

# Fruit Battery

**Overview:** Today you get to raid the refrigerator and test several different kinds of fruits and veggies to create the best battery with the highest voltage. Do *not* eat anything that was used in the lab.

**What to Learn:** This experiment shows how a battery works using electrochemistry. The copper electrons are chemically reacting with the lemon juice, which is a weak acid, to form copper ions (cathode, or positive electrode) and bubbles of hydrogen. These copper ions interact with the zinc electrode (negative electrode, or anode) to form zinc ions. The difference in electrical charge (potential) on these two plates causes a voltage, which kids will measure with your digital multi-meter.

## Materials

- zinc strip
- copper strip
- two alligator wires
- digital multimeter (DMM)

You can use a galvanized nail and a copper penny (preferably minted before 1982) for additional electrodes and connect them all the way around the fruit.

## Fruit to experiment may include:

- lemon
- lime
- apple
- potato
- tomato
- bananas
- grapes
- pineapple
- oranges
- tangerines

## Lab Time

1. Roll and squish the lemon around in your hand so you break up the membranes inside, without breaking the skin or leaking any juice. If you're using non-membrane foods, such as an apple or potato, you are all ready to go.
2. Insert the copper and zinc strips into the lemon, making sure they do not contact each other inside.
3. Clip one test wire to each metal strip using alligator wires to connect to the digital multimeter.
4. Turn on the DMM to 20 VDC. Read the multimeter and record your results in the data table.
5. What happens when you gently squeeze the lemon? Does the voltage vary over time?
6. Fill in the data table as you test these different ideas:
  - a. Try potatoes, apples, or other fruit or vegetable containing electrolytes. Record your measurements in the data table.
  - b. What if you use one electrode in one fruit and one in the other? What do you measure?

## Fruit Batteries Data Table

Trial #	Fruit Type	Volts Generated (V)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

### Reading

The basic idea of electrochemistry is that charged atoms (ions) can be electrically directed from one place to another. If we have a glass of water and dump in a handful of salt, the NaCl (salt) molecule dissociates into the ions Na<sup>+</sup> and Cl<sup>-</sup>.

When we plunk in one positive electrode and one negative electrode and crank up the power, we find that opposites attract: Na<sup>+</sup> zooms over to the negative electrode and Cl<sup>-</sup> zips over to the positive. The ions are attracted (directed) to the opposite electrode and there is current in the solution.

Electrochemistry studies chemical reactions that generate a voltage and vice versa (when a voltage drives a chemical reaction), called oxidation and reduction (redox) reactions. When electrons are transferred between molecules, it's a redox process.

Fruit batteries use electrolytes (solution containing free ions, like salt water or lemon juice) to generate a voltage. Think of electrolytes as a material that dissolves in water to make a solution that conducts electricity. Fruit batteries also need electrodes made of conductive material, like metal. Metals are conductors not because electricity passes through them, but because they contain electrons that can move. Think of the metal wire like a hose full of water. The water can move through the hose. An insulator would be like a hose full of cement – no charge can move through it.

You need two different metals in this experiment that are close, but not touching inside the solution. If the two metals are the same, the chemical reaction doesn't start and no ions flow and no voltage is generated – nothing happens.

This experiment produces around one volt of electricity, and the amps are in the micro-to-milli scale. For comparison, you'll need about 557 lemons to light a standard flashlight bulb.

### **Exercises**

1. What kinds of fruit make the best batteries?
2. What happens if you put one electrode in one fruit and one electrode in another?
3. What happens if you stick multiple electrode pairs around a piece of fruit, and connect them in series (zinc to copper to zinc to copper to zinc...etc.) and measure the voltage at the start and end electrodes?

**Answers to Exercises: Fruit Battery**

1. What kinds of fruit make the best batteries? (Citrus, because of the acid.)
2. What happens if you put one electrode in one fruit and one electrode in another? (The ions are not able to be attracted to the different electrodes, so there's no current flowing.)
3. What happens if you stick multiple electrode pairs around a piece of fruit, and connect them in series (zinc to copper to zinc to copper to zinc...etc.) and measure the voltage at the start and end electrodes? (You'll get a high voltage at first, which runs out more quickly than using only a single pair.)