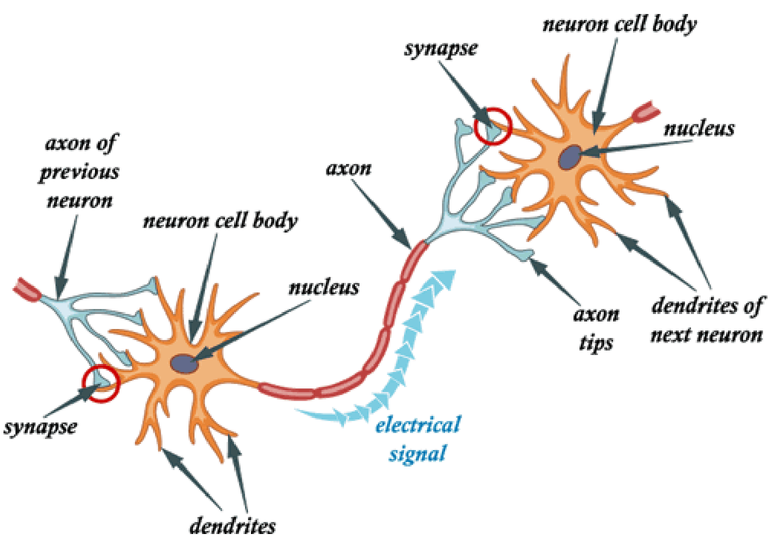
Name ____ Date ____________ Period _______

Lab: "Penny Battery"

HONORS BIOLOGY: CELL ENERGY

Background: What is energy? Energy causes things to happen around us. Look out the window. During the day, the sun gives out light and heat energy. At night, street lamps use electrical energy to light our way. When a car drives by, it is being powered by gasoline, a type of stored energy. The food we eat contains energy. We use that energy to work and play. The simple definition is that "Energy Is the Ability to Do Work." Energy can be found in a number of different forms. It can be chemical energy, electrical energy, heat (thermal energy), light (radiant energy), mechanical energy, and nuclear energy. (from: http://www.energyquest.ca.gov)

Everything we do is controlled and enabled by electrical signals running through our bodies. As we learned, everything is made up of atoms, and atoms are made up of protons, neutrons and electrons. Protons have a positive charge, neutrons have a neutral charge, and electrons have a negative charge. When these charges are out of balance, an atom becomes either positively or negatively charged. The switch between one type of charge and the other allows electrons to flow from one atom to another. This flow of electrons, or a negative charge, is what we call electricity. Since our bodies are huge masses of atoms, we can generate electricity. When we talk about the nervous system sending "signals" to the brain, or synapses "firing," or the brain telling our hands to contract around a door handle, what we're talking about is electricity carrying messages between point A and point B. It's sort of like the digital cable signal carrying 1s and 0s that deliver "Law & Order." Except in our bodies, electrons aren't flowing along a wire; instead, an electrical charge is jumping from one cell to the next until it reaches its destination.



Batteries are devices that convert chemical energy into electrical energy. When two different metals are connected by an electrolyte, a chemical reaction occurs at each metal surface, called electrodes, that either releases or uses electrons. When these electrodes are connected by a wire, electrons will move from one surface to the other, creating an electric current. (*Copied and modified from: http://www.exploratorium.edu/snacks/penny-battery*)

Tools and Materials:

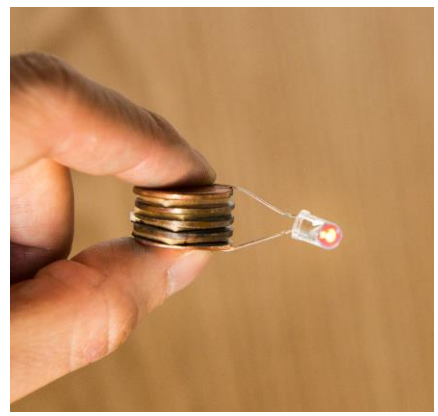
- Five or more post-1982 U.S. pennies
- Piece of 100-grit sandpaper
- Mat board or thick cardboard
- Salt
- Vinegar
- A red LED; high-intensity ones are easier to see
- Electrical tape
- A voltmeter
- Scissors (not shown)
- Cup with water (not shown)
- Paper towel (not shown)
- Optional: other LEDs of different colors, such as yellow and blue

Assembly:

1. Make a saturated salt solution by adding salt to water and stirring until it doesn't dissolve anymore. Add a splash of vinegar to this solution.
2. Cut your matboard into four 1/2-inch squares, each about the size of a penny. Soak the pieces in the salt-and-vinegar solution. Once the pieces are thoroughly wet, take them out and place them on a paper towel so they are still damp, but not dripping.
3. Use sandpaper to remove the copper from ONE side of each of four pennies. Leave the fifth penny intact. Sand until you see zinc (shiny silver color) covering the entire face of the coin. This takes some time and effort, so be patient. Try placing the sandpaper on a hard surface and moving the penny instead of the sandpaper. The "tails" side may be easier to sand because the Lincoln Memorial (or Union Shield) doesn't protrude as far as Lincoln's head. When you're done, the sanded coins should have a bronze-colored copper side and a silver-colored zinc side.

To Do and Notice:

1. Take one of your sanded pennies with the zinc side facing up (copper side down), and place a damp piece of matboard on it. Then stack another sanded penny (again, zinc side facing up) on top of this. Take your next piece of matboard and place it on top, and continue stacking pennies and matboard on top of each other to make a neat pile. Finally, place the un-sanded penny at the very top.
2. When you're done, you should have alternating layers of pennies and matboard with all the zinc sides facing up, and both the very top and the very bottom of your stack (facing down) should be copper. Make sure the pennies aren't directly touching each other and, likewise, that the pieces of matboard aren't touching each other.
3. Test your battery by connecting your LED. Touch the longer lead to the intact penny on the top and the shorter lead to the bottom of the stack. Make sure that the leads don't touch any other layer. Did the LED turn on? If not, make sure the LED leads are oriented correctly and use a paper towel to wipe off any excess water from the penny-matboard stack.
4. Check the voltage of the battery with a voltmeter by placing the leads on the top and bottom of your penny battery. If you want your LED to stay lit without having to hold it, wrap the entire assembly together with electrical tape. The LED will grow fainter as the matboards dry out, but it should stay lit for 24 hours! To recharge, just re-soak the matboards and reassemble.



What's Going On?

Batteries are devices that convert chemical energy into electrical energy. When two different metals are connected by an electrolyte, a chemical reaction occurs at each metal surface, called electrodes, that either releases or uses electrons. When these electrodes are connected by a wire, electrons will move from one surface to the other, creating an electric current.

Pennies that were made after 1982 have zinc cores that are plated with copper. By sanding off one face of a penny, you create a zinc electrode that can pair with the copper electrode on the face of the next penny. The matboard soaked in salty vinegar water serves as the electrolyte between the two terminals.

Each zinc-matboard-copper stack represents one individual cell. By stacking additional matboards and sanded pennies, you've created a battery, which is a series of electrochemical cells. This is also called a voltaic pile, which is named after Alessandro Volta, who created the first battery in 1800 by alternating zinc and copper electrodes with sulfuric acid between them. In Volta's battery and your penny battery, an oxidation reaction occurs at the zinc electrode that releases electrons and a reduction reaction occurs at the copper electrode that uses them.

With a voltmeter, you can see that each cell can generate over 0.6 volts. The penny battery you created for this lab has four cells. A stack of three cells should generate enough voltage to light a red LED, which usually require around 1.7 volts.

Going Further

For an added challenge, try making a battery powerful enough to light a blue LED.

Before 1982, pennies were made of 95% copper, but the rising costs of copper led the United States Mint to change the composition of the penny. The metal content in a pre-1982 penny is actually worth more than its one-cent face value. Consequently, in December 2006, the United States Mint implemented regulations that prohibit the melting or treatment of all one-cent coins.

Legal disclaimer: The Exploratorium does not take responsibility for any damaged coinage, and certainly don't try to sell your completed battery for more than 5¢!

Conclusion Questions:

1. Draw a diagram of your penny battery and label the following parts: pennies (and which side is copper or zinc), matboard (electrolyte), LED light bulb. Also show which way the electrons are traveling.

2. What was the purpose of sanding off the copper on one side of the penny?

3. Why did you soak the matboard in a salty/vinegar solution?

4. Which metal (copper or zinc) gives off electrons and which one takes up electrons? What do we call these materials?

5. How many volts does your penny battery produce?

6. How could you make a stronger battery?

7. Why did we use pennies that were made after 1982?

8. What creates the flow of electrons in your battery (or for all batteries for that fact)?

9. How is the flow of electrons in your battery similar to the electrochemical impulse in a nerve cell?

10. How is the flow of electrons in your battery different than a nerve impulse?

Taken from: http://www.exploratorium.edu/snacks/penny-battery