# Fruit Batteries

By Jerry Loomer

A battery is an electronic device that changes chemical energy into electrical energy. The chemical energy is sort of like the energy in the food we eat. When we want to run or jump, our bodies change the food (chemical energy) into motion (kinetic energy). Similarly, the chemicals in a battery are storing energy that can be released as a flow of electrons (electric energy).

Batteries need three parts. A cathode (positive electrode), and anode (negative electrode), and an electrolyte (material to push the electrons). When making a fruit battery, the juiciness of the fruit or vegetable is the electrolyte, and the two metals inserted into the fruit are the electrodes. Which is the



cathode and which is the anode depends on what pair of materials you are using.

## Materials

- Fruits or vegetables: lemon, orange, apple, kiwi, grapefruit, potato, sweet potato, onion.
- Metals: copper (penny), nickel (nickel), iron (regular nail), zinc (galvanized nail), aluminum, tin (solder), carbon (mechanical pencil lead), wood (dowel), plastic
- Paper Towels
- Multimeter

## **Purpose:**

- The purpose of this experiment is to determine the electrical voltage output of different combinations of electrodes and fruits.
- It is also to find out which fruits give the highest voltage outputs.
- It is also to find out if the separation of the electrodes affects the voltage output.
- It is also to find out the voltages given off by different pairs of electrode materials.
- It is also to examine the voltage outputs when the electrodes are connected in series and in parallel.
- It is also to find the amperage output of different pairs of electrodes.
- It will also examine whether the depth the electrode is inserted into the fruit affects either the voltage or amperage outputs.

## **Procedure:**

Roll the fruit a little to make it a little juicier in the inside. Insert one electrode material into the juicy part of the fruit. Insert a second electrode into the juicy part of the fruit, but not so the two electrodes touch.

#### Voltage measurements:

Set the Multimeter so that it is measuring DCV (Direct Current Voltages). The 200m setting will give voltage readings up to 2.000 volts. If the readings are too high or too low, just change the dial to an appropriate setting. Since it may be hard to maintain a solid contact with the pointed Multimeter probes, it might be better if you use a pair of alligator clip leads and attach one side to the end of the pointed probe and clip the other end of the lead to the electrode. If you get a negative voltage reading, reverse the clips on the electrodes. The red lead goes to the anode of the fruit battery and the black lead goes to the cathode.

#### **Current measurements:**

When making current or amperage measurements, turn the dial on the Multimeter to DCA (Direct Current Amperage) and set the dial at the range setting most appropriate for the range of current readings you are experiencing. The 200  $\mu$  is the most sensitive, which means that it will record the smallest currents while the 200 m is the range for the largest currents.

As you collect data, be sure to identify the fruit, the cathode material, the anode material, and the voltage that it reads so you can identify which experiment you were conducting.

#### Analysis:

For data where there are numerical values for both the variable quantity (ie. Separation, depth) and the results (ie. Voltage, current), a numerical graph can help show how the values change. When the variable quantity is not a numerical value (ie. Type of fruit, type of anode), bar graphs are sometimes helpful. For some experiments, just looking at the results gives enough information for determining

As in all scientific work, only change one variable at a time. By keeping all of the other variables constant, you will be able to see if the one that you are changing is causing the effect. If you vary two or more between trials (different electrodes placed at different separations in different fruits and inserted down to different depths), the different voltage or current values that you get can't be tied directly to any particular variable. Students often want to "let's try this, now let's try that, now let's try something else" and don't want to do a systematic search. This experiment is good for holding a lot of variables constant while testing each of them, one at a time.

# **Fruit Batteries Data Sheets**

## **Question 1: Does the distance between the electrodes affect the voltage?**

Measure the voltage as you change the distance between the electrodes. Be sure the electrodes are inserted parallel to each other and that they are inserted the same distance into the fruit each time. Use only one type of fruit.

Fruit 🗲				
Cathode $\rightarrow$				
Anode $\rightarrow$				
Separation (cm)	1.0	2.0	3.0	4.0
Voltage (V)				

# **Question 2: Does the distance between the electrodes affect the amperage?**

Measure the current (mA) as you change the distance between the electrodes. Be sure the electrodes are inserted parallel to each other and that they are inserted the same distance into the fruit each time. Use only one type of fruit.

Fruit →				
Cathode $\rightarrow$				
Anode $\rightarrow$				
Separation (cm)	1.0	2.0	3.0	4.0
Amperage (mA)				

## **Question 3: Does the type of fruit affect the voltage?**

Measure the voltage as you change the type of fruit. Be sure the electrodes are inserted parallel to each other, that they are always the same distance apart, and that they are inserted the same distance each time.

Cathode $\rightarrow$	
Anode $\rightarrow$	
Separation (cm)	
Fruit 🗲	
Voltage (V)	

# **Question 4: Does the type of fruit affect the amperage?**

Measure the current (mA) as you change the type of fruit. Be sure the electrodes are inserted parallel to each other, that they are always the same distance apart, and that they are inserted the same distance each time.

Cathode $\rightarrow$		
Anode $\rightarrow$		
Separation (cm)		
Fruit →		
Amperage (mA)		

#### **Question 5: Does the type of anode (-) affect the voltage?**

Measure the voltage as you change the anode. Be sure the anodes are inserted parallel to the cathode and that they are inserted the same distance into the fruit each time. Use only one type of fruit. Use only one type of cathode although the experiment can be repeated with different cathodes and checked against the different types of anode materials.

Fruit 🗲		
Cathode $\rightarrow$		
Separation (cm)		
Anode $\rightarrow$		
Voltage (V)		

## Question 6: Does the type of anode (-) affect the amperage?

Measure the current (mA) as you change the anode. Be sure the anodes are inserted parallel to the cathode and that they are inserted the same distance into the fruit each time. Use only one type of fruit. Use only one type of cathode although the experiment can be repeated with different cathodes and checked against the different types of anode materials.

Fruit →		
Cathode $\rightarrow$		
Separation (cm)		
Anode $\rightarrow$		
Amperage (mA)		

#### **Other Questions:**

- Does the insertion depth of the electrodes affect the voltage and/or current?
- Does the angle of insertion of the electrodes affect the voltage and/or current?
- How does having the electrodes touch above (or inside) the fruit affect the voltage and/or current?
- Using alligator clip leads, make a series set of fruit cells and see what maximum voltage you can get.
- Using alligator clip leads, make a parallel set of fruit cells and determine what the largest current you can get is.

Make a stack of alternating pennies and nickels separated by paper towel pieces. Use the Multimeter to find the voltage and current across the stack. Now, dampen the paper towel pieces with salt water and see the voltage and current readings. Dry toweling is an insulator while the salt water brine is a conductor. Do lemon juice or other liquids work as well as (or better than) the salt water?

This stack of coins is a multi-celled battery just like your 12 volt car battery is really a collection of six 2-volt cells that are connected in series to add up to 12 volts.