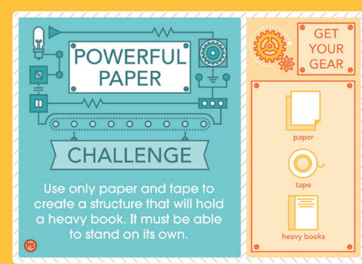
GRADES 2–5

STEM CHALLENGES

RESOURCE GUIDE

The STEM Challenges cards are the perfect way to include STEM (Science, Technology, Engineering, and Math) learning in your classroom. Simply grab a card and go! The low-prep activities use common classroom materials and are achievable by all learners. Use the hints on the card backs when students are struggling with the task. Use the STEAM questions to extend learning once students finish a task. The short explanation of the science behind each task connects learning to your classroom and beyond. Refer to pages 3 through 5 for more tips and ideas for using the STEM Challenge cards in your classroom.

The activities included in this Resource Guide will provide more formal connections to the science in each challenge. They are formatted like more traditional science experiments and can be done as a whole class before or after completing a STEM challenge to support your science curriculum. Or, make copies and send the experiments home to encourage a school-to-home science connection.



The Challenge Cards Are Perfect For

Individuals	Early finishers	Science warm-ups	After-school activities
Small groups	Indoor recess	Centers	Take-home activities

Current State ALIGNED Standards

Visit *carsondellosa.com* for correlations to Common Core, state, national, and Canadian provincial standards.

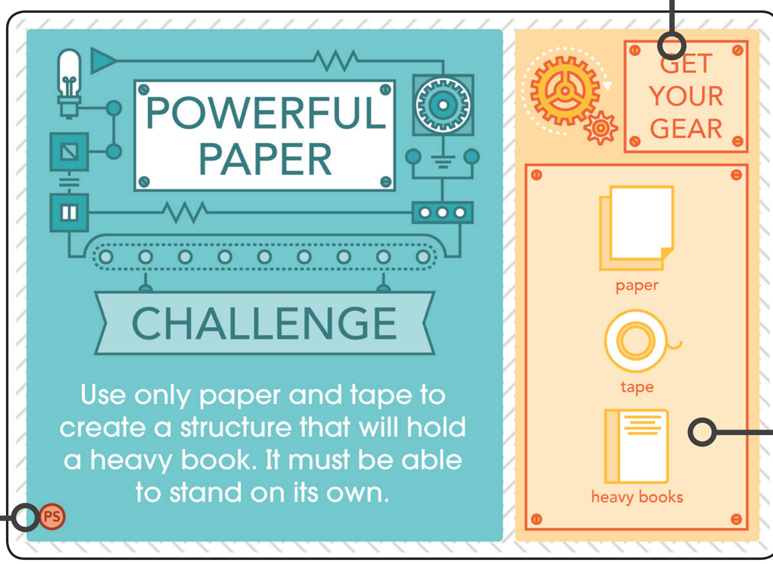
Table of Contents

Tips & Tricks for Using the STEM Challenge Cards

Gather the supplies and place them in a plastic pencil box or shoe box, along with the challenge card, to create a grab-and-go kit for each card. Then, students can grab kits and take them to their desks for morning work, during free choice time, or after finishing a task early.

To keep the set organized, use the color and letter code on the front of each card to replace each card behind the correct divider.

Or, place common supplies in a plastic drawer unit or tubs to allow students easy access to the materials they need to complete a chosen challenge.



You may want to include additional supplies such as hand wipes, a plastic tablecloth, etc., to help students keep their areas clean.

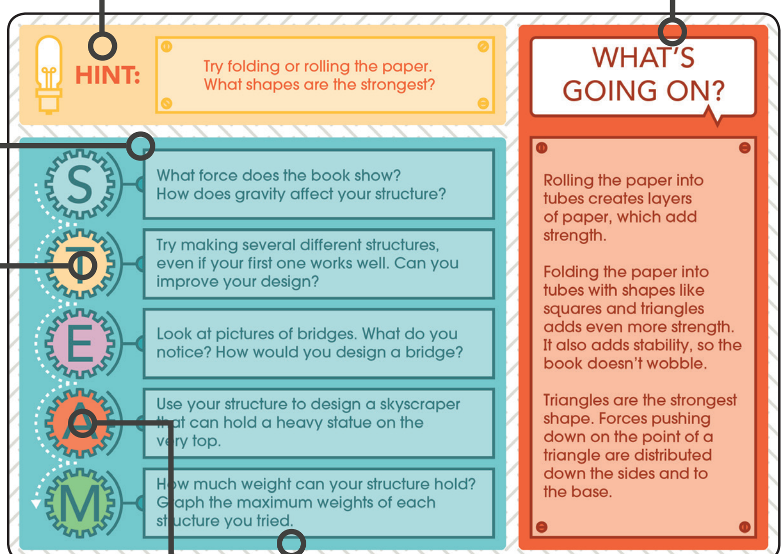
Tape, glue, and scissors are considered basic supplies and often aren't listed with the materials. They can be used to complete each challenge unless otherwise noted.

Tips & Tricks for Using the STEM Challenge Cards

This section often uses additional resources to extend learning, such as new materials or internet access. Make sure these items are available to students as needed.

To discourage students from using the hint immediately, place a piece of masking or paper tape over the Hint box.

Use the matching experiment in the resource guide to give students a more structured experience with the same scientific principles. Or, do the experiment first and let students use what they learned to complete the related STEM challenge.



With STEM, technology is not only calculators, computers, and software programs. Instead, it refers to using a tool to solve a problem or meet a need. For example, a paper clip can become a tool used to tighten a wheel on a vehicle.

Use the recording sheet on page 36 to guide students through completing each STEM challenge. It can also provide accountability if using the cards at home or as a self-directed activity.

Often, proponents change STEM to STEAM with the addition of art. The included art-and-design based questions and tasks will allow students to practice writing, visual arts, and more in the context of the original STEM challenge.

Tips & Tricks for Using the STEM Challenge Cards

Using the Challenge Cards

Decide how the STEM challenge cards would best fit into your classroom structure.

- **Whole Class** Incorporate STEM cards into your science curriculum. Use the challenges to introduce a topic and get students excited about it, or as a closing activity at the end of a unit of study. Choose a card that relates to your current science topic. Gather enough supplies and place students in small groups. Display the challenge and have groups work together to complete the challenge. Allow groups to share their final designs.
- **Morning Work or Early Finishers** As students arrive to school or finish their work early, allow them to choose a kit (see tip on page 3) or a card to work on. It may be helpful to designate a place where students can place works in progress. You may also choose to remove cards with activities that are messier or will take too much time or space to complete.
- **At-Home Activity** Send a card home with each student once a week or once a month. Encourage students to work with their families to complete a challenge and the related STEAM activities on the back of the card.
- **Indoor Recess** During indoor recess, allow students to choose a STEM challenge card to complete alone or with a small group of friends.
- **Science Centers** Choose cards related to your current topic of study in science. Place the cards and related materials in a science center. Allow students to choose a card and complete the challenge during center time.

Show and Share

Develop a way for students to share their creations.

- **Gallery Walk or STEM Museum** Have students display their projects with the related card. Have half of the class stay with their projects to describe them and demonstrate while the other half walks around and observes. Then, switch roles.
- **Dedicated Space** Create a special space in the classroom where students can display their projects. Have them label their projects with their names and the challenge. Allow students to visit the space during downtime, such as during morning arrival or after finishing work early.
- **STEM Day** Once a month or once a quarter, allow students who have completed challenges to present their designs to the class.

Community Connection

Connect STEM to your community and the world beyond.

- **STEM Careers** Invite community members and other special guests with jobs in STEM fields to talk to the class about their careers and how they use STEM. Then, complete a related STEM challenge card as a class.
- **Family STEM Night** Invite families from all grades to the school for an after-school STEM carnival or fair. Have students run small science experiment booths for families to visit. Place STEM challenge cards on tables with the related materials and challenge families to work together to complete them. Create a STEM career dress-up area to encourage role-playing. It may be fun to host the event each quarter with a seasonally appropriate theme.

BUILDING BRIDGES

QUESTION

Which shape can support the most weight?

MATERIALS

paper
tape
scissors
toy cars

PROCEDURE

1. Fold a piece of paper lengthwise 3 times to create a square tube. Make sure the folds are the same distance apart so it is square, not rectangular. Tape the ends together to close the tube.
2. Repeat step 1 with 3 lengthwise folds to create a triangular tube. Make a second triangular tube.
3. Use scissors to cut each tube into sections that are 1.5–2 inches wide. You should end up with about 7 shallow square tubes and about 14 shallow triangular tubes.
4. Cut 2 strips of paper that are about 11″ x 2″ (28 x 3 cm). This will be your road surface. You may need to tape the ends of strips together to create longer roads.
5. Place the square tubes side by side with the left and right sides touching (see diagram A). Place the paper road on top to create a bridge.
6. Place 2 triangle tubes side-by-side so their bottom corners touch. Then, place a triangle point down between them (see diagram B). Repeat until at least 11 triangles have been used. Place the paper road on top to create a bridge.
7. Drive a toy car across each bridge. What happens? Next, try heavier and lighter cars, or add more than one car.
8. Repeat steps 1–7 with different folds to test the strength of different shapes, such as circles, rectangles, or pentagons.


A


B

CONCLUSION

Square bridge supports can't hold the weight of a car. That is because the top of the square holds all of the force and the sides bow out. Triangles can hold more weight because, when weight presses down on the top point, the force is evenly divided down each side and shared equally by the base.

RUBBER BAND RACES

QUESTION

Does the size or shape of a rubber band affect the amount of energy it can store?

MATERIALS

rubber bands (various lengths and widths)
rulers
tape measure
masking tape
chalk (optional)

PROCEDURE

1. Place a line of masking tape on the floor to designate the start line. Or, draw a line in chalk if doing the experiment outside.
2. Create a table to record your data. Include a row for each different rubber band and spaces to record the distances from three trials for each rubber band.
3. To test each rubber band, stand on the start line. Place a rubber band on the 0 end of the ruler and pull it back to a designated length, such as 3, 4, or 5 inches (7, 10, or 12 cm). Then, release the
rubber band. Test each rubber band using the same length for consistency. For safety, make sure all participants stay behind the start line while rubber bands are being launched.
4. Use the tape measure to measure the distance from the start line to where the rubber band landed and record it in the chart.
5. Repeat steps 3 and 4 until each rubber band has been launched at least three times. To extend the activity, repeat with a single rubber band in order to test the differences in how far it flies when pulled 3, 4, 5, or more inches (7, 10, or 12 cm).

CONCLUSION

Because rubber bands are stretchy, they can hold energy when they are stretched. This is potential energy. The potential energy differs depending on the material, width, and size of the rubber band. It also changes based on how far the rubber band is stretched before being released. You see the potential energy being changed into kinetic energy when the rubber band is released and it starts moving.

SEEING SOUND

QUESTIONS

How does sound travel through materials?
What materials can sound travel through?

MATERIALS

- large mixing bowl
- plastic wrap
- large rubber band
- uncooked rice
- metal pans and cookie sheets
- large metal spoon

PROCEDURE

1. Stretch the plastic wrap over the top of the mixing bowl, pulling it tight. Place the rubber band around the top of the bowl to secure the plastic wrap and keep it taut.
2. Place a handful of rice on the plastic wrap.
3. Hold a metal pan near the bowl without allowing them to touch. Hit the pan with the metal spoon and watch what happens to the rice.
4. Try holding the pan at different distances from the bowl to see how it affects the movement of the rice. Then, try hitting the pan lighter or harder and watch the effect on the rice. Test other objects that make sound, such as a radio or a person singing. What happens?

CONCLUSION

Sound travels in invisible waves. The sound waves can travel through air, wood, and other materials. The waves cause vibrations in materials like the plastic wrap, which is what makes the rice move. When we hear sounds, it is because our outer ears collect the sound waves and funnel them to our inner ears, where they make our eardrums vibrate. Our brains interpret these vibrations as sound.

SOAK IT UP

QUESTIONS

Which materials are porous?
Which materials are non-porous?

MATERIALS

water
plastic cups
paper towels
toilet paper
sponges (natural and kitchen)
wax paper
printer paper
construction paper
plastic wrap
aluminum foil
parchment paper (optional)
food coloring (optional)

PROCEDURE

1. Add water to 6 to 8 plastic cups, depending on how many materials you are testing. You do not need a lot of water in each cup.
2. Cut or tear all of the different papers, plastic wrap, and foil into strips. If desired, cut the kitchen sponges into strips also, or use the sponges whole.
3. Place the end of each strip or sponge into the water in a cup. Observe what happens.
4. Extend the experiment by adding food coloring to the water and observing how quickly water climbs through each material, or by timing how long it takes for each material to absorb all of the water.

CONCLUSION

Porous materials have pores, or gaps or spaces, in their surfaces. Some pores are large enough to see, like in sponges. Others are not visible, like in printer paper. Some examples of porous materials are sponges, wood, cork, pumice stones, and even human skin and bones! Some materials do not have pores, so they are non-porous. Some examples include plastic and metal. Porous materials can absorb water because the water takes the space of the air in the pores. Non-porous materials cannot absorb water because there are no spaces to hold the water.

FIND THE FIELD

QUESTION

How do magnets attract iron without touching it?

MATERIALS

plastic tablecloths
gloves (latex or nitrile)
safety goggles
white paper plates
rulers
button magnets
bar magnets
horseshoe magnets
neodymium magnets (optional)
iron fillings
clear glass or plastic bottles

PROCEDURE

1. Before beginning, place plastic tablecloths over desks or tables to make cleanup simpler. Wear gloves and safety goggles throughout the activity.
2. Use 4 to 6 rulers to create two parallel bases for the paper plate. (You may also use chapter books of the same thickness.) Be sure to leave a space under the center of the paper plate to place the magnets.
3. Place a magnet under the paper plate. Sprinkle iron fillings on the plate over the magnet. Observe what happens. You may need to add more fillings to see the complete magnetic field. (Be careful not to let the iron fillings directly touch a magnet, since they will stick to the magnet and are difficult to remove.) Then, carefully pick up the plate and bend it to create a funnel so you can return the iron fillings to their container.
4. Repeat step 3 with different types of magnets. Then, try multiple magnets at the same time. Lay them in different orientations, and place like and/or unlike poles together to see how it affects the magnetic field.
5. Pour iron fillings into the clear bottle and replace the cap. Hold different magnets to the side of the bottle and tilt the bottle to bring the fillings near the magnet. Observe what happens. Then, tilt the bottle in different directions while continuing to hold the magnet in place. Try holding two magnets on opposite sides of the bottle and observe how it affects the fillings.

CONCLUSION

The iron fillings show where each magnet exerts force. Magnets are surrounded by invisible magnetic fields. The magnetic fields begin and end at the magnet's poles. The stronger the magnet, the larger the magnetic field will be. If an iron object is placed anywhere in a magnet's magnetic field, it will be attracted, even though they are not touching.

Caution: *Because the particles are so small, iron fillings can become embedded in skin or possibly inhaled. They should not be handled directly. Wear gloves and goggles and exercise caution when working with iron fillings.*
Caution: *Before beginning this activity, ask families about possible rubber/latex allergies.*
Caution: *Keep small magnets and small pieces containing magnets away from young children who might mistakenly or intentionally swallow them. Seek immediate medical attention if you suspect a child may have swallowed a magnet.*

PULLEY PULL ME!

QUESTION

How do pulleys affect the force needed to move something?

MATERIALS

- broomsticks or thick dowels (2 per group)
- long length of rope

PROCEDURE

1. Place students in groups of three. Tie the end of the rope to one of the broomsticks about one-third of the way from the end.
2. Have two students hold the two broomsticks about two feet apart, keeping them parallel. Have the third student loop the rope over the other handle and back several times, creating about 5 or 6 complete loops.
3. The two handle holders should pull away from each other while the third student holds the loose end of the rope. Then, she should try to pull the broomsticks together. What happens? (Be careful to stop pulling before the broomsticks meet to avoid injury.)
4. Experiment with more and fewer loops. How does it affect the strength needed to pull the broomsticks together?

CONCLUSION

A pulley uses a rope, belt, or chain over a wheel to decrease work. A pulley also often changes the direction of force. In this experiment, the broomstick functions as the wheel that the rope moves over. So, each time the rope is looped around the stick, it adds another pulley to the system. More pulleys make it easier to move the load, which in this case is the force of the students pulling the broomsticks apart. The pulleys made it easier for a single person to easily overcome the strength of two people!

NOODLE IT!

QUESTION

What does it mean to *distribute* force?

MATERIALS

2 pieces of disposable foam per group (at least 1/2" thick)

dry spaghetti noodles

textbooks or other heavy books

PROCEDURE

1. Take one piece of spaghetti. Stand it upright. Then, use your finger to press down on the top. What happens? How hard do you have to press to break it?
2. Place a piece of disposable foam on the table. Stick several pieces of spaghetti upright in it, and then add the second piece of foam on top. Place a heavy book on top of the structure and observe what happens.
3. Repeat step 2, adding more and more spaghetti each time. How many pieces do you need to hold the weight of the book? Does it matter how far apart or how evenly the spaghetti is placed?

CONCLUSION

The mass of the book and the force of Earth's gravity pulling down on it create the weight of the book. Weight is a force pushing down on your spaghetti structure. By itself, a piece of spaghetti is not strong enough to hold the weight of the book. Adding more spaghetti each time distributes the force of the book. That way, each piece of spaghetti is not holding the whole weight of the book. Instead, it is only holding a portion of it. That is why you often see triangular shapes in bridge designs. The point of a triangle distributes the force equally down both sides to the base. So, each triangle halves the force and makes it so the bridge can safely hold more weight.

MAGIC RICE

QUESTION

How strong is the force of friction?

MATERIALS

- uncooked rice
- funnel
- clear plastic bottles with narrow openings
- unsharpened pencil or chopstick

PROCEDURE

1. Use the funnel to fill the bottle with rice. Fill it completely and tap it on the table to make the rice settle.
2. Place the blunt end of the pencil into the rice, slowly pushing it down to the bottom. It may be helpful to tap the pencil or bottle to get it inserted all the way.
3. Once the pencil is touching the bottom of the bottle, pull up on the free end of the pencil. Observe what happens. (If the pencil does not lift the bottle on the first try, repeat step 2 and continue to tap the bottle on the table to compress the rice together.)
4. If desired, repeat the experiment with different types of rice and different pencil angles. How do they change the ability to lift the bottle?

CONCLUSION

When the rice is first added to the bottle, there are pockets of air around the rice. By tapping the bottle on the table and pushing the pencil into the rice, the rice gets packed more closely together so there is less air. So, the grains of rice push and rub against each other, the bottle, and the pencil. This creates greater friction, or the force an object has when it rubs against another object. They create enough friction so the pencil cannot move, which allows you to pick up the whole bottle!

HOVERCRAFT

QUESTION

How can air create a force?

MATERIALS

plastic caps that open and close (preferably caps from water bottles, but shampoo caps will also work)

CDs

glue sticks and hot glue gun

clear packing tape (optional)

balloons

binder clips or clothespins (optional)

PROCEDURE

1. Have an adult hot-glue the bottle cap over the hole in the CD. Or, use packing tape to secure it to the CD. There should be no gaps between the cap and the CD where air can escape. Close the cap.
2. Blow up a balloon and place the end over the top of the cap. It may be helpful to have a friend pinch the opening closed during this step. Or, use a binder clip or clothespin to hold it closed. Be sure to remove the clip before moving on to step 3.
3. Place the CD on a flat, smooth surface like a desk, table, or tile floor. Open the bottle cap. (Be sure to leave the balloon in place.) Give the CD a gentle push and observe what happens.

CONCLUSION

Although it is invisible, air is matter. It takes up space and can affect other objects. For example, pushing air into a balloon will make it expand. Moving air, or wind, can blow leaves off of trees or flip umbrellas inside out. On your hovercraft, the air is forced out of the balloon because the material of the balloon wants to return to its original shape. The air moves through the bottle cap and out under the CD. This creates a cushion of air under the CD, which allows it to move around like a hovercraft. It eliminates the friction that existed when the CD and the table were touching.

Caution: *Before beginning any balloon activity, ask families about possible latex allergies. Also, remember that uninflated or popped balloons may present a choking hazard.*
Caution: *Hot glue guns should only be handled by adults.*

LAYER UPON LAYER

QUESTION

What is density?

MATERIALS

tall, clear containers (such as vases or 2-liter bottles with tops cut off)

1/4 cup or less each of a variety of liquids (for example, water, vegetable oil, milk, dish soap, corn syrup, honey, rubbing alcohol, etc.)

food coloring

turkey baster (optional)

tweezers or tongs (optional)

a variety of solid items (for example, a die, nail, bottle cap, table tennis ball, plastic beads, popcorn kernels, etc.)

PROCEDURE

1. Add food coloring to the similarly colored liquids so you can tell them apart later. Record which color each liquid is.
2. Begin to add the liquids to the clear containers, one at a time. Pour very slowly to avoid disturbing each layer or creating bubbles in the liquids. A turkey baster will make this simpler. It is also helpful to add a little of each liquid at a time and to let it run down the side of the container instead of dropping it into the middle of the liquids already in the bottle. You may still need to wait for the liquids to resettle at times.
3. Drop in the solid items one at a time. Again, drop the items as carefully as possible into the liquids to avoid adding bubbles or disturbing them. It may be helpful to use tweezers or tongs to add each item slowly and carefully.
4. Observe what happens. Draw a diagram to show the order of the materials.

CONCLUSION

Solids, liquids, and gases all have different densities. Density is how much "stuff" is in the same volume. It is determined by the size of the molecules in a substance, how close they are, and how they are arranged. When you poured the different liquids in, they stayed separated and ordered themselves from most dense (at the bottom) to least dense (at the top). The less dense liquids are more buoyant than the denser liquids and float higher in the bottle. Notice where the air is—on top. Air is the least dense, because its molecules are far apart!

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

BRRR!

QUESTION

How do arctic animals like penguins stay warm?

MATERIALS

two bowls
ice
water
gallon-size resealable bags
shortening

PROCEDURE

1. Place ice and water in both bowls. Make sure there is enough ice to create very cold water. Place them side by side.
2. Place shortening inside a resealable bag. Then, place another resealable bag inside to create a sort of "glove" with a layer of shortening on the inside.
3. Stick one hand into the shortening glove. Place one hand into each bowl. How does each hand feel?

CONCLUSION

The shortening is fatty, like blubber, so it insulated your hand and kept it warmer than the other hand. Like whales, penguins have a layer of fat under their feathers and skin that is called blubber. This blubber helps penguins stay warm in their cold habitat. The blubber stores energy and insulates the penguins. The penguins' two layers of feathers and blubber insulate them, making sure they stay warm on land and in the water. The brood pouch contains blubber to keep the egg warm. The blubber also helps penguins to float in the water because it is less dense than the ocean water.

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

BIRD BEAK BONANZA

QUESTION

How have animals adapted to eat a specific type of food?

MATERIALS

round toothpicks
plastic spoons
plastic forks
clothespins (spring-loaded)
tweezers
eye droppers
shallow containers
sand
oats
rice
kidney beans
mini marshmallows
gummy worms
o-shaped cereal
rotini pasta
plastic cups
measuring spoons

PROCEDURE

1. Before beginning the activity, place the sand, oats, rice, kidney beans, marshmallows, gummy worms, cereal, and pasta in a shallow container. Make one container per group.
2. Give each group at least one each of the toothpicks, spoons, forks, clothespins, tweezers, and eye droppers, as well as the shallow container prepared in step 1. Give each student a plastic cup. This will be the bird's "stomach."
3. Have students choose utensils to serve as their bird beaks. Using a clock, give each student 30 seconds to collect as much "food" from the shallow container as possible, using only their "beaks." It does not matter which type of food they collect. Explain that collecting more pieces is better—the size of the food does not matter.
4. Have students record their data from step 3: the type of beak they used, the type of food collected, and the amount of food collected. (For sand, students can use a measuring spoon to find out about how much they collected.) Then, return the food to the shallow container.
5. Have students switch beaks and repeat steps 3 and 4. Continue until each student has been able to try each type of beak. Discuss which beaks were best for each type of food and why.

CONCLUSION

Animals are well-adapted to their environments, including the type of food available. Scoop-type beaks, such as pelicans and flamingos have, are better for scooping food in large areas. Pointy beaks, such as egrets have, are useful for stabbing at food. Some beaks, such as hummingbirds have, are like straws or eye droppers and can suck up nectar. Some beaks are like tweezers, such as robins or woodpeckers have, and can easily grab food like worms under the ground or insects under tree bark. Think about other types of animals and their mouths and tongues. How are they adapted to the food the animal eats?

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

PLANT MAZE

QUESTION

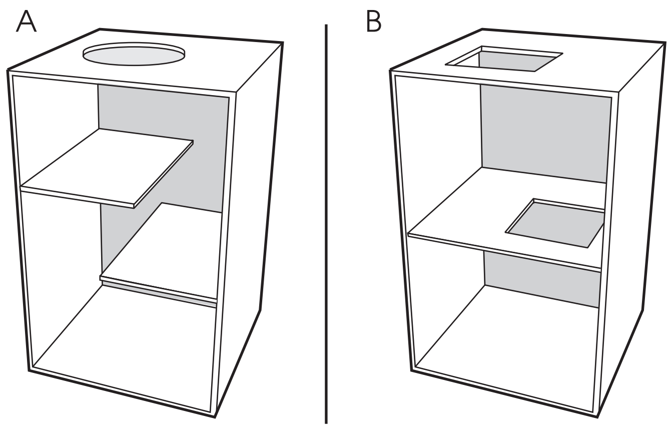
How do plants adapt when sunlight is hard to get to?

MATERIALS

shoeboxes
cardboard (i.e., cereal boxes)
ruler
scissors
tape
bean plant

PROCEDURE

1. Before beginning, grow a bean plant that is 1–2 inches (2.5–5 cm) tall. Plant a bean seed in soil, place it in a sunny window, and water it often.
2. Turn a shoebox on its end and remove or open the lid. Cut a hole in the top of the shoebox. The hole can be circular or rectangular (see diagrams A and B).
3. Cut and tape the cardboard inside the shoebox to create two shelves at different heights. The shelves should be one-third and two-thirds of the way from the bottom. They should be long enough to overlap slightly in the center of the shoebox (see diagram A). Or, add one shelf in the center that touches both sides. Add a hole to this shelf opposite of the hole in the top of the shoebox (see diagram B).
4. Place the well-watered bean plant in the bottom of the shoebox under the solid section of the cardboard shelf. Put the lid on the shoebox and place it in a sunny window.
5. Check on the plant every day or so. Water it if needed. Be sure not to move the plant! What happens?
6. Try making more plant mazes and see if the plant can find the sunlight each time.



CONCLUSION

Plants need soil, water, carbon dioxide, and sunlight to survive. Plants can often grow without soil as long as they have the nutrients they need. They can even grow in water and on materials such as sponges or paper towels. When sunlight isn't plentiful, they grow toward the light so they can create more energy through photosynthesis. Check out sunflowers—their "faces" follow the sun throughout the day!

A JOINT VENTURE

QUESTION

Why are backbones flexible?

MATERIALS

pool noodles
bread knife
thin cardboard discs (use cereal boxes or similar)
hole punch
rope
tape

PROCEDURE

1. Before beginning the activity, use a bread knife or craft knife to cut the pool noodles into discs 1" or 1.5" (2.5 or 3.75 cm) tall. Cut enough discs so each student can have 8–10 discs. Only adults should handle the bread knife. Cut the rope into 18–inch (46 cm) lengths. Cut the cardboard into discs that are a bit smaller than the pool noodle discs.
2. Give each student 8–10 pool noodle discs, cardboard discs, and a length of rope.
3. Have students punch several holes in the center of each cardboard disc to create a hole large enough for the rope to pass through.
4. Thread one pool noodle disc on the rope, and tape the rope to the underside of the disc. Then, add a cardboard disc. Repeat until all pool noodle discs have been added. Tape the rope to the top of the final pool noodle disc. Leave some slack so the spine can move and bend a bit.
5. Explain that this is a model of a spine. The pool noodle discs represent the vertebrae: the rope is the spinal cord, and the cardboard discs are the discs. Have students move their models to see how the spine allows vertebrae to move while protecting the spinal cord. The discs prevent each bone from rubbing against another bone.

CONCLUSION

Vertebrates all have backbones, or spines. These spines are flexible to allow for movement but are hard to protect the spinal cord. Because the vertebrae are all separate bones, they can move more freely so we can twist, turn, bend, and lean in many directions. Humans have 33 vertebrae in all. Just like humans, giraffes only have seven vertebrae in their necks. But, each one can be over 10 inches (25.4 cm) long! A humpback whale's vertebrae can be over 2 feet tall and almost 3 feet wide!

RAINBOW PLANTS

QUESTION

How does water travel from a plant's roots to the leaves and petals?

MATERIALS

- white carnations or celery
- craft knife
- large cup or vase
- water
- food coloring
- spoon

PROCEDURE

1. Have an adult use a craft knife to cut the bottom of each flower stem or celery stalk at an angle to expose more of the inside of the stem.
2. Add water to the cup or vase. Add at least 20 drops of food coloring to the water and use the spoon to stir it and mix it evenly.
3. Place the flower or celery stem in the water.
4. Observe the flower after one, two, four, eight, 24, and 48 hours. Draw a picture each time. What happens?

CONCLUSION

Water travels through solids with capillary action. Capillary action happens when water moves through narrow spaces, such as a tube or something spongy, against the pull of gravity. Plants use capillary action to keep their roots, stems, leaves, and flowers healthy. They draw water up from their roots through their spongy stems and spread it out to their leaves and flowers. When you added color to the water, you could see the water as it was pulled up the stem and into the leaves and flower.

WE'VE GOT ROOTS

QUESTION

What do the roots of different plants look like?

MATERIALS

- potato with eyes
- toothpicks
- water
- clear plastic cups
- soil
- grass seed
- paper towels
- bean seeds
- resealable plastic bag
- mini spider plants
- tape
- carrots
- onion or green onion bulb with roots attached
- dandelion
- hand lenses

PROCEDURE

Note: You may choose to do steps 1–4 independently or allow students to do them as well.

1. A few weeks before the experiment, place toothpicks around the "equator" of a potato. Fill a cup with water and place the potato on the cup so the toothpicks rest on the rim and the bottom of the potato is setting in the water. Place it in a window with direct sunlight and replenish the water if it gets low or becomes brown or cloudy. Soon, roots and sprouts should start growing.
2. Place soil in a cup and sow it with grass seed. Water the soil and place the cup in a sunny window. Keep the soil moist until the seeds sprout and grass grows.
3. Dampen a paper towel and place it into a resealable plastic bag. Place bean seeds on the paper towel and seal the bag. Tape it in a sunny window and the beans should sprout.
4. If you have mini spider plants, place them in shallow cups of water until they grow roots. They do not need soil.
5. Gather several plants with different types of roots, such as onions, carrots, and dandelions, as well as the plants grown in steps 1–4. Give each student a hand lens. Have students observe the different types of roots. They may choose to sketch the roots, draw diagrams, or try to organize the roots into types. Discuss the major types of roots (taproot, fibrous, and adventitious—see Conclusion section) and work together to categorize each type.

CONCLUSION

Roots do many different things for plants. They provide stability, anchor the plant in the ground, absorb water and nutrients, store food and nutrients, and can also help the plant reproduce. There are three major types of roots: taproots, fibrous roots, and adventitious roots. Taproots, like carrots and dandelions, have one main root that is larger than the others. Fibrous roots, like grass and onions, have many small roots that branch out and stay close to the surface of the soil. Adventitious roots, like on the potato or spider plant, can grow roots from a different part of the plant such as a stem or leaf.

Caution: *Before beginning any nature or food activity, ask families' permission and inquire about students' plant and animal allergies, food allergies, and religious or other food restrictions. Remind students not to touch plants or animals during the activity.*

BLOWING IN THE WIND

QUESTION

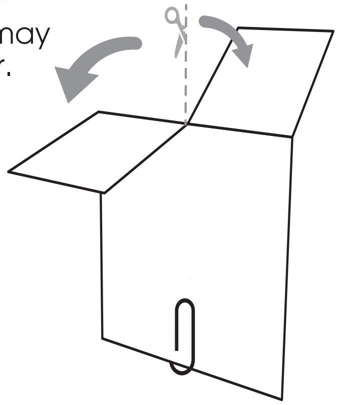
How do different types of seeds disperse?

MATERIALS

- sunflower seeds
- glue
- hook-and-loop dots
- felt sheets
- paper rectangles
- scissors
- small paper clips
- cotton balls
- small fan

PROCEDURE

1. Discard the fuzzy sides of the hook-and-loop dots. Glue a sunflower seed to the back of the remaining side of the hook-and-loop tape.
2. Cut an animal shape out of the felt.
3. Create a paper helicopter (see diagram). Fold a paper rectangle in half lengthwise and widthwise. Unfold. Cut to the center on the long fold to create two flaps at the top. Fold one flap to the front and the other to the back. Add the paper clip to the bottom of the opposite end. Glue a sunflower seed to the end with the paper clip.
4. Pull apart a cotton ball to make it fluffy like a dandelion puff. You may discard some of the cotton ball. Glue a sunflower seed in its center.
5. Test each seed type to see how it travels the farthest. Move the felt animal by the seeds so it touches them all. What happens?
6. Place the seeds in front of a fan. Which seeds move? How far?
7. Drop each seed from the same height. What happens? Do any of the seeds go somewhere other than straight down?



CONCLUSION

Seeds are dispersed by wind, water, animals, and plant explosions. How well seeds are scattered is important for the survival of plant species. Some seeds are adapted to float on the wind. Plants such as dandelions have feathery parts that carry them. Seeds from plants such as maple trees have "wings" that help them float and spin in the wind. They can be carried long distances. Some seeds are "sticky," such as hook-and-loop tape, and will stick to the fur of passing animals or even clothing! That way, the seeds can travel long distances without wind or water.

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

NO PLACE LIKE HOME

QUESTION

What makes a habitat the best home for an animal?

MATERIALS

large glass jars
sand
potting soil
water
dark construction paper
tape
healthy earthworms

PROCEDURE

1. Pour about 1 inch (2.5 cm) of sand into the bottom of the jar.
2. Pour about 1 inch (2.5 cm) of potting soil on top of the sand. Make 4 or 5 more layers, alternating sand and potting soil.
3. Pour a small amount of water into the jar to dampen the mixture.
4. Put 3–4 earthworms on top. Watch them burrow into the soil! Sketch what the jar and earthworms look like.
5. Cut a piece of dark construction paper and tape it around the jar to shield the earthworms from the light.
6. Three or four days later, take the paper off of the jar. What do you see? Sketch what the jar and earthworms look like now. Compare it to your drawing from step 4. What happened?

CONCLUSION

Animals have different kinds of homes depending on what habitat best fits their needs. All animals need air, water, food, shelter, and space (to raise their young or make nests, etc.). A habitat can be as small and wet as a tide pool or as large and dry as a forest canopy. Some examples of habitat regions include oceans, deserts, forests, rivers, lakes, tundra, and mountains. Many things make up the perfect habitat for an animal, including location, temperature, soil, rainfall, available food, and light (or absence of light). Earthworms need a dark habitat where there is moisture and dead plant material (found in the potting soil).

HIGH AND DRY

QUESTION

How do feathers help birds stay dry in water?

MATERIALS

cotton balls
vegetable oil
clear cups filled with water

PROCEDURE

1. Place one cotton ball in front of each of three cups of water.
2. Predict what will happen to a dry cotton ball when it is placed in the water. Place a dry cotton ball in the first cup, representing a duck that has not coated its feathers with oil. Observe what happens.
3. Dip the bottom half of another cotton ball in oil, representing a duck that has coated its bottom feathers with oil. Predict what will happen when it is placed in the water. Observe what happens.
4. Dip the entire third cotton ball in oil, representing a duck that has coated all of its feathers with oil. Predict what will happen when it is placed in the water. Observe what happens.

CONCLUSION

Ducks and other birds *preen* several times a day to keep themselves clean. Preening is when birds straighten and clean their feathers using their beaks. They also waterproof their feathers by spreading oil to each feather. This oil also keeps their wings moist, flexible, and strong so that they can fly better. The oil comes from their own bodies. Ducks and many other birds, like penguins, have a preen gland near the base of their tails. By rubbing their bills and heads over the preen gland, they force oil to come out. They can then spread the oil all over their feathers.

AS THE STOMACH TURNS

QUESTION

How does the digestive system break down food?

MATERIALS

- balloon
- vegetable oil
- plastic cups or paper plates
- bread or dry oats
- white vinegar
- teaspoon
- eyedropper

PROCEDURE

1. Use the eye dropper to place a few drops of oil into the balloon. Rub the outside of the balloon with your hands until the inside is entirely coated with the oil. Squeeze the balloon with the open end pointed down over a trashcan or plastic cup to remove any extra oil.
2. Drop several pieces of bread or a dozen oats into the balloon.
3. Pour 1 teaspoon of vinegar into the balloon.
4. Rub the balloon between your hands again with the open end up so all of the materials remain inside the balloon.
5. Starting at the fattest end of the balloon, squeeze up. (Note: do this over a plastic cup or paper plate to catch whatever comes out.) Observe what comes out and how it has changed.

CONCLUSION

Digestion allows your body to get the nutrients needed for a healthy body from the food you eat. First, saliva starts breaking down the chemicals in the food. Then, after the food is swallowed, it travels to the stomach through the esophagus. The muscles of the esophagus squeeze the food as it moves it along and drop it into the stomach. The stomach churns and grinds the food as it mixes it with stomach acids. The stomach acids break the food down even farther. The stomach empties its contents little by little into the small intestine. At this stage, the food is thin and watery so the nutrients can easily enter the bloodstream. The food continues its journey through the large intestine and the material left over after the nutrients are pulled out leaves the body as waste. In this activity, the balloon acted as the stomach, and the vinegar was like the stomach acids.

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

WIND SPIN

QUESTION

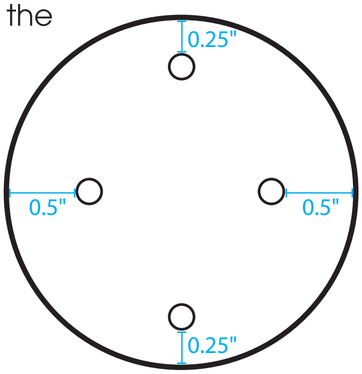
How can we measure wind?

MATERIALS

- 5 small (3 oz.) paper or plastic cups
- hole punch
- scissors
- duct tape
- 3 thin wooden dowels
- permanent marker
- empty water bottle
- stopwatch

PROCEDURE

1. Take four of the cups and punch one hole in each, about 1/2 inch (1.5 cm) below the rim.
2. Punch two holes in the fifth cup, directly opposite from each other, about 1/2 inch (1.5 cm) below the rim. Punch a second set of holes only 1/4 inch (1 cm) from the rim, halfway between the original holes. The four holes will be at north, south, east, and west on the compass (see diagram). This cup will be the center part of the anemometer.
3. Slide a dowel through each pair of holes in the center cup so they cross at right angles.
4. Insert the ends of the dowels into the holes of the other cups and tape them into place. Make sure the cups are all facing the same direction. Mark one of the cups with an "X," or use a marker to color the cup a different color so it stands out.
5. Take the last wooden dowel and make a hole in the bottom of the center cup.
6. Push the dowel up until it meets the X and tape everything together. This will be the rotation axis.
7. Put the center dowel into an empty water bottle.
8. Take the anemometer outside. Measure the wind speed by using a stopwatch to time one minute and counting how many times the cup with the X passes the same point. Do at least three trials and record your data in a table.



CONCLUSION

Wind is more than moving air; it is a powerful force. You may not be able to see it, but it can strip a tree of leaves, create waves or tornadoes, change the shape of a rock, and more. It is a major factor in weather. Meteorologists use wind to describe and predict weather by measuring its direction and speed. Wind direction is measured with windsocks, flags, and weather vanes. The speed of wind is measured in miles per hour (or kilometers per hour), usually with a tool called an *anemometer*.

WHICH WAY IS NORTH?

QUESTION

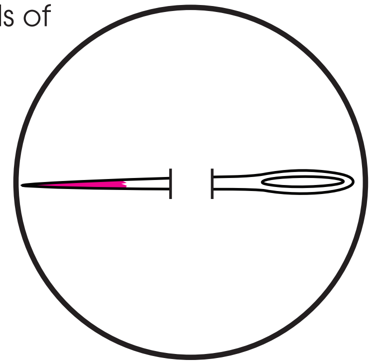
How does a compass work?

MATERIALS

magnet
sewing needle
red permanent marker
scissors
waxed paper
small bowl of water

PROCEDURE

1. Magnetize the sewing needle by rubbing one end of the needle across the north pole of the magnet 50 times. Use steady, even strokes in one direction, rather than a back-and-forth movement. Use a red permanent marker to color this end of the needle.
2. Use scissors to cut a circle about 1 inch (2.5 cm) in diameter out of the waxed paper.
3. Carefully thread the needle back and forth through the middle of the wax paper circle, as you would thread a needle into cloth. Leave the needle half-way through the wax paper with the needle lying flat on the surface of the wax paper (see diagram).
4. Place the wax paper on the surface of the water so that the ends of the needle are facing up on the wax paper.
5. Watch what happens when the needle and wax paper float on the surface of the water. The needle will rotate on the surface. The red end of the needle, the end you magnetized with the north pole of the magnet, will point north.



CONCLUSION

The metallic core of Earth helps create Earth's magnetic field. The compass reacts with Earth's poles to point in the direction of Earth's North Pole. When the magnet was rubbed against the needle in one direction, it caused the iron atoms in the object to line up and create a weak magnetic field, which made the needle act like a magnet. You had to rub in one direction to get the atoms to all line up in the same manner. If you had rubbed back and forth, the atoms would not have lined up as well, and the magnetic field would probably not be as strong.

BLAST OFF!

QUESTION

How can gases be used to launch a rocket?

MATERIALS

empty water bottle
vinegar
tablespoon
toilet paper
baking soda
teaspoon
cork (should fit snugly in the mouth of the water bottle)
safety goggles

PROCEDURE

1. Pour approximately 3 tablespoons (15 mL) of vinegar into the water bottle.
2. Place 2 squares of toilet paper on a flat surface. Place 1 teaspoon (5 mL) of baking soda onto the toilet paper.
3. Fold the ends of the toilet paper in toward the middle and roll it shut (like a burrito) to create a time-release capsule.
4. Go outside in an open area and put on your safety goggles before completing this step. Drop the time-release capsule into the water bottle. Immediately place the cork into the mouth of the bottle. Stand the bottle so it is sitting upside down on the cork. Step far back!
5. Allow time for the paper to unravel and for the baking soda to mix with the vinegar. Wait for the blastoff!

CONCLUSION

As the paper dissolves in the water, it slowly releases the baking soda, creating a chemical reaction with the vinegar. The chemical reaction releases invisible carbon-dioxide gas that builds up inside the bottle. As more and more gas builds up in the small space, the pressure grows. Finally, there is too much gas to fit inside the bottle, so it forces the cork out at a high speed and forces the bottle rocket to fly up. Space rockets work in a similar way to the bottle, but instead of using vinegar and baking soda, they burn fuel to make a powerful jet of hot gas. The downward force of the gas pushes the rocket upwards.

Caution: *Activity should be conducted in an open space supervised by adults. Wear appropriate eye protection during the entire experiment. Allow time for the chemical reaction to occur.*

SLIDE SHOW

QUESTION

How do Earth's tectonic plates move?

MATERIALS

wax paper
frosting or peanut butter
graham crackers
plastic knife

PROCEDURE

1. Spread a thick layer of peanut butter or frosting in the center of a sheet of wax paper.
2. Break a whole graham cracker into two square pieces. Lay the two pieces of graham crackers side by side on top of the frosting. The sides of the graham crackers should be touching.
3. Slide one away from you and the other one back toward you. Do the sides slide smoothly? Or, do they get stuck as you move them back and forth?
4. Place the graham crackers back in the center with the sides touching. Try to press them toward each other at the center. Apply more and more force until something happens. Did they slide smoothly? Did one or both break? Did they make a hump, or did one slide over the other? Look at what happened to your neighbors' crackers. Did they all react the same?

CONCLUSION

Earth's outer layer, under the land and water, is made of very large pieces of solid rock called tectonic plates. These were represented by the graham crackers. The plates float on a layer of partially melted rock, which was represented by the frosting. Where the plates meet, there are often cracks, or *faults*. The large crack where two huge plates move against each other is called a *fault line*. Most of the time the plates are moving slowly and smoothly against each other. Sometimes the moving plates get stuck on each other, sending waves of vibrations through the earth's interior. This reaction is called an earthquake. There are several different ways plates can move against each other. Some cause large cracks like the San Andreas fault or the Mariana Trench. Others can create volcanos or mountain ranges.

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

THE ART OF THE SUN

QUESTIONS

How does solar energy create a chemical change?
Do different SPFs of sunscreen matter?

MATERIALS

- direct sunlight
- large resealable plastic bags
- photosensitive paper
- different brands and SPFs of sunscreen
- latex gloves (optional)
- timer
- large pan of water (if needed for your photosensitive paper)

PROCEDURE

1. Label the back of each sheet of paper with the different sunscreen brand and SPF. There should be one sheet of labeled paper per sunscreen you have plus one sheet as a control.
2. Place each sheet of the photosensitive paper in a resealable plastic bag.
3. Smear each sunscreen on the outside of the matching bag, over the blue side of the paper. If desired, use latex gloves to avoid touching the sunscreen. Do not add sunscreen to the bag with the control paper.
4. Place the bags in a sunny spot with the blue sides faceup. Leave the paper undisturbed for two to four minutes. The exposed parts of the photosensitive paper should turn a light shade of blue.
5. Remove the bags from the sun. If your photosensitive paper calls for it, soak the sheets in the pan of water for about one minute to remove the chemicals. Take the paper out and hang it up or lay it flat to dry inside.
6. Observe each sheet of paper. How did they change? Compare them to the control paper. How well did each sunscreen protect the paper?

CONCLUSION

The photosensitive paper is coated with light-sensitive chemicals that react to the ultraviolet (UV) rays in sunlight. The UV rays cause a chemical change in the paper, which we see as a change in color. On the control paper, there was nothing to stop the UV rays from reaching the paper, so the entire paper changed color. The sunscreens are designed to block or filter the UV rays. So, they were able to protect the paper from the UV rays and prevent the chemical change. This is also how sunsceens protect your skin in the sun.

Caution: *Before beginning any outdoor activity, ask families' permission and recommend use of sunscreen and/or sun protective clothing. Inquire about students' skin sensitivities and/or allergies and use protective gloves if needed. Ask families about possible rubber/latex allergies.*

MELT DOWN

QUESTION

How can concentrating the sun's rays be used to change matter?

MATERIALS

- plastic or paper plate
- a marshmallow
- a piece of a chocolate candy bar
- a candy-covered chocolate
- small magnifying glass
- sunshine

PROCEDURE

1. Place a marshmallow, a piece of a chocolate candy bar, and a candy-covered chocolate on the plate.
2. In direct sunlight, hold the magnifying glass closely at an angle on the marshmallow for 3 minutes. You should see a concentrated beam of light directed on the marshmallow. Be careful to only direct the beam at the ground and the food. Do not direct it at people, insects, or animals. Observe what happens. Did the physical property of the marshmallow change? How? Record what you see.
3. Repeat the procedure with a small piece of chocolate candy bar and a candy-covered chocolate. Record the results.
4. Would varying the distance of the magnifying glass to each object make a difference? What about holding it on the object for a longer period of time? At a different angle? Try the experiment again and find out.

CONCLUSION

The secret to making this work is to hold the magnifying glass at an angle to the sun. When you have the correct angle, a small bright dot will appear on the object you are trying to heat. The magnifying glass has refracted, or bent, the sun's rays and concentrated the sun's energy at that point. The heat energy from the sun's rays then causes the physical changes in the candy and marshmallow. While they may melt and/or change shape, the candy and marshmallows are still the same substance.

Caution: *Before beginning any food activity, ask families' permission and inquire about students' food allergies and religious or other food restrictions.*

FABULOUS FOSSILS

QUESTION

How are fossils formed?

MATERIALS

- 1 cup of wet, used coffee grounds
- 1/2 cup cold coffee
- 1/2 cup salt
- 1 cup flour
- mixing bowl
- spoon
- parchment or wax paper
- magnifying glass

PROCEDURE

1. Before beginning the activity, collect objects to "fossilize," such as plant leaves, flower petals, tree bark, seashells, and pine cones.
2. Mix the coffee grounds, coffee, salt, and flour together in a bowl. Add more flour if the dough is too sticky.
3. Divide the dough into even pieces and place on wax or parchment paper.
4. Press the objects into the dough with the back of a spoon. Carefully lift out each item after the desired impression is made.
5. Allow the fossils to dry on parchment or wax paper. Fossils may need to be turned over in order to completely dry out.
6. Use a magnifying glass to closely examine your fossils.

CONCLUSION

Sometimes footprints left by animals and prints of plants turn into fossils. When the conditions are right, the prints are pressed into sediment and minerals that harden into rock over time, just like the prints you created in this experiment. When fossils of hard objects like bones and teeth are formed, they usually form a raised-up "rock" in the shape of the object instead of an indentation. That's because water seeps into the objects and the minerals in the water replace the minerals in the bone or tooth. Those minerals harden and are left behind as fossils. A special type of fossil preserves more than just bones and impressions. Animals and insects that fall into tar and resin are preserved exactly like they were when alive, but these types of fossils are very rare.

Caution: *Before beginning any nature activity, ask families' permission and inquire about students' plant and animal allergies. Remind students not to touch potentially harmful plants during the activity.*

SEEING STARS

QUESTION

What is light pollution and how does it affect how visible stars are at night?

MATERIALS

empty paper towel tube
clear night sky
paper
pencil
calculator

PROCEDURE

1. One by one, turn to face each of the four compass directions (north, south, west, and east).
2. Hold the tube three-quarters of the way up from the horizon in each direction and count and record the number of stars seen through the tube. Hold the tube halfway up from the horizon and repeat the count. Repeat the procedure again with the tube pointed a quarter of the way up. Record your data each time.
3. Add up the numbers of stars for each of your 12 sightings. It takes about 144 tubes to view the entire sky, so you have observed one-twelfth of the sky. Multiply your total by 12 to estimate the total number of stars in the sky. Record this number.
4. Next, add and compare the three measurements for each direction. Why do you think you see more stars in certain directions?
5. Repeat the experiment again in a different location. How do the results differ?

CONCLUSION

When you view the clear night sky in the mountains away from the city lights, you can see many more stars. In a city or urban area, there is more light pollution, which makes it more difficult to view stars. Light pollution includes lights from homes, businesses, streetlights, cars, etc. The number of stars in the sky does not change from place to place. Light pollution just makes the fainter stars more difficult to see. Light pollution alters the color and contrast of the nighttime sky. It can also affect people's sleep cycles, the environment, energy resources, wildlife, and astronomy research. The threat of light pollution continues to grow as cities grow larger and humans spread farther into the country.

THE BIG CHILL

QUESTION

How does freezing and thawing erode rocks?

MATERIALS

- several varieties of rock such as granite, sandstone, and limestone
- plastic bottles or containers
- water

PROCEDURE

1. Observe the rocks carefully. Make a prediction as to which rock you think will erode the most. Then, place each rock sample in a plastic bottle or container and cover each rock with water.
2. Place the bottles in the freezer. After the water has frozen, take them out and let them thaw.
3. After the water melts, put the bottles back in the freezer.
4. Repeat steps 2 and 3 four more times. Each time, observe how the rocks have changed.
5. Remove the rock samples from the water. Look at them carefully. Which ones have changed the most? Can you see particles that have been split off of the rock by the freezing water process? Was your prediction correct?

CONCLUSION

Rocks can be eroded by wind, rain, moving bodies of water, and rock slides. But, they can also be broken apart by freezing and thawing. When water freezes, it expands. So, when water seeps into a rock and freezes, it expands and causes cracks in the rock. Rocks can even begin to break off from one another after they freeze and thaw several times. Over time, whole mountains can be worn down by this process.

RUNNING WATER

QUESTION

Why does water adhere to objects?

MATERIALS

two plastic cups

water

2 feet of absorbent cotton string or twine

PROCEDURE

1. Fill one cup halfway with water.
2. Soak the string in the water until it is soaked through.
3. Keep one end of the string in the cup with water. Hold the other end above the empty cup.
4. Hold the cup with the water up in the air, using your finger to keep the string at the bottom of the rim of the cup as you tip it toward the empty cup.
5. Pour the water slowly along the string. Observe how it clings to the string and drips off the end into the empty cup.
6. Repeat steps 3–5 with a dry string. What happens? Compare it to what happened earlier.

CONCLUSION

Have you seen how raindrops gather together as they move down a windshield or window on a rainy day? Water has both cohesive and adhesive properties. It can stick to itself and to other things. When the string was soaked in the water, the water adhered to it. When you poured the water along the string, the water molecules clung to the other water molecules within the string. The little stream of water underneath the string was an example of cohesion between the water molecules. If the string is dry, the water molecules don't have other water molecules to cling to. So, the poured water doesn't flow easily down the string.

Name ______________________________ Date ______________

STEM Challenge Recording Sheet

CARD	TITLE

Did you complete the challenge? Why or why not?

____
____
____
____
____
____
____

Explain how your creation works. Why is your design the best?

____
____
____
____
____
____
____

Use each space to answer the question, plan for a design or change, or reflect on the information given.

S

T

E

A

M

Name ______________________________ Date ____________

STEM Design Process

Ask

What do you already know? What do you need to know to get started? Where can you find the information you need?

____

____

____

Imagine

What are the possibilities? Come up with several different options.

____

____

Plan

Choose an idea. Draw a model and label it. Consider making different models for each stage of construction or separate diagrams of more complex parts.

What are your steps? Use your drawing to guide your plan. Number your steps and write clearly so that others can understand them.

____

____

____

Create

Follow your plan to create your model. What worked? What didn't? What did you need to change as you went through your plan? Why?

___

___

___

Improve

How could you improve your model? Do you need to start over, or can you redo a single part? If it works, can it work even better?

___

___

___

Communicate

How well did it work? Is the problem solved? Write a statement to describe how your model meets the guidelines of the task and why it is successful.

___

___

___

Reflect

Did your design meet the challenge? Are you happy with how it turned out? What would you tell someone else before they start this challenge? Why?

___

___

___