ST[EMpower]

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH
COLORADO STATE UNIVERSITY EXTENSION

Mad Scientist Experiments
For Taking Over the World (MUW—Ha-Ha-Ha-Ha)

BACKGROUND
Humans are curious, and from our very earliest ancestors, we have wondered about our place in the world and universe. In the New World 5,000 years ago, the Mayans developed an extremely accurate calendar system. These ancient people had a written language and the most accurate pre-telescope astronomy in the world. The Mayans adopted the use of zero from the Olmec who lived nearby. Can you imagine doing math without using a zero? Their advances, however, were isolated to the New World (North, Central, and South America.)

CAREERS
Instead of the career exploration being in the sidebar this month, it is part of each activity.

First clarify and articulate potential future directions that would be enjoyable to you. Look for clues. You will naturally find some activities more engaging than others.

Try out each of these activities, and then follow the links from Colorado State University to find out more about the 4-year education you will need to pursue that option. There are also 2 year programs at many community colleges that could be a better fit. And of course, there is always a career in academics.

You and your parents can check out the CSU Career Center and take a quiz to find your perfect major!

https://career.colostate.edu/resources/take-this-quiz-to-find-your-perfect-major-at-csu/

Have fun, as you begin plotting your world domination!

(MUW—Ha-Ha-Ha-Ha)

The people in Mesopotamia and Ancient Egypt were the first to explore mathematics, astronomy, and medicine in the Old World, and that knowledge spread to other cultures, including the Greeks. Ancient Greek philosophy is the foundation of today's Western Culture.

For centuries, science worked very differently than it does today. Aristotle lived in Athens in the 4th Century BC. He founded the methods used by scientists for almost 6,000 years! He applied techniques of logical thinking, observation, inquiry and demonstration to every problem.

Muslim scholars, between the 10th and 14th centuries, developed the scientific method. Ibn al-Haytham lived from 965 to 1040, and he was a mathematician, astronomer, and physicist. He is considered the architect of the scientific method:

1. Observation of the natural world
2. Stating a definite problem
3. Formulating a robust hypothesis
4. Test the hypothesis through experimentation
5. Assess and analyze the results
6. Interpret the data and draw conclusions
7. Publish the findings

Europeans brought these ideas back with them during the Crusades, and Roger Bacon (1214-1284) is the first person to promote inductive reasoning as part of the scientific method.

1. Observation
2. Hypothesis
3. Experiment
4. Verification

Galileo Galilei was the first modern scientist. He lived from 1564-1642, and he was prolific in exploring the universe, mathematics, and engineering. He was the first person to look through a telescope (a modern invention of his day) at the stars.

If you found the introduction fascinating, perhaps a career in human sciences is for you. Archeologists study human history and prehistory through the excavation of sites and the analysis of artifacts and other physical remains. Anthropologists study human biological and physiological characteristics and their evolution. https://anthropology.colostate.edu/ and https://anthropology.colostate.edu/archaeology/

Objectives—you will:

- Have fun exploring several science and engineering activities!
- Follow the scientific method
- Explore education for careers in archeology, anthropology, microbiology, chemistry, food science, engineering, computer science, and robotics
- Plot your world **domination** schemes

(MUW—Ha-Ha-Ha-Ha)

"So please welcome our keynote speaker, Professor Melvin Fenwick — the man who, back in 1952, first coined the now common phrase: 'Fools! I'll destroy them all!'"

POWER WORDS

Many of the bold words found in the text may be new terms for you. They are defined below:

- **acid**: compound usually having a sour taste containing hydrogen ions capable of reacting with a base to form a salt and water.
- **alkaline**: another term for base—having a pH greater than 7.
- **anthocyanin**: a blue, violet, or red pigment found in plants.
- **bacteria**: unicellular microorganism that have cell walls but lack organelles.
- **base**: a compound capable of reacting with an acid to form a salt and water.
- **diorama**: a model representing a scene with three-dimensional figures in miniature.
- **caustic**: able to burn or corrode organic tissue by chemical reaction.
- **chemical**: a compound or substance and its interactions.

- **contamination**: the action or state of making or being made impure by polluting or poisoning.
- **distilled water**: water that has been boiled into vapor and condensed back into liquid in a separate container to remove impurities.
- **domination**: the exercise of control or influence over someone or something.
- **extract**: remove or take out, especially by force.
- **fungi**: group of unicellular or multicellular organisms that produce spores for reproduction, and feed on organic matter (examples, mold, mildew, and mushrooms).
- **indicator**: a compound that changes color at a specific pH value or in the presence of a particular substance and can be used to monitor **alkalinity**, acidity, or the progress of a reaction.
- **inoculate**: introduce cells or organisms (like bacteria or fungi) into a culture medium (like agar).
- **litmus paper**: a paper stained with litmus (an indicator); blue litmus paper turns red in acidic condition, and red litmus paper turns blue in basic conditions.
- **logarithmic**: a mathematic concept to abbreviate big numbers.

GROSS GARDENS

Microbes are **organisms** that are everywhere, but too small to see (like Horton's Whos who lived in Whoville). We can grow colonies of them that we can see. Your mad plot is to grow colonies of **bacteria** and **fungi** in colonies to see them for yourself!

Materials:

- Safety goggles
- Disposable gloves
- 10 clear plastic 9 ounce Solo brand cups (they work the best)
- Sharp scissors
- 5 teaspoons of beef stock powder
- 5 cups of water
- 5 teaspoons of sugar
- 5 teaspoons of gelatin
- Saucepan for boiling mixture
- Mixing spoon
- Hot pads
- Sticky tape
- Felt-tip pen to label "Petri dishes"
- Cotton swabs

DO:

Directions:

Petri Dishes

- Make your "Petri dishes." Cut the rim of five of the clear plastic solo cups between 1" and 2" shorter. This will be the base of your Petri dish. The five **unaltered** cups will be your Petri dish tops.
- As soon as you cut your Petri dish, place the lid over it to keep it **sterile**.

Homemade Agar

Note: Agar is derived from red seaweed. Gelatin is derived from animal bones, hooves, horns, etc.

- Put on your safety gear (goggles and gloves). Remember that the pot and agar will be HOT! Use potholders.
- Pour water into a saucepan and bring to a boil.
- Add beef stock powder, sugar and gelatin to the boiling water and stir for a minute until all the ingredients have dissolved.
- Place lid on your pan, and cool the agar mixture for 15 minutes. The mixture needs to be hot to avoid the gelatin setting in the saucepan, and the lid will help prevent **contamination** from bacteria in the air.
- Take the lid off each Petri dish and divide the agar among the 5 Petri dishes (remember to pour into the shorter cups). You can fill each dish about half-way. Put the lids on as soon as you are done to prevent contamination with the bacteria in the air.

- Place your Petri dishes in the fridge for about 4 hours until the agar has set. Do not touch the agar or you will contaminate it with bacteria on your fingers.

Inoculate Your Garden

- Now it is time to collect and grow your microbes on the agar Petri dishes. Use them immediately (store up to 2 days in the fridge).
- You will collect microbes from five different places. For example, the toilet seat, a cell phone, your mouth, your hands, and the bottom of your shoes. You can pick any five places (the above are examples).
- Do one Petri dish at a time, and keep the others in the refrigerator. Use the cotton swab by rubbing a surface to collect the microbes. Open the lid and gently rub the surface of your agar. Place the lid over the base. With the tape, seal the two sides together. You do not want your lid or base to slip, and you do not want to open this again. Ever. Turn the Petri dish upside down. Water condensation will collect at the bottom of the dish—away from the upside down agar and the bacteria and fungi growing on the agar. Label your dish with today's date and location of your microbes.
- Repeat until you have **inoculated** all five of your Petri dishes.
- Looking at your five locations, number them between 1 and 5, predicting which one will grow the most bacteria to the least bacteria.
- Find a warm dark spot for your Petri dishes. For example, the refrigerator motor pumps out warm air. You could place your Petri dishes on the floor next to your fridge (if there is a space). Another spot could be under the bathroom sink. Place your five Petri dishes in that spot. Be sure to tell everyone not to disturb them.
- Check them each day. Depending on how warm the spot, your colonies will start to appear between 1-3 days. It can take up to a week if the spot is cooler.

REFLECT:

Examine Your Garden

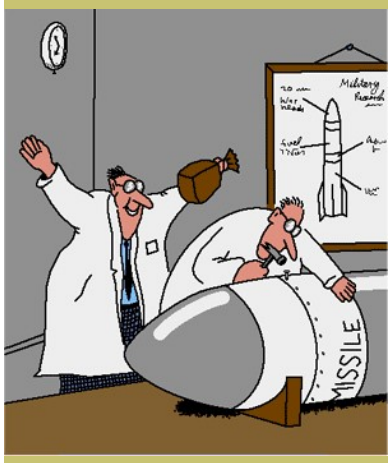
- Put on goggles and gloves. **DO NOT OPEN THE PETRI DISHES!**
- Take your Petri dishes out and examine them. Which place grew the most microbes? Which location grew the least microbes? Are you surprised? Did you guess right? Take pictures of your microbes. Name your microbes. Teach your microbes to take over the world. Wait, they already have…(Microbes are EVERYWHERE!)
- The microbes you grew were most likely common, harmless bacteria and fungus. You do not know that for sure, though. **Do not open your sealed Petri dishes**. Throw away the entire unopened and still taped Petri dish in the outdoor garbage can.

APPLY:

- Are there mad microbes that you can enlist in your plans for world domination?
- If this activity was absolutely "IT," explore careers in microbiology. http://csu-cvmbs.colostate.edu/academics/mip/Pages/default.aspx

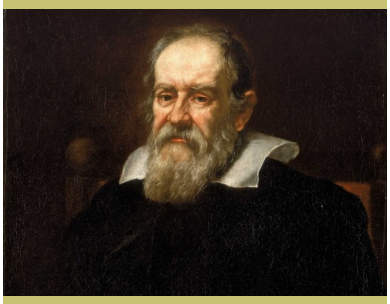
(MUW—Ha-Ha-Ha-Ha)

- **microbe**: a microorganism, especially a bacterium causing disease or fermentation.
- **nemesis**: the inescapable agent of someone's or something's downfall or a long-standing rival; an archenemy.
- **organism**: an individual animal, plant, fungus, or single-celled life form.
- **pigment**: the natural coloring matter of animal or plant tissue.
- **solution**: a liquid mixture in which the minor component (the solute) is uniformly distributed within the major component (the solvent).
- **sterile**: free from bacteria or other living microorganisms; totally clean.
- **unaltered**: remaining the same; unchanged.



Featured Cartoons:
Gary Larson is an American cartoonist. He is the creator of *The Far Side*, a single-panel cartoon series that was syndicated internationally to over 1,900 newspapers for fifteen years. The series ended with Larson's retirement on January 1, 1995. https://en.wikipedia.org/wiki/Gary_Larson

FASCINATING FACTS
MALE SCIENTISTS:



- **Galileo Galilei** was known for his work as astronomer, physicist, engineer, philosopher, and mathematician. He has been called the "father of observational astronomy", the "father of modern physics", the "father of the scientific method", and even the "father of science". Galileo studied speed and velocity, gravity and free fall, the principle of relativity, inertia, projectile motion and also worked in applied science and technology, describing the properties of pendulums and "hydrostatic balances," inventing various military compasses, and using the telescope for scientific observations of celestial objects. He was a devout Catholic, yet his observations and reasoning were often at odds with the Churches teachings. The Church tried and condemned Galileo for "vehemently suspect of heresy" and he remained under house arrest for the last 9 years of his life.

ACIDS & BASES & COLORS—BOOM!

Well, everything except the boom! A really messy fizz, definitely! While you are planning world domination, you never know if you will need **caustic chemicals**! **Acids** and **Bases** would do the trick!

Materials:

- Small red cabbage
- Knife
- Cutting board
- Bowl
- Sieve
- **Distilled water**
- Freezer or Blender
- Disposable gloves
- Goggles
- Clear plastic cups
- Measuring cup
- Permanent marker
- Household chemicals (more about this later)
- Plastic spoons
- Datasheet (page 19)
- Pencil
- Large plastic garbage bag
- Coffee filters (flat filters work best)
- Scissors
- Large pot
- Hot pads

DO:

Directions:

Red Cabbage Indicator

- ***Cabbage is very difficult to cut. For this first step, ask an adult to help you.***
- There are several ways to **extract** juice from the cabbage:
  - Cut the cabbage into quarters and place in a plastic shopping bag. Put into the freezer overnight. Remove and thaw. Put a bowl into the sink, and with your hands, squeeze the juice from the cabbage into the bowl. Remove any pieces of cabbage in the juice.
    OR
  - Cut the cabbage into ~2" chunks and place into the pot. Add distilled water until just covered. Turn on the burner and bring to a boil, then turn off the burner. Allow to steep until cool.
    OR
  - Cut the cabbage into ~2" chunks and place into a blender. Cover with distilled water. Thoroughly blend. Use the sieve and strain the cabbage from the juice into a bowl.
  - Refrigerate in a bowl covered with plastic wrap up to 1 week.

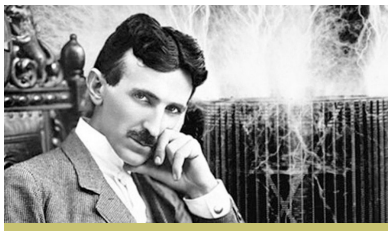
Preparing the Household Chemicals

- **DO NOT MIX CHEMICALS! (For example, if you mix bleach and ammonia, it produces a poison gas that can kill.)**
- **DO NOT pick drain cleaner, oven cleaner, or bleach. Very dangerous! Be sure that your parent approves of all the chemicals you are going to use.**

- **Practice safe chemistry:** regardless of the chemical you select, practice good chemistry safety precautions. Many chemicals can burn your skin or damage your clothes. Should you get some on you, IMMEDIATELY remove the article of clothing and wash your skin completely rinsing in lots of water (5 minutes to be safe). Do not handle the clothing on the spots of the spill, but wash immediately. Lab chemicals can burn holes in the fabric.
- Follow the directions below precisely.
- **Involve your parent.** Be sure that your parent is there with you as you conduct your experiment. If you are uncomfortable handling these chemicals, ask your parent to add the chemical and the red cabbage juice.
- Make a garbage bag lab coat. This will help protect you and your clothing in case of an accidental spill. Lay the garbage bag flat on a table. Slit the top of the bag in the center so you can put your head through (indicated by the blue line at the top of the image to the right). Slit the sides at the top (indicated by the green lines) for your arms. With a permanent marker, make the pocket (of course, with the mandatory mad scientist pocket protector), a collar, and button opening if so inclined!

- **(MUW-Ha-Ha-Ha-Ha!)**

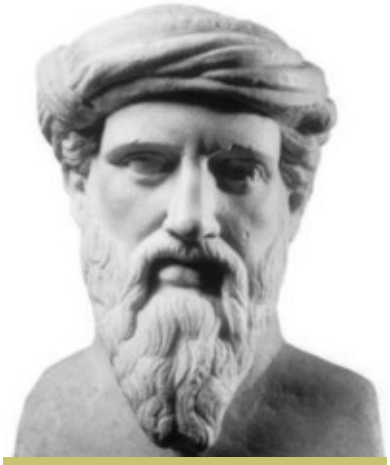
- Safety Equipment: put on your lab coat, goggles and disposable gloves.
- Explore your house for potential liquid chemicals to use. The best choices are clear with little to no color (like vinegar). Check with a parent that you can test them.
- **Liquids**:
  - When you find a chemical you would like to include, label your cup with the chemical's name with the permanent marker (for example, "vinegar"). Add 3 plastic spoons of the chemical to your cup. Use a clean spoon for each chemical (**Do NOT reuse the same spoon!**)
  - Chemicals to consider: vinegar, tap water, ammonia, dish soap (especially if it is clear), fabric softener, liquid laundry detergent, bleach, clear soda (like sprite or 7-up), distilled water, liquid bath bubbles, glass cleaner, shampoo, lemon juice, mouthwash (especially if it is clear), saliva (spit spit spit!!!) apple juice, etc.
- Explore your house for potential powder (solid) chemicals to use. The best choices are white powders with little to no color (like baking soda). Check with a parent that you can test them.
- **Solids**:
  - When you find a chemical you would like to include, label your cup with the chemical's name with the permanent marker (for example, "baking soda"). Add 1 plastic spoon of the chemical to your cup. With the same spoon, add 3 spoons of distilled water. Dissolve the solid in the water stirring with the same spoon.
  - Use a clean spoon for each chemical (**Do NOT reuse the same**



- **Nikola Tesla** was an amazing scientist. His experiments in electricity were fundamental in developing the way we safely get our electricity today. He immigrated from Serbia (now Croatia) and worked for Thomas Edison when he first arrived. There is evidence that he, not Edison, made the first vacuum lightbulb. He later had labs in Colorado Springs where he did most of his work.

  He had Obsessive Compulsive Disorder, and needed to do things in threes. Before he entered a building, he would walk around the block three times. He used 18 (6x3) napkins at every meal.

  He believed that power should be free, and it is rumored that he found a way to tap into unlimited energy from the atmosphere. He, unfortunately, never kept lab books, so we don't know what he had discovered. His life was spent in and out of insane asylums, and he died in absolute poverty. There is no way we could ever repay the debt of his life.



- **Pythagoras** lived about 2550 years ago. He was a mathematician from Ancient Greece born on the island of Samos. He traveled to Croton and founded a school. The students were sworn to secrecy and lived very simply. He is credited with many mathematical and scientific discoveries, including that the Earth was a sphere. Long before telescopes, he identified the "morning and evening star" as the planet Venus. He divided the Earth into Climatic Zones. We still learn his Pythagorean theorem in school! He was an influence on Plato and classical philosophy.

  He was a vegetarian, but he would not touch or eat beans. In fact, instead of escaping through a bean field, he was killed by attackers.

Q: **What's a mad scientist's favorite kind of dog?**
A: A Lab!

spoon!) Some powders will mix completely, others will not.
  - Chemicals to consider: flour, salt, sugar, corn starch, baking soda, baking powder, powder sugar, talc (baby powder), borax, laundry detergent powder, powder bath bubbles, cake mixes, etc.

Conducting the Experiment

- There are some caustic chemicals found in homes that your parents probably said not to test. These chemicals, like oven cleaner and drain cleaner, are VERY CAUSTIC. As a future mad scientist, you need to practice the skills when using these dangerous chemicals. To practice:
  - IMMEDIATELY remove the article of clothing and wash your skin completely rinsing in lots of water (5 minutes to be safe). Do not handle the clothing on the spots of the spill, but wash immediately. Some chemicals may burn holes in the fabric.
  - Follow the directions below precisely.
  - **Involve your parent.** Be sure that your parent is there with you while you finish your experiment. If you are uncomfortable handling these chemicals, ask your parent to add the chemical and add the red cabbage juice.
  - Wear your protective gear the entire experiment. If your goggles fog on the inside lenses, step away from your experiment to remove them and de-fog them.
- Measure 1/2 cup of cabbage juice and set aside (in another clean plastic cup is fine).
- Divide the remaining amount of red cabbage juice among your chemicals to be tested. To do that, measure the total remaining cabbage juice with your measuring cup. Divide that by the number of chemicals you are testing, and that will give you how much of the red cabbage juice you have available for each chemical. Use 3/4 a cup of red cabbage juice maximum, or if you have less, use that amount.

  Total remaining cabbage juice: _____ cups

  Divided by # Chemicals to be tested: _____

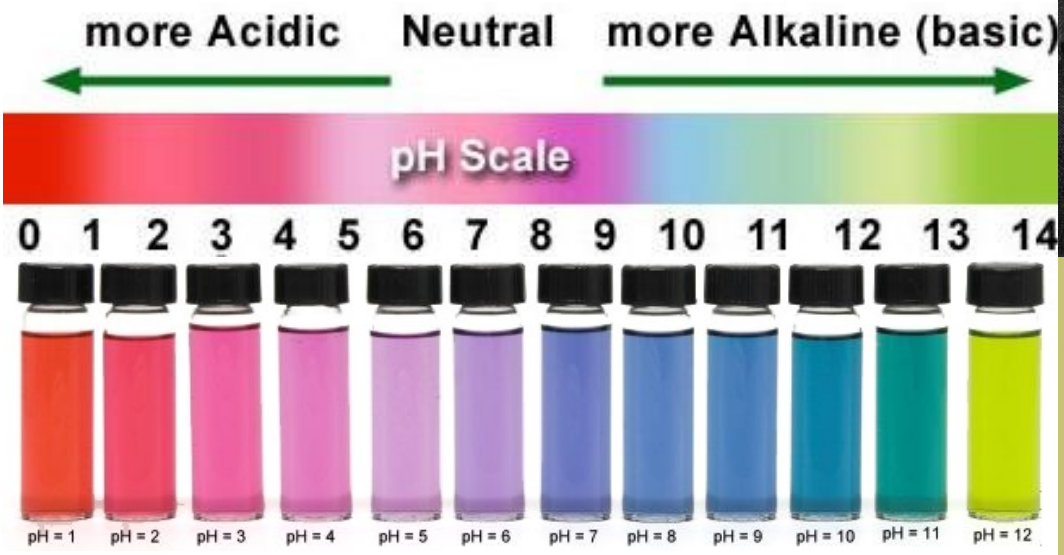
  Equals amount Cabbage juice per chemical: _____ cup

  NOTE: if you have more than 8 ounces (1 cup) per chemical, only use 6 ounces (3/4 cup).

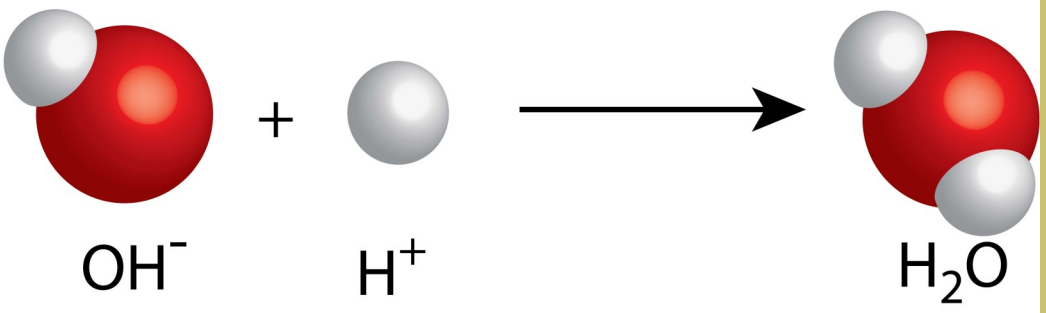
- Place each of the cups with the chemicals in a line in the kitchen sink.
- **Do NOT taste or touch.** Acids generally taste sour, like vinegar and bases generally taste bitter like baking soda. Use your experience to make a best guess. Look at each chemical, guess, and separate the acids on the left from the bases on the right. Record your guesses on your data sheet.
- Measure the red cabbage juice to the amount you calculated (up to 3/4 cup) and add it into each cup containing a household chemical.
- What happened? Are the colors in the two groups similar? Would you like to rearrange any of your colors? Go ahead and move the chemicals, and on your data sheet, indicate the changes.

REFLECT:

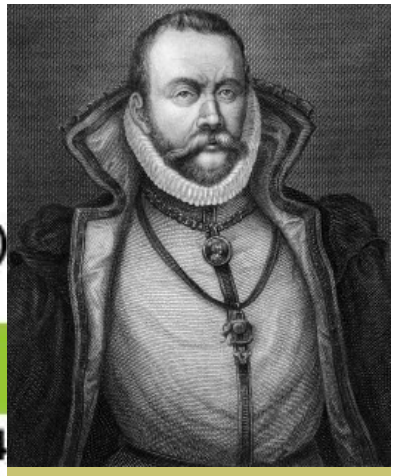
- Now take each chemical and match the color to the pH scale below. This is a scale from very acidic (scale of 0) to neutral (scale of 7, or equal numbers of hydrogen ions and hydroxide ions) to very basic (scale of 14).



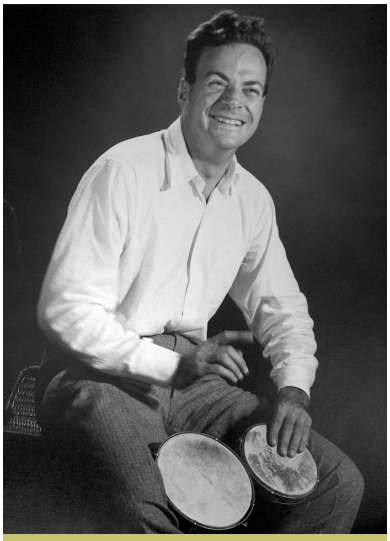
- Water is one oxygen atom and two hydrogen atoms bonded very tightly together. The oxygen is similar to a South Pole magnet, and the hydrogen are like the North Pole. Sometimes, a hydrogen atom breaks the bonds with the water molecule, and forms a hydrogen ion (H+) and a hydroxide ion (one oxygen and one hydrogen, OH-). In equal amounts, the solution is neutral.



- A solution is acidic or basic depending on the number of hydrogen ions in the liquid. A hydrogen ion is like a weak North Pole magnet. It is attracted and attaches to a South Pole magnet or a metal. If the chemicals you add act like a metal or a South Pole magnet, it will attract the hydrogen ions to it. This is a base. If the chemicals act like North Pole magnets, they will repel the hydrogen ions, and the ions will not attach to those molecules. The more hydrogen ions, the more acidic.
- The acronym pH means "potential of Hydrogen." The pH scale is a **logarithmic** scale of the number of hydrogen ions in the solution. This is weird math, because the lower the number on the pH scale, the more hydrogen ions in the solution. It is crazy to think that the pH of 3 has 100 times more hydrogen ions than a pH of 4, 1000 times more hydrogen ions than a pH of 5, 10,000 times more than a pH of 6, and so on. These are enormous numbers of hydrogen ions!



- **Tycho Brahe** was a Danish nobleman from a wealthy family. He was fascinated with astronomy and the movements of the stars. He hired people from all over Europe with excellent eye sight to make and record observations in the night sky at his observatory. This was before the invention of the telescope; in fact, Brahe died several years before Galileo looked at the planets. While he was in college, he lost his nose in a duel. After that, he wore a metal nose. He was also really quirky! He had a pet elk, and both he and his elk loved to drink. It was the death of both of them (but not at the same time). His elk, after drinking beer fell down some stairs and died. Brahe was drinking too much at a party. He needed to urinate, but it was rude to leave before the king. He developed a bladder infection that eventually killed him.



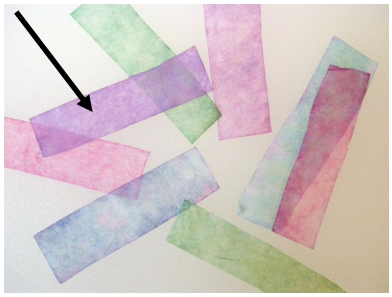
- **Richard Feynman** is considered the finest physics instructor of the 20th Century. He earned the Nobel Prize for his theory on quantum electrodynamics. He also was a junior scientist working on the Manhattan Project at Los Alamos, NM (the first atomic bomb). He was a practical joker, and would pick locks and crack open safes. He would spend time working in nightclubs, and played the bongos. Feynman was part of the NASA investigation team trying to determine the cause of the Challenger explosion in 1986. He found it difficult to get the NASA team to listen, so instead, he casually threw a rubber o-ring in ice water. The o-ring immediately warped in the cold water, and the room was stunned into silence. It was determined that was the cause of the accident.

- Red cabbage juice is an **indicator**; it changes color in acids and bases. The **pigment** in cabbage juice is **anthocyanin**. It gives cabbage its purple color. Anthocyanin molecule changes shape by attaching more and more hydrogen ions as a solution becomes more acidic, and it loses more and more hydrogen ions as the solution becomes more basic. The different shapes reflects light differently, so we see different colors!
- Record each of the chemicals you selected and write down the pH of the color that most closely matches the color of your chemical. Which are the acids? Which are the bases?
- What happens when you mix vinegar (acid pH 3) and baking soda (base pH between 8 and 9)? Reaction that releases a gas, massive bubbles, and is great for volcanos! Acids and bases react, but the product is neutral called a salt. Strong acids (like hydrochloride) and strong bases (like sodium hydroxide) violently react. As much fun as that sounds, it is VERY DANGEROUS! Chemistry labs keep acids far away from bases in case of an earthquake (or other catastrophe)!

- What do you think will happen if you mix one of the acids with one of the bases? We know that vinegar and baking soda are safe, so we will use these to chemicals to find out. Get a clean cup and put it into the sink. Measure and pour one-quarter cup of the vinegar (with red cabbage juice) into the cup. Measure and slowly add one-quarter cup of the baking soda/ red cabbage juice solution into the same cup. What happened? What is the final pH of the vinegar / baking soda / red cabbage juice solution?
- To clean up, start with dripping water into one cup at a time, slowly filling it with water. Keep filling it until the cup is overflowing. Slowly increase the water and flush the cup for about 1 minute. If there is still any color from the experiment in the cup, continue flushing until it is clear. Empty the cup into the sink and throw the cup into the outside garbage can. Repeat with each cup.

APPLY:

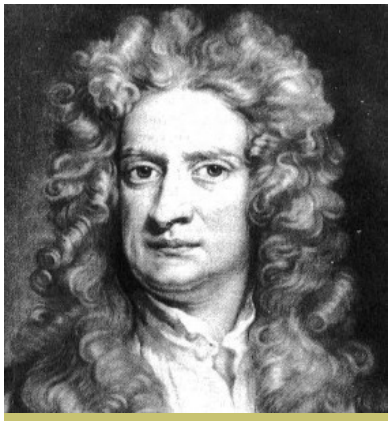
- All foods are acidic, basic, or neutral. You can test them yourself.
- You can always test them the same way you tested your household chemicals, or you can make **litmus paper**.
- You need the 1/2 cup of red cabbage juice you set aside, coffee filters and scissors.
- Cut the coffee filter into strips following the diagram on the right. You can get six strips (the filter is two sheets crimped together) about 6 inches long and 1 inch wide. Cut off the crimped edges, and then cut your strips.



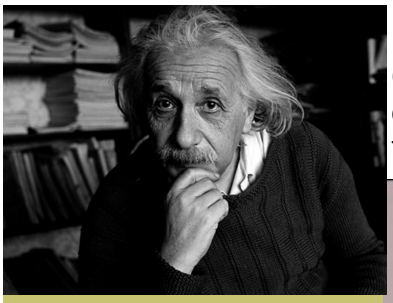
- Put your red cabbage juice cup in the sink. Take each filter strip you cut and put it into the red cabbage juice until thoroughly soaked. Remove and gently squeeze out the extra juice. Carefully unfold the filter and allow it to dry. You should have each strip the same color as the neutral (pH 7) red cabbage juice, like the strip with the arrow on the prior page.
- For liquid foods (i.e. chicken broth, milk, etc.) pour three spoons into one of your plastic cups and add 1/4 cup distilled water. Dip the litmus paper about half way into the liquid, remove, rinse with distilled water, and dry. Check the color of the litmus paper against the pH scale on page 8.
- For solid foods (i.e. broccoli, bread, etc.) you can puree in a small blender. For example, add broccoli flowerets into your blender, add 1/2 cup of distilled water, and puree. Dip the litmus paper about half way into the liquid, remove, rinse with distilled water and dry. Check the color of the litmus paper against the pH scale on page 8.
- Once you have tested several kinds of food, make predictions if the food is acidic, neutral, or basic before testing. Keep a record of all your experiments.
- Do the colors of the food give you any information about their pH factor?
- How can this information help you as you plan your world domination?

- If this activity really captured your interest, explore careers in chemistry! http://www.chem.colostate.edu/

(MUW—Ha-Ha-Ha-Ha)



- **Sir Isaac Newton** studied motion, light, gravity, calculus, and optics during the first prolific (producing a large number) 40 years of his life. The last 40 years, he became very eccentric (acting oddly), almost paranoid. Evidence shows that he may have had mercury poisoning (quite common in early days of chemistry). Here are some fascinating facts:
- Newton was born the year that Galileo died.
- He was a premature baby and not expected to live.
- Newton did not like criticism and made lifelong enemies with those who criticized him.
- During the plague epidemic, his university closed. He returned to his mother's house and continued studying light. He cut a hole in her curtain. He held a prism in the beam of light, and another prism upside down. From these experiments, he determined that the rainbow of color was part of the light..



Alfred Einstein is the most famous modern scientist, and his name is among the very few greats in science: Galileo, Newton, and Darwin. Einstein excelled in math, science, and music, but he didn't do well in other subjects.

- The beginning of Einstein's fascination about science came from a pocket compass, which was shown to him by his father when Einstein was five years old. He wondered what made the needle point in a certain direction and not anywhere else.
- Albert Einstein never learned to swim. However he loved sailing and continued to do so as a hobby throughout his life. Also, Einstein never wore socks. He thought wearing socks was a pain, and he would often get holes in them.
- "Imagination is more important than knowledge, for knowledge is limited, but imagination encircles the world."
- **Time magazine** named Albert Einstein its **"Person of the Century."**

"WITCHES" FINGERS

Of course, as you plan your world domination, you will need to take an occasional cookie break! This is the perfect recipe to program your robot to make!

This recipe is on the Food Network courtesy of Giada De Laurentiis (https://www. foodnetwork.com/recipes/giada-de-laurentiis/witch-finger-cookies-2229436). The article is unaltered and only formatted to fit this series of STEM activities. Ms. De Laurentiis is an Italian chef; she appears on several TV networks, and authors cookbooks.

Materials:

- Vegetable oil cooking spray
- 2 cups all-purpose flour
- 1/2 teaspoon baking powder
- 1/4 teaspoon fine salt
- 1/2 cup (1 stick) unsalted butter, at room temperature
- 1 cup sugar
- 1 large egg, at room temperature
- 1 teaspoon pure vanilla extract
- 28 large sliced almonds
- 1/2 cup raspberry jam

DO:

Directions:

- Place an oven rack in the center of the oven. Preheat the oven to 325 degrees F. Spray a rimmed baking sheet with vegetable oil cooking

spray or line with a silicone baking mat. Set aside.

- In a medium bowl, whisk together the flour, baking powder and salt. Set aside.
- In the bowl of a stand mixer fitted with the paddle attachment, beat the butter and sugar together until light and fluffy, scraping down the sides of the bowl with a spatula as needed, about 2 to 3 minutes. Beat in the egg and vanilla until smooth. Gradually beat in the flour mixture until a dough forms.
- Using about 11/2 tablespoons of dough at a time, roll the dough between your palms into 5-inch-long fingers about 1/2-inch thick. Firmly press a sliced almond into the end of each finger to make fingernails. Make several horizontal cuts, about 1/4 inch deep and 1/2 inch long, in the center of each finger to make knuckles. Press the dough on either side of the cuts to shape the knuckles. Arrange the fingers on the prepared baking sheet and bake until light golden, 16 to 18 minutes. Transfer the fingers to a wire rack and cool completely.
- In a small saucepan, heat the jam over low heat until warm, about 2 minutes. Dip the blunt ends of the fingers in the warm jam and arrange on a platter.

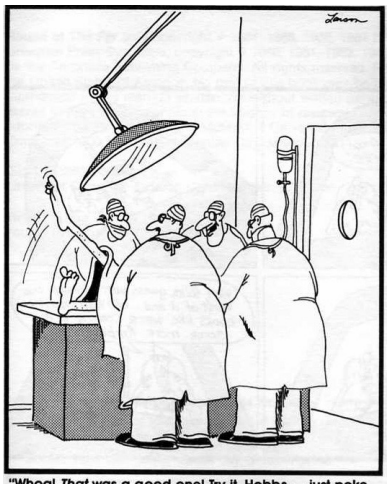
REFLECT:

- What an incredible idea—using delicious and nutritious food to take over the world! Colorado State University has an entire department in Food Science and Human Nutrition. If you love food and science, maybe this is the place to find your future career! http://www.fshn.chhs.colostate.edu/

APPLY:

- Share your cookies with family and friends!
- Spend time online exploring careers in food science!

(MUW—Ha-Ha-Ha-Ha)



"Whoa! *That* was a good one! Try it, Hobbs — just poke his brain right where my finger is."

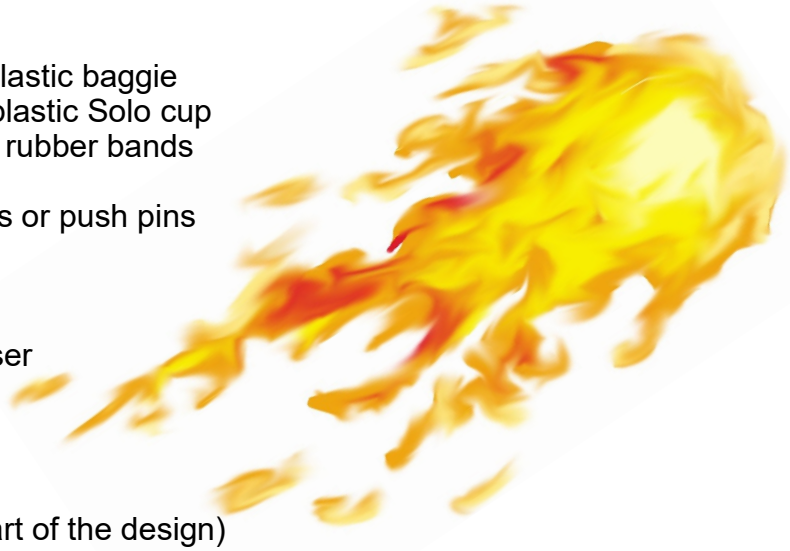
Female Scientists and Scientists of Color:

- Looking at the scientists included in this issue, it is evident that there are no people of color or females in that list. There are several reasons. Many women and people of color were denied access to scientific societies or publishing their work. Jared Diamond has a very interesting hypothesis that explains why Eurasian and North African civilizations conquered so much of the rest of the world. It has to do with their agriculture and the ability to domesticate animals and plants. Agriculture allowed more time for these people to develop "better" weapons. It is not because of any inherent genetic superiority. So, this next section includes these "Mad" scientists—and their contributions.

- **Benjamin Banneker**, an African American, was born in 1731 in the colony Maryland to a free family. His grandfather was a slave. His grandmother, an Englishwoman living in the colonies, owned him. They fell in love, so his grandmother freed and married his grandfather. He attended Quaker School, but he was primarily self-taught. He studied astronomy, predicted an eclipse, and was most famous for writing Almanacs. His Almanacs were very successful because of his knowledge of astronomy. He would wrap himself in a great cloak, settle under a pear tree, and meditate on the heavenly bodies all night long. He slept in the morning and worked in the afternoon. He was part of the group who surveyed the original boundary of the District of Columbia (Washington D.C.).

MAD SCIENTIST LAUNCHER

How else will you lob your mad inventions at the world? Yes, with your mad scientist catapult!



Materials:

- 1– quart size plastic baggie
- 1—9 oz clear plastic Solo cup
- 2—heavy-duty rubber bands
- 4—craft sticks
- 5—thumb tacks or push pins
- 3—feet string
- 5—paper clips
- 5—small nails
- 1—rubber eraser
- Marshmallows
  - Mini
  - Regular
  - Jumbo

Equipment (not part of the design)

- Scissors
- Hammer
- Tape measure
- Masking tape
- Datasheet (page 20)
- Pencil

DO:

Directions:

- Your task is to design the most efficient launcher you can design. Since you do not want to burn down your house launching flaming balls of fire, you will use marshmallows instead.

- Construct your launcher following these rules:
  - You may only use the materials listed above, and only in the quantities specified.
  - You do not have to use all of the materials listed.
  - You may not use any other materials.
  - The equipment (scissors, hammer, tape measurer, masking tape except for 12”, datasheet and pencil) may be used to alter the materials, but they may not be used in the marshmallow launcher design.
  - When your launcher is operated, your hand may move in a downward and or backward direction only. You may not move your hand in an upward and/or forward direction (meaning, you may not toss or throw the marshmallow).
  - Find a good launch site. Be sure your launch area has plenty of room for lobbing your marshmallows. Mark that spot with a piece of masking tape.
  - When you are ready to launch the marshmallows, Launch each size of marshmallow 3 times each. Measure the distance and record how far each marshmallow traveled on your datasheet.

REFLECT:

- What observations did you make about each launch?
- Is there a relationship between the size of marshmallow and the distance launched?
- What do you think that difference is?
- While you were launching your marshmallows, did you think of ways to improve your launcher? How?
- If you choose, you may include searching the internet for improving your launcher.

APPLY:

- Make modifications to your launcher. You can use additional materials now.
- Retest your launcher from the same launch site. Launch all three sizes of marshmallows.
- Did your design improve how far you could launch your marshmallows?
- Mechanical engineers design and build machines that use energy (like elevators, airplanes, and conveyor belts) and machines that produce energy (like wind turbines). If this activity helped you best envision how you will dominate the world, look into engineering careers. https://www.engr.colostate.edu/

(MUW—Ha-Ha-Ha-Ha)

Q: **What do you get when you divide a pumpkin's circumference by it's diameter?**
A: Pumpkin Pi

- **Hypatia** was a philosopher, astronomer, and mathematician, who lived in Alexandria, Egypt, then part of the Eastern Roman Empire. She was a prominent thinker of the Neoplatonic school in Alexandria, where she taught philosophy and astronomy. She is well known for her generosity, love of learning and expertise in teaching. None of her works survived after the burning of the Library of Alexandria.

  It isn't known when she was born, but she was brutally murdered in 415 AD. Her murder signaled the end of the classical period.

- **Maria Curie** was born in Poland in 1867. She is the first woman to win a Nobel Prize, and the only person to win two Nobel Prizes in two different disciplines in chemistry and physics. She and her husband, Pierre Curie, developed the theory of radioactivity (a term she coined). She was the first woman faculty member at the University of Paris in 1900. She continued her work in both chemistry and physics after the death of her husband (1906). She discovered the elements, polonium and radium, and the element curium is named in her honor.

CITATIONS

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MAD SCIENTIST DOODLE-BOT

Of course, you will need your own robot to do your doodle bidding, freeing up your hands for plotting your world domination. This is the only activity with a couple of items you will probably have to purchase online.

Materials:

- Electric motor (1.5-6v Electric Motor or a 9v Electric Motor) with leads (the wires) at a hobby store, or order online:
  - Use a search engine and search on “Electric Motor 1.5-3V” for using 2 AA batteries, or “Electric Motor 9v” using a 9 volt battery
  - If you find a 1.5-3V motor, also search and purchase a “AA 2 battery holder”

- 1 plastic Solo 8 ounce cup
- 1 felt-tipped pen (water-based ink)
- 2 AA batteries or 1 9v battery
- 1 rubber eraser
- 2 wires if you did not get a motor with leads
- 4 pipe cleaners
- 2 craft sticks
- 3 heavy-duty rubber bands
- 12” masking tape (1 roll for the class)

Equipment (not part of the design):

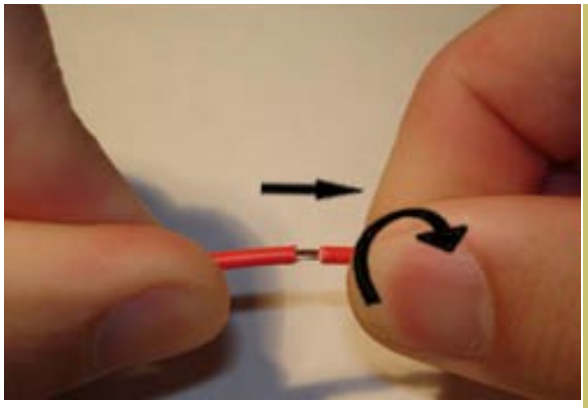
- Scissors
- Butcher paper or newspaper to cover table and testing section of floor
  - Home improvement stories have paper rolls in the painting department

DO:

Directions:

- Your challenge is to design a Doodle-Bot. A Doodle-Bot is a robot that will automatically doodle for you.
- Take a large piece of butcher paper (or spread out several sheets of a newspaper) and tape it (them) to the floor with the masking tape.
- Connect your battery to the motor. The leads will probably not have any exposed wire under the plastic insulating sheath. It would be very easy to pull the wires out of the battery holder or the motor, so be sure to anchor the wire whenever you pull.
  - If you have a wire stripper, you can use that. Find the gauge (diameter) by looking at the tip. You can see the wire surrounded by the plastic. Find the right size hole. Clamp down with the wire stripper about 1/4 inch from the end, hold the wire so it will not pull out of the motor/ holder, and gently pull the plastic off the wire. If not sure of the gage wire, start with a larger gage, and decrease until you have the correct size.
  - If you do not have a wire stripper, you can use a sharp pair of scissors. You need to be very careful not to nick the

wire. Gently clamp the scissors down on the wire, but do not cut through it. Next, holding the scissors, take each end of the wire and gently pull towards the scissors' handle, twisting the wire along the blades of the scissors. This will score and cut the plastic around the wire, but not the wire.



Once you see the wire all the way around the plastic insulating sheath, gently pull it off the tip. Remember: DO NOT PULL on the motor or the battery holder wires.

- Check to verify that your motor and battery are working. Attach the two wires with the black insulating plastic together (be sure it is wire touching wire) by gently twisting them together. Touch wires with the red plastic sheath together. Your motor should be spinning. Do not connect them yet. You do not want to run out of battery while designing and building your doodle-bot.

Building Your Doodle Bot:

- Here are the rules:
  - You MUST use all the materials listed (not the equipment) in your design.
  - You may use the equipment to only alter the materials.
  - You may not use any different or additional materials, other than those listed.
  - Only test your Doodle Bot on the butcher paper or newspaper.
  - You may not touch your Doodle Bot while it is doodling.

REFLECT:

Modifying Doodle Bot's Doodles:

- You can adjust the line smoothness by trying different eraser weights and positions.
- The path that the Doodle Bot takes can be adjusted by changing the angle or height of the pen and/or craft sticks. Detach the pen and craft sticks, and reposition them at different heights and angles.
- Once you have experimented with a design, you can, with minor adjustments, make some cool patterns.

APPLY:

- Robotics is a multi-disciplined career in both computer programming and engineering. If this activity sparked your imagination into new ways to dominate the world, look into careers in one or both of these fields.
  https://compsci.colostate.edu/ and https://www.engr.colostate.edu/

(MUW—Ha-Ha-Ha-Ha)

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MAD SCIENTIST LAIR

Every mad scientist needs that defining lair for creating havoc on the world. In this activity, you will begin to design your very own lair! Once you have the overall look, you can build a **diorama** of your dream mad laboratory!

Materials:

- Paper
- Color pencils
- Stuff around the house
- Mad Scientist imagination!

DO:

Directions:

- Spend some time exploring the old science fiction movies for ideas (they were the BEST for creating mad scientist laboratories).
- Do you envision yourself more as a Dr. Victor Frankenstein (biology), Dr. Henry Jekyll (chemistry to change humans), Dr. Hans Zarkov (Flash Gordon's scientist and rocket builder), The Brain (from Pinky and the Brain), or perhaps a new and terrifying **nemesis**?

- A traditional diorama is built in a box with a window or side cut-away. Shoeboxes work great, but you can also use a larger box if so inspired.
- Start with the floor and walls. How do you want your lab to look? Is it Steampunk? Stainless Steel (use aluminum foil), or something else?

REFLECT:

- Once you have your idea, begin designing your diorama.
- Joan Steiner was an artist and designer who made wonderful scenes using everyday objects, like pretzels for logs, a postage stamp for a picture on the wall, an upside down chess pawn as a hanging lamp, or safety pins to be handles).
- You can use Legos to make equipment, floors, walls, etc.

- What materials can you use to represent your lab. For example, a spool of thread would make a great stool, and fishhooks are excellent hooks for pulley and winch. Use barbless hooks.
- Legos are great for adding gears and switches.

APPLY:

- Put everything together in your diorama. When you are pleased with your diorama results, take a picture and send it to Dr. Shaw at barbara.shaw@colostate.edu. She will include your images in future issues of ST[EMpower] articles posted online!
- Architecture is a wonderful career. If this activity captured you, then architecture may be a career for you. http://la.agsci.colostate.edu/

(MUW—Ha-Ha-Ha-Ha)

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ACIDS & BASES & COLORS—BOOM! DATASHEET

HOW MUCH RED CABBAGE JUICE TO ADD TO EACH CHEMICAL:

How many chemicals are you testing? _____

Measure 1/2 cup, and place in the refrigerator for later.

Measure the remaining cabbage juice: _____ cups

Equals amount Cabbage juice per chemical: _____ cup. If your answer is more than 3/4 cup (6 ounces), only use 3/4 cup.

Chemical	Guess Acid/Base	Color	pH

MAD SCIENTIST LAUNCHER DATASHEET

Sketch your launcher design here:

	Small Marshmallow	Medium Marshmallow	Large Marshmallow
Trial 1 Launch 1			
Trial 1 Launch 2			
Trial 1 Launch 3			
Average of Trial 1			
Trial 2 Launch 1			
Trial 2 Launch 2			
Trial 2 Launch 3			
Average of Trial 2			
Trial 3 Launch 1			
Trial 3 Launch 2			
Trial 3 Launch 3			
Average of Trial 3			