Shocking Science

Presented by:

Hands On! Discovery Center

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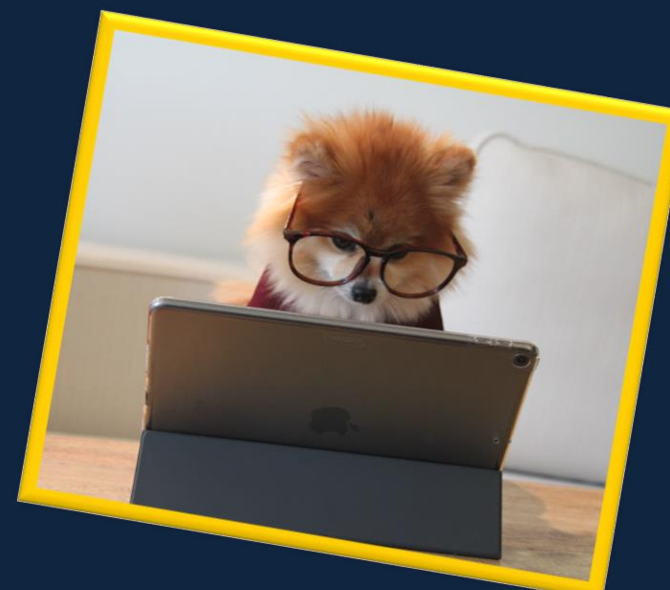
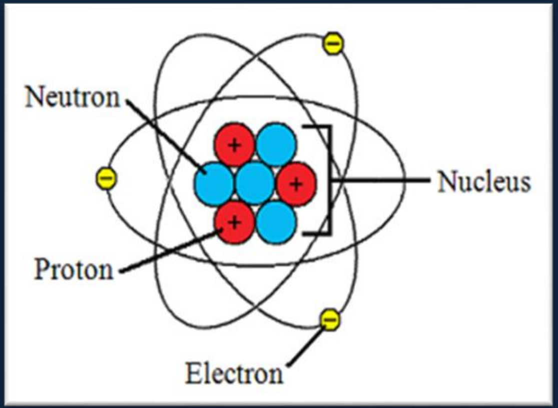
Electricity is all around you…

You probably already know a lot about electricity just from observing the world around you and using it around your home. But do you know how electricity works? Where is comes from? How it's used? And how about the different types?



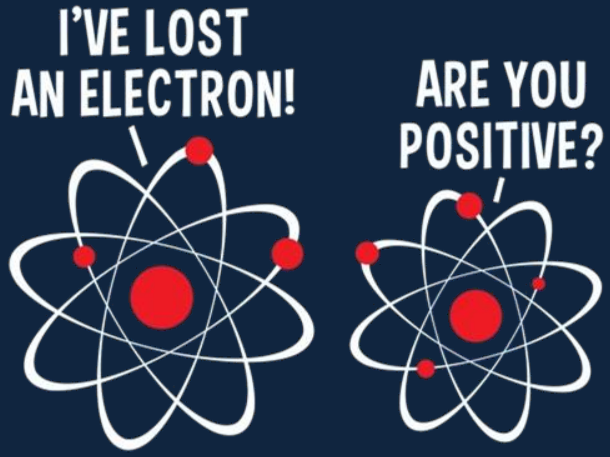
Who is Atom?

Atom is not a person's name! Atoms are small parts that make up all things, the basic building blocks of all matter. You can't see atoms because they are so small. To understand what electricity is, it helps to first understand more about atoms.



Inside an atom are smaller parts called particles: **electrons**, **protons**, and **neutrons.** Electrons have a **negative charge** **(-)** and the protons have a **positive charge** **(+)**. The protons and neutrons stick together in the center of the atom, called the nucleus. The electrons spin fast around the outside.

The positive charge of the protons keeps the electrons from flying off and leaving the atom. The electrons in the atom are where electricity gets its name. When a bunch of atoms are together and electrons are moving from one atom to the other in the same direction, this is called electricity. Electricity is the "flow" of electrons.



Charge an Object

An object can be charged THREE different ways:

#1-Friction

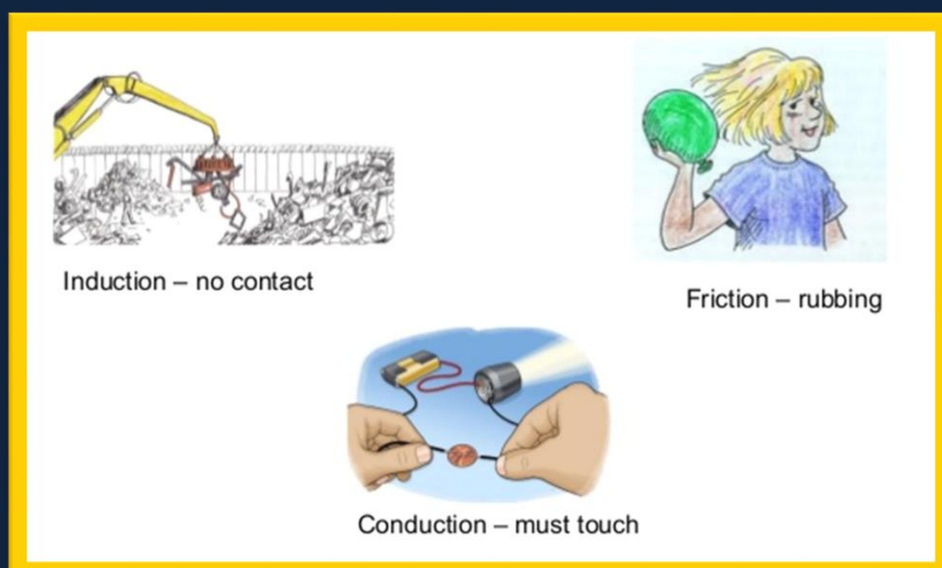
Rubbing two objects together can cause electrons to be "wiped" from one object and transferred to the other.

#2-Conduction

Transfer of electrons from one object to another **THROUGH direct contact**.

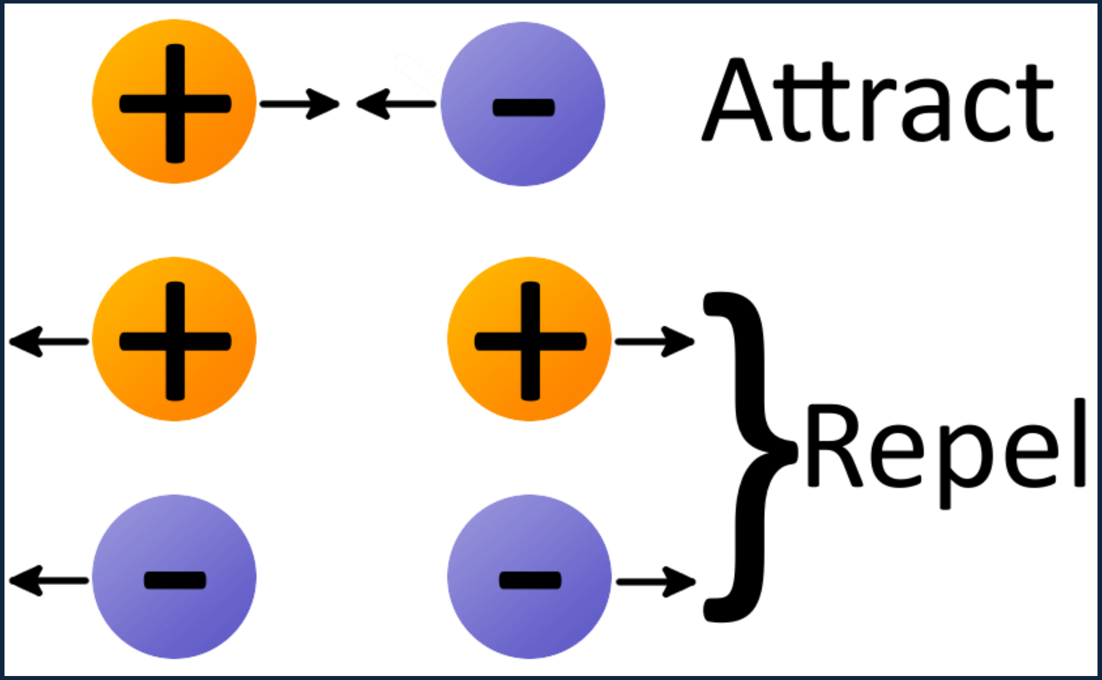
#3-Induction

Occurs when charges in an uncharged object are rearranged **WITHOUT direct contact** with the charged object.



Law of Electrical Charge

Like charges repel each other. Opposite charges attract each other.



What is energy?

Energy is the ability to do work or to make something move or change. It is different from power, which represents the rate at which energy is used. It takes energy to cook food, drive to school, and jump in the air.

There are seven forms of energy: **heat**, **light**, **motion**, **electrical**, **chemical**, **nuclear**, and **gravity**.

Energy can be described as either **potential energy** (stored) or **kinetic energy** (working or moving). A good example of this when you eat food the energy is stored in your body. If you eat too much, the energy is stored as fat. When your body needs it, it will find it in the stored energy reserves.

Another way of describing energy is to say it is **renewable** and **non-renewable**. Renewable means that the source can be restored and not used up. Examples of renewable energy are the sun (solar), heat from inside the earth (geothermal), wind, moving water (hydropower).

Non-renewable sources are **fossil fuels** (oil, gas, coal), and nuclear power. When these products are used up, the source is gone and cannot be replaced.

What is electricity?

Electricity is all around us powering technology. Can you imagine a world without electricity? That would mean no hot water, no air conditioning, no television, and no smartphones. Gasp! But that's not the only place you find electricity because it also exists in nature from lightning in a thunderstorm to the synapses in the human body. Your electricity might come from power stations, the wind, the sun, water, and even animal excrement! Yes, you heard that right!

Electricity, or electrical energy, is a type of **energy** that can build up in one place or flow from one place to another. Electricity is a form of energy that makes heat and light. It involves the movement of electrons from one point to another.

There are two types of electricity, static and **current**.

Safety First

Don't use electronics with frayed cords.

Never pull a plug by it's cord.

Don't place drinks near electronics or cords.

Never climb trees or fly a kite near lines.

Stay away from places marked with warnings.

More Safety Tips

Indoors

- Never turn on a light switch or electrical appliance while you are wet or while you are in the bathtub.
- Be careful not to leave electrical cords where people might step on them. Wear and tear on the cord can cause it to become unsafe.
- Check electrical cords for exposed wiring before plugging anything in. If you see a worn-looking cord, point it out to an adult.
- Never put any object other than a plug designed for that purpose into an electrical outlet. If you have questions about whether a plug is safe to use, ask an adult.
- Never touch electrical outlets with your fingers or with objects.
- Ask an adult to help you change light bulbs. Always turn lamps and other light fixtures off before changing a bulb.
- In case of an electrical fire at home get out of the house, then call 911 and an adult.
- Never use water to try to put out an electrical fire—you could be killed.

Outdoors

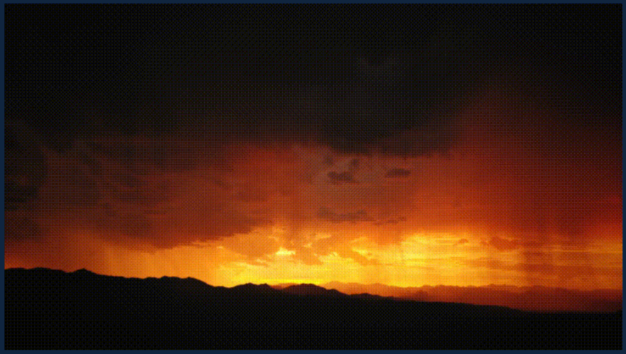
- Never climb utility poles, transmission towers, or fences around electrical plants or substations (which house equipment that reduces high voltage electricity so it can be used by consumers). If you see other people doing these things, tell an adult right away.
- Stay away from areas or buildings marked with signs that read “Danger: High Voltage.”
- If you enjoy climbing trees, avoid trees that are near electrical power lines.
- Never, ever touch an outdoor electrical pole or wire that has fallen to the ground. It could kill you!
- Stay away from and never touch transformers (usually large metal boxes attached to utility poles or on the ground) or substations. They contain high-voltage equipment that can hurt or kill you.
- Come inside during a thunderstorm (or even occasional flashes of lightning with no rain). Many people around the world are struck by lightning each year. Nearly all are badly injured and some are killed.
- Call 911 if you see a person who has been or is being electrocuted. Do not touch the person because they could be carrying the flow of electricity.
- Never swim during storms. As soon as you hear thunder or see lightning, get out of the water.

Static Electricity

When electricity gathers in one place it is known as **static electricity** (the word static means something that does not move). When an electric charge builds up on the surface of an object it makes static electricity.

When you touch a doorknob after you shuffle across the carpet, you feel a shock or static electricity. Your movement across the carpet causes you to lose some electrons. They start jumping around from one to another and you feel a shock when you make contact with the doorknob.

Lightning is also caused by static electricity. As rain clouds move through the sky, they rub against the air around them. This makes them build up a huge electric charge. Eventually, when the charge is big enough, it leaps to Earth as a bolt of lightning. You can often feel the tingling in the air when a storm is brewing nearby. This is the electricity in the air around you.



How static electricity works

Electricity is caused by electrons, the tiny particles that "orbit" around the edges of atoms, from which everything is made. Each electron has a small negative charge. An atom normally has an equal number of electrons and protons (positively charged particles in its nucleus or center), so atoms have no overall electrical charge. A piece of rubber is made from large collections of atoms called molecules. Since the atoms have no electrical charge, the molecules have no charge either—and nor does the rubber.

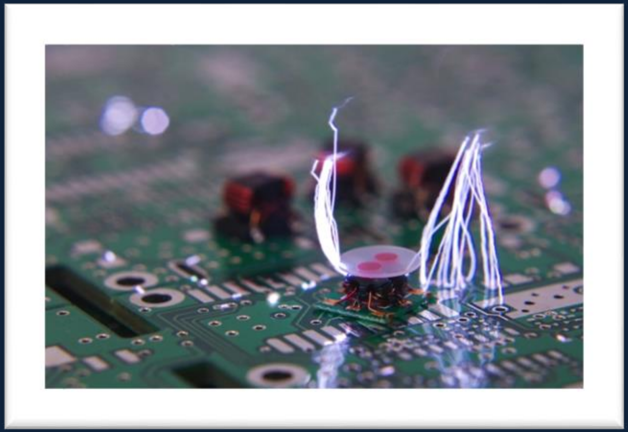
Static-Good or Bad?

Does static have any real uses?

Static electricity has several uses in the real world. One main use is in printers and photocopiers where static electric charges attract the ink, or toner, to the paper. Other uses include paint sprayers, air filters, and dust removal.

Static can damage electronics …

Static electricity can also cause damage. Some electronic chips, like the kind that are in computers, are very sensitive to static electricity. There are special bags to store these in. Also, people that work with these kinds of electronics wear special straps that keep them "grounded" so they won't build up a charge and ruin the electronic components.



Triboelectric Series

Scientists have ranked materials in order of their ability to hold electrons. This ranking is called the Triboelectric Series. If two of these materials are rubbed together, the one higher on the list should give up electrons and become positively charged. Static electricity occurs when there is an excess of positive or negative charges on an object's surface by rubbing certain materials together.

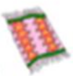
<u>TRIBOELECTRIC SERIES</u>

your hand
glass
your hair
nylon
wool
fur
silk
paper
cotton
hard rubber
polyester
polyvinylchloride plastic

Current Electricity

Electricity that moves from one place to another is called **current electricity**. Current electricity is the flow of electrons in a circuit through a **conductor**.

When **electrons** move, they carry electrical energy from one place to another. This is called **current electricity** or an **electric current**. Electric currents help power electrical appliances that you use like televisions, microwaves, and computers.

Static electricity	Current electricity
Socks	T.V 
Rugs 	Microwave 
Hair 	Oven 
Hands 	projector 
Balloons 	Netbooks 
doorknob 	Radio 
Trampoline' 	computers 

How current electricity works!

When electrons move, they carry electrical energy from one place to another. This is called current electricity or an electric current. A lightning bolt is one example of an electric current, although it does not last very long. Electric currents are also involved in powering all the electrical appliances that you use, from washing machines to flashlights and from telephones to MP3 players. These electric currents last much longer.

Have you heard of the terms potential energy and kinetic energy? Potential energy means energy that is stored somehow for use in the future. A car at the top of a hill has potential energy because it has the potential (or ability) to roll down the hill in the future. When it's rolling down the hill, its potential energy is gradually converted into kinetic energy (the energy something has because it's moving). You can read more about this in our article on energy.

Static electricity and current electricity are like potential energy and kinetic energy. When electricity gathers in one place, it has the potential to do something in the future. Electricity stored in a battery is an example of electrical potential energy. You can use the energy in the battery to power a flashlight, for example. When you switch on a flashlight, the battery inside begins to supply electrical energy to the lamp, making it give off light. All the time the light is switched on, energy is flowing from the battery to the lamp. Over time, the energy stored in the battery is gradually turned into light (and heat) in the lamp. This is why the battery runs flat.

Measuring Electricity

Electricity can be measured in several different ways, but a few are especially important:

Watts are the basic unit of measurement for electricity. Watts are a combination of voltage and amperage.

Electric current is measured in **amperes**, called **amps** for short. The amps are the number of electrons moving.

Electric potential energy is measured in **volts**. Voltage is the name for the electric force that causes electrons to flow. It's the measure of the potential difference between two points in the circuit. Voltage may come from a battery or a power plant.

The power or energy used by a circuit is measured in **Watts**. You can calculate the number of Watts by multiplying the Voltage times the Current. When your parents get their electrical bill it's generally in kilowatt hours. This is the measurement of power over time or how much power was used that month.

Power companies figure out how much electricity has been used by counting watts, kilowatts – that's a THOUSAND watts and megawatts – that's A MILLION watts!

They usually take measurements in kilowatt hours, megawatt hours, and gigawatt hours.

Conductors vs. Insulators

A **conductor** is any material that allows electrons to move through it easily. Most metals such as copper and aluminum make good conductors. Water is also another conductor.

Insulators are materials that electrons have a hard time going through.

Common Conductors

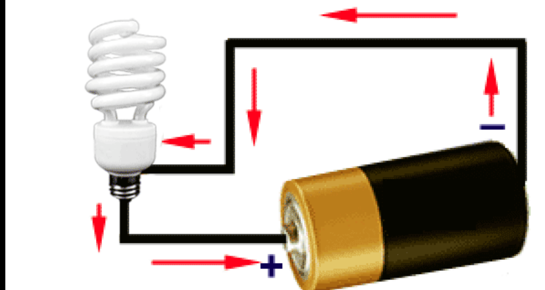
Copper
Iron
Aluminum
Steel
Gold
Silver
Water

Common Insulators

Wood
Rubber
Chalk
Cotton
Plastic
Glass

Circuits 101

A circuit is a way of guiding electricity along a path. For an electric current to happen, there must be a circuit. A circuit is a closed path or loop around which an electric current flows. Think about the word circuit for a moment, does it remind of the word for a shape? Did you guess circle? If so, you are correct! Just like a circle, a circuit goes round and round and doesn't have any spaces or gaps in it. That's true for a circuit too. There can't be any spaces in the path the electricity takes, otherwise it will stop.



Simple circuit with light

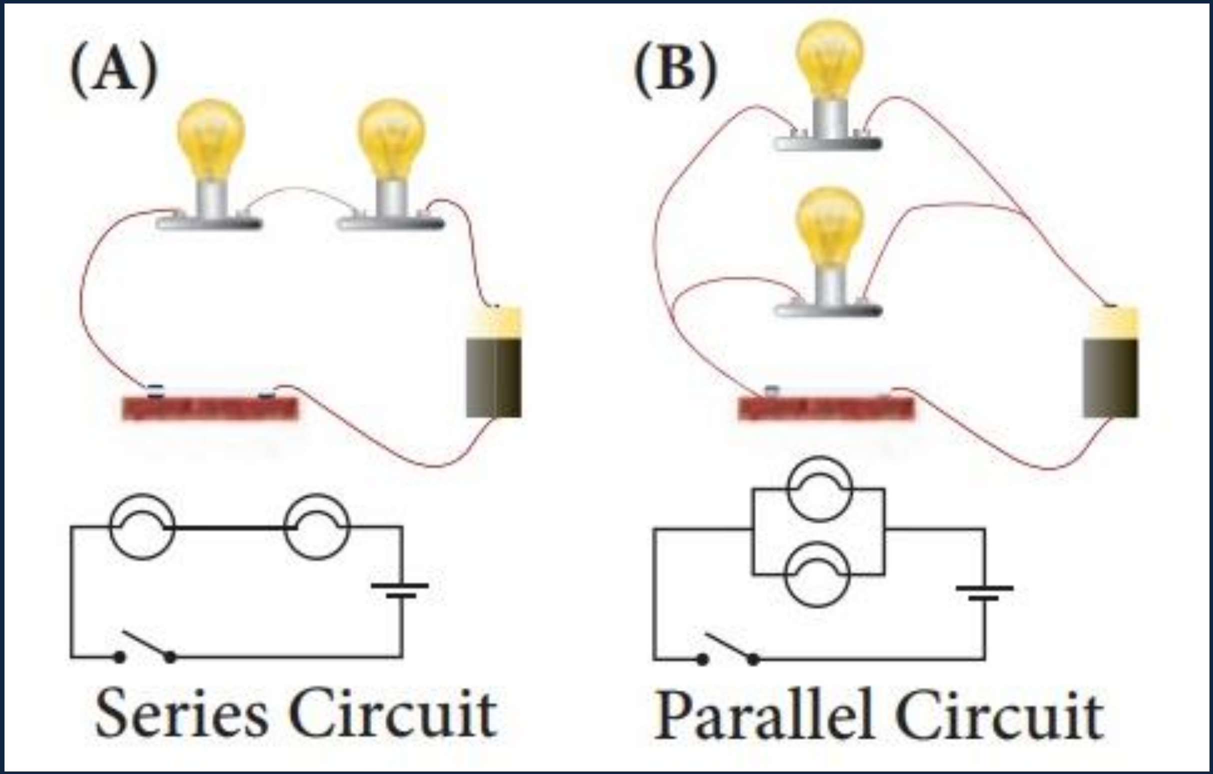
Even the most basic circuits have a few components:

- A basic circuit needs a **power source**, like an outlet in a wall or a battery, to provide a steady source of electrons.
- Along the circuit's path, there is usually a **load**, a device that uses electricity. Electrons flow through the device giving it power.
- Electrons begin by flowing out of the device from the **negative terminal**. From a wall outlet, electrons come from the shorter/smaller of the two slots called the hot slot.
- Then, the electrons head to the opposite side of the power source at the **positive terminal**. In a wall outlet, the taller of the two slots is called the neutral slot. The real key to an electrical circuit is that electrons have to have somewhere to go.
- To control when an electrical device is on or off, you need a **switch**. A switch controls the flow of electrons by opening and closing a circuit. When the switch is in an off position, the circuit is open. When the switch is in the on position, the circuit is closed and the electrons can flow through.

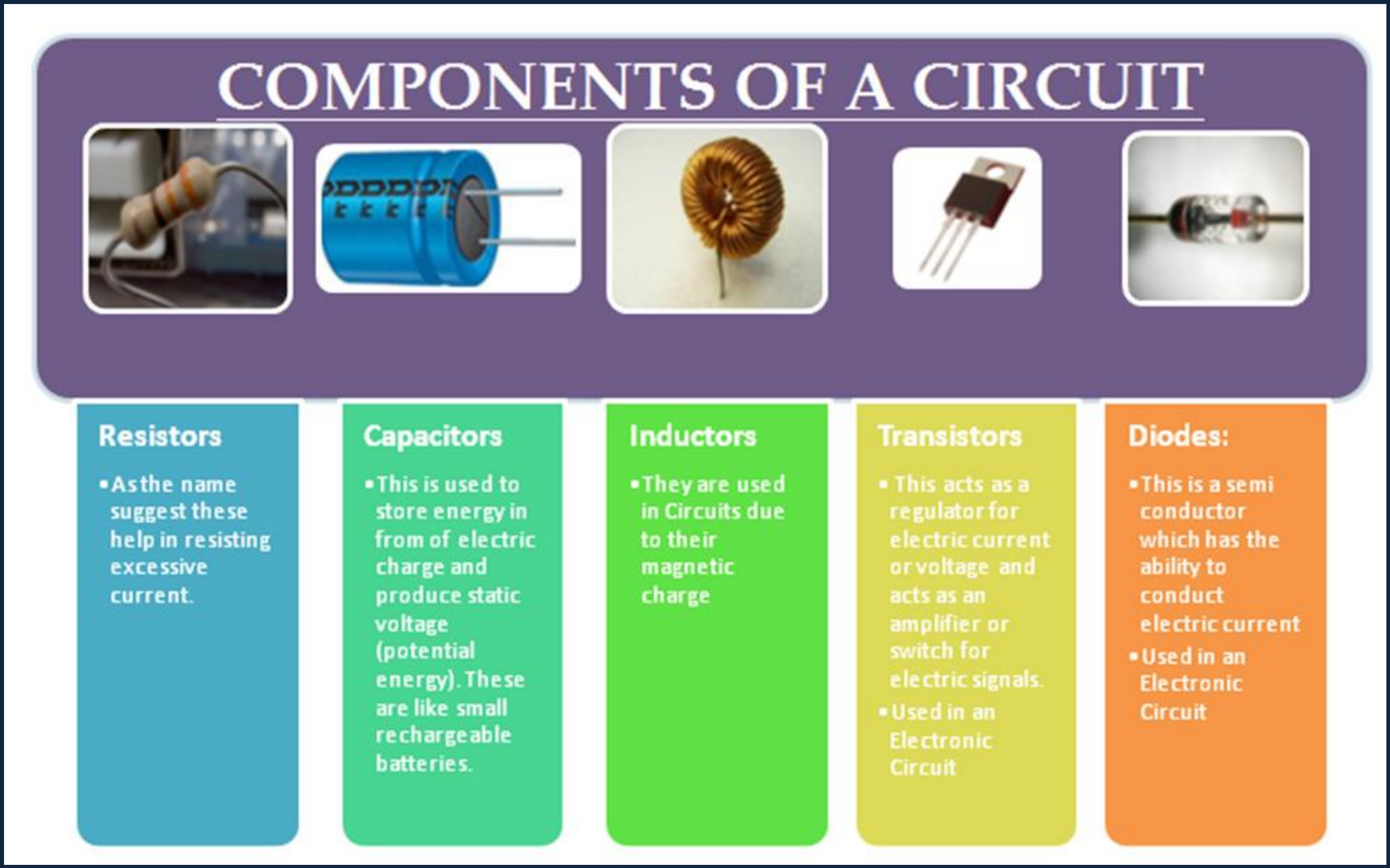
Types of Circuits

Series Circuit: circuit where all parts are connected in a single loop –only one possible path for charges to flow

Parallel Circuit: A circuit in which different loads are on separate branches – charges can flow in more than one route



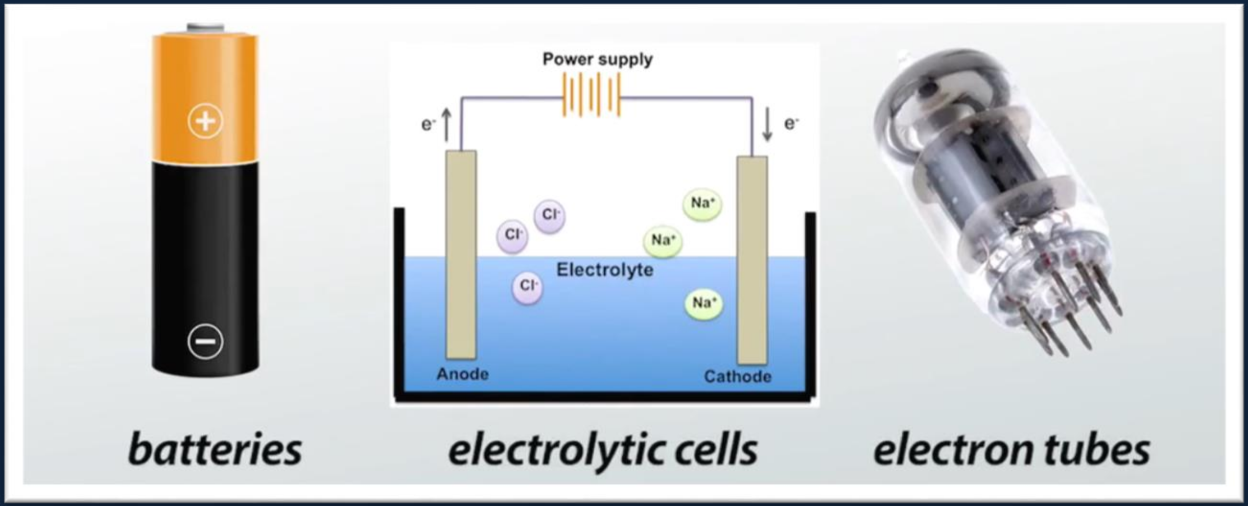
Components of a Circuit



Electrodes

An **electrode** is an electrical conductor that carries electricity. It is used to touch a non-metal part of a circuit. The two types of electrodes are **anode** (positively charged electrode) and **cathode** (negatively charged electrode).

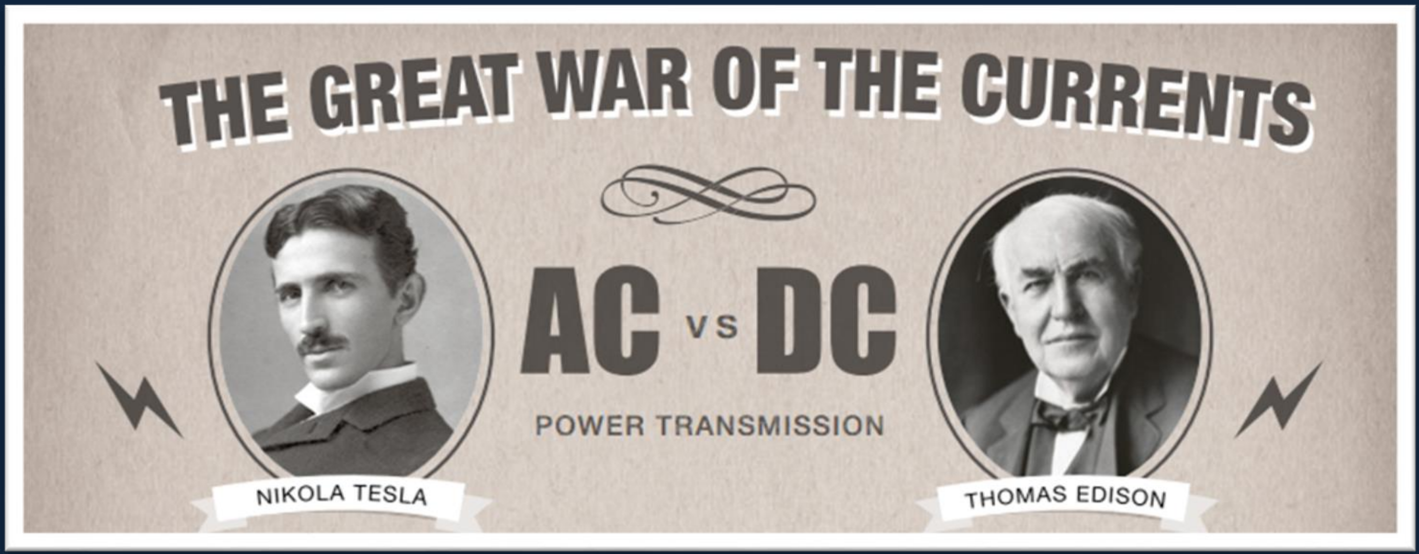
Electrodes can be found in batteries, electrolytic cells, and electron tubes. Electrodes are made from conductors, such as metals including copper, zinc, gold, and platinum.



History of Electricity

600 BCE: Greek philosopher Thales of Miletus first discovered static electricity.
1600 CE: English scientist William Gilbert began using the word "electricity."
1733: French scientist Charles du Fay found that there were two different kinds of static electric charge.
1752: American scientist Benjamin Franklin named the two kinds of electric charge "positive" and "negative."
1780: Italian biologist Luigi Galvani touched two pieces of metal to a dead frog's leg and made it jump. This led him to believe electricity is made inside animals' bodies.
1785: French scientist Charles Augustin de Coulomb explored the mysteries of electric fields.
1800: Italian physics professor Alessandro Volta, realized "animal electricity" was from the metals Galvani used. He found how to make electricity by joining different metals together and invented batteries.
1827: German physicist Georg Ohm found some materials carry electricity better than others.
1820: Danish physicist Hans Christian Oersted put a compass near an electric cable and discovered electricity can make magnetism.
1821: French physicist Andre-Marie Ampère put two electric cables near each other and wired them to a power source. This caused them to push apart and showed electricity and magnetism can work together to make a force.
1821: English chemist and physicist Michael Faraday developed the first, primitive electric motor.
1830s: American physicist Joseph Henry and British inventor William Sturgeon independently made the first practical electromagnets and electric motors.
1831: English chemist and physicist Michael Faraday invented the electric generator.
1840: Scottish physicist James Prescott Joule proved that electricity is a kind of energy.
1870s: Belgian engineer Zénobe Gramme made the first large-scale electric generators.
1873: British physicist James Clerk Maxwell created a detailed theory of electromagnetism.
1881: The world's first experimental electric power plant opened in England.
1882: American businessman and inventor Thomas Edison built the first large-scale electric power plants in the USA.
1890s: Edison's former employee Nikola Tesla, a Serbian-American inventor, electrical and mechanical engineer promoted alternating current (AC) electricity, a rival to the direct current (DC) system promoted by Edison.

War of the Currents!



Starting in the late 1880s, **Nikola Tesla** and **Thomas Edison** were mixed up in a battle now known as the **War of the Currents**.

Edison developed **direct current** **(DC)** -- current that runs constantly in one direction, like in a battery. During the early years of electricity, direct current was standard in the U.S. There was one problem, direct current is not easily converted to higher or lower voltages.

Tesla believed that **alternating current** **(AC)** was the solution to this problem. Alternating current reverses direction a certain number of times per second and can be converted to different voltages relatively easily using a transformer.

War of the Currents! Continued

Edison did not want to lose the royalties he was earning from his direct current patents, so he began a campaign to question alternating current. He spread half-truths saying that alternating current was more dangerous.

In 1893, General Electric bid to electrify the Chicago World's Fair using Edison's direct current for $554,000 but lost to George Westinghouse, who said he could power the fair for only $399,000 using Tesla's alternating current.

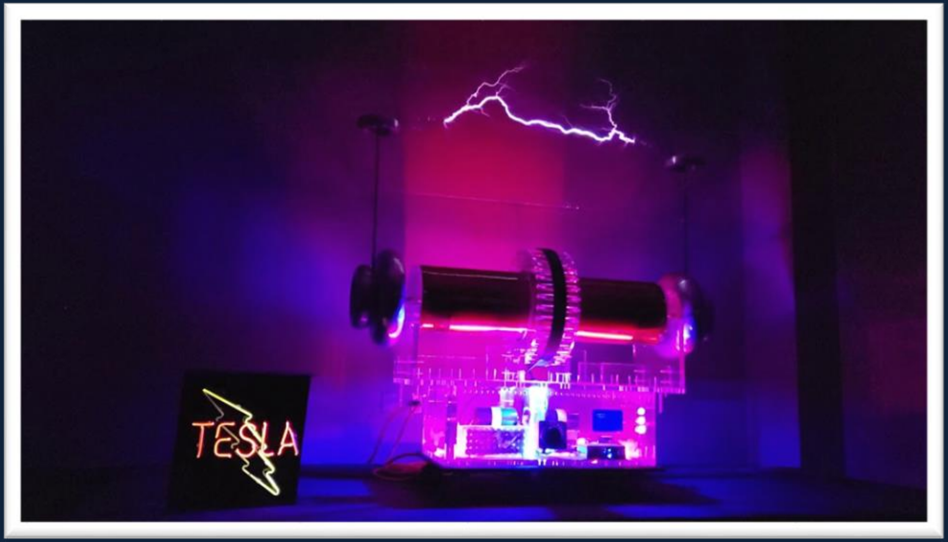
That same year, the Niagara Falls Power Company decided to award Westinghouse the contract to generate power from Niagara Falls to power all of Buffalo, New York. On Nov. 16, 1896, Buffalo was lit up by the alternating current from Niagara Falls. By this time General Electric had decided to jump on the alternating current train, too.

Today our electricity is still predominantly powered by alternating current, but computers, LEDs, solar cells, and electric vehicles all run on DC power. Methods are now available for converting direct current to higher and lower voltages.

Hands On! Discovery Center
Tesla Coil

Did you know that Hands On! Discovery Center has its very own Tesla Coil? In fact, it holds a Guinness Record as the world's most powerful, musical, bi-polar Tesla Coil. How cool is that?

The unique Tesla Coil at Hands On! Discovery Center converts 240 volts of electricity into up to 200,000 volts!



Did you know you are around a Tesla Coil almost every day and may not know it? A mini Tesla coil is in the vehicle that takes you to school– it's called a spark plug. It's the same basic principle.