Lunar Reconnaissance Orbiter: (LAMP)

Audience
Grades 6-8

Time Recommended
2-4 Hours

AAAS STANDARDS

- 1B/1: Scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- F/5: Human eyes respond to only a narrow range of wavelengths of electromagnetic waves— visible light. Differences in wavelength within that range are perceived as differences of color.

NSES STANDARDS

Content Standard A (5-8), Science as Inquiry:

c. Use appropriate tools to gather, analyze and interpret

d. Develop descriptions and explanations using evidence

e. Think critically and logically to make the relationships between evidence and explanations.

Content Standard B (5-8), Physical Science:

c. Transfer of energy: The Sun is a major source of energy for changes on the Earth's surface. The Sun loses energy by emitting light. A tiny fraction of that light reaches the Earth, transferring energy from the Sun to the Earth. The Sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

MATERIALS

- Return to the Moon: Lunar Exploration (LAMP) DVD
- Student worksheet: How can ultraviolet light help us detect water on the Moon?
- Several black flashlights (one for each group of students)
- Black T-shirt or cloth squares
- White T-shirt or cloth squares
- Any or all samples of the following:
  - » Tonic water
  - » Laundry detergent
  - » White paper
  - » Vinegar
  - » B-12 tablets
  - » Highlighters
  - » Teeth whitener paste
  - » Toothpaste

Seeing in the Dark: Searching for Water on the Moon

Learning Objectives:

- To understand where ultraviolet waves lie on the electromagnetic spectrum.
- To understand scientists can detect a variety of substances using ultraviolet light.
- To explore samples of materials not easily seen by the naked eye.
- To understand that a spacecraft, the Lunar Reconnaissance Orbiter (LRO), is equipped with an instrument, LAMP, which uses ultraviolet light to detect water ice on the surface of the Moon.

Students will use an ultraviolet flashlight to search for materials that cannot be seen with the naked eye. Students will make connections between their experiments/ observations and the LAMP technology used on LRO to detect water on the Moon's surface. Note: students must have learned about the electromagnetic spectrum before starting this lesson.

Preparation:

1. Prepare liquid samples of several of the substances located on the materials list to the right. If the substance is solid, dilute it in water. Place several drops of each prepared liquid on some cut-up white T-shirt pieces or cloth.
2. Cut several squares from a black T-shirt, or black cloth, that have been washed and dried in a dryer. (This should leave lint particles on the black material that is difficult for students to see with a naked eye).
3. Photocopy the related worksheet for each student.
4. Obtain at least one black flashlight for each group of students. Black lights can be purchased for under $10 at http://blacklightonline.us

Background Information:

There are many everyday materials that fluoresce, or glow, when placed under a black light. A black light gives off highly energetic ultraviolet light. Ultraviolet waves are found beyond violet wavelengths (located within the visible light spectrum) on the electromagnetic spectrum. Fluorescent substances absorb the ultraviolet light and then re-emit it almost instantaneously. But, some energy gets lost in the process, so the emitted light has a longer wavelength than the absorbed radiation, which makes this light visible and causes the material to appear to "glow."

The LAMP instrument uses ultraviolet light to search for water ice on the surface of the Moon. Using ultraviolet waves from the Sun and stars, LAMP's sensory equipment will read the spectra of materials reflected off of the Moon's surface. A part of the ultraviolet spectrum of hydrogen atoms is called the Lyman series. The brightest of this series (the Lyman alpha) has a specific wavelength that LAMP has been calibrated to "see." When Lyman alpha light emitted by hydrogen bounces off the surface of the moon, LAMP is able to detect and record it. This data is then used to detect water ice.

Procedure:

1. Watch Chapter 4 of the Return to the Moon: Lunar Exploration (LAMP) DVD, Lights, Camera, Action!

2. Tell students they will be working with ultraviolet light, a light not normally visible to the naked eye. Hand each student the lesson worksheet: **How can ultraviolet light help us detect water on the Moon?**

3. Place students into groups of 3 or 4. Give each group of students several samples of the prepared white T-shirt pieces or cloth. Ask the students to observe the white fabric before giving them a black flashlight. Have them record their preliminary observations of the prepared samples on the worksheet provided.

4. Give each group an ultraviolet (black) flashlight. While the students are at their desks, turn off the lights in the classroom and instruct each group to turn their black flashlights on. Instruct students to shine the black flashlight over the prepared samples. Observe what happens carefully. Provide ample time for this part of the experience.

   Note: instruct students to be absolutely careful of these flashlights. Do not point them in another's eyes (as this can potentially damage them) and handle them with great care.

   Note: while it does not need to be completely dark, dimming the lights will help with seeing things that one's naked eye cannot see (objective), as well as providing the ideal conditions to view a black light experiment.

5. After groups have had enough time to experiment, turn on the classroom lights and ask each group to turn off their black light. Ask students to record his or her observations with ultraviolet light on the worksheet provided.

6. Repeat steps 3 and 4 with the black cloths containing lint. Again, have students observe and record their before/ after observations on the worksheet charts related to the black samples.

7. Have each group use their observation data charts to complete the "Claims and Evidence" chart located in their worksheets. See the sample Claims and Evidence chart below for guidance. (Model this activity if necessary)

   Note: this chart provides possible responses. The students should generate their own claims and evidence based on their individual group's findings.

8. Using the completed Claims and Evidence chart, conduct a discussion with students to ensure they have made the appropriate connections between the activity and the mission of the LAMP instrument: finding water ice on the Moon using ultraviolet light.

Example here:

Claim	Evidence
• I claim you can use ultraviolet light to detect substances that cannot be seen with the naked eye.	• I claim this because we could not see the stain on the cloths until we turned on the black light.
• I claim you can use ultraviolet light to better detect materials on a dark surface.	• I claim this because we did not really notice anything on the black cloth, but when we shone the black light on it there were many fibers glowing on the cloth.

worksheet

HOW CAN ULTRAVIOLET LIGHT HELP US DETECT WATER ON THE MOON?

Name ______________________________________

1. Record your preliminary observations for each white material sample in the chart below:

List White Material Samples:	Observations:

2. After shining the ultraviolet flashlight over the prepared white samples, write your observations in the following chart below:

List White Material Samples (under ultraviolet):	Observations:

worksheet

3. Record your preliminary observations for each black material sample in the chart below:

List Black Material Samples:	Observations:

4. After shining the ultraviolet flashlight over the prepared black samples, write your observations in the following chart below:

List Black Material Samples (under ultraviolet):	Observations:

worksheet

5. Using data from your observation charts regarding both the white and black samples, fill in the Claims and Evidence chart on the next page. Think about ultraviolet light: make claims based on the evidence you found when experimenting with the various samples.

Claim:	**Evidence:**

Assessment:

In order to check for understanding, make sure students have a clear meaning of the following after completing the worksheet and overall lesson (see teacher resources for additional guidance):

- The main idea: “How can ultraviolet light help us detect water on the Moon?”
- To explore samples of materials not easily seen by the naked eye; however, using a different wavelength like ultraviolet, can in fact view the “unseen.” (Just like the LAMP instrument on the Moon!)

SUPPLEMENTAL IMAGES/ MATERIALS/ RESOURCES:

Teacher Resources:

Denver Museum of Nature and Science. (2006). The Lyman alpha mapping project: Seeing in the dark. Retrieved September 20, 2008, from http://www.boulder.swri.edu/lamp/index.html

Introduction to spectroscopy: http://imagine.gsfc.nasa.gov/docs/teachers/lessons/xray_spectra/background-spectroscopy.html

Build your own spectroscopes:
http://www.exploratorium.edu/spectroscope
http://sci-toys.com/scitoys/scitoys/light/cd_spectroscope/spectroscope.html

More information about the electromagnetic spectrum:
http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html

Helmenstine, A. (2008). What materials glow under a black or ultraviolet light? Retrieved September 20, 2008 from http://chemistry.about.com/cs/howthingswork/f/blblacklight.htm

Information on ultraviolet light:
http://missionscience.nasa.gov/ems/10_ultravioletwaves.html

Extension Activities:

Allow students to design and conduct their own experiments using the ultraviolet light.

Glossary:

Lyman alpha line: A spectral line of hydrogen (specifically within the ultraviolet spectra) emitted when the electron falls from the n=1 orbital to the n=2 orbital, where n is the principal quantum number. Note: the LAMP instrument of the Lunar Reconnaissance Orbiter uses the Lyman Alpha spectrum to detect water ice on the Moon.

Wavelength: The distance between one peak or crest of a wave of light, heat, or other energy and the next corresponding peak or crest (expressed in Angstroms).

Frequency: Number of waves that pass a fixed point in unit time (expressed in Hertz). Note: the greater the energy, the larger the frequency and shorter (smaller) the wavelength. Given the relationship between wavelength and frequency, the higher the frequency, the shorter the wavelength. Thus, short wavelengths are more energetic than long wavelengths.