AKA SCIENCE

IMPACT NW

Instructor Copy

Virtual **Learning**: Session III

AKA Science is funded by our generous community partners.

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ABOUT YOUR KIT:

For the next 4 class sessions, you and your students will embark on a virtual journey of scientific discovery that explores the exciting worlds of biology, chemistry, physics, and engineering. We hope you enjoy the ride!

CLASS FLOW:

Class 1: Explore Life (Biology)

- Pre-Activity – *AKA Science Pre-Survey*
- Activity 1 – *Blooming Flower*
- Activity 2 – *Fly Feet*
- Activity 3 – *Doggy DNA*
- Activity 4 – *Strawberry DNA*

Class 2: Explore Matter (Chemistry)

- Activity 1 – *Solar Art*
- Activity 2 – *Elephant Toothpaste*
- Activity 3 – *Fantastic Flubber*

Class 3: Explore Forces (Physics)

- Activity 1 – *Pie Pan & Tablecloth Trick*
- Activity 2 – *Tightrope Balancer*
- Activity 3 – *Drag Race Cups*

Class 4: Explore Possibilities (Engineering)

- Activity 1 – *Mechanical Hand*
- Activity 2 – *Cargo (Egg) Drop*
- Activity 3 – *Knots For Your Life*
- Post-Activity – *AKA Science Post-Survey*

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GENERAL SUPPLY BAG:

The "General Supply Bag" includes supplies that are used throughout the course (i.e. used in multiple classes and activities.) Each individual class will have its own additional list of supplies needed for that day's particular set of activities. **Please remind your students to return all general supplies to the General Supply Bag at the end of each session.**

General Supply Bag contents:

- Cup (9oz, plastic punch) x 1
- Cup (1 oz, calibrated) x 1
- Crayons x 4
- Lab Notebook x 1
- Pen x 1
- Pencil x 1
- Pie tin (small) x 1
- Pie tin (large) x 1
- Scissors x 1
- Spoon x 1
- Tape (masking, roll) x 1
- Tape (scotch, roll) x 1

BEFORE YOU START:

★ Activities marked with black stars are student favorites! **Pre- and post-survey questions will pertain to the topics covered in these activities.** If you have limited time, these activities should be prioritized; please take special care to include the survey themes into your discussion of the activity.

- Discuss and establish basic science safety protocol with your students. **NOTHING from their AKA Science kit should go in their mouths, nose, eyes, or ears.** If students have younger siblings, make sure those younger siblings do not have access to the AKA Science supplies.

- Some activities involve water or other liquids. **Please make sure students are placing their laptop/Chromebook/phone in a position/place where any accidental spills will not damage their technology!**

- Lab Notebooks and pen/pencil is listed as a supply for each activity so that students can record observations and brainstorm ideas in their notebooks as they go. **Please encourage students to use their Lab Notebooks!**

- **The "The Science Behind It" sections are designed to be supplemental information for you, the Class Leader**, and the student if they are interested. **You do NOT have to read the *Science Behind It* section aloud** (unless you want to).

- The Engineering class approaches learning slightly differently; you'll notice more creative problem-solving and less prescriptive activity procedures. **For Engineering, the "The Science Behind It" section is replaced by a simple "Background"** information section. This is for the Class Leader to gain knowledge that relates to that activity's topic. You will also notice **the "Real-World Human Connection" section, which is a narrative that is <u>designed to be read aloud</u> to your students if you wish.** The Real-World Human Connection pieces are examples of engineering achievements made by people from around the world and are a great way to help your students "see themselves" in the engineering activities.

- If at any point in this class you have questions about a particular activity or an activity's supply, please don't hesitate to reach out! You may email Siira Rieschl at srieschl@impactnw.org.

CLASS 1: EXPLORE LIFE (BIOLOGY)

Welcome to Biology!

Biology is the study of life and living organisms. Biology studies everything from the teeny tiny cells in our bodies and the rainbow of plants and animals in our backyards, to the complex systems of our bodies and the big trees that make up forests.

There is so much to learn and explore in the great world of Biology! Today, you will be investigating what makes flowers bloom, how flies walk on walls, why dogs look the way they do, and what makes strawberries so unique!

But first, we will start out with a little survey to see what you think about science and what you know about Biology.

Pre-Activity: AKA Science Pre-Survey

- **Please conduct a pre-survey** at the **<u>BEGINNING of the FIRST class</u>** by asking the questions (*see next section*) and **<u>record</u> each student's response**.

- **Read each question and its possible answers aloud** as well as typing the questions/possible answers into the chat box of your virtual learning platform.

- **<u>The following are options for survey response collection:</u>**

  1. **Administer the survey in real-time during the class session. We recommend the following method:**

     a. **Have students close their eyes** or put their heads down (for anonymity among peers) and **respond to the questions by raising their hands**.

     b. **Record each student's response** (e.g. Kerry said "boring", Kevin said "fun", Kamil said "Sorta fun"). Students' responses will be compared to their post-survey responses at the end of the program to assess learning growth.

     All student responses must be passed along to Kathryn Sechrist via email at (ksechrist@impactnw.org).

  2. **If it is easier for your students, they can fill out a simple Google Form.** This can be found at **www.tinyurl.com/AKASciencePre3**.

     a. **Enter the link into the virtual classroom chatbox** and have students complete the survey then and there.
     b. **Please be sure your students complete the survey!** You might want to copy/paste the link into the chatbox several times to ensure students access the survey and give students time to complete the survey before you delve into the activities.

<u>SURVEY QUESTIONS:</u>

1. **What do you think about science?**
   a) It's fun
   b) It's sort of fun
   c) It's boring

2. **Do you like doing science experiments?**
   a) Yes
   b) Sort of
   c) No

3. **Do you want to learn more about science?**
    a) Yes
    b) Sort of
    c) No

4. **Fill in the blank: __________ is the genetic material that carries all the information about how a living thing will look and function.**
    a) Polymer
    b) **DNA (Deoxyribonucleic acid)**
    c) Hydrogen Peroxide

5. **Fill in the blank: A chemical __________ happens when one or more chemicals are changed into one or more different chemicals.**
    a) **Reaction**
    b) Diffusion
    c) Pollination

6. **When you turn the knob of a wind-up toy or pull back on a pinball ball-launch peg, what are you storing up?**
    a) Kinetic energy
    b) Gravitational pull
    c) **Potential energy**

7. **Fill in the blank: _____________ is used to develop prosthetics, artificial organs, and other medical innovations and is an example of how engineering is used to solve real-world problems.**
    a) Newton's First Law of Motion
    b) Flubber
    c) **Bio-engineering**

Activity One – Blooming Flower

Time: 5 Minutes

Supplies:

General Supply Bag	**#**
Crayon (bag)	1
Pencil	1
Cup (punch, 9 oz)	1
Scissors	1
Pie tin (small)	1
Folder	**#**
Lab Notebook	1
Paper	1
Worksheet: Blooming Flower	1

Goal: To investigate how flowers bloom by floating paper models of flowers in water.

Procedure:

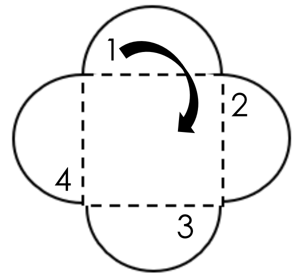
1. Start a discussion about signs that Spring is here (or near). Ask students what they know about flowers and why flowers are important.

   Discussion Prompts:
   - ***What are flowers? What kinds of flowers are there?***
   - ***Do flowering plants have flowers all the time or just certain times of year?***
   - ***What is the purpose of a flower?*** *(To reproduce by attracting pollinators or dispersing seeds)*
   - ***What are pollinators?*** *(An animal that helps plants to make fruit or seeds by moving pollen from one part of the flower of a plant to another part. This pollen fertilizes the plant. Only fertilized plants can make fruit and/or seeds, and without them, the plants cannot reproduce.)*
   - ***Why do flowers unfold their petals?*** *(In order for a bee to pollinate a flower, the flower petals must be open so the bee can reach the pollen.)*

2. Give each student a Blooming Flower worksheet
3. Students should have crayons and scissors available in their General Supply Kits.
4. Have students color their flower with crayons on the side with the dotted lines and cut it out.

   NOTE: *Only* ***color ONE side*** *of the flower only, otherwise it won't work! If crayon gets on the bottom side, it may prevent water from absorbing into the paper.*

5. <u>Ask students</u> what does a flower look like before it blooms? Depending on their responses, ensure they understand that the bud looks compact since all the petals are folded up.
6. Have students fold the "blooms" or rounded edges of their flower inward towards the center of the flower along the dotted line. Fold all of the petals this way so they overlap. It may be helpful to fold the petals going clockwise (see picture to the right.)



7. <u>Ask students</u> what they think they could do to this example of a flower bud to make it bloom?
8. Students should have a cup of water, and a small aluminum pan. Put the newspaper beneath the pan then fill the pan halfway with water.
9. Gently place the flower but onto the surface of the water so it is floating on top. Make sure the folded part of the flower is facing up towards the sky.
10. Observe for at least 30-60 seconds.

<u>Discussion Prompts:</u>

- ***What happened to the flower bud once you placed it on top of the water?***
- ***What does this tell us about what plants need to open their buds to flower?*** *(Plants need water!)*
- ***What does this tell us about how flowers get the water they need?*** *(Plants absorb water through their roots from the soil or water they live in)*
- ***Do you think you could design your own blooming flower?***

11. Students should get out their pencil and two quarter-sheets of white paper. Have students design their own flower then use crayons to decorate it. They are welcome to try the experiment again using their own flower design.
12. Facilitate a discussion about pollination while students work on their flowers:

<u>Discussion Prompts:</u>

- ***After a flower gets pollinated, what do you think happens to the seeds it makes?*** *(Typically, after a flower blooms it attracts pollinators such as bees, butterflies, and birds who pollinate the flower and help it to create the seeds it needs to reproduce. The seeds will get dispersed by wind, water, animals and once they land on the ground and germinate will grow into new plants. Living things are constantly interacting with each other and the environment; this is called an <u>Ecosystem</u>!)*
- ***How do you think flower pollination might affect you personally?*** *(Without flowers and pollinators, we wouldn't have most of the produce we eat. For example, apples, strawberries, onions, almonds, avocado, and broccoli all depend on pollination!)*
- ***What are some other animal/plant interactions we know about?***

13. Remind your students to keep their general supplies and their pie tin for future activities.

<u>The Science Behind It:</u>

Plants don't have muscles or bones to keep them upright and support their flowers. Water pressure in their cells holds them up, much like how air in a tire keeps the tire inflated. Blooming happens in much the same way. Once the flower's petals are formed, water pressure builds and builds until it pushes the petals outward. (www.wired.com/2011/03/flower-bloom-physics/)

If you are curious about pollination:

Pollination—the transfer of pollen between flowers—is part of the process that creates new seeds that make new plants. It helps produce many of the fruits, nuts, and vegetables that carry seeds inside them. Bees aren't the only pollinators; moths, wasps, hummingbirds and even the wind can help plants reproduce. Most pollinators don't realize they are helping the plants. When creatures like bees and hummingbirds feed on the nectar in flowers, the pollen sticks to them, and the pollen gets deposited inside the next flower as they move from plant to plant.

Different types of animals specialize in pollinating different types of plants. For instance, bees can't see the color red very well, so flowers that depend on bees for pollination are usually other colors. However, bees can use their sense of smell as well as their sense of sight—and they can see special ultraviolet patterns on flowers that are invisible to the human eye.

Without flowers and pollinators, we wouldn't have most of the produce we eat (e.g. apples, strawberries, onions, almonds, avocado, and broccoli!)

Activity Source: VanCleave, J. P. (1997). *Janice VanCleave's play and find out about nature: Easy experiments for young children*. New York, NY: John Wiley & Sons, Inc.

Activity Two – Fly Feet

Time: 10 Minutes

Supplies:

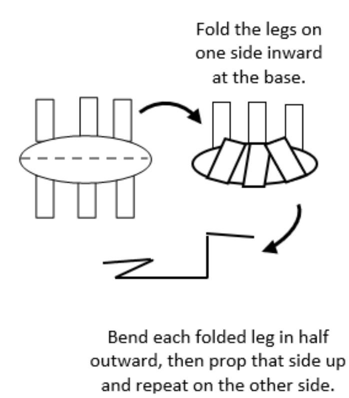
General Supply Bag	**#**
Crayons	1
Pencil	1
Cup (punch, 9 oz)	1
Scissors	1
Pie tin (small)	1
Folder	**#**
Lab Notebook	1
Paper	1
Worksheet: Fly Feet	1
Class 1 Supply Bag	**#**
Plate (9 in, paper, white)	1

Goal: To investigate how flies walk upside down by making a paper model of a fly hang upside down from a plate.

Procedure:

Ask students:

1. Ask students: *Have you ever heard the expression, "I wish I had been a fly on the wall…?" This is a phrase that means you wish you had been eavesdropping on a private conversation. But, have you ever stopped to consider how it is that flies are able to "walk" on walls, or on the ceiling? Let's find out!*
2. Students should have a Fly Feet Worksheet and scissors.
3. Have students:
    a. Cut out the fly.
    b. Fold the fly's body in half on the dotted center line, then unfold it.
    c. On one side of the fly's body, fold its legs inward at the base where they meet the body (see upper right diagram).
    d. Fold each of those legs in half outward, then prop that side up and repeat on the other side of the body (see bottom diagram).
    e. Flip the fly over so it stands on its "feet."



Discussion Prompt:

- ***How do insects defy gravity and walk upside down on the ceiling? Let's see if we can make this model fly hang upside down!***

4. Students should get out their paper plate and cup of water.
5. Lightly touch the bottoms of their fly's feet to the surface of the water.
6. Hold up the plate parallel to the ground.
7. Lightly press the fly's feet to the underside of the plate.

   Discussion Prompts:
   - ***What happened?*** *(The fly stuck to the bottom of the plate, hanging upside down!)*
   - ***Why do you think that happened?*** *(In this paper model, the adhesive property of water—which makes water molecules stick to other things—made the fly cling to the plate. For something as small and lightweight as a paper fly, the force of adhesion is greater than the downward force of gravity.)*
   - ***Can you think of a way to make a better model fly?***
   - ***How would you design your fly?***

8. If time allows, students can get out a pencil, crayons, and quarter-sheet of white paper.
9. Have students create and test their own fly models.
10. Remind students to keep their general supply kits and other supplies, such as their pie tin.

TIPS:
- **Don't color the underside of the feet.** (It could keep them from sticking).
- As a variation, students could put the plate flat on the table, set the fly on it, then pick up the plate and turn it upside down so the fly is hanging down.

The Science Behind It:

Flies can land and walk almost anywhere – on windows, walls, even hanging upside down from the ceiling. This ability to defy gravity puts them in good company, along with geckos, tree frogs, and spiders. Although fly feet were one of the first things ever looked at with a microscope, it wasn't until recently that scientists gained new insight into how they work. Flies' feet have adhesive pads with lots of tiny hairs on them (similar to geckos), and they release a fluid (different than geckos). For a long time, it was thought that the fluid made the tips of the hairs stick to the surface the fly was on, the way soggy paper sticks to things. However, recent data has caused scientists to hypothesize that the fluid might actually help flies with *un*sticking their feet. Flies sometimes make the release process easier for themselves by only setting down three of their feet at a time. (https://phys.org/news/2015-10-insect-unsticks.html, www.naturalhistorymag.com/biomechanics/172099/shoe-fly)

Activity Source: VanCleave, J. P. (2000). *Janice VanCleave's science around the year.* New York, NY: John Wiley & Sons, Inc.

Activity Three – Doggy DNA

Time: 20 Minutes

Supplies:

General Supply Bag	**#**
Crayons	1
Pencil	1
Scissors	1
Lab Notebook	1
Folder	**#**
Paper (8.5inx11in sheets, white)	2
Worksheets: Doggy DNA	1
Class 1 Supply Bag	**#**
Crayons (box of 24)	1
Doggy DNA bead bag: blue, green, red, yellow	1

Goal: To learn how DNA affects visual appearance by randomly drawing beads that represent different traits of a dog and drawing the resulting dog.

Survey Connection:

Q. ___________ is the genetic material that carries all the information about how a living thing will look and function.
A. DNA (Deoxyribonucleic acid)

Procedure:

1. Start a discussion about DNA (Deoxyribonucleic acid) and our characteristics, or traits.

   Discussion Prompts:
   - ***Why do you have your eye color? Your height? Where do those biological traits come from?*** *(You inherit them from your parents and grandparents through genes in DNA).*
   - ***Have you ever heard of DNA? What is DNA?*** *(DNA is short for* ***Deoxyribonucleic acid*** and *is the material that carries all the information about how a living thing will look and function. For instance, DNA in humans determines such things as what color the eyes are and how the lungs work. Each piece of information is carried on a different section of the DNA. These sections are called genes.)*

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2. Have students get out a piece of white paper, pencil, crayons, scissors and Doggy DNA Bead Pack (in white paper bag).
3. You are going to determine a dog's traits by picking out beads from a bag that represent its DNA. Then, based on the traits you pick, you'll draw your dog.
4. First, have students cut the top of their white paper bag, to prevent reaching past staples. Have students reach into the bag (without looking) and pick a bead. The color of the bead represents the dog's DNA sequence for body shape. Students will proceed to:
    a. Match the color of the bead to the same color in the "Body Shape" section of the worksheet. Note that the "red" beads look dark orange.
    b. Draw the body shape that corresponds to that color
    c. Put the bead back in the bag.
    d. Repeat for each trait on the worksheet. As students pick beads, they'll gradually reveal their dog's head shape, ears, legs, eyes, tail, etc.

Discussion Prompts:

- ***What does your dog look like?***
- ***Have you ever seen a dog that looks like this?***
- ***Would you get the same results if you repeated this process? Let's try again!***

5. Have students get out a new piece of paper or turn their first piece over and draw on the back side. Repeat the process of drawing their dog.
6. Ask students if their second dog looks the same as their first dog? Their second dog probably looks different. Although a few specific traits may be the same, they've been mixed with other traits in a new way. Different sequences of DNA create genetic variation, which makes each individual unique. Within the same species, most of the DNA sequence is very similar from one individual to the next. That's why both of their drawings look like dogs instead of flowers.

The Science Behind It:

DNA is like a code that determines the features of a living thing that get passed along by its biological parents. Within the code, there are sets of instructions called genes. Each gene creates proteins to help different kinds of cells do their jobs. In mammals (like dogs and humans), when a baby is born, it has a random combination of genes that it inherited from its mom and dad. The baby's specific mash-up of genetic information is what makes it unique! Within a given species, though, any individual is only *somewhat* unique. For instance, all humans are more than 99% genetically similar to each other—and we share almost as much genetic code with chimps! The observable traits of a living thing are known as its phenotype. Eye and hair color, flower size and shape, and stripes or spots on fur are all phenotypes. Phenotypes are often caused by DNA (i.e., by a living thing's genetic code); however, a change in the environment can also change an organism's phenotype. For instance, flamingos are naturally white, but the food they eat (shrimp) gives them their famous pink color. (evolution.berkeley.edu/evosite/evo101/IIIA1Genotypevsphenotype.shtml, https://ghr.nlm.nih.gov/primer/basics/gene, www.ducksters.com/science/biology/dna.php, www.scientificamerican.com/article/tiny-genetic-differences-between-humans-and-other-primates-pervade-the-genome/, http://kidshealth.org/en/kids/what-is-gene.html)

Activity Source: *A Recipe for Traits,* Genetic Science Leaning Center, University of Utah

Activity Four - Strawberry DNA

Time: 20 minutes

Supplies:

General Supply Bag	**#**
Cup (calibrated)	1
Cup (punch, 9 oz, plastic)	1
Pencil	1
Lab Notebook	1
Class 1 Supply Bag	**#**
Filter (coffee, round)	1
Isopropyl Alcohol container	1
Salt (straw tube)	1
Soap (straw tube)	1
Strawberry (freeze dried, bag)	1

Goal: To learn how scientists can extract DNA to study genes.

Survey Connection:

★

Q. ___________ is the genetic material that carries all the information about how a living thing will look and function.
A. DNA (Deoxyribonucleic acid)

Procedure:

1. **NOTE:** this activity works best when the isopropyl alcohol is slightly chilled. If possible, have students put their isopropyl alcohol container in a freezer at the beginning of your class.
2. Begin a discussion about DNA.

   Discussion prompts:
   - ***What did we learn about DNA in our last activity?***
   - ***Do all living things have DNA?*** *(We learned that dogs have DNA, humans have DNA, but also all living things have DNA—even plants such as fruit!)*
   - ***Can we see DNA with our bare eyes?*** *(Usually we can only see DNA with a high-powered microscope, it is microscopic!)*
   - ***How could we see DNA with our bare eyes?*** *(If we put so much DNA together, it will be big enough to see)*

3. Tell students that today they'll be looking at the DNA from strawberries. Have your students take out their freeze-dried, powdered strawberry in their plastic bag.

4. Gently put in one oz of water using the calibrated cup from the General Supply Kit and carefully seal the bag. Let this soak for a minute.
5. Explain that strawberries in this activity are freeze-dried and powdered. This allows the strawberry cells to spread out, so our solution can access them more easily. The freeze-drying process doesn't influence the strawberry cells themselves.
6. Pour in your soap.

   Discussion prompt:
   - ***What does soap do? Why do we wash our hands with soap?*** *(It helps get dirt and grime off!) The soap breaks down the lipids (fat) that surrounds the cells, with one end of the soap molecule attracted to the fat and one end attracted to the water; this is similar to our Milk Motion activity (in Virtual Kit II).*

7. Pour in your salt. Explain that the salt helps the strawberry DNA clump together (precipitate).
8. Let this soak for about a minute. Massage very gently.
9. Put your coffee filter over your 9 oz cup. Either gently pour your mixture on top of the coffee filter, or keep your Ziploc bag closed, and gently cut a hole in a bottom corner of the bag and let the mixture pour onto the coffee filter.
10. Let the strawberry mixture trickle through the coffee filter. If this takes a while, you could (gently) squeeze the coffee filter! If chunks of strawberry end up in the cup, that is totally fine—it might just be difficult to see what particles are DNA and what are strawberry fibers.
11. When the strawberry mixture has filtered through the coffee filter, have your students pour your isopropyl alcohol VERY gently into the cup. The goal is to disrupt the strawberry mixture as little as possible. If you're able to pour the isopropyl alcohol on the edge of the inside of the cup, this might help. Wait up to five minutes, and you should be able to see a white clump form! They can take their pencil and gently scoop it out to examine further.

    Discussion Prompts:
    - ***Why did we add the isopropyl alcohol?*** *(isopropyl alcohol can then separate the DNA from the rest of the cells)*
    - ***What do you think this is?*** *(It's DNA!)*
    - ***Why can we see this DNA, even though DNA is microscopic?*** *(We lumped so much DNA—without the rest of the cells—together that it was big enough to see)*
    - ***What else do you think we could use to extract DNA?***

The Science Behind It:

DNA (deoxyribonucleic acid) is the blueprint, or instructions, for cells to build living organisms. All living organisms have DNA. How can we see something that is *microscopic* (so small, we would normally need a microscope to see it)? If you piled all your clothes on top of a dresser, it would look a lot bigger than if you organized your clothes neatly in the dresser. We are doing the same thing with DNA. DNA is highly organized and compact in a double-helix form. With our procedure, we took all of the DNA from the strawberry cells, chemically "chopped" it up, and clumped it together. By making DNA disorganized and lumping it all together, we can see it with our bare eyes! If we were able to unravel our

DNA and stretch it out from just one human cell, it would reach 6 *feet*. If we unraveled and lined up all our DNA from all the cells in just one human body, it would be over 10 billion miles, ***longer than the distance from Pluto and back!***
Why strawberries? Strawberries are the perfect fruit to use during this experiment because they are *octoploid*. This means that each type of their DNA chromosomes have 8 copies (humans usually have two sets of each chromosome, making us *diploids*!). This means that we are able to see strawberry DNA much easier than if we used another fruit. You can easily use fresh or frozen strawberries—just make sure to spread it out by mashing in a plastic bag! If you have extra supplies, try with other (once) living things such as blueberries or bananas. You may find evidence to confirm that strawberries work the best. Or, swishing around Gatorade in your mouth for 30 seconds and gently chewing your cheeks, you could extract your own DNA!

Activity Sources: https://www.scientificamerican.com/article/squishy-science-extract-dna-from-smashed-strawberries/, https://www.stevespanglerscience.com/lab/experiments/strawberry-dna/, https://imb.uq.edu.au/strawberry-dna-extraction-activity & https://scienceaces.wordpress.com/2015/06/18/biotechies-bucket-biology-on-the-cheap-gatorade-dna-extraction/ (extracting your own DNA using Gatorade!)

CLASS 2: EXPLORE MATTER (CHEMISTRY)

Welcome to Chemistry!

Chemistry is the study of the properties of matter and how matter interacts with energy. Chemistry can explain all sorts of things, such as why soap gets your hands clean, why there are bubbles in soda, how medicine works in your body, and why cutting onions make you cry.

There is so much to learn and explore in the great world of Chemistry and chemical reactions! Today, you will explore solar reactions, get fizzy by creating your own elephant toothpaste, and mix up some fantastic flubber!

Activity One – Solar Art

Time: 25 Minutes

Supplies:

General Supply Bag	#
Pencil	1
Cup (punch, 9 oz)	1
Tape (scotch, roll)	1
Scissors	1
Lab Notebook	1
Folder	**#**
Index cards (4inx6in)	1
Index cards (half-size, 2.5inx3in)	1
Solargraphics paper	2
Transparency	1
Class 2 Bag	**#**
Paper towel	1

Goal: To explore a chemical reaction by developing an image on sun-sensitive paper.

Survey Connection:

★ **Q. A chemical ___________ happens when one or more chemicals are changed into one or more different chemicals.**
A. Reaction.

Procedure:

TIPS:

- **It's best to do this activity on a non-rainy day when students can go outside**. The activity will work when it's cloudy, though it works *faster* when it's sunny. If you can't go outside, it works with strong sunlight through a window.
- **Don't remove the Solargraphics paper from its package until you're ready to work with it.** (Also, don't let the paper get exposed to sunlight—including near a window—until you reach that part of the activity.)

1. Facilitate a discussion about what students might know about sunlight and chemical reactions.

   Discussion Prompts:
   - ***What is a chemical reaction?*** *(A chemical reaction happens when one or more chemicals are changed into one or more other chemicals. For example,*

washing grease off of dishes with soap and water, photosynthesis, rust, baking bread, digestion)

- ***What kind of chemical reaction do you think sunscreen is?***
- ***Are there other ways sunlight can trigger chemical reactions?***

2. Have students cut out a simple shape out of their half-size index card.
3. Make sure all students are in a shaded area of the room where there's <u>as little sunlight as possible</u> coming in from windows or skylights.
4. Students should place their Styrofoam plate <u>upside-down</u> in front of them.
5. Ready two pieces of tape.
6. <u>Tell students:</u> ***The blue side of the paper is the "active" side. It reacts with sunlight, so your mission is to keep it away from sunlight until it's time to do our experiment.***

7. <u>Have students</u>:
   a. Put their piece of Solargraphics paper on top of the upside-down plate, with the <u>blue</u> side of the paper facing up.
   b. Put their cut-out shape on top of the Solargraphics paper.
   c. Use their piece of transparency to cover both items like a clear shield.
8. Have students tape two sides of their transparency to their plate. (Only the transparency gets directly taped to the plate; the paper and shape are under it.)
9. Students should ready their full-sized 4inx6in index card and another piece of tape.
10. <u>Have students</u>:
    a. Use the index card to fully cover the transparency and block out light.
    b. Tape one of the long edges of the index card to the plate. (Run the tape parallel to the edge of the card to attach the card securely.)

11. <u>Tell students:</u> ***We're going to carry our plates to the window for this reaction! Your mission is to make sure your index card stays in place until you're in position and ready. Put one hand underneath your plate. Put your other hand on top of your index card to hold it flat and steady in case it's windy outside.***

12. <u>Gather all the items to go to the window</u>. Students will carry their plate (holding the index card flat), as well as their large pie tin full of water.

13. Talk with students about Ultraviolet (UV) light:

    <u>Discussion Prompts:</u>

    - ***Has anyone ever heard of ultraviolet (UV) light?***
    - ***Where does it come from?*** *(UV light is a form of energy that radiates from the sun).* ***We're going to use UV light from the sun for our experiment today. Let's head out!***

14. Instruct students to go to their window, to an area that's fully in the shade, but close to an area with strong sunlight. Students should hold their index card flat against their plate until it's time to reveal the Solargraphics paper.

<u>TIP</u>:
- **You may want to bring any extra pieces of Solargraphics paper with you** (in the original package with the top folded over).

15. Put the pan in the shade and make sure it is full of water.

<u>TIPS</u>:
- **Don't put anything directly over the Solargraphics paper, or it will become part of the final design.** (Also avoid accidental shadows.)

16. <u>Have students</u>:
    a. Stand in the sunny area and put their upside-down plate on the ground.
    b. Flip back their index card on its tape "hinge" to reveal the transparency-covered Solargraphics paper.
    c. Leave the paper uncovered in the sun until the paper turns <u>pale</u> blue.
    d. Once the paper is pale blue, flip the index card back into place to cover it.
    e. Bring the plate back to their pan.

<u>TIP</u>:
- **Watch for the Solargraphics paper to turn light-colored in the sun.** Pay attention to the lightness of the paper. (The reaction can take anywhere from 2-7 minutes, depending how bright or cloudy it is.)

<u>Discussion Prompts:</u>
- ***What happened to your blue paper?*** *(It got lighter in the sun.)* ***We're going to take turns "developing" the papers to see what happened with everyone's designs!***

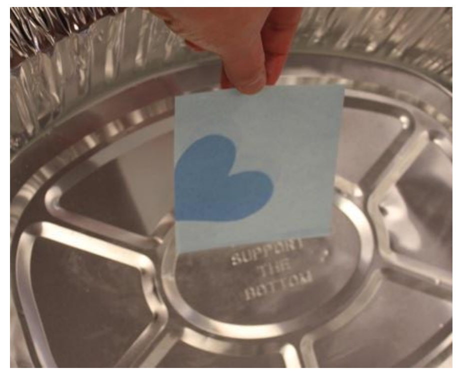
<u>TIP</u>:
- **Students who *aren't* using the water immediately should keep their index card covering their paper.**

17. <u>At the pan have students</u>:
    a. Flip back their index card on its tape "hinge" to reveal the transparency-covered Solargraphics paper.
    b. Gently remove the transparency from the underside of the plate.
    c. Set aside their cut-out shape.

<u>Discussion Prompts:</u>

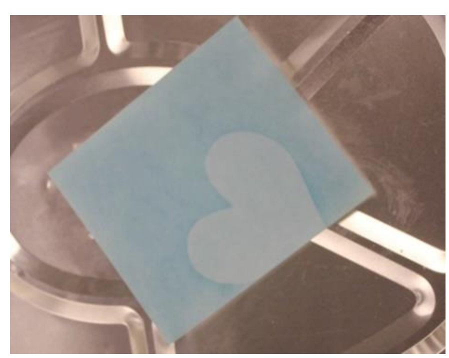
- ***What happened underneath your cut-out shape?*** *(The paper under the shape didn't change color, even though the rest of the paper got lighter in the sun.)*
- ***Why do you think that happened?*** *(Solargraphics paper has a white paper base coated with a chemical compound that's sensitive to sunlight. When the blue coating is struck by rays of UV light, it undergoes a chemical reaction that creates new molecules. The new molecules are colorless, so the white paper base starts to show through, and the paper looks pale. However, the marker blocks the sunlight, so those parts of the paper don't change.)*
- ***What do you think will happen when we put the paper in water? Let's try!***

18. Have students:
    a. Submerge their Solargraphics paper in the water.
    b. Keep the paper submerged for about 1 minute, or until the paper around the design has returned to a significantly darker shade of blue.
    c. Lift the paper up by a corner and let the water drip off over the pan.
    d. Put the piece of paper towel on top of the Styrofoam plate.
    e. Put the Solargraphics paper on top of a paper towel or plate to dry in the shade.



TIPS:
- **The Solargraphics images won't be "set" on the paper until they're developed in the water.** (The process is like developing film photos.)
- **The water might turn blue as students develop their paper (especially if they do this more than once).** The blue dye is non-toxic, but students should avoid splashing it on their clothes.
- **If you happen to develop the paper indoors, rinsing the paper under running water for 1 minute is an alternate option.**

Discussion Prompts:
- ***What happened?*** *(The light and dark areas of the paper switched places in the water!)*
- ***Why do you think that happened?*** *(When the Solargraphics paper was placed in the water, two important things happened. The parts of the paper that were blocked by the cut-out shape still had the original blue coating on them. However, that coating is water soluble, so it dissolved in the water and washed away, leaving a pale-looking design. On the other hand, the parts of the paper that reacted with the sunlight had a new, different set of molecules on them. Those*



molecules, which started out colorless, gradually reacted with the water and turned darker blue.)

19. If desired, have students gather small items with interesting shapes (like leaves, flowers, etc.) and place them on extra pieces of Solargraphics paper. Alternately, if you have a permanent marker, you could use thick lines to draw a design directly on a transparency. Arrange the materials in the shade before repeating the activity.
20. Dump out the water from the pan, and make sure your students keep all general supplies.
21. Have students wash their hands.

<u>The Science Behind It:</u>
Solargraphics paper is coated with chemicals that react to sunlight. When the paper is exposed to sunlight, a chemical reaction occurs. However, if something blocks the sunlight from reaching part of the paper, the blocked part of the paper doesn't react. Soaking the paper in water triggers a second reaction. This reaction turns the parts of the paper that were exposed to sunlight blue and leaves the rest white. This is a chemical reaction because you can't undo it: once you've soaked the paper in water, the pale parts can't turn blue again. (www.sunprints.org/how-it-works/)

<u>Activity Source</u>: *GeoSafari Solar Graphics Kit*

Activity Two – Elephant Toothpaste

Time: 20 Minutes

Supplies:

General Supply Bag	**#**
Pencil	1
Cup (9 oz, plastic, punch)	1
Cup (1 oz, calibrated)	1
Spoon	1
Lab Notebook	1
Class 2 Supply Bag	**#**
Dish soap (straw)	1
Food coloring (straw, assorted colors)	1
Gloves	1
Yeast packet	1
Hydrogen Peroxide (in 8 oz plastic bottle)	1

Goal: To explore a yeast/hydrogen peroxide reaction by having the reaction bubble over the top of a water bottle.

Survey Connection:

★

Q. Fill in the blank: A chemical ___________ happens when one or more chemicals are changed into one or more different chemicals.
A. Reaction.

Procedure:

TIPS:
- **Review the cautions about hydrogen peroxide.**
- **If preferred, you could do this activity together as a whole class.**
- **For the best/fastest reaction, use very warm (but not hot) water.**

1. Start a group discussion about things that fizz.

   Discussion Prompts:
   - ***What materials do you know that fizzes?*** *(e.g. soda, alka seltzer tablets in water)*
   - ***What do you know about yeast?***
   - ***What do you know about hydrogen peroxide?***

- ***What might happen if we mix yeast and hydrogen peroxide with soapy water? Let's find out!***

2. Students should have: a pair of gloves, an aluminum roasting pan, a packet of yeast, a 1oz cup, a paper cup, a plastic spoon, soap and food coloring.
3. Students should have a water bottle with hydrogen peroxide (this equals approximately 3oz). Put the caps on the bottles.
4. Students should also prepare a pitcher of warm water (not hot, just warm) and get their water bottle ready.

TIP:

- **The best plan is to use very warm water for this activity. It's ideal to get the water just before you're ready to do the activity. If you won't have a way to do that, though, fill the pitcher with hot water as prep (and put the lid on) so the water will still be warm by the time you're ready to use it.**

5. Have students:
   a. Dip their 1oz cup in the pitcher of very warm water.
   b. Transfer the water to their paper cup.
   c. Open the packet of yeast and dump it into the cup with water.
   d. Use the spoon to thoroughly mix the water and yeast. (It will be lumpy.)

6. While the mixture proofs (sits at least 30 seconds), remove the cap from the bottle of hydrogen peroxide and add a large squeeze of soap and a drop of each of the two food coloring colors to the bottle.
7. When you say "GO", have students:
   a. Squeeze the rim of their paper cup together to make a spout.
   b. Pour the yeast/water mixture into the bottle all at once and stand back.

   Discussion Prompt:
   - ***What happened?*** *(After a few seconds, the foam overflowed from the bottle into the pan!)*

8. Discard the bottles and paper cups in a trash can with a liner (but save the pans).
9. Have students remove their gloves, discard them, and wash their hands.

The Science Behind It:

When you mix hydrogen peroxide with yeast, the yeast causes a chemical reaction where the hydrogen peroxide molecule to break down into water and oxygen. The reaction happens so quickly that it generates foam as the air moves through the soapy water. (The name “elephant toothpaste” is just a fun way to describe the foam—there’s enough for an elephant!) (www.using-hydrogen-peroxide.com/elephant-toothpaste.html)

Activity Source: www.stevespanglerscience.com/lab/experiments/elephants-toothpaste

Activity Three – Fantastic Flubber

Time: 20 Minutes

Supplies:

General Supply Bag	**#**
Pencil	1
Lab Notebook	1
Class 2 Supply Bag	**#**
Baking soda (1 oz bag)	1
Bowl (paper)	1
Eye Contact solution	1
Gloves (pair)	1
Glue (4oz bottles, Elmer's Washable School)	1
Jumbo popsicle stick	1
Vinegar (1 oz container)	1

Goal: To explore the properties of a stretchy polymer (flubber) made from glue.

Survey Connection:

Q. Fill in the blank: A chemical ___________ happens when one or more chemicals are changed into one or more different chemicals.
A. Reaction.

Procedure:

1. Before you get started, have a discussion with your class about polymers. A great place to start is by building a foundation of understanding:
    - The term ***polymer*** is based on the Greek words *poly* and *meros,* which mean "many parts."
    - In science, polymers refer to large molecules made of small, repeating molecular building blocks called ***monomers***.
    - Polymers make up many of the materials in living organisms. For example, proteins are polymers of amino acids, cellulose is a polymer of sugar molecules, and nucleic acids such as deoxyribonucleic acid (DNA) are polymers of nucleotides.
    - Synthetic (human-made) polymers include nylon, paper, plastics, and rubbers.

    Discussion Prompts:

- ***Have you ever experimented with polymers before? For example, have you played with Instant Snow or Fortune Teller Fish? What were some properties of these polymers?*** *(Instant Snow and Fortune Teller Fish are both solids and they both absorb lots of water.)*
- ***Glue is made of polymer chains—but glue is a liquid, and it's non-absorbent. Do you think we could combine glue with something else to make a new polymer? Let's try!***

2. If any students have skin sensitivities or irritations on their hands (cuts, scrapes, etc.), have them wear gloves. (If preferred, you can have all students wear gloves.)
3. Each student should have a paper bowl and a 4oz bottle of glue.
4. Have students empty the glue into the paper bowl.
5. Fill their 1oz calibrated cup filled with .5tsp of baking soda and stir in the baking soda with their jumbo popsicle stick.
6. Have students fill their calibrated cup with contact solution to the unmarked line <u>between</u> 1/4oz and 1/2oz (this line = 3/8oz).

<u>TIP</u>:
- **Although the consistency of flubber in this activity should work for any grade level, if you want to minimize stickiness/sliminess/mess** (i.e. have flubber that's more solid/stiff before students start playing with it), suggest a full 1/2oz of contact solution in the bowl instead of 3/8oz.

7. Carefully pour the contact solution into the bowl and stir.
8. <u>Stop</u> stirring as soon as it starts to ball up and form a glob.

<u>TIP</u>:
- **The glue will stick to the sides of the bowl at first, but keep mixing the contact solution into the glue.**
- **<u>Stop</u> stirring once a glob forms.** (This happens within about 5 stirs.)

9. Have students observe their newly-formed glob for about 60 seconds <u>without</u> stirring *(this is important to let the glob to gel & makes it much easier to handle)*.
10. Then continue to stir the mixture until the contents of the bowl all stick to each other and stop sticking to the bowl—this is flubber (also known as slime or polymer putty).
11. Students should prep a plate to use as a play surface.
12. <u>Have students:</u>
    a. Roll the flubber into a ball between their hands. This helps the flubber not stick to their fingers.
    b. Play with the flubber.

<u>Discussion Prompts:</u>
- ***What happens when your flubber is stretched?***
- ***What else can it do?***
- ***What happens to flubber over time as you play with it?*** *(It gets stiffer and harder to stretch.)*

13. At the end of the activity, discard the flubber in a trash can with a liner. Have any students who are wearing gloves remove them. **Have *all* students wash their hands thoroughly**.

TIP:
- **If needed, vinegar dissolves flubber from clothes, hair, carpet, furniture, etc.** For clothes, another option is to soak the affected area with dish soap and then gently rub the fabric together to remove the flubber.
- **If you don't end up needing your remaining vinegar to dissolve stuck-on flubber, you could put some flubber in a bowl, add vinegar, and stir to see how the flubber dissolves.** Additionally, as a demo for comparison, you could put some flubber in a different bowl, add more contact solution, and stir to see how it makes the flubber even stiffer.

The Science Behind It:

The stretchy flubber you made is a polymer. A polymer is a substance made from long chains of repeating molecules all linked together. Unlike some polymers like Instant Snow and Fortune Teller Fish, flubber does not absorb water. You made flubber by taking glue (which contains polymer chains in a liquid state) and adding contact solution which causes a chemical reaction to occur.

The borate ions in the contact solution linked the glue polymer chains together. These woven-together polymer chains had a harder time sliding past each other (though they still had room to move). The resulting substance—flubber—is a different type of polymer!

Flubber is considered a non-Newtonian fluid. That means it's actually a fluid that flows at a different rate depending on how much force or pressure is applied to it. Another common example of a non-Newtonian fluid is Ooblek. The more pressure is put on it, the more it acts like a solid. (Newtonian fluids, on the other hand—like water—have a consistent viscosity.) Flubber has some pretty unique properties—and as you've learned in this class, identifying properties helps us understand the wild world of matter!
(www.acs.org/content/acs/en/education/whatischemistry/adventures-in-chemistry/experiments/slime.html, www.hometrainingtools.com/a/slime-recipes-project, www.stevespanglerscience.com/lab/experiments/glue-borax-gak)

Activity Source: www.creativekidsathome.com/activities/activity_19.shtml & www.elmers.com/slime

CLASS 3: EXPLORE FORCES (PHYSICS)

Welcome to Physics!

Physics is the study of matter and its motions as well as how matter interacts with energy and forces. Physics is a ginormous area of exploration! Physics investigates electricity, color and light, waves and motion, and looks at the tiniest atomic particles to the largest stars and the universe.

There is so much to learn and explore in the great world of Physics! Today, you will play with gravity, test your balance, and build two simple machines that get things moving!

Activity One – Pie Pan & Tablecloth Trick

<u>Time:</u> 15 Minutes

<u>Supplies:</u>

General Supply Bag	**#**
Pencil	1
Pie Pan (small)	1
Lab Notebook	1
Folder	**#**
Paper (8.5x11)	1
Paper (half size, 4.25x5.5)	2
Class 3 Supply Bag	**#**
Binder clips (large)	1
Cup (8oz paper)- Keep for next activity	1
Marble (small)	1
Rubber band (size 33)	1

<u>Goal</u>: To demonstrate that an object at rest stays at rest until a force acts on it by learning the secret behind the magician's tablecloth trick.

<u>Procedure</u>:

1. Ask students if they have ever heard of "Newton's Laws of Motion" or the word "inertia" and what they think they might mean.

   <u>Discussion Prompts:</u>

   - ***What is Newton's First Law of Motion?***
     - *<u>Newton's First Law of Motion:</u> An object at rest will stay at rest, and an object in motion will stay in motion unless a force acts on it. It is sometimes called the "Law of Inertia" because inertia is the resistance of any physical object to a change in its state of motion; this includes changes to its speed, direction or state of rest. It is the tendency of objects to keep moving in a straight line at constant velocity.*
   - ***Do you know any other Laws of Motion?***
     - *<u>Newton's Second Law of Motion:</u> Force equals mass times acceleration. Essentially, this means that two objects with different weights will need different forces to move them and the acceleration levels will be different. For example, it is easier to push an empty shopping cart than a full one, because the full shopping cart has more mass than the empty one.*
     - *<u>Newton's Third Law of Motion:</u> For every action, there is an equal and opposite reaction, and forces come in pairs. This means, for example, when you jump, your legs apply a force to the ground, and the ground*

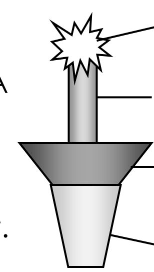
applies and equal and opposite reaction force that propels you into the air.

- ***What are some forces that might affect an object as per Newton's First Law?*** *(e.g. gravity).*
- ***Can you think of an instance where an object is in a state of rest until a force acts up on it? For example, what happens if you are holding a basketball then let go of it?*** *(Gravity pulls it to the ground!)*

2. Students should prepare one half-sheet of paper, rubber band, cup, and binder clip.
3. Have students:
   a. Roll one half-sheet of paper into a short cylinder (about the diameter of a golf ball) and put a rubber band around it so that it makes a paper tube.
   b. Fold the silver parts of the large binder clip against the black base. Put the binder clip in the cup with the black base at the bottom.
   c. Center the pie pan over the cup opening.
   d. Crumple the other half-sheet of paper into a ball (see diagram at right).
   e. Place the paper tube upright in the center of the pie pan, then balance the paper ball on the top opening of the tube.

Discussion Prompt:

- ***What do you think will happen to the ball if you knock the pie pan sideways? Let's try!***



4. Have students use a quick (yet gentle) sideways chop with one hand to knock the pie pan out of the way (see top photo at left). A short chop that only touches the pie pan works best. The motion of the pie pan should be parallel to the table, and the hand should rebound back after the chop (to get out of the way).
5. Allow students to practice the motion until they see a reliable result.

Discussion Prompts:

- ***What happened?*** *(The ball falls into the cup.)*
- ***Why?*** *(The ball was at rest—so it didn't want to move. When the pie pan and paper tube got knocked out of the way, there was a split second where the ball still didn't move…until gravity pulled it straight down.)*

6. Set aside all the supplies except for the paper tube (with rubber band around it).
7. Give each student a sheet of 8.5inx11in paper and a small marble.

Discussion Prompts:

- ***Have you ever seen the magic trick where a magician pulls a tablecloth out from underneath a table full of plates and glasses—but nothing falls or breaks?***
- ***Do you think we could use INERTIA to perform our own magic trick?***

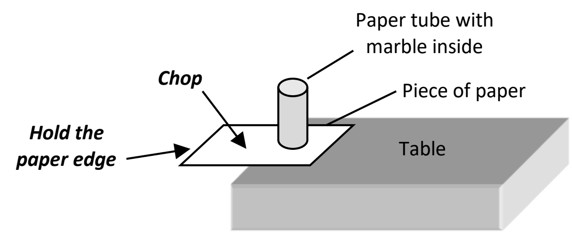
8. Have students:
   a. Lay the paper flat on the table, with about half of it hanging off the edge.

b. Place the tube upright on the table on top of the sheet of paper.
c. Slide the rubber band around the tube down toward the bottom of the tube, to help weigh the tube down.
d. Place the marble inside the paper tube (see bottom photo at left).

Discussion Prompt:

- ***What do you think will happen if you pull the piece of paper out from underneath the paper tube?***

9. Have students pull the full sheet of paper out sideways from underneath the paper tube.



Discussion Prompts:

- ***What happened?*** *(The tube fell over.)*
- ***How can we use INERTIA to keep the paper tube from falling over?***

10. Have students reset the paper, marble, and tube. Hold the loose edge of the paper level with the table. With the other hand, give it a sharp downward karate chop (see diagram above and photo on next page).

Discussion Prompt:

- ***What happened?*** *(The paper tube should have stayed standing.)*

11. Students may need to try a few times to keep the tube upright. The key is to chop the paper quickly *down*, not pull it sideways.
12. For more of a challenge, have students try to keep the tube upright without using the marble. For less challenge, leave more of the paper hanging off the table.

Discussion Prompt:

- ***Why does it work?*** *(At low speed, the force of friction between the paper and tube was stronger than the tube's inertia, so the tube fell over. With the downward chop, though, the paper moved faster. At high speed, the tube's inertia was greater than the force of friction, so the tube stayed still.)*

13. Make sure to have students keep their paper cup and general supplies.

The Science Behind It:

Remember that **Newton's First Law** is about inertia—an object at rest stays at rest until something acts on it. When you hit the pie pan, your hand forced the pan and tube to fly sideways. Why didn't the paper ball go flying sideways as well? Because it was at rest and wanted to stay at rest! It only moved downward because gravity pulled it down once it had nothing to rest on.

With the tablecloth trick, when you tried pulling the paper from under the tube, the friction between the two was enough to overcome the tube's inertia and make the tube fall over. When you karate chopped the paper, your hand forced the paper to move down and out from underneath the tube very quickly. There was much less friction from the paper, and less force on the tube. There wasn't enough force to overcome the tube's inertia, so it stayed still while the paper moved. This is the same trick magicians use when they pull a tablecloth off a table full of dishes. Can you think of another way to use this trick? (https://www.grc.nasa.gov/www/k-12/airplane/newton1g.html, http://www.physicsclassroom.com/class/newtlaws/u2l1a.cfm, www.electronicsteacher.com/succeed-in-physical-science/motion/newtons-laws-of-motion.php)

Activity Source: http://www.stevespanglerscience.com/experiment/egg-drop-inertia-trick & http://www.stevespanglerscience.com/experiment/trick-with-tablecloth

Activity Two – Tightrope Balancer

Time: 10 Minutes

Supplies:

General Supply Bag	#
Pencil	1
Lab Notebook	1
Class 3 Bag	**#**
Nuts (metal hexagons)	2
Pipe cleaners (full size)	1
Popsicle sticks (jumbo)	1

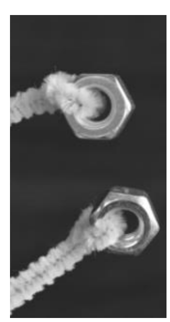
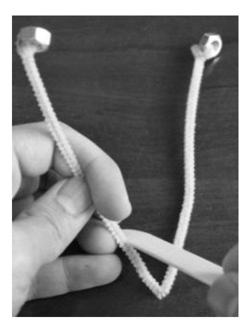
Goal: To observe how changing an object's center of gravity affects its balance using a popsicle stick and a pipe cleaner with weights on the ends.

Procedure:

1. Have students try to balance on one foot.

   Discussion Prompts:
   - ***What happens when you try to balance?***
   - ***How does your body move?***
   - ***Do you have to make some changes in the way you're standing in order to balance?*** *(Many people hold their arms out to their sides to balance, shifting their bodies and tilting their arms as needed. Rumor has it that you can place a finger on your bellybutton to help keep still!)*

2. Each student should have: two metal nuts, one full-size pipe cleaner, and one jumbo popsicle stick.
3. Have students:
   a. Slip one end of the pipe cleaner into a metal nut and tightly loop the end of the pipe cleaner to lock the nut in place. Repeat for the other nut on the other end of the pipe cleaner (see photo).
   b. Fold the pipe cleaner in half, gently. There should be an equal distance from each nut to the center of the pipe cleaner.
   c. Place the flat part of the jumbo popsicle stick on the fold that marks the midpoint of the pipe

cleaner, about an inch from one end of the popsicle stick. Make sure the popsicle stick is pressed flat against the pipe cleaner (see photo).

d. Wrap one side of the pipe cleaner tightly around the stick until it loops back to where it started. Repeat for the other side of the pipe cleaner in the opposite direction. The "arms" of the pipe cleaner will be shorter, but each nut should still be an equal distance from the popsicle stick.

Discussion Prompt:

- ***You've just built a Tightrope Balancer! How can you get it to balance on just one finger?***

3. Allow students time to explore points of balance on the stick.

Discussion Prompts:

- ***What worked the best?*** *(Placing a finger under or near the pipe cleaner probably had the best results.)*
- ***The point where the Tightrope Balancer can balance on your fingertip is called its center of gravity. Do you know why it's called that?*** *(Every object has a point where it will balance—a point where its weight is equally distributed on all sides. That point is its center of gravity because it's the center where gravity pulls down on all the parts of the object equally!*
- ***Does the Tightrope Balancer work if you put your finger under the popsicle stick in the inch of space between the pipe cleaner and the end of the stick?*** *(No!)* ***Why not?*** *(Because that's not where its center of gravity is.)*
- ***Do you think you could change its center of gravity by adjusting the pipe cleaner "arms?" Try it!***

4. Guide students through bending and rearranging the pipe cleaner "arms" until they can get the Tightrope Balancer to balance with a fingertip under the inch of space between the pipe cleaner and the end of the stick.

TIP:	• The best way is to push the arms forward (toward the nearest end of the stick) so the arms and stick form a "Y" shape when the stick is flat on a surface. When the stick is balanced on a fingertip, the weight of the nuts will naturally pull the arms down below the stick.

Discussion Prompts:

- ***How can the whole thing balance on such a small point?*** *(The metal nuts at the ends of the pipe cleaner add extra weight to the arms. By moving the arms and changing where that weight is, you can change the Tightrope Balancer's center of gravity.)*
- ***Would the Tightrope Balancer balance on its tip if it weighed the same all over?*** *(No—it wouldn't balance on its tip, since its weight would be spread out too much. The center of gravity of an evenly-weighted object is at its middle.)*
- ***How far can you tip the Tightrope Balancer over until it falls off your finger?***
- ***Can you get the longer end of the popsicle stick to stand straight up with the short end on your fingertip? Try it!***

5. Allow students time to experiment with tipping the Tightrope Balancer and rearranging its arms to create new centers of gravity.

The Science Behind It:

In this experiment, the main force you were working with (and against) was gravity! At first, when you tried to balance the Tightrope Balancer at one end of the popsicle stick, the problem was that gravity was pulling down on the entire figure at once, but your fingertip could only support one side of it. That's where the secret of the "center of gravity" came in! By changing the placement of weight in Tightrope Balancer's arms, you were able to shift the center of gravity toward one end of the popsicle stick. When you put your finger under that new center of gravity, the entire Tightrope Balancer was able to balance at one end of the stick.

Everything has a center of gravity! On humans, it's usually somewhere near your hips. When scientists try to find the center of gravity in an object, they have to use difficult calculations—but they also use familiar concepts like symmetry. An object is symmetrical if there's a place where you can split it in half and have one half be the mirror image of the other (i.e., the same size and shape, just flipped). Did you notice that your balance bird is symmetrical? Where could you cut it in half so that both halves would be the same size and shape? (https://www.grc.nasa.gov/www/k-12/airplane/cg.html)

Activity Source: www.raft.net/ideas/Gravity%20Defying%20Frog.pdf & mrguay.blogspot.com/2008/07/make-your-own-balance-toy.html & https://www.instructables.com/Impossible-Balancer/

Activity Three – Drag Race Cups

Time: 25 Minutes

Supplies:

General Supply Bag	**#**
Crayons	1
Pencil	1
Scissors	1
Tape (rolls)	1
Lab Notebook	1
Class 3 Supply Bag	**#**
Beads (plastic, pony)	1
Straw (clear, full size)	1
Lids (for 8oz cups)	2
Paper clips (regular size)	1
Rubber band chains	1
Washers (small)	1

Goal: To observe how rubber bands can store up potential energy and convert it to kinetic energy by building a set of "drag-racing" coffee cups.

Survey Connection:

★

Q. When you turn the knob of a wind-up toy or pull back on a pinball ball-launch peg, what are you storing up?
A. Potential energy.

Procedure:

1. Start a discussion about energy and how things move:

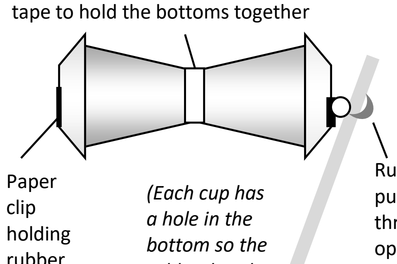
   Discussion Prompts:
   - ***Have you ever played with a wind-up toy?*** *(To use the toy, you twist a knob as far as it will go, then release it.)*
   - ***What happens when you release it?*** *(The toy moves on its own until it runs out of energy. When you wind up the toy, you are creating* ***potential energy***—*storing the energy until you release it. When you release the toy, it is propelled forward using* ***kinetic energy*** *(the stored potential energy in action!))*
   - ***Have you ever played pinball?*** *(When you pull back on the ball-launch peg, you are storing up potential energy. When you release the launch, it propels the ball using kinetic energy.)*

- ***Do you think we could make something similar using a rubber band as the wind-up mechanism?*** *Let's try!*

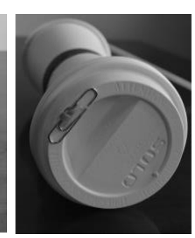
2. Students should have a rubber band chain, two coffee cups, and a pencil. They will also need either masking tape or painter's tape available (both types work).
3. <u>Have students</u>:
    a. Poke a hole in the center of the bottom of each cup. Use the pencil to widen the holes to about the diameter of a quarter.
    b. Tape the cups together, bottom to bottom, with a strip of painter's or masking tape that runs all the way around the bottoms of both cups. The holes should line up.

4. Students should prepare two lids, a paper clip, a washer, a pony bead, and a straw. They may want an extra paperclip handy as well—they should pull the outer end of the extra clip out slightly so that it can be used to poke a rubber band through a bead.
5. Pull one end of the rubber band chain through the drinking hole in one of the lids, so a little bit hangs outside the top of the lid.
6. Next, hook the paper clip through the part of the rubber band that's outside the lid.
7. Tape the paper clip to the top of the lid (on the outside) to hold the rubber band in place.
8. Put the taped lid on one of the cups.
9. Run the rubber band chain through the middle of both cups.
10. Use a pencil to pull the chain through the holes in the bottoms of the cups into the second cup.

11. Pull the free end of the rubber band chain through the hole in the second lid (from the bottom of the lid to the top).
12. Put the lid on the second cup, keeping the end of the rubber band pulled through. (Students may want to help each other in pairs with this step and the next one.)
13. Thread a washer onto the end of the rubber band. Push the washer against the lid, creating a rubber band loop sticking out of the washer.
14. Thread a pony bead onto the rubber band, next to the washer. (Students may want to share the slightly-unbent paper clips to poke the rubber band through the pony bead.)



15. Insert the tip of the straw into the rubber band loop, next to the bead (see the diagram above and the top and middle photos at left).
16. Wind up the racer by holding the cups sideways in one hand and spinning the straw around the bead. (You can place one finger at the long end of the straw and make circles with your hand to guide the straw around.)



17. Set the cups down on their sides (ideally on a flat surface) with the long end of the wound-up straw pointed toward you. Let the cups go.

Discussion Prompts:

- ***What happened?*** *(The cups rolled forward!)*
- ***Why does it work?*** *(When you wound the straw around the bead, you were also winding up the chain of rubber bands inside the cups. This stored up potential energy in the chain of rubber bands. When you released the straw, the rubber band chain started to unwind, which converted the stored potential energy into kinetic energy that made the cups move.)*

The Science Behind It:
The rubber band was used to convert potential energy into kinetic energy. For our drag-racing cups, we had a big vehicle, so we needed a whole chain of rubber bands! With power and wheels, we were able to store potential energy and see kinetic energy come out of it! The drag-racing cups traveled much farther than a small wind-up toy would have travelled. Does this remind you of a certain law of physics? Maybe **Newton's Third Law**, which says that for every action, there's an equal and opposite reaction??

Real drag-racers need a lot more power to move a lot more weight a lot faster. They can reach speeds of over 300 miles an hour! That's more than 5 times an average freeway speed. (http://www.topspeed.com/cars/drag-racing/ke446.html)

Activity Source: www.stevespanglerscience.com/experiment/drag-racing-coffee-cups

CLASS 4: EXPLORE POSSIBILITIES (ENGINEERING)

Welcome to Engineering!

Engineering is the process of creating and building structures, products, and systems by using math and science. Engineers solve problems by planning, building, testing, innovating, and inventing to solve a problem. Engineering is one of the most basic human instincts. From the invention of the wheel to present day marvels like Burj Khalifa, the tallest skyscraper in the world, people across the globe are constantly engineering! And, don't forget animals do it too! Think about the beaver who engineer their habitat by building lodges and dams. Pretty cool!

There is so much to learn and explore in the great world of Engineering! Today, you will creatively (with less procedural steps and more free-thinking) construct a mechanical hand, design a crack-proof cargo egg drop, and learn life-saving knots!

Activity One – Mechanical Hand

Time: 30 Minutes

Supplies:

General Supply Bag	**#**
Pencil	1
Scissors	1
Tape (straw roll, masking)	1
Tape (rolls, Scotch)	1
Lab Notebook	1
Class 4 Supply Bag	**#**
Chipboard	1
Colorful Straws	5
Jumbo Popsicle Sticks	2
String (1 ft each)	5

Goal: Follow the criteria and constraints below to reverse engineer a mechanical model of a human hand.

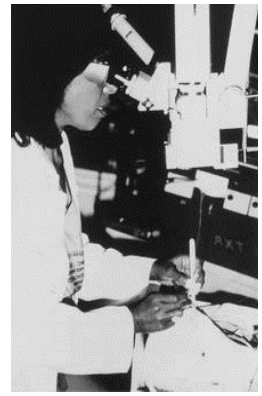
Survey connection:

★

Q. Fill in the blank: _______________ is used to develop prosthetics, artificial organs, and other medical innovations and is an example of how engineering is used to solve real-world problems.
A. Bio-engineering

Background:
While towers, bridges, and cars are all things that engineers design and build, engineering doesn't have to mean building big or complicated structures out of metal beams or engines. Entire areas of engineering are focused on small things. ***Bio-engineering*** is designing and innovating for our own bodies and health. Everything from crutches and advanced prosthetic limbs to pacemakers and x-ray machines falls under the tent of bioengineering. Bioengineers work with doctors and other researchers to come up with new solutions to medical problems. They focus on inventions that can help humans (and other living creatures) live longer, healthier lives.

Real-World Human Connection:



Dr. Patricia E. Bath performing surgery with her patented invention, the Laserphaco.

Dr. Patricia Bath was a medical doctor, researcher, inventor, and trailblazer in her field. She accomplished many "firsts" in her lifetime, such as being the first African American person to complete training as an eye-doctor and being the first woman to run an eye-doctor training program in the United States. Dr. Bath developed an interest in science early on. She chose to pursue medicine because she was inspired by a "love of humanity and passion for helping others". At just 16 years old, Dr. Bath won a national award for her contributions to cancer research. While she was in school to become an eye-doctor, Dr. Bath noticed that treatment for patients was unequal across race and class divisions. She worked hard throughout her career to bring quality medical care to the communities and people that were most in need of it.With her focus on eye-health and preventing and treating blindness, in 1986 Dr. Bath engineered a laser-surgery treatment for cataracts, a very common cause of blindness. The tool and surgery, called Laserphaco was extremely innovative for its time, and is still used today. Dr. Bath continued to improve upon her invention and went on to engineer further surgical methods throughout her lifetime. Through her ingenuity, Dr. Patricia Bath saved the vision of millions of people and paved the way for future inventors, doctors, and engineers to follow in her footsteps.

(https://www.biography.com/scientist/patricia-bath, https://lemelson.mit.edu/resources/patricia-bath, https://cfmedicine.nlm.nih.gov/physicians/biography_26.html)

Procedures:

1. Facilitate a discussion about engineering and what people use engineering for.

   Discussion Prompts:
   - ***How do engineers help people, animals, or the environment?***
   - ***How can we use engineering to solve problems?***
   - ***What is a problem in your community, or the world that you would like to help solve?***
   - ***What do you think bio-engineering is?*** *(The process of designing biological devices such as prosthetics, artificial organs to assist, repair, and provide support with medical problems.)*
   - ***Do you know what a prosthetic limb is?***
   - ***Can engineers help in medical situations?***
   - ***Could you design a working replica of your hand?***
   - ***How would you design a working replica of your hand?***

2. Tell students that we are going to be following **criteria** and **constraints** to build a mechanical hand!

   - **Criteria**(things you or your design need to accomplish):
     - ✓ Your model hand should have five fingers.
     - ✓ Your model hand's fingers should be able to bend and unbend at least 3 times

- ✓ Each finger on your model hand should move in response to an attached string.

- **Constraints** (ways that you or your design are limited):
  - ✓ You can only use the materials provided.
  - ✓ The model hand's fingers must bend and unbend without you touching them with your actual hands.
  - ✓ The model fingers must bend in the same number of places as your actual fingers.
  - ✓ You have 25 minutes to engineer your design.

3. Have students look at their own hands and make observations about how they bend and move.

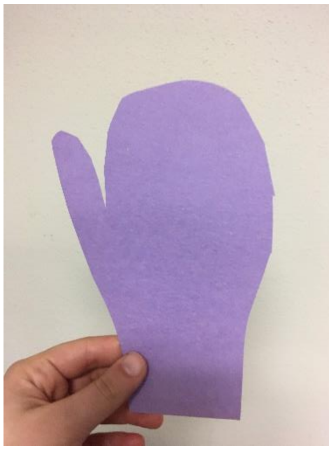
   Discussion Prompts:
   - ***At how many points does each finger bend?***
   - ***Is this number the same for all fingers? Different?***
   - ***Can we move fingers one at a time, or only all at once?***
   - ***Which directions can our fingers bend in?***

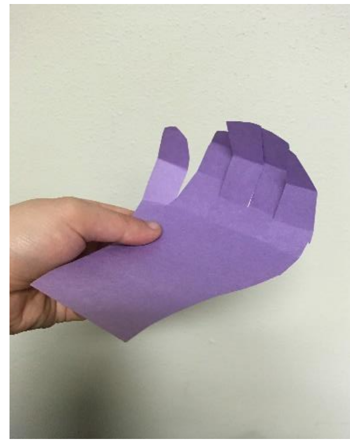
4. It may be helpful to have students draw a diagram of their own hands, indicating points where bending happens.
5. Discuss with students what our hands can do and are useful for. Introduce the concept of a prosthetic hand to students. Have students imagine how they might make something that works similarly to our own bodies.
6. Students should get out their Lab notebooks, Rulers, and Pencils.
7. Students should also prepare their straws, chipboard, and string as the basis for their mechanical hand designs.
8. Allow students 5 minutes to plan out and sketch their mechanical hand designs in their Lab Notebooks.
9. Make sure students have:
   a. 1 Chipboard sheet
   b. Scissors
   c. 5 Colorful Straws
   d. 1 set of 5 String Pieces (1ft)
   e. 2 Jumbo Popsicle Sticks
   f. Adhesive tape

10. Allow students 25 minutes to build their mechanical hands.

TIP: Students may struggle to cut out a hand outline from their chipboard, if that is part of their design. An easy way to get a hand cut-out is to cut a rough "mitten" shape and then make 4 downward slits to create individual fingers.

11. Share an example of how they could design their hand:
    a) Cutting out a hand-shape then bending the fingers at the same place our own fingers bend.





12. Share examples of how they could construct their hand:

    1. one way to do it…




2. Another way to do it…





13. Have students test their mechanical hands by demonstrating that each finger can be bent at least 3 times by pulling on a string.
14. Allow students time to improve or repair the mechanical hands for another round of testing.
15. Allow students time to reflect on this activity and discuss what worked and what was challenging. Have students compare their final mechanical hands to their actual hands.

<u>Discussion Prompts:</u>

- ***What can our hands do that these mechanical hands cannot?***
- ***What could we do to make our designs even better?***
- ***What worked? What didn't work?***
- ***What did we learn about reverse engineering?***
- ***What did we learn about our own bodies?***
- ***What would you do differently next time?***

Activity Two – Cargo (Egg) Drop

Time: 25 Minutes

Supplies:

General Supply Bag	**#**
Pencil	1
Tape (straw, masking)	1
Tape (scotch, rolls)	1
Scissors	1
Lab Notebook	1
Class 4 Supply Bag	**#**
Straws	15
Eggs (plastic, colorful)	1
Egg (chalk)	4

Goal: Design a model cargo drop that meets the criteria and constraints.

Background: Sometimes parachutes are impractical (or not enough). For example, to protect cargo being dropped into a forested area, where a parachute might get stuck or snagged, alternative measures might be used. That's when shock absorbance becomes important! Hitting the ground at terminal velocity involves A LOT of force. When you can't prevent or slow impact, another option is absorbing and distributing that force away from the cargo. Lots of different materials can be used to absorb shock. Imagine all of the different things you could use to safely bundle a fragile package being sent in the mail: bubble wrap, packing peanuts, newspaper, or foam. In this activity, we'll be using straws as shock absorbers.

Real-World Human Connection:

The best inventions can be the simplest. Transportation and rescue devices don't always need to involve multiple pulley systems. What's best is often what is most intuitive and basic. During the 1800's, housing in cities across the United States was becoming increasingly dense. More and more people were being packed into smaller spaces in order to house a growing population. With apartment buildings getting larger and closer together, urban fires became bigger and more destructive.

People were often injured in these fires when they became trapped in the higher floors of a building and tried to jump to safety. An especially big fire in New York City in 1860 prompted a wave of inventions to try to assist those fleeing a blaze. A couple of these zany inventions included a head-mounted parachute device to help a person float to the ground (it did not work very well) and a basket that lowered people down from higher floors one-at-a-time (not very useful when hundreds are trying to escape a building).

Enter Anna Connelly—a woman who saw another, easier way around the problem. She knew that, during a fire, the only option people had was often to travel upwards. So, Anna engineered the fire escape bridge. This bridge connected the rooftops of buildings to one another, allowing people to exit a burning building from the very top and get to safety. The bridges were made of sturdy iron, had railings on either side, and were inexpensive enough for many building owners to agree to install them. Anna Connelly's invention saved lives, and for decades a version of the external fire escape was required on New York City buildings. (https://americacomesalive.com/newsletter/important-inventions-women-may-2014/)

A more recent simple, but effective, rescue invention comes from Alexis Lewis in 2011. Alexis was only 13 when she came across news of famine in Somalia. She read reports of parents with multiple children walking miles every day to access resources. Alexis saw a need for a device that could be used to easily carry more than one child, while also keeping the carrier's hands free to perform other tasks. Alexis knew that, in the aftermath of a disaster, moving supplies or people who cannot move themselves is critical. She entered the Smithsonian Spark! Lab Invent It Challenge, and won with her invention of the Rescue Travois. Alexis' design was inspired by the original Travois, a multi-purpose, 2-poled sleds created by the Native American Plains tribes.

Alexis's engineered the Rescue Travois out of bamboo so that it is light, durable, and inexpensive. The device is easy to construct, and can be folded for storage. The Rescue Travois allows people to carry loads much heavier than themselves for long distances, with minimal effort. Her invention is now in use around the world!
(https://www.alexislewisinventor.me/travois)

Procedure:

1. Tell students that today we are going to be building a cargo drop—a "package" that needs to be delivered by air that will drop at its destination. In our case, the package is a delicate egg. Think about how things both in the animal and human world are used to protect precious cargo…

   Discussion Prompts:
   - ***What are some creatures in nature that have a design that protects them from being crushed or bonked or squished or eaten?*** *(e.g. Turtles have hard shells they can retreat into, Roly-Polies can curl up into a hard ball, and Pufferfish can inflate their bodies so that when they are tossed about in rocky rivers they are protected.)*
   - ***Can you think of any inventions or designs that were inspired by living things found in nature?*** *(**Bio-Mimicry** is the design and production of materials, structures, and systems that are modeled on biological entities and processes. SmartCars, for example, are designed to mimic the Pufferfish.)*
   - ***What are some things that birds use to make their nests softer to protect their eggs?*** *(e.g. feathers, dried grass, leaves, twigs, fur)*
   - ***What are some things humans use to protect their bodies?*** *(e.g. shoes protect our feet, hard hats protect our heads in construction zones, bike helmets for when we ride bikes, pillows to cradle our heads at night, life vest to keep us afloat in water)*
   - ***What do shipping companies use to protect breakables when they send fragile items in the mail?*** *(e.g. packing peanuts, air pockets, bubble wrap, crinkled brown paper, etc.)* ***Why do they use those things?*** *(Shock absorbance!)*

2. Students must follow the criteria and constraints to design their own cargo drop:

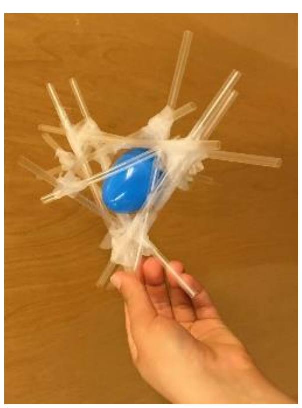
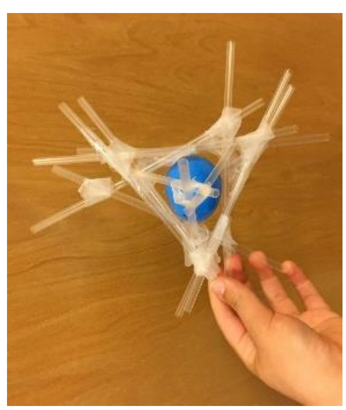
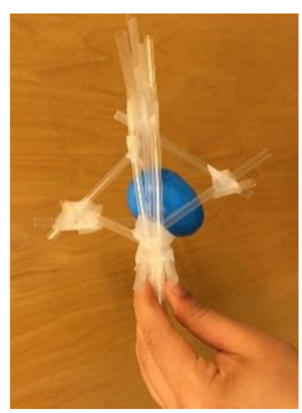
- **Criteria:**
    - ✓ Your cargo drop must be able to withstand a 5 foot drop.
    - ✓ Your cargo drop must be able to protect your egg from cracking or popping open.

- **Constraints:**
    - ✓ You can only use the materials provided.
    - ✓ Your cargo drop cannot be attached to your hand in any way during the drop.
    - ✓ You cannot test the structure until the *designated* testing time.
    - ✓ You have 15 minutes to engineer your design.

3. Students should prepare their eggs, pencil, and lab notebook.
4. Discuss with students if they think the plastic egg in their hands is sturdy enough to stay together when dropped, then test it! Have students try dropping their eggs from various heights and see what happens. Encourage them to *drop*, not *throw*!
5. Have students imagine what could they design that would protect their egg from falling apart when dropped. Encourage students to think about the examples discussed in class earlier.
6. Students should have 15 straws. Make sure students have their tape too.
7. Have students plan egg protection devices using the supplies they were just given. They can discuss their ideas with classmates and/or use their lab notebooks to plan.
8. Give students 15 minutes to create their cargo drop device.

TIPS:
- Remember to think in 3-D! Your cargo might twist and turn while falling, and you want it to be protected on all sides.
- Linking straws together by inserting one straw end into another can be helpful.
- Straws can be bent, cut, twisted together, etc. There are lots of ways to be creative!

9. Have students test their creations during the designated testing time by dropping their cargo protection devices with the egg inside. Try dropping each device from different heights and see what happens.
10. If possible, students can replace their plastic egg with the chalk egg. Does it survive the fall?
11. Give students an opportunity to reflect on their successes and challenges and improve their design for another round of testing.
12. **OPTIONAL**: Share any examples of designs you can find using a quick internet search. Below

are photos of a design tested by AKA Science, however our design was not successful.

13. Ask students: *What could the AKA Science team do to improve their design and/or build a better design? Why didn't this design work? Try re-creating their design with your suggested improvements!*

Activity Three – Knots For Your Life

Time: 10 Minutes

Supplies:

Class 4 Supply Bag	#
Paracord (2ft)	1
Knot Tying Worksheet	1

Goal: Learn to understand axles by creating a basic pinwheel.

Background: Knots are a valuable skill in engineering, but they can also be useful for artistic creations like macramé, practical tasks like tying your shoes. Knots can even safe your life! Knots are important in constructing pulleys, simple machines, and rescue devices. Knot tying takes time and patience, so encourage your students to keep at it and work through any frustration they might feel if it they don't master each knot right away. Any skill takes time to learn, and practice helps you improve! Sometimes, reminding students that all of their hard work will give them a skill that they can use immediately helps keep morale high. For example, a square knot can help them tie two pieces of rope together so they can extend the length of their rope or securely. Got a broken shoe lace? No problem! Use a square knot to add another piece of string to the broken lace to extend its length!

Procedure:

1. Pass out Knot Tying worksheets and a 2ft length of paracord to each student.
2. Have students try to tie the knots by following the worksheet instructions.
3. For knots that secure 2 lines together, instruct students to use each end of their paracord as if they were separate ropes.
4. Ask students to imagine how they could use these knots in the real world as they are attempting to master each knot design.
5. Encourage students to keep practicing their knots, even at home, because knots will come in handy as they engineer their designs!

Post-Activity: AKA Science Post-Survey

- **Please conduct a pre-survey** at the **BEGINNING of the FIRST class** by asking the questions below and **record each student's response**.

6. **Read each question and its possible answers aloud** as well as typing the questions/possible answers into the chat box of your virtual learning platform.

7. **Have students close their eyes** or put their heads down (for anonymity among peers) and **respond to the questions by raising their hands**.

8. **Record each student's response** (e.g. Kerry said "boring", Kevin said "fun", Karim said "Sorta fun"). Students' responses will be compared to their post-survey responses at the end of the program to assess learning growth.

9. **If it is easier for your students, they can also fill out a google form.** This can be found at www.tinyurl.com/AKASciencePost2.

10. **Please note that stamped postcards with the pre- and post-survey questions are in each student's folder.** While an emailed record from Class Leaders is preferred, the postcards are an option if that is not feasible.

11. **All student responses must be passed along to Kathryn Sechrist** (ksechrist@impactnw.org).

Survey questions:

1. **1 What do you think about science?**
   a) It's fun
   b) It's sort of fun
   c) It's boring

2. **Do you like doing science experiments?**
   a) Yes
   b) Sort of
   c) No

3. **Do you want to learn more about science?**
   a) Yes
   b) Sort of
   c) No

4. **Fill in the blank: ___________ is the genetic material that carries all the information about how a living thing will look and function.**
   a) Polymer

b) **DNA (Deoxyribonucleic acid)**
c) Hydrogen Peroxide

5. Fill in the blank: A chemical ___________ happens when one or more chemicals are changed into one or more different chemicals.

a) **Reaction**
b) Diffusion
c) Pollination

6. When you turn the knob of a wind-up toy or pull back on a pinball ball-launch peg, what are you storing up?

a) Kinetic energy
b) Gravitational pull
c) **Potential energy**

7. Fill in the blank: ______________ is used to develop prosthetics, artificial organs, and other medical innovations and is an example of how engineering is used to solve real-world problems.

a) Newton's First Law of Motion
b) Flubber
c) **Bio-engineering**

WE HOPE YOU HAD A GREAT TIME ON YOUR VIRTUAL AKA SCIENCE LEARNING ADVENTURE!

Thank you: