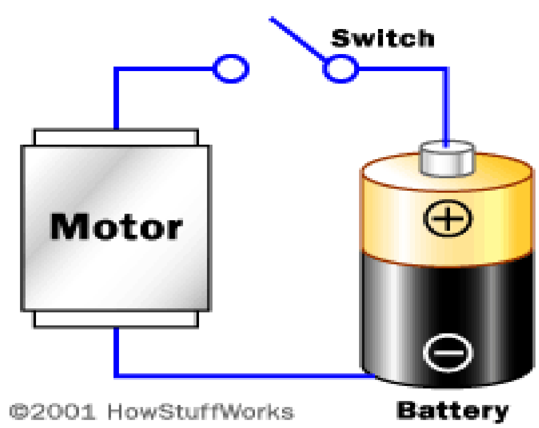
Batteries

Okay kids, I pulled this off the internet and some of it gets a little advanced regarding chemical reactions. Most of it you should be able to follow, and you will learn a lot from it. You will probably even want to build something after reading this. Ask mom and dad for a multitester (volt-ohm meter) for x-mas. Mom might already have one for fixing electronic stuff around the house. **Just don't mess with the electricity in the walls.** It can kill.

Battery Basics

If you look at any battery, you'll notice that it has **two terminals**. One terminal is marked (+), or positive, while the other is marked (-), or negative. In an AA, C or D cell (normal flashlight batteries), the ends of the battery are the terminals. In a large car battery, there are two heavy lead posts that act as the terminals.



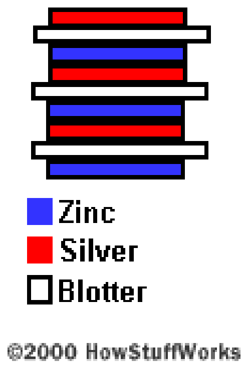
Electrons collect on the negative terminal of the battery. If you connect a wire between the negative and positive terminals, the electrons will flow from the negative to the positive terminal as fast as they can (and wear out the battery very quickly -- this also tends to be dangerous, especially with large batteries, so it is not something you want to be doing). Normally, you connect some type of **load** to the battery using the wire. The load might be something like a light bulb, a motor, an electromagnet, or an electronic circuit like a radio.

Inside the battery itself, a chemical reaction produces the electrons. The speed of electron production by this chemical reaction (the battery's **internal resistance**) controls how many electrons can flow between the terminals. Electrons flow from the battery into a wire, and must travel from the negative to the positive terminal for the chemical reaction to take place. That is why a battery can sit on a shelf for a year and still have plenty of power -- unless electrons are flowing from the negative to the positive terminal, the chemical reaction does not take place. Once you connect a wire, the reaction starts.

Battery Chemistry: Voltaic Pile

The first battery was created by Alessandro Volta in 1800. To create his battery, he made a stack by alternating layers of zinc, blotting paper soaked in salt water, and silver, like this:

This arrangement was known as a **voltaic pile**. The top and bottom layers of the pile must be different metals, as shown. If you attach a wire to the top and bottom of the pile, you can measure a voltage and a current from the pile. The pile can be stacked as high as you like, and each layer will increase the voltage by a fixed amount.



Experiments: Voltaic Pile

If you want to learn about the electrochemical reactions used to create batteries, it is easy to do experiments at home to try out different combinations. To do these experiments accurately, you will want to purchase an inexpensive ($10 to $20) **volt-ohm meter** at the local electronics or hardware store. Make sure that the meter can read low voltages (in the 1-volt range) and low currents (in the 5- to 10-milliamp range). This way, you will be able to see exactly what your battery is doing.

You can **create your own voltaic pile** using coins and paper towels. Mix salt with water (as much salt as the water will hold) and soak the paper towel in this brine. Then create a pile by alternating pennies and nickles. See what kind of voltage and current the pile produces. Try a different number of layers and see what effect it has on voltage. Then try alternating pennies and dimes and see what happens. Also try dimes and nickels. Other metals to try include aluminum foil and steel. Each metallic combination should produce a slightly different voltage.

Another simple experiment you can try involves a baby food jar (if you don't have a baby around the house, just purchase a few jars of baby food at the market and empty them out), a dilute acid, wire and nails. Fill the jar with lemon juice or vinegar (dilute acids) and place a nail and a piece of copper wire in the jar so that they are not touching. Try zinc-coated (galvanized) nails and plain iron nails. Then measure the voltage and current by attaching your volt meter to the two pieces of metal. Replace the lemon juice with salt water, and try different coins and metals as well to see the effect on voltage and current.

Battery Reactions

Probably the simplest battery you can create is called a **zinc/carbon battery**. By understanding the chemical reaction going on inside this battery, you can understand how batteries work in general.

Imagine that you have a jar of **sulfuric acid** (H_2SO_4). Stick a zinc rod in it, and the acid will immediately start to eat away at the zinc. You will see hydrogen gas bubbles forming on the zinc, and the rod and acid will start to heat up. Here's what is happening:

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* The acid molecules break up into three ions: two H^+ ions and one SO_4^{--} ion.

* The zinc atoms on the surface of the zinc rod lose two electrons (2e-) to become Zn^{++} ions.

* The Zn^{++} ions combine with the SO_4^{--} ion to create $ZnSO_4$, which dissolves in the acid.

* The electrons from the zinc atoms combine with the hydrogen ions in the acid to create H_2 molecules (hydrogen gas). We see the hydrogen gas as bubbles forming on the zinc rod.

If you now stick a carbon rod in the acid, the acid does nothing to it. But if you connect a wire between the zinc rod and the carbon rod, two things change:

* The electrons flow through the wire and combine with hydrogen on the carbon rod, so **hydrogen gas begins bubbling** off the carbon rod.

* There is **less heat**. You can power a light bulb or similar load using the electrons flowing through the wire, and you can measure a voltage and current in the wire. Some of the heat energy is turned into electron motion.

The electrons go to the trouble to move to the carbon rod because they find it easier to combine with hydrogen there. There is a characteristic voltage in the cell of 0.76 volts. Eventually, the zinc rod dissolves completely or the hydrogen ions in the acid get used up and the battery "dies."

Modern Battery Chemicals

Modern batteries use a variety of chemicals to power their reactions. Typical battery chemistries include:

* **Zinc-carbon battery** - Also known as a **standard carbon** battery, zinc-carbon chemistry is used in all inexpensive AA, C and D dry-cell batteries. The electrodes are zinc and carbon, with an acidic paste between them that serves as the electrolyte.

* **Alkaline battery** - Used in common Duracell and Energizer batteries, the electrodes are zinc and manganese-oxide, with an alkaline electrolyte.

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* **Lithium photo battery** - Lithium, lithium-iodide and lead-iodide are used in cameras because of their ability to supply power surges.

* **Lead-acid battery** - Used in automobiles, the electrodes are made of lead and lead-oxide with a strong acidic electrolyte (rechargeable).

* **Nickel-cadmium battery** - The electrodes are nickel-hydroxide and cadmium, with potassium-hydroxide as the electrolyte (rechargeable).

* **Nickel-metal hydride battery** - This battery is rapidly replacing nickel-cadmium because it does not suffer from the memory effect that nickel-cadmiums do (rechargeable).

* **Lithium-ion battery** - With a very good power-to-weight ratio, this is often found in high-end laptop computers and cell phones (rechargeable).

* **Zinc-air battery** - This battery is lightweight and rechargeable.

* **Zinc-mercury oxide battery** - This is often used in hearing-aids.

* **Silver-zinc battery** - This is used in aeronautical applications because the power-to-weight ratio is good.

* **Metal-chloride battery** - This is used in electric vehicles.