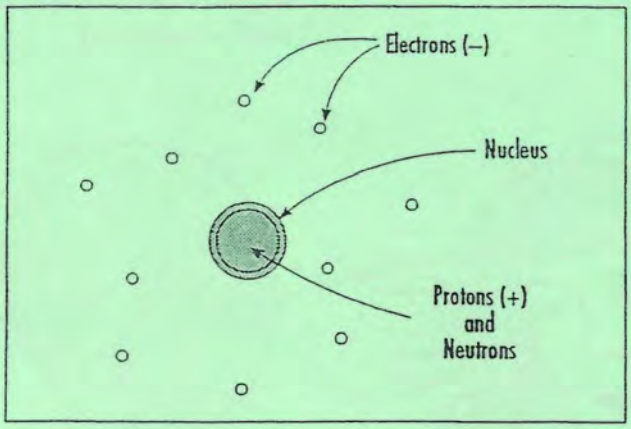
All About Electricity

What is "Matter"?

- All matter is made of tiny particles called "*atoms*".
- Atoms are made up of even smaller particles called:
  - *Protons* (particles with a positive charge found in the centre *(nucleus)* of the atom
  - *Neutrons* (particles with neither a positive nor negative charge found in the nucleus)
  - *Electrons* (particles smaller than protons that have a negative charge that move around the outside of the nucleus)
- How big is an atom? If the nucleus were about the size of a golf ball, the electrons would be smaller than popcorn kernels and the entire atom would be three kilometers in diameter.

The Atom



An atom has an equal number of electrons and protons giving it a neutral charge.

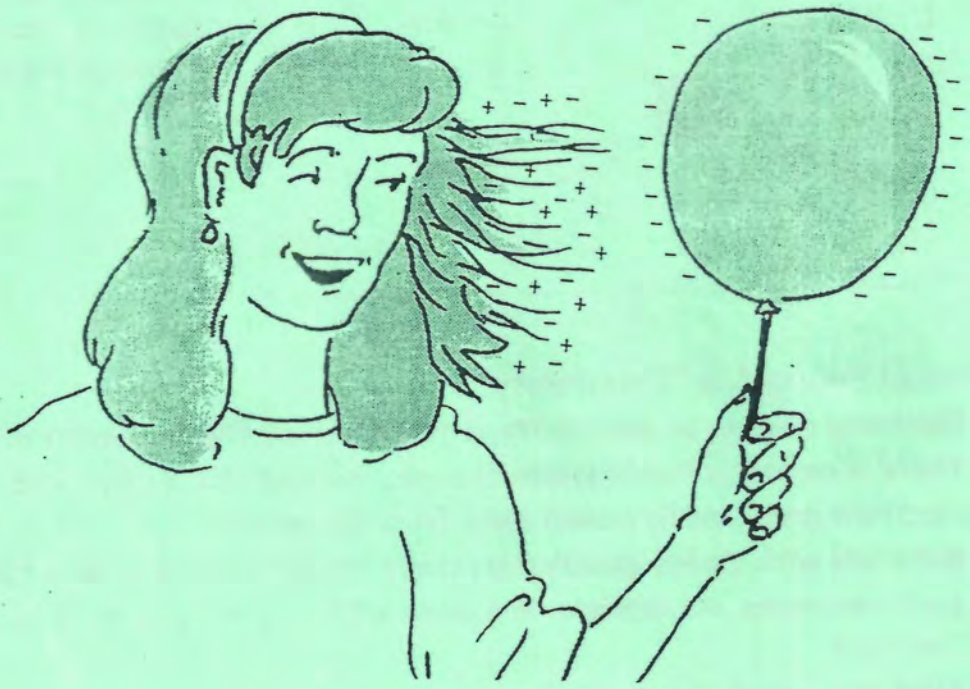
"Electrical Energy" is "Electricity"

- Electrical energy, or *electricity*, is the result of the movement of electrons.
- There is an attraction between the *electron* and the *nucleus*, and the electrons aren't easily moved away from the nucleus.
- Materials with *tightly bonded* electrons (the attraction is very strong), are good *insulators*. An *insulator* is a material that prevents the flow of electricity.
- What happens if the electrons are not attracted very strongly to the nucleus? They will move away from the nucleus if *heat, chemical, light or any other form of energy* is added. Here's an example:

"Static" Electricity

- When you rub a balloon on your hair, heat energy is produced by the rubbing. The rubbing action is called "friction". While you're rubbing the balloon on your hair, the loosely bonded electrons in your hair absorb the heat energy, and *escape* their nucleus. They move onto the surface of the balloon. All of those electronics on the surface of the balloon build up a *negative electrostatic charge* (remember, electrons are negative) because there are so many of them.
- *Static electricity* is the buildup of a *stationary* (unmoving) negative electric charge (or lots of electrons) on the *surface* of an object.
- *Look at the picture below to discover what really happens when you rub a balloon on your hair!* Write your answer below the picture.

Electrons from the hair build on the surface of the plastic (an insulator with tightly bonded electrons to create a negative electrostatic charge - static electricity).



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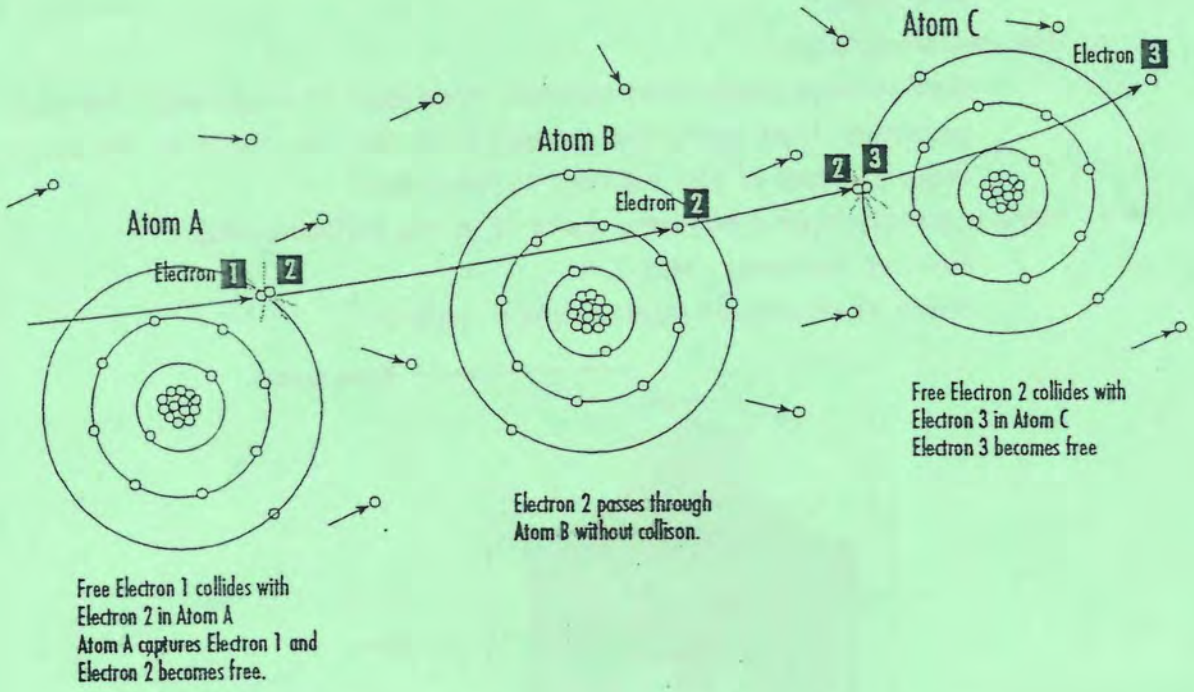
Electricity in "Circuits"

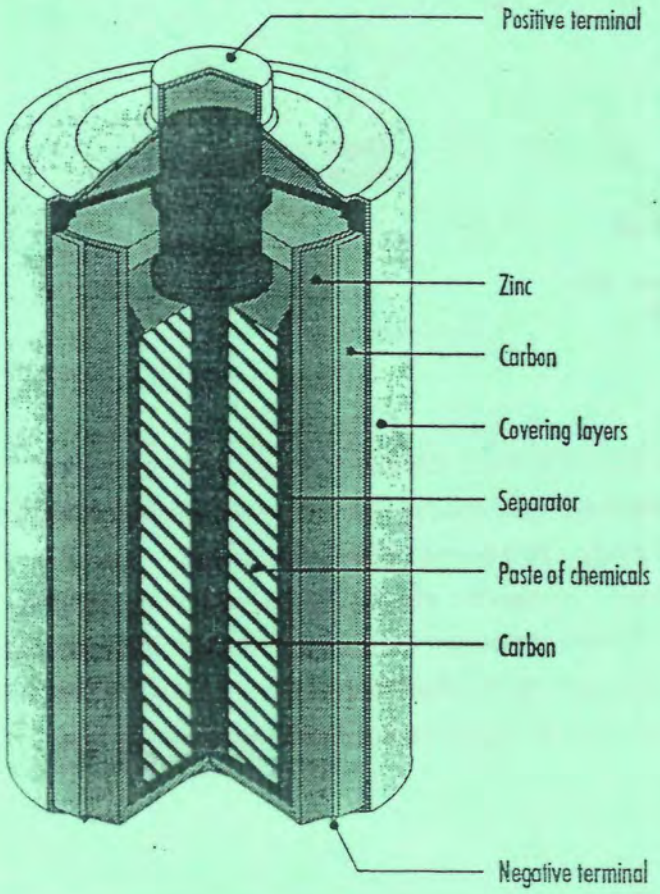
- A *current of electricity* occurs when electrons "flow".
- *When do electrons flow in a current?* They flow when the electrons absorb some kind of energy (chemical, heat, or light) and *move* along a continuous path *through* an object.
- Current moving in a wire can be compared to water moving through a garden hose. While the tap is turned on, water enters the hose through one end and pushes the water already in the hose further along until it leaves through the other end. It's the same with electricity. Electrons moving through a wire will bump into other electrons in the wire and push them along the circuit.
- Use a yellow, orange or red marker to highlight the movement of the electrons through the wire in the picture below.



Converting Electricity into Useful Forms of Energy

- Electrical devices can change (or *convert)* electricity into other useful forms of energy. Here are some examples:
  - Toaster: converts electrical energy into *heat* to toast your bread
  - Light Bulb: converts electrical energy into *heat and light*
  - Stereo: converts electrical energy into sound
  - Motor: converts electrical energy into *motion*

- Electrical energy can only be produced through the conversion of some other form of energy.
- The continuous pathway through which the electricity flows is called a *circuit.* In order to work, a *circuit* needs a source of electrical energy.
- *Batteries* are often used to supply electrical energy. In a battery, electrical energy flows from the negative terminal through the circuit to the positive terminal.
- A battery is made up of one or more cells that are connected in *series* or in *parallel* (more about this later).
- A battery *cell* is a single unit consisting of two *electrodes* and an *electrolyte.*
- The *electrodes* are:
    - made of different metals or carbon.
    - *conductors* which allow electrons to leave and enter the cell.
    - most often called the positive (cathode) and negative (anode) terminals.
- The *electrolyte* is:
    - a solution or paste that contains *free ions*, or negatively charged particles, that carry the current from one electrode to the other (or from one end of the battery to the other).
- Here is a picture of a battery. Color it in the following way:
    - Positive terminal - red
    - Paste of chemicals (electrolyte) - yellow



"Volts" and "Voltage"

- The strength of a battery cell is measured in *volts*.
- *Voltage* is the energy (force, pressure, or push) that each electron carries.
- The higher the energy in each electron, the higher the voltage.
- Batteries are commonly called *A, C* or *D* to distinguish the cell *size*.
- These cells (A, C, or D) all produce the *same voltage!* That's right! They all produce 1.5 volts *BUT* they contain different amounts of electron-producing materials. For example:
    - a 9V battery has ...
        - six cells
        - connected in series
        - to produce 9 volts (6 x 1.5 = 9)
- Larger cells last longer.
- The size difference allows the batteries to be used in large or small electrical devices.

More About "Currents" and "Amps"

- *Current* is the number of electrons that pass a point (eg., a light bulb) per second.
- Current is measured in *amps* (A). The more electrons that pass, the higher the current.

More About "Circuits"

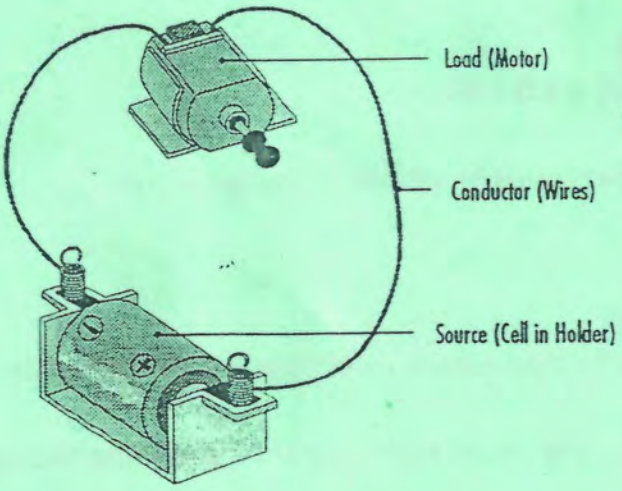
- Remember, a *circuit* is a continuous pathway along which the electrons can move.
- In its simplest form, a circuit consists of:
    - a power source (like a battery)
    - a conductor (like a wire)
    - a load (like a light or a motor) - *remember, this converts the electricity into another useful form of energy!*

Switches: Open and Closed Circuits

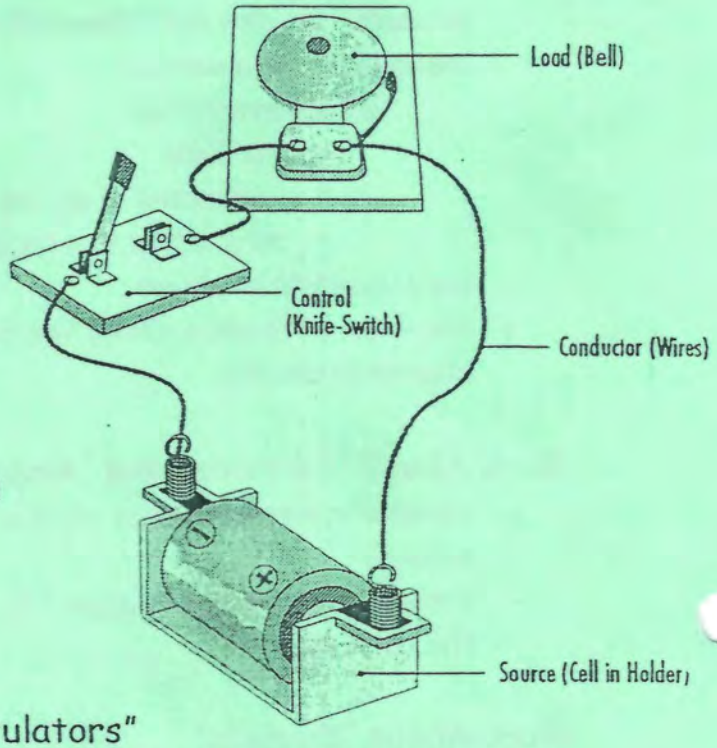
- Another name for switch is a "resistor".
- A switch, or resistor, is a "control device" that can be added to a simple circuit.
- A circuit may be "open" or "closed".
- An *open circuit* has a gap that prevents the electrons from moving through the circuit.

- A *closed circuit* is a complete loop in which the electrons are able to move from the negative to the positive terminal.
- Here are two diagrams. One shows a Simple Electric Circuit (without a switch). The other shows a Basic Electric Circuit (with a switch). Color the switch red and the load in each diagram blue.

A Simple Electric Circuit



A Basic Electric Circuit



More About "Conductors" and "Insulators"

- Materials that permit electrons to flow through them easily are called *conductors.*
- Examples of good conductors are:
  - copper
  - aluminum
  - silver
- Materials that prevent electrons from moving out of the wire are called *insulators.*
- Examples of insulators are:
  - plastic
  - wood
  - rubber
- Insulators make poor conductors, and are sometimes used as a coating for wires. Plastic is used on the outside of electrical wires to prevent uncontrolled movement of electrons outside of the wire. This movement of electrons outside the wire causes a "short circuit".

More About "Resistors"

- Materials that permit electrons to pass through them but put up some opposition to the flow are called *resistors.*
- Through *friction*, resistors slow down the speed of electrons causing the electrons to lose energy as heat and/or light.
- For example:
    - Electricity flows freely through the metal base of a light bulb but encounters *resistance* in the tungsten filament.
    - This causes the filament to heat up and glow.

Role Playing "Resistance"

- Actors: Power Source
  Electron
  Light Bulb
  Obstacles (3 students in nichrome wire)
  Obstacles (6 students in tungsten wire)
  Resistor (9 students as insulator)

- Set-Up: 1) Straight Pathway (copper wire) - no obstacles
  2) Resistance Pathway (nichrome wire) - obstacles

- Goal: Electron is to across the room as quickly as possible, following an imaginary wire path, to light the bulb at the other side.

- The Plays: 1) *Copper Wire:* Power source gives electron a push through the long, narrow space. It should move quickly and easily across the room. There is little resistance in the copper wire. The electron will arrive with a high energy level, and the light bulb will glow very brightly.

  2) *Nichrome Wire:* Power source gives electron a push through the long, narrow space that contains three "obstacles". The "Obstacles" slow down, but do not block the passage of the electron. *Arms, hands, legs, or feet are not to be used.* The electron should make its way through the resistance to the other end of the wire. The electron will be hotter and more tired than in the first situation where it traveled through the copper wire. The electron will arrive with a lower voltage (energy level), and the light bulb will not glow as brightly.

3) *Tungsten Wire:* Power source gives electron a push through the long, narrow space that contains six " obstacles". Even more resistance is encountered. It takes an even greater amount of time to reach the goal. It also takes a greater amount of energy to get through the obstacles. A lot of the electron's electrical energy will be converted through friction into heat. The result is that the light bulb will be quite dim.

4) *Insulator:* Power source gives electron a push through the long, narrow space that contains "resistance". The pathway is completely blocked and the electron can't get through. It loses all of its electrical energy and the light bulb does not shine.

"Fuses"

a. A *fuse* is a safety device that prevents appliances from being ruined when circuits are overloaded.

b. A fuse is a thin piece of wire that turns up if a large electric current goes through it. When the fuse burns up, the circuit is broken and the flow of electricity will stop. That's what it means when someone says, "I've blown the fuse."

c. The fuse will have to be replaced, but the appliance will not be damaged.

"Breakers"

- A *breaker* is a safety device that is used to prevent the overloading of circuits.
- A breaker is put into a household circuit. It will flip up and "break" the circuit if the current is to strong.
- This will happen if too many appliances are plugged into one socket at the same time. Once some of the appliances have been unplugged, the breaker can be flipped back.
- The difference between a fuse and a breaker is that a fuse must be replaced with a new one each time it burns out.