Safety Science Tools

Power to the Electron

Open your students' eyes to the importance of scientific literacy. As a Science Educator, you can help them draw connections between science, engineering, math, and language. These lessons can help build their confidence, strengthen their interest, and apply their knowledge to solve new problems.

Can I control the power of electrons? Experimenting with electrical safety!

THE SAFETY LESSON

We use electricity in some form practically all day, every day. It's pure energy. We use electricity to run computers, lights, televisions, and dishwashers, all kinds of stuff. Electricity is invisible and it's powerful. We have to be careful with it.

Electrons are the very small particles that flow through wires and circuits, creating currents of electricity. Electrons move from negatively charged parts to positively charged ones. The negatively charged parts of a circuit have extra electrons, while the positively charged parts want more electrons. The electrons jump from one area to the other. When the electrons move, a current of electricity is flowing through the circuit. Electricity can go through metals and other materials called "conductors." Conductors carry electricity. But electricity can't go through things like rubber, wood or plastic. These materials are called "insulators" because they stop electricity from passing through them.

To see how electricity works and test the conductivity of certain materials we are going to build a simple electrical circuit (Experiment #1). Then we will investigate the importance of insulators in electrical safety (Experiment #2).

MATERIALS

2 – 3 each AA, AAA and C Batteries

EXPERIMENT #1

- 2 D Batteries
- Masking tape
- Working flashlight that you can unscrew and take apart (incandescent, two-battery)
- Conductors and insulators:
- 12" (30 cm) strip of heavy-duty aluminum foil
- 12" (30 cm) wire
- 12" (30 cm) strip of paper
- Shoelace
- Pipe cleaner
- Rubber band
- Large paper clip

Safety Science Tools

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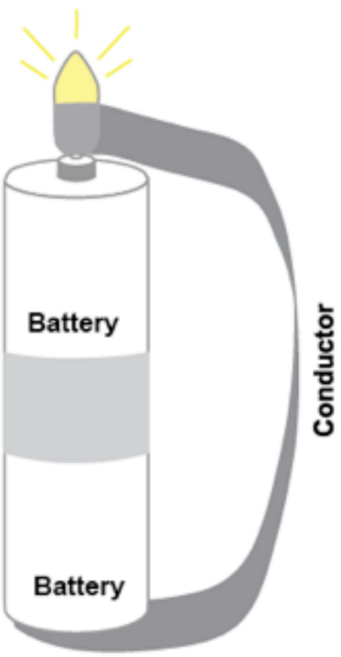
EXPERIMENT #2

- 3 – 4 Batteries (9 volt, not rechargeable)
- Penny
- Thick rubber band
- Extension cord cut in half

EXPERIMENT #1

- We can make our own electrical circuit safely because the batteries have very low current. Even though we can touch this electrical current without danger, you should never touch the electrical socket of a real lamp.
- Ask for 2 -3 volunteers. Divide up the following steps:
- Unscrew the flashlight and remove the light bulb.
- Tape the two D batteries together, putting the positive and negative ends together.
- Starting with the strip of aluminum foil. Wrap one end around the metal screw threads on the light bulb. Secure with tape. Do not cover the tip of the light bulb.
- Tape the other end of the foil to the flat (negative) end of the stacked batteries.
- Touch the metal tip of the light bulb to the post (positive) end of the battery stack.



WHAT'S GOING ON?

- Ask the children if they can explain how the electricity (current) is flowing from the battery to the light bulb.
- The aluminum foil strip provides a pathway for the current. The foil is a conductor of electricity. The light bulb will glow only if there is an electrical current flowing through it in a complete and uninterrupted path. The conductor connects the electricity from the batteries to the light bulb so the current can flow through and light

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RE-RUN EXPERIMENT #1

- Ask for 2 – 3 different volunteers. Repeat the experiment with the other materials (wire, paper, shoe lace, pipe cleaner, rubber band, and paper clip) asking students to predict which material will be a conductor and which will be an insulator.

EXPERIMENT #2

- Now that we've learned about the benefit of electricity, let's try this experiment to get a sense of the possible danger of electricity.
- Ask for 2 volunteers. Divide up the following steps:
- Compare the 9 volt battery to the D battery, note the difference of where the negative and positive terminal ends are located for both batteries. Ask what the volunteers think will happen if they lay a penny across the terminals of the 9 volt.
- Lay the penny across the battery terminals of the 9 volt. Hold in place for about 15 seconds. Ask the volunteer to describe what they feel? Can they explain why they feel the penny heating up?
- (Note: the 9 volt battery will drain of power very quickly. Don't leave the penny on for more than a few seconds – just long enough to feel the heat.)
- Explain that they are creating a simple closed circuit by connecting the two terminals with a conductor. The penny is made mostly of copper and copper is a very good conductor of electricity. Ask your students if they can think of something in their homes that is made of copper. (Answer: Household wiring and electrical cords!)
- Now lay the rubber band across the terminals.
- Hold the penny over the rubber band. Ask the volunteer to describe what they feel – any heat?
- Remind the students that rubber is an insulator. So when the rubber band is put between the battery and the penny, the circuit is broken and no circuit, no heat!
- Ask your students if they can think of a product in their home that has an insulator on it. Electrical cords! In order to protect surroundings from the heat of the electricity and to keep the electricity inside, electrical cords are wrapped in an insulating material.
- Show students the damaged extension cord and point out the copper wiring and plastic wrapping. Ask them if they know what to do with damaged extension cords in their homes. Throw them away, and replace with new ones.

Safety Science Tools

Power to the Electron

THE SCIENCE

It's important to know the difference between voltage and current. A volt is a measure of electromotive force (the voltage created by a source of electrical energy like a battery). Here's a simple way to think about electricity: voltage can be compared to the pressure that pushes water through a hose, where the water is the current of electricity and the hose is the conductor. Earlier in history, people thought electricity really was a fluid, like water, but we now know electricity is not a fluid.

Current is the flow of electrons through a circuit. Current, not voltage, does the work in an electrical circuit. For example, the flow of water through a turbine is what makes the turbine spin. The flow of current through an electrical circuit is what lights the light bulb, heats a stove, or runs a motor.
Batteries come in different sizes, A, AA, C, D. But notice that no matter the size of the battery the labels indicate each one measures 1.5 volts – that's the power of the battery. So all alkaline batteries have an electrical force of 1.5 volts. How can that be?

The amount of current an alkaline battery can deliver is roughly proportional to its physical size. This is a result of decreasing internal resistance as the internal surface area of the cell increases. A general rule of thumb is that an AA alkaline battery can deliver 700 mA without any significant heating. Larger batteries, such as C and D's, can deliver more current.

Charge Up Your Cheerios®!

What you need:

- 2 Cheerios
- Wire coat hanger
- Thread
- Plastic comb or pen
- Felt or wool

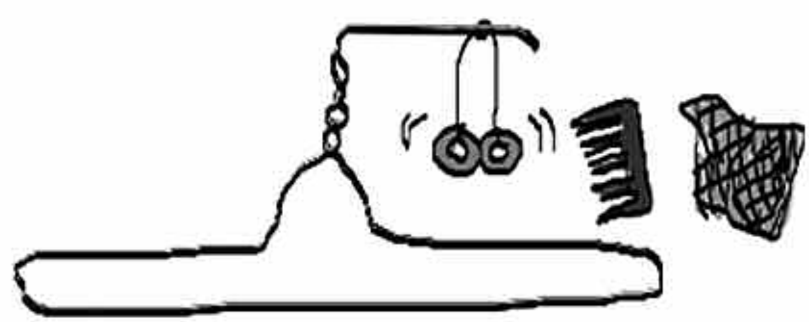
1) Bend the coat hanger so it makes a stand like the one shown in the diagram.

2) Tie one Cheerio to each end of the thread and wrap it around the end of the coat hanger top.

3) Make sure the Cheerios are even and aren't touching the table.

4) Now, rub the comb through the piece of wool and touch the comb to one of the Cheerios.

5) What happens?



DIAGRAM

Charge Up Your Cheerios®!

Educator Note: The following Safety Smart® Science "teaching opportunity" is designed to focus on improving safety knowledge through understanding the science behind the safety.

Protons have a positive charge. Electrons have a negative charge. Neutrons are neutral so they have no charge. While protons and neutrons make up the nucleus (the middle) of an atom, electrons revolve around the nucleus.

However, electrons can move. The flow of electricity is based on the movement of charged particles like electrons. Materials that allow electric current to flow through them are called conductors. Metals (aluminum and copper) and water are conductors. Some materials do not allow electric current to flow through them. These materials are called insulators. Plastic, rubber, air, glass are insulators.

By rubbing the comb on the wool, electrons (which have a negative charge) moved from the wool to the comb. The result is the comb receiving a negative static charge.

We all know that "opposites attract" - a positive and a negative charge will pull towards each other. A charged object will also attract an object that is neutral. In contrast, things with the same charge (positive to positive or negative to negative) will push away or repel from each other.

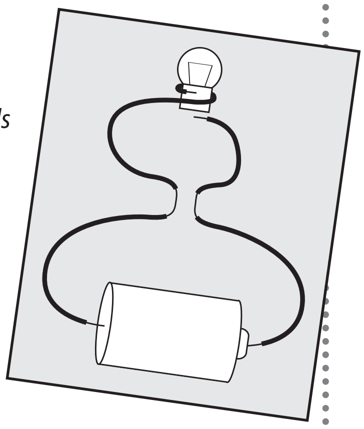
In this case the cereal was neutral and was free to move, so the cereal was attracted to the comb. When the comb touched the cereal, the electrons moved to the cereal. Once the cereal and the comb were both negatively charged, the cereal was repelled.

Static electricity can also build up on a person. When you walk across a carpet, electrons move from the carpet to you. Those extra electrons create a negative static charge. If you were to touch a doorknob the electrons would jump from you to the knob and you would feel the static shock. The doorknob is a conductor.

Positively ELECTRIC

In his new **UL/Disney Educational Productions DVD, *Safety Smart Science with Bill Nye the Science Guy: Electricity***, Bill demonstrates how an electrical circuit can be interrupted by a fault—even if that fault is a young student! Try it…and positively electrify your classroom.

MATERIALS:



- *Two 10-inch lengths of insulated wire, (with outer insulation removed at ends and in a two-inch middle section)*
- *A "D" cell battery*
- *A flashlight bulb*
- *Cardboard*
- *Masking tape*

PROCEDURE:

- The goal of the classroom experiment is to demonstrate what causes a "short circuit." Students will demonstrate how to "break" an electrical circuit—but they won't be in trouble.
- Before the experiment, use wire strippers or a file to take the insulation off of both ends of each 10-inch wire. Also strip away the insulation from the middle of each so you have about 2 inches of exposed wire.
- Select 2 or 3 "safety scientists" in your class to perform the experiment. Then, have the students bend each wire in the middle to make a kind of "bump" in it.
- Attach the wires to the top and bottom of the battery, then tape the wires down side by side so the exposed wire lines up.
- Use a piece of cardboard to make a stand for the bulb. Wrap one end of one wire around the base of the bulb. Then, touch the end of the other wire to the bottom of the bulb and tape in place.
- With the circuit complete, the bulb should light up.
- Instruct students to watch what happens when they touch a conductor, like a piece of wire, to the exposed parts of the other two wires. The bulb should go out—because it's short-circuiting.

CONCLUSIONS:

- The experiment results illustrate that electricity always takes the shortest path to complete a circuit. So in this case, the electricity flows from the battery, through the wire and then jumps from one exposed wire to the other to complete the circuit. Since it completely cuts the bulb out of the loop, it's a "short" circuit.
  - This short circuit isn't dangerous because there is so little electricity flowing through the wires. But if you hold this wire in place long enough, it does start to get warm.
- Remind students that when a short circuit happens with household wiring, it can heat up and start a fire, or shock you. That's why controlling the flow of electricity is Safety Smart®.
- After the experiment (or before), view the DVD, *Safety Smart Science with Bill Nye the Science Guy: Electricity* and compare your results.

Safe... or Sorry?

Take this UL safety quiz and test your electrical brain "power."

1. To decrease the risk of burn or electrical shock for small children:

a) Keep small appliances out of reach
b) Avoid using extension cords when children are present
c) All of the above

2. To use extension cords safely in your home:

a) Replace worn extension cords with new ones
b) Run cords through and around doors and windows, so you won't trip on them.
c) Duct-tape them to the floor

3. Your chances of receiving a serious shock increase when:

a) Your hands are wet
b) You are standing on carpet
c) There is a lot of static electricity in the air

4. If an electrical outlet is hot to the touch:

a) Increase the size of the extension cord
b) Unplug all appliances and make sure an adult (or service person) checks the wire as soon as possible
c) Wrap it with duct tape

5. If you don't know what size bulb to use in a lamp, you should:

a) Use a 25-watt bulb
b) Use a 60-watt bulb
c) Check with the manufacturer. All UL-listed products are marked with wattage ratings

6. The "UL" mark on a product means:

a) The product will perform to your expectation
b) The safety of a sample of the product has been evaluated by UL (Underwriters Laboratories)
c) The government has tested and approved the product

7. When you need to use a three-pronged plug and only have a two-pronged extension cord, you should:

a) Break off the third prong
b) Use the appliance with one prong exposed, keeping your hands dry
c) Avoid using the appliance until you can buy an appropriate extension cord

8. If you damage an electrical appliance, you should:

a) Assume it's safe, as long as no electrical parts are exposed
b) Make sure your parents have it checked by a qualified service center
c) Duct-tape over any exposed electrical parts

9. The majority of electrocution cases occur in:

a) Winter
b) Summer
c) All seasons

10. If an electrical appliance falls into the water, the first thing to do is:

a) Unplug it, then have your parents take it to a service center
b) Call 911, then have your parents take it to a service center
c) Take it out quickly, and then have your parents take it to a service center

"Safe… or Sorry" Answers:

1. To decrease the risk of burn or electrical shock for children:
   a) Keep small appliances out of reach
   b) Avoid using extension cords when children are present
   c) All of the above

C. These practices will all help decrease the risk of injury to children. Children may see cords as toys and play with them in dangerous ways.

2. To use extension cords safely in your home:
   a) Replace worn extension cords with new ones
   b) Run cords through and around doors and windows, so you won't trip on them.
   c) Duct-tape them to the floor

A. Hiding cords or running them around doors and windows can present a serious fire hazard. It is safer to have a qualified electrician install outlets where you need them.

3. Your chances of receiving a serious shock increase when:
   a) Your hands are wet
   b) You are standing on carpet
   c) There is a lot of static electricity in the air

A. Our skin's natural resistance to electricity is considerably reduced when it is wet.

4. If an electrical outlet is hot to the touch:
   a) Increase the size of the extension cord
   b) Unplug all appliances and make sure an adult (or qualified electrician) checks the wiring as soon as possible
   c) Wrap it with duct-tape

B. If an electrical outlet becomes hot to the touch your parents should contact a qualified electrician.

5. If you don't know what size bulb to use in a lamp, you should:
   a) Use a 25-watt bulb
   b) Use a 60-watt bulb
   c) Check with the manufacturer. All UL- listed products are marked with wattage ratings

C. Check to see if your manufacturer has specified which size bulb to use. All products listed by UL are marked with wattage ratings. If no marking is available, do not use bulbs rated more than 60 watts.

6. The UL mark on a product means:
   a) The product will perform to your expectation
   b) The safety of a sample of the product has been checked by UL (Underwriters Laboratories)
   c) The government has tested and approved the product

B. The UL Mark tells you that representative samples of the product have been tested to UL's rigorous requirements for safety.

7. When you need to use a three-pronged plug and only have a two-pronged extension cord, you should:
   a) Break off the third prong
   b) Use the appliance with one prong exposed, keeping your hands dry
   c) Avoid using the appliance until you have the appropriate extension cord

C. Leaving open the third prong of a plug could expose you and your family to the threat of electric shock.

8. If you damage an electrical appliance, you should:
   a) Assume it's safe, as long as no electrical parts are exposed
   b) Not use it and make sure your parents have it checked by a qualified service center
   c) Duct-tape over any exposed electrical parts

B. Even if it functions normally, damaged appliances should always be checked by a qualified service center. Make sure to remind parents to be wary of older appliances, especially if they are not familiar with their history. Products that have deteriorated or have been previously damaged can present unsuspected hazards.

9. The majority of electrocution cases occur in:
   a) Winter
   b) Summer
   c) All seasons

B. High humidity and outside activities involving water and electricity make summer the time of year when you are most likely to be electrocuted using an appliance.

10. If an electrical appliance falls into the water, the first thing to do is:
    a) Call your parents to unplug it and then take it to a qualified service center
    b) Call 911, then have your parents take it to a qualified service center
    c) Take it out quickly, and then have your parents take it to a qualified service center

A. When an electrical appliance falls into the water, first unplug it. Then, have it checked by a service center to make sure there is no damage that could cause injury.

Safety Smart®

Safety Science Crazy Quiz!

1. Knowing electricity travels 186,000 miles per second, if you had a lamp on the moon connected to a light switch in your house, how many seconds would it take for it to light up 238,857 miles away?
   a. 1.28 seconds
   b. 1005 seconds
   c. .0007 seconds
2. In 1978, only eight percent of U.S. households had microwave ovens. What percent have them today?
   a. 12 percent
   b. 99.99 percent
   c. 83 percent
3. Standby power is the electricity consumed by appliances while switched off or in a standby mode. Which appliance consumes standby power?
   a. a washing machine
   b. a battery charger for a cell phone with cell phone attached
   c. a kitchen light
4. Electricity is measured in units of power called
   a. quarks
   b. nanos
   c. watts
5. True or False. Birds don't get shocked when they sit on power lines because they only touch one wire.
6. Utility workers wear special rubber gloves, rubber sleeves and other protective gear that won't allow any electricity to pass through because, rubber is:
   a. a conductor
   b. an insulator
   c. a semiconductor
7. The temperature of a typical lightning bolt is hotter than the surface of the sun! One lightning strike can generate up to how many volts of electricity?
   a. 1 million
   b. 1 trillion
   c. 1 billion
8. Everyone knows that the electric eel produces electricity but do you know how many other kinds of fish also produce electricity?
   a. 500
   b. 1
   c. 3000

Safety Science Crazy Quiz!

Educator Note: Along with the answers you will find Safety Smart® Science "teaching opportunities." These focus on improving safety knowledge through understanding the science behind the safety.

1. a) 238,857 ÷ 186,000 = 1.28

Discuss the science behind using a Compact Fluorescent Light Bulb (CFL) versus using a standard incandescent bulb. CFLs are more energy-efficient than incandescent light bulbs because fluorescent technology does not use a metal filament to create light. Instead fluorescent technology uses gases that require less electricity to create the same amount of light. CFLs use 1/3 the energy and last up to 10 times longer than an incandescent light bulb. Only 10% of the electricity used by an incandescent light bulb is used for light, the other 90% escapes as heat. CFLs create the same amount of light, but generate about 70% less heat loss. By using a CFL you can use less energy.

Demonstrate this to your students by comparing the light and heat produced from each type of bulb. Note, a 60 watt incandescent bulb and a 13 watt CFL will generally produce equivalent light levels. Ask students to visually compare the light from each bulb. Measure the temperature from each bulb by holding a thermometer 4 – 6 inches above the lighted bulb for one minute. Compare results.

2. c) 83%

Ask your students if anyone knows why metal causes sparking and arcing in a microwave. Microwave energy is electrical energy. Think of it like lightning. When a storm approaches, the clouds have a positive electrical charge and the earth has a negative electrical charge. The electricity in the clouds wants to be neutral and so it is trying to get to the earth. The positive charge builds until it is strong enough to neutralize itself by flowing to the earth. When the charge neutralizes itself, you see lightning (arcs and sparks).

The same phenomenon is true in microwave ovens but in a little different way. The electrical energy (the positive charge) is "shot" from the magnetron's antenna within the microwave. If you have a metal object inside, the electrical field is disrupted and the electricity actually flows through the metal. The metal becomes charged until it can flow to the earth (through the microwave oven inside walls). If, for example, you have the metal spaced far from the walls, it needs to build a bigger charge before it will spark. If the metal is close to the walls, the arcing happens quicker.

Another way to explain it is when your house is dry and you rub your feet on the carpet. You actually become charged and when you touch something metal, the charge flows from your finger to earth to neutralize it. The size of the charge in your body determines how close you need to get to the metal to feel the "shock".

3. b) a battery charger for a cell phone with the cell phone attached
Standby power is the electricity consumed by appliances while switched off or in standby mode. For example, televisions continue to draw a little power after it has been switched off with the remote control. Even when they are turned off, many modern electronic devices are waiting for input from their remote controls. When they receive it, they turn themselves on, but that function of waiting for input requires electricity. Many electronic products with external power supplies, like laptops, also draw standby power even when turned off. There are many appliances in our homes that consume standby power. Some to consider are products that feature a digital clock like a microwave or coffee maker. The standby power of a household electronic product is typically very small, 0.5 – 10 watts, but the number of products within the household is great. A European, Japanese, Australian, or North American home often contains twenty devices constantly drawing standby power.

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Engage your students in a classroom project to reduce standby power. Ask students to make a list of standby power consuming products they have in their homes, remind them that the battery charger for their remote control car and the battery charger for their cell phone is using standby power if it is plugged in and not charging the product. The easiest way to reduce wasted standby power is to unplug the unused device. Ask the students to identify which products from their list can they unplug when they are not using it, thus reducing standby power use. Remind students to never to unplug safety devices like smoke detectors.

4. c) watts
When you are referring to an electrical device that uses a tremendous amount of power, the commonly used measurement is the kilowatt. A kilowatt is 1,000 watts. Power plants measure the electricity they generate in kilowatt-hours (kWh). Kilowatt-hours are determined by multiplying the number of watts required by the number of hours of use, and then dividing by 1,000.

Test student math skills by asking them to figure out how much kWh of electrical energy would be used if a 60-watt light bulb was used for five hours a day for 30 days (60 watts multiplied by 150 hours divided by 1000 equals 9 kWh).

5. True
If the birds were to touch two wires at the same time it would electrocute them because the electricity would flow through their body (an excellent conductor) to complete the circuit. Share this interesting fact with your students - California wildlife experts are teaching endangered California condors to steer clear of power lines. With an extended wingspan of more than nine feet the birds can easily touch two power lines at the same time!

6. b) an insulator
An insulator is a material that resists the flow of electric current. When used in electrical equipment isulators are intended to support or separate electrical conductors without passing current through. By contrast an electrical conductor is a material or object that

conducts electricity. Electrical conductors allow charged particles (usually electrons) to move relatively free through the material; a voltage applied across the conductor therefore creates an electric current.
Ask students to identify conductors of electricity (metal, aluminum, water) and insulators (wood, rubber, air).

7. c)1 billion
There are thousands of lightning strikes every day. Scientists think that lightning hits somewhere on the earth about 100 times every second. More people are killed by lightning then by any other kind of storm, including hurricanes and tornadoes. In the whole world, lightning kills more than 1,000 people in a year.

Lightning can strike as far as 10 miles from the area where it is raining. That's about the distance you can hear thunder. If you can hear thunder, you are within striking distance. Seek safe shelter immediately in a house, building or car (not a convertible)**.** If you are in a car, be sure that the windows are rolled up.

When there is a storm, stay away from windows, water faucets, pipes and electrical outlets.

8. a) 500
Electric eels (*Electrophorus electricus*) are really fish, electric fish. Electric fish produce electricity by means of organs usually developed from modified muscle tissue. If a fish has the ability to generate electric fields it is said to be electrogenic. If a fish has the ability to detect electric fields, it is said to be electroreceptive. The electric eel is a South American freshwater fish related to the carp, and it is capable of producing from 450 to 600 volts of electricity—enough to light a neon light bulb.

The Amazing
Water Bending Trick

Try this trick at home—or in class if your classroom includes a sink.

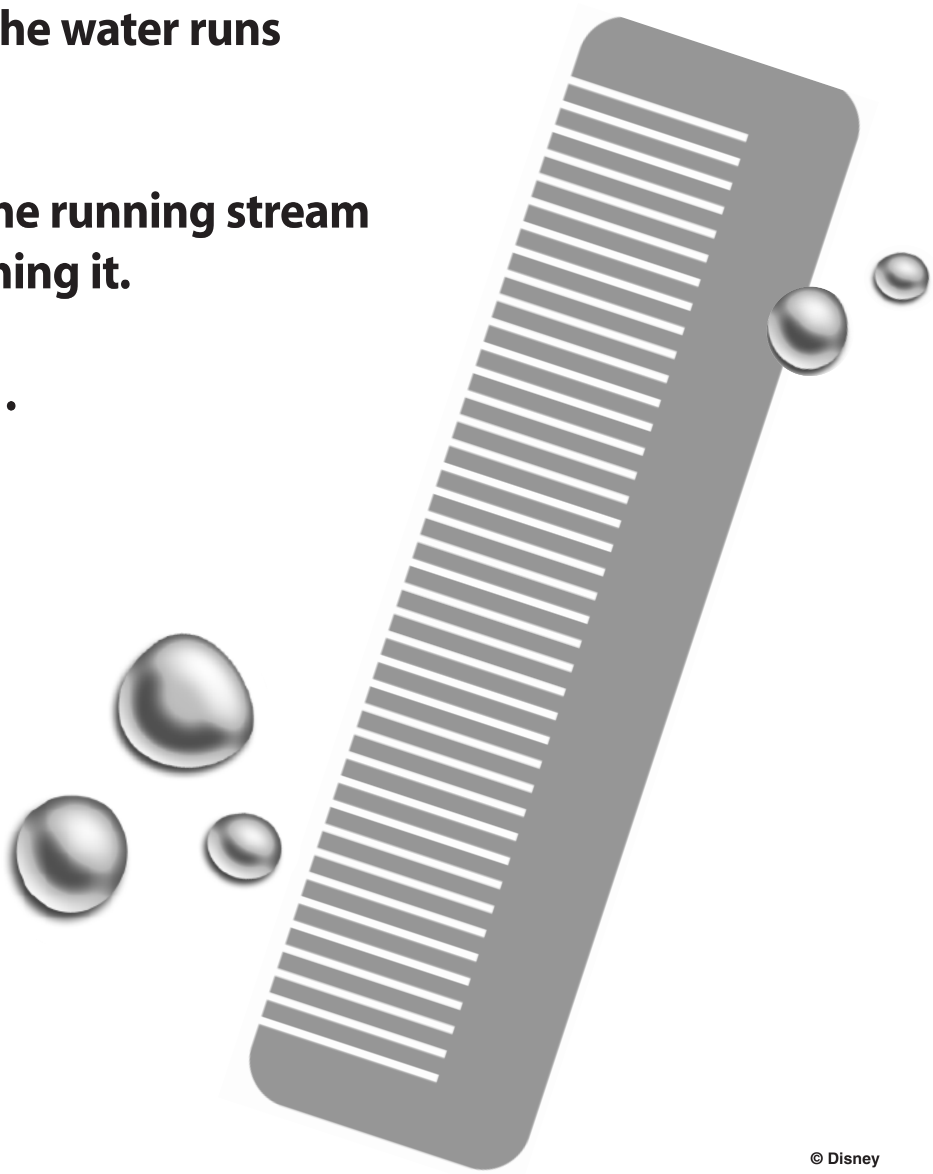
All you need for this experiment is a faucet with running water and a comb.

1) **Create static electricity on a plastic comb by combing your hair.** *(You can also "charge" any type of plastic rod with wool.)*

2) **Turn on the faucet so the water runs slowly but smoothly.**

3) **Bring the comb near the running stream of water without touching it.**

4) **Watch what happens…**



The Amazing Water Bending Trick

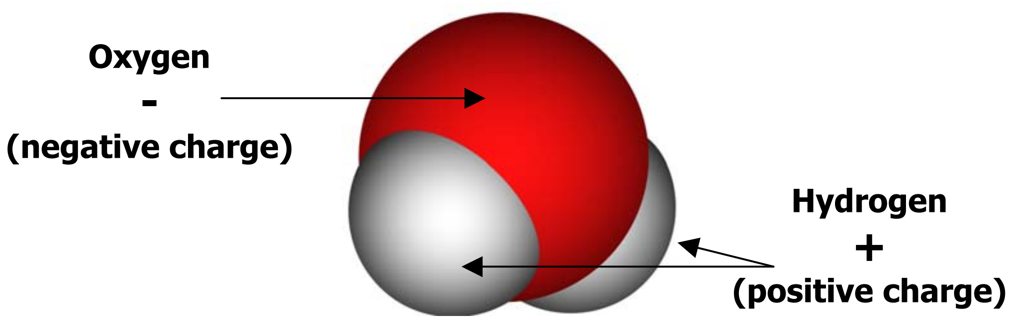
Educator Note: The following Safety Smart® Science "teaching opportunity" is designed to focus on improving safety knowledge through understanding the science behind the safety.

Protons have a positive charge. Electrons have a negative charge. Neutrons are neutral so they have no charge. While protons and neutrons make up the nucleus (the middle) of an atom, electrons revolve, move around the nucleus.

By running the comb through hair, the electrons (which have a negative charge) moved from the hair to the comb. The result is the comb has a negative static charge.

We all know that "opposites attract" - a positive and a negative charge will pull towards each other. In contrast, things with the same charge (positive to positive or negative to negative) will push away or repel from each other.

An important feature of water is its polar nature. A water molecule has both a negative and positive charge. Each molecule of water has two hydrogen atoms bonded to a single oxygen atom, H_2O.



As the negative charge in the comb gets closer to the water, the side of the molecules with the positively charged hydrogen atoms will be attracted – opposites attract. The attraction is strong enough to pull the water towards the comb as it is flowing.

The polar nature of water is one of the reasons water is such a good conductor of electricity. That is why it is important to remember that water and electricity don't mix.

TAKE-HOME ACTIVITY

Watts going on There?

Calculate how many watts it takes to power all the stuff in your bedroom.

Lamps, clock radios, computers—many devices in your bedroom consume electricity. But how much do they consume on an average day? You can figure it out…without looking at a utility bill. Here's how…

Use the spaces below to list all of the electrical devices in your room (including lights) **as well as how many watts of energy each one uses when it's running** (most appliances list energy usage information on them. Some will show volts and amps but not watts. To calculate watts, multiply volts times amps).

Then, estimate how many hours or minutes each device is on during a typical day. Calculate the daily total of watts used.

Electrical Device	Watts x	Time =	Total

ELECTRICITY: *FACT OR FICTION*

1. It takes more energy to turn on a light than to leave it on.

FICTION. Turning off any light ALWAYS saves electricity.

2. Compact Fluorescent Light Bulbs use 60-75% less energy than incandescent bulbs.

FACT. And CFB (Compact Fluorescent Bulbs) last 5-7 years longer.

3. One kilowatt-hour (kWh) equals the amount of electricity needed to power a 100 watt light bulb for 1 hour.

FICTION. 1 kWh can power a 100-watt light bulb for 10 hours.

4. If an appliance or device isn't turned on, it's using zero electricity.

FICTION. "Phantom" power, which is the small amount of power some plugged-in devices use to keep them "awake," can really add up. A recent study revealed that Americans consumed more phantom power in a year than Italy uses in regular power.

5. A "sleeping" computer still uses electricity.

FACT. Even in "sleep" mode, a typical computer can consume between 1-5 watts of electricity.

If needed, you can use the space below to calculate how many watts are used by each electrical device in your room. (volts x amps = watts).