Name Period Date

# Voltage: Fruit Battery/Generator

## Driving Questions

What is voltage and where does it come from?

How can a piece of fruit be used to construct a fundamental form of an electric cell?

## Background

The volt is the unit of measurement used to describe the difference of electric potential energy between two points (often called voltage). A volt is equivalent to the amount of electric potential energy that the voltage source gives to each coulomb of charge within it.

$$\text{Volt} = \frac{\text{Joule}}{\text{Coulomb}}$$

Electrochemical cells convert chemical energy into electric energy. They have 2 electrodes (usually 2 types of metal) immersed in an electrolyte (a chemical solution such as copper sulfate, salt water, or, in this activity, fruit juice). The chemicals in the electrolyte work (react) to decrease the number of negative charges on one electrode and decrease the number of positive charges on the other electrode. As the work is done to remove charges, chemical energy is converted to electric potential energy.

Because of the net charge imbalance created by the chemicals, the electrochemical cell becomes a voltage source similar to a battery. As more charge is taken from each electrode, the electric potential (voltage) increases.

In 1800, Alessandro Volta invented the first battery made from electrochemical cells composed of copper and zinc disks (the electrodes) separated by pasteboard (thick paper) soaked in salt water or vinegar (the electrolyte).

## Materials and Equipment

### *For each student or group:*

- Data collection system
- Voltage sensor
- Piece of copper
- Piece of zinc
- Series/parallel battery holders
- Batteries, "D" cell (3)
- Alligator clips (one red, one black)
- Variety of fruit (minimum of 1 piece per student group)

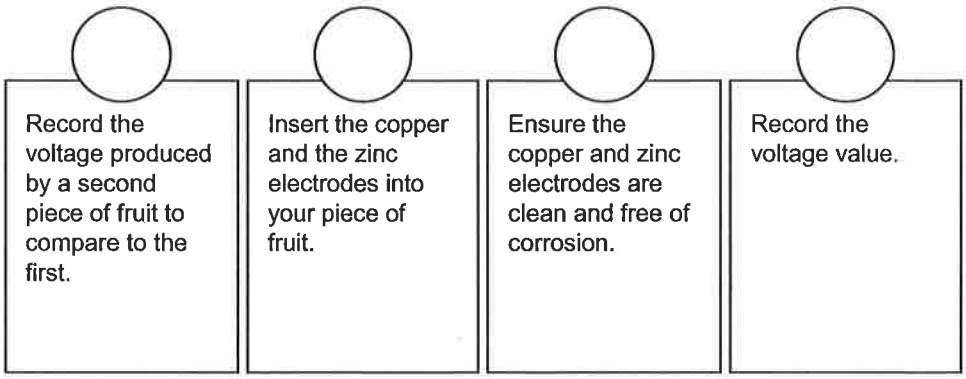
## Safety

**Add these important safety precautions to your normal laboratory procedures:**

- The fruit should not be consumed after use in this lab.

## Sequencing Challenge

**The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**




## Procedure

**After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.**

**Note:** When you see the symbol "◆" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

### Part 1 – Electrochemical cells

#### *Set Up*

**1.** ☐ Start a new experiment on the data collection system. ◆(1.2)

**2.** ☐ Connect your voltage sensor to the data collection system. ◆(2.1)

**3.** ☐ Configure the data collection system to monitor live data without recording. ◆(6.1)

**4.** ☐ What happens to two "like" charges (positive and positive, or negative and negative) when they are near each other?

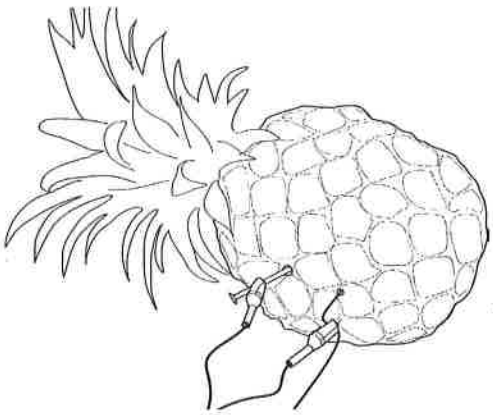
**5.** ☐ Mount the red and black alligator clips on the voltage sensor's 4 mm banana connector leads.

**6.** ☐ Choose the first piece of fruit.

**7.** ☐ Push the copper wire and the zinc-coated nail into the fruit about 5 cm apart. Leave about 2 cm of each electrode exposed.

**8.** ☐ Connect the red alligator clip to the copper wire.

**9.** ☐ Connect the black alligator clip to the zinc-coated nail.



**10.** ☐ As the electrolytic solution decreases the number of positive charges on one of the metal electrodes, is the number of negative charges changing on that same electrode? Is that electrode now positively charged or negatively charged?

### *Collect Data*

**11.** ☐ Let the voltage value stabilize, and then record the voltage value and fruit (cell) type in Table 1 in the Data Analysis section.

**12.** ☐ Remove the electrodes from the fruit, clean them off, and insert them into the next piece of fruit.

**13.** ☐ Let the voltage value stabilize, and then record the voltage value and fruit (cell) type in Table 1 in the Data Analysis section.

**14.** ☐ Remove the electrodes from the fruit, clean them off, and insert them into the next piece of fruit.

**15.** ☐ Let the voltage value stabilize, and then record the voltage value and fruit (cell) type in Table 1 in the Data Analysis section.

**16.** ☐ Detach the leads of the voltage sensor from the alligator clips.

**17.** ☐ Hold the red lead to the positive end of a battery and the black lead to the negative end. Let the voltage value stabilize, and then record the voltage value and fruit type (D-cell battery) in Table 1 in the Data Analysis section.

## Part 2 – Multiple cells

### *Set Up*

**18.** ☐ Place three batteries in individual battery holders.

**19.** ☐ Connect the voltage sensor across the terminals of one of the batteries, red to positive and black to negative.

### *Collect Data*

**20.** ☐ Record the voltage value of one cell in Table 2 in the Data Analysis section.

**21.** ☐ Connect a second battery holder to the first so that the positive terminal of the first is connected to the negative terminal of the second (connected in series).

**22.** ☐ Connect the voltage sensor across the outer most terminals of the batteries.

**23.** ☐ Record the voltage value for two cells in series in Table 2.

**24.** ☐ Connect a third battery holder to the first two so that the positive terminal of the first two is connected to the negative terminal of the third (connected in series).

**25.** ☐ Connect the voltage sensor across the outer most terminals of the batteries.

**26.** ☐ Record the voltage value for three cells in series in Table 2.

**27.** ☐ Disconnect the batteries and connect one of the batteries to the voltage sensor again, and enter the voltage value for one cell in Table 3.

**28.** ☐ Connect a second battery holder to the first so that the positive terminal of the first is connected to the positive terminal of the second and the negative terminal of the first is connected to the negative terminal (connected in parallel).

**29.** ☐ Connect the voltage sensor across the outer most terminals of the batteries.

**30.** ☐ Record the voltage value for two cells in parallel in Table 3.

**31.** ☐ Connect a third battery holder to the first two so that the positive terminal of the second is connected to the positive terminal of the third (connected in parallel), and the negative terminal of the second is connected to the negative terminal of the third.

**32.** ☐ Connect the voltage sensor across the outer most terminals of the batteries.

**33.** ☐ Record the voltage value for three cells in parallel in Table 3.

## Data Analysis

Table 1: Fruit and voltage

| Fruit | Voltage (V) |
|---|---|
| | |
| | |
| | |
| "D" Battery | |

Table 2: Connected in series

| Number of Cells | Voltage (V) |
|---|---|
| 1 | |
| 2 | |
| 3 | |

Table 3: Connected in parallel

| Number of Cells | Voltage (V) |
|---|---|
| 1 | |
| 2 | |
| 3 | |

## Analysis Questions

**1.** How does the voltage of the first piece of fruit compare to the voltage of the second piece of fruit? Why do you think they are different or similar?

**2.** How does the voltage of either piece of fruit compare to the voltage of the D-Cell battery? Why do you think they are different or similar?

**3.** What is one thing that might increase the voltage from the piece of fruit?

**4.** Could you light the bulb from a flashlight with the voltage of a piece of fruit? Why or why not?

## Synthesis Questions

Use available resources to help you answer the following questions.

**1.** **An electrochemical cell made from a piece of fruit may supply a sufficient voltage to power some small electrical devices. However, its total charge on each electrode and the rate at which the net charge is produced is not sufficient to produce a proper current for these devices. What is one way to fix this problem using several electrochemical cells?**

**2.** **What would happen to the voltage measurement from your fruit battery if the two electrodes accidentally touched each other? Justify your answer.**

## Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

**1.** **What are two key parts of any electrochemical cell?**

- **A.** Copper and zinc
- **B.** Electrodes and electrolyte
- **C.** Fruit juice and copper sulphate
- **D.** Unknown

**2.** **If you measured the voltage across two pieces of metal, and that voltage was zero, which of the following statements is true?**

- **A.** Each piece of metal has zero charges on it.
- **B.** There are more positive charges on one piece of metal than the other.
- **C.** Each piece of metal has the same net charge on it.
- **D.** There are more negative charges on one piece of metal than the other.

**3. If you connected the electrodes from two identical fruit batteries together (zinc to zinc and copper to copper), the voltage would be:**

- **A.** Twice as much as one fruit battery
- **B.** Half as much as one fruit battery
- **C.** Zero
- **D.** The same as one fruit battery

## Key Term Challenge

**Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.**

**1.** We have found many ways to turn _____. Wind power, hydro power, burning fossil fuels, and splitting atoms have all been used to ultimately turn a generator and provide a _____ to the various appliances we use in our everyday life. The need for consistent reliable _____ force to move _____ across the ever growing consumer _____ has given rise to a global, multi-billion dollar power generation industry.

**2.** Most electronic devices that have rechargeable batteries use a combination of smaller _____ connected in _____ to provide just the right voltage required for each device. The manufacturers must balance how long a device will last on a single charge with how much space and weight the _____ can have when deciding how many cells they can connect in _____.

**3.** The electric _____ between the terminals of a battery causes charge to flow in a conductor when it is connected to the _____. If one of the terminals is connected to the Earth, it is said to be grounded. A large potential _____ can cause charge to flow through things that are not very _____, like a dramatic lightning discharge in air.

## Key Term Challenge Word Bank

| Paragraph 1 | Paragraph 2 | Paragraph 3 |
|---|---|---|
| charge | battery | conductive |
| current | cells | battery |
| electromotive | generator | difference |
| generators | parallel | potential |
| gravitational | series | sum |
| load | voltage | terminals |
| voltage | | |