UW-MADISON EXTENSION

Mechanical Sciences

ELECTRICITY

Activity Plan – Fruit Batteries ACTpa110

Project Skills:
- Create a battery from fruit, learn the process of scientific inquiry, about connecting batteries in series, and develop familiarity with basic electrochemistry

Life Skills:
- Develop critical thinking skills
- Gain familiarity with the scientific method
- Develop data tabulation skills
- Learn collaboration and teamwork

Academic Standards:
- Science C. 4.2. Use the science content being learned to ask questions, plan investigations, make observations, make predictions, test predictions, and offer explanations

Grade Levels: 5th-8th

Time: 60 minutes

Number of Youth: 10-20
- This activity has been designed for 10 workstations. You can have one or two youth at each workstation.

Supplies Needed:
For 10 workstations:
- 4 apples, 3 bananas, 3 oranges
- 10 small bags (plastic sandwich bags or lunch bags) to put the electrodes in
- 10 strips each of copper, aluminum and zinc. Available at hardware stores. You can cut aluminum cans (remove the paint using steel wool) or cake tin (aluminum foil is not stiff enough to push into the fruit), zinc

BACKGROUND

Like charges repel and opposite charges attract. Therefore, electrons repel other electrons but are attracted to protons. Atoms can be thought of as positively charged cores (nuclei) with the negatively charged electrons distributed around the nuclei. Metals are good conductors of charge; this means that some of their electrons are free to move from one atom to another within the metal. A current is moving charge. Non-conductors (wood, plastic, etc.) have strongly bound electrons and so do not conduct electricity. Metals are not all equally good conductors and not all have the same potential when used in electrochemical cells. Some metals have greater reduction potential than others (they lose their outer or "valence" electrons more easily than others). The more easily these electrons are given up, the greater the "reduction potential" or the more reactive the metal.

When two metals of different reduction potentials are placed in a conducting medium, referred to as an 'electrolyte' (the acid of the fruit in this case), one metal (the one with the greater reduction potential) will be an "electron donor" and the other (the metal with a lower reduction potential) will be an "electron acceptor" resulting in the flow of charge. A battery (or more correctly an electrochemical cell) can be made when the electrons are made to travel through an external circuit (from one metal to the other via connecting wires instead of directly through the cell medium). The electrons traveling from one metal to the other can be made to do work. The work (lighting a bulb, driving a fan) that each unit of charge flowing can do, is measured by the Volt. The higher the voltage the more work can be done per unit flow of charge. A large energy (potential) gap between the "giver" and "taker" will result in a high voltage between the electrodes.

When inserted into the fruit, it takes time for the reading to stabilize. Please note that when a stable reading has been reached, the reading will begin to drop after some time. Like any battery, this battery has a limited life. There are chemical reactions occurring at the electrodes that prevent the flow of current. Usually, hydrogen is produced at the copper electrode and oxides are deposited on the surface of the zinc electrode that insulates the electrode from the electrolyte.

Details of the processes involved can be found in any chemistry textbook in the chapter on electrochemistry.

WHAT TO DO

Pair youth up. Ask them to choose a fruit and take the handout that accompanies it. They will then sit at a workstation that corresponds to the fruit that they have chosen. Ask the youth where they use batteries, and thus have them identify that batteries "do stuff like run a toy." Ask them to pick up the Duracell battery and read what's written on it. Tell them that "1.5 V" (or whatever the voltage happens to be) is a measure of 'how much stuff (work) it can do; so the higher the voltage rating, the more work it can do.

Ask them to measure the voltage of the Duracell battery using the voltmeter setting of the multimeter. *Briefly* discuss units. Tell them that the multimeter will measure how much work their fruit battery can do. Ask them not to change the settings on the mulitmeter. Show them how to poke the electrodes into the fruit and to attach the multimeter leads to them. Orange skin can be quite hard to pierce, so a pen knife or a kitchen knife can be used here. After they embed electrodes in the fruit, and measure it voltage using the multimeter. They will notice that the reading keeps changing. Have them observe reading for a short while and report back. Youth will

galvanized nails and copper wiring that has the plastic stripped off it. Make sure that the metal is shiny and has no deposits on it. Polish with steel wool (or sand paper) if necessary. Remember that some copper wire comes with an invisible non-conducting coat that would need to be stripped off before use. Label each with a sharpie pen for ease of identification

- 10 digital multimeters set to measure up to 2 V. Leads must have alligator clips for ease of connection. Cheap multimeters are available at Science surplus stores, online, and at hardware stores
- 6 red LEDs (Light Emitting Diodes) rated at 3 V. Cheap LEDs are available at Science surplus stores and online
- Some leads with alligator clips
- 10 AA batteries
- 10 sharpie pens
- 10 rulers
- 10 pen knives or butter knives
- Paper towels
- 10 handouts, one for each station (3 for each fruit and one for the reliability station)
- Flip chart

Optional:

- Icon to indicate type of workstation (apple, banana etc.)

Do Ahead:

- It is strongly recommended that you do the entire activity yourself before hand. You will gain familiarity with the dynamics of the experiment, the instruments and most importantly, with what can (and will) go wrong!
- Prepare the handouts, one for each pair of students. Place the electrode pairs in a bag, label them and staple them to the appropriate handouts. Each handout

come to a consensus that the readings tend to fall off after a time. Ask youth if it is a fair comparison if not all the readings are taken at the same time. Get them to yell the numbers 1-5 in unison for standardization of timing. Ask them to follow the instructions on their handout and to write down their results on the sheet and on the board.

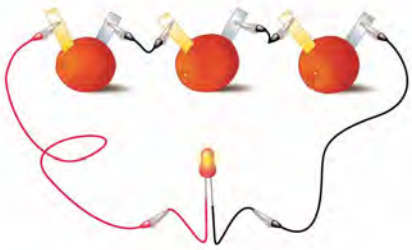
Once all the data is entered on the board, praise them for their collaboration. Point out that they collected a lot of data in a very short time with very little effort on each person's part. Ask "What does this tell us?" "Can you think of some questions that this data is able to answer?" {The data addresses the questions: "Does an apple make a better battery than a banana?" and "Does it matter which metals are used for the electrodes?"}Write all questions and answers generated on a flip chart.

Remember to point out the importance of the 'quality control' data. We must be certain that the data we have can be replicated. During an experiment, every reading is always repeated at least 3 times, and the average of the three entered as data.

While facilitating the youth to draw a conclusion from the data, it might help to draw the following table on the board:

	Average Voltage in Volts		
Fruit	Copper & Zinc	Copper & Aluminum	Zinc & Aluminum
Apple			
Banana			
Orange			

Ask two volunteers to come forward with their batteries and try to light a red 3 V LED with it. When nothing happens, guide them towards the idea of connecting their batteries in series. Have them connect their batteries and have them arrive at the correct way of connecting batteries in series (positive to negative) and connecting to an LED. LEDs are directional and will not light up if connected the wrong way. Most LEDs have different colored leads to indicate this. It takes three orange batteries to light up the LED reasonably well. Four are not recommended as they might exceed the 3 V tolerance limit for the LED. While the voltage produced is independent of the fruit, the current generated is not. Orange batteries have the highest current and so light the LED.



Connecting the batteries in series to a LED

TALK IT OVER

Reflect:

- How does fruit compare with conventional batteries as an energy source?
- What did we learn about connecting batteries together (in series)?
- What can we say about the essential components of a battery?
- What makes a test 'fair' or 'unfair'?
- What are the advantages of collaboration and teamwork?

Apply:

- What do we need to keep in mind when testing out a statement? How many things can we vary at a time?
- Why is it a good idea to do conduct a test more than once?
- Why is it a good idea to change only one thing at a time? (In other words, ask only one question at a time?)

Web Resource:

- Fun Science Gallery http://www.funsci.com/fun3_en/electro/electro.htm

Sources:

- Created by Maria Habib, 4-H Youth Development Agent, University of Wisconsin Division of Extension, Waukesha County

ENHANCE:

"What more fun can we have with this?"
Generate questions from the group. Go back to the chart, if necessary, to generate more questions. "Are two electrodes absolutely essential?" "Can we use the same metal for both electrodes?" "Can we have more than one fruit to comprise one battery (a lead between the fruit can serve as a link to complete the circuit)?" "Do we need a closed circuit?" "What about the depth to which the electrode is embedded in the fruit?" "What kinds of things can my fruit battery run" (Very few: a clock or thermometer with an LCD display etc.) "Would using pieces of fruit make any difference to the voltage?" "Does the difference in the fruit effect how much current is generated?" (For this last investigation, set the multimeter to read microamperes; it will be indicated on the dial by the symbol "μA.")

Working hypothesis behind these questions: a battery consists of two metallic conductors in a partially conducting medium separated by a short distance.

Have youth brainstorm experimental arrangement and conduct each experiment. Each question generated would need a separate 'test' to be able to draw a useful conclusion. If two items (or processes) are exactly similar in all respects except for one, then it is reasonable to say that any difference in properties arises due to that one difference.
Emphasize the criteria for a 'fair test.'

SIMPLIFY:

Instead of three separate types of fruit, have just one. Any fruit or vegetable will do (except cabbage!).

Instead of having three metal electrodes, create your battery out of just one pair. This will eliminate the need for the table for data entry.

Reviewed by Wisconsin 4-H Learning Resources Team: April 2009

APPENDIX A

Vocabulary:

You may find it helpful to have these vocabulary words in handy in either a handout or written on a flip-chart. It will be more helpful to talk about these ideas as they come up in the activity instead of discussing all of them before you start. You lose the attention of youth if you talk for longer than 5-6 minutes before doing anything. At the end, you can go over these ideas again as a review.

Electrode: Electrical conductor (in this case the metal strip) that serves as a contact between the conducting and non-conducting or partially conducting parts of the system (in this case the partially conducting part is the fruit).

Volt: Systeme Internationale (S.I.) unit of electric potential. Best definition for our purposes here is: measure of the work a battery can do for each unit of charge that it moves through the system.

Charge: Fundamental property of sub-atomic particles (electrons, protons etc.), displayed in their electromagnetic interactions. Electrons are negatively charged and protons are positive. It is important to realize that 'positive' and 'negative' are just *names* to distinguish opposite manifestations of the same property. "Positive" and "negative" (instead of Ben and Jerry!) were chosen for mathematical convenience: to aid the calculation of 'how much charge'. Another important thing to realize is that scientists have not yet answered the philosophical question "What *is* charge?" Neither do we know where it arises from. We can only define charge in terms of its observed interactions with other charged and uncharged particles.

Current: Moving charges constitute a current. It takes energy (work) to move charges. Batteries are storehouses of energy that can move charge around a circuit. It is important to realize that neither batteries nor the electric company are "sources of electrons, whose flow constitutes current." Batteries (and the electric company) are sources of *energy* that move the charged particles already existing in a circuit around.

Circuit: Closed path necessary for the flow of current. Current cannot jump a gap. Switches are essentially gaps that can be closed or opened, thus blocking or enabling the flow of current.

Digital Multimeter: Instrument used to measure electrical potential, current and resistance. More expensive versions also measure temperature difference and transistor ratings.

Multimeter

The Apple Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Copper and Zinc

What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the copper electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the zinc electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 1. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to zinc and the black one to copper and take your next reading just as you did your first one. Please write your reading in line 2 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Apple Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Aluminum and Zinc

What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the zinc electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the aluminum electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 5. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to aluminum and the black one to zinc and take your next reading just as you did your first one. Please write your reading in line 6 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Apple Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Aluminum and Copper

What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the aluminum electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the copper electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 3. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to copper and the black one to aluminum and take your next reading just as you did your first one. Please write your reading in line 4 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Banana Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Copper and Zinc

What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the copper electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the zinc electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 9. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to zinc and the black one to copper and take your next reading just as you did your first one. Please write your reading in line 10 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Banana Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Aluminum and Zinc

What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the zinc electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the aluminum electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 13. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to aluminum and the black one to zinc and take your next reading just as you did your first one. Please write your reading in line 14 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Banana Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Aluminum and Copper

What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the aluminum electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the copper electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 11. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to copper and the black one to aluminum and take your next reading just as you did your first one. Please write your reading in line 12 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Orange Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Copper and Zinc

What to do:

1. Roll your orange firmly on the table top to break up some of the small sacks of juice within.

2. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

3. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

4. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).
- Poke the electrodes in the fruit one below the other. That way you ensure that they are both inside a single section of the orange.

5. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the copper electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

6. Connect the black lead to the zinc electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 15. Please also write down whether the voltage was positive (+) or negative (-).

7. Now connect the red lead to zinc and the black one to copper and take your next reading just as you did your first one. Please write your reading in line 16 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Orange Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Aluminum and Zinc

What to do:

1. Roll your orange firmly on the table top to break up some of the small sacks of juice within.

2. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

3. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

4. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).
- Poke the electrodes in the fruit one below the other. That way you ensure that they are both inside a single section of the orange.

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the zinc electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the aluminum electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 19. Please also write down whether the voltage was positive (+) or negative (-).

7. Now connect the red lead to aluminum and the black one to zinc and take your next reading just as you did your first one. Please write your reading in line 20 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Orange Handout

Names of Young Scientists working on this project:

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Metal Electrodes given to you: Aluminum and Copper

What to do:

1. Roll your orange firmly on the table top to break up some of the small sacks of juice within.

2. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

3. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

4. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).
- Poke the electrodes in the fruit one below the other. That way you ensure that they are both inside a single section of the orange.

5. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the aluminum electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

6. Connect the black lead to the copper electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 17. Please also write down whether the voltage was positive (+) or negative (-).

7. Now connect the red lead to copper and the black one to aluminum and take your next reading just as you did your first one. Please write your reading in line 18 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

The Quality Control Apple Handout

You have picked a very special task!

Names of Young Scientists working on this project:

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Metal Electrodes given to you:
Copper and Zinc

You will be doing the same thing as another pair of scientists. You are making sure that everyone is doing a good job and that work can be repeated and is not just a fluke!
What to do:

1. Remove your electrodes from the bag. With your ruler and the sharpie pen, mark off half an inch from one end of each of your electrodes.

2. Carefully poke one of the metal strips into the fruit. If you find this difficult, you may want to poke a hole in the fruit with a knife first. Push it in as far as the mark you made with your sharpie.

3. Now poke the other electrode in about half an inch from the first. Use your ruler!

Make sure that:

- the metal strips do not touch each other either inside or outside the fruit
- you wipe the surface of the fruit and the electrode dry with a paper towel (a wet surface can mess things up).

4. Turn on the digital multimeters (please do not push any of the buttons or turn any dials!) and connect the red lead to the copper electrode. At this time, you might see numbers changing rapidly on the screen of your multimeter. Wait until the screen shows zero.

5. Connect the black lead to the zinc electrode. As soon as you make the second connection, start counting to five. At the count of five, write down on the chart on the next page, the number that appears on the screen. This is the voltage of your battery in Volts. This is your 'reading.' You will use line 7. Please also write down whether the voltage was positive (+) or negative (-).

6. Now connect the red lead to zinc and the black one to copper and take your next reading just as you did your first one. Please write your reading in line 8 of the chart.

When your reading is positive, please mark the electrode that the red lead is connected to with a large positive sign.

When you are done, please enter your readings into the chart on the front of the room.

	Fruit	Red lead Connected to	Black Lead Connected to	Voltage in V
1		Copper	Zinc	
2		Zinc	Copper	
3		Aluminum	Copper	
4		Copper	Aluminum	
5		Zinc	Aluminum	
6		Aluminum	Zinc	
7		Copper	Zinc	
8		Zinc	Copper	
9		Copper	Zinc	
10		Zinc	Copper	
11		Aluminum	Copper	
12		Copper	Aluminum	
13		Zinc	Aluminum	
14		Aluminum	Zinc	
15		Copper	Zinc	
16		Zinc	Copper	
17		Aluminum	Copper	
18		Copper	Aluminum	
19		Zinc	Aluminum	
20		Aluminum	Zinc	

Quality control Data