Chemistry in the Library:

Fun with Electronics

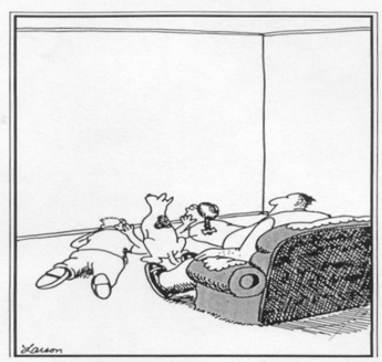
Website: http://mdchem.org/citl/CitL_main.html
e-mail: chemists4fun@yahoo.com

Electronics are here, there, and everywhere – from TVs to radios to cars to toys … But we don't often understand how they work or sometimes even how to use them. Today we are going to walk through a series of experiments using common electronic gadgets and examine how they work and what they do that we might enjoy or make our life easier somehow. We will examine how a motion detector works, make and test a simple amplifier, and make and test a simple microphone.

Think about the following:

BEFORE
Turn-of-the-Century
(1900)

- Life expectancy – 47
- No medicine as we know it
- 1885 - Karl Benz designed and built the world's first internal-combustion engine automobile
- Late-1700s to 1800 – usage of hot air balloon travel, gliders
- 1870s – invention of practical DC (Direct Current) generator & incandescent filament lamp (electricity as we know it (almost))
- 1876 - Alexander Graham Bell invented the telephone



In the days before television

By the
Turn-of-the-Century
(2000)

- Life expectancy – 80
- Penicillin – 1940s
- 1903 - Orville and Wilbur Wright and the First Flight
- 1926 - world's first public demonstration of a mechanical television apparatus
- 1931 – invention of nylon
- Computers:
  - 1946 - First generation electronic computer: Electronic Numerical Integrator and Calculator (ENIAC)
  - 1975 – Microsoft is founded

Safety Rules

- **Wear safety goggles.** This means from when you're told to put them on until you're told they can come off.
- **Detect odors safely.** Use you hand to wave fumes to your nose. Never stick your nose directly into anything.
- **Wash spills immediately.**
- **No running, pushing, or shoving.**
- **Clean up your mess!**
- **Get help.** If you have any questions, please ask before proceeding.
- **No eating or drinking.**
- **No unauthorized experiments.** Only do the things the leader tells you to.

The experiments in this session/handout were largely adapted from the Materials World Module kit on Smart Sensors (www.materialsworldmodules.org).

Experiment #1: Motion Detectors

While there are several types of motion detectors, they all do the same thing: detect movement of an object through a room of otherwise stationary objects. Let's think about what types of detectors might be around our home and how they work:

1. True motion detectors – lights, bells, toys, etc
2. Heat sensors – some cups, shirts, etc
3. Pressure sensors – shoes, toys, etc

Materials:

Pencil	Paper	Motion Detector (can be purchased at Radio Shack)

Procedure:

1. Place motion detector on something in an area where movement is available over a wide space
2. Someone walk in front of it to determine what the indication is that it is working – is it a bell?
3. Try different methods to try to 'fool' the detector while still walking in front of it – what is the sensor sensing? Movement? Heat? Light changes? Write your observations down:

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4. What is the range of the sensor? Does it only work 3 feet in front of the sensor? Does it work 10 feet or more in front of the sensor? Write your observations down:

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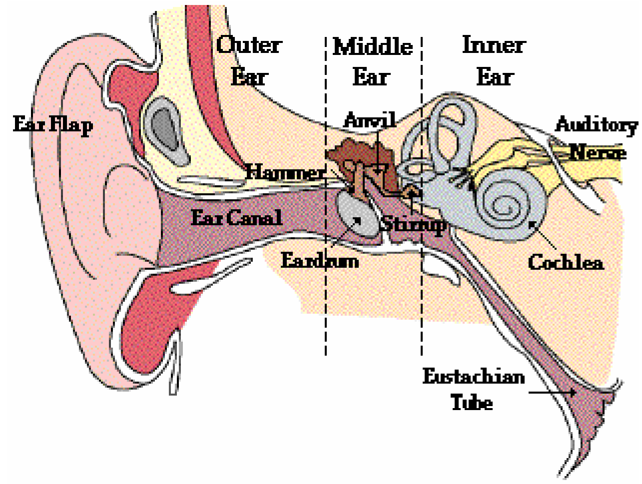
Questions:

1. What uses can you think of for this type of motion detector?
2. What is the sensitivity of the motion detector?
3. What are some advantages/disadvantages of using a motion detector?

Experiment #2: Amplifying Sound

The human ear (and those of many animals) is a natural sensor. The ear flap helps direct sound waves into the ear canal. When these sound waves hit the eardrum they cause vibrations, which are then transferred to the middle ear. There are three tiny bones in the middle ear (the hammer, anvil, and stirrup) that transfer the vibrations of the eardrum to the inner ear. The Cochlea, in the inner ear, converts these physical vibrations into electrical impulses, which are then transferred by the auditory nerve to our brain. Our brain processes the impulses, interprets the sound, and stimulates our body to respond to the sound.



You may have studied sound waves in a class and can distinguish between short sounds or pulses, such as a dog lapping at a water bowl or the tapping of a pencil on a table, and long sounds, such as a fire alarm. These are different patterns of sound waves. One feature of sound waves is frequency – or the number of back and forth motions in a specific period of time – think about the slow tapping of a pencil versus the quick tapping of a pencil on a desktop – these are different frequencies. Different frequencies of sound produce different impact on your eardrum and therefore similar actions can cause you to act very differently (think about how your mother or father responds when quietly close the door as opposed to slamming it shut).

In this experiment, we will make a simple amplifier and examine the difference between different amplifying materials.

Materials:

1-clear, plastic cup	2-balloons	Scissors
Rubber band	1-amplifier (can be obtained from Radio Shack)	Connecting leads with alligator clips
Double-sided sticky tape	1 piece of flexible PVDF (polyvinylidene floride)	1 piece of rigid PVDF

Procedure:

1. Using just the **soft PVDF** connected to the amplifier, flick the film with your finger and observe the response. See if changing the way you flick or touch the film changes the response. Write down your observations:

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2. Scratch the film and observe the response. See how changing the way you scratch the film changes the response. Write down your observations:

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3. Blow on the film and observe the response. See how changing the way you blow on the film (hard versus softly) changes the response. Write down your observations:

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4. Talk to the film and observe the response. See how close you have to get to the film to observe a response. Write down your observations:

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5. Using just the **rigid PVDF** connected to the amplifier, flick the film with your finger and observe the response. See if changing the way you flick or touch the film changes the response. Write down your observations:

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6. Scratch the film and observe the response. See how changing the way you scratch the film changes the response. Write down your observations:

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7. Blow on the film and observe the response. See how changing the way you blow on the film (hard versus softly) changes the response. Write down your observations:

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8. Talk to the film and observe the response. See how close you have to get to the film to observe a response. Write down your observations:

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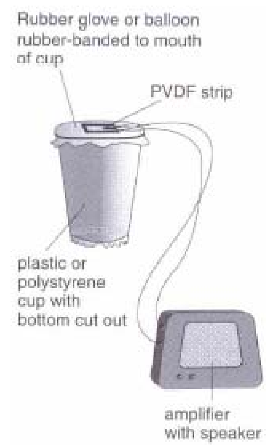
Experiment #3: Making a Microphone



Cup Microphone - Make a microphone using the Diagram and soft PVDF

Directions:

- Cut off the bottom of the cup
- Cut off the end of a balloon and stretch it across the mouth of the cup – secure it with a rubber band
- Attach the PVDF film with double-sided sticky tape (make sure the film is flat against the balloon)

1. Using just the **soft PVDF** connected to the microphone, flick the film with your finger and observe the response. See if changing the way you flick or touch the film changes the response. Write down your observations:

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2. Scratch the film and observe the response. See how changing the way you scratch the film changes the response. Write down your observations:

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3. Blow on the film and observe the response. See how changing the way you blow on the film (hard versus softly) changes the response. Write down your observations:

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4. Talk to the film and observe the response. See how close you have to get to the film to observe a response. Write down your observations:

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5. Using just the **rigid PVDF** connected to the microphone, flick the film with your finger and observe the response. See if changing the way you flick or touch the film changes the response. Write down your observations:

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7. Blow on the film and observe the response. See how changing the way you blow on the film (hard versus softly) changes the response. Write down your observations:

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8. Talk to the film and observe the response. See how close you have to get to the film to observe a response. Write down your observations:

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Questions:

- Which film responded better to various actions (scratching, blowing, etc) the flexible film or the rigid film?
- Did the films respond better to direct contact (scratching, flicking) or indirect contact (blowing, talking)?

Experiments To Do at Home with a friend and/or a parent:

- When working at Home: ALWAYS remember the safety rules!!
- When working at Home: ALWAYS ask a parent before you start any experiment!!
- When working at Home: ALWAYS remember to work on a surface that is easily cleaned – never work directly on a table. Working on a wax paper or plastic surface will minimize any problems with cleaning up afterwards!

Experiment (To Do at Home!): Food Batteries

Overview:
Create a battery from common foodstuffs, sufficient to light a small lightbulb or LED display.

Materials:

One large potato or lemon	
Zinc electrode - a 3cm x 0.5cm piece of zinc metal will suffice. You can inquire at a local hardware store.	Copper electrode - Similarly sized piece of copper metal
Copper wire - Sufficient length of wire to create a circuit from the zinc electrode to a lightbulb (or other device) and copper electrode.	Small lightbulb - flashlight or penlight bulbs work best. You can experiment with other devices such as LED displays, or time pieces.

Safety:
If no copper electrode is used, hydrogen gas is given off as a by-product of the reactions taking place.
Be wary of performing the experiment near heat sources or an open flame.

Though the voltages and amperages given off are low, care should be taken in handling the wire and other parts of the circuit.

Procedure:

- Stick your zinc electrode all the way into the potato or lemon.
- Place the copper electrode on the opposite side.
- Connect the small lightbulb to the two electrodes with copper wire.
- Observe what happens!

How to Measure Electricity in produce:

The way to measure electricity in anything is with a multimeter, but typically in fruits & veggies this may result in no results.

The reason for this is that there ***is no electricity*** in any fruit or vegetable (in the sense that they are like little batteries). Perhaps you are confused by the fact that you can use the chemical properties of certain fruits and vegetables to generate electricity.

A lemon, for example, can be made to power a small electrical device because the lemon is quite acidic (for a food). The way you do this is to stick a piece of zinc metal and a piece of copper metal (a zinc electrode and a copper electrode) into the lemon. You can then draw electrical power from the lemon through an external circuit and do work. (I am told that a lemon cell is about equivalent to a single calculator battery.)

Here's the chemistry behind the lemon cell: zinc is an active metal and will react readily with acid; acid's active ingredient is positively-charged hydrogen. So a transfer of electrons takes place between the zinc and the acid; the zinc (Zn^0) is oxidized to Zn^{++} and the acid (H^+) is reduced to hydrogen gas (H^{-1}), which you can see bubbling out around the electrodes.

Oxidation: $Zn \rightarrow Zn^{++} + 2e^-$ (Zinc looses 2 electrons.)
Reduction: $2H^+ + 2e^- \rightarrow H_2$ (Hydrogen ions gain electrons.)
Net Reaction: $Zn + 2H^+ \rightarrow Zn^{++} + H_2$

Of course, this will happen whether or not you have a copper electrode present, but you need the copper electrode to draw power from the lemon cell; the copper helps channel the electrons through the external circuit. This sort of cell will work for any fruit or vegetable with some acid content; lemons are best simply because they're more acidic than any other food.

Further comments:
Try the effect with different fruits and vegetables. How well do other citrus fruits or tomatos work? If using potatoes, how does the size of the fruit or vegetable relate to how long the bulb stays lit? Does the pH of the vegetable relate to the amount of electricity generated? Lastly, what is the maximum Watt light bulb you can light from your food battery? Try using some electricity equations to calculate parameters such as resistance, voltage and current.