!

Hi I'm Miguel! I flat out don't know what I want to do when I grow up. I'm just content being a kid right now. I do think science and math are cool, but I also like reading, writing, PE, and most of my other classes. I just started trying out for sports now that I'm in middle school and so far, my favorites are soccer and football.



My name is Jack and I've always been good at understanding how things work. As a kid I've been noticing differences in friction between ice, snow, and rain by riding my bike across each of those surfaces, until I crashed and got hurt. Now I just learn about friction in different ways, like using my prosthetics to help me snowboard and skate. I'm a strong learner and I'm always reading. I LOVE books!

My name is Emily and I don't like school. Don't get me wrong, I like hanging out with my friends, but I don't like learning at school. I would rather go on field trips to learn. I really like making crafts and exploring. I like meeting new people and getting to know about them, too.

I'm Miya and I'm into soccer and tennis. Sports are my favorite activities, but I also like chemistry. You know, the kind of stuff where you mix vinegar and baking soda together and create a volcano of bubbles? Yep, that's me! I want to be where the action is—learning how the world works around me…but taking time to smell the roses is pretty important too.

I'm Hunter and I love the outdoors and seeing different rock formations as I travel with my family across the country. I especially like the red rocks of Utah and Colorado. While I love geology, I'm honestly very afraid of mathematics. I'm struggling with it—a lot. I'm afraid I can't keep thinking about exploring geology because of all the math.

Notes:

CHEMISTRY

The Crystal Tree

NGSS

2-PS1-4; MS-PS1-2; MS-PS1-6

Objective

The student will understand the role of capillary action on water uptake in plants and trees in addition to how concepts like evaporation and saturation can affect solutions.

The student will be able to develop a crystallized cardboard structure, (a tree, in this case). Students will also be able to provide an explanation for why salt remains on the skin after sweating (recrystallization), similar to the crystallization process they will observe with the cardboard structure.

Vocabulary

Capillary Action: The tendency of a liquid to rise into narrow tubes or spaces.

Saturation: The point at which a solution of a substance can dissolve no more of that substance and additional amounts of the substance will appear as a separate phase.

Evaporation: The changing of a liquid to its gaseous state.

Re-crystallization: An important technique to purify solids.

Background

The solution mixed in the bowl at the beginning of this experiment is supersaturated with bluing and salt. When the cardboard tree is placed into the supersaturated solution, 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 the "crystals" you see on your tree or other cardboard cut-out.

Materials

For trees:

(Per student)

- Sturdy cardstock/thin cardboard or cereal box (enough to trace two trees approximately 6x4cm)
- Tree pattern (copy Figure 1)
- Scissors
- Food coloring
- Plastic bowl

For the Crystallization:

(Per student)

- Polystyrene bowl
- Plastic spoon
- Tablespoon (to measure)
- 1 tbsp. salt
- 1 tbsp. laundry bluing
- 1/2 tbsp. Ammonia

Procedure

1. Introduce the concepts of capillary action, solutions, saturation and super-saturation, and re-crystallization. Bring along a completed tree to pique students' interest.
2. Have each student trace two trees onto the cardboard then cut along the black lines shown in Figure 1, forming a slot at the top half of one tree and the bottom half of the other. ***Students can make any design they want with the cardboard, it does not have to be a tree for the exercise!***

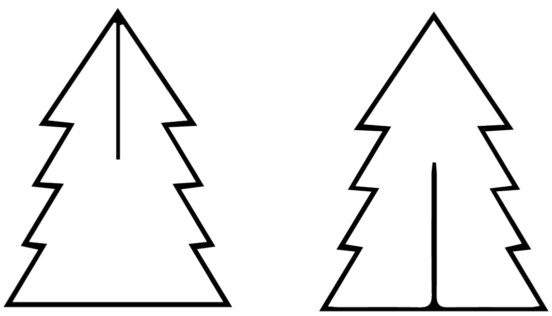


Figure 1. Tree pattern.

3. Slide the two slots together; creating a three-dimensional structure that can stand on its own.
4. Add drops of food coloring to the edges of the cardboard - these will color the crystals later.
5. Distribute a bowl to each student, and have them mix the following with a spoon:
    a. 1 tbsp. water
    b. 1 tbsp. bluing
    c. 1 tbsp. salt
    d. ½ tbsp. ammonia
6. 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 pre-constructed example tree and review the concepts of saturation, super saturation, and evaporation. This is also a great place to explain capillary action to students, expressing that the rise in 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 the process of trees moving water from their roots through an inner tube, called the xylem, to their outer leaves.

Tips for Home:

- Advise students to keep their projects in a warm place to keep the crystals growing at a fast rate. This should take half a day to complete, so remind students that they will have to wait for the finished product.
- Increased air circulation will allow for increased evaporation and faster crystal growth.

Guiding Questions

- Why do you think it would be important for scientists to recrystallize certain solids?
- How could saturation play a role in making kool-aid?
- What ways is capillary action observed in our every day lives (e.g. paper towel and water touching one end of it)?

Career/Future Application

Crystallization is a major topic in chemistry. Students who really enjoy the process of creating and precipitating a solution may consider a related career using chemistry. Chemists are an an important part of diverse fields, such as food processing and development, pharmaceutical development, materials manufacturing, energy science, and environmental ecology.

Sources

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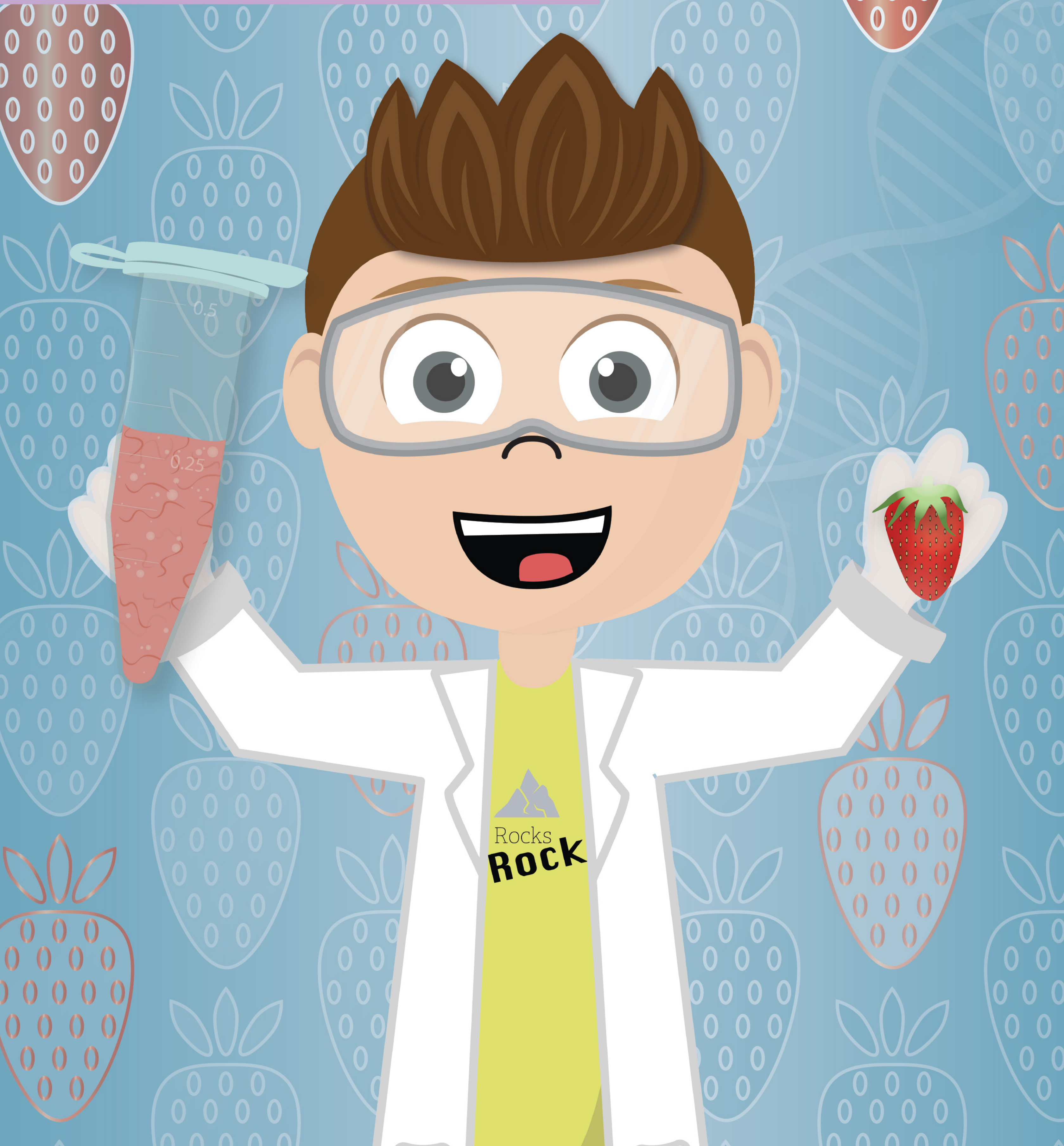
BIOLOGY

Fruitful DNA



Fruitful DNA

NGSS

MS-LS3-1; MS-LS4-5

Objective

The student will understand and reason that every cell in each plant and animal has DNA, just like all human cells (except red blood cells) contain DNA.

The student will be able to explain what DNA is and what it looks like, after successfully isolating it from a banana or strawberry.

Vocabulary

DNA/Deoxyribonucleotide: The genetic instructions for an organism

Genome: An organism's genetic material encoded by DNA

Chromosome: Structure composed of DNA, RNA, and protein that carries genetic material in the form of genes

Background

DNA is the genetic material that provides the blueprint, or genetic instructions, for how an organism will develop and function. Each cell has the exact same copy of DNA housed in the nucleus. This DNA is turned into protein, which then performs a specific function.

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 strawberry and banana 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 they have 8 chromosomes in each cell.

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.

To release the DNA strands, we then use salt to break up the protein chains that bind around the nucleic acids.

Because DNA is not soluble in isopropyl alcohol, it will precipitate, and then the DNA can be scooped up.

Materials

Supplies (per student group of 2-3 students multiply by number of groups as needed)

- Strawberries (1 per student)
- Bananas (1/2 or 1/3 per student)
- Isopropyl alcohol (100% and 70%; keep chilled)
- Distilled water (sink water can also work, but may have contaminants)
- Dish soap
- Salt
- Quart sized resealable plastic bags (1 per student)
- Plastic cups (2 per student)
- Spoons or stir sticks (non-metal) (1 per student)
- Plastic Pasteur pipettes or turkey basters (1 per student)
- Coffee filters (1 per student)
- Measuring spoon set
- Rubber bands (1 per student)
- Microcentrifuge tubes and string
- Colored gumdrops/mini-marshmallows (or other type of candy or material that has 4 different colors; 2 boxes per group)
- Box of toothpicks
- Twizzlers
- 1 paper plate per student
- Pens or Pencils

Procedure

1. Introduce topic, go over concepts and background
2. Start the experiment
    a. Split students into groups. Groups get to choose whether they'll extract DNA from a banana or from a strawberry.
        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, but ultimately together in their small group
    c. Pass out to each student:
        i. ¼ 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

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:

Instructor: Give 1 strawberry per student along with one bag.

Students (individually):

1. Place strawberry (without the leaves) in the bag.
2. Add ¼ cup of distilled H_2O to the bag.
3. Mash up the strawberries so there are no large chunks left.
4. Place the mashed up strawberry mixture aside.
5. In one of the plastic cups:
    a. Fill cup roughly 1 centimeter high with soap
    b. Dump salt for a count of 3 seconds
    c. Add ¼ cup of distilled H_2O
6. Pour all of the mashed banana solution from the bag into the cup.

7. Stir for about 5 minutes. Stir slowly to avoid producing too many bubbles.
8. Strain the contents of this cup through the coffee filter into another clean cup.
    a. Make sure coffee filter is resting on the top of the cup. 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 the rubber band to secure the filter.
9. Once all the mixture has been filtered into a new cup, slowly pour cold isopropyl alcohol down the side and into the cup (add about ½ inch of isopropyl alcohol into the cup). This should precipitate the DNA and make it float to the top.
10. Gather the precipitated DNA at the surface of the fluid using the plastic pipette. You can put the DNA in the micro-centrifuge tubes to hold on to!

Banana Group:

This is the same procedure as strawberry group)

Instructor: Give 1 banana per student along with one bag.

Students (individually):

1. Place banana (without the peel) in the bag.
2. Add ¼ cup of distilled H_2O to the bag.
3. Mash up the banana so there are no large chunks left.
4. Place the mashed up banana mixture aside.
5. In one of the plastic cups:
    a. Fill cup 1 centimeter high with soap
    b. Dump salt for a count of 3 seconds
    c. Add ¼ cup of distilled H_2O
6. Pour all of the mashed banana solution from the bag into the cup.
7. Stir for about 5 minutes. Stir slowly to avoid producing too many bubbles.
8. Strain the contents of this cup through the coffee filter into another clean cup.
    a. Make sure coffee filter is resting on the top of the cup. 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 the rubber band to secure the filter.
9. Once all the banana mix has been filtered into a new cup, slowly pour cold isopropyl alcohol down the side and into the cup (add about ½ inch of isopropyl alcohol into the cup). This should precipitate the DNA and make it float to the top.
10. Gather the precipitated DNA at the surface of the fluid using the plastic pipette. You can put the DNA in the micro-centrifuge tubes to show it off.

11. Compare results of the student groups
    a. How does the DNA extraction compare between groups? Were all successful? What does it look like?
        i. The students should be able to observe what the DNA extractions look like via a white mucousy substance!

Build a Candy DNA Model of the Product:

1. Each student group will build a candy DNA model and will need the following:
    a. 2 Twizzlers (the backbone)
    b. ~10-12 toothpicks
    c. Colored 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)
    d. DNA Handout
2. Each student will decide which color of candy represents each base. They must indicate their choices when they share out their designs. When they build their model, the bases must pair properly (A-T & C-G).
3. Have the students assist with cleanup.

Guiding Questions

- Does every cell within an organism contain the exact same DNA sequences?
- What is the name of an organism's complete set of genes or genetic material encoded by DNA?
- Do you think if you isolated DNA from another organism that it would look the same? Why or why not?

Career/Future Application

DNA 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. Forensic scientists use DNA analysis to determine whether samples from crime scenes match suspects' DNA. Doctors use DNA to help diagnose genetic illnesses. Genetic engineers study the mechanisms of DNA replication. There are even scientists who conduct genetic research on our food!

Sources

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BIOLOGY

Honey Purity Test

Honey Purity Test

NGSS

MS-LS1-7; MS-PS1-2; MS-PS1-3

Objective

The student will understand the chemical makeup of honey by performing a test on distinct honey brands.

The student will be able to identify the differences between natural and synthetic honey via visual observations from the test.

Vocabulary

Synthetic: Made by chemical synthesis, imitates a natural product.

Adulterate: To lower the quality of something by adding another substance.

Enzyme: Catalyst that accelerates chemical reactions.

Antioxidant: Compound produced in the body, found in foods, defends one's cells from damage caused by harmful molecules.

Soluble: Can be dissolved, specifically in water

Background

Honey is a product loved by millions of people. Not only is natural honey delicious, but many studies have also linked its antioxidants with many health benefits. However, it can be challenging to find natural honey rather than a synthetic honey 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 are 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 with water to determine which home variety honey brands are synthetic, and which are natural.

Materials

- 2 brands of pure honey
- 2 brands of artificial honey (synthetic)
- Bring snacks to eat with honey for fun (i.e. pretzels, bread)

Per Group (2-3 Students):

- 4 Bowls
- 4 Spoons

Procedure

Water Test

1. Fill a bowl with water.
2. Add a spoonful of honey into the bowl (keep bottles unmarked so that the students can guess which bottles are the artificial/synthetic honey).
3. Stir for 5 seconds.
4. Observe results.
5. Repeat for each brand of honey (4 total).
6. Artificial/synthetic honey will begin to dissolve quickly and break apart in the water because it has been adulterated with additives, particularly sugar, which are soluble in water.
7. Natural honey will not dissolve or will dissolve very slowly in water, because natural honey contains hardly any water. This is because water promotes the growth of fungi, which is undesirable to bees. Thus, natural honey must be stirred for a longer period to be incorporated into the liquid.

Guiding Questions

What do you think will happen when honey is mixed with water? Natural versus synthetic?

Why doesn't natural honey dissolve quickly in water? Why does synthetic honey dissolve more quickly in water than natural honey?

Career/Future Application

Nutritional Therapist, Food Process Engineer, Agricultural Food Scientist, Horticulture Research, Apiarist

Sources

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https://www.mybeeline.co/en/p/how-can-we-differentiate-100-pure-honey-and-adulterated-honey

BIOLOGY

Human DNA Extraction

Human DNA Extraction

NGSS

MS-LS1-1

Objective

The student will understand that cells contain DNA and that this DNA contains base pairs.

The student will be able to isolate DNA from their own cheek cells.

Vocabulary

DNA/Deoxyribonucleic acid: The genetic instructions for an organism.

Genome: The whole collection of an organism's genetic material, composed of DNA.

Double Helix: The twisting shape of DNA composed of nucleotides in two long chains that twist around each other.

Genes: Carry the information that determines the features or characteristics that are inherited by offspring from parents.

Background

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. A genetic code 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, and special sugars and other atoms make up the handrail.

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. However, they are very choosy about their friends:

A and T are best friends and always hang out together.

G and C are best friends and always hang out together.

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.

Think of all the words you can spell. I bet there are loads of them, 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.

Materials

Pens or Pencils

Human DNA Extraction Demonstration

- Clear cups (2 per student)
- Large cup (Used to pre-mix salt and water)
- Coffee stirrers (1 per student)
- Isopropyl alcohol (keep chilled)
- Distilled water
- Dish soap
- Salt
- Food coloring
- Spoons (1 per student)
- Plastic pipettes (1 per student)
- Micro centrifuge tubes and string (1 per student)

Origami DNA Model Demonstration

- DNA Origami Template (1 per student)
- DNA Origami Instructions (1 per group)

Procedure

1. **Introduce topic**
2. **Safety Precautions**

a. Do not let students handle alcohol.

3. **Human DNA Extraction Demonstration**
    a. Each student should begin with two clear cups.
    b. Fill one large cup with water and add salt until the solution is saturated (until no more salt dissolves).
    c. Transfer approximately 3 tablespoons of salt solution into each student's first clear cup.
    d. Gargle the second cup of salt water for 1 minute.
    e. Spit the water back into the first cup. This salt solution will contain suspended cheek cells.
    f. Dip a coffee stirrer into the dish soap, add a medium-sized drop of soap to the second cup, and gently stir while avoiding bubbles as much as possible.
    g. Fill each student's second clear cup ¼ full of isopropyl alcohol and add 3 drops of food coloring.
    h. Tilt the first cup containing the student's DNA and slowly add the contents of the second cup to the first cup. A layer will form on top.
    i. In approximately 3 minutes, the students will start to see a white mucousy substance. This is the DNA that has been extracted.

4. **Origami DNA Model Demonstration**
    a. Fold paper in half lengthwise. Make all creases as firm as possible.
    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.
    c. Fold the top two segments down along the next horizontal line. Unfold.
    d. Repeat for all segments.
    e. Turn paper over.
    f. Fold along the first diagonal line. Unfold and fold along the second diagonal line. Repeat for all diagonal lines.
    g. Fold the white edge without letters up.
    h. Fold the other edge away from you. Partly unfold both edges.
    i. You can now see how the model is starting to twist.
    j. Twist and turn the paper while pushing the ends towards each other.
    k. Now let go.

5. **Clean up!**

Guiding Questions

- What types of living organisms contain DNA?
- Does every cell within an organism contain the exact same DNA sequences?
- Which pair of organisms share the same DNA?
    a. Banana and a strawberry
    b. Identical twins
    c. Mother and child
    d. Snake and cat
- What is the name of an organism's complete set of genes or genetic material encoded by DNA?
- What is a nucleotide? Give an example.

Career/Future Application

DNA 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. Forensic scientists use DNA analysis to determine whether samples from crime scenes match suspects' DNA. Doctors use DNA to help diagnose genetic illnesses. Genetic engineers study the mechanisms of DNA replication. There are even scientists who conduct genetic research on our food!

Sources

Scan QR Code for Website

PBS DNA Video - https://www.youtube.com/watch?v=DaaRrR-ZHP4

Scan QR Code for Website

Origami DNA - http://www.yourgenome.org/activities/origami-dna http://www.chem4kids.com/files/bio_dna.html

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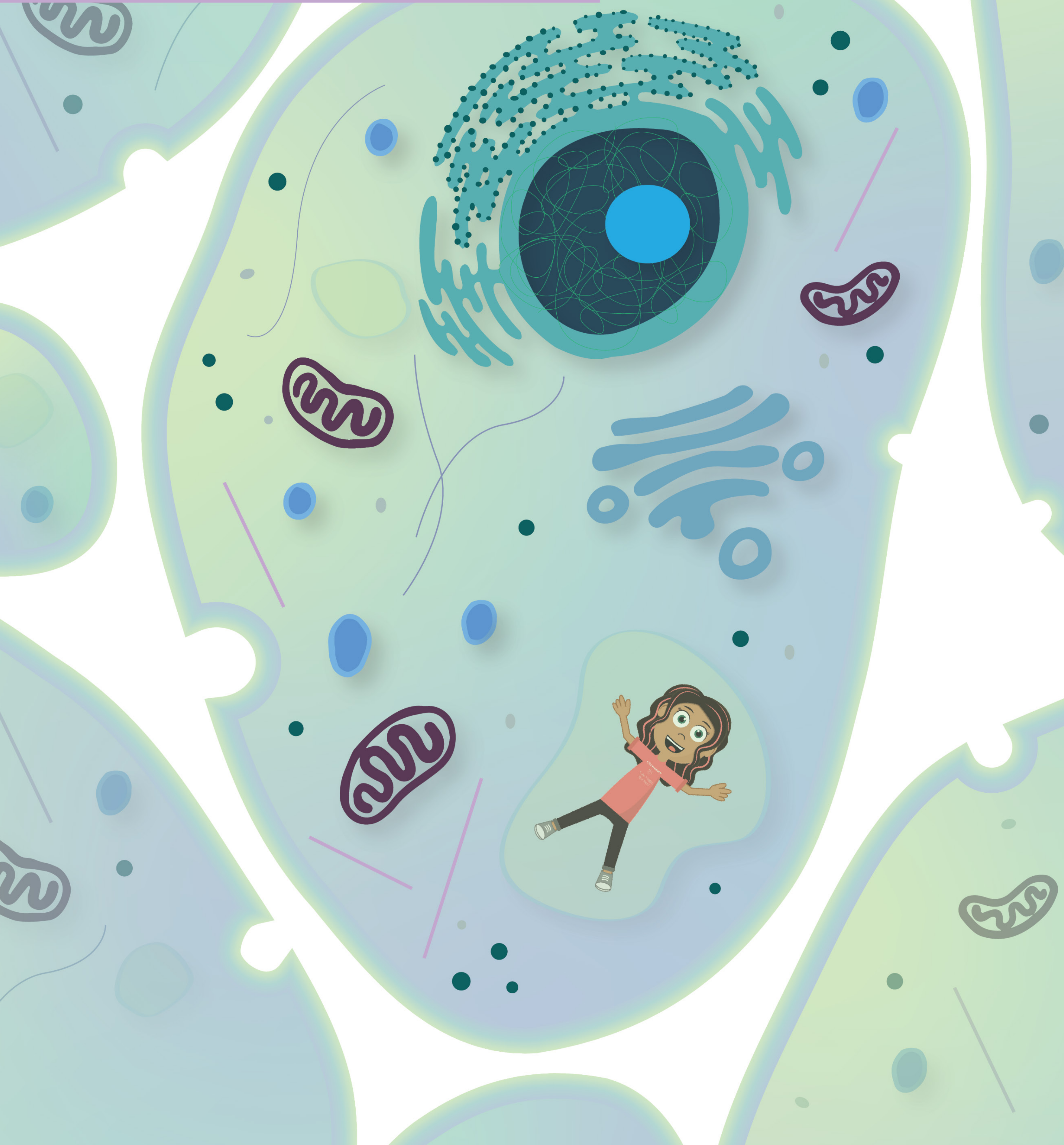
BIOLOGY

Model Cell



NGSS

MS-LS1-2

Objective

The student will understand the role that each component of a cell plays for the total function of the cell.

The student will be able to identify the basic components of a cell and create a model of an animal cell.

Vocabulary

Cell: Smallest structural and functional unit of an organism/life.

Nucleus (candy brains): The brain of the cell – contains DNA and RNA that is responsible for growth and reproduction

Plasma Membrane (Nerds Rope): Thin layer of proteins and fats that surround the cell. It is semipermeable (some substances can pass, others cannot), much like a gatekeeper!

Cytoplasm: Jellylike material outside of the cell nucleus in which other organelles are located

Endoplasmic Reticulum (Air Heads Xtremes): Helps transport materials around the cell

Lysosome (shark candy): The trash can of the cell, will "eat" particles in the cell.

Ribosome (sprinkles): Helpers inside a cell to make different products (DNA and proteins)

Golgi Apparatus (Gummy Worms): Near the nucleus, provides a membrane for lysosomes that can be exported from the cell

Vacuoles (Gushers): A space within the cytoplasm of a cell, enclosed by a membrane and typically containing fluid

Mitochondira (Mike and Ikes): POWERHOUSE, creates energy for the cell.

Tissue: A mass of like cells that form specific organs, which then form systems, which then form organisms.

Background

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 sequence, you can ask the students if they recall extracting DNA from a fruit or from their own saliva – DNA is located in the nucleus, etc....

Materials

- Toothpicks, pens, and masking tape for labeling
- 15 paper plates to put the cell model on
- 15 spoons to spread out the frosting/cytoplasm
- Jar of frosting (cytoplasm)
- 15 Gummy Brains (nucleus)
- 15 Nerds Ropes (Plasma membrane)
- 15 Air Head Xtreme (ER)
- 15 shark candies (Lysosomes)
- Sprinkles (Ribosomes)
- 15 Gummy Worms (Golgi Apparatus)
- 5 packs of Gushers (vacuoles)
- Bag of Mike and Ikes (pick a color for the mitochondria)

Procedure

1. Introduce the concept, generally – It will probably be best to talk about each part of the cell as you go. You know your students – you can decide!
2. Pass out toothpicks and masking tape. Give each student 9 toothpicks, and demonstrate how to fold masking tape over one end of each toothpick to use as a label.
3. You can either have students write everything out at the beginning, or go organelle by organelle.
4. Explain what each part of the cell does as you go along and ask questions.

5. This lesson is pretty self-explanatory. After all discussion, students can eat their cell!

Guiding Questions

- Why would we choose a shark to be the lysosome?
- Why is the nucleus the brain?

Career/Future Application

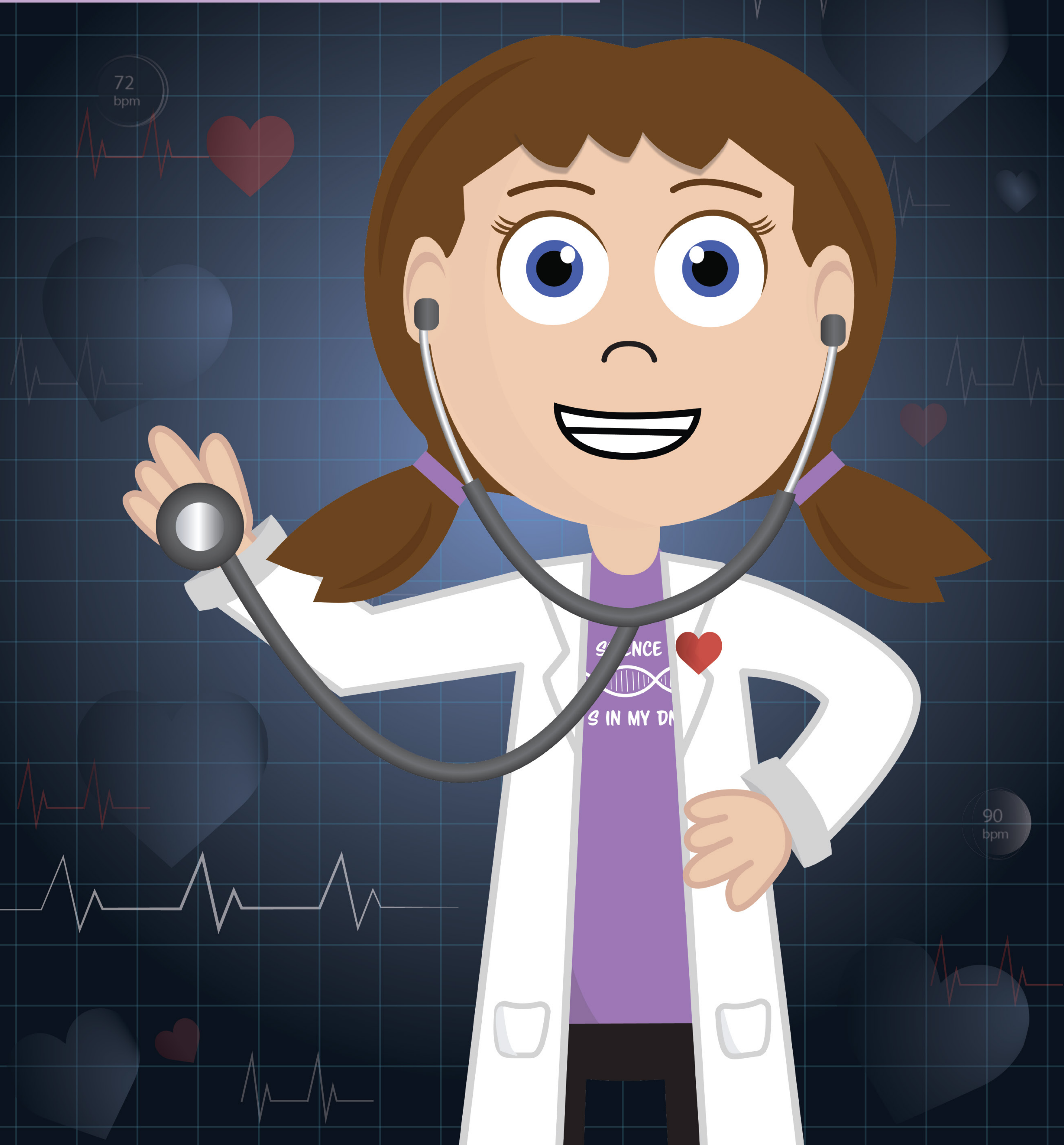
Biologists, Doctors, Researchers… the possibilities are endless! So many careers rely on the knowledge of cells to do research. The cell is at the very basis of so many processes, and therefore understanding of these processes are important to continued research application.

Sources

https://sciencetrends.com/the-parts-of-an-animal-cell/

BIOLOGY

Stethoscopes and Heart Rate



Stethoscopes and Heart Rate

NGSS

MS-LS1-1

Objective

The student will understand what heart rate is and how heart rate changes in response to physical activity or other stimuli (e.g. stress).

The student will be able to take a pulse and use a stethoscope to listen to the heart.

Vocabulary

Pulse: Rhythmic throbbing of arteries as blood is being pumped through them

Heart Rate: Number of heart beats per minute (bpm)

Red Blood Cell: Cell located in the blood that transports oxygen and carbon dioxide to and from tissues

White Blood Cell: Defenders of the body, which make up the immune system

Platelets: Colorless blood cells that help blood clot

Plasma: Liquid component of blood that holds the blood cells in whole blood suspension

Stethoscope: A medical instrument used to listen to a person's heart.

Background

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: the veins pick up oxygen in the lungs and deliver it to the heart and other areas of the body). The heart is about the size of your fist and weighs about the same as a lemon. (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.) The heart also pumps nutrients into the tissues by contracting and relaxing (same concept as before: it's a delivery system!).

The rate at which our heart pumps blood into the periphery is directly related to how much oxygen our body needs at that time. For example, when we are sleeping, we are not burning many 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 the body with oxygen, the heart rate will increase as needed (Average resting pulse is about 60-100 bpm). A 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. In this exercise, we will have students determine their resting heart rate by measuring their pulse (neck or wrist) for 30 seconds.

This 6-minute video does an excellent job of explaining the heart: http://www.aboutkidshealth.ca/en/justforkids/body/pages/heart.aspx

Materials

Candy Blood Vessel Demonstration

- Red Hots (or a red candy) (10 per student)
- Certs (or a white candy) (2 per student)
- Salt (1 pinch per student)
- Candy sprinkles (1 pinch per student)
- Light corn syrup
- Red food dye
- Ziploc sandwich bags (1 per student)
- Plastic spoons (for mixing) (1 per group)

Pulse Demonstration

- A phone or clock

Stethoscope Demonstration

- 1 large funnel (per group)

- 1 small funnel (per group)
- 1 hose, cut into 18-inch pieces (per group)
- Duct tape
- 1 stethoscope (per group)

Procedure

1. Hand out candy, bags, salt
    a. Red candy – red blood cells
    b. White candy – white blood cells
    c. Salt – ions in blood
    d. Sprinkles – platelets
    e. Corn syrup - plasma
2. Fill bags ½ way with corn syrup, then add candy, salt, and food dye. Mix well.
3. Close the bags tightly and then roll each bag into a cylinder.
4. Explain the functions of the various components in this blood vessel.

Pulse Demonstration

1. 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).
2. 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).
3. Have the students record their resting heart rates.
4. Have students do jumping jacks until they do ~50 reps.
    a. Immediately record heart rate at the 0 minutes mark.
    b. Record every minute thereafter for 3 minutes.
5. Have students hold their breath for 30 seconds and record heart rate while holding breath.

Stethoscope Demonstration

1. Have the students pair up, and have a volunteer group pass out a large and small funnel and one hose piece to each group.
2. Ask another student to hand out two 8-inch pieces of duct tape to each group.
3. Instruct the students to attach a funnel to either end of the hose piece with the duct

tape.

4. Allow the students to attempt to listen to both their own and their partner's heart with their custom stethoscope and with the regular stethoscope.
5. Have students listen to lung sounds by placing stethoscopes on their partner's back and instructing their partner to "deep breathe". Then have students listen while that person wheezes. (They will have to fake the wheezing).
6. Have students try to listen to bowel sounds by placing stethoscopes onto their abdomens. If they just ate, they may have good luck.
7. Clean up!

Guiding Questions

- Why does our heart beat?
- What is the purpose of blood in the body?
- Who uses stethoscopes? (Good opportunity to talk about health careers)

Career/Future Application

Any job in a healthcare setting (physician, nurse, PA, phlebotomist, medic, paramedic, etc.) must understand how and why blood circulates to the peripheral tissues and how stethoscopes work.

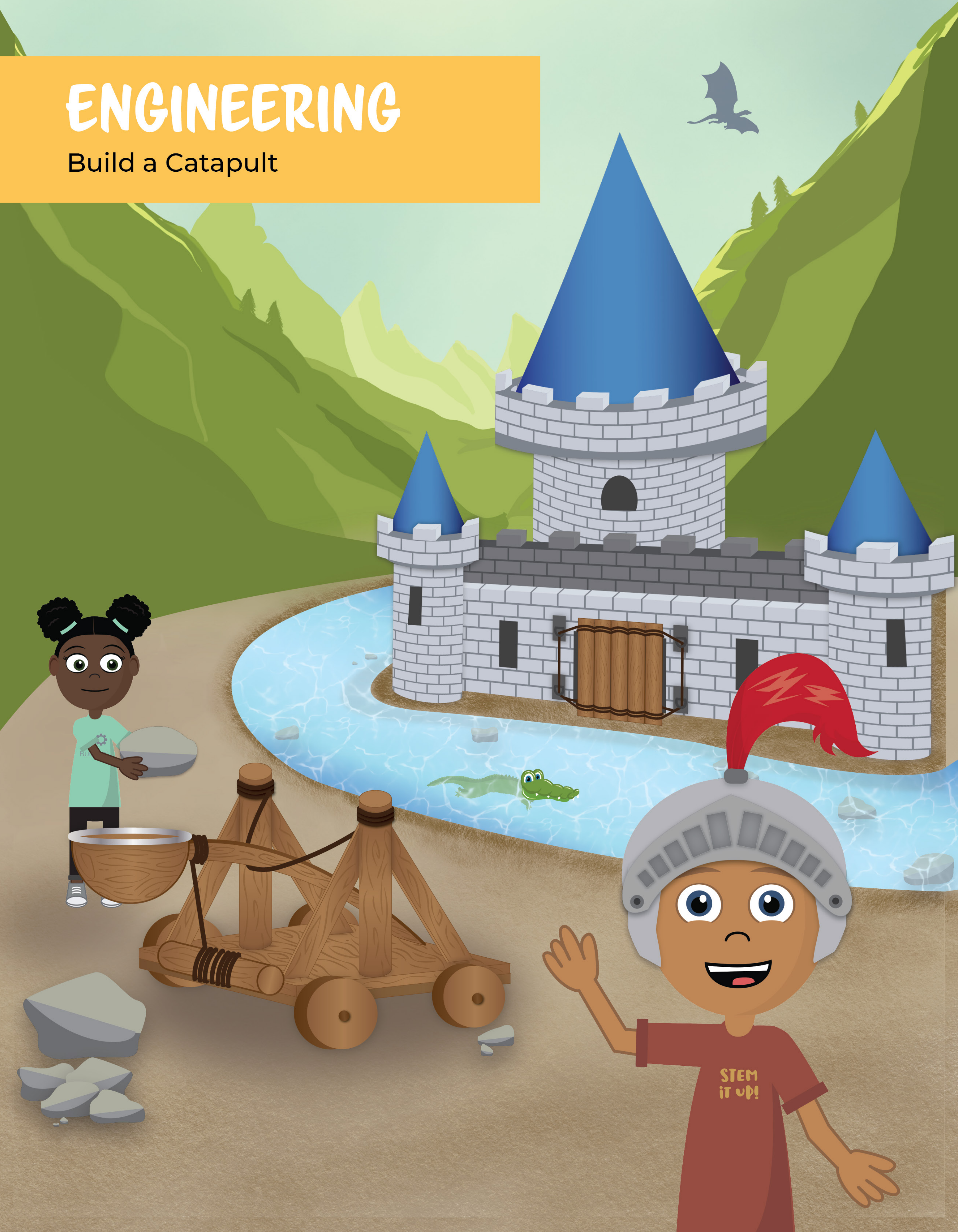
Sources

http://health.howstuffworks.com/diseases-conditions/cardiovascular/heart/exercise-important-for-heart-health1.htm

http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBio_p033.shtml?from=Pinterest#procedure

ENGINEERING

Build a Catapult



NGSS

4-PS3-3; 5-PS2-1

Objective

The student will understand the engineering process and the interdependence of simple machines within a compound machine.

The student will be able to create a compound machine (catapult) to launch marshmallows the farthest distance possible.

Vocabulary

Simple Machine: 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.

Compound Machine: Consists of two or more simple machines and allows for work to be done more easily.

Structural Engineering: The branch of civil engineering that is responsible for the design of structures.

Background

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 may not function as well. Engineers use their knowledge of simple machines to create many of the compound machines we use every day.

Engineering firms do work for people in a variety of ways. A structural engineering firm, for instance, may at one time help build a skyscraper wherein people can work, then build a bridge that connects people with one another, and yet another time 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 a large tent, or “big top”. During this activity, we are going to imagine that we are structural engineers.

To cover the most horizontal distance possible, a projectile should be launched from a 45° angle. Remember this fact, because you will need to apply it to the construction of your catapults in the upcoming activity.

If a projectile is launched from an angle greater than 45°, 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 45°, 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.)

Materials

Per Group (2-3 students):
The idea here is to provide a variety of useful supplies that allow students to brainstorm and design their own original catapults.
INSTRUCTORS: Construct at least 1-2 sample catapults in advance of the lesson.

For catapults:

- Newspapers
- Popsicle sticks (thick and thin)
- Plastic spoons
- Dixie cups
- Rubber bands (various sizes)
- Soup cans
- Cans of pop
- Bottle caps

- Scissors
- Tape (masking or duct)
- Measuring tape or meter sticks
- Paper & pencil

NOTE: *This is just a sample of potential items to include. Materials can be added or omitted from this list.*

For the Target game:

- Jumbo marshmallows
- Mini marshmallows
- 1-2 decks of cards
- Printouts of targets. (Cut out and taped to empty soda bottles)
- Empty soda bottles
- Material to stack bottles on top of (cereal boxes, shoe boxes, etc.)

Procedure

1. Introduce the topic using background information and thinking prompts/guiding questions.
2. Split students into groups of two (if necessary).
3. Lay out all of the available supplies for building the catapult. Show examples of catapult designs.
4. You can make all materials available to students or incorporate budgeting by adding a price tag to each supply.
5. Have students sketch a rough design for their catapult based on available supplies.
6. Once students have made their preliminary drawing, they can gather or "purchase" their supplies.
7. Allow students time to design, build, test, redesign, rebuild, retest their catapults.
8. Once students are happy with their catapult, move on to Angry Birds competition.
9. Set up one or two target stations (depending on available supplies)
10. Tape targets onto plastic bottles
    a. Build structures using cereal boxes (or any other available supplies) and incorporate the pig bottles.
        i. Students should help build these structures.
    b. Think Angry Birds. If you don't know what this is, Google it.

11. The deck of cards is used to determine how many marshmallows and which kinds of marshmallows each student can launch.
    a. The student will pull a card from a shuffled deck. (Remove Jacks, Queens, and Kings.)
        i. If the card is an Ace-5, students get the respective number of jumbo marshmallows (note: aces are low and represent 1)
        ii. If the card is a 6-10, students get to use the respective number of mini marshmallows.
        iii. If the card is a Joker, students get to draw two cards and receive the combined number of marshmallows.
    b. The student then gets to use all of their marshmallows as ammunition in their catapult to try to knock all of the pig bottles down to the floor.
        i. If a student does not knock all the pig bottles down to the floor...
            1. Pull two more cards.
            2. Take the difference between the two numbers.
            3. Use that number of mini marshmallows.
12. Students will take turns during the target activity. Shuffle the deck between each student. Replace cards immediately after pulling them out of the deck.
13. Clean up workspaces together.

Differentiation

1. Use budgeting component for building the catapults or place limits on supplies.
2. Change the rules for the target game to increase difficulty.
    a. Change the card/marshmallow rules.
    b. 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.

Guiding Questions

- What does a catapult look like? (Discuss where the students get their ideas. Perhaps from a film.)
- Does anyone have an idea of how to build a catapult? Have a student come up and draw a catapult design on the board based off the available supplies.
- 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 axle.)

Career/Future Application

Simple machines and compound machines are the foundation of many modern conveniences. Engineers use a combination of levers, wedges, screws, wheels and axles, 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 must design within certain constraints including time, money, and human resources.

Sources

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https://www.scientificamerican.com/article/build-a-mini-trebuchet/

https://www.teachengineering.org/activities/view/cub_simp_machines_lesson04_activity1

http://www.vivifystem.com/blog/2014/12/23/catapult-challenge

https://www.youtube.com/watch?v=kRz_PRoCCgg

ENGINEERING

Building Bridges

Building Bridges

NGSS

3-5-ETS1-2; 3-5-ETS1-3

Objective

The student will understand the engineering process and various types of bridges.

The student will be able to construct a bridge and apply their knowledge of bridge components to build a bridge that can hold the most weight.

Vocabulary

Engineering: Applying scientific and mathematical knowledge to create solutions for various technical problems. There are different disciplines that include chemical, civil, electrical, and mechanical engineers.

Truss: A framework, typically consisting of rafters, posts, and struts to support a roof, bridge, or other structure.

Crossbeam: A horizontal or transverse beam, especially a structural beam resting on two supports.

Background

Bridges are important and should not break. Humans rely on bridges to support travel and trade. Bridges are largely used for transporting goods and people over various obstacles. Bridge design can range from small and simple to very large and complex. Important weight-bearing components of bridges include crossbeams and trusses.

Think about all the types of bridges that you may have seen. For example, pedestrian bridges, bridges that support cars or trains, bridges that lift to allow boats to go through them. There are so many types, but all use those same fundamental components to function.

Materials

Groups of 2-3 students

- 100 wooden skewers
- 1 meter of masking tape
- Scissors
- Construction paper (Purpose: road across the bottom of the bridge)
- Weights (ranging from 0.1 to 5 grams)
- Hot Wheels car
- Scale (if masses of weights are unknown)

Procedure

1. Start with an icebreaker question to work on community building amongst the group.
2. Necessary Explanations
   a. Opener. Talk about bridges. Reflect on what students know and briefly share relevant examples (e.g. https://www.youtube.com/watch?v=G3bkkKvBoOg).
3. Start the experiment.
   a. Split into groups of 2-3 students per group.
   b. Propose the challenge to students: Build the strongest bridge you can with the materials available. The bridge must cover the foot distance from table to table (variable), must be wide enough to accommodate a Hot Wheels car, and will be judged based on the amount of weight it can support without breaking. (Possible variations: longer distance, bonus for multiple "lanes", maximum weight limit, alternative materials, etc.)
   c. Check bridges: This is the best part of the challenge! Check each bridge ceremonially, so everyone gets to watch as the strength of each bridge is tested until it breaks. First, push the car across the bridge. Then, gradually add weights until the bridge breaks. Record the amount of weight each bridge supported.

d. Discuss which techniques/structures worked and which did not. Be specific. Ask why certain designs are inherently weaker (or stronger) than others. What forces enable the most successful bridges to hold the most weight?

Guiding Questions

Where is the support of the bridge most important?
Why is it important to conduct annual checks on bridges that support car traffic?

Career/Future Application

Teamwork and problem solving are part of Every job. Individuals must work together to identify solutions, accomplish goals, and be cooperative. This can be a good team-building exercise as well as an experience for students to learn from each other.

Engineering is cool. Engineers apply advances in science to create more useful products and machines. Examples: building rockets, buildings, cars, particle accelerators, etc. Engineers are constantly designing things to be stronger, better, and more aesthetically pleasing. Engineering concepts are not limited to bridges. Architecture and engineering are involved in almost every aspect of our day-to-day lives in the 21st century.

Sources

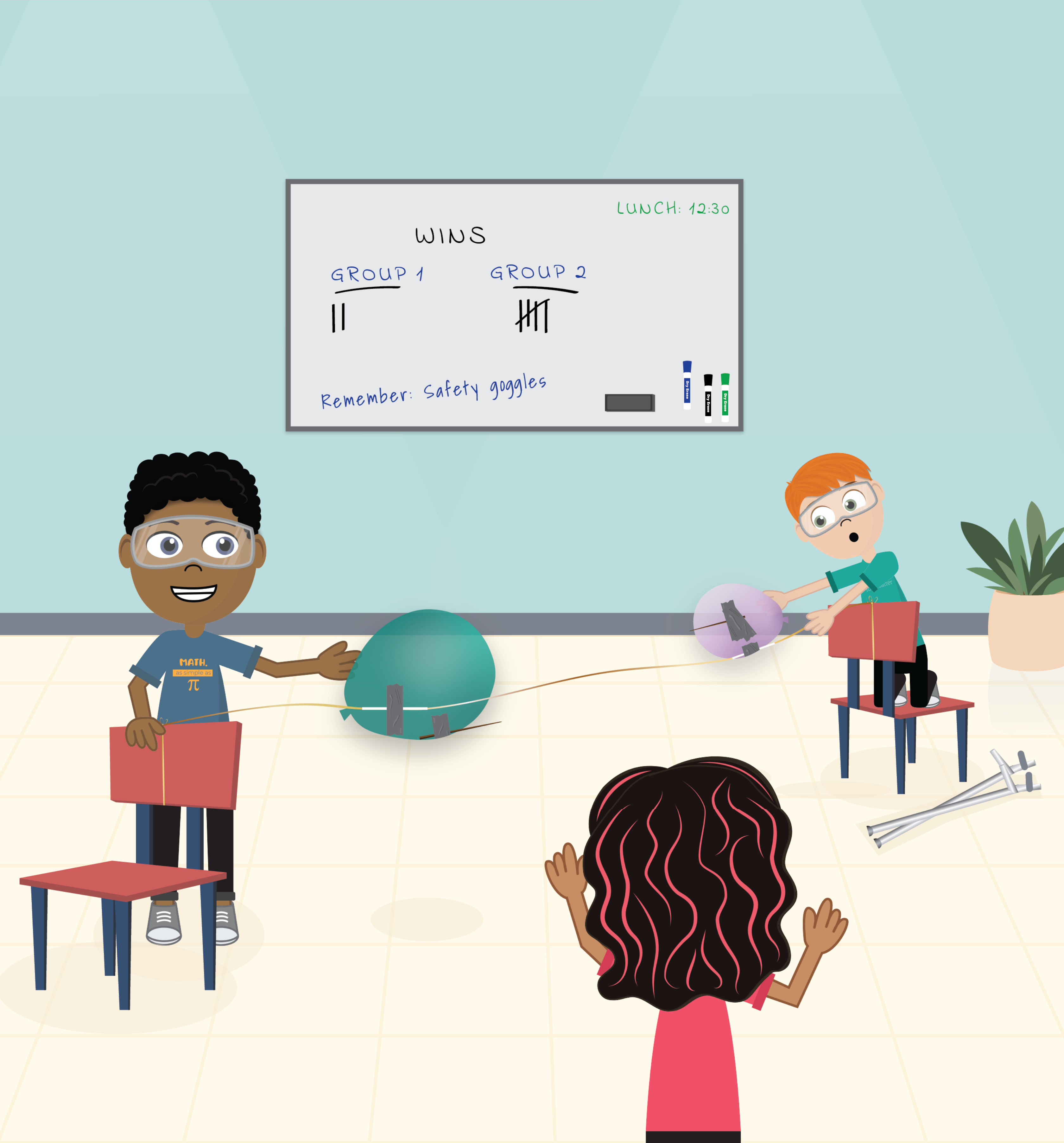
http://www.sciencekids.co.nz/sciencefacts/careers/engineer.html

http://www.oxforddictionaries.com/us/definition/american_english/truss

http://www.thefreedictionary.com/crossbeam

PHYSICS

Battling Balloons



NGSS

3-PS2-1; MS-PS2-1

Objective

The student will understand the basic physics of rocketeering and the engineering design process.

The student will be able to design a balloon popper using the engineering process.

Vocabulary

Force: Strength or energy as an attribute of physical action or movement.

Thrust: The propulsive force of a jet or rocket engine. This is explained by Newton's Third Law of Motion.

Newton's Third Law of Motion: 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 force on the first object equals the size of the force on the second object.

Pressure: Force per unit area.

Potential Energy: The energy possessed by a body by virtue of its position.

Kinetic Energy: Energy that a body possesses by virtue of being in motion.

Engineering Design Process: A series of steps that engineering teams use as a guide to solve problems. The design process is cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way.

Background

Sir Isaac Newton first presented his three laws of motion in the " Philosophiæ Naturalis Principia Mathematica" 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.

In aerospace engineering, the principal of action and reaction is very important. Newton's third law explains the generation of thrust by a rocket engine. In a rocket engine, hot exhaust gas is produced through the combustion of a fuel with an oxidizer. The hot exhaust gas flows through the rocket nozzle 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 second law of motion.

Materials

***** Students will be in groups of 2-3 depending on class size. (Up to 5 groups)**

- 26 large balloons, minimum 12 inches (limit 5 per group, 1 for demonstration)
- 25 straight drinking straws (5 per group limit)
- ~30 feet of string (Make two ~15 ft strings... smooth line, like fishing line, strong thread, or kite string)
- 10 barbeque skewers (limit 1 per jouster)
- Duct tape
- Clear tape or masking tape
- 10 styrofoam cups (limit 2 per group)
- 10 plastic cups (limit 2 per group)
- 25 popsicle sticks (limit 5 per group)
- 5 scissors (1 per group)
- Assorted color sharpies
- 25 pieces of white printer paper (5 per group)
- Pencils (1 per student)

Note: Additional supplies can be added, but this is a good start. Students can brainstorm about other materials they could use to design a better popping mechanism (i.e. for protection, stability, etc.) Get creative!

Procedure

1. Introduce the topic and the scientific concepts related to balloon rockets.
2. **Balloon Rocket Demonstration**
    a. Thread a 15ft piece of string through a straw.
    b. Blow up a balloon and tape it to the straw.
    c. Two student volunteers should hold the string up tight between them and release the balloon so it rockets over to the other side.
    d. Discuss the physics concepts at work here.
        i. Newton's Third Law, Thrust, Kinetic and Potential Energy, etc.
3. **Balloon Popper Battling**
    a. Split students into groups of 2-3 (no more than 5 groups).
    b. Tell the students that they will design and build balloon jousters and then compete against other groups to determine the best design.
    c. IMPORTANT: Limit supplies consistently for each group. Either assign flat limitations for each item (refer to the "materials" section) or use other creative methods such as allocating a set budget for each group and assigning prices to the materials available.
    d. There are no restrictions on how each supply is used. Materials can be used for protection, extension, stability, increased attacking abilities... anything the students can imagine. Limit of one barbeque skewer per balloon is recommended, but not required.
    e. Tie the ends of a string to two stable objects (chair, table, etc.), at an even height above ground to allow the balloons to pass freely. Then, place the objects far enough apart to remove any slack in the string. IMPORTANT: To avoid eye injury, students should wear safety glasses and string should be tied at a height below the students' eye level.
    f. <u>BRAINSTORM & DESIGN (~5 min)</u>
    g. Display materials on a table and allow each group to come up one at a time and look at the available materials.
    h. Each group must then draw up a blueprint design and list the proposed materials for their first jouster.
    i. <u>BUILD, TEST, EVALUATE, and REDESIGN (~40 min)</u>
    j. Each group will build their first balloon jouster and then challenge another group.
    k. Instructors, keep track of wins and losses for each group. A bracket is

recommended for easy tracking!

l. After each round, groups can redesign, rebuild, and compete again. Groups are limited to 5 balloons, so they will have a maximum of 5 attempts.
m. Using a smart phone, try filming the jousts in slow motion so students can watch what happened in greater detail.
n. DISCUSS WHAT HAPPENED (~5 min)
o. Between each round and at the end of the lesson, take some time to talk about which designs worked and why.
p. Come back to the basic physics concepts involved in the lesson.

4. Clean up as a group. Save and return as many of the supplies as possible.

Optional extension activities:

1. Darts:
    a. Make a "dart" by attaching a balloon, skewer, and straw together, just like in the balloon joust.
    b. Make a target by inflating a second balloon, but tie this one closed, and tape it at one end of the string. Alternatively, draw/print a bullseye on a piece of paper or cardboard.
    c. Launch the dart balloon at the target.
2. Push over:
    a. Place two straw-balloon combos on a single line, aimed at each other (NO SKEWERS).
    b. Mark the center-point of the string with tape, marker, etc.
    c. Launch the balloons.
    d. The balloon that pushes the other beyond the center line is the winner.
3. Race:
    a. Set up two long lines, side by side.
    b. Race the two balloons.
    c. Which balloon travels the farthest? Which balloon crosses the finish line first?

Guiding Questions

What makes a rocket ship move? Why did some balloon poppers travel farther and faster than others? What are ways that you could protect your balloon popper?

Career/Future Application

The engineering design process is a valuable model for daily and occupational life regardless of career. You can find the importance of problem solving in just about everything!

Sources

http://pbskids.org/designsquad/build/balloon-joust/

https://www.physicsclassroom.com/class/newtlaws/Lesson-4/Newton-s-Third-Law

PHYSICS

Balloon Popping

Balloon Popping

NGSS

4-PS3-2; 4-PS4-1; 5-PS1-4

Objective

The student will understand that light is made up of different wavelengths and the reflection or absorption of those wavelengths is related to color and heat energy.

The student will be able to explain why objects react to light differently by using lenses to direct sunlight onto different-colored objects.

Vocabulary

Wavelength: The distance between peaks of a wave (such as waves of light or sound).

Absorption: When a wave comes into contact with and causes the molecules of an object to vibrate, thereby absorbing the wave energy rather than reflecting it.

Convex Lens: A lens that is thicker in the middle; these lenses focus light waves.

Heat: A transfer of energy; caused by objects near each other having different temperatures.

Background

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 and green light has less energy than violet light. White light is made up of all the different wavelengths of light. Objects appear different colors depending on the wavelength(s) of light they reflect. Black objects look black because they absorb almost all wavelengths of light and convert the energy into heat. Conversely, white objects look white because they reflect all the wavelengths of light.

In this experiment, 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.

Materials

Per Group of 2-3 Students:

- 1 magnifying lens
- 1 transparent balloon
- 1 black balloon
- Sunlight

Procedure

1. Partially inflate the transparent balloon. Do not fill it completely or tie off the end.
2. Insert the deflated black balloon into the opening of the transparent balloon. Make sure to leave the end of the black balloon hanging out the end of the transparent balloon.
3. Inflate the black balloon and tie off both ends.
4. In direct sunlight, position the magnifying lens to focus on the center of the balloons.
5. Observe. Did any balloons pop?

Guiding Questions

Why does only one balloon pop? i.e. What determines whether the light will cause each balloon to pop?
Do you think this experiment would work with another transparent balloon (instead of black) inside the first?

Career/Future Application

Optometrist, Photographer, Thin Film Engineer

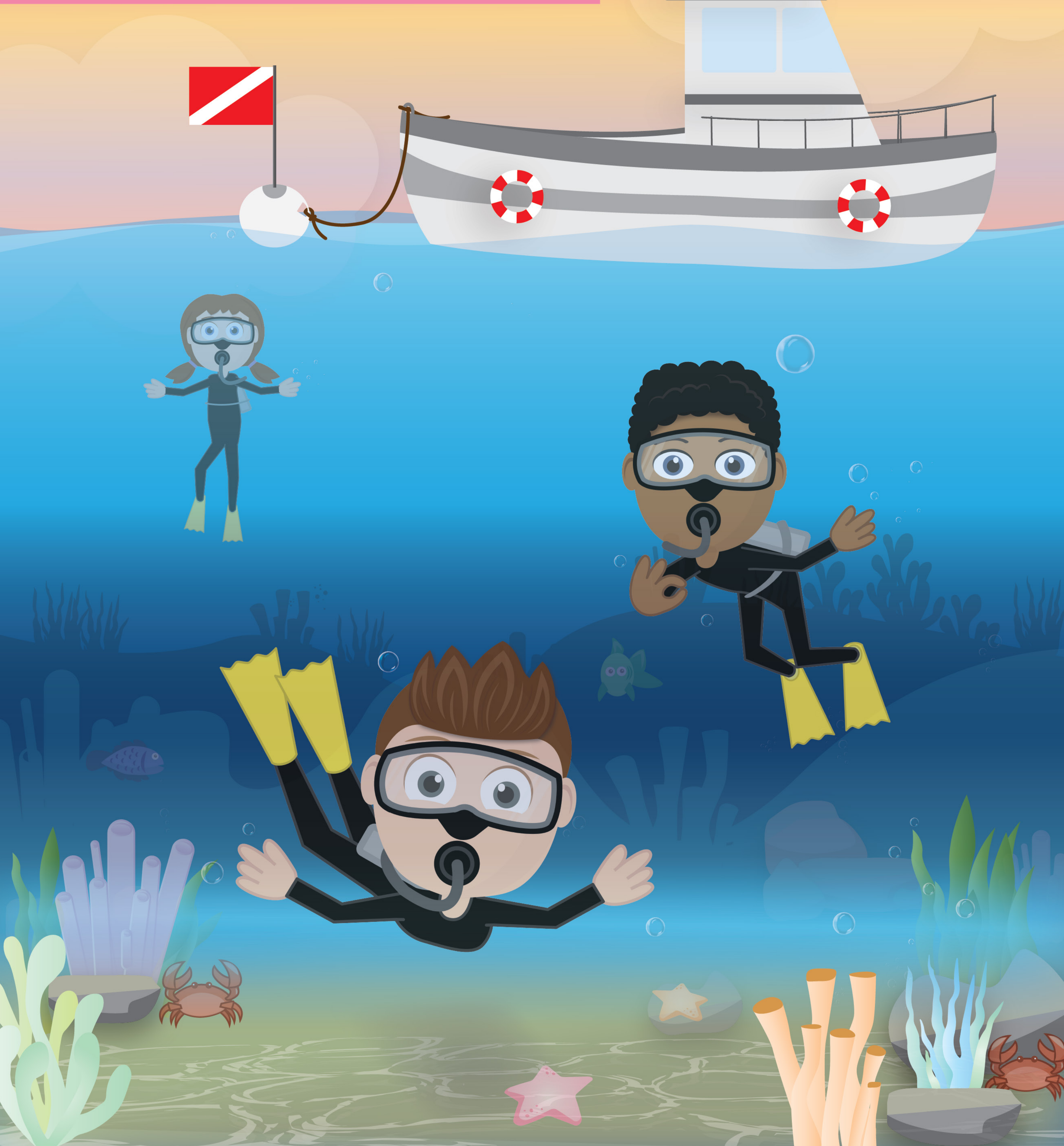
Sources

Dark Colors Absorbing Light: https://sciencing.com/colors-absorb-heat-8456008.html

Wavelength and Color: https://www.sciencelearn.org.nz/resources/47-colours-of-light

PHYSICS

Divin' Challenge



NGSS

3-PS2-1; MS-PS2-2

Objective

The student will understand the basic concepts of density, buoyancy, pressure, and states of matter.

The student will be able to conduct a series of experiments to manipulate a hook in a bottle to grab targets at various depths in an effort to learn more about density, buoyancy, pressure, and states of matter.

Vocabulary

Buoyancy: An upward force exerted by a fluid that opposes the weight of an immersed object.

Density: Mass of a substance per unit volume. More simply, the weight of something compared to how much space it takes up. (Density equals Mass / Volume).

Mass: 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. Mass is an intrinsic property of matter.

Volume: The amount of space that a substance or object occupies.

Pressure: The ratio of force to the area over which that force is distributed.

Background

The purpose of the activity is to manipulate various tubes within water to various depths. In order to do so, the ideas behind Pascal's law and Archimedes' Principle are applied.

Pascal's Law

This law highlights that pressure is consistent throughout an enclosed fluid, or in this case of the experiment, the 2-liter bottle, meaning that only the forces of gravity and pressure are acting on the system. However, this is drastically changed in the system when a targeted stress is applied, such as is the case in the experiment when you squeeze the bottle. Therefore, the bottle no longer follows Pascal's Law of uniform pressure. As a result, there is an additional force applied to the bottle which affects the air inside the tube that leads to displacement to change the pressure for negative buoyancy to sink the tube.

Archimedes Principle

The principle states that a buoyant force is equal to the weight of the displaced object. Therefore, the weight of the object being displaced will sink IF it is less. Likewise, the object will float if it is equal.

Archimedes Principle is important when considering the topics of buoyancy, especially for the development of ships. Additionally, trying to float in the pool or a lake largely uses the principle described because the body is at equilibrium and there must be an equal buoyancy pressure to allow for the float to occur successfully.

During the experiment, consider how manipulation of the bottle changes the behavior of the tubes. When the pressure on the container is released, the air expands, which in turn increases the weight of the water displaced and the tub will again move to the surface to float.

Materials

Note: the same supplies are reused in most of the activities. Groups can be 2-3 students or individual (supplies will vary depending on this)

One Versus One Pressure

- 2 100 mL plastic syringes with a cap
- Duct tape (for securing caps)

Tube Diver Experiment

- 2-liters plastic bottle
- 10 mL plastic pipette (skinny neck) – (5 total)
- Hex nut (5 total)

- Clear plastic cup
- Water
- Scissors

Find your Targets Challenge

- All elements from previous 'Tube Diver Experiment'
- Coat wire or pipe cleaner

Procedure

Lesson

1. Do some sort of ice break activity as a community building component to start your activity.
2. Go over the background information with the students and vocabulary words to introduce the topic for the day embedded in the activity.

Activities

One Versus One Pressure

1. Pull out your 100mL syringes and fill one with air and the other with 30mL of water
2. Have two student volunteers race to see who can compress the syringes fastest.

What's happening: Air (gas) is compressible, while water (liquid) is not to a certain extent. The reason is that there is more space between molecules in air, while molecules are closer together in the water.

Tube Diver Experiment

1. Set up your tubes:
    a. Fill up a cup of water ¾ full as your test space for the tube.
    b. Put the hex nut onto the 10 mL pipette so that it is snug up to the bulb. Cut off the neck of pipette so that about 1 cm remains below the hex nut.
    c. Make 5 of these and drop into the cup of water to check if they float.
    d. Then push on the bulb to suck water into the tube. Observe what happens to the flotation.

What's happening: The tube has become denser because water was added to the bulb and water in the tube is denser than the air in the tube. Drawing up all of the water will see the tube sink in the cup.

2. Now that you have seen how they sink, label the tubes 1-5.
3. Fill tubes with various amounts of water so that the tubes drop in the 2-liter bottle in the order of 1-5 when you push on the sides of the bottle.

Find your Targets Challenge

4. Add a “poke” attachment to one of the five tubes. This is your vessel for finding targets
5. Get the other 4 tubes to sink to various depths in the tube and manipulate the fifth tube to “poke” one of the targets. Can you “poke” all 4 tubes??

Guiding Questions

- Why do some things float and others sink?
- What is something you can think of in your everyday life that has a large density?
- How would changing the volume or mass of an object affect its density?

Career/Future Application

Density is an 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. Additionally, shipbuilders must recognize buoyancy as an important force for ships to float.

Sources

https://www.sciencedirect.com/topics/engineering/pascals-law

https://physics.weber.edu/carroll/archimedes/principle.htm

https://www.sciencedirect.com/topics/engineering/archimedes-principle

PHYSICS

Life Jackets and Buoyancy

Life Jackets and Buoyancy

NGSS

5-PS1-1

Objective

The student will understand buoyancy and its application in life jackets.

The student will be able to build a functional personal floatation device from unorthodox materials.

Vocabulary

Buoyancy: The ability or tendency to float in water or some other fluid.

Life Jacket: A device designed to help keep a person or animal afloat - whether they are conscious or not.

Patent: A form of intellectual property.

Background

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.

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 by blowing into a tube with a one-way valve to seal in the air.

Life jackets are also provided on both recreational and commercial seafaring vessels - so all crew and passengers can wear one in an emergency. In addition to humans, personal flotation devices are even available for dogs and some other animals.

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 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.

Simple flotation devices are used by many children learning to swim.

Materials

- Resource handout

Soup Can Demonstration (assortment of supplies listed for the whole class)

- Identical soup or vegetable cans (unopened; 1 per group)
- Paper cups
- Straws
- Paper towels
- Rubber bands
- Paper clips
- Tape
- Balloons
- Plastic bags or lunch bags
- Glue
- Corks
- Foam pieces
- String
- Foil
- Hose or tubes
- Small containers
- Paper towels
- Bucket

Procedure

1. Introduce topic

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.

2. Soup Can Demonstration

a. Discuss the rules for building a life jacket:

i. The device can be made up of several parts, but the final product must be one combined piece.

ii. Must be able to affix the device to the can within a 20-second period (so students cannot just add foam or balloons to it for an hour).

iii. Some portion of the can must touch the water and get wet.

b. Put students into teams of 2-3 and allow 10-15 minutes to plan their design. Students should create a list of materials and a drawing of their design before the time is up.

c. Students build their life jackets and test whether they can keep a can of soup afloat.

3. Clean up the room!

Guiding Questions

- Why is buoyancy important when building a life jacket?
- What are some of the best materials for a life jacket and why?
- What conclusions can you draw from your observations?
- In what types of careers might bouyancy be important/relevant?

Career/Future Application

PFD's are used in many maritime and military careers. Problem solving and teamwork are used in every STEM field. Buoyancy is especially important in some engineering projects such as boat design or oil rigs.

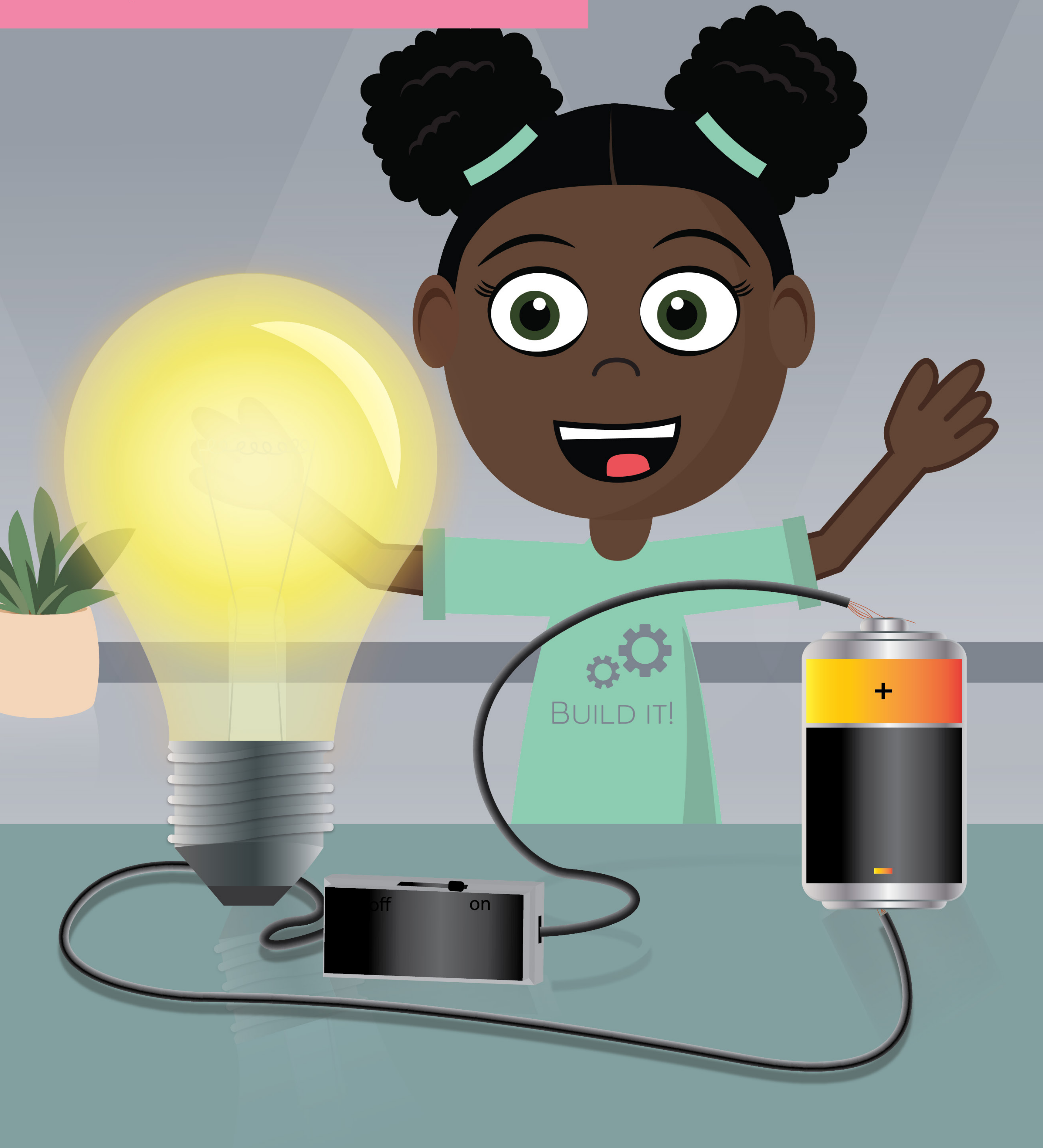
Sources

Scan QR Code for Website

http://tryengineering.org/lesson-plans/life-vest-challenge

PHYSICS

Simple Circuits



NGSS

4-PS3-4; MS-PS3-2

Objective

The student will understand the difference between series and parallel circuits, as well as how different circuit setups change power through a circuit.

The student will be able to build an operational simple circuit.

Vocabulary

Power: 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.

Circuit: For the sake of this lesson, a circuit is defined as being composed of a source of current (battery) that has at least one complete path from the positive terminal to the negative terminal.

Series: 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.

Parallel Circuit: Circuit arranged in such a way that multiple resistors, each with an A and B side, are connected 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.

Battery: Power source that creates a flow of electricity due to a difference in potential between a positive and negative terminal.

Light Bulb: Electric light with a small filament (thin piece of wire) that connects one end of the lightbulb to the other inside a glass bulb.

Background

Circuits are a critical component that allow for the lights in our homes to turn on. In order to understand this process, we must dive into the various components that allow for our lights to turn on and off within our homes.

Resistance quantifies the resistance to the flow of electrical charge through an electrical component and is measured in ohms (W). 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 light bulbs 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.

Power is simply the rate of flowing electricity flowing through a circuit. 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 for the charge to flow 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.

For circuits, the path or paths can travel through wires and various components that conduct electricity (light bulbs). A circuit with one end of the battery connected to a light bulb and 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 terminal. A circuit with 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. 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.

The total resistance of series circuits is the sum of resistances among all the resistors. This is so because there is only one path for electricity to travel; therefore, the resistance of each resistor slows down the electricity like heavy traffic through a narrow street. In a parallel circuit, adding multiple resistors, one effectively creates more paths for electricity to flow, so instead of traffic being forced down one narrow street, the traffic can be split between 1, 2, 3, 4, ... streets and, therefore, moves much faster.

For example, someone has taken a bunch of electricity and stuffed it into one end of the battery and that electricity 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 there is in the circuit, the slower the electricity will travel to the other end.

Due to resistance, the filament in light bulbs 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 passes through the light bulb, the brighter it shines.

Materials

Per group of 2-3 students:

- 9-volt battery
- 2-5 mini incandescent lights (Lights can be cut from a strand. Cut leads to about 3 cm and trim insulation about 1 cm).
- 2 longer pieces of the cut wire from the Christmas lights for connecting the circuit.
- Strip of electrical tape

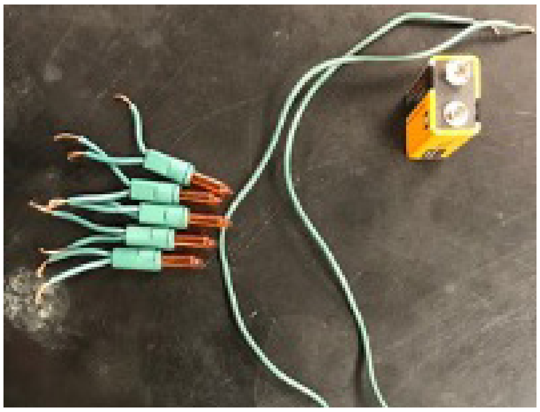


Figure 1. Circuit components.

Procedure

Electrical connections to the battery can be made by sandwiching each of the two leads between a battery post and a piece of electrical tape.

Connections among lightbulbs can be made by twisting the exposed copper together.

Activity 1 (Complete the Circuit):

Describe the characteristics of a complete circuit. Students should experiment with connecting the lights to the batteries in different ways. Emphasize 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.

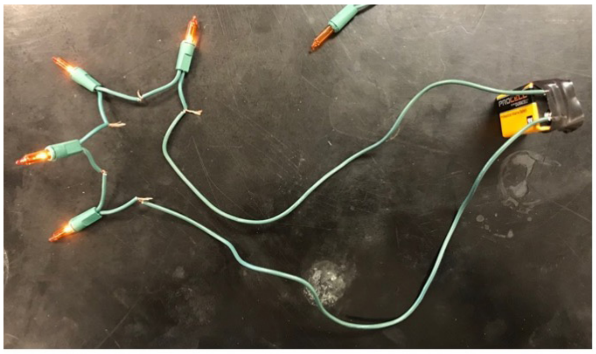


Figure 2. Series Circuit

Next, have the students make a parallel circuit. The lights should be much brighter in the parallel circuit than the series circuit. Ask students to explain why the lights on the parallel circuit are brighter.

Figure 3. Parallel Circuit.

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. If the students are having trouble getting creative, you can demonstrate different circuits, like the one pictured below.

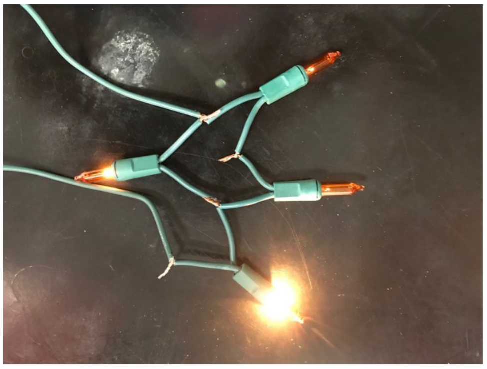


Figure 4. Combination Circuit.

Activity 4 (Large groups/class activities):

Students can pool their materials to make larger circuits with multiple batteries. If larger circuits are assembled with many lightbulbs, you can explain 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 +) or the batteries could overheat.

Guiding Questions

- Continually ask 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.
- What happened when you had a large group try to make the bulbs turn on?
- How did you modify the experiment? How do you think scientists or engineers use similar creativity?

Career/Future Application

Electrical engineering, Electrical Contracting, Computer Science

Sources

https://www.edinformatics.com/math_science/what-is-an-electric-circuit.html

PHYSICS

Newton's Tower

Newton's Tower

NGSS

5-PS2-1; MS-PS2-1

Objective

The student will understand Newton's first and third laws of motion.

The student will be able to demonstrate Newton's first and third law by explaining the forces acting on the materials.

Vocabulary

Force: A push or pull upon an object resulting from the interaction of the object with another object.

Inertia: The resistance of any physical object to any change in speed, direction, or state of rest.

Newton's first law: An object at rest will remain at rest and an object in motion will remain in motion unless acted upon by an external force.

Newton's third law: For every action there is an equal and opposite reaction.

Background

While at rest, the egg/roll/pan complex you assemble during this experiment will experience the force of gravity and the normal force. The force of gravity pulls it downward while the normal force pushes up. By striking the pie pan, the horizontal force is transferred to the pie pan 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.

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 a marble in motion strikes a stationary marble, the marbles bounce off each other and then both are in motion. Why is it that the marbles stop moving on their own if we don't see an outside force stopping them? The force of friction between the marble and the floor causes the marble to stop. In a frictionless world, the marbles would continue on their trajectory until acted on by an external force.

When two marbles in motion 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.

Materials

Items needed per group (2-3 students)

- 2-3 pie pans
- 2-3 glass cups or beakers
- 2-3 toilet paper tubes
- 2-3 hardboiled eggs
- Water (to go into glass cup or beaker)
- Newspaper and paper towels (in case of spills)
- Small bag of marbles of various sizes

Procedure

http://www.youtube.com/watch?v=STQRUzalH2M (Watch this video prior to starting the experiment)

Experiment 1: The Tower

1. Do a whole-group demonstration and then have the students set up the experiment at each group. (For the demonstrations, follow steps 4-9).
2. Fill 3/4 of a clear glass cup with water.
3. Place a pie pan on top of the glass cup.

4. Place a toilet paper roll in the middle of the pie pan.
5. Place a hardboiled egg on top of the toilet paper tube.
6. Hit the pie pan with a horizontal sweeping motion! (Do not hit the egg).
7. Watch as the egg drops into the cup of water, even though the pie pan and toilet paper tube shoot off of the glass cup!
8. As you proceed through the experiment, relate what you are doing to Newton's Laws.
9. Encourage students to try!

Differentiation

- Have the students lead the experiment after you have done the main example. 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 the objects?

Experiment 2: Marble collisions

Note: The following steps should be done at a constant velocity IF POSSIBLE: therefore, we can relate this to inertia.

1. Place a stationary marble on the floor, then roll another marble of the same size to collide with it.
2. What happens?
3. Place a larger stationary marble on the floor, then roll a small marble to collide with it.
4. Place a small stationary marble on the floor, then roll a larger marble to collide with it.
5. In which instance did the stationary marble move the most?
6. Why?
7. Which marble had more inertia?
8. Have students try out different settings with the marbles (example: line up two stationary marbles and roll a larger marble to collide into them).
9. Have students make observations, discuss the results, and reflect on the activities today.

Guiding Questions

- What will happen when we strike a stationary marble with a marble in motion?

- What will happen when two identical marbles rolling towards each other collide?
- Let's change the size of one of the marbles: what happens now?
- Does one have more inertia than the other?

Career/Future Application

Understanding all potential forces in a system is critical for designing structures. Physics is therefore highly relevant to engineering, construction, architecture, etc.

Sources

http://www.physicsclassroom.com/class/newtlaws/u2l2a.cfm

GEOLOGY

Aquifers and Artesian Wells

NE STEM 4U

NGSS

5-ESS2; MS-ESS3

Objective

The student will understand what an aquifer and water table are, and how an artesian well functions with regards to these two elements.

The student will be able to develop their own artesian well to highlight its functionality in regards to the vocabulary components.

Vocabulary

Aquifer: An underground lake in which groundwater is contained in permeable rock.

Artesian well: A well drilled into an aquifer, underneath the water table where the natural water pressure pushes the water out.

Water table: The line between the unsaturated and saturated zone; the top of the aquifer.

Permeable rock: Rock that allows air and liquid to pass through due to tiny holes throughout the entire rock.

Background

The scientific method is a multi-step, repetitive process to help people conduct 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 supports their hypothesis, and then analyze the data (results) from their test and draw a conclusion on why the hypothesis was supported or not. If desired, other steps can be added, such as troubleshooting or adding on more experiments or research into why the experiment did not support the hypothesis.

An aquifer is 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 can 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 it contains little to no water. The water table is located between the two zones, just below the unsaturated zone and at the very top of the saturated zone.

Artesian wells are wells that are dug into an aquifer below the water table, which do not require extra force to extract water due to the natural water pressure. Water will naturally rise from the bottom of the well to the water table due to pressure, and when the pressure is great enough, the water will rise past the water table and come out of the top of the well.

Materials

For each group (2-3 students):

- Plastic cups (one for each student)
- Small pebbles or rocks
- Straws or small plastic tubing
- Water
- Napkins or paper towels
- Permanent marker
- Tin foil, plastic wrap, or a plastic lid for artesian well models
- Sheet of paper and writing utensil

Procedure

1. Beforehand, create a model that students can observe; it's okay if the model doesn't work, because the students will attempt to design and create a model that works better.
2. Instruct students to write out their hypothesis and the steps of their experiment.
3. Prompt students to create their artesian well models and test them. Have them share with the class whether their hypothesis came true and they were able to get water to rise.

Guiding Questions

- What do you already know about aquifers?
- What do you already know about artesian wells?
- What is your understanding of the scientific method?
- How can the scientific method help us with day-to-day activities?

Career/Future Application

Geologists, geographers, and housing developers. In rural communities, oftentimes a well must be dug to support the house for water use. Digging wells and understanding how to properly extract groundwater are important in these careers.

Sources

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/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects

https://www.sciencebuddies.org/science-fair-projects/science-fair/steps-of-the-scientific-method

GEOLOGY

The Center of the Earth

The Center of the Earth

NGSS

5-ESS2; MS-ESS3

Objective

The student will understand the dynamic properties of the three layers of the Earth and what each layer consists of (in terms of general properties).

The student will be able to create a model of the Earth.

Vocabulary

Inner core: The core of the Earth considered to be composed primarily of iron.

Outer core: Presumed to be liquid, or rather fast-moving magma.

Lower mantle: Located below the transition zone from the upper mantle, is composed primarily of simple iron and another mineral called magnesium silicate, in denser forms as depth increases.

Upper mantle: Presumed location on which the tectonic plates ride. Molten rock is believed to originate from this region of the mantle.

Crust: The part humans live right on top of. It consists of soil, rocks, and the sea floor.

Background

The interior of the Earth consists of three basic parts: the crust, mantle, and core. The mantle and core are composed of two parts each: the upper and lower mantle and the outer and inner core, respectively. The crust is the surface that humans inhabit: it includes the soil, rocks, and seabed underneath us. The upper mantle below the crust is the site of tectonic plates. These plates are the cause of earthquakes, mountains, and volcanos. The lower mantle is made up of the elements of simple iron and magnesium silicate materials, which become more dense with gradual depth increases. Transitioning from the mantle to the core actually reveals a decrease in earthquake wave velocity, but an increase in density, partially due to 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.

Materials

For each group (2-3 students):

- A plastic cup
- Tin foil
- Red food dye (three drops per cup)
- Aloe vera
- Foam sheets
- Popsicle sticks
- Sprinkles
- Napkins or paper towels

Procedure

1. Spread napkins or paper towels on the table or desk and place materials on top.
2. Crumple tin foil into a ball and place into the plastic cup.
3. Pour the Aloe vera on top of the tin (about ¾ full).
4. Add three drops of red food dye onto the Aloe vera and mix with popsicle sticks until the mixture is a clear red color.
5. Place foam sheets on top of the Aloe vera, ensuring that the sheets overlap.
6. Scatter sprinkles on top of foam sheets.

Guiding Questions

- What do you think the foam sheets and other materials will represent in the model of the Earth?
- What have you learned before today about the inside of the Earth?
- What metal makes up the core of the Earth?
- Optional extension question: Why do the foam sheets not sink through the Aloe vera? (Density, primarily)

Career/Future Application

Environmental Scientist, Geologist, Geographer

Sources

https://pubs.usgs.gov/gip/interior/

https://www.nationalgeographic.org/encyclopedia/mantle/

GEOLOGY

Mapping and Location Intelligence

Mapping and Location Intelligence

NGSS

5-ESS2-1; 4-ESS1-1

Objective

The student will understand the basic principles of GIS and the importance of cartography.

The student will be able to determine coordinates for a location on a map and develop their own map of their community.

Vocabulary

GIS: Geographic Information System

Latitude: Lines that run East to West (horizontal) on a map.

Longitude: Lines that run North to South (vertical) on a map.

Cartography: The science/practice of making maps.

Key: Element that defines the meaning of symbols on a map.

Background

Cartography is the science or practice of making maps. We use maps and Geographic Information Systems (GIS) for city planning, farming, disaster relief, and transportation services. Some fundamental ideas involved in map making are longitude, latitude, coordinates, the equator, and the prime meridian. Longitude (going north to south) and latitude (going east to west) are lines on a map that enable us to pinpoint a location using coordinates. Coordinates define where on a map something is located with respect to lines of latitude and longitude, and we can also use maps (like Google Earth) determine the coordinates of a landmark or other location. Coordinates are expressed in degrees or "minutes," always with latitude listed first and longitude listed second. The equator is a line of latitude (so it runs east to west) and splits the earth in half between north and south. The prime meridian is line of longitude (so it runs north to south) and splits the earth in half between east and west. Other important elements of a map are the key and scale. The map key tells us what the symbols on the map mean and the map scale indicates the relationship (ratio) of space on the map to the corresponding distance on the ground.

Materials

For each group (2-3 students):

- Sheet of paper
- Pencil or pen
- Ruler
- Clipboard
- Google map printouts of the area where the students live or attend school

Procedure

1. Print out the area of a school, home, or other location from Google maps to figure out coordinates of a location familiar to the students.
2. Using a pencil and ruler, draw longitude and latitude lines on a blank piece of paper, with the middle of the paper being the coordinates found on Google Maps for the location.

Note: Students will be making their own map version of the printed out map.

3. If weather permits, have the students choose two landmarks to walk between to figure out the distance between the landmarks. These will be placed onto the blank sheet of paper relative to the location that was determined in step 1. The printed Google map can be a guide in determining where to place the landmarks.
4. Students should work to add detail to their map by adding features like roads, building, or trees. Symbols can be used to help highlight some of these features.
5. Then, have the students create a key to show what the symbols mean on the map.
6. Additionally, have the students add a scale for their map to determine distances for the real life locations. An example could be 1 inch on the map corresponds to 100 actual steps between two locations.

7. Have the students share out their respective maps. If time allows, students can collaborate to design a map for a fictitious island with any feature that they would like to have on it.

Guiding Questions

What is cartography?

What are some different types of maps?

Where is the prime meridian?

Where is the equator?

What are latitude and longitude?

What is scaling up or scaling down in relation to a map?

Career/Future Application

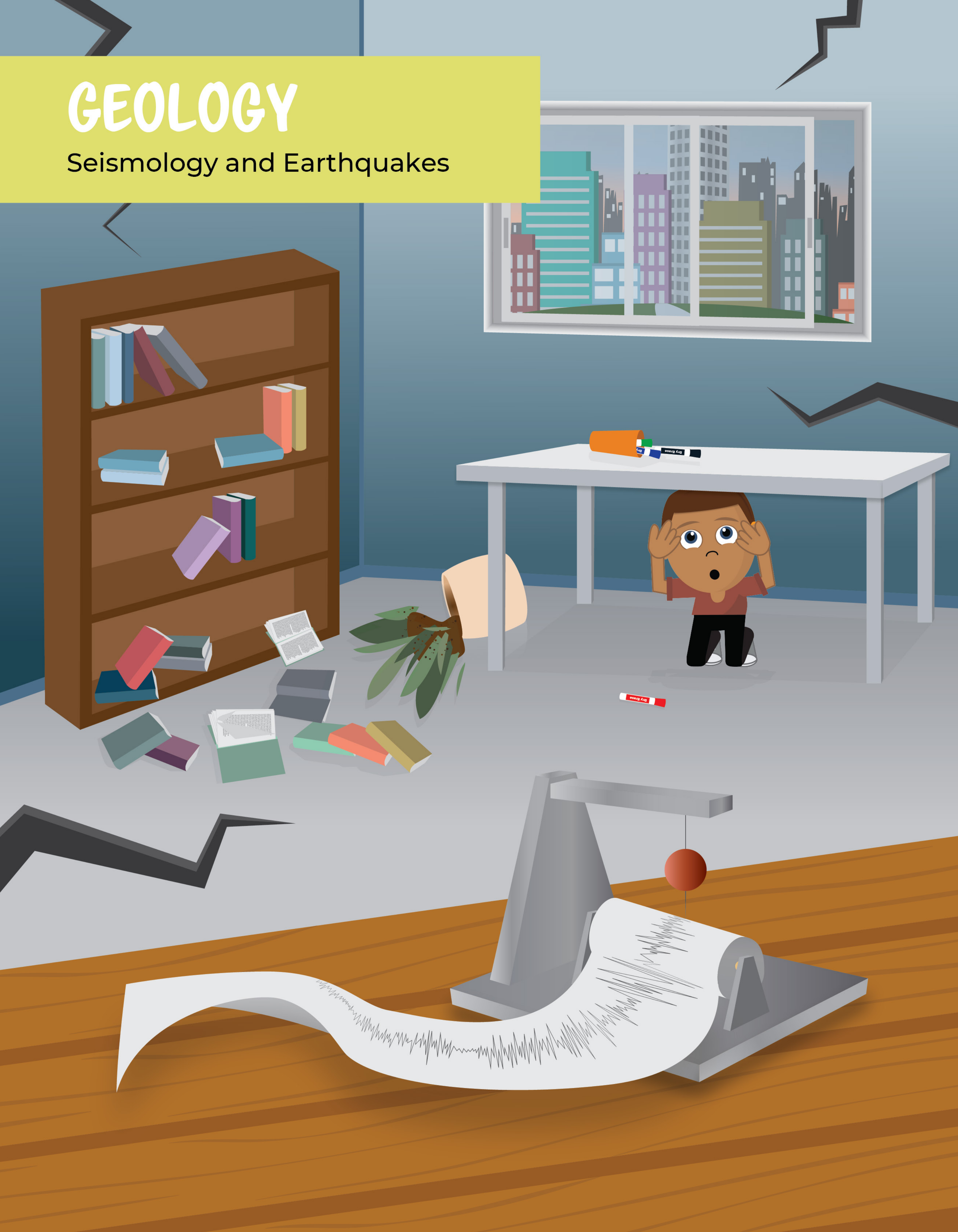
Cartographer, City Planner, Geographer, Civil Engineer

Sources

The Complete Book of Maps and Geography for Grades 3 through 6 by Carson Dellosa.

GEOLOGY

Seismology and Earthquakes



Seismology and Earthquakes

NGSS

2-ESS2-2; 4-ESS3-2

Objective

The student will understand seismology and how earthquakes affect people and the world around them. The importance of good engineering will play a major role in demonstrating how structures withstand the forces of earthquakes.

The student will be able to explain the differences between seismic waves, describe the two scales used to measure the strength of an earthquake, and replicate the effects of an earthquake on their own marshmallow buildings - all while working as a team!

Vocabulary

Epicenter: The point on the Earth's crust directly above the origin of an earthquake.

Body Wave: Type of seismic wave from an earthquake that travels through the ground.

Surface wave: Type of seismic wave from an earthquake that travels along the surface of the Earth.

Aftershock: Smaller earth-quakes or tremors that occur after an earth-quake.

Seismograph: Instrument that records how powerful an earthquake is by recording how much the ground shakes.

Seismogram: Graphical record of an earthquake produced by a seismograph.

Richter Scale: Scale used to measure the magnitude of an earthquake, expressed from 1 to 9, with 9 being the strongest.

Mercalli Scale: Scale used to measure the intensity of an earthquake, expressed from I to XII, with XII being the most intense and damaging.

Background

Earthquakes typically happen around tectonic plates. Earthquakes produce waves, called seismic waves, which can be divided into two main types. Surface waves travel along the surface of the earth, and body waves travel below the surface, causing major damage. Waves can be further categorized into P waves (primary waves) and S waves (secondary waves). P waves are the first to occur, 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 springs 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 moving like a snake. Smaller tremors, called aftershocks, can follow after the original earthquake is over. These aftershocks can occur for days or even longer after the earthquake has passed. In the first demonstration, you will be able to see how these waves affect a building (i.e. your toothpicks and marshmallow stuctures). When you tap on the pan, the vibrations travel through the Jell-O, and into the buildings. The buildings may just shake or fall over completely, depending on on the strength of the vibration and how well the buildings are constructed.

To measure how strong an earthquake is, scientists created seismology. Seismology records the vibrations created by an earthquake, and measures their strength using an instrument called a seismograph. The first seismograph was invented in 132 A.D. in China. This was called a seismoscope. 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 locate the epicenter of an earthquake. Today, earthquakes are measured according to a numerical scale called the Richter scale. The Richer scale ranges from 1 (weaker) to 9 (stronger). Although often undetected by humans, a seismograph can detect earthquakes with magnitudes as low as 1-2 on the Richter Scale. Each value on the Richter Scale represents a 10-fold increase in strength (i.e. a logarithmic scale). Earthquakes are also measured using the Mercalli Scale. This scale ranges from I (not felt at all) to XII (nearly total damage caused). In the second demonstration, you will build a seismograph using a pen suspended from a ruler onto a piece of paper. When vibrations occur, the pen will move and leave marks on the paper. This resulting marked-up piece of paper represents a seismogram, or graphical record of an earthquake.

Materials

For each group (2-3 students):

Marshmallow Building:

- 1 box toothpicks
- 1 bag mini marshmallows
- 2 baking pans with Jell-O (prepared according to package directions and set up in advance)

Seismograph Building:

- 2 12" rulers
- 2 fine line markers (e.g. Sharpies)
- 1 roll of adding machine paper
- 1 small box approximately 6" L x 3" W x 2" H to fit the adding machine paper roll
- Several rubber bands
- Strip of tag board or cardboard (about 1.5'' by 3'')
- Cork or square eraser
- 2 pencils or a thin wooden dowel that can fit through the holes in the rulers

For the class

- 4-6 large, heavy books
- Tape
- Scissors

Procedure

Procedure: Jell-O Earthquakes

1. Before handing out experiment materials, explain that the students will be pretending to be engineers by building marshmallow structures.
2. Show the students an example of marshmallow building blocks: cubes, triangles, pyramid, and explain any building restrictions that may increase the difficulty or excitement level. Provide appropriate guidelines based on grade level.
3. Pass out 30 toothpicks and 30 marshmallows to each student and limit students to building one large structure or two smaller stuctures. Keep in mind that every student should have space in the Jell-O pans for their structures.
4. Once complete, place the marshmallow structures on top of the Jell-O surface. If you decide to only test a few student's structures at a time, make sure that the Jell-O is still

relatively intact.

5. Test each structure with different types of forces such as: shaking from side to side, shaking forwards and backwards, tapping the pie pan from below, wave like motions, etc. Discuss and relate each motion to the forces described in the vocabulary.
6. Allow students to re-engineer and test their own structures again if time permits.

Procedure: Seismograph

1. Place a pen/pencil through the middle of the paper roll and place the paper roll on the end of the table. When running the seismograph, have a student secure the roll of paper (while still allowing it to unroll) by holding onto either side of the pen/pencil without touching the paper.
2. Place a cork between two rulers at the 6" mark and tape it in place.
3. Wrap a rubber band around the 1" mark of both rulers together.
4. Place a marker/Sharpie just past the rubber bands so that it is at the very end of the rulers.
5. 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).
6. Suspend the seismograph using 6-8 textbooks, 8 inches apart.
7. Tape a strip of paper to the table on top of the roll of paper to act as a guide for the machine paper.
8. After the apparatus is prepared, have one student hold the seismograph in place by adding pressure on the books, while another student intermittently shakes the paper roll, and a third student (or instructor) pulls the end of the paper in a smooth, gradual motion.
9. Make sure to explain what this experiment is simulating and see if the students can relate the seismograph readings to the Jell-O earthquake experiment.
10. All students should participate in cleaning up the workspace/room.

If time permits, students can go through another round of building using the same materials to see if they can improve the integrity of their buildings.

Guiding Questions

- Ask: What kinds of shapes can you make with the materials provided to withstand an earthquake?
- Can you make your building better? How?
- What do the lines on the seismograph represent?
- Why are some lines on the seismograph taller than others and what does the size of the peaks on the seismograph mean (look at picture above)?

Career/Future Application

Civil, structural, mechanical, and materials engineers ensure the structures we rely upon are built strong enough to keep us safe. To reduce the number of human injuries and casualties, these engineers research and test new and improved techniques and materials that help structures withstand the tremendous forces of an earthquake. For example, engineers have developed shock absorbers and structure sliders, which isolate the foundation of a building from the ground so the building and the earth move independently. Engineers also create monitoring equipment to predict and measure earthquakes and warn surrounding communities when an earthquake is coming.

Sources

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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_activity2.xml

http://earthscience.stackexchange.com/questions/352/how-to-distinguish-p-s-love-and-rayleigh-waves-in-a-seismogram

GEOLOGY

Volcanoes

Volcanoes

NGSS

4-ESS2; 5-ESS2

Objective

The student will understand the main parts of a volcano in addition to different types of volcanoes that exist.

The student will be able to demonstrate the main parts of a volcano by building a model.

Vocabulary

Magma Chamber: Chamber at the very bottom of a volcano where the magma is stored.

Conduit: Pipe that magma travels through to reach the top of a volcano.

Vent: Opening at the top of a volcano where magma comes out.

Crater: The area at the top of a volcano that surrounds the vent; normally looks like a large dent.

Magma: Melted rock.

Lava: Magma that has reached the top of the vent.

Background

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 comes out. The crater is a large dent that surrounds the vent. Magma is molten (melted) rock stored in the earth's crust, which also 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 main differences between these volcanos are shape, size, and explosiveness. Cinder cones are the most explosive but are very small. Lava domes tend to become violent over time - at first the lava seeps out and cools and dries around the vent, then explodes as pressure builds, sending the cooled lava flying. Shield volcanos are very wide, large volcanos, but tend to be non-explosive and instead the lava simply flows out like water. Composite volcanos tend to be very tall and skinny and are known to explode violently.

Materials

For each group (2-3 students):

- Markers and white boards.

Materials to build a volcano:

- Large bowl, small plastic bottle, 6 cups flour, 2 cups salt, 4 tablespoons cooking oil, 2 cups of water

Materials for eruption:

- 1 tbsp baking soda, 1 tbsp dishwasher liquid, 2 tbsp water, ½ cup vinegar, 1 tbsp red food coloring

Procedure

1. Discuss the main parts of a volcano with students.
2. Allow students to draw or write a description of how they will create a model with the materials they have been given on the white board.
3. Instruct the students to create their own model volcanoes with the materials provided. Mix the materials together to build the volcano in a large bowl. Then, take this 'paste' material and create the volcano around the small plastic bottle. Specify each element that the students should include in the model. Provide wait time for the volcano model to harden.
4. Have each group share about their respective model and identify each of the main components of their volcano.
5. Allow students to vote for the best model volcano (optional expansion – design a scoring rubric for judging).
6. After the vote has been made, allow the students to place all materials for the eruption inside the plastic bottle mouth, except for the vinegar.
7. Allow all students to pour vinegar at the same time to watch the volcano eruptions!

Guiding Questions

- What do you already know about volcanos?
- If you could choose the materials to create a model volcano, what materials would you choose for each part?
- How are volcanoes related to the state of Hawaii?
- Do you know of any volcanos? If so, which one(s)?

Career/Future Application

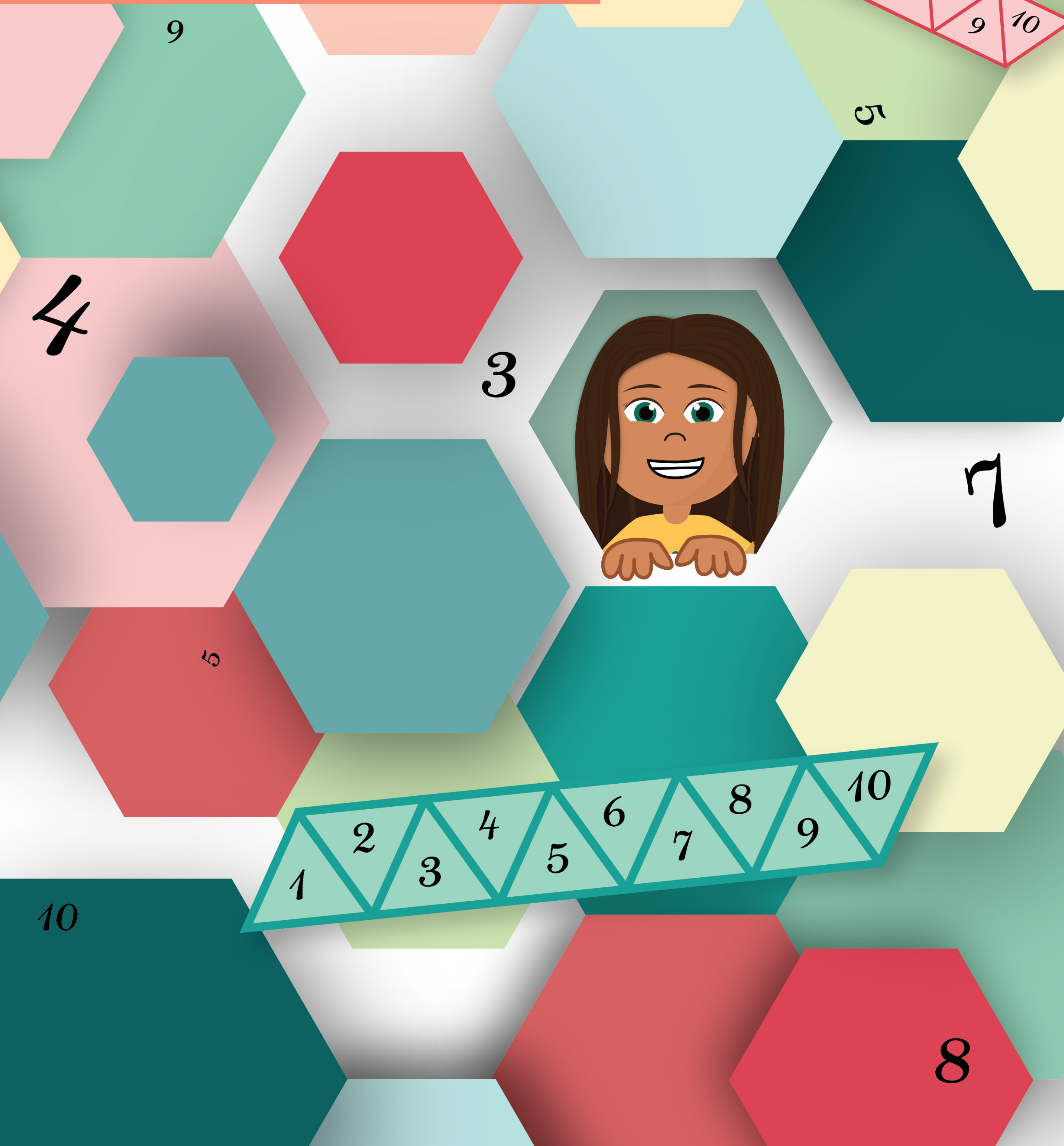
Geologist, Geographer, Volcanologist

Source

https://volcanoes.usgs.gov/vhp/about_volcanoes.html

MATHEMATICS

Hexaflexagons



Hexaflexagons

Objective

The student will understand the significance of shapes and how they can affect our understanding of the universe.

The student will be able to build a hexaflexagon.

Vocabulary

Hexaflexagon: A folded paper construction that can be flexed along its folds to reveal and conceal its faces alternately.

Geometry: The area of mathematics that deals with points, lines, shapes, and space.

Equilateral Triangle: A triangle with three equal sides and three equal angles.

Mobius Strip: A two dimensional, non-orientable object that has only one side and one edge.

Hexagon: A six-sided geometric shape made up of triangles.

Background

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 will 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.

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.

Materials

- Markers
- Pens
- Scissors
- Hexaflexagon handouts
- Tape/Glue
- iPad or computer

Procedure

1. First, ask students to define a Möbius strip and share whether they believe that a Möbius strip only has one side and one edge.
2. Have them build a Möbius strip and test it by tracing the edge and side.
3. Watch the video:

https://www.youtube.com/watch?v=VIVIegSt81)

4. Hand out the hexaflexagon sheets to each student.
5. As the students follow along, use your handout to explain how to build a hexaflexagon.
6. Allow students to color in the sides of the surface.
7. Discuss vocabulary terms as the students are working.
8. If time permits, show this video:

https://www.khanacademy.org/math/math-for-fun-and-glory/vi-hart/hexaflexagons/v/flex-mex

9. Optional Extension Activity: Challenge students to find another way to fold a hexaflexagon and/or make another flexagon shape.

Guiding Questions

How many sides does a hexaflexagon have?
How about a hexagon?
How many sides and edges does a Möbius strip have and why?

Career/Future Application

Spatial recognition is a valuable skill in many careers. Engineers incorporate shapes and an understanding of their functions into their everyday job.

Sources

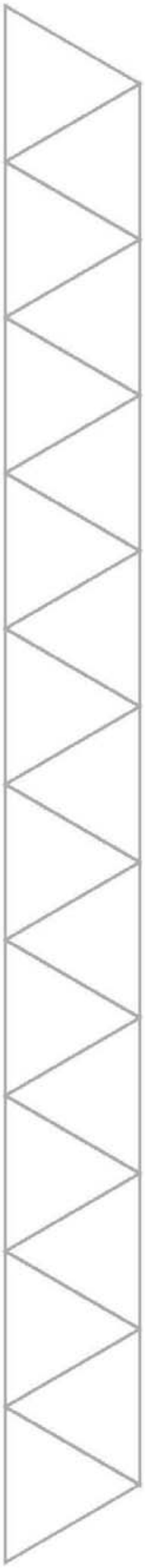
http://www.wikihow.com/Fold-a-Hexaflexagon

http://mathequalslove.blogspot.com/2012/12/hexaflexagon-love.html

http://www.puzzles.com/hexaflexagon/img/instructions_for_folding_trihexaflexagon.pdf

http://www.puzzles.com/hexaflexagon/img/blank_trihexaflexagon_template.pdf

https://www.khanacademy.org/math/math-for-fun-and-glory/vi-hart/hexaflexagons/v/flex-mex

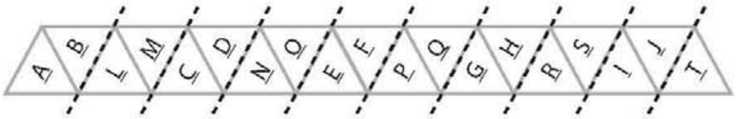


HEXAHEXAFLEXAGON BLANK TEMPLATE

INSTRUCTIONS

1. CUT OUT THE TEMPLATE & LIGHTLY LABEL IT WITH PENCIL AS SHOWN BELOW. LATER, YOU CAN ERASE THE PENCIL AND DECORATE YOUR FLEXAGON.

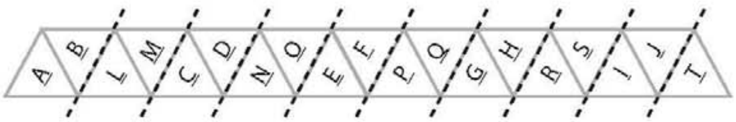
FRONT



BACK

2. MAKE MOUNTAIN FOLDS ALONG THE LINES SHOWN BELOW:

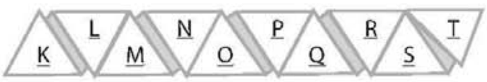
FOLDS



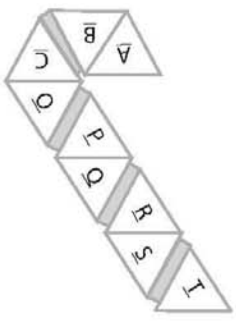
3. NOW FOLD THE STRIP SO THAT IT LOOKS LIKE THE DIAGRAM BELOW:

FRONT

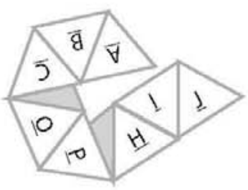
BACK



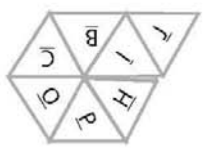
4. NOW FOLD YOUR STRIP IN TO THE SHAPE SHOWN HERE:



5. ...AND FOLD AGAIN LIKE SO:



6. BEND THE J FLAP AWAY FROM YOU & GLUE FACE T TO FACE K.



..AND NOW YOU HAVE A WORKING HEXAHEXAFLEXAGON!

MATHEMATICS

Stick Puzzle

Stick Puzzle

Objective

The student will understand spatial reasoning and the role that it plays in their life.

The student will be able to use puzzles to initiate spatial thinking and to think geometrically; describe various types of polygons and their applications for problem solving.

Vocabulary

Polygon: A closed figure for which all sides are line segments.

Line: The straight path connecting two points and extending beyond the points in both directions.

Square: A rectangle with all sides of equal length

Quadrilateral: A polygon with four sides.

Triangle: A polygon with three sides.

Background

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).

Materials

Group of 2-3 students

- A copy of the toothpick puzzles (see sources section)
- 24 toothpicks
- A coin

Procedure

In this exercise the student will use puzzles to initiate spatial thinking and a geometric perspective. Students will walk through the toothpick puzzles sheet.

As the students work, look to provide guided questions to the students in regards to the activity.

Guiding Questions

- Did you brainstorm with other students to figure out these puzzles?
- How do you think working in a group helps solve problems?

Career/Future Application

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 – or realize it doesn't! Engineers use spatial reasoning to plan out a project. Hairdressers use spatial reasoning to achieve the intended look of a haircut. Spatial reasoning is happening all around us on a continuous basis.

Sources

http://www.education.com/activity/article/Toothpick_Math/ **(Puzzle Worksheets)**

http://serc.carleton.edu/research_on_learning/synthesis/spatial.html

STEM EXTRAS

Cloud Formations

NGSS

4-ESS2; MS-ESS2

Objective

The student will understand how clouds are formed and the effects of cold/warm temperatures on clouds.

The student will be able to create a contained cloud in a bottle.

Vocabulary

High Pressure System: A mass of air with a high amount of pressure.

Low Pressure System: A mass of air with a low amount of pressure.

Water Vapor: Water in the form of a gas.

Warm Front: The area where a mass of warm air is beginning to replace a mass of colder air.

Cold Front: The area where a mass of cold air is beginning to replace a mass of warmer air.

Background

Clouds are made up of tiny droplets of water or ice crystals. These droplets of water or ice crystals form from water vapor, the gaseous form of water. Clouds form when water vapor is pushed upward from a high-pressure system where a lot of air molecules and water vapor are packed together tightly to a low-pressure system where there is more space for the water vapor and air molecules to move around.

Low- and high-pressure systems bring warm fronts and cold fronts. A front is the area between large masses of air that are warm or cold (i.e. warm front and cold front). As air warms it rises, and as it rises it cools, causing water vapor to cool down and form either ice or water. This is similar to what happens to the steam that forms when boiling a pot of water. When the steam touches a cold surface, it will form water droplets.

Materials

For each group (2-3 students):

- Empty large bottle
- Air pump
- Rubber stopper with hole
- Rubbing alcohol

Procedure

1. Put a small amount of rubbing alcohol in the bottle and coat the entire inside of the bottle by moving it around.
2. Put the rubber stopper in the top of the bottle, and secure it tightly.
3. Put the tip of the air pump in the hole of the rubber stopper, again make sure it is tightly secured.
4. Start pumping air into the bottle and continue for 30-45 seconds. This may become difficult and the students may need help.
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.

Guiding Questions

- What different types of clouds do you know of?
- What kind of clouds have you seen?
- Is there currently a cold front or warm front in your area?
- Why does fog form?

Career/Future Application

Meteorologist, Environmentalist

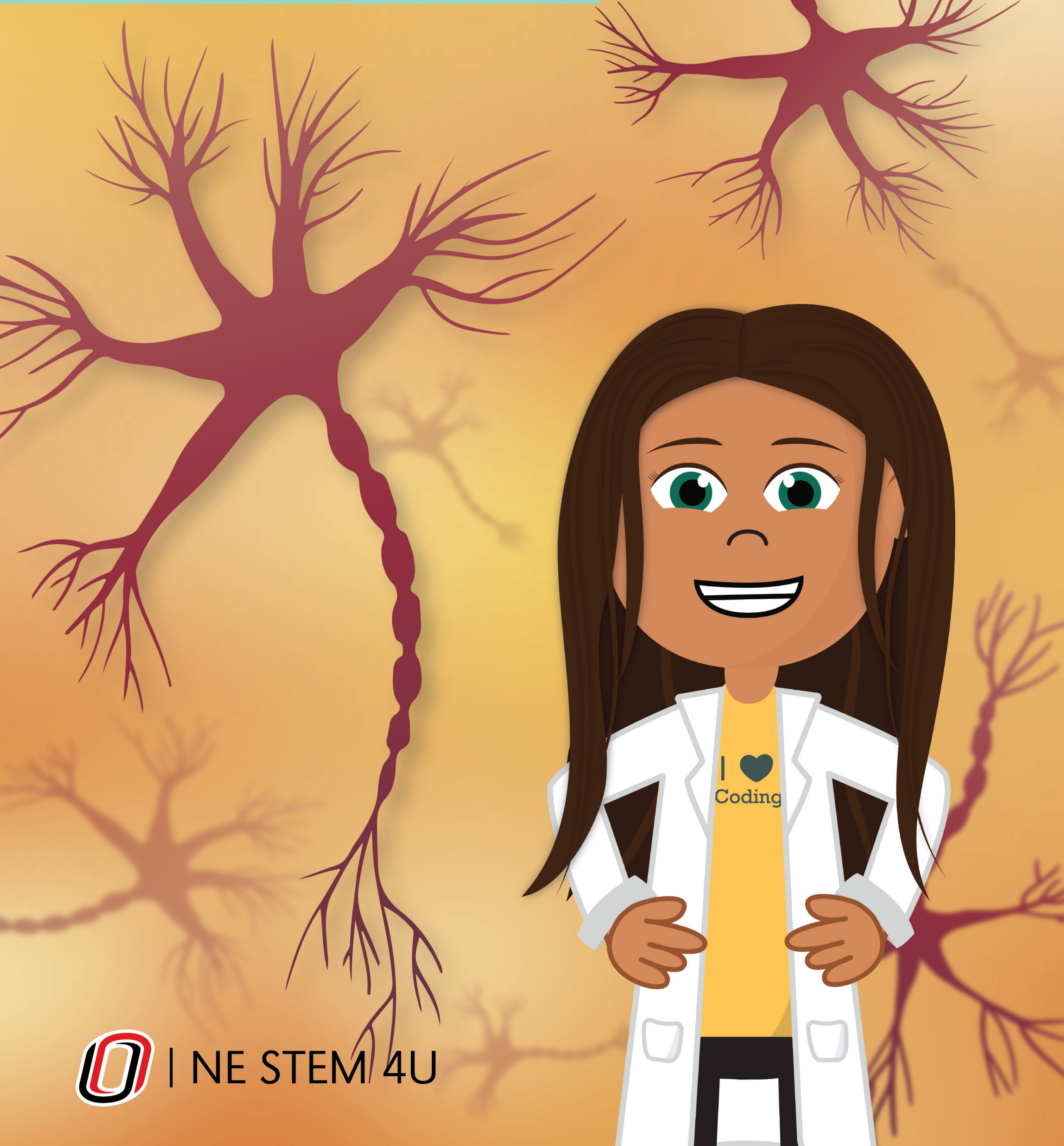
Sources

Clouds And How They Form, Center for Science Education

Cloud in a Bottle Video by Sick Science

STEM EXTRAS

Nervous About Neurons



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Nervous About Neurons

NGSS

MS-LS1-1; MS-LS1-2; MS-LS1-3

Objective

The student will understand how a neuron functions and the basic components of a neuron.

The student will be able to build and explain the key components of their own beaded neuron.

Vocabulary

Neuron: Nerve cell and primary functional unit of the nervous system. Comes in various shapes and sizes.

Dendrites: 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.

Cell body (soma): The area in a neuron where electrical charges are interpreted. Contains the DNA or genetic material of the cell and takes all the information from the dendrites and puts it into the axon hillock.

Axon: If the signal from the dendrites is strong enough, then the signal travels to the axon. The signal is called action potential at this point.

Axon Terminal: 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.

Background

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.

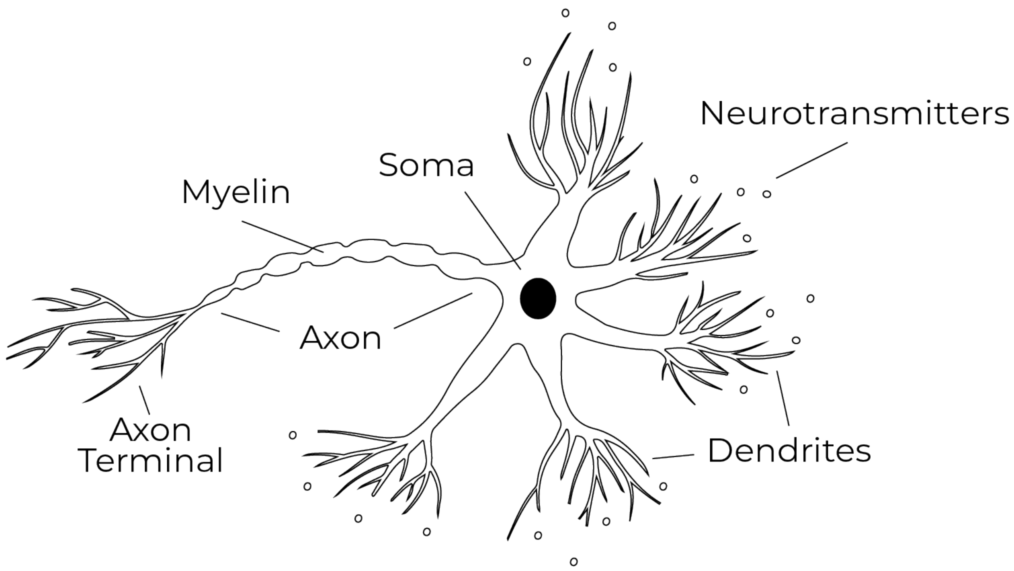
Dendrites extend from the neuron cell body and often look like "tree branches." They have contact points that allow for communication with another neuron, receiving a signal from a chemical called a neurotransmitter.

The sending and receiving of messages by neurons is facilitated by 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 to speed up the signal.

After traveling down the axon, the signal reaches the axon terminal, which, 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).

Example:
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 communicate with nerve cells, which create a signal cascade that reaches the nerve cells in your brain to indicate the painful event of burning your hand on the cookie sheet.

Diagram of a typical Neuron



Materials

Large Group:

- Rope
- Plastic containers
- Pool noodle
- Plastic Balls
- Plastic Cups

Per Group (work in pairs):

- Flexible wire
- Three assorted colors of beads

Procedure

Group Activity

1. Two large groups will build a large neuron.
2. Each group must assign roles of axon, axon terminal, dendrites, cell body, and neurotransmitters.
3. The students will work together to build and then act out the job of a neuron.
4. Both groups will work together to demonstrate how a signal transfers from one neuron to the next.

Note: The plastic container can represent the soma of the neuron, with rope portions coming off as 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.

Partner Activity

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 **must have the essential parts** (dendrites, soma, axon, and axon terminal).
2. Assign partners to build their own neuron using supplies available at the front table.

3. Provide an opportunity for partner teams to showcase their designs. Place all designs on a table and have each partner team describe the parts of their neuron.

Review what students learned and have students reflect on their thoughts on the activity.

Guiding Questions

- Why is the myelin sheath important for a neuron signal?
- What would happen if neurotransmitters were not released?
- When people are paralyzed, describe how that relates to their neurons for lack of movement or inability to feel.
- Do people with quick reflexes have neurons that fire quicker? Why?

Career/Future Application

Neurology, neuroscience; *Everything we do is dependent on neurons.*

Sources

https://www.brainfacts.org/brain-anatomy-and-function/anatomy/2012/the-neuron

https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/overview-of-neuron-structure-and-function

Institute of Neuroscience—University of Oregon

STEM EXTRAS

Constellations

Constellations

NGSS

5-ESS1-1

Objective

The student will understand what comprises a constellation, why constellations change in the sky throughout the year, and how early navigators used the stars when at sea.

The student will be able to develop their own unique constellation and differentiate between a star and a galaxy; the student will be able to describe their constellation design and the components of that constellation.

Vocabulary

Constellation: A group of stars forming a recognizable pattern that is traditionally named after its apparent form or identified mythological figure.

Star: An astronomical object that is luminous and held together by its own gravity.

Galaxy: A culmination of stars, as Earth's Sun is only one star in the Milky Way Galaxy.

Planet: Distinguished from fixed stars by moving in an elliptical orbit around a star.

Moon: A natural satellite that revolves around a planet.

Solar System: Consists of the sun (a star), and its orbiting planets (like Earth) along with moons, asteroids, rocks, dust, and comet materials, among others.

Universe: Includes all stars, planets, and galaxies (of which there are billions) combined.

Background

Did you know that there are 88 officially recognized constellations in the night sky?! And of these, just over half are deemed ancient/original because they were described by early observers of the stars (the Greeks and Babylonians). Interestingly, the sky was noticed to have an astrological significance in relation to the Zodiac signs, as many of them were visible in the sky, thus their name and relative shape as a constellation were provided.

Because the telescope was not invented until the 17th century, many of the early constellations were named and coined after some of the brighter stars in the sky. More modern constellations - which filled the spaces between these brighter constellations with dimmer, less vibrant stars - were named following the invention of the telescope.

Stars are constant in the sky, just more pronounced at night. Also, due to the tilt of the Earth and in reference to the time of year, the constellations in the night sky – such as Orion the Hunter, the Big Dipper, and Polaris (the brightest star in the sky) - all change their relative positions. This is observable with the change in seasons. Additionally, the night sky in the Northern Hemisphere looks very different than that of the Southern Hemisphere (below the equator).

Navigation has been an important tool for moving, whether by land or sea for many centuries. The earliest navigation methods involved using the direction of the sun and stars. Sailors used celestial navigation in the open water when landmarks could not be seen at shore. The stars, moon, sun and even horizon were all used to calculate relative position on a map, given the time of year. Therefore, navigators not only carried with them a map of the sea and land, but also one of the stars corresponding to the time of year, as different constellations were visible during different seasons or were in relatively different positions based on the time of year. It was even important to know what hemisphere one was sailing in, as familiar constellations in the Southern Hemisphere (e.g. Southern Cross) were not visible in the Northern Hemisphere and vice versa (e.g. Big Dipper). Navigators would often use a tool called a sextant to measure the angle between a constellation in the sky and the horizon to inform them of their relative location at sea.

Materials

Per student:

- LED single tealight
- Plastic cup
- Constellation sheets (5 in total)
- Rubber band
- Tape
- Pencil or pen
- Scissors

Procedure

1. Begin lesson with a community building activity, via an ice breaker question.
2. Provide an overview of the objectives for the day to the students, and begin discussing the pertinent background information.

   ****Relate to students' everyday lives. What do they see when they look up at the night sky?**
3. Encourage students to begin building their apparatus to "hold their constellation." This will utilize the plastic cup with paper taped to the top and a rubber band around it. The bottom will be cut out so that the tealight can shine to the top.

   ****Check in with students for apparatus building. Demonstrate if necessary.**
4. Then, have the students use the Zodiac Sign Indicator and Constellation key to: **determine 1) the zodiac sign for their birthdate and 2) what the constellation for their sign looks like.**
5. Students will then transfer this constellation design to **Blank #1 (in resources) to be placed on top of the apparatus.**
6. Students will share their constellation to the group. Other students observing will use the Constellations key to guess the presenter's Zodiac sign based on how the constellation lights up on the apparatus.
7. After all students have had a chance to share, provide students with the opportunity to design ANY Constellation that they would want to fill the night sky AND name it. They will use **Blank #2 (in resources)** for this portion.
8. Again, students will have an opportunity to share out the name, design, and reason for choosing their respective constellation.
9. Close the activity with a recollection of two vocabulary terms and provide students with an opportunity for reflection on the activities.

Guiding Questions

- Why do you think early travelers on boats used the stars to guide for navigation?
- What do you think would be a cool constellation?
- Why is it that the constellations in the sky change their positioning throughout the year?

Career/Future Application

NASA and other agencies working on missions to space! Looking up at a clear sky at night and being able to spot some constellations.

Sources

https://nightsky.jpl.nasa.gov/news-display.cfm?News_ID=573

https://astronomy.com/observing/astro-for-kids/2008/03/learn-the-constellations

https://www.nationalgeographic.org/encyclopedia/navigation/#:~:text=For%20sailors%2C%20celestial%20navigation%20is,and%20horizon%20to%20calculate%20position.&text=Navigators%20using%20this%20method%20need,the%20sky%20and%20the%20horizon.

https://www.space.com/15486-night-sky-constellations-names.html

Aries

Taurus

Leo

Virgo

Gemini

Cancer

Libra

Scorpio

Sagittarius

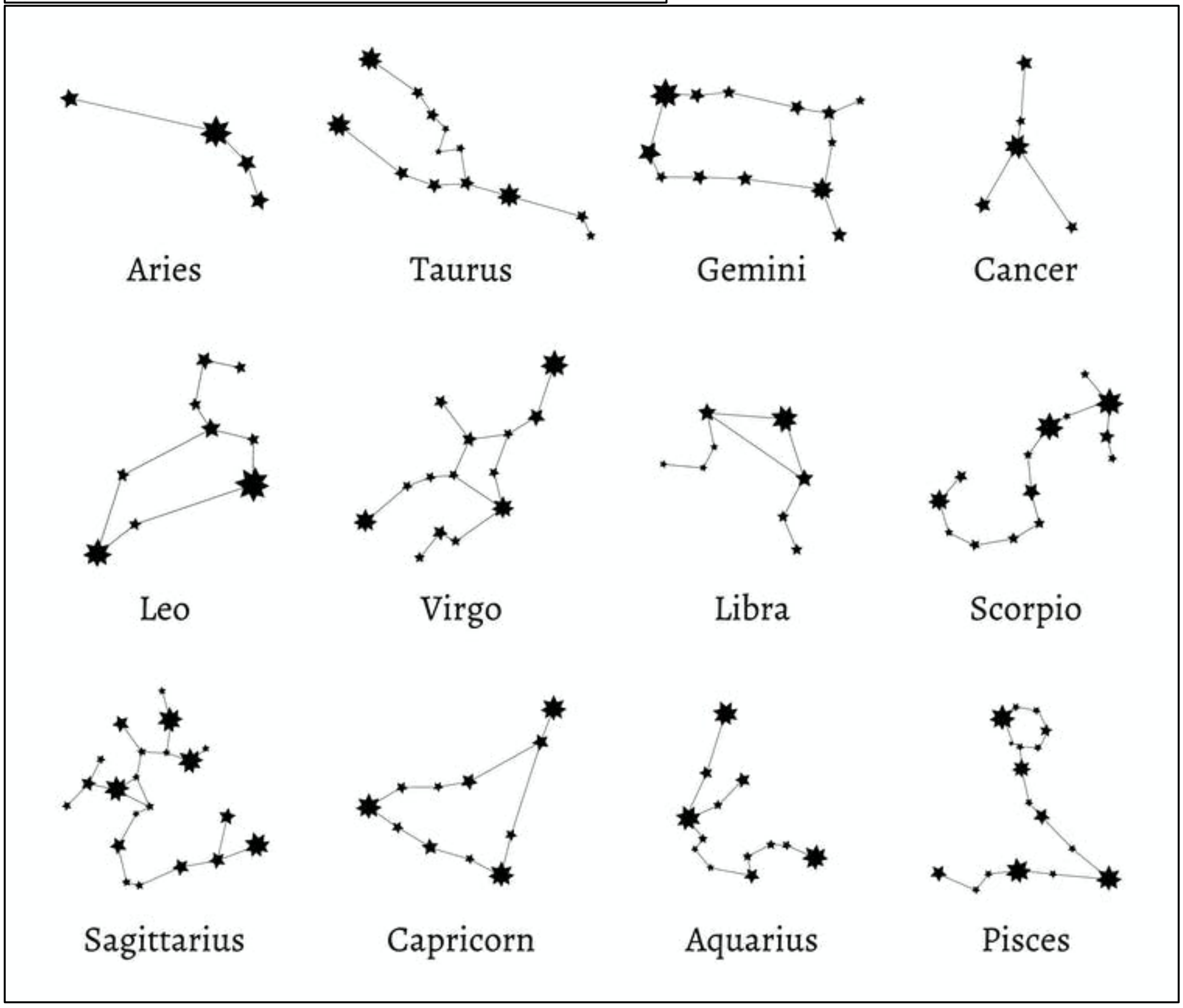
Capricorn

Aquarius

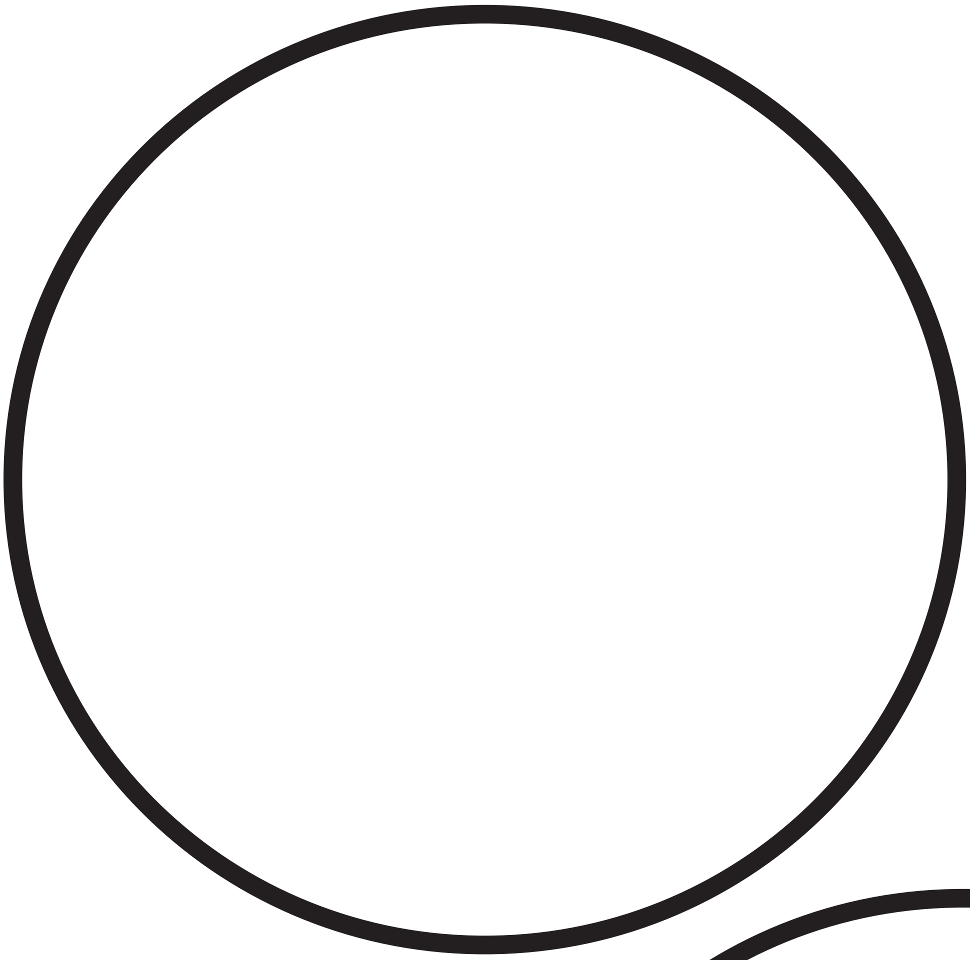
Pisces

Zodiac Sign Indicator	
Zodiac Sign	**Birth Date Range**
Aries	Mar 21 - Apr 20
Taurus	Apr 21 - May 20
Gemini	May 21 - Jun 21
Cancer	Jun 22 - Jul 22
Leo	Jul 23 - Aug 23
Virgo	Aug 24 - Sep 23
Libra	Sep 24 - Oct 23
Scorpio	Oct 24 - Nov 22
Sagittarius	Nov 23 - Dec 21
Capricorn	Dec 22 - Jan 20
Aquarius	Jan 21 - Feb 18
Pisces	Feb 19 - Mar 20

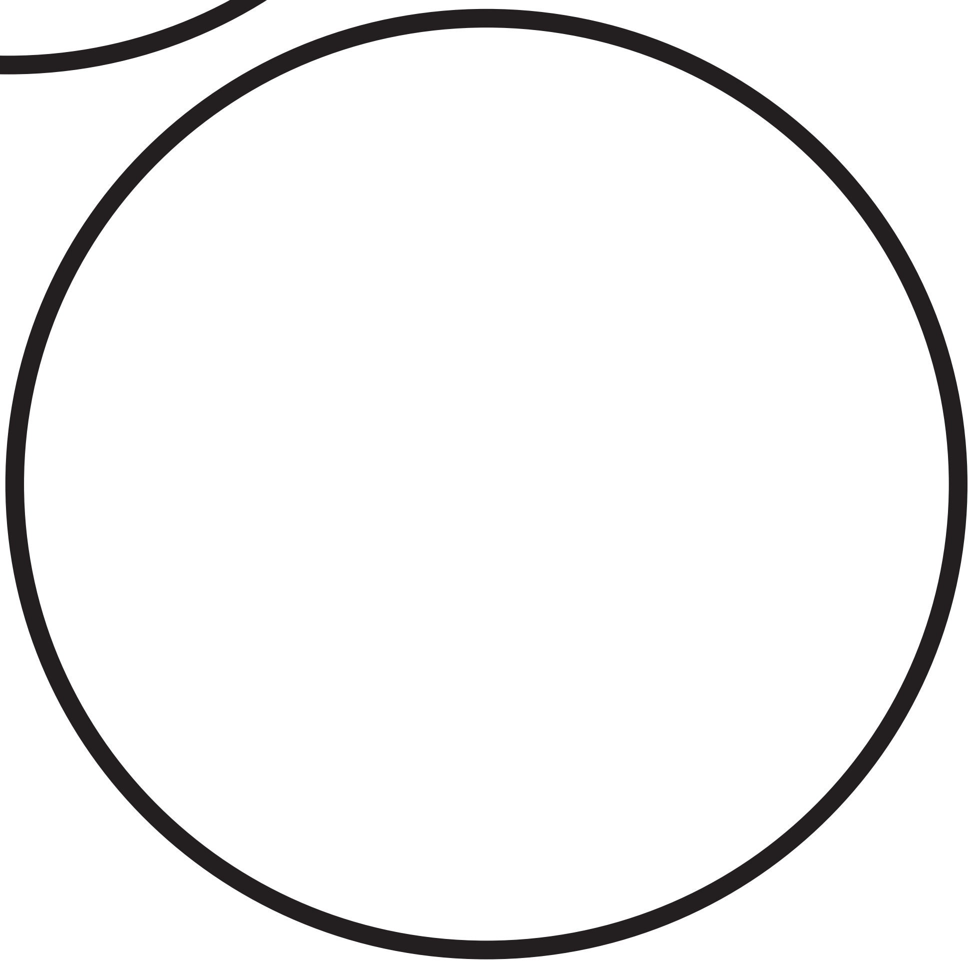
Zodiac Sign Constellations KEY



What is your Zodiac Sign?!



Blank #1



Blank #2

NETWORK SCIENCE

Fish Supply

| NE STEM 4U

Fish Supply

Objective

The student will understand how being a part of a network (e.g. different roles) influences an individual's decision-making in addition to understanding positions of power within a fish supply network.

The student will be able to identify fish transfer (and money) in a fish supply chain network while seeing how each participant's goals compete with one another and are balanced by the network.

The student will engage with NGSS Crosscutting Concept 4. *Systems/System Models.*

Vocabulary

Networks: 1) are a set of relationships 2) show how things are connected 3) reveal hidden information.

Edge: A line that connects vertices in a network and represents a relationship. Arrows can indicate the direction of the relationship between two parties. The first example below shows an undirected edge where there is no communication between the two parties, but they are connected; the second example shows a directed edge where communication only flows one way; the third example shows a bidirectional edge where communication flows two ways. For this activity, think about the deliberation for selling/ buying fish and how these interactions demonstrate these arrow examples.

Background

Scan this QR code to open an explanation of supply chain networks! →

The Fishing Industry has been around for a very long time. Many jobs are tied to the industry, including people who actually catch the fish, sell the fish, and everything in between. This includes marketing, transporting, and even farming the fish. The fishing industry has become very large and generates a lot of revenue globally. This industry has also gained popularity through viewership of reality tv shows (e.g. Wicked Tuna) amongst others, to demonstrate parts of the supply chain. Within the seafood industry, commercial fishing is a major component that highlights a supply chain.

A supply chain is expressed as the process of making and selling goods. It includes supplies and materials, manufacturers, distributors, and consumers. Supply chains are used for many reasons, and are efficient at providing the 'big picture' of the flow of a good or resource amongst various stakeholders, in addition to the intercollaboration that exists amongst various stakeholders in the supply chain.

This supply chain activity demonstrates the network of the fishing industry as a supply chain. Throughout the activity, students are provided with different scenarios that would mimic the real world and possible situations faced by the industry. In some activities, the fish catchers are limited to the number of fish they can take, mimicked by the fact that people do not always have a good day at sea when catching fish. Also, prices may differ from wild-caught and farm-raised fish or in relation to the availability of the resource (fish). The conversations that develop in the scenarios about prices between the fish market and consumer or the fish catcher and fish market are all elements of the supply chain network at large. The network can branch out many different ways with the introduction of new stakeholders or changes in power, but will always keep the same cycled structure of a supply chain (supplier, distributor, retailers, and consumers).

***Feel free to use some of the video resources in the references section for a deeper overview of supply chains if needed! ***

Materials

For the class (Group size 4-5 students) [We recommend having enough complete sets of money and fish, so each group of four youth has their own set (e.g., 20 youth = 5 groups/sets).]

- Mini whiteboard sets or paper/pencil (to draw individual network)
- 120 paper fish (wild-caught)
- 90 paper fish (farm-raised)
- Fake Money amounts of $10s, $5s, $1s
- Facilitator chooses amount for each role to start with (must be the same)
- Fish "player cards" with rules sheet (in resources)

- Dice
- Timer
- Plastic cups (one for each fish catcher role card)
- Ping-Pong balls (one for each fish catcher role card)

Procedure

Activity – Fishing Market

1. Welcome youth and provide an ice breaker activity to promote community building amongst the students *(e.g. What is your favorite activity to do outside of the school day?).*
2. Introduce the topic of how the fishing industry and supply chains work together to create a network concept.
3. Provide youth with a quick summary about the roles in the game and that there will be a different scenario each round.
4. Have youth pick a face-down role card. This will be their role for the duration of the activity.
    a. There are four role cards:
        i. Consumers
        ii. Fish market sellers
        iii. Fish catchers
        iv. Fish policy-maker

****Note: Each role starts with 45 dollars of money, or an amount chosen by the facilitator (except for the fish policy-maker, which will have zero). [Larger denominations make the game less interesting – less ability to barter]**

5. Have the youth read their cards and then see if they have any questions about their roles.

Scenario One: No Regulation

1. Provide the rules for scenario one to the group:
    a. Fish catchers are allowed to take as many wild fish as they want from the lake. However, they cannot take more than 15 fish at once because that is the LIMIT for how many fish their boat can hold.
        i. Here is the ‘catch’: For a fish catcher to take from the lake, they must

bounce a ping-pong ball into a cup on the table in front of them (can be as close or as far away from them as facilitator chooses). IF fish catchers are unable to bounce the ping-pong ball into a plastic cup, then they had a bad day of fishing and are unable to take fish from the lake.

   b. Fish catchers will sell fish to the fish market at a price they agree upon.
   c. Fish markets will sell fish to consumers at a price they agree upon.
   d. Fish policy-maker will keep track of how many fish are caught by the fish catcher and how many fish remain in the water. They will make a graph out of this information to report out at the end of scenario one.
2. This scenario is played out for 6-7 minutes.
3. Once complete, ask individuals to draw a network of their transactions, drawing lines to the different roles or people with whom they did business and where the fish traveled through the group.
4. Have students reflect on what happened and what strategies they used.

Scenario Two: When Regulation Happens

1. Rules for scenario two are the same as scenario one, but with one ADDED piece below:
   a. Fish policy-maker rolls dice, making sure the fish catchers do not take extra fish beyond the allotted amount below. There will be 30 seconds for each fish catcher to catch fish under the fish policy. Every 30 seconds the fish policy-maker will roll the dice to determine the 'new policy' for the number of fish the fish catcher can take from the lake per successful ping-pong ball bounced into the cup. This is monitored by the fish policy-maker.
      i. Rolls 1 = Nothing, proceed as normal (can take up to 15 fish at once for a successful ping-pong ball bounced into cup).
      ii. Rolls 2-3 = Fish catcher catches 1 fish per successful ping-pong ball bounced into the cup.
      iii. Rolls 4-5 = Fish catcher catches 2 fish per successful ping-pong ball bounced into the cup.
      iv. Rolls 6 = Fish catcher catches 3 fish per successful ping-pong ball bounced into the cup.

****Note: The fish catcher can only take out fish caught as a result of a successful Ping-Pong ball bounced into the cup and per the policy constraint for the time. This is**

enforced by the fish policy-maker.

2. The scenario is played out for 6-7 minutes.
3. Once complete, ask individuals to reflect on how this scenario was different than the first. Did the network for selling or buying fish change?
4. Have students reflect on what happened and what strategies they used.

Scenario Three: When You Introduce Farm-Raised Resources

1. Rules for scenario three are the same as scenario one, but with one ADDED piece below:
    a. Fish policy-maker rolls dice, making sure the fish catchers do not take extra fish beyond the allotted amount below. There will be 30 seconds for each fish catcher to catch fish. Every 30 seconds the fish policy-maker will roll the dice to determine the 'new policy' for the number of fish the fish catcher can take from the lake per successful ping-pong ball bounced into the cup. This is monitored by the fish policy-maker.
        i. Rolls 1 = Nothing, proceed as normal (can take up to 15 fish per successful ping-pong ball bounced into the cup from either wild-caught OR farm-raised fish)
        ii. Rolls 2-5 = Fish catchers catch 4 farm raised fish from the "farm lake" after a successful ping-pong ball bounced into the cup
        iii. Rolls 6 = Fish catchers catch 2 wild-caught fish from the "main lake" after a successful ping-pong ball bounced into the cup

****Note: The fish catcher can only take out fish caught as a result of a successful Ping-Pong ball bounced into the cup and per the policy constraint for the time. This is enforced by fish policy-maker.**

2. The scenario is played out for 6-7 minutes.
3. Once complete, ask individuals to reflect on how this scenario was different than the first two scenarios. Did the network for selling or buying fish change?
4. Have students reflect on what happened and what strategies they used.

Differentiation/Extension

Encourage students to imagine what happens when there are disruptions in supply chains (e.g. reducing the number of fish) and who has more or less power to set the price in a supply chain. Encourage youth to think of examples in their own lives where the price may have gone up or supply was short (e.g. Toilet paper at the start of the Covid-19 pandemic; lumber later in the pandemic).

Thinking Prompts/Guiding Questions

Scenario 1: No Regulation

- What interactions did you have where there was two-way communication for setting a price? Who did you feel like had the most power in their role?
- How many fish were left in the lake? Would this method be sustainable to a wild population or a resource without control?

Scenario 2: When Regulation Happens

- What happened to the fish population when the fish policy-maker controlled the fishing?
- How did the interactions change based on the number of available fish for setting the price? Who did you feel like had the most power in this scenario?

Scenario 3: When You Introduce Farm-Raised Resources

- Why would a farm-raised fish population be important for the wild fish population?
- How did your original network and communication change from the first scenario to the second and then to this final scenario? Did anything change? Did you communicate buying/selling the fish differently? How so?
- What happens with non-renewable resources?
- In what ways could the supply chain be "cheated?"
- Example: Fish catcher pays off the fish policy-maker to 'look the other way' or the consumer decides to just go fishing themselves and cut out all the other people.

Career/Future Application

Environmental scientists or Fisheries scientists would be interested to know about processes that can influence overfishing, while someone involved in marketing might be interested in how different transactions take place. In healthcare, supply chain experts plan for the dissemination of vaccines to reach the people who, if vaccinated, can save the most lives. Supply chain experts use computer software and data to solve challenges such as how to get all of the equipment necessary for hospitals during disasters. It is possible to major in Supply Chain Management in college.

Job Description:

Nike Supply Chain experts ensure that every year 1.3 billion pieces of footwear, apparel, and equipment arrive at the right destination on time. That is no easy task. The complex process involves more than 60 distribution centers, a network of thousands of accounts, and more than 100,000 retail stores around the world. Supply Chain professionals constantly push for ways to make Nike's supply chain faster, more efficient and more responsive to Nike's always-changing consumer needs.

References

- 1:27 minute video and brief write up on the "power of the network" for supply chains on this web page – useful background for facilitators:

- 7-minute video by a business consultant looking at good shapes of networks and what factors influence them:

Academic Articles

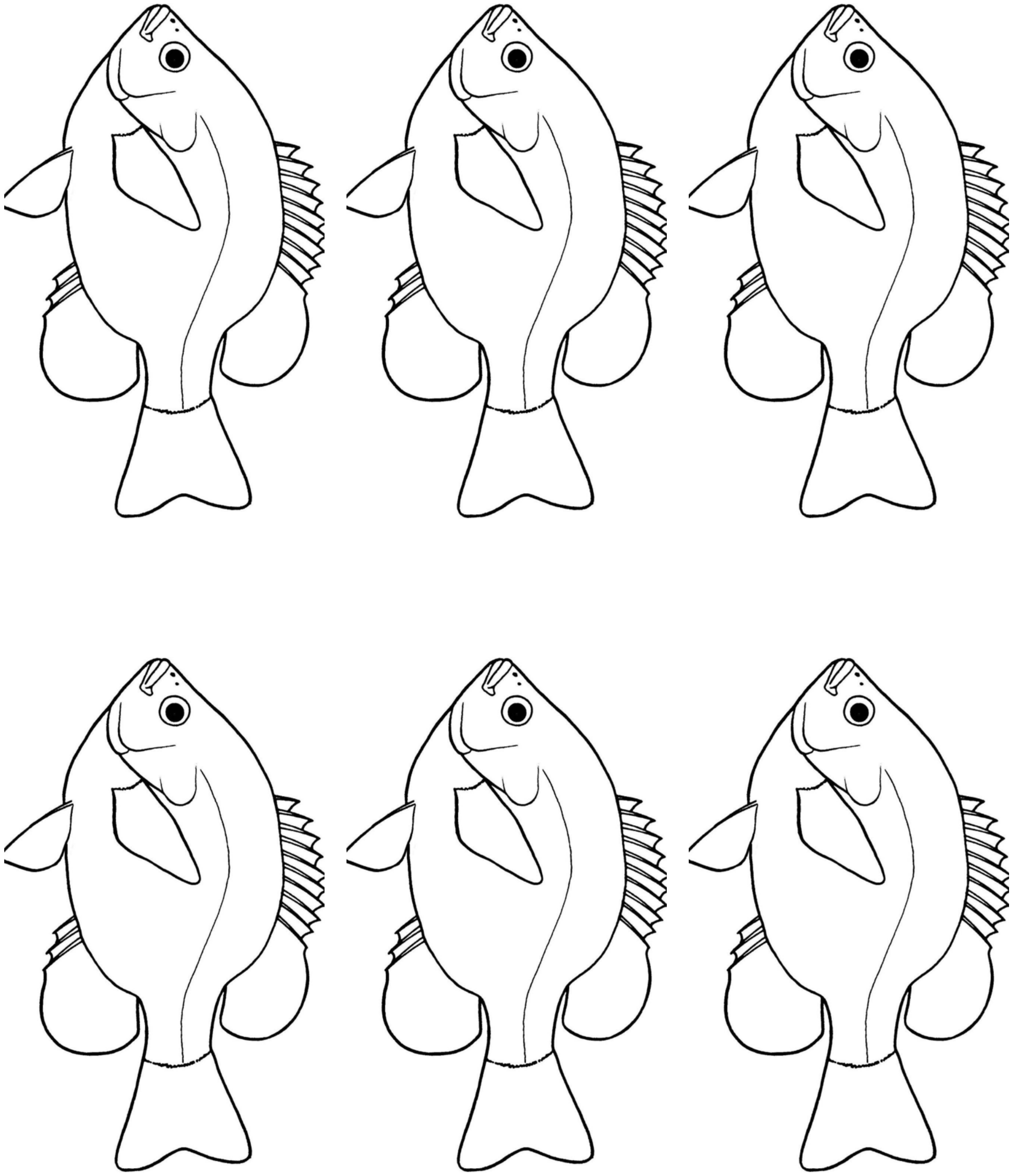
Bellamy, Marcus A. and Rahul C. Basole. 2013. Network Analysis of Supply Chain Systems: A Systematic Review and Future Research. Systems Engineering. 16:2:235-249. DOI 10.1002/sys.21238

Cramer, Mary E., Ozgur M. Araz, and Mary J. Wendl. 2017. Social Networking in an Agricultural Research Center: using Data to Enhance Outcomes. Journal of Agromedicine. 22:2:170-179. http://dx.doi.org/10.1080/1059924X.2017.1282905

Frerichs, Leah, Ozgur M. Araz, Larissa Calancie, Terry T-K Huang, and Kristen Hassmiller Lich. Dynamic Empirically Based Model for Understanding Future Trends in US Obesity Prevalence in the Context of Social Influences. Obesity (2019) 0, 1-11. d o i :10 .10 0 2 /o b y. 2 25 8 0

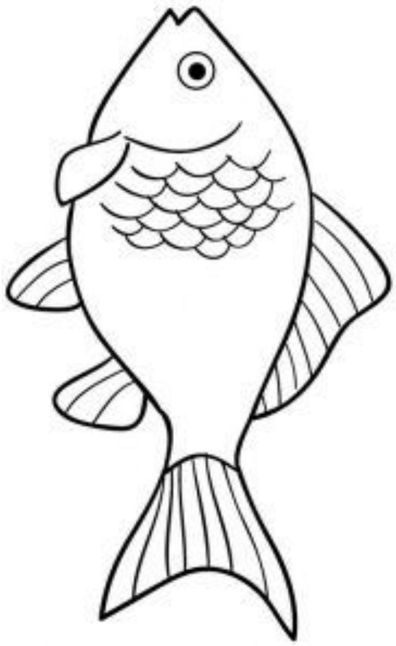
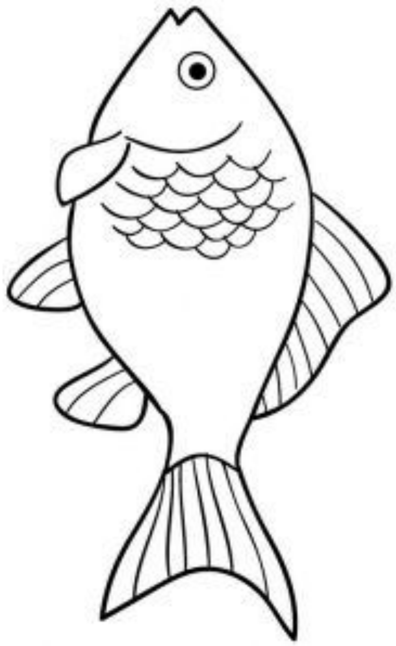
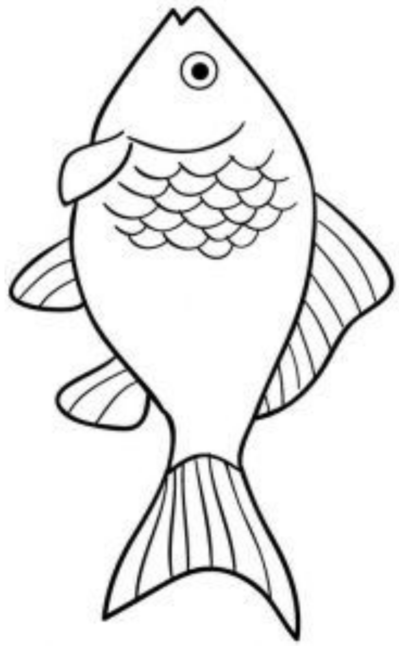
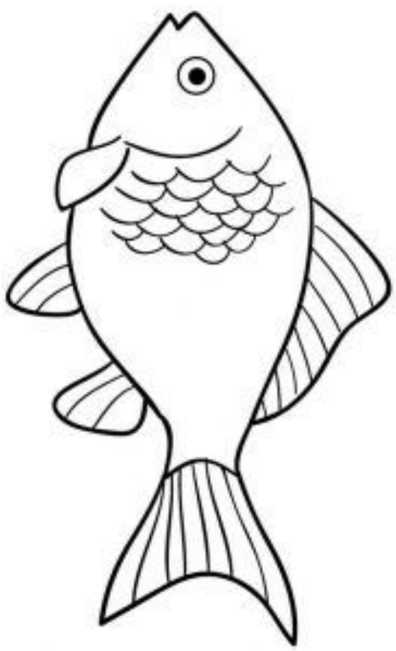
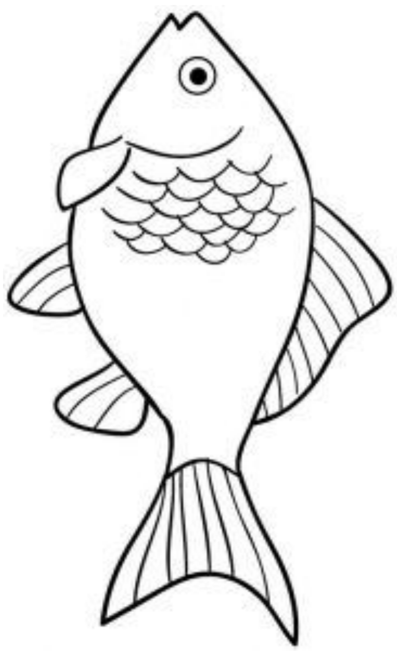
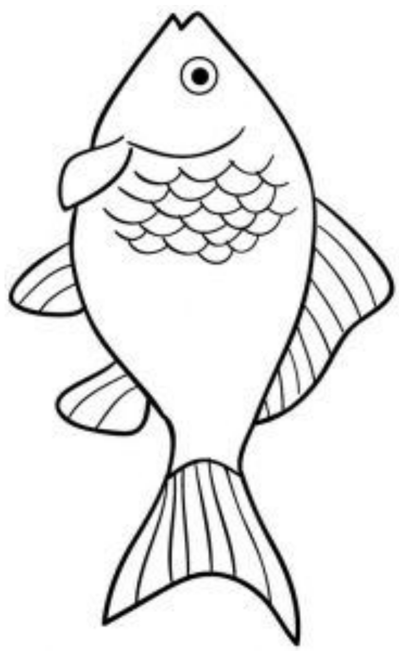
Nooy, W.D., Mrvar, A., & Batagelj, V. (2005). Exploratory social network analysis with Pajek. Cambridge: Cambridge University Press.

Rastogi, Aditya P., John W. Fowler, W. Matthew Carlyle, Ozgur M. Araz, Arnold Maltz, and Burak Burke. 2011. Supply network capacity planning for semiconductor manufacturing with uncertain demand and correlation in demand considerations. International Journal of Production Economics. 134. 322-332. doi:10.1016/j.ijpe.2009.11.006



Wild-Caught Fish Printout (20 sheets)

Farm-Raised Fish Printout (15 sheets)

The Fish Catcher:

Goal is to catch fish and make money selling fish to fish market.

Fish Fun Fact: *Operations in the Alaskan fisheries have generated a gross earning of around $455 million in one year.*

Important Rules for the Game

- *Overall Rules/ Scenario One*
  - Your boat is only so large, so you can grab a maximum of 15 fish at one time from the wild fish lake.
  - In order to grab fish, you must bounce a Ping-Pong ball into a plastic cup.
    - When you successfully do this, then you had a 'good day' of fishing and can grab fish from the lake.
    - IF you are unable to bounce the Ping-Pong ball into a plastic cup, then you had a bad day of fishing and are unable to take fish from the lake.
  - Once you catch fish successfully, you must sell the fish to the fish market role.
    - It is up to you to decide on a price with the fish market role.

- *Specific to Scenario Two:*
  - If the fish policy-maker rolls a 1 then no policy change, so proceed as normal (can take up to 15 wild fish at once for a successful Ping-Pong ball bounced into the cup).
  - If the fish policy-maker rolls a 2 or 3, then the policy is enforced that you can only catch 1 fish per successful Ping-Pong ball bounced into the cup.
  - If the fish policy-maker rolls a 4 or 5, then the policy is enforced that you can only catch 2 fish per successful Ping-Pong ball bounced into the cup.
  - If the fish policy-maker rolls a 6, then the policy is enforced that you can only catch 3 fish per successful Ping-Pong ball bounced into the cup.
  - **Pay attention** to what the fish policy-maker SAYS in relation to the current policy!

- *Specific to Scenario Three:*
  - If the fish policy-maker rolls a 1 then no policy change, so proceed as normal (can take up to 15 fish at once for a successful Ping-Pong ball bounced into the cup).
  - If the fish policy-maker rolls a 2, 3, 4, or 5, then the policy is enforced that you can only catch 4 farm-raised fish per successful Ping-Pong ball bounced into the cup

- If the fish policy-maker rolls a 6, then the policy is enforced that you can only catch 2 wild-caught fish from the main lake per successful Ping-Pong ball bounced into the cup
- **Pay attention** to what the fish policy-maker SAYS in relation to the current policy!

The Fish Market:
Goal is to buy fish from fish-catcher and sell to consumer and make as much money as possible.

Fish Fun Fact: *Seattle is home of one of the oldest public farmers market in the US that is still up and running.*

Important Rules for the Game

- *Overall Rules*
    - During each scenario it is up to you to decide on a price to buy fish from the fish catchers.
        - Be aware, they may have had a bad day fishing or may not have much to sell!
    - You must then look to sell for a profit to the fish consumer.
        - Work with the fish consumer to decide on a price to sell the fish to the fish consumer.
    - Collect as much money as possible!

The Fish Consumer:
Goal is to buy fish as cheaply as possible.

Fish Fun Fact: *Through calculations of different fisheries, the approximate global demand for fish consumption is around 144 Million tons per year. One ton is approximately 2,000 pounds…That's a lot of seafood!!*

Important Rules for the Game

- *Overall Rules*
  - During each scenario, it is up to you to decide on a price to buy from the fish market. You are a hungry customer, so you don't want to buy too expensive!
  - Be aware, there may not be a lot of fish up for sale if the fish catchers had a bad day out on the lake.
  - Look to get the best deal possible and buy the fish as inexpensively as possible from the fish market.

The Fish Policy-Maker:
Goal is to keep fish supply from being depleted.

Fish Fun Fact: *According to Marine Biologist Enric Sala, around 70 percent of fisheries are overfished. This is why it is important to have these policy-makers, to make sure these wild fish populations don't get overfished and depleted to a point that they cannot recover.*

Important Rules for the Game

- *Specific to Scenario One*
    - Keep a detailed log of how many fish are caught by the fish catcher and how many fish are remaining in the lake
    - Jot the information down on a sheet of paper and make a graph to share with the class after scenario one.
    - Who is taking the most fish?

- *Specific to Scenario Two*
    - As the fish policy-maker, you also have to ensure the population of wild fish does not run out, so you will roll the dice to determine the policy to deliver to the fish catchers.
    - Start a timer and every 30 seconds roll the dice, announce the rule to the fish catchers every 30 seconds.
        - If you roll a 1, nothing happens, have the fish catchers proceed as normal.
        - If you roll a 2 or 3, fish limit of 1!
        - If you roll a 4 or 5, fish limit of 2!
        - If you roll a 6, fish limit of 3!

- *Specific to Scenario Three*
    - As the fish policy-maker, you also have to ensure the population of wild fish does not run out, so you will roll the dice to determine the policy to deliver to the fish catchers.
    - Start a timer and every 30 seconds roll the dice, announce the rule to the fish catchers every 30 seconds.
        - If you roll a 1, nothing happens, have the fish catchers proceed as normal.
        - If you roll a 2, 3, 4, or 5, fish catchers can use the farm-raised fish and can catch 4!
        - If you roll a 6, fish limit of wild-caught fish is 2!

NETWORK SCIENCE

Ecology

NE STEM 4U

Objective

The student will understand that taking away nodes in a network (e.g. wooden block pieces) sometimes means simply changing what the network looks like and other times can lead to a total collapse of the network (breaking all of the links/ties).

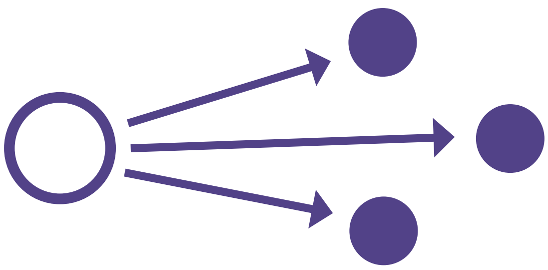
The student will be able to describe how a model (e.g. wooden block tower) gives insights to real world phenomena related to Ecology (e.g. if crickets disappear, what happens to the larger food network?).

The student will engage with NGSS Crosscutting Concept 4. *Systems/System Models*.

Vocabulary

Networks:
1) A set of relationships, 2) which show how things are connected, 3) and reveal hidden information.

Degree:
The number of lines connected to a node. The leftmost vertex (pictured below) has a degree of three:



Robustness:
Refers to the response of a network when pieces are removed. A robust network is one where the remaining network connections still maintain the function of the network when nodes are removed (i.e. pieces taken away).

Cascade (after percolation reaches a threshold):
Small changes to a network might have little to no visible impact on a robust network, until multiple changes accumulate and cause the entire system to change structure (i.e. collapse or become completely connected).

Background

Building a network using wooden blocks demonstrates that some pieces in a network are more important than others. Removing pieces of a network will change the structure, but removing the pieces that are most connected or more foundational to the network will have more significant impacts on the network. In an ecosystem network, the more connected the network, the more robust it is.

Think about ecosystems and food webs as networks with varying degrees of robustness depending upon how many connections and kinds of connections they contain (e.g. if there are "hubs" or "key links" in the chain).

In an ecosystem, one organism may rely on another for energy (e.g. predator-prey) whereas others rely upon each other not for a food source, but for notification of oncoming danger. We can model these relationships with arcs. The arrows represent the directionality of energy when the organisms are eaten. This food chain makes up only a tiny part of a network. Networks help us see the bigger picture.

At the beginning of the "Jenga" game, the wooden block network model is robust. A robust network means that the network does not change much when we take pieces away; it means the network is not as sensitive to losing nodes/vertices. Typically, in robust networks, removing nodes at random will not change the network as much compared to removing pieces with the most connections (high degree). The different impacts of removing more or less connected (higher- or lower-degree nodes) does not just happen in ecosystem networks. Removing pieces with the most connections can have a big impact in any network (e.g. if you have to close an airport hub -versus a small regional airport- because of weather, it has impacts all over the country).

Materials

Per group

- Handout
- Colored wooden block set (e.g. Jenga) with extra blocks
- Six-sided die

Procedure

Introduction

1. Distribute a handout sheet, a wooden block set, and a 6-sided die to each group (ideally 3-4 students per group).
2. Introduce the concept of ecosystems as examples of networks, with **Thinking Prompts and Guiding Questions.**

Activity One: Wildfire

3. For this round, the ecosystem is experiencing a wildfire. Students must each roll the dice to determine the degree of damage. Use the following rules:
    a. If the student rolls an odd number:
        i. Hooray, the firefighters were able to get the fire under control for minimal damage and only a little grass was destroyed! Remove 1 green block.
    b. If the student rolls an even number:
        i. Oh no, the fire is spreading uncontrollably and killing a lot of grass. Remove 2 green blocks.
    c. Every time 3 green blocks are removed:
        i. The loss of grass is hurting the grasshopper population. Remove 1 blue block.
    d. If two consecutive students roll the same number:
        i. Woohoo, the firefighters beat the fire! You won!
4. Proceed to **Activity Two.**

Activity Two: Hunter

5. For this round, hunters have entered the ecosystem. Students must each roll the dice to determine which species were eliminated. Use the following rules:
    a. If the student rolls a 1, 2, or 3: The hunters killed a prairie chicken, which led to more grasshoppers. Remove 1 yellow block. Add 1 extra blue block to the top of the stack.
    b. If the student rolls a 4 or 5: The hunters killed a coyote, which led to more prairie chickens. Remove 1 orange block. Add 1 extra yellow block to the top of the stack.

    c. If the student rolls a 6: The hunters killed a mountain lion, which led to more coyotes. Remove 1 red block. Add 1 extra orange block to the top of the stack.
6. Guide classroom discussion with **Thinking Prompts and Guiding Questions.**

Activity Three: Regular

7. This round will be ordinary "Jenga" style. Use the following rules:
    a. Students take turns removing one block and then putting that block at the top of the stack. (Students cannot take pieces from the top three rows.)
8. Guide classroom discussion with **Thinking Prompts and Guiding Questions.**

Activity Four: Insecticide

9. Introduce a scenario in which the use of insecticide to protect farmers' crops is eliminating the grasshopper population.
10. Ask students to consider how this would affect the other parts of the ecosystem and to develop a set of rules for gameplay.

Thinking Prompts and Guiding Questions

Introduction

- In this food web, what is connected and how? *Ensure that students understand that all organisms are connected and interdependent, in both direct (e.g. coyotes eat prairie chickens) and indirect (e.g. if coyotes consume prairie chickens more than usual, the grasshopper population might increase, and the grass might decrease) ways.*
- What would happen if a certain organism disappeared altogether from this food web? *If a species disappeared altogether in this food web, the changes would be severe (e.g. if prairie chickens were eliminated, coyotes would not be able to live off only grasshoppers). In real life, coyotes would likely find a different food source or develop adaptations to digest different organisms over time.*

Activities One and Two – Wildfire and Hunter

- What did you observe?
- Does the removal of blocks from the bottom versus the top of the stack affect the likelihood that the structure will collapse? Does this make sense with what would happen in a real-life ecosystem?

- In the game of Jenga, removing blocks from the bottom is more risky than removing from the top. However, in a real ecosystem, nearly every organism is important (e.g. removing an apex predator would cause dramatic change throughout the ecosystem).
- What happens to the stability of the structure as you take pieces away and change their location? What ultimately causes the stack to crash?
    a. Because the structure is stable ("robust"), it can handle considerable change, until one key piece with important connections is removed, at which point the entire structure collapses ("percolation").
- Besides wildfires and hunters, what other factors could disturb a prairie ecosystem (or other type of ecosystem)?
    b. Insecticides, pesticides, pollution, oil spills, and deforestation are some examples (which are all human-made – i.e. anthropogenic!).

Activity Three – Regular

- What did you observe?
- Which pieces are most important and why? How did you decide which pieces to remove? *Blocks which singlehandedly have the most connections (e.g. the last remaining block in a row) are the most essential. Blocks that are not the sole providers of strong connections (e.g. one wobbly block in a row of three) are more expendable.*

Career/Future Application

Ecologists can use networks to study the relationships between animals in an ecosystem. For example, ecologists are interested in network characteristics such as the level of connectivity within an ecosystem and the robustness and stability of an ecosystem. There are also applications to human ecosystems (e.g. transportation, global food distribution) – people working in logistics work on these systems.

References

Ch. 8 of the book Network Science by Barabási describes the phenome we discuss in this activity as "network robustness":

Houston-Edwards, Kelsey. 2021. "The Mathematics of How Connections Become Global:

Percolation theory illuminates the behavior of many kinds of networks, from cell-phone connections to disease transmission." Scientific American.

Shows a "three-dimensional Square Lattice" (looks like a Jenga) as an illustration of how percolation works.

The concepts in this activity were adapted from the following research article:

Dunne, J. A., Williams, R. J., & Martinez, N. D. (2002). Network structure and biodiversity loss in food webs: robustness increases with connectance. Ecology letters, 5(4), 558-567.

Wildfire Jenga

For this round, the ecosystem is experiencing a wildfire. Students must each roll the dice to determine the degree of damage.

If the student rolls an odd number:
Hooray, the firefighters were able to get the fire under control for minimal damage and only a little grass was destroyed! Remove 1 green block.

If the student rolls an even number:
Oh no, the fire is spreading uncontrollably and killing a lot of grass. Remove 2 green blocks.

Every time 3 green blocks are removed:
The loss of grass is hurting the grasshopper population. Remove 1 blue block.

If two consecutive students roll the same number:
Woohoo, the firefighters beat the fire! You won!

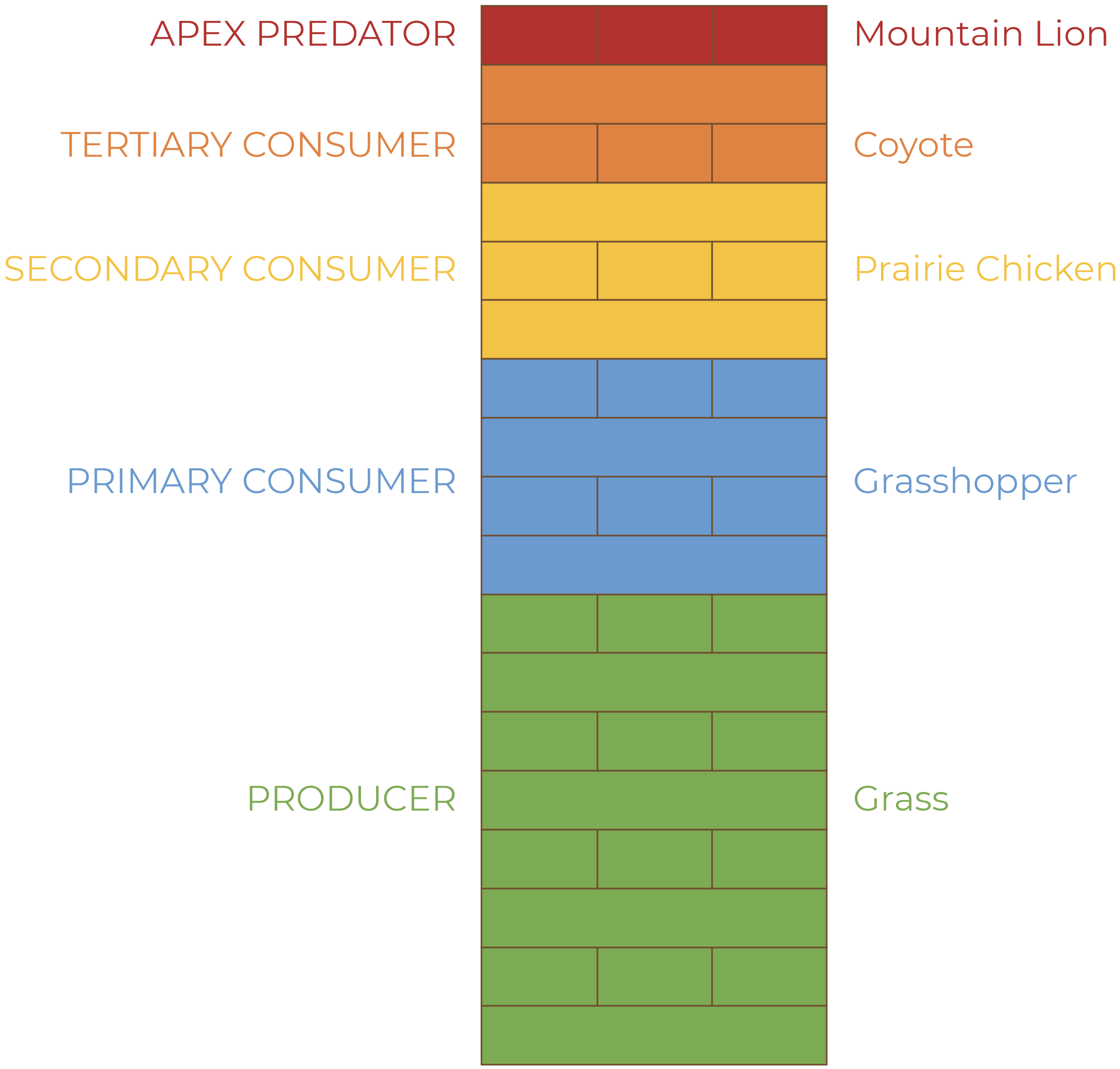
Hunter Jenga

For this round, hunters have entered the ecosystem. Students must each roll the dice to determine which species were eliminated.

If the student rolls a 1, 2, or 3:
The hunters killed a prairie chicken, which led to more grasshoppers. Remove 1 yellow block. Add 1 extra blue block to the top of the stack.

If the student rolls a 4 or 5:
The hunters killed a coyote, which led to more prairie chickens. Remove 1 orange block. Add 1 extra yellow block to the top of the stack.

If the student rolls a 6:
The hunters killed a mountain lion, which led to more coyotes. Remove 1 red block. Add 1 extra orange block to the top of the stack.


APEX PREDATOR
Mountain Lion
TERTIARY CONSUMER
Coyote
SECONDARY CONSUMER
Prairie Chicken
PRIMARY CONSUMER
Grasshopper
PRODUCER
Grass

NETWORK SCIENCE

Genealogy

Genealogy

Objective

The student will understand how network models are used by geneticists to better understand genetic inheritance.

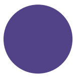
The student will be able to visualize how traits flow (or do not flow) from generation to generation by using a model family tree network, discern the direction of flow in relation to inheritance, and practice modeling the flow of inherited traits with an inheritance tree.

The student will engage with NGSS Crosscutting Concept 4. *Systems/System Models*.

Vocabulary

Networks: 1) are a set of relationships, 2) show how things are connected, and 3) reveal hidden information. Examples of networks include social networks, or the people that an individual interacts with on a daily basis, such as their immediate or extended family.

Vertex (vertices): Also called a node, usually drawn as a circle; can represent different things in a network (e.g. people, animals, cells in the body, organizations, etc.). For example, vertices or nodes in our immediate family can include any siblings, parents, or even pets.



Edges: The lines connecting vertices in a network that represent a relationship. Arrows can indicate the direction of the relationship. The first example below shows an undirected edge; the second example shows a directed edge; the third example shows a bidirectional edge.

Background

Genetics is the study of heredity and the variation of inherited characteristics. Heredity is the passing on of physical or mental characteristics genetically from one generation to another. In most cases, the inheritance of traits is dependent on probability.

Remember that family trees are a type of network. The network we create helps us understand which traits were passed down and who they came from. While humans can inherit traits like hair color and eye shape, sometimes they can inherit genetic diseases or be more likely to develop health issues because of their genetics. In most cases, inherited traits are based on probability, so tracing family networks can tell us how likely people are to have these types of diseases.

When tracing the genealogical flow of relatedness from one generation to the next one or two generations, it is easy to see how family members from different generations are connected by shared traits. When trying to trace the flow of relatedness on a larger scale - for example, across centuries or for a whole population - network science can help illustrate patterns of inheritance. For example, *why do some traits occur together*?

Genes and genetics explained:

https://www.betterhealth.vic.gov.au

“Mom vs. Dad: What Did You Inherit?” video by AsapSCIENCE and 23andMe:

Materials

Activity One – Emoji Game

Per pair

- 1 coin
- Washable markers
- Square slips of paper
- Clear tape
- Giant sticky note
- Yarn (optional—see Step 7)

Extension

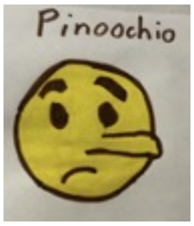
Per pair

- Hat
- Slips of paper (see Differentiation/ Extension section)

Procedure

Activity One – Emoji Game – Introduce Topic

1. Each participant should draw an emoji using markers and paper. They must have 4 traits (face shape, eyes, nose, mouth) and can take on any appearance. Encourage students to be creative. The sillier the emoji traits, the more fun this activity becomes. See examples:
2. Ask students to name their emojis, then have each student introduce their emoji to a partner. These are **Generation 1 Emojis.**
3. Hand out one coin and another paper square per pair and assign one partner “heads”



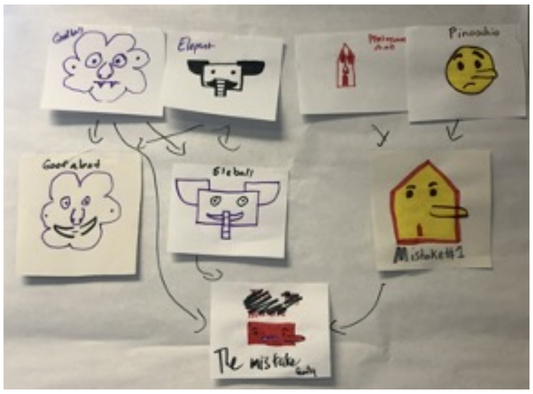
and another “tails” for the coin toss for the subsequent steps. *(NOTE: if there are uneven numbers of students, adjust the activity so that every student can participate – have some students create multiple emojis or involve facilitators within groups, etc.).*

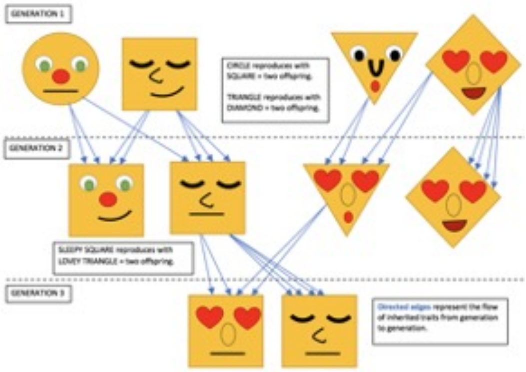
   a. Tell participants that their emojis are going to "reproduce." Youth will go through each feature (head shape, eyes, nose, and mouth) and flip a coin. Depending on which side the coin landed, that person’s original emoji feature will now belong to its offspring.
   b. Repeat the process until participants have gone through all the features.
   c. Draw the offspring of the participant 1 and participant 2 “pairing” with the new features determined by the coin flips.
   d. Repeat this process to make a second offspring. These are **Generation 2 Emojis.**
   e. Each pair of participants should team up with another pair. Flip a coin to determine which of the Generation 2 Emojis will have offspring together. Repeat the steps above to create two **Generation 3 Emojis** per team.

Activity Two – Inheritance Tree

1. After the emojis have created **Generation 3**, teams work together to build the comprehensive emoji family tree on a larger poster board or sticky note.

2. Participants should identify how certain family members are related. For example, pick two of their emojis and ask how they are related to each other; pick a trait and see how it is passed down (or not) through generations.
3. Ask them to use a marker (or tape and yarn) to draw lines representing the genealogical flow of relatedness. This way the participants will draw the network of what "flowed" from emoji to emoji and what did not. Review vocabulary of network, edge, and vertex in relation to the emoji family tree created by the groups.





4. Ask the four participants in each team to figure out if any of the Generation 1 Emojis had more influence (more traits) on the flow to Generation 3 Emojis.

Whole Class Challenge

5. As the facilitator, choose groups at random and incorporate the features of their emojis into a **long lost emoji.** The class must work together based on the traits on display to decide what Emoji Family Tree (network) the newly-discovered emoji belongs to.
    a. Ask the students to use the terms network, vertex, and edge as they figure out the potential relationships of this long lost relative.

6. After the **Generation 2 Emojis** are made, have a hat/cup prepared with slips of paper that students can draw from to add variety to the family network.
    a. Examples may include not having children, having identical twins, additional siblings, step siblings, adopted offspring, genetic diseases, etc. Ask students – "How would genetic traits flow given these additions?"

Guiding Questions

- Did anyone have any features that stuck around until the very end of your family network?
- What do the vertices (nodes) and edges (lines and arrows) in this network represent?
    Vertices represent people, lines represent relationships and arrows represent direction of relationship
- Why do you think it's important to create family networks like the ones we just created?
    Ancestry and connection, genetic traits (hair color, eye shape), inherited diseases

Career/Future Application

Genetic counseling is a process to evaluate and understand an individual or family's risk of an inherited medical condition. A genetic counselor is a healthcare professional with specialized training in medical genetics and counseling.

https://www.nsgc.org/page/frequently-asked-questions-students#what

Genetic counselors interpret results of gene analyses and help people make sense of what their genes mean for their health and the health of their children. Websites like Ancestry.com, National Geographic, and 23andMe enable people to piece together their own family networks. People can even send a sample of their DNA to 23andMe and receive information about their genetic traits and risk for certain diseases.

References

Vocabulary terms were adapted from the following text:

Nooy, W. D., Mrvar, A., & Batagelj, V. (2005). Exploratory social network analysis with Pajek. Cambridge: Cambridge University Press.

Information about genetic counseling was taken from the following link:
https://www.nsgc.org/page/frequently-asked-questions-students#what

This activity was adapted from an activity done in Dr. Eileen Hebets' University of Nebraska-Lincoln Communicating Science Through Outreach class

Examples of diseases that can be inherited through genetics.
https://www.umdf.org/what-is-mitochondrial-disease/inheritance-and-genetics/

Article: Network Medicine: A Network-based Approach to Human Disease
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3140052/

Systems genetics is an approach to understand the flow of biological information that underlies complex traits:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3934510/

Article (technical) about family trees/genealogy as "sparse" networks:
Batagelj, Vladimir and Andrej Mrvar. 2008. Analysis of Kinship Relations with Pajek. Social Science Computer Review. 26:2:224-246. <https://www.researchgate.net/publication/228978456_Analysis_of_Kinship_Relations_With_Pajek>

The background was written using definitions generated by Google dictionary.

NETWORK SCIENCE

Play Dough Liaisons

| NE STEM 4U

Play Dough Liaisons

Objective

The student will understand the basic concept of brokerage roles and their applications to health communication through gameplay.

The student will be able to demonstrate how liaisons, a form of broker, have more power than others in communication networks.

The student will engage with NGSS Crosscutting Concept 4. *Systems/System Models.*

Vocabulary

Broker: A "middle person" between two separate nodes; vertex that plays an important role in the access and sharing of information; a broker is connected to two or more nodes that are not connected to each other, so each node must communicate with other nodes through the broker. (e.g. a third party who is not the buyer nor the seller)

In the example below, the blue nodes are connected to the orange broker node but have no connection to each other; thus, they must use their connections to the orange broker to exchange information from blue node to blue node.

Liaison: A type of broker in a network in which each node belongs to a different group or category. For example, the blue node below represents a member of NE STEM 4U; the orange node, drama club; and the purple node, the soccer team. The soccer player (purple node) needs help on math homework, so they ask their classmate who is in drama club (orange node). The drama club member asks their friend who is in NE STEM 4U (blue node) for help. Thus, the drama club member is a liaison between the soccer player and the NE STEM 4U member.

Background

Brokers play an important role in the access of information and transactions. What makes a person a broker is the fact that the parties the broker is connected to have no way of communicating with each other without the broker. This gives a broker power in what they choose to do with the information they have received.

For more information, see the brokerage role sheet (Handout 2). According to the brokerage role sheet, there are five different types of brokers. The brokerage roles can all be depicted as having directed or undirected lines, except for the gatekeeper and the representative. Directed lines are used to differentiate between gatekeepers and representatives, but if the lines are undirected, then the situation depicts a broker that is both a gatekeeper and representative. Vertices that are different colors in the brokerage role depictions mean that they belong to different groups, while vertices that are the same color indicate that they belong to the same group. The second vertex in every brokerage role depiction on the brokerage role sheet is the broker. A liaison is a type of broker where everyone belongs to a different group or category. People are not always aware that they are brokers, so analyzing their social network can allow them to determine their role(s) and discover how information flows within that network.

Materials

Activity One – Liaison Game

Whole Class

- Example 1 – Brokerage Role Network

Activity Two – Play Dough Liaisons

Per group (3 students each)

- Play dough
- Play dough cut-out tools
- Folder board
- Pre-made play dough sculptures
    a. You could have the students make some shapes with play dough before starting the lesson.
    b. For the first round, use the shape in Figure A. The remaining shapes should be created by the student who was previously the sculptor before each round.
- Handout – Brokerage Roles
- Play Dough Liaisons Set-up Guide
- Handout - Play Dough Sculpture Guide

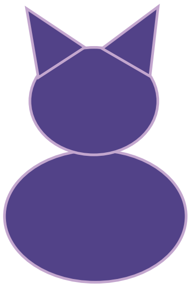


Figure A.

Procedure

Set Up

- Push desks to the back of the room. When students arrive, ask them to sit in a circle on the floor.
- Provide one pre-made play dough sculpture to each group of students for each round. Groups can have the same sculptures or different ones.
- See the set-up guide to help you set up folder boards and direct students on their roles and seating.

Activity 1 – Liaison Game

1. Do a quick (5-min) run-through of the game of Telephone with students (e.g. share a sentence with one student and have the student whisper the sentence to the next student in line; repeat until the last student hears and repeats the sentence aloud).
2. Discuss: *What are some things that can spread in a network of people? Possible examples:*
    a. Diseases
    b. Information
3. When information spreads in a network of people, some people can get more information than others and can even control who gets that information. Let's take a look at this network (Example 1 - Brokerage Roles):

    a. *If each vertex in this network represents a person and the connections represent friendship, then the different colors represent a different friend group. Which person do you think is going to be able to access the most information?*

i. The person at vertex 5 can get information from anyone because they are connected to people from the yellow group, someone from the blue group, and someone from the green group.

b. *If everyone in the green group shares with all their connections that they are giving out free ice cream at recess, how would the blue group know?*

   i. The blue group would need to get that information from the person at vertex 5. The person at vertex 5 can control where the information goes. They have power over this information because they can decide whether to tell people from the blue or yellow group.

c. *What would happen if we removed Vertex 5?*

   i. Then there would be no way for the yellow or blue group to find out about the free ice cream. Again, vertex 5 can control the flow of information. People with this power are called brokers. There are five types of brokers; today we are going to play a game and talk about two different types.

Activity Two – Play Dough Liaisons:

1. Participants sit on the floor in rows of 3.
2. Draw the following on the board to help students orient themselves and know the roles and limitations for each of the three positions (i.e. gesturer, communicator, and sculptor):

This drawing is especially helpful for the wrap-up where youth will indicate which direction the information is flowing. (See the photo above as the set up in the classroom or space of your choosing).

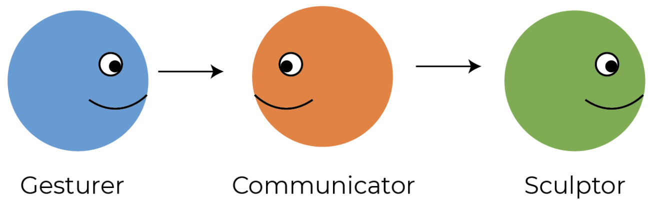
3. Game Rules:

a. There are three different roles:
    i. The **gesturer** has access to the play dough sculpture that the sculptor must replicate. (Set up a folder board to keep others from seeing the clay sculpture.)
        1. Must only use gestures to communicate what they see
        2. Must remain silent throughout the game
    ii. The **communicator** faces the gesturer and interprets what the gesturer is gesturing.
        1. May speak
        2. Must face the gesturer at all times during the game
    iii. The **sculptor** must replicate the sculpture that the gesturer sees using the information from the communicator. (Set up a folder board to prevent others from seeing their sculptures.)
        1. Must remain silent throughout the game

b. Each round should be around 5-7 minutes long. There should be 3 rounds where each person alternates roles, so everyone has a chance to play each role once.

c. At the end of each round, have students place their original sculpture next to the new creation to see how they compare. Ask them what they thought about their roles.

d. At the end of the third round, have students look at the drawing you drew on the board from the beginning of class and ask them which direction the information about the sculpture was flowing. Draw directed or undirected edges/connections depending on what the students suggest.
    i. The drawing should look like this:



4. *What do you think would happen if we cut out the communicator BUT added a direct connection between the gesturer and sculptor? Do you think it would be easier or more difficult to replicate the sculpture? Let's try it!*
    a. Tell students who were the communicators for the last round to partner up

with another communicator so that groups consist of only two people, a gesturer and sculptor.

   b. Both gesturers and sculptors should have a folder board in front of them to prevent cheating.
   c. This round should also be 5-7 minutes. If time allows, have the gesturer and sculptor switch places and play an additional round.

5. Can you think of examples of brokers/liaisons in your life?
   a. For example, if you have siblings, is one better at getting something all the kids in your family want from your parents?
   b. Can coaches be liaisons?

Differentiation/Extension

Hand out sheets depicting the five different types of brokerage roles (see Handout 2) and have youth make a list of any personal situations/movies/games where they have seen brokerage roles in action.

Guiding Questions

- Which role was harder than another? Who received information and controlled where it was shared? What would happen if we removed this person (the broker)? *Use Handout – Brokerage Roles to aid in this discussion as needed.*
    - If you remove the broker, the other two people would not be able to communicate at all. There would be no way for the sculptor to replicate the sculpture because the gesturer would have no one to transmit information to and the sculptor would have no one communicating to them about what the sculpture looks like.
- What types of miscommunications might occur if there were no liaison between two separate types of individuals?
    - *Have the students consider individuals who might speak different languages or belong to different professions.*
- Can you think of any situations in your own life where YOU were the one to receive information and control where it went? How about health-wise?
    - *Ask the students if they have ever had to communicate with a doctor on*

behalf of a family member.

- Do liaisons always have to be people? Would technological liaisons be more or less effective?

Take home messages:

- The same person in a "liaison" role has more power than when they are not in that role. Why? Because they have information that others need and cannot get another way.
- In the health field, communication is extremely important. Consider, for example, a patient, a doctor, and a pharmacist. When a patient goes to the doctor, they tell the doctor what is wrong, what kinds of allergies they have, and if they have been taking medication lately. The doctor has to communicate this information with the pharmacist, who needs to make sure the doctor does not give the patient medicine that will react to the ones they are already taking and give them the right amount of medicine to take. The pharmacist can also check that the doctor gives the patient medicine that will not cause serious side effects. The pharmacist communicates this to the doctor and then the doctor can prescribe the right medicine to the patient.

Career/Future Application

Sociologists and communication researchers can use networks to study how people interact, spread ideas, and share information.

References

Vocabulary terms were adapted from the following book:

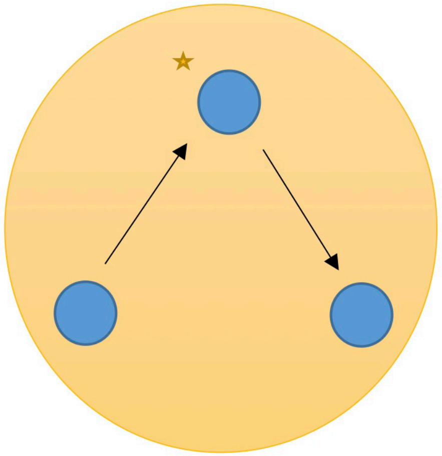
Nooy, W. D., Mrvar, A., & Batagelj, V. (2005). Exploratory social network analysis with Pajek. Cambridge: Cambridge University Press.

Chapter 7: http://vlado.fmf.uni-lj.si/pub/networks/course/ch07/Chapter7.pdf

This activity was adapted from the following source:

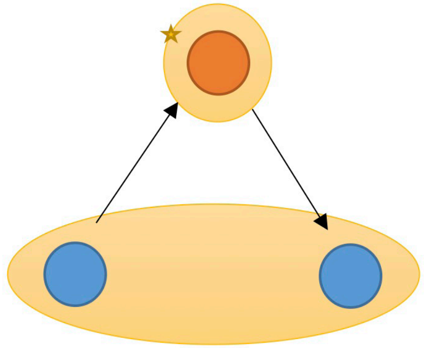
https://smallbiztrends.com/2015/09/team-building-exercises-and-games.html

Brokerage Roles



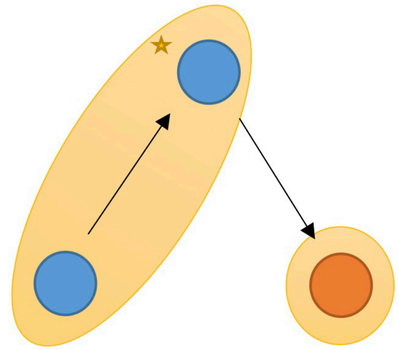
Coordinator

Someone whose job is to organize and work with others to achieve a goal



Itinerant

A person who moves place to place (moving information)

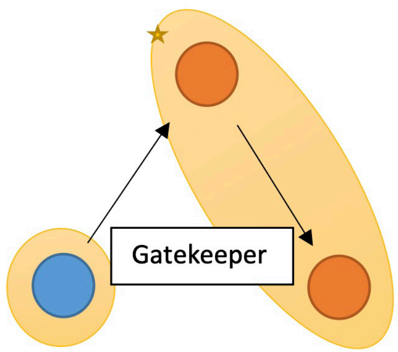


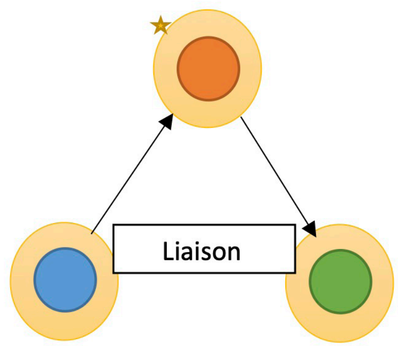
Representative

A person who represents a group of people (e.g. Mentors representing NE STEM 4U)

Someone who controls access to something (e.g. information from one group to another)

Someone who facilitates the flow of information between groups of people.





Play Dough Sculpture Guide


Figure A. Cat


Figure B. Dog

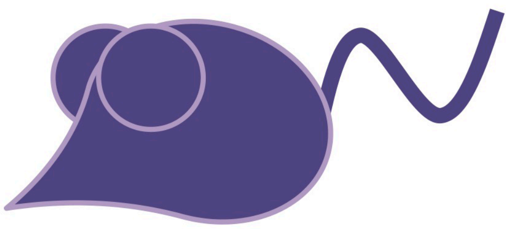


Figure C. Mouse


Figure D. Snail

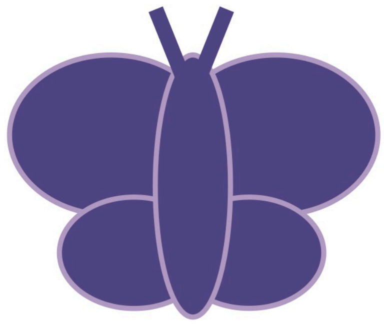


Figure E. Butterfly

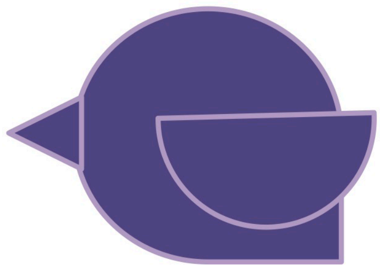


Figure F. Bird


Figure G. Cup

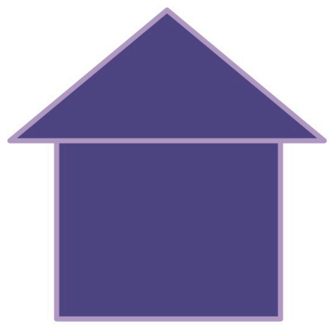


Figure H. House

FIND IT!

We challenge you to a game of **I SPY, STEM Edition.** Answer these ten questions below in regards to the cover art of each of our lesson activities in the workbook and submit your responses to nestem4u@unomaha.edu.

You never know what treasure might await IF you submit a correct response!

1. Stars make up the night sky, but just how many total stars appear on the covers?
2. Squirrels, squirrels everywhere! Find the total number of squirrels on the cover art.
3. Buzzzzzzzzzzz buzzzzzz… I am an insect and make honey, how many are there of me?
4. Let's go fishing! How many fish and crabs could you find?
5. How many times does Emily appear on a cover art?
6. An alligator AND a dragon… What lesson has these two creatures on its cover art?
7. There's smoke, it's hot, and grass is burning! Which lesson cover art am I?
8. Humpty Dumpty was an egg… How many total eggs are on all lesson cover art?
9. Goggles are an important safety device when doing some STEM experiments. How many pairs of goggles can you find on the lesson cover art?
10. How many markers can you spot on the various white boards of the lesson cover art?

How did you do? Remember to send your responses to nestem4u@unomaha.edu. A prize could await the lucky submitter!

Hands-on with NE STEM 4U: For budding STEMers in grades 4-8

Our NE STEM 4U program provides students with hands-on, minds-on engagement in STEM principals. For states and jurisdictions that utilize Next-Generation Science Standards (NGSS), our activities align as indicated within the lesson templates. We seek to foster curiosity and future focus of students by engaging them with new and fun activities in STEM and to make students aware of career opportunities across the STEM disciplines. Furthermore, we present activities that follow a standard design to couple best practices from Dimensions of Success (DoS) and the Youth Program Quality Assessment (YPQA) goals for activity quality. Many activities have projects with tangible products to “show off” and to take home to family and/or friends.

The World of Connections project is a National Institutes of Health SEPA awardee bringing Network Science related thinking and activities to the afterschool setting. The project utilized the NE STEM 4U model to engage youth in the afterschool setting in these activities found within the workbook.

The information throughout this book is a result of the collective efforts of the authors through the NE STEM 4U program over the last eight years. These activities have been developed and tested in the out-of-school time / afterschool space for K-8 learners, primarily in grades 5 through 8.

“It’s AMAZING! I’m going to do it again!” -5th grade NE STEMer

“I think this club is fun to do. One of the things I look forward to. This club helped me with my science class and also with my grade!” -7th grade NE STEMer

“The activities seem fun for youth. They have peaked the curiosity of our students!” -Elementary afterschool Site Director

Scan our QR codes to check out our website with a variety of resources and a brief video to highlight our program. STEM ON!