EXPLORATIONS

Activity 2

Energy from Foods — Part I

In this activity you will
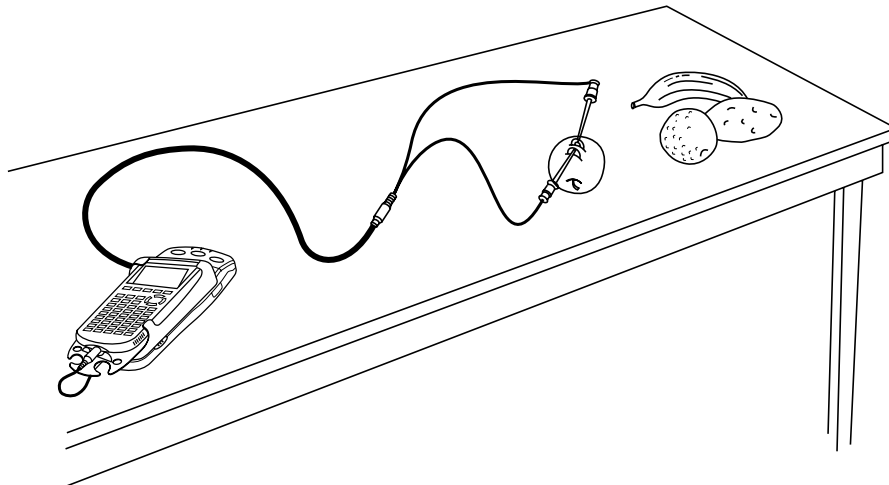
♦ Use fruits and vegetables to make an electrochemical cell.

♦ Use the CBL 2™ with the voltage sensor to measure the electrical energy produced by each food.

Problem

Which fruit or vegetable will make the wet cell with the highest voltage?

Introduction

Fruits and vegetables can be used to make an electrochemical cell. If you insert copper and zinc strips into slits in the food, the metals act as electrodes and are connected by wire when the leads are attached. When connected, the electrons flow through the juice. The fruit/vegetable juice acts as the electrolyte. Voltage is produced as chemical energy is converted into electrical energy. The CBL 2 with the voltage sensor can be used to measure this electrical energy in volts.

Hypothesis

Before testing, complete the table on the **Data Collection and Analysis** page to predict which fruits or vegetables will generate the highest voltage. Also, answer the questions in the **Experimental Design** section to help you understand the lab procedure for this activity.

Procedure: Collecting the Data

1. Collect four to six different fruits and/or vegetables.

2. Make two slits, one centimeter apart, in the fruit/vegetable. Insert a zinc strip in one slit and a copper strip into the other slit.

3. Plug the voltage sensor into Channel 1 (**CH 1**) on the CBL 2™.

4. Start the DATAMATE program.

5. The Main Screen is displayed.

6. Select **1:SETUP**.

7. Select **MODE** by pressing ▾ ▾ ▾ ▾ to highlight **MODE** and pressing ENTER. Then select **3:EVENTS WITH ENTRY**.

8. Select **1:OK** to return to the Main Screen.

9. Attach the positive lead to the copper strip and the negative lead to the zinc strip.

10. When you are ready to begin, select **2:START**. The screen displays **PRESS ENTER TO COLLECT OR STO TO STOP**.

11. When the voltage reading is steady, press ENTER.

12. The program asks you to enter a value. This value is the number of your sample fruit/vegetable, NOT the voltage reading. Type the number for this sample (for example, if this is your first sample, type **1**) and press ENTER. Record the sample name beside the number in the table on the **Data Collection and Analysis** page. The program returns to the data collection screen, ready for your next fruit/vegetable.

13. Repeat steps 10 through 12 for each sample, using the number for the sample when the program asks for a value after your have the voltage. After you enter the first sample number, the last number you used is displayed at the bottom of the screen.

14. After you have collected the voltage reading for your last sample, press STO▶. A scatter plot is displayed showing the voltage reading for all of the samples. Use ▶ and ◀ to move to each data point and record the values in the table on the **Data Collection and Analysis** page.

15. To exit from the DATAMATE program, press ENTER to return to the Main Screen. Select **6:QUIT** and press ENTER.

16. To display the lists showing the results, press LIST. The sample numbers are stored in **L1**. The voltage readings are stored in **L2**.

17. To change the sample numbers in **L1** to the names of the liquids:

   a. Highlight the first element in the list.

   b. Press 2nd [TEXT]. Press the arrow keys to move to the letters in the name, pressing ENTER after each one. The first name must be enclosed in quotation marks, and names can be no more than five letters long.

   c. When the name is finished, move to **Done** and press ENTER.

   d. Press ENTER again to paste the name in the list.

   e. When you finish working with the lists, press 2nd [QUIT] to return to the home screen.

Procedure: Graphing the Data

Review the pH values on two different graphs — a bar graph and a circle graph. Record the graphs on the **Data Collection and Analysis** page.

Bar Graph

Create a bar graph to display voltage data for each fruit. The bar graph has a limit of seven bars.

1. Press 2nd [PLOT] **4:PlotsOff** ENTER to turn off all stat plots.

2. Press 2nd [PLOT] ENTER to select **Plot1**.

3. Press ENTER to select **On** (to turn on **Plot1**).

4. Select ⅃⅃ℼₘ (the bar graph) for **Type**.

5. Plot **L1** (fruit/vegetable numbers) as the categorical list and **L2** as data list 1 (voltage readings).

6. Press ZOOM **7:ZoomStat** to automatically set the window for the data and display the graph.

7. Press TRACE to display the fruit/vegetable numbers with their voltage readings.

Circle Graph

1. To make a circle graph displaying the number or percent of all tested beverages as being acids, neutral, or bases, you must first enter the lists.

    a. Press ⌊LIST⌋ to display the List Editor; then press ◄ to move to the first unnamed list. Using ⌊2nd⌋ [TEXT], name the list **PH**.

    b. Using ▼ ⌊2nd⌋ [TEXT], enter the categories **ACID, BASE, NEUTR** (limit of 5 text spaces). Put the first element of the list in quotes.

    c. Press ► ▲ to move to the header of the next unnamed list. Name this list **FREQ** for the frequency of the type of beverages.

    d. Press ▼. Enter the number of beverages beside each category.

2. Plot the categorical list **PH** and the numerical list of beverage frequencies **FREQ** as a circle graph.
    To set up the plot:

    a. Press ⌊2nd⌋ [PLOT] **4:PlotsOff** ⌊ENTER⌋ to turn off all stat plots.

    b. Press ⌊2nd⌋ [PLOT] ⌊ENTER⌋ to select **Plot1**.

    c. Press ⌊ENTER⌋ to select **On** (to turn on **Plot1**).

    d. Select ✪ (the circle graph or pie chart) as the **Type**.

    e. Press ▼ ⌊2nd⌋ [STAT] to specify the categorical list. Press ▼ to select **PH** and press ⌊ENTER⌋.

    f. Press ⌊2nd⌋ [STAT] to specify the data list. Press ▼ to select **FREQ** and press ⌊ENTER⌋.

    g. Press ► ⌊ENTER⌋ to select **Percent**.

    h. Press ⌊ZOOM⌋ **7:ZoomStat** to display the graph.

Data Analysis

Using the data you collected and the bar graph, answer the questions on the **Data Collection and Analysis** page to analyze your results.

Extension

Think of another question you can investigate with the fruits/vegetables and your CBL 2™/voltage sensor. Design an experiment where you change one variable. Keep everything else constant. Test your hypothesis.

Data Collection and Analysis

Name _____

Date _____

Activity 2: Energy from Foods — Part I

Problem

Which fruit/vegetable will make the wet cell with the highest voltage?

Hypothesis

Before testing, complete the table below to rank the fruits and/or vegetables in order by voltage (1 = highest voltage).

Food Name	**Predicted Rank** (Highest Voltage to Lowest)

If a _____ is used to make a wet cell, then it will generate a higher

voltage than _____ .

Experimental Design

1. Independent Variable: We are changing _____ .

2. Dependent Variable: This variable might change as a result. We are measuring _____ in _____ (units).

3. Constants: Which variables stay the same each trial?

   _____

   _____

4. Number of Trials: _____

5.   Sketch the CBL 2™ lab setup for making a wet cell and label it.


6.   The red lead is _____; the black lead is _____ .

7.   The positive lead (+) is hooked to the _____ .

8.   The negative lead (-) is hooked to the _____ .

9.   The voltage is measured in _____ by the _____ .

Data Collection

1.   After you test the fruits/vegetables, use the displayed scatter plot to fill in the voltages on the table below. Then rank the foods in order by voltage (1 = highest).

Sample Number	Food Name	Voltage (Volts)	Actual Rank (Highest Voltage to Lowest)
1			
2			
3			
4			
5			
6			

2. Display the voltage data for each fruit/vegetable in a bar graph. Sketch the bar graph and label it with food types and voltages or print it on the computer and attach it to this page.
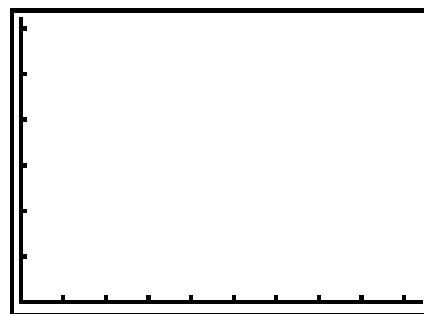
Data Analysis

Use your data and graph to answer the following questions.

1. The zinc and copper act as _____;

    the _____ acts as the electrolyte through which the

    _____ flow.

2. Compare the actual voltage rankings to your predictions. Discuss any surprises or differences you find.

    _____

    _____

3. Which food produced the highest voltage? _____

    Lowest? _____

4. What is the range in the voltage readings? _____

5. What is the median voltage value?

    _____

    _____

6. Using the median value, about how many wet cells made from fruits/vegetables would you have to link in order to produce the voltage of a 9-volt battery?

    _____

7. Give reasons why some foods make better wet cells than others. Do research to find out more information.

    _____

    _____

Conclusion

If a _____ is used to make a wet cell, it will have a

higher voltage reading than using _____ because it

_____ .

Teacher Notes

Activity 2

Energy from Foods — Part I

Preparation

♦ Students can bring in fruits and vegetables to test. Plan to have a variety of four to six food items at each lab station.

♦ Provide small plastic knives and measuring tapes for cutting the slits.

♦ Copper and zinc 2" strips can be cut from sheet metal by the shop teacher in your school. In a pinch, pre-1982 pennies (except steel) can be used for copper and zinc washers can be used for zinc strips.

♦ Alligator clips may be used to save wear on the voltage sensor leads that can break off if handled roughly.

♦ Paper towels are a must to keep the juice from the fruits away from the CBL 2™ equipment.

Management

♦ Ask students to sketch the lab setup before starting the lab and label the sketch with key terms. Students learn vocabulary in context and will be less confused by the procedure.

♦ Explain that the fruits and vegetables will create one wet cell as opposed to a battery that is made from a series of cells. An example of a dry cell is a AAA; a 9-volt is a true battery as it contains six 1.5 volt cells. All 1.5 volt dry cells have the same voltage, regardless of size.

♦ Assign these student jobs for this lab:

  – Materials/setup person (sets up samples, sensor)

  – Tech person (operates CBL 2 and TI-73)

  – Data recorder (reads voltage readings from the TI-73 at each collection interval)

    – Runner (brings CBL 2™ and TI-73 to the computer to print out graphs with TI-GRAPH LINK™ or TI™ Connect and brings **Data Collection and Analysis** pages to the teacher)

♦ Clear covered plastic shoeboxes will hold the CBL 2, voltage sensor, electrodes, and other equipment neatly at each station.

♦ Students can record voltage readings in their lab journals as they are displayed on the TI-73. This keeps them engaged throughout the data collection period and if they lose or overwrite their data/graph later, they can still write up their lab report. Students can also access the data in the TI-73 lists after data collection. You can send the lists to all students' calculators using APPS **1:Link**.

    a. Press APPS.

    b. Press ENTER to select **1:Link**.

    c. Select **4:List** and press ENTER.

    d. Press ▾ to move the ▸ beside the list you wish to send. Press ENTER.

    e. Repeat step **d** for each list you wish to send.

    f. Set the receiving unit by pressing APPS ENTER ▸ to select **RECEIVE**. Press ENTER. **Waiting…** displays on the TI-73 screen.

    g. On the sending unit, press ▸ to select **TRANSMIT** and press ENTER.

    For more permanent storage of data, use TI-GRAPH LINK or TI Connect to save the lists in a computer folder.

♦ Students can assess each other using a teamwork rubric after the lab. Provide a checklist of positive and negative lab behaviors. Copy these on quarter sheets of paper.

Data Analysis

♦ Students can print their graphs on the computer using TI-GRAPH LINK or TI Connect software and cable. They can also paste the graph into a word processing program. Students can then write their lab report/conclusion with the graph.

♦ In a one-computer classroom, a student from each lab station can use TI-GRAPH LINK or TI Connect to print copies of the graphs for each team member. Students then can incorporate these graphs in their lab reports.

♦ Middle school students are often learning initial graphing skills. Skills such as determining the scale for the axes and determining the quartiles are difficult for many. Plotting the data by hand is always an option in each lab and space has been provided for this on the **Data Collection and Analysis** page.

♦ Use **MODE** to round voltage data to the nearest thousandth. Increased resistance should cause voltage to decrease with distance but the difference is only in hundredths of a volt. Discuss sources of experimental error if there is a positive or no correlation.

♦ Since each group is getting only one value for each beverage, average all of their results and have the students record the results on the **Data Collection and Analysis** page.

Selected Answers

Experimental Design

1. Independent Variable: We are changing *type of fruit or vegetable*.

2. Dependent Variable: This variable might change as a result. We are measuring *voltage* in *volts* (units).

3. Constants: Which variables stay the same each trial?

   Electrodes (zinc/copper), distance between electrodes, CBL 2/sensor

4. Number of Trials: *Will vary*

6. The red lead is *positive*; the black lead is *negative*.

7. The positive lead (+) is hooked to the *copper*.

8. The negative lead (-) is hooked to the *zinc*.

9. The voltage is measured in *volts* by the *CBL 2*.

Data Analysis

1. The zinc and copper act as *electrodes*; the *juice* acts as the electrolyte through which the *electrons* flow.

2. Compare the actual voltage rankings to your predictions. Discuss any surprises or differences you find.

   Answers will vary.

3. through **5**.

   Answers will vary - students use experimental data

6. Using the median value, about how many wet cells made from fruits/vegetables would you have to link in order to produce the voltage of a 9-volt battery?

   Answers will vary, but should be about 9. Each wet cell produces close to 1 volt.

7. Give reasons why some foods make better wet cells than others. Do research to find out more information.

   More juice, acidity, age of fruit.

Conclusion

Answers will vary based on food item.