SECTION 2 ACTIVITIES

Activity 5: Create a Solar Cell

ACTIVITY TYPE: Teacher Demonstration

OVERVIEW: In this two-part demonstration, a sheet of copper flashing is transformed into a semiconductor to demonstrate the photovoltaic principle.

GOAL: Students learn that semiconductors can be used to generate current and are introduced to the photovoltaic principle.

SUBJECTS: Science, Earth Science, and Chemistry

TIME FOR PART I: 1 hour to cooker copper flashing and 20 minutes for the flashing to cool
TIME FOR PART II: 30 minutes for class demonstration and discussion

The steps can take place during two class periods, or Part I could be done before class.

SETTING FOR PART I: Kitchen or science lab with a burner to cook copper flashing.
SETTING FOR PART I: Outside on a sunny day to perform demonstration.

MATERIALS FOR PART I: 2 pieces of 4 x 4 copper flashing (in science kit), scissors, sandpaper or wire brush, mental tongs, and a stove or single burner.
MATERIALS FOR PART II: Plastic container (3-liter bottle with the top cut off), multimeter (in science kit), alligator clips, and saltwater.

KEY VOCABULARY: Red cuprous oxide, copper, multimeter, photovoltaic cell, and semiconductor..

CORRELATIONS TO STANDARDS	
NATIONAL	**Physical Science – 6:** Interactions of energy and matter. **Earth and Space Science – 1:** Energy in the earth system.
IDAHO	**Science – Goal 4.2:** Understand the geo-chemical cycles and energy in the earth system. **Science – Goal 2.3:** Understand the total energy in the universe is constant.
OREGON	**Science – Matter:** Analyze the effects of various factors on physical changes and chemical reactions.
WASHINGTON	**Science – Systems 1.3 Changes:** Understand how interactions within and among systems cause changes in matter and energy.

ABOUT THE AUTHORS: Founded in 1998, Bonneville Environmental Foundation (BEF) is essentially a non-profit business. Through the sales and marketing of green power products (known as carbon offsets) BEF gives individuals and businesses a way to participate in solving our most pressing environmental issues. All of the net revenues, or "profits," that the organization makes are reinvested in projects that restore damaged watersheds and support the development and understanding of renewable energy technologies such as solar, wind, and biomass.

Create a Solar Cell: Teacher Guide

Background:

The cuprous oxide created during the cooking process turns an ordinary piece of copper into a type of material called a semiconductor. A semiconductor is in between a conductor and an insulator. In a conductor electricity can flow freely. In an insulator electrons are bound tightly to their atoms and do not flow freely. In a semiconductor there is a gap (called a bandgap) between the electrons that are bound tightly to the atom and the electrons that are farther from the atom which can move freely and conduct electricity. Electrons cannot stay inside the bandgap. An electron cannot gain just a little bit of energy and move away from the atom's nucleus into the bandgap. An electron must gain enough energy to move farther away from the nucleus, outside of the bandgap. Similarly, an electron outside the bandgap cannot lose a little bit of energy and fall just a little bit closer to the nucleus. It must lose enough energy to fall past the bandgap into the area where electrons are allowed.

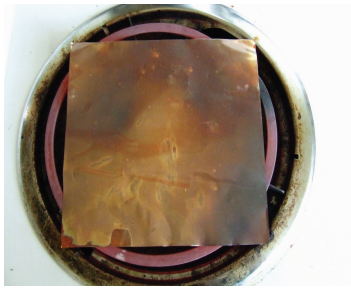
When sunlight hits the electrons in the cuprous oxide, some of the electrons gain enough energy from the sunlight to jump past the bandgap and become free to conduct electricity. The free electrons move into the saltwater, then into the clean copper plate, into the wire, through the meter, and back to the cuprous oxide plate.

To Create a Solar Cell:

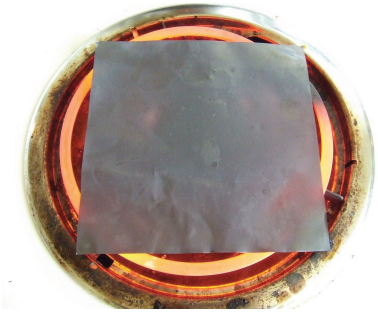
1. **Prepare the Copper:** Wash your hands so they don't have any grease or oil on them. Use metal sheers or strong scissors to cut a piece of the copper sheeting roughly 6 x 6 inches, about the size of the small burner on a stove. Then wash the copper sheet with soap or cleanser to get any oil or grease off of it. Use sandpaper or wire brush to thoroughly clean the copper sheeting so that any sulfide or other light corrosion is removed.

2. **Turn Copper into Cuprous Oxide:** Place the cleaned and dried copper sheet on the burner and turn the burner to its highest setting.

As the copper starts to heat up, oxidation patterns will begin to form. Oranges, purples, and reds will begin to cover the copper sheeting.



As the copper gets hotter, the colors are replaced with a black coating of cupric oxide. This is not the oxide we want, but it will flake off later, showing the reds, oranges, pinks, and purples of the cuprous oxide layer underneath.



The last bits of color disappear as the burner starts to glow red.

When the burner is glowing red-hot, the sheet of copper will be coated with a black cupric oxide coat. Let it cook for a half hour until the black coating is thick. This is important because a thick coating will flake off nicely, while a thin coat will stay stuck to the copper.

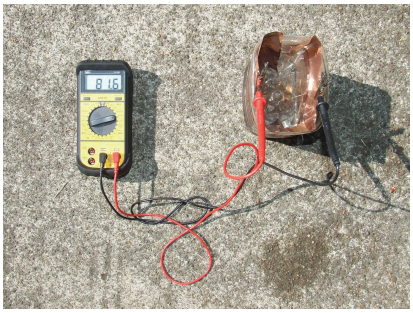
Use tongs to remove the copper sheet form the heat and place it in a sink to cool. As the copper sheeting cools, it will shrink. The black cupric oxide now covering the surface also shrinks, but at a different rate than the copper beneath. Black flakes of cupric oxide will pop off the copper with enough force to make them fly into the air.

When the copper has cooled to room temperature (about 20 minutes), most of the black oxide will be gone. Rub the sheet lightly with your hands and run it under water to remove most of the remaining black oxide. You do not need to remove all of the black spots, as doing so might damage the delicate red cuprous oxide layer, which is needed to make the solar cell function.

3. **Assemble the Solar Cell:** Fill the container with hot tap water so that a top portion of both pieces of copper will remain dry. Mix about two tablespoons of salt into the container, and stir the water until all the salt is dissolved.

Carefully bend the two pieces of copper (one that you cooked in Step 2 and one that has not been cooked) and fit them in the plastic container so that they do not touch each other. The cooked copper should have the reddest side facing out towards the sun.

4. **Monitor the Solar Cell:** Connect the cuprous oxide to the positive (red) lead of the multimeter, and connect the clean copper sheet to the negative (black) lead of the meter.



Set your multimeter to provide readings in millivolts. When the sun shines on your solar cell, you will begin to generate power. In the photo to the right the solar cell is generating 81.6 millivolts. Notice that if you block the sunlight striking the container the voltage quickly decreases

5. Now move your container out of the sun light. Notice that the solar cell still generates an electrical charge even in darker conditions.