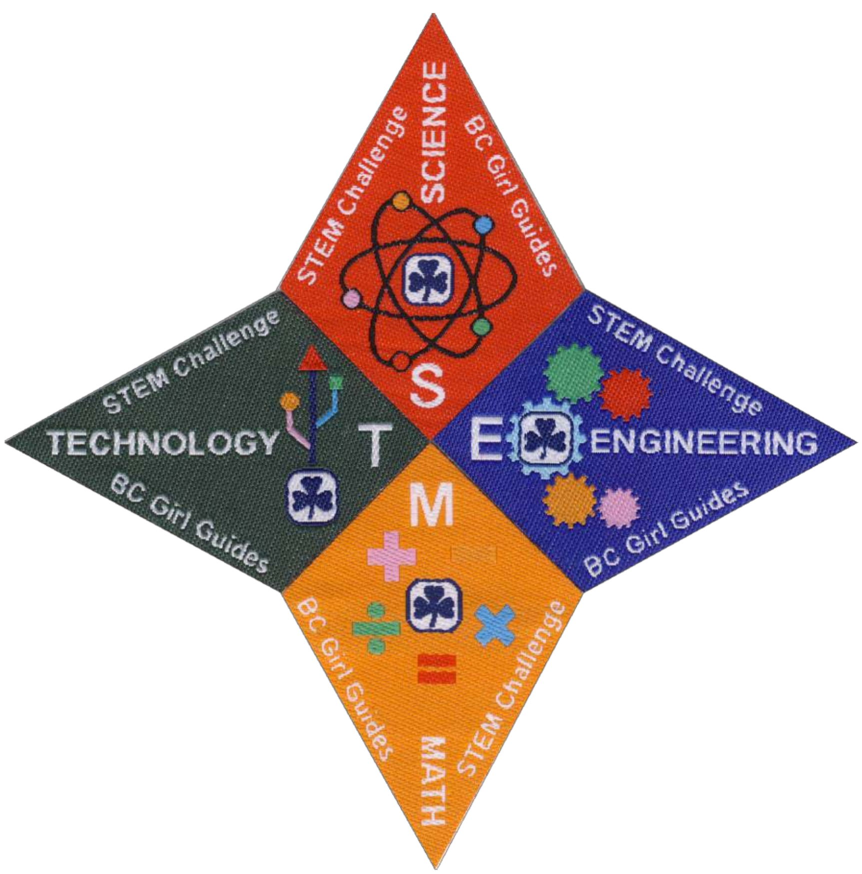
Girl Guides
BC Council

# STEM CHALLENGE: SCIENCE

A FOUR-PART STEM CHALLENGE
FROM THE BC PROGRAM COMMITTEE



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# INTRODUCTION TO THE STEM CHALLENGE

Welcome to the new, updated Science, Technology, Engineering and Math Challenge from the BC Program Committee. This is a four-part challenge: one booklet, and one ribbon crest, for each of Science, Technology, Engineering and Math. Do just the parts that interest you, or tackle all four and proudly display the complete crest on your camp blanket.

The STEM Challenge is an update of the Science in a Box and Girls Exploring Technology (GET) challenges that were launched by the BC Program Committee several years ago.

As you work on the challenge, please remember: We'd love to hear from you! Please feel free to let us know what activities you've done and what you thought of the STEM Challenge.

Sincerely,

The BC Program Committee

## Objectives

To engage girls in science.

To have fun experimenting with different fields of science.

## Outcomes

At the completion of this challenge, girls will demonstrate an improved awareness of and interest in:

1. biological reactions and/or processes.
2. chemical reactions and/or processes.
3. concepts of physics.

## Why Science?

"What happens when...?" "Why does the...?" "How does it...?" Girls of all ages are genuinely curious about the world around them. When you incorporate science into your unit or camp program, you help your girls learn basic scientific principles that can provide answers to all sorts of questions. Even better, when you do science in a fun and interactive way, with lots of experimenting and exploring, you are helping the girls learn how to find answers to their questions themselves.

Science adds variety and interest to any program. Often the girls' programs tend to be fairly arts-and-crafts intensive, particularly for younger girls. There is nothing wrong with that, of course, especially if the girls really like arts and crafts. However, as we strive to keep girls engaged and interested in Guiding, it is important to shake things up once in a while and explore different areas. Adding some science is one great way to do that.

 

Feeling apprehensive about planning an entire meeting around a science theme? You aren't alone – many of us feel out of our depth when it comes to science and technology. While science nights and science-themed sleep-overs are always fun, you don't need to tackle such a big project for this challenge. Most of the activities in this booklet can be used in other, non-science activities. Going camping? Plan to make sparkling lemonade for your afternoon snack and edible slime for dessert. Need a simple, fairly quiet gathering activity? Try Blind Spot or When the Coin Drops. Be creative and open-minded, and you'll soon find yourself asking, "Why *not* science?"!

## Challenge Requirements

To earn the ribbon crest for this part of the STEM Challenge, you need to complete activities in order to earn "challenge credits", depending on your branch of Guiding. You can select these activities from this booklet, or you can choose activities from the Internet, books or magazines, other Guiders or people in your community, or any other resources. As long as the activities are challenging for your group and fit the objectives of this part of the STEM Challenge, go ahead and use them. (And if you come across something really cool, please let us know so we can add it to any future STEM-related challenges!)

The "challenge credit" system is new – activities that require more time to complete will earn more credits than the quick activities. The activities included within this resource are all "quick" activities, which earn you one credit each. However, if you would like to complete an alternate activity which requires more time and in-depth study, you can use your judgment to determine how many credits the activity should be worth.

The Program Committee has produced a variety of program resources that include STEM activities. Look for these resources on the *BC Girl Guides website*:

- Science in a Box – Program tab > Program Resources > STEM
- Eco-Pak Challenge – Program tab > Challenges & Activities > Provincial Challenges
- CSI Challenge – Program tab > Challenges & Activities > Provincial Challenges
- Branch-specific Instant Meeting booklets – Program tab > Instant Meetings
- FunFinder Program Resource – Volunteers tab > Guider Resources > Publications > FunFinder

| | Sparks | Brownies | Guides | Pathfinders | Rangers/ Adults |
|---|---|---|---|---|---|
| **Total number of credits required.** | 3 | 4 | 5 | 5 | 5 |

When you have completed the activities, complete the BC Challenge Crest, Pin, and Camp To Go Order Form which can also be found on the BC Girl Guides website (click on Girl Engagement > Program > Program Challenges). Before filling out the Order form, please read the BC Challenge Crest, Pin, and Camp To Go Information document in order to understand the pricing and payment for the various crests, pins and merchandise.

# STEM Challenge: Science Tracking Sheet

| Sparks | Brownies | Guides | Pathfinders | Rangers/ Adults |
|---|---|---|---|---|
| 3 | 4 | 5 | 5 | 5 |

All activities in this challenge are worth 1 credit each.

- ❑ Edible Slime
- ❑ Cabbage Juice pH Indicator
- ❑ Magical Milk
- ❑ Magically Moving Water
- ❑ Blind Spot!
- ❑ When the Coin Drops
- ❑ Gravity-Defying Balls
- ❑ Sparkling Lemonade
- ❑ Molecules in Motion
- ❑ Exploding Pop
- ❑ Animation, Old School
- ❑ Build a Biodome
- ❑ Gravity-Defying Water
- ❑ Hot Water
- ❑ How to Build a Lung
- ❑ Ping-Pong Ball Race
- ❑ Potato Obstacle Course
- ❑ Raw or Hard Boiled?
- ❑ Tasty Ants
- ❑ Floating Egg
- ❑ Mixing Water and Oil
- ❑ Glow in the Dark Water
- ❑ Creating Music with Water
- ❑ Static Charge
- ❑ Chromatography
- ❑ Cartesian Diver

**Science in a Box Activities**

All activities listed below are worth 1 credit each.

- ❑ 1: Ack, It's Gak!
- ❑ 2: Mix 'n Match
- ❑ 3: Freeze and Thaw
- ❑ 4: Science in the Deep Freeze
- ❑ 5: Slippery Stuff
- ❑ 6: Listen to the Lifeguard
- ❑ 7: Make Metal Float
- ❑ 8: Touching the Tent
- ❑ 9: Clean it Up
- ❑ 10: Climbing Colours
- ❑ 11: How Does Water Climb a Tree?
- ❑ 12: Butterfly Beauties
- ❑ 15: Taste Test
- ❑ 16: Using Your Nose
- ❑ 17: Flashes of Light
- ❑ 20: Dancin' Cranberries
- ❑ 21: Balloon Blowing
- ❑ 22: Poppin' Rockets

*Note: Unfortunately, the Splitting the Smartie activity from the Science in a Box booklet no longer works. Nestle has changed the dye they use in Smarties, and the new colours do not run like the old ones did. This activity will not work with the new Smartie colours.*

**Other Science Activities**

Activities that meet the objective of this challenge.

- ❑ ____________________
- ❑ ____________________
- ❑ ____________________
- ❑ ____________________

# Activities

# Edible Slime

**Alternate Activity: Science in a Box 1: Ack, It's Gack!**

The cornstarch mixture you make in the activity "Ack, It's Gak!" is, in scientist-speak, something called a non-Newtonian fluid. The slime you make in this activity is, like Gak, a non-Newtonian substance. Unlike Gak, when you're done playing, you can eat it!

### Directions

1. Combine the condensed milk, chocolate syrup and cornstarch in a saucepan. Heat it over low heat, stirring, until it thickens.

   **Note:** Be careful working around a hot stove! Ask an adult for help if you need it.

2. Let the mixture cool.
3. Experiment with your slime. What neat tricks can you do with it?

   **Note:** The chocolate in your slime can cause stains, so keep it away from clothing, furniture and the living room carpet. Clean it off of other surfaces with warm soapy water.

4. If the slime is still clean enough after you've finished playing with it, eat it. Or, store it in a zipper-lock bag in the fridge for up to two days.

**Supplies**

- ❑ 400-ml can of sweetened condensed milk
- ❑ 2 tablespoons chocolate syrup
- ❑ 1 ½ tablespoons cornstarch
- ❑ saucepan
- ❑ stove
- ❑ spoon

### Explanation

What exactly is a non-Newtonian fluid, anyway? Any fluid has a property called viscosity – basically, how thick it is. Water has a very low viscosity (eg. it is not very thick); molasses has a very high viscosity (eg. it is very thick). A non-Newtonian fluid is one whose viscosity changes depending on how you treat it. If you apply a sudden force to your chocolate slime, for example by poking it hard with a spoon, it acts like a solid (i.e., like it has a really, really high viscosity). If you slowly press the spoon into it, however, it acts like a liquid – albeit a very thick one. And if you set it on the edge of a counter, it will slowly ooze its way down the cupboard doors and all over the floor. Better clean that one up before your mother sees it.

# Cabbage Juice pH Indicator

**Alternate Activity: Science in a Box 2: Mix and Match**

Scientists use a pH indicator to figure out if a particular substance is acidic or not. Substances that are acidic are called **acids** (predictably) and have a pH between 1 and 6.9; substances that are not acidic are called **bases** or **alkalis** and have a pH between 7.1 and 14. Substances that are neither have a **neutral pH** of 7 Many different things can be used as a pH indicator. Most of them turn one colour if they are added to an acid and another colour if they are added to a base.

In this activity, make your own pH indicator that you can use in other experiments.

### Directions

1. Grate the cabbage, or chop it finely with the knife. Put it in the bowl.
2. Pour cold water over the cabbage and let it sit for 45 minutes.
3. Strain the cabbage juice into the water jug. Your pH indicator is now ready to use!

### Supplies

- ❑ head of red cabbage
- ❑ large bowl
- ❑ grater or sharp knife **Note:** be careful with the grater or knife; ask an adult for help if you need it.
- ❑ cold water
- ❑ strainer
- ❑ water jug

### What else you can do with this

Use your cabbage juice pH indicator in any experiment that involves testing different substances to see if they are acidic or basic. You can use it in place of other pH indicators, such as phenolphthalein, indigo carmine, methyl red, methyl orange, litmus paper, bromothymol blue, that might be hard to find. When you mix your cabbage juice with an acidic substance it will change to a pinkish-red colour. When you mix it with a base, it will turn blue or green.

# Magical Milk

This activity is a spectacular demonstration of the effects of surface tension in a liquid.

**Alternate Activity: Science in a Box 6: Listen to the Lifeguard**

### Directions

**Supplies**

- ❑ pie plate or similar wide, shallow dish
- ❑ milk
- ❑ food colouring in two or more colours
- ❑ dish soap

1. Pour the milk into the pie plate so that it is about 1 cm deep.
2. Put a few drops of food colouring into the milk. Use two or more colours, and put them at different locations in the dish so that the colours stay separate for now.

   **Note:** For a great effect, make several spots of each colour.
3. Add a small drop of dish soap in each of two or three different locations in the dish and watch what happens.
4. Investigate what would happen if you used milk with different fat contents (eg. skim milk, 2% milk, homogenized milk, buttermilk, etc.)

### Explanation

Most liquids, including milk, have surface tension. That means the molecules of milk are attracted to one another and they want to stick close together, creating a kind of "skin" on the surface of the milk. You can see this if you fill a small glass up to the brim with water, then use an eyedropper or small spoon to carefully add more water, drop by drop. Instead of spilling over, the water mounds up at the top of the glass – surface tension is holding the water together, so you can actually fill the glass up a tiny bit higher than the brim.

When you first put the drops of food colouring into the milk, it forms small coloured patches because the surface tension in the milk won't let the food colouring spread out very much. Dish soap breaks the surface tension, forcing the milk molecules to move away from one another. They take the food colouring with them, resulting in the colourful swirling patterns you see in the dish.

# Magically Moving Water

Can you figure out how to get water from one cup to another without touching either cup or the water? Find out how in this activity!

**Alternate Activities: Science in a Box 10: Climbing Colours; 11: How Does Water Climb a Tree?**

## Directions

1. Fill up one of the glasses with water, nearly to the top. Leave the other one empty.
2. Twist the paper towels together into a small rope.
3. Bend the paper towel rope into an upside-down U shape. Place one end in the glass of water and the other in the empty glass.

**Supplies**

- ❑ two drinking glasses, preferably clear
- ❑ water
- ❑ two or three paper towels

## Explanation

After a few minutes (this activity requires some patience), you will notice water seeping its way along the paper towel rope and dripping into the empty glass. If you leave it alone, the water will transfer until there is an equal amount in each glass.

The water is actually being pulled through tiny channels in the fibres of the paper towels. This process, called *capillary action*, is the same one that brings water from the roots of a plant all the way up the stem to the top.

# Blind Spot!

You might not notice it all the time, but there is a spot on either side of you that you can't see when you are looking straight ahead. Do this activity to find out where your blind spot is.

**Supplies**

- ❑ paper
- ❑ pencil or pen with dark-coloured ink
- ❑ ruler

### Directions

1. Draw a small X on the left-hand side of the paper.
2. Use the ruler to measure 12-15 cm to the right of the X. Make a dot about 1 cm across at that point.
3. Hold the paper in front of you. Close your left eye and look at the X with your right eye. You should still be able to see the dot; if you can't, move the paper a little farther away from you.
4. Slowly move the X toward your nose, while keeping your right eye looking at the X. At some point, the dot will disappear. It is in your blind spot!
5. Turn the paper upside down, and try the activity again with your right eye closed and your left eye looking at the dot.

### Explanation

Your eye has special light sensors called rods and cones that are connected to your brain by nerves. The rods and cones "catch" the light around you and send messages to your brain over the nerves. Your brain uses the messages to figure out what you are looking at. All the nerves from the rods and cones go through the back of your eyeball (the retina) at one spot. That spot doesn't have any rods or cones--there is no room for them, with all those nerves passing through--so that point of your eye cannot catch any light. It can't see!

So why don't you notice this blind spot all the time? Well, it isn't very big, for one thing. For another, your brain is pretty good at filling in the blind spot with what it thinks should be there. In this activity, for example, your brain fills in the empty spot with an image of blank paper.

### What else you can do with this

See if you can figure out how big your blind spot is. Does the dot disappear faster or more completely if you make it smaller? What happens if you make it much bigger?

Try combining this activity with the Using Your Nose and Taste Test experiments (from the Science in a Box booklet) for an investigation into human senses.

# When the Coin Drops

Find out how your eyes work together to tell you exactly where something is.

**Directions**

**Supplies**

- ❑ a partner
- ❑ a small paper or plastic cup
- ❑ ten coins or other small objects

1. Sit across a table from your partner. Set the cup on the table in front of you and put the pennies nearby.
2. Hold one coin in your hand and move it back and forth above the cup.
3. Your partner tries to make you drop the coin into the cup. She watches the coin as you move it back and forth, and when she thinks it is in just the right spot, she says "Drop!"
4. When your partner says "Drop!", drop the coin. Does it land in the cup?
5. Repeat this with all ten coins. How many coins land in the cup?
6. Do the investigation again, but this time, your partner closes one eye while she watches you with the coins. How many coins land in the cup this time?
7. Trade jobs.

**Explanation**

You probably found that it is easier to make the coins drop into the cup when you use both eyes. When you look at an object, you might think that both your eyes see exactly the same image, but they don't. Each eye, in fact, sees a slightly different view of the object. (Try this: hold a pencil up at arm's length. Close one eye, then open it and close the other. See how the image of the pencil shifts? That's because each eye sees something just a little bit different.) Your brain combines the two images into one for you, and uses the images from both eyes to decide just how far away the image is. Using both eyes also makes it easier for your brain to judge how fast and in what direction something is moving.

**What else you can do with this**

Try combining this activity with the Taste Test and Using Your Nose experiments from the Science in a Box booklet for an investigation into human senses.

# Gravity-Defying Balls

**Alternate Activity: Science in a Box 19: Gravity in Motion**

### Directions

1. Hold the tennis ball in one hand and the basketball in the other. Extend both hands out to the front or side, at the same height. If you drop them at the same time, which one do you think will hit the ground first? How high will each one bounce?
2. Drop the balls to test your prediction. Make sure you release both of them at exactly the same time. Which one hits the ground first? How high do they bounce?
3. Hold both balls out in front of you, with the tennis ball resting on top of the basketball. Drop them both at the same time. What happens this time?

**Supplies**

- ❑ basketball (or another ball of similar size and weight)
- ❑ tennis ball (or another ball of similar size of weight)

### Explanation

While you're holding the balls above the ground, they have *potential energy*-- energy that is stored up and ready to do something. Energy cannot be created or destroyed; it can only be converted from one form to another, or transferred from one object to another. When you drop the balls, their potential energy gets transformed into *kinetic energy*, or motion. When a ball hit the floor, some of its kinetic energy gets transferred to the floor, mostly as heat and sound energy, but also as a very small amount of movement in the floor itself. The rest rebounds into the ball and makes it bounce back up into the air.

When you rest the tennis ball on top of the basketball and drop them together, they both fall together. When they hit the ground, the energy from the basketball gets transferred to the tennis ball. The basketball hardly bounces at all, but the tennis ball gets an extra energy boost and flies way up into the air.

When you drop the balls separately, they both hit the ground at the exact same time (as long as you were holding them at the same height and dropped them at the same time). The tennis ball is bouncier than the basketball, but it cannot bounce any higher than the height you dropped it from.

# Sparkling Lemonade

In this activity, you use a simple chemical reaction to make your own sparkling lemonade.

**Alternate Activities: Science in a Box 21: Balloon Blowing; 22: Poppin' Rockets**

### Directions

1. Cut the lemon in half and squeeze as much juice as you can out of it into the glass.
2. **Note:** Be careful using the knife! Ask for help if you need it.
3. Add an equal amount of cold water to the glass.
4. Stir in the baking soda.
5. Add sugar if you like your lemonade a little bit sweeter.

**Supplies**

- ❑ lemon
- ❑ knife
- ❑ drinking glass
- ❑ water
- ❑ 1 teaspoon baking soda
- ❑ sugar

### Explanation

Lemon juice is an acid, and baking soda is a base (or *alkali*). When you mix these two substances together, you create a chemical reaction that releases carbon dioxide gas. The carbon dioxide forms bubbles in the drink. Your sparkling lemonade is pretty similar to any pop you can buy in a store – water, sugar, and some kind of flavouring, with carbon dioxide added to make it fizzy.

# Molecules in Motion

Everything is made of tiny particles called molecules, and molecules are pretty active little things. In this activity, you'll see that evidence of that activity for yourself.

**Alternate Activities: Science in a Box 20-22: Things in Motion**

**Note:** If you let the hot water cool off too much, this activity won't work very well. Once you start, work quickly (but carefully – spilling hot water all over yourself doesn't work very well either).

### Directions

1. Fill one glass with cold water and the other with hot water. This activity works best if you have the same amount of water in each glass.
2. Working quickly, put one drop of food colouring into each glass. What happens?

**Supplies**

- ❑ two clear glasses
- ❑ cold water
- ❑ hot water; **Note:** be careful handling hot water. Ask an adult for help you if you need it.
- ❑ food colouring

### Explanation

Water molecules are very tiny, so you can't actually see individual molecules moving around in the glasses. However, when you put the food colouring in, you can see the effects of that movement. The water molecules carry the food colouring molecules with them as they move around the glass, so you see the food colouring spreading out in the water.

Did you notice that the food colouring spreads out much faster in the hot water than in the cold? That's because molecules in hot things move a lot more, and a lot faster because the molecules have more kinetic energy, than molecules in cold things do.

# Exploding Pop

If you're having trouble finding film canisters for the Poppin' Rockets activity in the Science in a Box booklet, try this one. You don't actually launch a rocket, but you get a terrific eruption!

**Alternate Activity: Science in a Box 22: Poppin' Rockets**

**Note:** This is a very messy demonstration. Do it outside, and pick a place where nobody will mind that there's pop all over the place. A large grassy area that can be hosed down afterward is good. A spot next to your neighbour's car is not.

It's also a good idea to note which way the wind is blowing, and make sure there are no people or cars on the downwind side.

**Directions: Easy**

1. Set the bottle of pop upright in your chosen area and take the cap off.
2. Quickly drop the Mentos in and step back.
3. Observe what happens as the Mentos reacts with the pop in the bottle.

**Supplies**

- ❑ four or five Mentos candies
- ❑ 2-litre bottle of pop. Some people say Diet Coke works best; we have had success with all kinds of cola and with root beer.

**Directions: Hard (but so much more satisfying)**

In this version, you make the opening at the top of the bottle much narrower by using a bottle cap with a hole drilled in it. The trick, though, is getting the Mentos into the bottle. This method is pretty tricky to do, but you get a much better eruption out of it.

1. Take the cap off the pop bottle and drill a hole in the middle of it. A drill makes this easy, but a pair of scissors with a sharp point will work too.

   **Note:** Be very careful with this! Ask an adult for help if you need it.

   **Note:** If you have a spare cap, drill the hole in one and leave the other on the bottle until you get to step 4.
2. Line the Mentos up and stick them together. Attach a short length of string (10-15 cm) to one end of the line of Mentos. There is no really easy way to do this. We've had some success with wrapping a narrow strip of masking tape around the candies, but do whatever works for you. Your goal is to have all the candies stuck together in a line, with a string at one end, in a way that leaves as much of the candies' surface area exposed as possible.
3. Set the bottle of pop upright in your chosen area. Thread the string through the hole in the cap so that the Mentos are inside the cap.
4. Hold onto the string to keep the Mentos out of the pop while you put the cap back on the bottle. Make it nice and tight.
5. Let go of the string so that the Mentos fall into the pop, and step back. Way back.

**Explanation**

There are a lot of theories about why the pop explodes when you drop the Mentos in, and as far as we know there have not been any rigorous scientific studies done to prove or disprove any of them. However, the explanation that seems to have the most support is this: There is a lot of carbon dioxide gas in pop (that's what gives it its fizz), and when the pop bottle is just standing still the carbon dioxide is held in the liquid. When you disturb the pop (for example, by shaking it or pouring it into a glass), you break the surface tension in the pop and allow that carbon dioxide to escape as bubbles. The more carbon dioxide that gets released, the more bubbles you see.

Dropping something into the pop speeds up the process because, in addition to releasing the carbon dioxide, it gives the bubbles a surface to form on. Why is the effect so dramatic with Mentos? Possibly because the Mentos have lots of tiny dimples that create an especially large surface area for the bubbles. The larger surface area, the faster the reaction rate. More bubbles, more explosion!

When you use a bottle cap with a hole in it, you get a much higher eruption. This is because you are forcing the exploding pop through a much smaller opening, which makes it move faster (and go higher).

# Animation, Old School

Many toys work on scientific principles. In this activity, you build a toy called a phenakistoscope (say Fee-nah- KISS-toe-scope) to explore how animation works.

**Directions**

**Supplies**

- ❑ white poster board or light cardboard
- ❑ pencil with eraser
- ❑ scissors
- ❑ pushpin
- ❑ mirror

1. Draw a large circle (approximately 20-25 cm in diameter) on the poster board. You might want to use a compass (the geometry kind, not the magnetic kind) or trace a plate or other round object to make sure your circle is perfectly round.
2. Cut out the circle.
3. Draw lines to divide the circle into twelve equal slices, like a pizza. The easiest way to do this is to first divide it into quarters, then divide each quarter into three.
4. On each line, cut a slot about 4 mm wide from the edge of the circle in about 3 cm.
5. On each slice, draw a series of simple images showing a sequence of motion. Each image should be slightly different than the one before.

   **Note:** Pick a motion sequence that repeats, like a butterfly flapping its wings, a face that winks an eye or a snake slithering along the ground.

   **Note:** Plan your drawings so that you end with the same image you started with.
6. Push the pushpin through the centre of the circle and jiggle it around a little bit so to make the hole a bit bigger. Then push it into the pencil eraser. The circle should spin easily on the pushpin.
7. Stand facing a large mirror and hold your phenakistoscope so that the drawings are turned away from you toward the mirror.
8. Hold the phenakistoscope up so that you can see through the slots around the edge. Give it a good spin and look through the slots so you can see your drawings in the mirror.

**Explanation**

Your drawings should appear to move as the phenakistoscope spins. Because you are looking through the narrow slots, you only see each image for a very brief moment of time, before the circle of cardboard blocks your view. Your brain "remembers" the image, though, so you don't realize that you spend a lot of the time looking at the back of a sheet of paper. When the next slot comes around, the image is updated in your brain with one that is slightly different, making you think that you are seeing movement.

**What else you can do with this**

If you are stepping back in time and experimenting with semaphore code, try making a phenakistoscope for each letter. Arrange the letters to spell words, and challenge your friends to figure out the words by looking at the images in the phenakistoscopes.

# Build a Biodome

A biodome is a closed ecosystem--a collection of plants, animals, soil, water, and so on that supports itself and does not require anything from outside the system. The waste products of one organism are used by another, and the whole system can exist without any inputs from outside. The Earth itself is a biodome, although the term usually refers to smaller, human-made systems. In this investigation, you build your own miniature biodome for plants.

**Note:** Make sure you have an adult to help you cut the pop bottles.

### Directions

**Supplies**

- ❑ three two-litre pop bottles, preferably clear, with caps
- ❑ thick cotton string
- ❑ cordless drill, or scissors and pushpin
- ❑ small knife or good scissors
- ❑ potting soil
- ❑ seed or a small plant
- ❑ tape

1. Remove the labels from the pop bottles and wash them out. Rinse them thoroughly with clear water – you don't want soap in your biodome!
2. Soak the string in water while you continue with the next few steps.
3. Make a hole in one of the bottle caps large enough to get the string through. To do this, you can either use a cordless drill (carefully) or poke a hole with the pushpin and enlarge it with scissors.

   **Note:** Be very careful! Ask for help if you need it.
4. Use a knife or good sharp scissors to cut the top off of one of the bottles, about 2 cm **above** the top curve of the bottle. Cut the bottom off of the same bottle, about 2 cm **below** the bottom of the curve. This cylinder is the body of your biodome, and the top part will be the cover. Make sure there is a bottle cap on the top part.

   **Note:** Be very careful using knives and scissors. Ask an adult for help if you need it.
5. Cut the top off of another bottle, about 2 cm **below** the top curve. Put the cap with the hole in it on this top, and recycle the bottom part.
6. Cut the bottom off of the third bottle, about 2 cm **above** the bottom curve. Recycle the top part, and use the bottom part for the base of your biodome.
7. Turn the capped top upside down, so the cap is at the bottom, and run the string through the hole in the top. Set the capped top into the base of your biodome (from step 6).
8. Slide the cylinder from Step 4 into the capped top. Hold the string vertically (so it doesn't get pressed up against the side of your biodome) and add some potting soil to the cylinder and capped top.
9. Plant a seed or small plant in the soil, and add a little water--just enough to moisten the soil.
10. Put the top cover (from Step 4) onto your biodome.
11. Put some water in the base, just until it touches the bottle cap with the string through it. The string acts as a wick to draw water up into your biodome.
12. Set your biodome in a sunny spot and watch your plant grow.

 

**Explanation**

Your biodome has everything it needs to grow plants--you shouldn't even need to water it again! The string soaks up the water from the base to provide water for the plant. The potting soil provides nutrients, and sunshine is all the plant needs to manufacture its own food.

**What else you can do with this**

Build several biodomes. Once your plants are growing well, try adding pollutants to the biodomes to see what effect they have. Keep one biodome clean as a control system that you can compare the polluted systems to. Then add one of these items to each of the other biodomes:

- Vinegar to simulate acid rain.
- Cooking oil to simulate an oil spill. Mix it with a little cocoa if you want something that looks dark and gloppy like crude oil.
- Dish soap to see the effect of phosphates.
- Try adding pests (aphids, mites, etc.) to your biodome. What happens?

# Gravity-Defying Water

Gravity pulls everything down to the ground, right? That's true, as long as there isn't something else pushing up.

**Note:** Practice this activity outside or over a sink or bathtub until you get the knack. Then do it over your friend's head.

### Directions

1. Set the glass on a table or counter and fill it right to the brim with water.
2. Place the cardboard on top of the glass.
3. Holding the cardboard firmly in place, turn the glass upside down. Check that there is no air inside the glass.
4. Make sure the glass is not tilted, then carefully let go of the cardboard. It should stay in place, with the water inside the glass.

**Supplies**

- ❑ drinking glass
- ❑ water
- ❑ piece of cardboard large enough to cover the mouth of the glass

### Explanation

Air exerts pressure on everything, including the cardboard covering the mouth of the glass. When you let go of the cardboard, air pressure outside the glass holds it in place so the water doesn't spill out.

# Hot Water

You may have heard that some colours absorb heat energy and other colours reflect it. In this activity, you'll see it for yourself.

**Directions**

**Supplies**

- ❑ two identical clear glass jars or drinking glasses
- ❑ sheet of white paper
- ❑ sheet of black paper
- ❑ elastic bands or tape
- ❑ a jug of room-temperature water
- ❑ measuring cup
- ❑ thermometer

1. Wrap the black paper around one of the jars and use elastic bands or tape to hold it in place. Do the same with the white paper and the other jar.
2. Using the thermometer, take the temperature of the water in the jug. Write it down so you don't forget it.
3. Fill each jar with an equal amount of water from the jug. Use the measuring cup to make sure you have exactly the same amount of water in each jar.

   **Note:** Don't run water directly from the tap. Use a jug of water that has been sitting at room temperature for a while so that the water in both jars is the same temperature.
4. Set both jars in a sunny location and leave them for an hour or two while you go do something else.
5. When you come back, take the temperature of the water in each jar. Which is hotter?

**Explanation**

Dark colours absorb heat energy, and light colours reflect it. The water in the glass that was wrapped in black paper, therefore, will be warmer than in the white-paper glass, because the black-paper glass (and the water inside it) has absorbed more heat energy from the sun.

# How to Build a Lung

You can't live without oxygen, and you know your lungs are an essential part of getting oxygen into your body. But how do your lungs actually work?

**Supplies**

- ❑ empty plastic water bottle, 500-750 ml size
- ❑ scissors
- ❑ two large balloons
- ❑ tape
- ❑ straw
- ❑ modeling clay

**Directions**

1. Cut the bottom off the plastic bottle.

   **Note:** Be careful with the scissors. Ask an adult for help if you need it.
2. Tie a knot in the end of one of the balloons (without inflating it first). Cut the other end off of this same balloon.
3. Stretch the cut balloon over the cut end of the bottle, with the tied end out. The balloon should fit securely, with no leaks. Use tape or an elastic band to hold it if needed.
4. Cut a section about 5 cm long from the straw. (If it is a bendy straw, don't use the bendy part.)
5. Tape the second balloon securely to one end of the straw. There must not be any air leaks.
6. Put the balloon and straw into the neck of the bottle, with the free end of the straw sticking out of the neck. Press modeling clay around the straw to hold it in place and to make a good tight seal. Again, there must not be any air leaks.

**Explanation**

The bottle represents your chest cavity (inside your rib cage), and the balloon inside it is your lung. (It's true, most people have two lungs, but this investigation demonstrates just one.) The balloon stretched over the bottom of the bottle is the diaphragm – a large muscle that stretches across your abdomen, just below your rib cage.

To make your model lung "breathe", pull the tied end of the diaphragm balloon downwards. When the diaphragm contacts (pulls down), this increases the volume of the thoracic cavity and allows the lungs to fill up with air That opens up some extra space inside the bottle (the chest cavity). To fill up that space, air enters through the straw and inflates the lung balloon. The diaphragm is relaxed (pushes up), this decreases the volume of the thoracic cavity and air is pushed out of the lungs. When you let the diaphragm balloon go, the extra air is pushed out through the straw and the lung balloon will deflate.

**What else you can do with this**

You have two lungs that are connected to your trachea or windpipe (represented by the straw in the neck of the bottle) by two smaller "straws" called bronchi. Can you figure out a way to build a more accurate model that has two lungs (two small balloons) inside the bottle, connected to a single straw?

# Ping-Pong Ball Race

You've probably participated in a race where you had to carry an egg on a spoon without dropping it, or a cupful of water without spilling it. Here's a new variation: carry a Ping-Pong ball in a funnel! Sound easy? There's a catch: the large, open end of the funnel must be pointing downward, and you cannot use your hands to hold the Ping-Pong ball inside it.

**Directions**

1. Place the Ping-Pong ball in the funnel.
2. Figure out a way to carry the Ping-Pong ball with the large, open end of the funnel pointing downward. You cannot touch the ball with your hands. How far can you go before the Ping-Pong ball falls out of the funnel?

   **Note:** You can blow into the funnel or suck on it.

**Supplies**

- ❑ clean kitchen funnel **Note:** Only use a clean funnel from the kitchen for this activity. DO NOT use a funnel that has been used in a garage or shop.
- ❑ Ping-Pong ball

**Explanation**

Did you figure out a way to keep the ball in the upside-down funnel without using your hands? Did you try blowing through the narrow end of the funnel?

When you blow air into the funnel, you create a low-pressure area at the top of the Ping-Pong ball (at the narrow end of the funnel). The higher-pressure air below the Ping-Pong ball works to push the ball up into the funnel. As long as you can keep blowing enough air into the funnel fast enough, the Ping-Pong ball won't fall out.

See a video to demonstrate this at http://youtu.be/n7U0H05Kduw

# Potato Obstacle Course

Build an obstacle course and watch a potato plant find its way.

### Supplies

- ❑ shoebox with a lid
- ❑ scissors
- ❑ variety of scrap cardboard, paper towel tubes, empty thread spools or small boxes, and other small objects that can become obstacles
- ❑ tape
- ❑ sprouting potato or small vine-like plant (e.g., bean or ivy)
- ❑ small flowerpot that can fit into the shoebox
- ❑ potting soil
- ❑ water

### Directions

1. Cut a hole about the size of a quarter in one of the short ends of the shoebox.
2. Tape scrap cardboard and other small objects inside the box, along the bottom and long side, so that they stick out into the box like partitions.

   **Note:** Make sure there is a path all the way through the shoebox, from one short end to the other.

   **Note:** You can put an obstacle all the way across the box; just make sure you cut a hole in the middle of it so that there is a path through it.

   **Note:** Leave a little space at the end opposite the hole for the flowerpot.
3. Place the sprouting potato into the flower pot with as many sprouts as possible pointing up. Cover it with potting soil and give it just a little water.
4. Set the flowerpot into the shoebox at the end opposite the hole you made in Step 1.
5. Put the lid on the shoebox and set it in a sunny window, with the hole facing the light.
6. Leave the lid on except to water the plant every two or three days. While you water it, check how it is doing in the obstacle course!

### Explanation

Plants need sunlight and oxygen to carry out photosynthesis and manufacture food in the form of glucose for themselves. There is plenty of oxygen inside the shoebox, but the only way the plant can get sunlight is by getting through all the obstacles to the little hole in the end of the box. It may take several days, but your plant should start winding its way through the path you built for it.

# Raw or Hard-Boiled?

Have you read *Ramona Quimby, Age 8* by Beverly Cleary? Remember the part where Ramona cracks a hard-boiled egg on her forehead and discovers that her mother packed a raw egg in her lunch by mistake? This will never happen to you, once you've learned this simple trick for finding out if an egg is raw or hard-boiled.

**Supplies**

- ❑ hard-boiled egg
- ❑ raw egg

**Directions**

1. Set one of the eggs on the table. Be careful – it might be the raw one!

   CAUTION: Raw eggs may contain harmful microorganisms that can make you sick. Make sure to wash your hands with soap after handling raw eggs.
2. Give the egg a spin, like a top, so that it spins around on the counter top. This might take some practice. Try not to spin it right off onto the floor.
3. Carefully put your finger on top of the egg to stop it spinning, then let it go again. Does the egg stay still, or does it start spinning again?
4. Try the same thing with the other egg. Do you get the same result?

**Explanation**

One of the eggs will start turning again after you let go of it. This one is the raw one. Why doesn't it stay still? Well, when you spin the egg, the whole thing spins – the shell, the white and the yolk. When you touch the egg to stop it, you stop the shell, but the white and the yolk keep moving. This, by the way, is an example of Newton's First Law of Motion, which says that an object in motion tends to stay in motion, unless an outside force acts it on. In this case, the outside force is the pressure from your finger. It acts on the shell, stopping it from spinning, but it can't reach the liquid inside--so the liquid keeps moving. When you lift your finger off the shell, the liquid inside gets the whole egg moving again.

A hard-boiled egg, on the other hand, is solid all the way through. When you touch the shell, you stop the whole egg – the yolk and the white can't move around inside the shell. When you let go of the egg, it stays stopped.

 

# Tasty Ants

Don't worry – you don't actually taste ants in this investigation. But you will find out what kind of tastes ants prefer.

**Note:** You will need some ants for this investigation. Look for the small black ones; the red ones have painful, stinging bites. Collect them carefully in a small jar or other container--be careful not to hurt them. We've all squished ants when they invaded our picnics and our homes, but when you are voluntarily seeking them out, and freaking them out by catching them, it's only fair to treat them gently. When you have finished this activity, let the ants go near where you got them.

## Directions

1. Pour the water into the three small bowls. Stir a teaspoon of sugar into the water in one bowl and a teaspoon of salt into another. Leave the water in the third bowl plain.
2. Draw three circles on a sheet of paper. Space them out around the paper. Label the circles "Sugar," "Salt" and "Plain".
3. Use the eyedropper or a small spoon to place a small amount of the three types of water into the corresponding circles on your paper.
4. Gently place the ants in the centre of the paper. Watch for a few minutes as the ants sample the different kinds of water. Which one do they prefer?

**Supplies**

- ❑ water
- ❑ 3 small bowls
- ❑ sugar
- ❑ salt
- ❑ paper
- ❑ pencil
- ❑ eyedropper or small spoon
- ❑ ants

# Floating Egg

Would an egg float in plain water or salt water? What does density have to do with it?

**Directions**

1. Pour some tap water into a tall glass until the glass is half full.
2. Add about 7 tablespoons of salt into the glass. Use a spoon to mix the water with the salt.
3. Pour in some more tap water into the same glass, making sure not to disturb the salt water solution below. NOTE: The salt water should not mix with the plain water.
4. Carefully lower an egg into the glass. Observe what happens to the egg.

**Supplies**

- ❑ water
- ❑ 1 egg
- ❑ 7 tablespoons of salt
- ❑ spoon
- ❑ glass

**Explanation**

The density of plain water is less than the density of salt water and that is why it remains as a separate layer above the salt water. When the egg is placed in the glass, the egg sank in the plain water because the egg's density is greater than that of plain water. But once the egg hit the salt water, it floated on the salt water because the density of the salt water is greater than the density of the egg. The egg should appear to suspend in the middle of the two separate layers of water.

# Mixing Water and Oil

Does water and oil mix? Mix them together and see how they interact.

### Directions

1. Pour ½ cup of tap water into a 1L pop bottle.
2. Add several drops of food colouring to the water and shake well.
3. Pour ½ cup of cooking oil to the coloured water in the pop bottle.
4. Place the lid back on the pop bottle and shake well. Allow the water and oil to settle and observe how they interacted. Where does the oil settle?

**Supplies**

- ❑ 1L pop bottle with lid
- ❑ ½ cup of water
- ❑ food colouring
- ❑ ½ cup of cooking oil

### Explanation

The oil should settle on top of the water because it is less dense than water. Water molecules tend to stick together because of their cohesive property and therefore are attracted to each other. Water and oil do not mix because oil is a lipid and is not water-soluble (it cannot dissolve in water). Oil is said to be “hydrophobic” (hydro = water; phobic = “scared or does not like”) and therefore does not like mixing with water.

# Glow in the Dark Water

Investigate what black light allows you to see in tonic water.

**Directions**

1. Conduct this investigation in a dark room.
2. Hold the black light up to the bottle of tonic water.
3. Observe what happens to the tonic water in the bottle.

**Supplies**

- ❑ black light from hardware store
- ❑ bottle of tonic water (e.g. Canada Dry)
- ❑ dark room

**Explanation**

Tonic water contains phosphors which emit luminescence (or fluorescence in this investigation) when they are excited by black light. Black light is also known as ultraviolet (UV) light, which is a form of energy on the Electromagnetic Spectrum. Ultraviolet light is not visible to the human eye. The phosphors turn the UV light into visible light, which we can see. That is why we see the tonic water glow in the dark when black light is brought up to it. Black light is also used in photography, forensic sciences and verifying the authenticity of bank notes.

# Creating Music With Water

Investigate how music could be made from water and some drinking glasses.

**Directions**

**Supplies**

- ❑ 6 drinking glasses
- ❑ water
- ❑ wooden chopstick

1. Fill 6 drinking glasses with different amounts or volume of water.
2. Place the 6 drinking glasses side-by-side, starting with the glass with the least amount of water and ending with the glass with the most amount of water.
3. Use a wooden chopstick to hit the side of the glass. Start with the glass with the least amount of water. Listen to the sound that it creates.
4. Use a wooden chopstick to hit the side of the glass with the most amount of water. Compare the sound that this creates to the sound that the other glass created.
5. Continue to hit the 6 different glasses and create a song.

**Explanation**

The vibrations from the striking action of the wooden chopstick against the glass cause sound waves to travel through the water. The less water there is in the glass, the faster the vibrations and the higher the tone that is created.

# Static Charge

Have you ever heard of the saying “opposites attract”? This is true in physics. Opposite charges are attracted to each other, that means a positive charge will be attracted to a negative charge.

**Directions**

1. Blow up a balloon and tie it off.
2. Rub the balloon against your hair to build up a charge.
3. Hold the balloon above some salt that is sitting on the table. Observe what happens to the salt.
4. Charge another balloon by rubbing it against your hair again.
5. Bring this balloon near an aluminum pop can that is lying on its side on a table. Observe what happens to the pop can.
6. Take a comb and comb your hair with it. This will build up a static charge.
7. Bring the comb near a pile of confetti. Observe what happens to the confetti.

**Supplies**

- ❑ 2 balloons
- ❑ comb
- ❑ confetti (or paper from a hole punch)
- ❑ salt
- ❑ aluminum pop can

**Explanation**

When you rub a balloon against your hair, you are charging the balloon through static electricity. This means there is a build-up of electrons (negatively charged particles). When you bring the charged balloon near salt it is going to be attracted to the neutral object and make the salt “dance” or “jump”. When you bring the charged balloon near the pop can, the pop can is going to start rolling on the table because it is attracted to the charged balloon. This is the same for the case of the charged comb and the confetti. The confetti are going to be attracted to the comb and will appear to “jump up” towards the comb.

# Chromatography

What colours make up the colour black?

**Directions**

1. Use a pair of scissors to cut a coffee filter into a rectangular strip (eg. 15 cm wide by 18 cm high).
2. Take a ruler and measure 3 cm from the bottom of the rectangular strip.
3. Use a pencil and draw a line at the 3 cm mark.
4. Use a black felt pen and make a dot in the centre of the pencil line.
5. Add some water to a cup so that the water is at a height of about 2 cm high.
6. Carefully lower the rectangular coffee filter strip into the cup making sure that the black dot is above the water level.
7. Tape the coffee filter strip to the side of the cup making sure that it is suspending in the water, but the black felt mark is above the water.
8. Observe what happens to the coffee filter paper.

**Supplies**

- ❑ coffee filter
- ❑ water
- ❑ cup
- ❑ scissors
- ❑ black felt pen
- ❑ pencil
- ❑ ruler
- ❑ tape

**Explanation**

The black dot on the coffee filter paper is a mixture of colours. Chromatography is used in this investigation to separate the different colour pigments in the black dot made by the black felt pen. Different bands of colours will appear on the coffee filter paper as the colour molecules separate by solubility due to their difference in weight and size. The different colour pigments dissolve in the water and move up the coffee filter paper by capillary action. The molecules that are more soluble will travel higher up the coffee filter paper.

# Cartesian Diver

Investigate the concepts of density, buoyancy and pressure using a Cartesian Diver.

**Directions**

**Supplies**

- ❑ 2L pop bottle
- ❑ water
- ❑ condiment package
- ❑ plastic cup

1. Select the best Cartesian Diver by testing out different plastic condiment packages (eg. Vinegar, ketchup, mustard, etc.). Place the several condiment packages into a cup with water. The package that barely floats makes the best Cartesian Diver because it has a density close to that of water, 1 g/mL.
2. Place the selected condiment package into a 2L pop bottle.
3. Add water to the 2L pop bottle so that it filled to the top. Screw on the cap to the bottle.
4. Squeeze the sides of the pop bottle. Observe what happens to the Cartesian Diver.

**Explanation**

When the bottle is squeezed, the Cartesian Diver sinks to the bottom. When the bottle is no longer squeezed, the Cartesian Diver moves back up to the top. There is a small air bubble inside the condiment package. As pressure increases due to the squeezing of the bottle, the volume of the condiment package decreases because pressure and volume are inversely proportional. As the volume decreases, the density increases to greater than 1 g/mL and therefore causes the Cartesian Diver to sink. Objects with a density greater than water (1 g/mL) will sink and objects with a density of less than water will float.

# PROGRAM CONNECTIONS

The Girls First program is girl-driven and designed to be highly flexible and agile. We encourage you to visit the Digital Platform to best determine how this challenge fits into the Program Areas and Themes.

You may want to start exploring the following Program Areas:

- Experiment and Create
- Build Skills
- Into the Outdoors

This is not a comprehensive list, and remember that you can apply your activities to the Girls First program as you see fit.