Science Connected

Science Experiments

For 5-9 Year Olds

Brought to you by Science Connected, GotScience Magazine, and the GotScience STEM Education Resource Center

Funded by a generous grant from the Pollination Project

Writers: Dr. Jonathan Trinastic and Emily Rhode
Copyeditor: Rachel McCabe

Science Experiments for 5- to 9-Year-Olds

Published by Science Connected

Funded by a generous grant from the Pollination Project

Writers: Dr. Jonathan Trinastic and Emily Rhode

Project Management: Kate Stone

Copyeditor: Rachel McCabe

PO Box 190213, San Francisco, CA 94119 USA

www.scienceconnected.org

info@scienceconnected.org

Table of Contents

An Experiment Guide for Parents and Teachers **5**
What It's About *5*
What You Need *5*
Useful Words *5*
What to Do *6*
Science to Know *6*
Demonstrating the Forces of Flight **7**
What It's About *7*
What You Need *7*
Useful Words *7*
What to Do *8*
Science to Know *8*
Make It Move: Measuring the Static Friction of a Shoe **9**
What It's About *9*
What You Need *9*
Useful Words *9*
What to Do *10*
Science to Know *10*
How Do Different Materials Affect Temperature? **12**
What It's About *12*
What You Need *12*
Useful Words *12*
What to Do *13*
Science to Know *13*
How Are Colors Created? **14**
What It's About *14*
What You Need *14*
Useful Words *14*
What to Do *14*
Science to Know *15*
How Can You Turn Saltwater into Drinking Water? **17**
What It's About *17*
What You Need *17*
Useful Words *17*
What to Do *18*
Science to Know *18*
How Can Geckos Climb Walls? **20**
What It's About *20*
What You Need *20*

Useful Words 20
What to Do 21
Science to Know 21

How Does a Solar Cell Create Electricity? **22**
What It's About 22
What You Need 22
Useful Words 22
What to Do 23
Science to Know 23

How Is the Aurora Borealis Created? **25**
What It's About 25
What You Need 25
Useful Words 25
What to Do 26
Science to Know 26
About the Writers 27
About Science Connected 27

An Experiment Guide for Parents and Teachers

Each of the sections below will appear in each experiment. Read the short descriptions below to understand what type of information is included in each section before moving on to individual experiments.

The contents of this guide are aligned with the Next Generation Science Standards (NGSS).

What It's About

In this section, you will learn about the basic scientific premise of the experiment. You will find out what the student will do, what the student will learn, and why this experiment is interesting. Read this section with your student to help them understand what the experiment will be about.

What You Need

Here you will find the materials needed to successfully complete the experiment. If you do not have a specific material, you can often make substitutions without changing the procedure or outcome of the experiment. Feel free to use your best judgement!

Useful Words

Here you will find:

- What new words students will learn from this experiment
- What words they will need to know to talk about the experiment

Be sure to go over these words and their definitions before you begin the experiment. You can start by saying the word and asking the student if they know what it means. After you go over the definitions, it might be helpful to see if your student can use the words in a sentence in the correct context before starting the experiment.

What to Do

Here you will find the steps you and your student will take to complete the experiment. Be sure to take your time and follow the steps in order. Have the student record their observations along the way, and ask them questions such as the following: What do you think will happen? What did you notice? Why do you think that happened?

If something does not work, talk about what happened. Just because the experiment did not work does not mean that it was a failure! Feel free to start over and try again, and make sure to compare your results from the second try to the results from the first try. Science is all about making mistakes and learning from them!

Science to Know

Here you will find even more information about the science behind each experiment. This section is meant to help parents and teachers further explain the scientific concepts. We provide more details about the science, and we take a closer look at what might have happened in the experiment. You will also find a link to a GotScience article that reviews recent scientific research that directly relates to the experiment! The article serves as a way to connect concepts learned during the experiment to the work of scientists around the world. Through this connection, the student can understand how scientific experiments are used in a broader context to develop new technology or understand the world in which we live.

Feel free to read the GotScience article with your student before you do the experiment. Have them read along with you and write down any questions they might have about the article. When you finish the experiment, it is a great idea to revisit the article and see if any of their questions were answered!

Demonstrating the Forces of Flight

NGSS Standards: 3-PS2-1 Forces and Interactions

What It's About

Have you ever wondered how birds are able to fly? Or how an airplane that weighs so much can make it off the ground? The air around us has lots of properties, including mass. Air pressure and gravity can make flying a tricky task. Luckily, we know that there are many forces that make it possible for animals and airplanes to fly. In this experiment, you will demonstrate one of these forces by simulating the flow of air over an airplane or bird wing. You might be surprised by the results!

What You Need

- A pencil
- A piece of notebook or printer paper
- Scissors
- Tape
- Two pieces of string, each about 30.5 cm (12 inches) long
- Two latex balloons
- One ruler or wooden dowel at least 30.5 cm (12 inches) long

Useful Words

- *Air pressure*: the force exerted on a surface by the weight of the air
- *Lift*: a force created by differences in air pressure that directly opposes the weight of an object

What to Do

1. Use scissors to cut a strip of paper from the long side of the piece of paper.
2. Tape one short end of the strip of paper to the middle of the pencil.
3. Hold the pencil in both hands and bring the end of the strip of paper that is attached to the pencil up to your lips.
4. Blow a steady stream of air over the *top* of the strip of paper. What happens to the strip of paper? Did you expect this to happen? Why do you think this happened? What does this have to do with air pressure and lift?
5. Now blow up each balloon to approximately the same size.
6. Tie a piece of string to each balloon.
7. Tie the other end of each piece of string to the ruler so that the balloons are hanging from the ruler at the same length and not touching each other.
8. Hold the ruler up so the balloons are hanging in front of your face.
9. Gently blow a steady stream of air through the space between the balloons. What happens to the balloons? Did you expect this to happen? Why do you think this happened? What does this have to do with air pressure and lift?

Science to Know

The wing of an airplane is shaped kind of like a teardrop. The same amount of air flows above and below the wing as a plane flies. Because of the teardrop shape, the air that flows over the top of the wing has to travel a longer distance than the air that flows under the wing. This means that the air on top of the wing has to travel faster than the air below. The faster air molecules spread out and are less dense than the air molecule below the wing. Higher density below the wing and lower density above the wing creates an unequal force, and the wing rises.

When you blow over the top of a strip of paper, you are making the air molecules move quickly, which is making them spread out. This creates an uneven force, or lift. The same thing happens when you blow air through the space between the balloons. Lift is one of the forces that helps planes overcome the force of gravity during takeoff, and keeps planes flying through the air.

Now read Ruminations on Flight, a GotScience article about the physics of flying, and see how it compares to your experiments!

Make It Move: Measuring the Static Friction of a Shoe

NGSS Standards: 3-PS2-3 and 3-PS2-4 Forces and Interactions

What It's About

Friction is a force. When something is not moving, we say it has static friction. This means that it will take a certain amount of force to make an object slide past the object it is resting on and start moving. Some things have more static friction than others. This is why walking on ice feels more slippery than walking on carpet! In this experiment, you will find out how much force you need to overcome static friction and make something move. In order to test this, you will pull a shoe over different surfaces. To learn more about static friction after you've completed the experiment, you can read the GotScience article in the Science to Know section about how a new type of rubber can grip icy surfaces!

What You Need

- A shoe without a heel (any size is fine)
- A rubber band
- A ruler or measuring tape
- Weights to place inside the shoe (coins, rocks, etc.)
- Cooking oil

Useful Words

- Friction: the resistance that one surface or object encounters when moving over another
- Force: something that causes a change in the motion of an object
- Static friction: force between two or more solid objects that are not moving relative to each other

What to Do

1. Cut a rubber band loop so that it makes one long rubber band.
2. Tie one end of the rubber band to one end of a shoe.
3. Place the shoe on a smooth surface like a table or counter top.
4. Hold a ruler along side the rubber band so that the end of the ruler lines up with the place where the rubber band is tied to the shoe.
5. Pull on the loose end of the rubber band until the shoe starts moving.
6. Measure how far the rubber band had to stretch before the shoe moved. Record your measurement. Was it easy or hard to move the shoe?
7. Add weighted materials (such as rocks or coins) to the shoe. What do you think will happen when you try to pull the shoe now?
8. Pull on the loose end of the rubber band until the shoe starts moving.
9. Measure how far the rubber band had to stretch before the shoe moved. Record your measurement. Did the rubber band stretch more or less than when the shoe had no weight in it?
10. Tape a piece aluminum foil to the ground.
11. Place the shoe on the aluminum foil.
12. Pull on the loose end of the rubber band until the shoe starts moving.
13. Measure how far the shoe had to stretch before the shoe moved. Record your measurement.
14. Now try adding a small tablespoon of cooking oil to the aluminum foil. Spread the oil into a thin layer on the foil.
15. Pull on the loose end of the rubber band until the shoe starts moving.
16. Measure how far the rubber band had to stretch before the shoe moved. Record your measurement. Was there more static friction between the shoe and the aluminum foil with cooking oil or without it?

Science to Know

Friction affects our lives every day. When you go down the slide at the playground, friction eventually slows you down at the end of the slide. Friction makes it hard for you to push a heavy piece of furniture across the floor. And friction helps to slow your car down when the driver uses the brakes. Friction is a force that acts in the opposite direction of the way something wants to move.

Static friction is the force between two things that keeps them from slipping or sliding past each other. When you want to run down the sidewalk, the static friction between your shoe and the sidewalk lets you move forward. If there were no static friction, you would just be running in place as if you were on a treadmill.

Kinetic friction is the force that slows down an object that is already in motion. This force will try to reduce the speed of the sliding until the object comes to a stop. Without kinetic friction, a soccer ball would keep rolling forever after you kicked it (as long as no objects were in the way to stop it).

By designing new materials or using old materials in new ways, scientists are finding exciting ways to overcome these forces to help us live safer lives. Read the GotScience article "Winter Hack: New Rubber Grips Icy Surfaces" about how scientists are using glass fibers embedded in shoes to make it easier to walk around in the winter without slipping on the ice.

How Do Different Materials Affect Temperature?

NGSS Standards: K-PS3-1 Energy

What It's About

When the sun shines on something, the object heats it up. Have you ever noticed that different colored objects sitting in the sun feel warmer or cooler when you touch them? What does it feel like when you wear a dark shirt on a bright summer day? In this experiment, you will test to see which color paper will absorb heat energy better. After you are done, you can then read the GotScience article in the Science to Know section about how cities tend to be much hotter than the areas around them!

What You Need

- One piece of white construction paper
- One piece of black construction paper
- Tape
- A lamp with an incandescent bulb (or a heat lamp)
- A thermometer (digital is fine)
- Something to keep time

Useful Words

- *Absorb*: take in or soak up by chemical or physical action
- *Heat:* a form of energy associated with the movement of atoms and molecules in any material
- *Reflect:* to move in one direction, hit a surface, and then quickly move in a different and usually opposite direction
- *Temperature:* the degree or intensity of heat present in something

What to Do

1. Fold each piece of paper in half.
2. Tape two edges of each piece closed. Be sure to leave one edge open so the paper forms a pocket.
3. If using an analog (not digital) thermometer:
    a. Place the thermometer inside of the white envelope.
    b. Turn on the lamp.
    c. Place the envelope with the thermometer inside of it under the lamp.
    d. Wait 5 minutes.
    e. When 5 minutes are up, read the temperature of the thermometer and record it.
4. If using a digital thermometer:
    a. Turn on the lamp.
    b. Place the empty white envelope under the lamp.
    c. Wait 5 minutes.
    d. When 5 minutes are up, turn on the thermometer and place it inside of the envelope.
    e. When the thermometer beeps, read and record the temperature.
5. Repeat the same procedure with the dark envelope. Which envelope had a higher temperature? Why do you think that is? You can repeat the same procedure with different colored paper. How do you think the color will affect the temperature inside the envelope? What might happen to the temperature if you used a different material than paper? Give it a try!

Science to Know

Visible light is a type of electromagnetic radiation. These waves can be seen, but there are many types of electromagnetic waves that cannot be seen by human eyes. Infrared waves are one type of electromagnetic wave that cannot be seen by our eyes. The sun heats up objects by moving energy in the form of infrared waves.

When an object soaks up, or absorbs, the infrared waves, its temperature goes up. Some materials absorb heat energy better than others. Some materials reflect heat energy. Dark surfaces such as roads and rooftops absorb more infrared radiation than lighter surfaces including trees, grass, or water.

How Are Colors Created?

NGSS Standards: 1-PS4-3 Waves and Their Applications in Technologies for Information Transfer

What It's About

Color is all around us—in the green trees, the blue sky, yellow flowers, and so much more! Even though there are only three primary colors (red, yellow, and blue), the human eye can see millions of colors (about 10 million to be exact!). We are most sensitive to the colors red, green, and blue. Scientists are always learning more about how our eyes detect these colors. In this experiment, you will use colored paper and colored plastic filters to add and subtract colors and create different color combinations!

What You Need

- A dark room
- A flashlight
- Construction paper (green, blue, and red)
- See-through colored cellophane paper or plastic wrap (green, blue, and red)
- A rubber band or tape

Useful Words

- *Absorb:* take in or soak up by chemical or physical action
- *Color:* the property of an object producing different sensations on the eye as a result of the way the object reflects or emits light
- *Light:* visible radiation having wavelengths in the range of 400–700 nanometers
- *Reflect:* to move in one direction, hit a surface, and then quickly move in a different and usually opposite direction

What to Do

1. Make a data table like this one:

Paper Filter	White	Green	Blue	Red
None				
Green				
Blue				
Red				

2. In a dark room, turn on the flashlight and point it at the piece of white paper (Paper: White, Filter: None). What color is the paper now? Record the color on your data table. Was this what you expected? Why or why not?
3. Repeat step 2 with the green, blue, and red pieces of paper (Filter: None). Did the color of the light change?
4. Use tape or a rubber band to cover the lens of the flashlight with a green plastic cellophane filter. Shine the flashlight first on the white paper, then on the green, blue, and red papers and record what color each piece of paper appears to be. What did you observe? Did you expect this? Why or why not?
5. Repeat step 4 using the blue filter and then the red filter. After each test, record your observations on the table. Were the colors that you saw what you expected? Why or why not? What do you think was happening to the light? Do you think you could make any other color combinations? Give it a try!

Science to Know

Visible light is made up of energy. When waves of light shine on something, some of the light is absorbed and some is reflected back to our eyes. That reflected light is how we see an object.

Depending on the length of the wave of light that is reflected, we see different colors. Our eyes send a message to tell our brain what colors of light have been reflected, and our brain mixes and blends the colors for us. That is how we can see such a wide variety of colors! Blue is one of the shortest wavelengths of light. It has a wavelength of 400 nanometers. Red light has a much longer wavelength of almost 700 nanometers.

When you look at a blue butterfly, you see blue because all of the other wavelengths of color have been absorbed by the butterfly and only blue wavelengths (or color) are reflected back to your eyes. When you look at green tree, all of the other wavelengths of light have been absorbed by the tree except for green. The green light is reflected back to your eyes.

In nature, animals often use bright color to attract mates or to scare off predators. Sometimes animals will use colors to camouflage themselves to hide from predators or even prey. Plants use color to attract pollinators or to warn of the danger of eating or touching the plant. These organisms may have very complex ways that they display their colors, and some of their colors can only be seen by using very powerful microscopes. Read the GotScience article "How Nature Uses Physics to Create the Color Blue" to learn about how scientists are studying how colors are made in nature and how that might help humans see better in the future.

How Can You Turn Saltwater into Drinking Water?

NGSS Standards: 2-PS1-1 and 2-PS1-2 Structure and Properties of Matter

What It's About

The ability to separate water from solids is important for many basic human needs, including access to clean drinking water. In this experiment, you will compare how well different materials can *filter* out contaminants from dirty water. You will also explore the different ways to separate materials by using physical and magnetic filters. The principles you learn in this experiment are being used by scientists today to gain access to drinking water from saltwater, as discussed in the associated GotScience article listed below.

What You Need

- A bowl that can hold at least a liter (a little over 1 quart) of water
- Several drinking glasses
- A measuring cup
- A funnel
- Water (around a liter, or a little over 1 quart)
- Dirt or soil
- A handful of glass marbles
- One coffee filter
- A paper towel
- Aluminum bolts or nails
- Steel bolts or nails
- A magnet

Useful Words

- *Filtration*: a process that separates solids and liquids from one another

- *Magnetism*: a force generated by magnetic fields that occur in some materials. Magnetic objects can be attracted or pushed away from one another.

What to Do

1. Fill a bowl with about a liter (a little over 1 quart) of water. Mix enough soil into the water until it becomes murky and opaque.
2. We will first test how well a very basic physical filter—glass marbles—works to separate out the dirt that has been mixed into the water. Pour the glass marbles into the funnel (be sure that the spout of the funnel is small enough so that marbles cannot fit through!). Set the funnel on top of a drinking glass so that the spout points into the glass.
3. Use the measuring cup to scoop two cups of the dirty water, and pour the water through the marbles in the funnel so that it falls into the glass.
4. Record observations comparing and contrasting the original, dirty water to the water in the glass that has passed through your marble filter. Do you see any noticeable differences? Why or why not?
5. Next, we will test a coffee filter's ability to separate dirt from the water. Set aside the glass with the water that passed through the marble filter. Also, remove the marbles from the funnel. Then, place one coffee filter over the funnel and place the funnel onto a new, empty glass.
6. Pour another two cups of dirty water onto the coffee filter. Again, record observations about the water that filters through into the glass. Is this water dirtier or cleaner compared to the water that passed through the marble filter? Why?
7. Finally, repeat the above two steps using a paper towel as the filter placed over the funnel. Again, record any observations about the water filtered into the glass.
8. Compare your notes about all three filters (marbles, coffee filter, paper towel). What are the major differences between the filters? What differences did you see in the water after filtration? What conclusions can you make about what determines whether a material will act as a good filter to create cleaner water?
9. Not all filters have to operate using a physical barrier! To demonstrate this, mix a handful of aluminum and steel nails or bolts together into a bowl. The goal is to separate this mix into aluminum and steel objects. What's the fastest way to do this other than separating them out one by one with your hands?
10. Try holding a magnet over the bowl. What happens? Can you use the magnet to easily filter these materials? What property of the bolts and nails is being used here to create the filter?

Science to Know

Physical filters work by creating spaces that liquid can pass through but solids cannot. The marble filter should not have worked well to separate the dirt from the water because both the water and the dirt particles could fit through the relatively large holes between marbles. In contrast, the coffee filter has much smaller holes that could trap some dirt, leading to cleaner water passing through into the glass. The paper towel should have performed as the best filter because it only has microscopic holes that can prevent almost all dirt from passing through. Therefore, the key to a physical filter is to leverage the fact that the material to be filtered out is larger than the water molecules.

Not all filters have to operate using physical barriers. A filter only relies on taking advantage of any property that is different between the two materials you want to separate. As an example, the *magnetic filter* used at the end of this experiment relies on the fact that aluminum nails and bolts are not magnetic and therefore are not attracted to a magnet, whereas steel nails and bolts will latch onto a magnet. We can use this difference in magnetic properties to create an effective filter using the magnet to separate steel and aluminum parts.

Many other properties like this can be used to construct creative filters; you just need to know what makes two materials different from one another! Read the GotScience article "Graphene Sieve Turns Saltwater into Drinking Water" to learn how scientists have created a molecular sieve to create drinking water from saltwater.

How Can Geckos Climb Walls?

NGSS Standards: 2-PS1-1 Structure and Properties of Matter

What It's About

Have you ever wondered how small lizards such as geckos can climb vertical walls without falling off? The answer lies in how tiny particles in the gecko's feet are attracted to the surface of the wall, opposing the force of gravity. In this experiment, you will explore a similar phenomenon known as surface tension that keeps liquids clinging together in much the same way as the gecko's feet stick to the wall.

What You Need

- Two handfuls of pennies
- A glass of water
- Enough water to fill the glass
- A shallow plate

Useful Words

- *Surface tension*: the attractive force between molecules in a liquid that tend to hold the liquid together and resist the effect of other forces acting on it
- *Gravity*: the force that attracts one object with mass to another object. The primary force of gravity we feel is Earth keeping us on the ground. This is because Earth is the most massive object in our environment, so its gravitational force is strongest.
- *Van der Waals forces*: attractive forces between molecules at the microscopic scale

What to Do

1. Fill the glass with water exactly up to its top brim. Then, place the glass onto the middle of the saucer (the saucer will help catch any water that spills).
2. You will now begin adding pennies into the glass, one at a time. It is important to add them in a particular way to prevent water from splashing over the sides of the glass. Instead of just dropping the pennies into the glass, slide them slowly along the rim and let them gently fall into the water.
3. As you add each penny, observe the behavior of the water at the top of the glass and along the rim. What changes do you see to the water's shape?
4. Continue to add pennies, one at a time, and continue to record observations about changes in the water.
5. After enough pennies have been placed in the glass, the water should eventually pour over the sides of the glass, ending the experiment.

Science to Know

You may have observed that as you added more pennies, the water rose above the brim of the glass without spilling. This effect occurs because of *surface tension* in the water. Surface tension occurs because individual water molecules are attracted to one another, feeling a force stronger than the force of gravity that tries to pull the water over the sides of the glass and onto the saucer. This cohesive action of surface tension in the water is stronger than gravity when only a small amount of water is above the brim of the glass. When enough pennies are added to the glass, the force of gravity is strong enough to overcome the surface tension in the water and pulls the water over the sides and onto the saucer.

Surface tension doesn't just apply to glasses of water—geckos also take advantage of this attractive force between molecules to stick to walls! These little lizards have tiny fibers called spatulae on their toes. The molecules in the spatulae interact with the molecules on the surface of the wall through *van der Waals forces*. These are naturally attractive forces between molecules that keep the gecko from slipping down the wall. In addition, on certain wet surfaces, the surface tension of the water on the surface helps the gecko keep a firm grasp on the wall.

Read the GotScience article "Why Spiderman Can't Exist, but a Gecko Can" to find out more about the science of gecko's feet and why there could never be a human-sized gecko!

How Does a Solar Cell Create Electricity?

NGSS Standards: 3-PS2-3 Forces and Interactions

What It's About

Electricity impacts every part of our lives—how we cook food, how we wash our clothes, how we watch television or read a book late at night. Today, solar cells are being used more and more to use sunlight to create electricity to power our homes. How does electricity work? This experiment will demonstrate the basic idea of how tiny particles called *electrons* can move between objects, leading to an electrical force that can attract or push away other objects. This ability of electrons to move between objects leads to electricity, and has also led to fascinating technologies such as solar cells. You can read more about some of the latest solar cell technology in the GotScience article referenced in the Science to Know section.

What You Need

- One or more balloons
- A small plate
- Several teaspoons of salt
- Several teaspoons of pepper

Useful Words

- *Electric charge:* a fundamental property of tiny particles of matter in every object around us. Positive and negative charges attract one another, and like charges repel one another.
- *Electricity*: the motion of electric charge that can be used to power motors, lights, and many other devices in our society

What to Do

1. Pour one teaspoon of salt and one teaspoon of pepper onto the small plate. Stir until thoroughly mixed.
2. Blow up one balloon, and then rub it hard against your hair. You should notice some of your hair will stand up straight if it's long enough!
3. Place the part of the balloon that you rubbed against your hair about 2.5 cm (1 inch) above the salt and pepper on the plate.
4. Record any observations about what happens. In particular, record roughly how much salt and how much pepper jump to the balloon.
5. Brush the salt and pepper attached to the balloon back onto the plate.
6. Then, rub the balloon against your hair again and place it about 5 cm (2 inches) above the plate.
7. Record your observations. Do you notice any difference between how much salt and pepper are transferred to the balloon?
8. Repeat the previous step while holding the balloon about 7.5 and 10 cm (3 and 4 inches) above the plate. Each time, record your observations.
9. What conclusions can you draw based on the data you gathered about how salt and pepper interact with the balloon?

Science to Know

When you rubbed the balloon against your hair, you created a lot of friction between the two surfaces. This friction knocks some *electrons* from your hair onto the balloon. Electrons are tiny particles with a *negative electric charge* that are inside every object in the universe! So we say that the balloon is now *negatively charged* because it has gained more electrons.

Now, when you place the balloon close to the salt and pepper without touching the plate, you should have seen individual pieces of salt and pepper suddenly jump to the balloon! Why does this happen? The negative charge on the balloon pushes away negatively charged electrons in the salt and pepper, because like charges repel. This only leaves tiny positively charged particles, called *protons*, in the salt and pepper that are still close to the balloon. Opposite charges attract, so this attractive force pulls the salt and pepper up to the balloon!

In the final steps of the experiment, you explored how changing the distance between the balloon and the plate affects how much salt and pepper jump to the balloon. You likely observed that as the balloon moved farther away, relatively more pepper than salt jumped to the balloon. This occurs because a single pepper flake is lighter than one piece of salt. The electrical attraction between the negatively charged balloon and the salt and pepper must overcome gravity to make the jump. As the balloon is moved farther away, only the lightweight pepper can overcome this downward gravitational pull to still reach the balloon.

This experiment demonstrated a simple way that anyone can observe electrical charge moving between objects. However, this same principle powers all the lights and appliances in your house through *electricity*! When you turn on a light or the dishwasher, electrons rush through the wires in your walls to provide the energy to run these devices.

To make these electrons move through the wires, we must give them energy. One way to do this is to use a solar cell that converts sunlight into a force to push electrons through the wires in your house. Solar cells separate and move electrical charge just like you did by rubbing the balloon against your hair, but solar cells achieve this using a complex combination of materials. To learn more, read the GotScience article "Nanostructured Honeycomb Creates Electricity from Light" about research designing solar cells in the shape of honeycombs!

How Is the Aurora Borealis Created?

NGSS Standards: 3-PS2-3 and 3-PS2-4 Forces and Interactions

What It's About

The aurora borealis is one of the most impressive natural phenomena we can see from the surface of Earth. Did you know that the aurora is created because of how particles from the sun interact with Earth's magnetic field? In this experiment, you will explore the fundamental properties of magnetic fields in your own home. Then, you can read the GotScience article in the Science to Know section about how magnetic fields from the sun and Earth interact with each other to create the aurora!

What You Need

- Iron filings (can be bought at most hardware stores)
- Two round neodymium or rare-earth magnets (can be bought at most hardware stores)
- Two pieces of white paper
- A pencil

Useful Words

- *Magnet:* an object with a north and south pole that has magnetic field lines connecting these two poles
- *Magnetic field:* a fundamental phenomenon of the universe that connects two opposite poles of a magnet. Other magnets will align along the direction of the magnetic field, and charged particles will rotate around the field.
- *Ferromagnet*: an object that has the special property of aligning with magnetic field lines
- *Magnetic force:* the push or pull on an object due to its interaction with a magnetic field

What to Do

1. Place the two magnets side-by-side underneath the piece of white paper, about 2.5–5 cm (1–2 inches) apart.
2. Slowly pour some iron filings onto the piece of paper on top of the location of the magnets. Observe and record what happens to the iron filings. Brush away any iron filings that are directly on top of the magnets.
3. Use the pencil to sketch the lines formed by the iron filings around the magnets. Do the lines connect the two magnets or move away from both of them?
4. Next, clean off all the iron filings. Then, flip one of the magnets over so it is still underneath the paper but its other surface is now touching the paper.
5. Slowly pour the iron filings onto the paper over the magnets again. Observe and record what happens to the iron filings. Have they changed the pattern they create around the magnets?
6. Use the pencil to sketch the lines formed by the iron filings. Then, compare this drawing to the first one and compare and contrast the line patterns. What differences do you see?

Science to Know

Your drawings have uncovered an invisible phenomenon of nature that is around you all the time—*magnetic fields*! Magnetic fields cause a *magnetic force* that pushes or pulls magnets as well as particles with positive or negative charge; we don't always notice the magnetic force in our everyday life because the force of gravity from Earth is so much stronger.

In this experiment, you studied two scenarios: one with the two magnets in an initial configuration, and a second with one of the magnets flipped over. You should have noticed distinct differences in the patterns of your iron filings. These filings are *ferromagnets*, which means they are a very special type of material that will change their orientation to follow the invisible magnetic field lines created by the magnets. In this way, you used the filings to track the magnetic fields that you couldn't see with your eye!

In one configuration, the iron filings should have created lines connecting the two magnets. This pattern would indicate that one of the magnets had its north pole facing up against the paper and the other had its south pole facing up, because magnetic field lines connect north to south poles. The second configuration should have seen the magnetic field lines curve away from both magnets. This pattern would indicate that both magnets had either their north or south poles facing up, since field lines from the same pole will repel away from one another.

Objects much larger than these small magnets can create magnetic fields. In fact, Earth and the sun are both giant magnets! Read the GotScience article "Debunking the Aurora Myth: What

Actually Causes an Aurora?" about how the magnetic fields created by Earth and the sun lead to the magnificent aurora borealis that we can see in the sky!

About the Writers

Dr. Jonathan Trinastic earned his PhD in physics at the University of Florida. He is interested in renewable energy technology and sustainable energy policies. You can follow him on Twitter @jptrinastic.

Emily Rhode is a science communicator and municipal water resources educator. Her goal is to make science accessible and interesting for everyone. She has worked as an environmental educator, science teacher, and professional communicator and trainer. You can follow her on Twitter @riseandsci.

Rachel McCabe is a professional copyeditor who is passionate about diversity and community engagement. She earned her BA in women's studies with a literature emphasis from UC Davis, her MPA from George Mason University, and a professional certificate in copy editing from UC Berkeley.

About Science Connected

Science Connected is a 501(c)(3) nonprofit organization based in San Francisco, California. We are a GuideStar platinum public charity.

Our mission is to create equal access to scientific research and STEM education for all learners. We build bridges between citizens and scientists. We expand scientific knowledge for the benefit of people and the planet.

At Science Connected, we work with scientists and educators to provide children with the scientific knowledge that will help employ them and empower them become the citizens, leaders, and innovators of tomorrow. But that's not all. We also work with researchers, journalists, universities, and industry leaders to provide cutting-edge research findings to people of all ages who continue to change our world for the better.

We develop exciting, relevant, research-based resources for middle and high school science education, and give those resources to teachers and schools serving underprivileged students.

Please help us continue to give free, supplemental science teaching materials to parents and teachers! To make your tax-deductible donation, visit www.scienceconnected.org/donate.

Science Connected
P.O. Box #190213 San Francisco, CA 94119