Shining Light on Pollution

Jen Irving and Maud Walsh
LSU Superfund Research Center, Research Translation Core

What is the LSU Superfund Research Center (LSU SRP)?

LSU SRP is studying Environmentally Persistent Free Radicals (EPFRs), a pollutant found in air, soil, and sediment. Researchers are studying how EPFRs are formed, how to reduce exposures, and how they may affect our health.

EPFRs form in combustion and thermal processes, including hazardous waste incineration and diesel combustion.
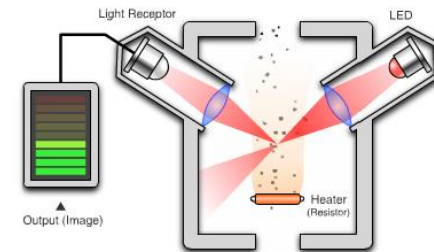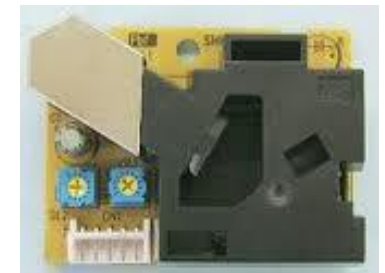
What does the Research Translation Core do?
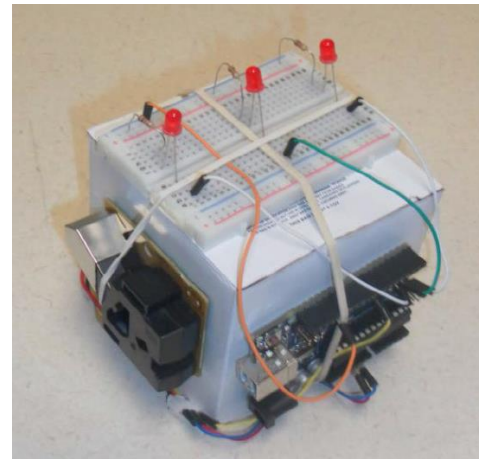
- The Research Translation Core is responsible for communicating research findings to a variety of audiences, including the general public, health and environmental professionals, regulatory agencies, businesses, and other researchers.

- One of the ways we do this is through direct programming to K-12 students, summer programs for youth, and workshops for environmental educators

What are we going to be doing?

- Learn about air pollution
  - Particulate matter (PM) pollution
- Build our own PM detectors
  - Activity and Arduino code developed by the US EPA.
  - Funding from the International Society for Optics and Photonics (SPIE)
    - Learn about how light makes this activity possible (**https://www.youtube.com/watch?v=ax-1dNyceo4**)

Photos: US EPA:
https://www.epa.gov/climate-research/build-your-own-particle-sensor

National Institute of Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center
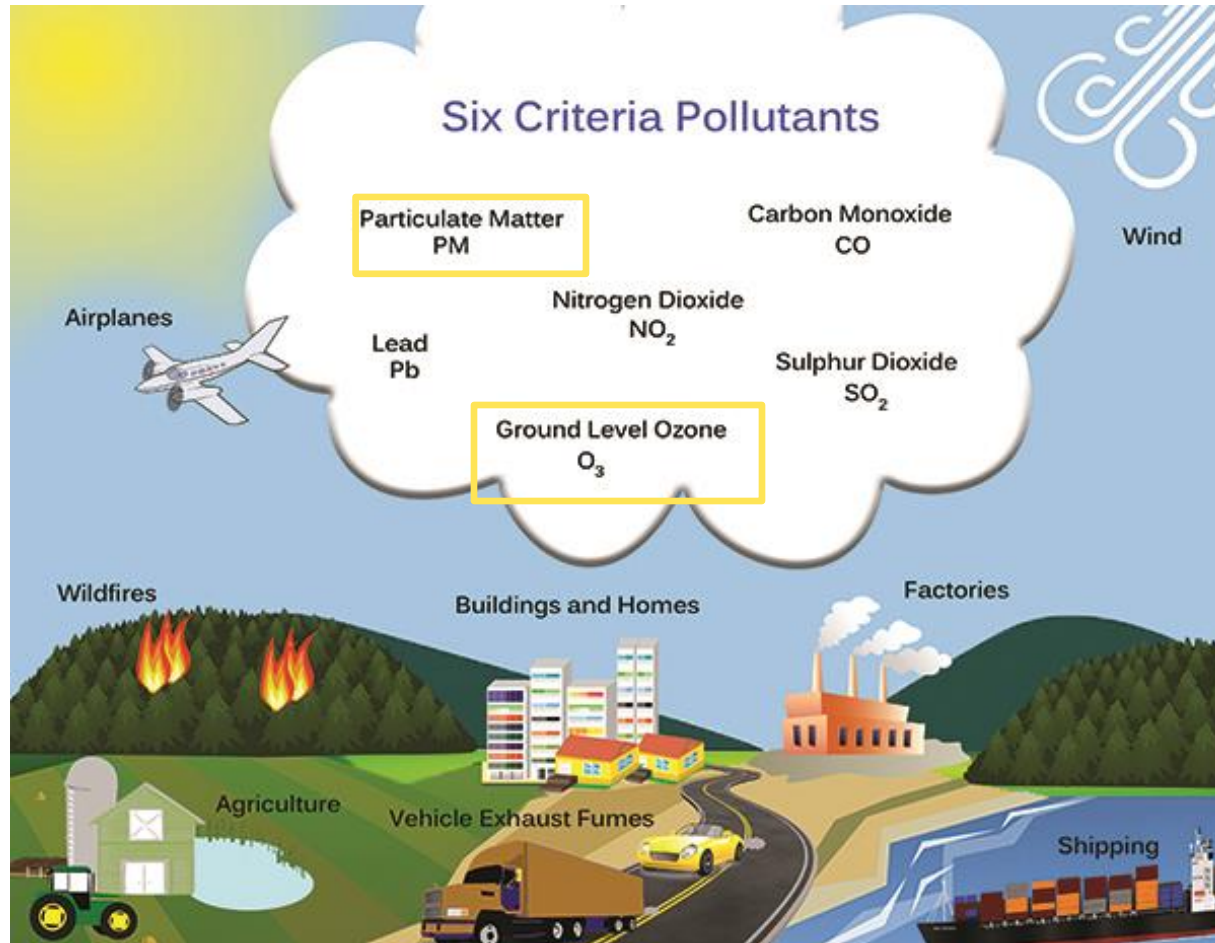
What is Air Pollution?

- Any substance that people introduce into the atmosphere that has damaging effects on living things and the environment can be considered air pollution.

- The United States Environmental Protection Agency (US EPA) is required by law to set standards, or limits, for certain types of air pollution.

- Can anyone name some examples of air pollutants?

Photograph by Peter Essick
http://www.nationalgeographic.com/environment/global-warming/pollution/

National Institute of Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center

Criteria Air Pollutants

Six Criteria Pollutants

Particulate Matter PM · Carbon Monoxide CO · Nitrogen Dioxide NO_2 · Lead Pb · Sulphur Dioxide SO_2 · Ground Level Ozone O_3

Airplanes · Wind · Wildfires · Buildings and Homes · Factories · Agriculture · Vehicle Exhaust Fumes · Shipping

- Criteria air pollutants are regulated by the EPA under the Clean Air Act because they have negative impacts on human health and the environment.
- The standards are known as the National Ambient Air Quality Standards (NAAQS)

Figure From:
Alamo Area Metropolitan Planning Organization
http://www.alamoareampo.org/AirQuality/standards.html

Particulate Matter (PM) Pollution?

- Particle pollution (also called particulate matter or PM) is the term for a mixture of solid particles and liquid droplets found in the air.

- Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye.

- Others are so small they can only be detected using an electron microscope.

- Small particles can cause serious health problems, because they can get deep into your lungs, and some may even get into your bloodstream.
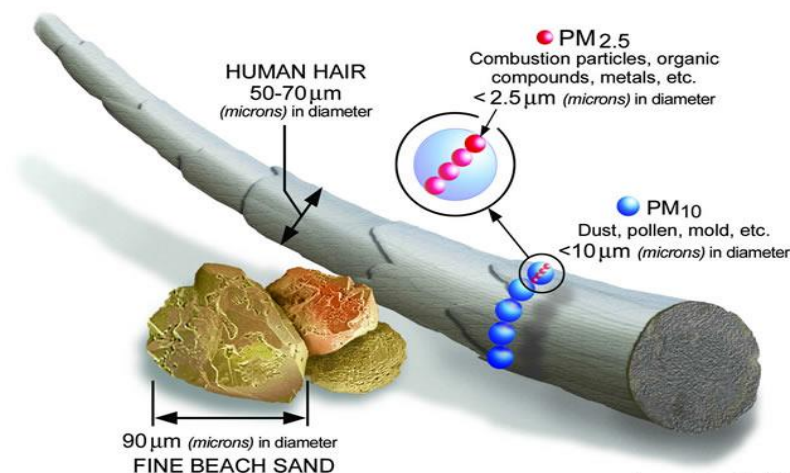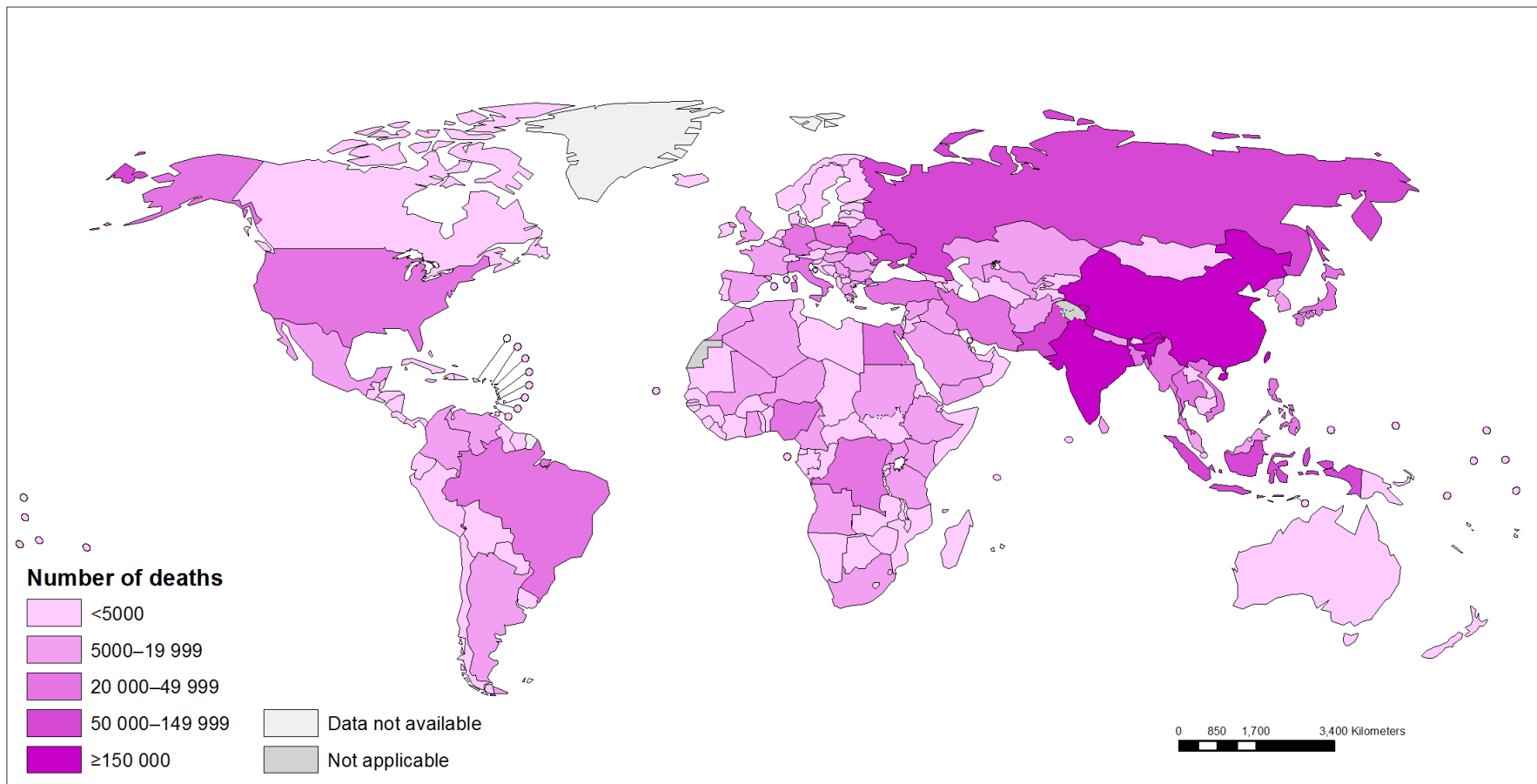

PM2.5
Combustion particles, organic compounds, metals, etc.
<2.5 μm (microns) in diameter

HUMAN HAIR
50-70 μm (microns) in diameter

PM10
Dust, pollen, mold, etc.
<10 μm (microns) in diameter

90 μm (microns) in diameter
FINE BEACH SAND

Image courtesy of the U.S. EPA

How small is 2.5 micrometers? "Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle."

(http://www.epa.gov/pm/basic.html)

Why Study PM Pollution ?

Deaths attributable to ambient air pollution, 2012

Number of deaths

- <5000
- 5000–19 999
- 20 000–49 999
- 50 000–149 999
- ≥150 000
- Data not available
- Not applicable

0   850   1,700   3,400 Kilometers

Data Source: World Health Organization
Map Production: Information Evidence and Research (IER)
World Health Organization

World Health Organization
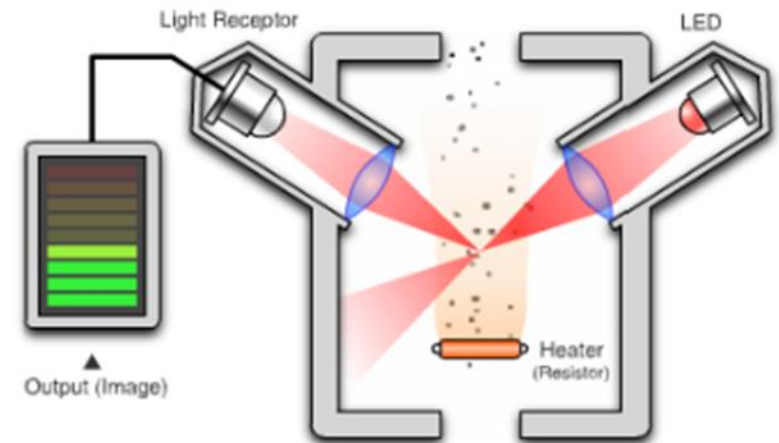
How Do We Measure PM?

- The EPA, DEQ and other regulatory agencies use large, expensive air samplers
  - These are called high volume air samplers
- We are going to build a PM detector that uses light to measure the number of particles in the air.
  - This type of sensor is called an optical sensor, or an optical counter.

LSU SRP trainees John Young and Cholena Ren collecting particulate matter pollution (PM) from a DEQ ambient air quality monitoring station in Baton Rouge, LA in 2014. The PM was extracted and tested for environmentally persistent free radicals (EPFRs) in the LSU SRP lab.

Basic Electronics

Circuit:

"An electric circuit is like a pathway made of wires that electrons can flow through. A battery or other power source gives the force (voltage) that makes the electrons move. When the electrons get to a device like a light bulb, your computer, or a refrigerator, they give it the power to make it work. The word 'circuit' sounds like 'circle,' and a circuit needs to be circular to work. The wires have to go from the power source to the device and back again, so that the electrons can go out and come back."
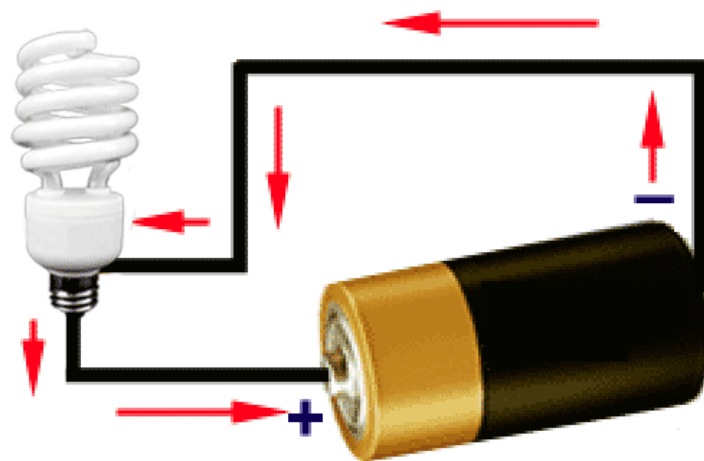
Simple circuit with light
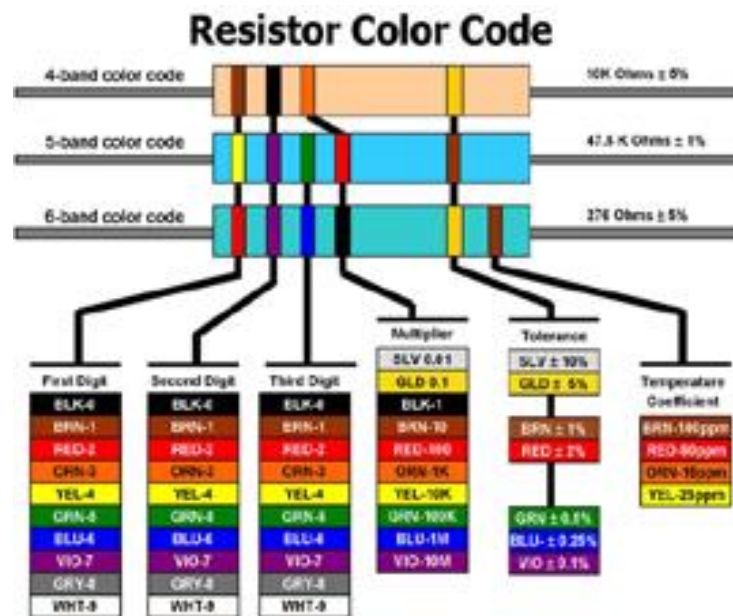
Basic Electronics, Continued

LED:

This is an LED. "Inside each LED is a small bit of chemical that when electrons are passed through, it emits radiation (i.e., light). By changing this chemical compound, you can in effect change the wavelength emitted - **infrared, green/blue/red, near-ultraviolet, etc.** Be aware that an LED is a diode, meaning that it is polarized. By convention, current can only go from the anode (positive end) to the cathode (ground, or negative end)...Note that the two wires on the LED are different lengths. The longer wire is always + and the shorter is -."
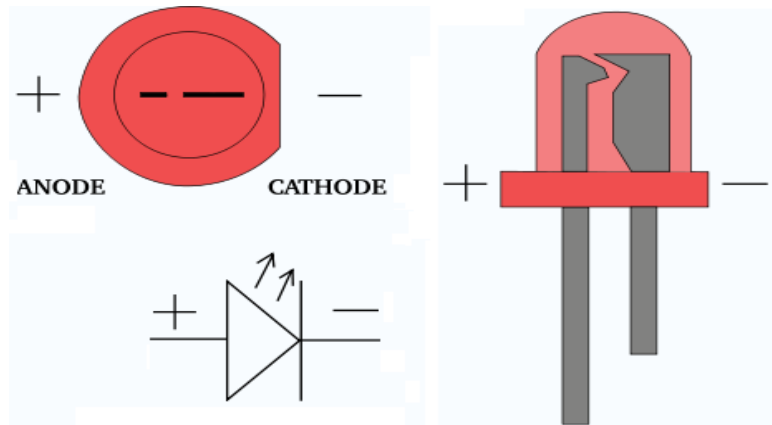
Basic Electronics, Continued

Resistor:

If there is too much current the LED will glow too brightly and will be damaged. The battery will also run out very quickly. The resistor resists current of electrons resulting in a lower current. Think of water flowing when you think of current. Inserting a resistor is like inserting a smaller pipe in the middle of a river. The stripes on the resistor are a code for the resistance and tolerance values of the resistor.

Resistor Color Code

National Institute of
Environmental Health Sciences
Superfund Research Program

LSU | **Superfund Research Center**
LSU | **Superfund Research Center**

Basic Electronics, Continued

Breadboard:

This is a bread board. This is a tool used to put together temporary circuits. Wires and components are pressed into the holes to make different circuits and can easily be removed. The holes are connected as shown; the 5 across on the left, the 5 across on the right and down the 2 columns on the two edges of the board. Plugging wires into two connected holes is the same as touching the two wires together. It is called a breadboard because it resembles the board bread is cooled on.

National Institute of
Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center
LSU | Superfund Research Center
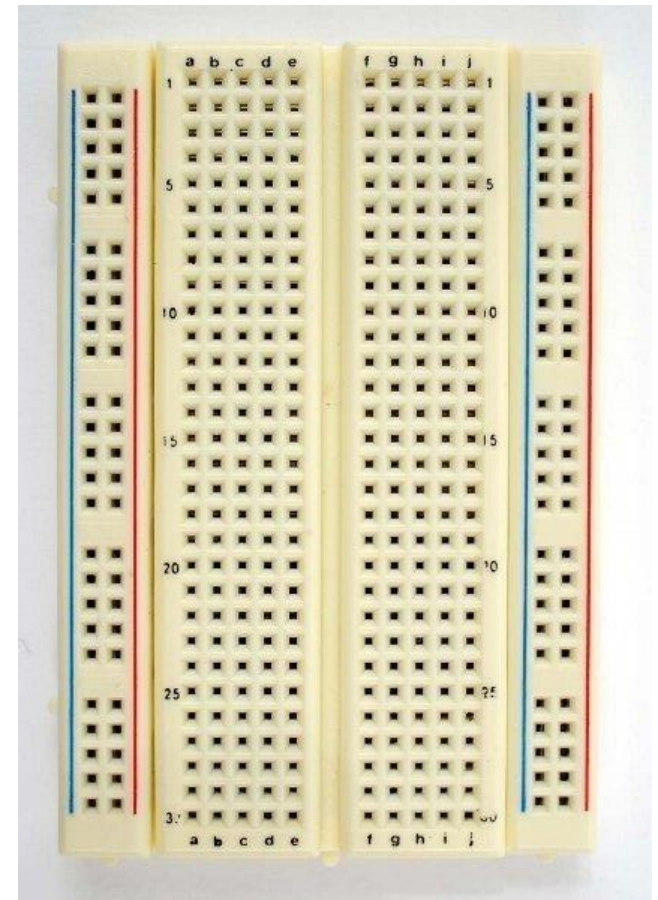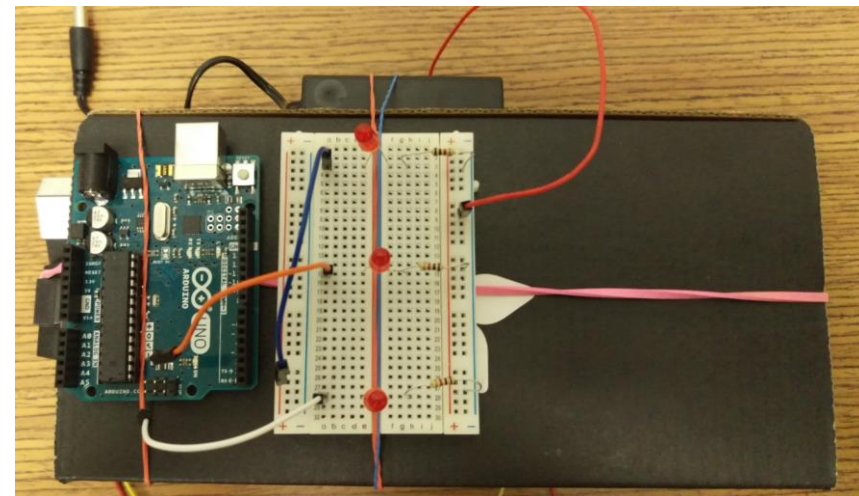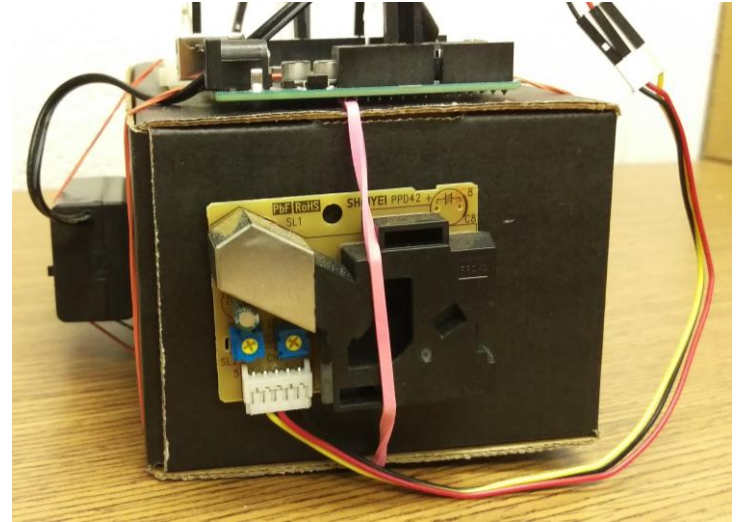
Basic Electronics, Continued

Arduino:

This is an Arduino; it is a mini computer that will be used to run our project. It is an open source platform which means the code and specifications are open and free to the public and people are allowed to build and even sell their own versions.

The one rule while we are doing this activity is: never adjust the wires on the Arduino or plug anything into the Arduino while it is plugged in to the battery.

National Institute of Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center
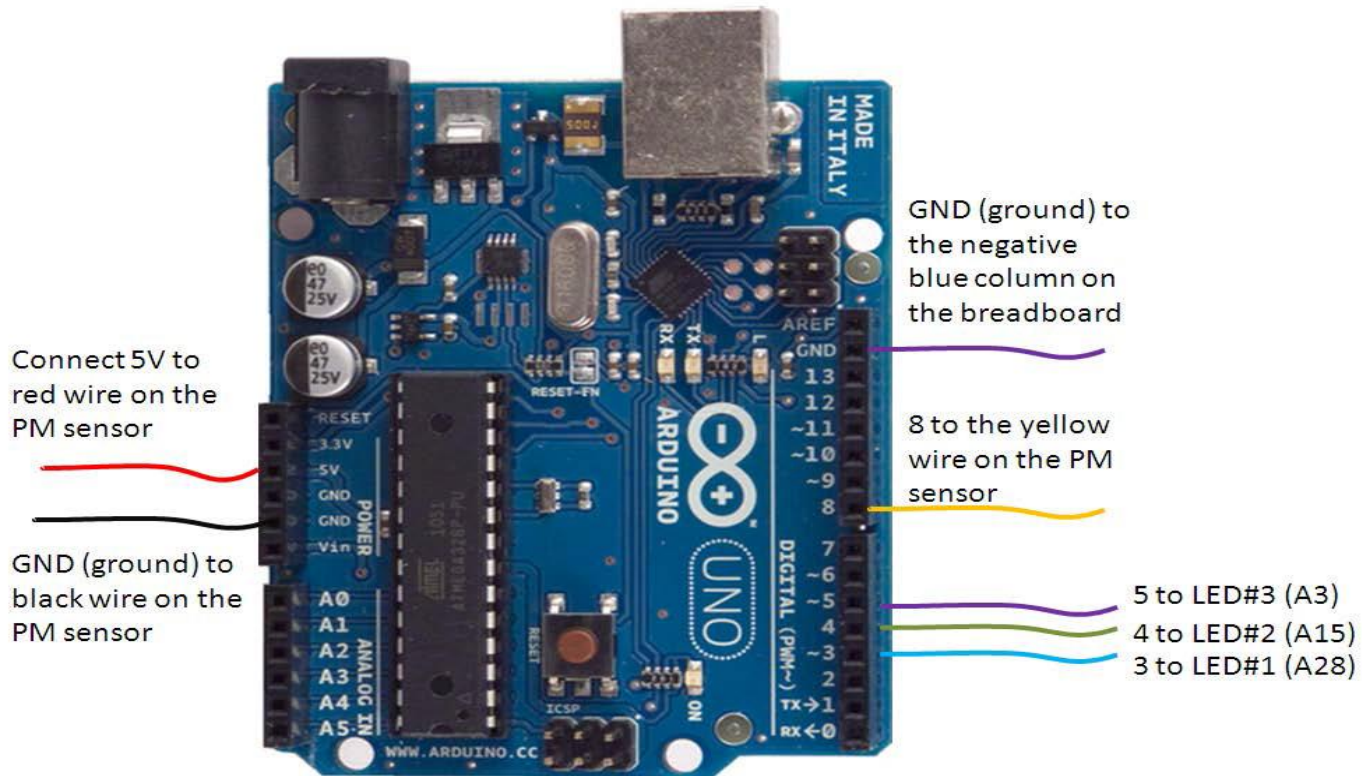LSU | Superfund Research Center

Building the PM Detector

- Step 1
  - Organize the components
  - Prepare the mounting box
- Step 2
  - Assemble the LED circuits
- Step 3
  - Connect everything to the Arduino
- Step 4
  - Test the PM detector
  - Explore and tinker

National Institute of Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center

Building the PM Detector

- Before you power up, review your wiring!!!!
  - Your Arduino should look like the picture below

Connect 5V to red wire on the PM sensor

GND (ground) to black wire on the PM sensor

GND (ground) to the negative blue column on the breadboard

8 to the yellow wire on the PM sensor

5 to LED#3 (A3)
4 to LED#2 (A15)
3 to LED#1 (A28)

Building the PM Detector

- Step 8: Program the PM Detector
  - Open the Arduino program by clicking on the desktop icon.
    - A "sketch" called PM_Sensor_Kit_Code should automatically open
    - If it doesn't and you need help, raise your hand
  - Plug your Arduino into your computer using the USB cable.
  - Go to "Tools" and highlight the "port" that is active.
  - Click the arrow button to upload the code.
  - You can check to see if the code loaded correctly but clicking on "Tools" and selecting "Serial Monitor)
    - After 30 seconds you should see numbers on your screen – these are PM values!

PM_Sensor_Kit_Code | Arduino 1.8.1

File Edit Sketch Tools Help

PM_Sensor_Kit_Code

```
/*Build your own PM sensor Outreach activity
 grey text preceded by // or surounded by /* is comme
int PM=8;//tell the arduino which pin you are pluggi
//tell the arduino which pin you are pluggin the LED
int LED1=3;
int LED2=4;
int LED3=5;//could easily modify to use more LEDs
//Amount of time the sensor collects data before disp
//For PM sensor accuracy should be 30 s or greater (
unsigned long sampletime_ms = 5000;//unsigned long
//Define additional Variables
unsigned long duration;
unsigned long starttime;
```

Arduino/Genuino Uno on COM3

LSU | Superfund Research Center

Test the PM Detector

- While hooked up to the computer try:
  - Ripping a paper towel in front of the sensor
  - Rubbing your hands together
  - Breathing on the sensor
  - Shaking your head/ hair by the sensor
  - Other ideas?
  - Make sure to watch the numbers on the serial monitor, do they change? How long does it take?
- Unhook the sensor from the computer and attach the battery pack
  - Put on gloves and goggles
  - Test the "hazardous waste incinerator"
  - As a group we will walk around outside and test the outdoor air
    - Unless it is raining ☹

National Institute of Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center

Clean Up!

- Turn off the battery

- Disconnect the wires

- Put all the parts back in their bags

- Put everything back in the box

Questions?

Jen Irving
jirvin6@lsu.edu

Maud Walsh
evwals@lsu.edu

National Institute of
Environmental Health Sciences
Superfund Research Program

LSU | Superfund Research Center