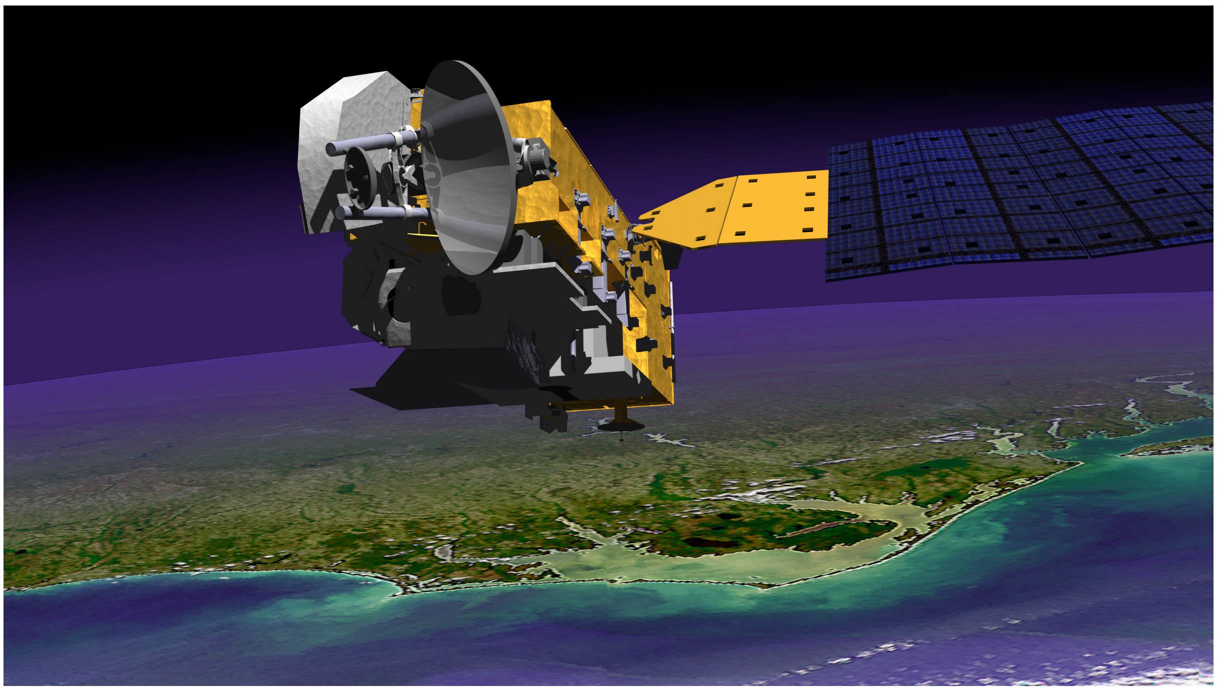
Sensors, Circuits, and Satellites
Lesson 3: Measuring the Atmosphere



Sensors, Circuit, and Satellites is a collection of classroom lessons created by NASA's Aura mission education and outreach that explore the electromagnetic spectrum and NASA remote sensing instruments using student assembled circuits. These lessons integrate inquiry with active-learning experiences to engage students in the properties of electromagnetic energy and remote sensing. The investigations are sequenced to help the learner construct their knowledge about the electromagnetic spectrum while offering real world examples from NASA.

Credits:
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Developed in collaboration with littleBits Electonics ™ via an Internal Research and Development (IRAD FY13-297) award from NASA Goddard Space Flight Center and continued collaboration under NASA Space Act Agreement SAA5-2013-3-N15210

Lesson 3: Measuring the Atmosphere

Summary: This lesson is a demonstration about the scattering of light waves. Students will investigate how scattering occurs when light reflects off an object in different directions. Students will observe a simulation of how light waves are affected when traveling through the atmosphere. Concepts of behaviors of light including scattering, absorption, and transmission are introduced.

Student Objectives: Students will compare and analyze data by measuring energy from light waves as they are scattered. Students will explore how light waves reflect off an object in a variety of directions. Students will be able to explain how this investigation is similar to how particles in the atmosphere can scatter light waves. Students will understand how scientists use satellite instruments to measure this scattering of light to detect and measure different gases and particles in the atmosphere.

Key Terms: Electromagnetic spectrum, spectrum of visible light, scattering, absorption, reflection, transmission, wavelength, sensors

Approximate Time: 30-45 minutes

Materials:

- littleBits™ components: power, bright led, and Energy meter (power + light sensor + wire + number bit)
    - *ALTERNATIVE MATERIALS - Flashlight and Light Meter/Lux Meter*
- large glass bottle with shoulder or *Erlenmeyer flask*
- prism or diffraction grating (a CD works well)
- water
- opaque liquid such as milk
- 2 books to sit the jar on
- photos/images as noted

NGSS – Disciplinary Core Ideas

- **MS-PS4-2** Waves and Their Applications in Technologies for Information Transfer - Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.[Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

NGSS – Cross-cutting concept

- Patterns: Graphs and charts can be used to identify patterns in data.

Set-up:

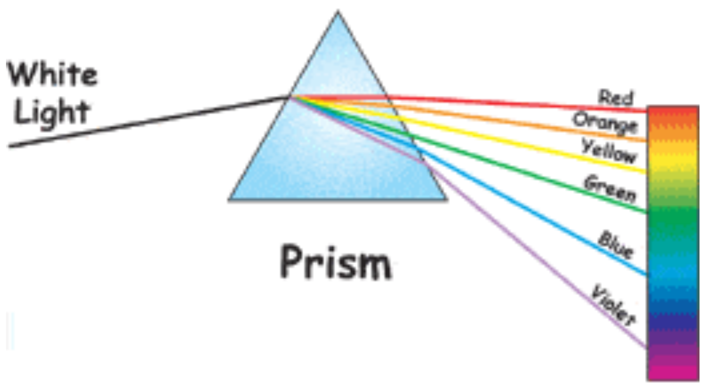
- Fill glass container with water up past the shoulder
- Put together first circuit: power, bright led [*or use Flashlight*]
- Set glass on two books leaving a gap large enough for the light sensor
- Assemble the sensor circuit: power + light sensor + wire + number bit [*or use light meter*]

Teacher Note: Turn off classroom lights and close blinds on windows close to student desks for this activity, so that the light sensor is only sensing the light through the jars. Florescent light is easily detected by the light sensor and skews the readings.

Engage: Show the students a photo of a blue sky. Ask students why the sky is blue? Ask students what color is the light from the sun? Is it really only white?

Demonstrate or allow students to use a prism (or diffraction grating) to break apart white light into the colors of the rainbow. (Or show diagram of white light passing through a prism)

Ask them to explain what is happening to the light to cause these different colors to emerge. Remind them of what they learned about different wavelengths in previous lesson about electromagnetic spectrum. Have them share with a partner and record their thoughts. Ask them to record a "claim" that they can make about the color of the light from the sun. Then ask them to make a list of the "evidence" they believe supports their ideas.



Explain:
Have students report out their findings and provide evidence from their observations to support their claim. Student reports should: define refraction/diffraction, and explain how a rainbow forms.

Explore:
Today we are going to investigate some other behavior of light that scientists rely on to study the atmosphere. See worksheet for set-up and procedure.

Procedure:

Invite the students to place light sensor under the glass (between the books). Make sure the number bit is not under the glass and is able to be read.

First, hold the Bright LED over the top of the glass. (Make sure for each trial the bright LED is held in the same place and is not touching the water. What do they notice? Have them record their observations. Using the energy meter (power + light sensor + wire + number bit), look at the amount of energy passing through the glass. Ask the students what data they see to make sure they understand the numbers on the energy meter are the "data" that is being collected. Ask them to also record this data on the data table.

Next, place Energy Meter on the side of the glass (about an inch below the water line) and hold the Bright LED in the same place over the glass. What do they notice? Record the data.

Then ask the students to record their observations and data with only clear water in the container (not shining Bright LED light – but using the energy meter)

Once they have done this ask what do you think will happen if you add a drop of milk to the water? Will the numbers be the same or different? Based on what you already know, record your hypothesis.

Teacher note: Remind students that a hypothesis is a prediction of what will happen based on what they already know.

Once they have recorded a hypothesis invite them to add a drop of milk to the water and record both measurements again – bottom and side. Continue adding drops of milk and recording observations to complete the Data Sheet.

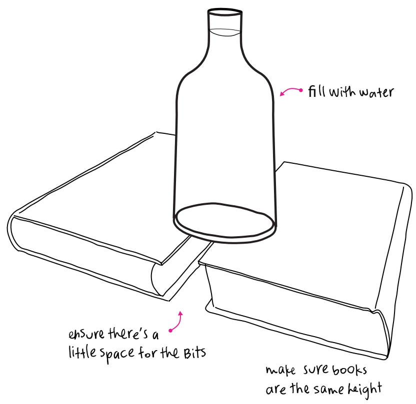
Have students graph their data and answer the journal questions. (second part of worksheet)

Explain:
Ask students to discuss with your partner(s) before answering these questions in your journal.

- What did you observe in the change in the ground-based (under the glass) measurement as you added milk?
- What did you observe in the change in the side-based (side of the glass) measurement as you added milk?
- Was your hypothesis correct?
- Do you see a pattern in the data?
- What is happening to the light in this experiment?

Measuring Our Atmosphere

Data Sheet



Set-up: Fill container with water above the shoulder. Set between books of equal height and high enough such that the littleBits' sensor will fit underneath the container.

The water in the bottle represents the atmosphere. What do you think will happen to the energy (light) as it passes through the atmosphere?

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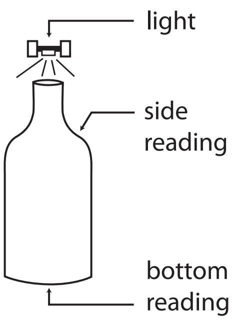

Record the energy circuit readings from both positions on the bottle - the side of the bottle and the bottom of the bottle. With each trial, add more drops of milk or creamer.

Energy Readings

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
	no drops	#___ drops	#___ drops	#___ drops	#___ drops
Side of bottle					
Bottom of bottle					

What did you observe in the change in the ground-based (under the glass) measurement as you added milk?

____

____

What did you observe in the change in the side-based (side of the glass) measurement as you added milk?

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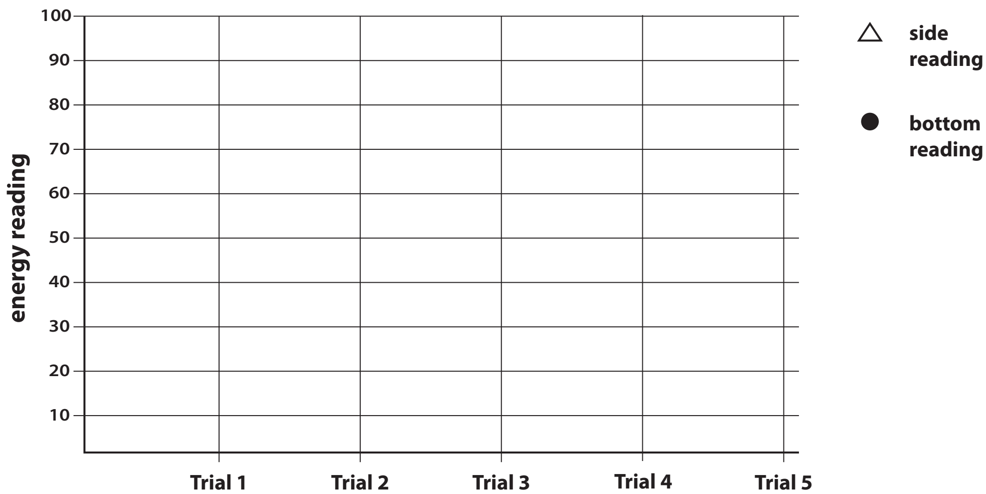
Measuring Our Atmosphere
Graph

Graph your data below. Use a triangle to plot the data for the “side” readings and a circle for the “bottom” readings. Connect the symbols using different colors.



Was your hypothesis correct?

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Do you see a pattern in the data?

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What is happening to the light in this experiment?

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Explain (cont.)
Invite students to share their interpretations with the class, making sure that when they share their analysis they are using data from the table to support their claims. Students should be able to describe that the small milk particles are scattering the light in all directions. The more milk in the glass, the more the light is scattered and less light reaches the bottom of the glass. In contrast, the more the light is scattered, the more light is scattered out the side of the glass.

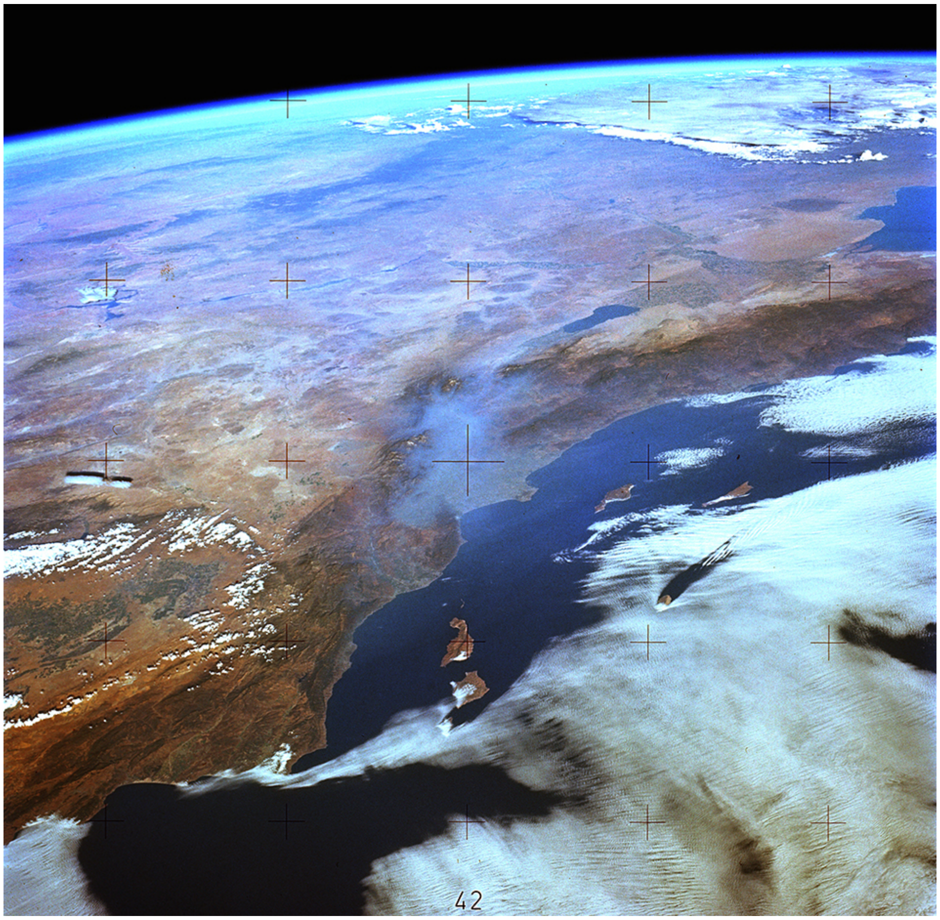
All light travels in a straight line unless something gets in the way to—

- reflect it (like a mirror)
- bend it (like a prism)
- or scatter it (like *molecules* of the gases in the atmosphere)

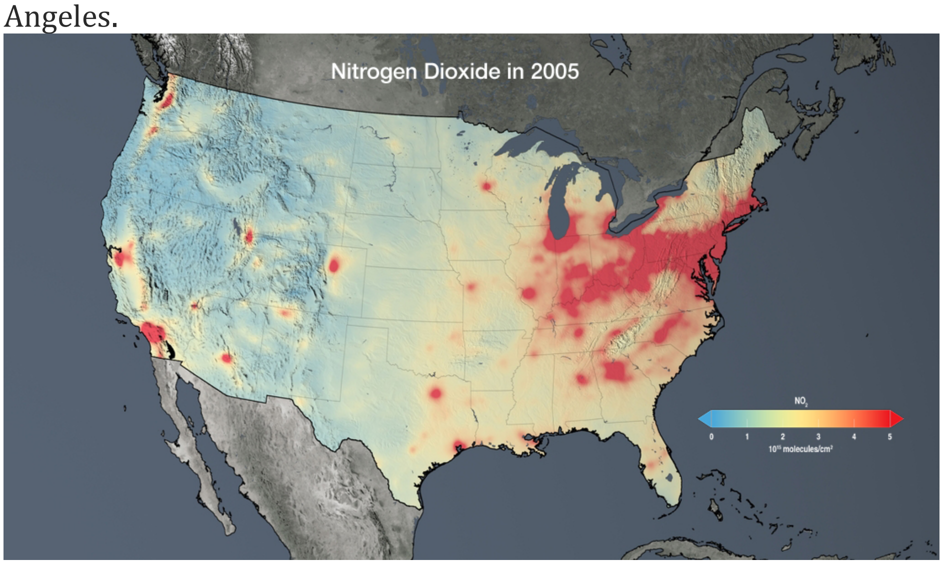
Extend: Discuss with your partner how the diagram (see page 10) relates to our experiment. You can add your own labels to the diagram below to show how the experiment is related. Have students share ideas and answers.

Explain:
In this experiment, the bright LED represents the sun. Measuring the light from the bottom of the glass represents measuring the light from the ground – at the bottom of the atmosphere. When sunlight reaches the atmosphere of the Earth, there are many gases and particles in the air, just like there were particles of milk in your glass. The light waves, are scattered by these substances, just as the light was scattered by the particles of milk. We learned that the blue waves travel in short, small waves and because of that, blue light waves scatter more than the other colors. That is why the sky appears blue most of the time. Measuring light from the side of the glass represents taking measurements from space, like onboard a satellite. The satellite sensor "sees" the light being scattered. Again, because blue light has the smallest wavelengths in the visible spectrum and these waves are scattered by oxygen and nitrogen molecules in the atmosphere. All the other colors such as red, yellow and green, are not scattered and pass though. Satellite sensors can detect what kind of molecules or particles are present by using information from light waves.

Extend: Study the images below. Explain how they show light being scattered.

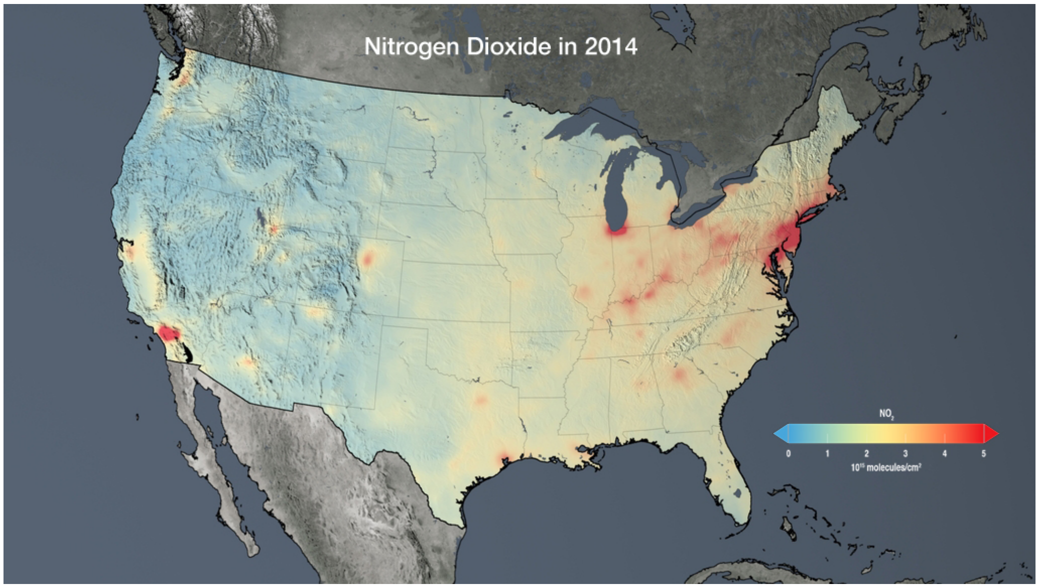


In 1972, this image was captured from Skylab. It shows smog covering Los Angeles.



This is an image of nitrogen dioxide – a harmful pollutant. This is an average distribution of NO2 for the year of 2005.

Teacher note: Before showing this second NO2 image, ask kids to hypothesize whether we will see more pollution, less pollution, or about the same amount in 2014.



Evaluate: What is a possible connection between this experiment and satellite sensors and the atmosphere?

Possible Answer: Measuring light from the side of the glass is like how satellites take measurements in space. The satellite sensor "sees" the light being scattered and measures the amount of light that reaches the satellite from different parts of the electromagnetic spectrum. Satellite sensors can detect nitrogen dioxide molecules in the atmosphere by measuring the different amount of light that reach the satellite from the part of the electromagnetic spectrum that indicate the presence of these particles. By gathering this data, scientists are able to monitor the amount of nitrogen dioxide, a pollutant, in the atmosphere, which has decreased between 2005 and 2014 as shown in the images.

How satellites instruments measure the atmosphere.