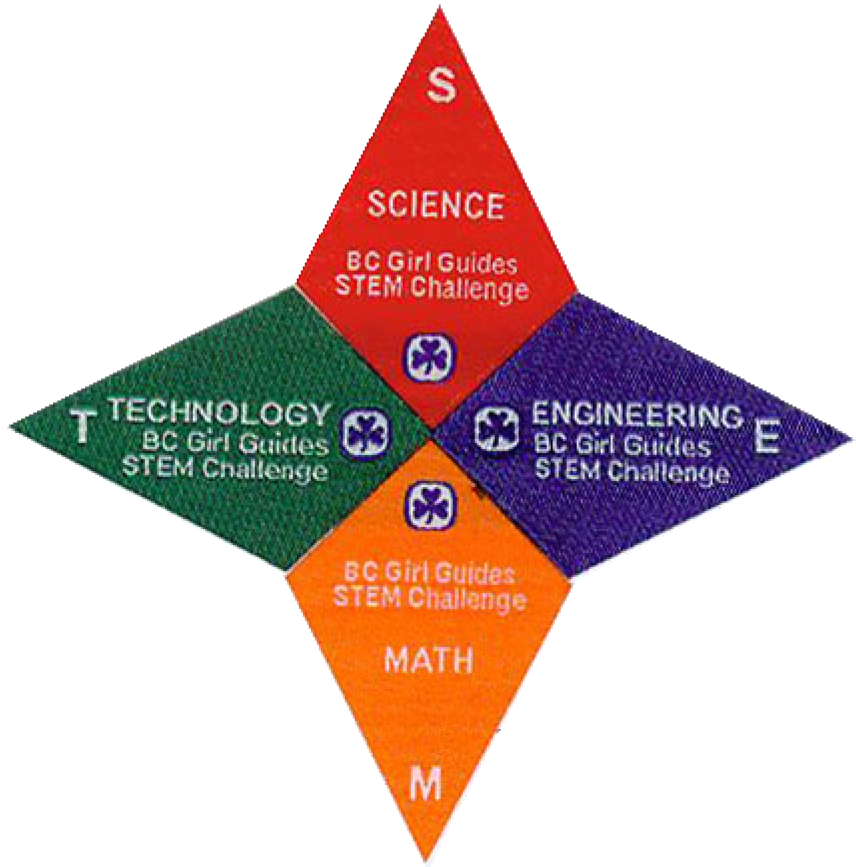

Science

STEM Challenge

BC Program Committee
September 2010

Chapter 1

Introduction

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. In the STEM Challenge booklets, you will find two or three categories of activities:

- Replacement Activities. Some of the activities in the original challenges are too complex for many groups to actually do; some require specific equipment that is difficult to find or no longer available; some are just so great that you've done them over and over. The Replacement Activities in the new STEM challenge provide fresh, new approaches to these activities.
- New Activities. Because you just can't get enough STEM, these activities provide a whole new set of things for you to experiment with.
- Obsolete Activities: In some cases, activites outlined in the older resources are just no longer workable for one reason or another. In these cases, we'll give you some suggestions for other things you can do instead.

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

BC Council

About This Challenge

Objectives

To have fun experimenting with different fields of science.

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 Penny Drops. Be creative and open-minded, and you'll soon find yourself asking, "Why *not* science?"!

Earning the Crest

To earn the ribbon crest for this part of the STEM Challenge, you need to complete a specific number of activities, depending on your branch of Guiding. You can select these activities from this booklet, or you can choose activities from the original Science in a Box and GET challenge materials that are related to this part of the STEM Challenge. However, you are not limited to the activities in these resources! Feel free to use ideas from the Internet, books or magazines, other Guiders or people in your community, or any other resources.

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

- Eco-Pak booklet and CD
- CSI Challenge booklet
- Branch-specific Instant Meeting booklets

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!)

Required Activities

Branch	Number of Activities Required
Sparks	4
Brownies	5
Guides	7
Pathfinders	9
Rangers	10
Adults	10

Ordering the Crest

When you have completed this portion of the challenge, you can order the crest by sending an email to the BC Program Committee at *program@bc-girlguides.org*. Please specify which portion of the challenge you have completed and the number of crests you need. Please allow four to six weeks for delivery.

A Word About Program Connections

Each activity in this booklet includes a list of program connections--areas of the girls' regular program that the STEM challenge meets the requirements for. These program connections are intended as guidelines to help you fit the STEM challenge into your regular program planning. In some cases, the challenge activity is very similar to an activity in the program area; in other cases, the challenge activity could be used as an alternative to activities mentioned in the program area. In all cases, remember that the girls' program is intended to be flexible: if an activity meets the objectives of the program area, and if it is interesting and challenging for the girls, by all means give them credit for it as part of their program requirements.

The lists of program connections is also not exhaustive. If you find another progam area that is covered by an activity in this booklet, don't hesitate to give the girls credit for it.

You may notice that very few of the activities include explicit program connections for Rangers. The Ranger program encourages in-depth exploration of topics of interest. Many of the activities in this booklet, on the other hand, are relatively short and simple—so that busy Guiders can easily incorporate them into unit meetings—and offer only a very superficial taste of the subject matter. That makes it difficult to draw direct connections between these activities and the Ranger program. However, because the Ranger program is also very flexible and self-directed, Rangers can certainly take any of these activities and expand or combine them to meet the objectives of one of the program areas. Rangers who are working in units can also plan and lead any of these activities for younger girls.

Chapter

2

Replacement Activities

- *Edible Slime*
- *Cabbage Juice pH Indicator*
- *Magical Milk*
- *Magically Moving Water*
- *Blind Spot!*
- *When the Penny Drops*
- *Gravity-Defying Balls*
- *Sparkling Lemonade*
- *Molecules in Motion*
- *Exploding Pop*

The activities in this section are intended as replacements for or updates to activities in the Science in a Box Challenge booklet.

Edible Slime

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

Replacement for:

- Science in a Box Experiment #1: Ack, It's Gack!

What you need:

- 400-ml can of sweetened condensed milk
- 2 tablespoons chocolate syrup
- 1-1/2 tablespoons cornstarch
- Saucepan
- Stove
- Spoon

What to do:

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.

How it works:

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; molasses has a very high viscosity. 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things); Tasty Treats badge; Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Cabbage Juice pH Indicator

Scientists use a pH indicator to figure out if a particular substance is an acidic or not. Substances that are acidic are called **acids** (predictably); substances that are not acidic are called **bases** or **alkalis**. Substances that are neither are **neutral**. Many different things can be used as a pH indicator, but 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 experiment, make your own pH indicator that you can use in other experiments.

Update for:

- Science in a Box Experiment #2: Mix and Match. Use cabbage juice instead of the pH kit from the box.

What you need:

- 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 to do:

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!

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 (phenol red), 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Beyond You (Try New Things); Chemistry badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Magical Milk

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

Replacement for:

- Science in a Box Experiment #6: Listen to the Lifeguard

What you need:

- Pie plate or similar wide, shallow dish
- Milk
- Food colouring in two or more colours
- Dish soap

What to do:

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.

How it works:

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 eye dropper 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

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 experiment!

Replacement for:

- Science in a Box Experiments #10: Climbing Colours; #11: How Does Water Climb a Tree?

What you need:

- Two drinking glasses, preferably clear
- Water
- Two or three paper towels

What to do:

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.

How it works:

After a few minutes (this experiment 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

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 experiment to find out where your blind spot is.

Extension for:

- Science in a Box Experiments #15: Taste Test; #16: Using Your Nose

What you need:

- Paper
- Pencil or pen with dark-coloured ink
- Ruler

What to do:

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 experiment again with your right eye closed and your left eye looking at the dot.

How it works:

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

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Body Works badge; Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

When the Penny Drops

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

Extension for:

- Science in a Box Experiments #15: Taste Test; #16: Using Your Nose

What you need:

- A partner
- A small paper or plastic cup
- Ten pennies or other small objects

What to do:

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 penny in your hand and move it back and forth above the cup.
3. Your partner tries to make you drop the penny into the cup. She watches the penny 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 penny. Does it land in the cup?
5. Repeat this with all ten pennies. How many pennies land in the cup?
6. Do the experiment again, but this time, your partner closes one eye while she watches you with the pennies. How many pennies land in the cup this time?
7. Trade jobs.

How it works:

You probably found that it is easier to make the pennies 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Body Works badge; Science badge
- Pathfinders: Exploring a Theme (Puzzle Me, Everything Comes from STEM)

Gravity-Defying Balls

Context for the experiment.

Replacement or extension for:

- Science in a Box Experiment #19: Gravity in Motion

What you need:

- Basketball (or another ball of similar size and weight)
- Tennis ball (or another ball of similar size of weight)

What to do:

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, 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?

How it works:

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 turned 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Sparkling Lemonade

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

Replacement for:

- Science in a Box Experiments #21: Balloon Blowing; #22: Poppin' Rockets

What you need:

- Lemon
- Knife
- Drinking glass
- Water
- 1 teaspoon baking soda
- Sugar

What to do:

1. Cut the lemon in half and squeeze as much juice as you can out of it into the glass.

   Note: Be careful using the knife! Ask for help if you need it.

2. Add an equal amount of cold water to the glass.
3. Stir in the baking soda.
4. Add sugar if you like your lemonade a little bit sweeter.

How it works:

Lemon juice is an acid, and baking soda is a base (or *alkali*). When you mix these two opposites 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper; Being Healthy Keeper
- Brownies: Key to STEM
- Guides: Disovering You (Stay Fit and Healthy); Chemistry badge; Science badge
- Pathfinders: Living Well (You Are What You Eat); Exploring a Theme (Everything Comes from STEM)

Molecules in Motion

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

Replacement or update for:

- Science in a Box Experiments #20-22: Things in Motion

What you should know before you start:

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

What you need:

- 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

What to do:

1. Fill one glass with cold water and the other with hot water. This experiment 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?

How it works:

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, than molecules in cold things do.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Exploding Pop

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

Replacement for:

- Science in a Box Experiment 22: Poppin' Rockets

What you should know before you start:

This is a very messy experiment. 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 Lexus is not.

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

What you need:

- Four or five Mentos candies. Other similar candies may work too; we haven't tried.
- 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.

What to do--the easy way:

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.

What to do--the hard (but so much more satisfying) way:

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 is 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.

How it works:

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. 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).

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Chapter 3

New Activities

This is a selection of new activities for you to try.

Animation, Old School

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

What you need:

- White poster board or light cardboard
- Pencil with eraser
- Scissors
- Pushpin
- Mirror

What to do:

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.

How it works:

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 your view is blocked by the circle of cardboard. 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper

- Brownies: Key to STEM; Key to the Arts
- Guides: Art Production badge; Body Works badge; Physics badge; Science badge
- Pathfinders: My music, Movies and More! (The Arts from A to Z); Exploring a Theme (Everything Comes from STEM)

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 experiment, you build your own miniature biodome for plants.

What you should know before you start:

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

What you need:

- Three two-litre pop bottles, preferably clear, with caps
- Thick cotton string
- Cordless drill, or scissors and push pin
- Small knife or good scissors
- Potting soil
- Seed or a small plant
- Tape

What to do:

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 push pin 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.

How it works:

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?

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to the Living World; Key to STEM
- Guides: Ecology badge; Plants and Animals badge; Science badge
- Pathfinders: Let's Take it Outside (Up Close and Personal with Nature); Exploring a Theme (Everything Comes from STEM, Our Environment)
- Rangers: Environment, Outdoors and Camping (Our Local Environment)

Crystal Snowflakes

Make your own sparkling snowflake that won't melt!

Replacement or update for:

- Science in a Box Experiment
- GET Challenge experiment

What you should know before you start:

This experiment requires you to handle boiling water. Be careful, and ask an adult for help if you need it.

What you need:

- Large canning jar or similar wide-mouth jar
- Measuring cup
- Borax (available in the laundry section of supermarkets)
- Tablespoon
- White pipe cleaner
- Scissors
- String
- Pencil or small wooden dowel
- Boiling water
- Blue food colouring (optional)

What to do:

1. First figure out how many cups of water your jar can hold. Measure one cupful of tap water at a time into the jar, keeping track of how many you need to fill the jar. Dump the water out.
2. You will need about three tablespoons of Borax for each cup of water your jar can hold. This is a good time to measure it out so it is ready to go.
3. Cut the pipe cleaner into three equal pieces and twist them together in the middle to make a six-pointed star. Trim the ends, if you need to, to make the points all the same length. Make sure the star will fit into the jar.
4. Tie one end of the string to one of the points on your star. Tie the other end of the string around the middle of the pencil.
5. Pour boiling water into the jar.

   Note: Be very careful with boiling water. Ask an adult for help if you need it.

6. Add the borax one tablespoon at a time, stirring after each tablespoon-full. Some of the Borax might settle at the bottom of the jar; that's okay.
7. Add a few drops of food colouring, if you like.
8. Carefully put your pipe cleaner star into the jar and rest the pencil across the top of the jar. Leave it overnight.
9. The next day, carefully remove your snowflake from the jar.

How it works:

Borax, or sodium borate, is a naturally-occuring mineral. It is a colourless crystal powder that dissolves easily in water--especially hot water. When your Borax solution cools, some of the Borax comes out of the solution. Chemists call this process *precipitation*, and in fact if you could see the Borax molecules it would look like they were "raining" onto the pipe cleaner. The Borax collects on your snowflake, and once enough of them have accumulated you have a pretty crystal snowflake.

Program connections:

- Sparks: Exploring and Experimenting Keeper

- Brownies: Key to STEM
- Guides: Chemistry badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Gravity-Defying Water

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

What you should know before you start:

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

What you need:

- Drinking glass
- Water
- Piece of cardboard large enough to cover the mouth of the glass

What to do:

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.

How it works:

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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Hot Water

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

What you need:

- 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

What to do:

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?

How it works:

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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

How to Build a Lung

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

What you need:

- Empty plastic water bottle, 500-750 ml size
- Scissors
- Two large balloons
- Tape
- Straw
- Modelling clay

What to do:

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 modelling clay around the straw to hold it in place and to make a good tight seal. Again, there must not be any air leaks.

How it works:

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 experiment just uses 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 outwards. 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. 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 (represented by the straw in the neck of the bottle) by two smaller "straws" called bronchii. 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?

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Body Works badge; Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

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.

What you need:

- Clean kitchen funnel

  Note: Only use a clean funnel from the kitchen for this experiment. DO NOT use a funnel that has been used in a garage or shop.

- Ping-pong ball

What to do:

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.

How it works:

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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Potato Obstacle Course

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

What you need:

- 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 flower pot that can fit into the shoebox
- Potting soil
- Water

What to do:

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 flower pot.

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 flower pot 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!

How it works:

Plants need sunlight and oxygen to manufacture food 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM; Key to the Living World
- Guides: Plants and Animals badge; Science badge
- Pathfinders: Let's Take it Outside (Up Close and Personal with Nature); Exploring a Theme (Everything Comes from STEM)

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.

What you need:

- Hard-boiled egg
- Raw egg

What to do:

1. Set one of the eggs on the table. Be carefull--it might be the raw one!
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?

How it works:

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 it is acted on by an outside force. 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.

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM
- Guides: Physics badge; Science badge
- Pathfinders: Exploring a Theme (Everything Comes from STEM)

Tasty Ants

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

What you should know before you start:

You will need some ants for this experiment. 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 experiment, let the ants go near where you got them.

What you need:

- Water
- 3 small bowls
- Sugar
- Salt
- Paper
- Pencil
- Eye dropper or small spoon
- Ants

What to do:

1. Pour the water into the three small bowls. Stir a teaspon 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 eye dropper 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?

Program connections:

- Sparks: Exploring and Experimenting Keeper
- Brownies: Key to STEM; Key to the Living World
- Guides: Plants and Animals badge; Science badge
- Pathfinders: Let's Take it Outside (Up Close and Personal with Nature); Exploring a Theme (Everything Comes from STEM)

Chapter

4

Obsolete Activities

This section outlines activities from the Science in a Box or Girls Exploring Technology challenges that have become obsolete, and gives some suggestions for alternative activities.

Splitting the Smartie

Unfortunately, the Splitting the Smartie experiment from the Science in a Box booklet no longer works.

Obsolete Activity:

- Science in a Box Experiment #13: Splitting the Smartie

Why it is absolete:

Nestle has changed the dye they use in Smarties, and the new colours do not run like the old ones did. This experiment will not work with the new Smartie colours.

What else you can do with this:

You could try this experiment with generic Smartie-like candies, or substitute one of the following experiments to explore capillary action:

- Science in a Box Experiment #10: Climbing Colours
- Science in a Box Experiment #11: How Does Water Climb a Tree?
- Science in a Box Experiment #12: Butterfly Beauties
- STEM Challenge, Science Booklet: *Magically Moving Water*