Virtual Learning:
Session III

WELCOME TO AKA SCIENCE!

For the next 4 class sessions, you 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!

AKA Science is funded by our generous community partners.

AKA SCIENCE IMPACT NW

Virtual **Learning**: Session III

- ABOUT YOUR KIT –

WHAT WILL YOU BE DOING?

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 – *Balloon Racer*
- Activity 4 – *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*

WHAT SUPPLIES WILL YOU NEED?

The "General Supply Bag" includes supplies that you'll use for different activities in more than one class. Each individual class will have its own additional list of supplies needed for that day's particular set of activities. For example, on the first day of class you'll see a list of General Supply Bag items you'll need AND a list of "Class Supply Bag" items that you'll also need. **After each class, return all general supplies back to their bag.**

What's inside the General Supply Bag?
- Cup (9oz, plastic punch) x 1
- Cup (calibrated) x 1
- Crayons x 4
- Lab Notebook 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

Virtual **Learning**: Session III

BEFORE YOU START:

- **NOTHING from your AKA Science kit should go in your mouth, nose, eyes, or ears.** If you have younger siblings, make sure those younger siblings do not have access to your AKA Science supplies.

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

- **Use your Lab Notebooks** and pen/pencil to reflect (i.e. think deeply and carefully about) and record observations as you go.

- **REMEMBER**: **We all make mistakes!** Mistakes are learning opportunities and in science, it's how discoveries are made. It might take some time, but you will learn how to do this, you will get better at this, and you will eventually overcome challenges that arise. <u>You can do hard things!</u>

  If an experiment didn't work the way you had hoped, we invite you to ask yourself:

  - ✓ *What happened today that made me try hard? How did that feel?*
  - ✓ *What can I learn from this?*
  - ✓ *What other strategies can I try? What could I improve for next time?*
  - ✓ *What do I need to learn about, get information about, or work on before I try this again?*
  - ✓ *Who could I get advice or help from?*
  - ✓ *How could I safely "break the rules" to try out a new idea or try this experiment in a different way?*
  - ✓ *What happened today that <u>DID</u> work? What did I do today that I am proud of?*
  - ✓ *What are my goals for the next class?*



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.

Activity One – Blooming Flower

Time: 5 Minutes

Supplies:

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

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

Procedure:

1. Before you start, and when something cool happens during your experiments, take a moment to reflect!

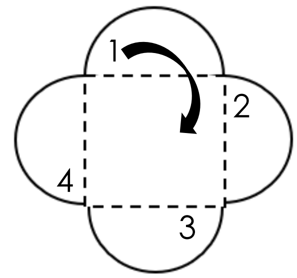
   Reflection:
   - ***Are there signs that Spring is here (or near?)***
   - ***What are flowers? What kinds of flowers are there?***
   - ***Do flowering plants have flowers all the time or just certain times of year?***
   - ***What is the purpose of a flower? Why are they important?***
   - ***What are pollinators?***
   - ***Why do flowers unfold their petals?***

2. Take out your Blooming Flower worksheet in your folder. You should also have crayons and scissors in your General Supply Kit.

3. Color your 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.*

Reflection:

- ***What does a flower looks like before it blooms?***



4. Fold the "blooms" or rounded edges of your 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.)

Reflection:

- ***What you think you could do to this example of a flower bud to make it bloom?***

5. You should have a cup of water, and a small aluminum pan. Fill the pan halfway with water.
6. Gently place the flower 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.
7. Observe for at least 30-60 seconds.

Reflection:

- ***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?***
- ***What does this tell us about how flowers get the water they need?***
- ***Do you think you could design your own blooming flower?***

8. Get out your pencil and two quarter-sheets of white paper. Design your own flower then use crayons to decorate it. You are welcome to try the experiment again using your own flower design!

Reflection:

- ***After a flower gets pollinated, what do you think happens to the seeds it makes?***
- ***How do you think flower pollination might affect you personally?***
- ***What are some other animal/plant interactions we know about?***

The Science Behind It:

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
Lab Notebook	1
Pie tin (small)	1
Folder	**#**
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.

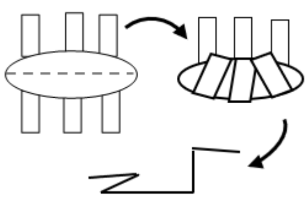
Procedure:

1. Before you start, take a moment to reflect on flies:

   Reflection:
   - ***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. Take out your Fly Feet Worksheet from your folder and scissors from your General Supply Kit.
3. Next:

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."



Reflection:

- ***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. Get out your paper plate and cup of water.
5. Lightly touch the bottoms of your 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.

Reflection:

- ***What happened?***
- ***Why do you think that happened?***
- ***Can you think of a way to make a better model fly?***
- ***How would you design your fly?***

8. If time allows, you can get out a pencil, crayons, and quarter-sheet of white paper.

TIPS:
- **Don't color the underside of the feet.** (It could keep them from sticking).
- As a variation, you 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.

9. Create and test your own fly models.

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 paper 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.

Procedure:

1. Take a moment to reflect on your uniqueness.

   Reflection:
   - ***Why do you have your eye color? Your height? Where do those biological traits come from?***
   - ***Have you ever heard of DNA? What is DNA?***

2. You should have a piece of white paper, pencil, crayons, and Doggy DNA Bead Pack.
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. Cut the top of the bag so you do not need to reach past the staples.
5. Reach into the bag (without looking) and pick a bead. The color of the bead represents the dog's DNA sequence for body shape.
6. Then:
   a. Match the color of the bead to the same color in the "Body Shape" section of the worksheet.
   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 you pick beads, you'll gradually reveal their dog's head shape, ears, legs, eyes, tail, coat color and hair.

Reflection:

- ***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!***

7. Take out a new piece of paper or turn your first piece over and draw on the back side. Repeat the process of drawing your dog.
8. Does your second dog look the same as your first dog? 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. That said, within the same species, most of the DNA sequence is very similar from one individual to the next. That's why both of your 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	**#**
Calibrated cup	1
Punch cup (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.

Procedure:

1. **NOTE**: This activity works best when the isopropyl alcohol is slightly chilled. If possible, put your isopropyl alcohol container in a freezer at the beginning of your class.
2. Take a moment to reflect on DNA:

   Reflection:
   - ***What did we learn about DNA in our last activity?***
   - ***Do all living things have DNA?***
   - ***Can we see DNA with our bare eyes?***
   - ***How could we see DNA with our bare eyes?***

3. Today we'll be looking at the DNA from strawberries. Take out your freeze-dried, powdered strawberry.
4. Gently put in one oz of water with your calibrated cup and carefully seal the bag. Let this soak for a minute. 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.
5. Pour in your soap.

   Reflection:
   - ***What does soap do? Why do we wash our hands with soap?***

6. Pour in your salt. Explain that the salt helps the strawberry DNA clump together (precipitate).
7. Let this soak for about a minute. Massage very gently.
8. Put your coffee filter over your 9 oz cup.
9. 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, 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.
12. Wait up to five minutes, and you should be able to see a white clump form.

Reflection:

- ***Why did we add the isopropyl alcohol?***
- ***What do you think this is?***
- ***Why can we see this DNA, even though DNA is microscopic?***
- ***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!

Virtual **Learning**:

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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.

Procedure:

TIPS:
- **It's best to do this activity on a non-rainy day when you 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. Take a moment to reflect on sunlight:

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

2. Cut out a simple shape out of your half-size index card.
3. Make sure you are in a shaded area of the room where there's as little sunlight as possible coming in from windows or skylights.
4. Place your Styrofoam plate upside-down in front of them.
5. Ready two pieces of tape.

6. <u>Carefully:</u> Take out your solargraphic paper from your folder. It a special type of paper that has a blue coating on one side. 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>Next</u>:
    a. Put your piece of Solargraphics paper on top of the upside-down plate, with the <u>blue</u> side of the paper facing up.
    b. Put your cut-out shape on top of the Solargraphics paper.
    c. Use your piece of transparency to cover both items like a clear shield.

8. Tape two sides of your transparency to your plate. (Only the transparency gets directly taped to the plate; the paper and shape are under it.)
9. Ready another 4inx6in index card and another piece of tape.
10. <u>Next</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. We're going to carry our plates next 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>. You will carry your plate (holding the index card flat).

    <u>Reflection:</u>
    - ***Have you ever heard of ultraviolet (UV) light?***
    - ***Where does it come from? We're going to use UV light from the sun for our experiment today. Let's head out!***

13. Go to an area that's fully in the shade, but close to an area with strong sunlight. Hold your index card flat against their plate until it's time to reveal the Solargraphics paper.
14. Put the pan in the shade and pour the water in.

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

15. Next:
    a. Stand in the sunny area and put your upside-down plate on the ground.
    b. Flip back your 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 pale blue.
    d. Once the paper is pale blue, flip the index card back into place to cover it.
    e. Bring the plate back to the shade.

TIP:	• **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 vs. cloudy it is.)

Reflection:
- ***What happened to your blue paper? We're going to take turns "developing" the papers to see what happened with everyone's designs!***

TIP:	• **If you *aren't* using the water immediately should keep their index card covering their paper.**

16. Gather around the pan of water and make sure it is full of water.
17. At the pan:
    a. Flip back your 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 your cut-out shape.

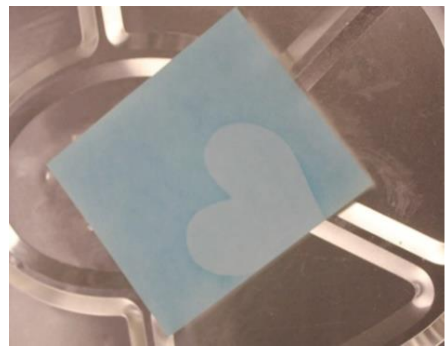
Reflection:
- ***What happened underneath your cut-out shape?***
- ***Why do you think that happened?***
- ***What do you think will happen when we put the paper in water? Let's try!***

18. Next:
    a. Submerge your 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 the paper towel 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 you develop your paper (especially if you 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.**

Reflection:

- ***What happened?***
- ***Why do you think that happened?***



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

The Science Behind It:
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/)

Activity Source: *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
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.

Procedure:

TIPS:
- **Review the cautions about hydrogen peroxide.**
- **For the best/fastest reaction, use very warm (but not hot) water.** 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 your 9 oz cup and cover so the water will still be warm by the time you're ready to use it.

1. Take a moment to reflect on fizzy things!

   Reflection:
   - ***What do you know of that fizzes?***
   - ***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. You 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. You should also prepare a cup of warm water (not hot, just warm).

3. Next:
   a. Dip your 1oz cup in the pitcher of very warm water.
   b. Transfer the water to your 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.)

4. 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.
5. When your teacher says "GO", follow these steps next:
   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.

   Reflection:
   - ***What happened?***

6. Discard the bottles and paper cups in a trash can with a liner (but save the pans).
7. Remove your gloves, discard them, and wash your hands.

The Science Behind It:

When you mix hydrogen peroxide with yeast, the yeast causes 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.

Procedure:

1. Take a moment to reflect on really weird and cool things called polymers!

   Reflection:

   - ***Have you ever heard of polymers before? What do you know about polymers?***

     Did you know: 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.

   - ***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?***
   - ***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 you have skin sensitivities or irritations on their hands (cuts, scrapes, etc.), wear gloves.
3. You should have a paper bowl and a 4oz bottle of glue.
4. Empty the glue into the paper bowl.
5. Fill your 1oz cup filled with .5tsp of baking soda and stir in the baking soda with their jumbo popsicle stick.
6. Fill your calibrated cup with contact solution to the unmarked line <u>between</u> 1/4oz and 1/2oz (this line = 3/8oz).

<u>TIP</u>:
- **If you want to minimize stickiness/sliminess/mess, you might want to try 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. Observe your 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. You should have a plate to use as a play surface.
12. <u>Next:</u>
    a. Roll the flubber into a ball between your hands. This helps the flubber not stick to your fingers.
    b. Play with the flubber.

<u>Reflection:</u>
- ***What happens when your flubber is stretched?***
- ***What else can it do?***
- ***What happens to flubber over time as you play with it?***

13. At the end of the activity, discard the flubber in a trash can with a liner. If you are wearing gloves remove them. **Wash your 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.

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!

Virtual **Learning**:

Session III

Activity One – Pie Pan & Tablecloth Trick

Time: 15 Minutes

Supplies:

General Supply Bag	**#**
Pencil	1
Aluminum 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, "coffee")	1
Marble (small)	1
Rubber band (size 33)	1

Goal: 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.

Procedure:

1. Take a moment to reflect on the laws of motion!

   Reflection:
   - ***Have you ever heard of "Newton's Laws of Motion or the world "inertia?" What do you think they might mean?***
   - ***What do you know about Newton's Laws of Motion?***

     Did you know:
     - ***Newton's First Law of Motion:*** *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.*

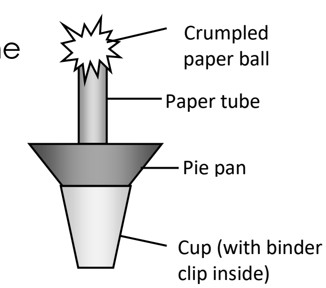
     There are some other cool Laws of Motion too..
     - *Newton's Second Law of Motion: Force equals mass times acceleration. Essentially, this means that two objects with different weights will need different forces to move them and the acceleration levels will be different.*

- *Newton's Third Law of Motion: 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?***
- ***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?***
- ***Have you ever seen someone pull a tablecloth out from under a fully-set table and the plates, glasses, and silverware stay exactly where they are? Why do you think that is? Let's test this idea!***

2. Today we will be investigating Newton's First Law of Motion! You should prepare one half-sheet of paper, rubber band, cup, and binder clip.
3. Next:
   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.

Reflection:

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



4. 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. Practice the motion until you see a reliable result.

Reflection:

- ***What happened?***
- ***Why?***

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

Reflection:

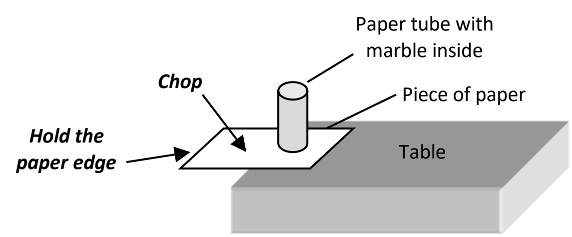
- ***Have you ever seen the magic trick where a magician pulls a tablecloth out from underneath a table full of plates and glasses—but nothing falls or breaks?***
- ***Do you think we could use INERTIA to perform our own magic trick?***

8. Next:
   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).

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

9. Pull the full sheet of paper out sideways from underneath the paper tube.

   Reflection:
   - ***What happened?***
   - ***How can we use INERTIA to keep the paper tube from falling over?***



10. 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).

    Reflection:
    - ***What happened?***

11. You 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, try to keep the tube upright without using the marble. For less challenge, leave more of the paper hanging off the table.

    Reflection:
    - ***Why does it work?***

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

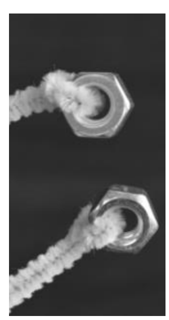
Goal: To observe how changing an object's center of gravity affects its balance using a popsicle stick and a pipe cleaner with weights on the ends.

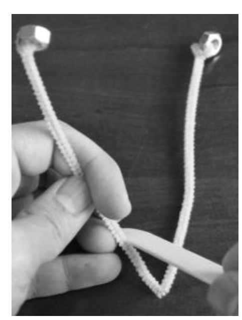
Procedure:

1. Try to balance on one foot. Now let's take a moment to reflect!

   Reflection:
   - ***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?***

2. You should have: two metal nuts, one full-size pipe cleaner, and one jumbo popsicle stick.
3. Next:
   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.

Reflection:

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

4. Take time to explore points of balance on the stick.

Reflection:

- ***What worked the best?***
- ***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?***
- ***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? Why not?***
- ***Do you think you could change its center of gravity by adjusting the pipe cleaner "arms?" Try it!***

5. Try to bend and rearrange the pipe cleaner "arms" until you 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.

Reflection:

- ***How can the whole thing balance on such a small point?***
- ***Would the Tightrope Balancer balance on its tip if it weighed the same all over?***
- ***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!***

6. Take 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.

Procedure:

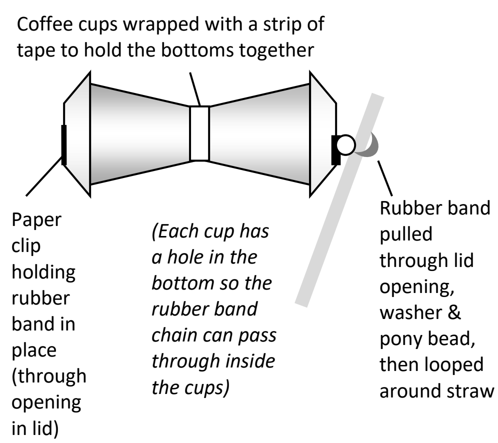
1. What do you know about energy and how things move?

   Reflection:
   - ***Have you ever played with a wind-up toy?***
   - ***What happens when you release it?***
   - ***What do you think the difference is between potential energy and kinetic energy?***
   - ***Have you ever played pinball?***
   - ***Do you think we could make something similar using a rubber band as the wind-up mechanism? Let's try!***

2. You should have a rubber band chain, two coffee cups, and a pencil. The masking tape from the General Supply Kit will work best.
3. Next:

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.

7. Next, you should prepare two lids, a paperclip, a washer, a pony bead, and a straw. You may want an extra paperclip handy as well—you 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.
8. 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.
9. Next, hook the paper clip through the part of the rubber band that's outside the lid.
10. Tape the paper clip to the top of the lid (on the outside) to hold the rubber band in place.
11. Put the taped lid on one of the cups.
12. Run the rubber band chain through the middle of both cups.
13. Use a pencil to pull the chain through the holes in the bottoms of the cups into the second cup.
14. 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).
15. Put the lid on the second cup, keeping the end of the rubber band pulled through.
16. 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.
17. Thread a pony bead onto the rubber band, next to the washer. (You may want to share the slightly-unbent paper clips to poke the rubber band through the pony bead.)
18. 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).
19. 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.)
20. 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.



Reflection:

- ***What happened?***

- ***Why does it work?***

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

<u>**Activity Source:**</u> 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 with inventions. Building and innovating to solve a problem 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!

There is so much to learn and explore in the great world of Engineering! Today, you will construct a mechanical hand, design a crack-proof cargo egg drop, and learn life-saving knots!

Activity One – Mechanical Hand

Time: 30 Minutes

Supplies:

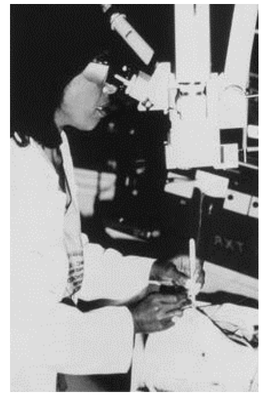
General Supply Bag	#
Pencil	1
Scissors	1
Tape (straw roll, masking)	1
Tape (rolls, Scotch)	1
Lab Notebook	1
Class 4 Supply Bag	**#**
Chipboard	1
Colorful Straws	5
Jumbo Popsicle Sticks	2
String (1 ft each)	5

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

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. Bioengineering 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 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)



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

Procedure:

1. Take a moment to reflect on what you know about engineering and what people use engineering for.

   Reflection:
   - ***How do engineers help people, animals, or the environment?***
   - ***What do you think reverse engineering is?***
   - ***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?***
   - ***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. We are going to be following **criteria** and **constraints** to build a mechanical hand!

   - **Criteria**:
     - ✓ 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**:
     - ✓ 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. Look at your own hands and make observations about how they bend and move.

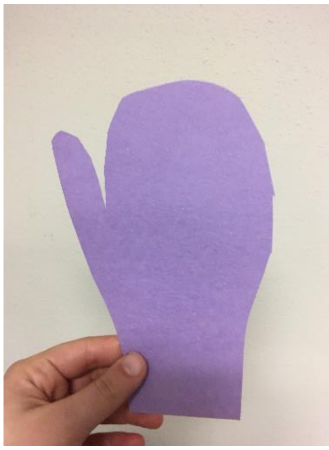
   <u>*Reflection:*</u>
   - ***At how many points does each finger bend?***
   - ***Is this number the same for all fingers? Different?***
   - ***Can we move fingers one at a time, or only all at once?***
   - ***Which directions can our fingers bend in?***

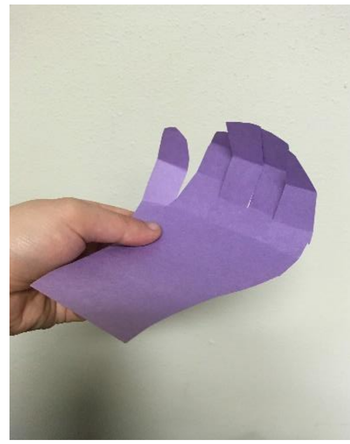
4. You can draw a diagram of their own hands, indicating points where bending happens!
5. What can our hands do and what are useful for? Do you know what a prosthetic hand is?
6. Get out your Lab notebooks, Rulers, and Pencils.
7. Also prepare their straws, chipboard, and string as the basis for their mechanical hand designs.
8. You have 5 minutes to plan out and sketch their mechanical hand designs in their Lab Notebooks.
9. <u>You should have:</u>
   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. You should have 25 minutes to build their mechanical hands.

> <u>**TIP:**</u> You 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. <u>Here is an example of how you could design your hand</u>: Cutting out a hand-shape then bending the fingers at the same place our own fingers bend.





12. Here are two examples of how you could construct your mechanical hand:

    a) one way to do it…




b) Another way to do it…





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

<u>*Reflection:*</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. 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…

   Reflection:
   - ***What are some creatures in nature that have a design that protects them from being crushed or bonked or squished or eaten?***
   - ***What are some things that birds use to make their nests softer to protect their eggs?***
   - ***What are some things humans use to protect their bodies?***
   - ***What do shipping companies use to protect breakables when they send fragile items in the mail?***

2. For this activity, we must follow the criteria and constraints to design our cargo drops:

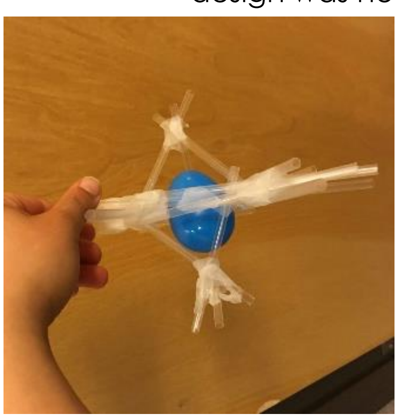
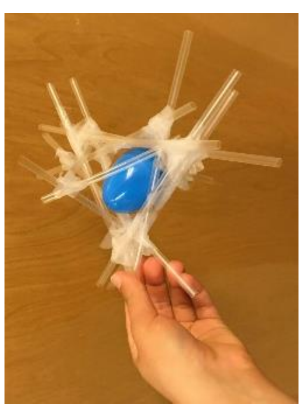
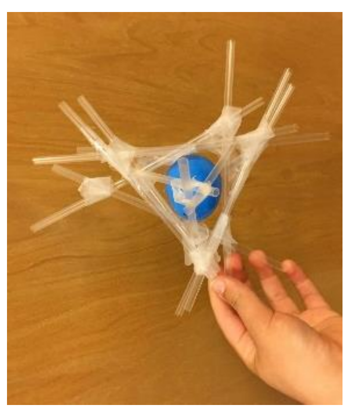
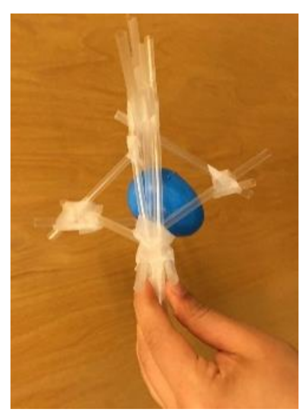
   - **Criteria**
     - ✓ Your cargo drop must be able to withstand a 5 foot drop.
     - ✓ Your cargo drop must be able to protect your egg from cracking or popping open.
   - **Constraints**
     - ✓ You can only use the materials provided.

- ✓ 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. Prepare their egg, pencil, and lab notebook.
4. Do you think the plastic egg in your 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. You will *drop*, not *throw*!
5. Imagine what could they design that would protect their egg from falling apart when dropped. Think about the examples discussed in class earlier. What needs to change if you drop the chalk egg?
6. You should have 15 standard straws. Make sure you have your tape too.
7. Plan egg protection devices using the supplies you have.
8. You have 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. Test your creations during the designated testing time by dropping your cargo protection devices with the egg inside. Try dropping each device from different heights and see what happens.
10. Reflect on your successes and challenges and improve your design for another round of testing.
11. **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.

Reflection:
- ***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. Take a moment to reflect on knots.

   Reflection:
   - **Where in your life would you use a knot?**
   - **Which knots do you know already?**
   - **How could you use knots to build something useful?**

2. You should have a Knot Tying worksheets and a 2ft length of paracord.
3. Try to tie the knots by following the worksheet instructions.
4. For knots that secure 2 lines together, use each end of their paracord as if they were separate ropes.
5. Imagine how you could use these knots in the real world as you are attempting to master each knot design.
6. Keep practicing their knots, even at home, because knots will come in handy as you engineer your future designs!

Virtual **Learning**:

Session III

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

Thank you: