



SENSING ENERGY

DESIGNING TO STAY COOL

LESSON OVERVIEW

LESSON SUMMARY

Students detect the unseen energy in UV light coming from the Sun, discuss why such light is harmful, and experimentally determine how we might protect ourselves.

OBJECTIVES

Students will be able to:

- ▼ light has components that are both visible and invisible to our eyes.
- ▼ exposure to light can be measured and controlled
- ▼ exposure to light can change the properties of an object

GRADE LEVEL
2-4

DURATION
2-45 minute periods

ESSENTIAL QUESTION
How can a spacecraft be protected from the Sun's visible and invisible radiation?

CONCEPTS

- ▼ The Sun produces energy- both visible and invisible to our eyes.
- ▼ The light we see is visible energy from the Sun reflected off surfaces.
- ▼ Some of the Sun's energy is received on Earth as ultra-violet energy that can produce skin burns and cancer.
- ▼ There are ways of blocking UV radiation.

MESSENGER MISSION CONNECTION

The atmosphere on Earth provides a measure of protection to the planet, and everything on it, from the harmful effects of exposure to sunlight. Once the MESSENGER Craft leaves the atmosphere, it will be more exposed to the dangerous invisible forms of the Sun's energy. As the craft gets closer to Mercury, this exposure will intensify. The potential for damage to the craft and its instruments is very high. MESSENGER team scientists are constantly refining their design of the craft so that exposure to the Sun's energy will be minimized.



STANDARDS & BENCHMARKS

NATIONAL SCIENCE EDUCATION STANDARDS

Standard D2 Objects in the Sky

- ▼ The Sun provides the light and heat necessary to maintain the temperature of the Earth.

Standard A2 Understandings About Scientific Inquiry

- ▼ Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).

Standard B8 Light, Heat, Electricity, and Magnetism

- ▼ Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object.

FROM THE NSES NARRATIVE

"Young children begin their study of matter by examining and qualitatively describing objects and their behavior. The important but abstract ideas of science, such as atomic structure of matter and the conservation of energy, all begin with observing and keeping track of the way the world behaves. When carefully observed, described, and measured, the properties of objects, changes in properties over time, and the changes that occur when materials interact provide the necessary precursors to the later introduction of more abstract ideas in the upper grade level."

"By experimenting with light, heat, electricity, magnetism, and sound, students begin to understand that phenomena can be observed, measured, and controlled in various ways. The children cannot understand a complex concept such as energy. Nonetheless, they have intuitive notions of energy—for example, energy is needed to get things done; humans get energy from food. Teachers can build on the intuitive notions of students without requiring them to memorize technical definitions."



SCIENCE OVERVIEW

We are a star-powered planet, and our star, the primary source of energy on Earth, is the Sun. Objects on Earth absorb some of that energy, and reflect or radiate away the rest. Light and heat are just two forms of energy or radiation emitted by the Sun. The word 'radiation' refers to the way energy is transmitted through space and through air.

Visible light is a form of energy to which our eyes are sensitive. Here on Earth, visible light is usually produced when material is heated so that it glows. For example, in a regular light bulb, electricity flowing through a filament in the bulb heats it up and causes it to glow. As a result, light and heat are produced.

The Sun, too, produces light, but this energy is caused by nuclear reactions deep within the Sun. The Sun is really just a mass of hot gasses that explode in a way similar to a nuclear bomb. However, in the Sun, the explosions have been going on for five billion years and are expected to continue for another five billion!

Visible light is only one kind of solar radiation (energy produced by the Sun). Other forms include gamma, X-rays, ultraviolet (UV), infrared and radio waves. We cannot see these forms of energy (though some animals can see a little infrared), but we have other ways of detecting their presence. For example, if we stay outdoors too long, we might get a sunburn, which is caused by the Sun's ultraviolet (UV) energy. We can also use instruments to measure the presence of such invisible forms of energy. This lesson will use

UV Detection Beads which change color in the presence of UV radiation.

Only some of the Sun's energy reaches us on the Earth. Much of it is stopped by the Earth's atmosphere. For example, most UV energy is absorbed by ozone in the upper atmosphere, but some of it still gets through. The UV energy that passes through the Earth's atmosphere can not only harm us by burning our skin, but it can cause other problems such as skin cancer and damage to our eyes.

The amount of Sun's energy (including the harmful ultraviolet) arriving at the Earth's surface depends on several things:

- ▼ How many clouds are overhead and how thick and dark they are (though remember that you can get sunburned even if it is cloudy!)
- ▼ The altitude. How high up from sea level are you?
- ▼ The amount of humidity. How much water vapor is in the air?
- ▼ How much dust and dirt is in the air?

These factors determine not only the amount of visible light reaching the planet, but also how much invisible energy is present. The question of invisible forms of the Sun's energy is important especially for spacecraft, because they fly outside of the Earth's protective atmosphere, and are more subject to their very dangerous effects.





LESSON PLAN: SENSING ENERGY

Using ‘UV beads’, which sense ultraviolet light by changing color, students detect UV light coming from the Sun. Students first test a number of light sources, such as fluorescent and incandescent bulbs, but find that it is the Sun that produces an obvious color change. A class discussion explores key concepts, including: forms of light that cannot be seen, that all light contains energy, and that the energy in ultraviolet light from the Sun poses a danger to us. Students then use the UV beads to develop methods to block UV light, and afford us protection. The activity will address the following questions:

What types of energy does the Sun produce?

How can we sense different types of solar radiation?

PREPARATION

Assemble the needed materials [e.g. in the center of each table, on each student’s desk, etc.]

WARM-UP & PRE-ASSESSMENT

At this age level, we are interested in exploring three aspects of energy from the Sun – light, heat, and UV. There are other activities in this module that can be used to develop more ideas about the sun’s energy. Since the children may know something about light, we begin here.

To reveal children’s ideas, ask them to think of everything they know about light from everyday experiences. Prompt with questions as needed:

- ▼ Think of as many things as possible that give off light.
- ▼ What senses other than sight could you use to find out whether a light bulb is turned on?

Materials

- ▼ Five or six Ultra-violet Detection Beads* per child
- ▼ lamps, overhead projector, a grow-light for plants
- ▼ 9 empty, opaque film canisters per group
- ▼ Colored filters
- ▼ a white piece of cloth
- ▼ a black piece of cloth
- ▼ a baseball cap
- ▼ water
- ▼ paper clips
- ▼ plastic wrap
- ▼ a paintbrush or sponge
- ▼ Sunglasses
- ▼ Sunblock lotion sunscreen (spf 5 or 8, and 30)
- ▼ Flashlight
- ▼ UV eyeglasses





Teaching Tip

Give the children the opportunity to explain their ideas by asking them to draw and write down their explanations.

PROCEDURES

Part 1

1. Provide each student with a few of the Ultra-violet light Detection Beads. Explain that they have a detection tool in their hand that will turn color when a special kind of energy is present.

Teaching Tip

Individual beads may be hard for some students to hold. String the beads and secure them with a knot if necessary. The beads come in different colors. For younger children, use beads all of the same color.

2. Have the students move around the room, looking at the color of their beads, placed under different sources of light (e.g. lamps, overhead projector, a grow-light for plants). Note that fluorescent lighting will not change the beads' color. As the students move towards the window they should notice that their beads will begin to change color. Take them outside if possible; it need not be a bright sunny day.
3. Class discussion: Prompt students with the following questions to help them develop an explanation for the changes they are seeing in the UV beads.
 - ▼ What do you notice about the beads? (They should say a change in color)
 - ▼ What color were they before? What color are they now?
 - ▼ Are all the beads changing color? If not why not? If so, why do you think?



Teaching Tip

It is important for the students to explore their ideas. Allow the students time to explore their beads and develop their own mini-investigations.

Some students may think that it is the Sun's light that is changing the color of the bead. Other may think that it is the Sun's heat. Encourage the students to think of different ways of testing their ideas.

Part 2

1. Choose a time when the sun is high in the sky. Work in an area that is in full sunlight but that has a shaded area nearby. This may be outside or indoors by a sunny window.
2. Arrange the students into groups of 3-4 and distribute materials.
3. Have each group of students put three UV beads in each film canister (you will not be using the lids unless you want to prevent the beads from escaping during the walk to the outdoors). Remove lids once outside. Different coverings will be tested in this experiment.
4. Instruct each group to test the following nine scenarios (if it is difficult to do all 9 tests at the one time, break the experiment into a couple of separate sessions):
 - ▼ Canister 1. (control) Set it on a desk or the ground with nothing over it.
 - ▼ Canister 2. Lay a white piece of cloth over it.
 - ▼ Canister 3. Lay a black piece of cloth over it.
 - ▼ Canister 4. Put sunglasses over this canister.
 - ▼ Canister 5. Put a baseball cap over this canister.
 - ▼ Canister 6. Fill this canister with water.. String the beads on a paper clip so that they will sink.
 - ▼ Canister 7. Cover this canister with plastic wrap.
 - ▼ Canister 8. Cover this canister with plastic wrap and then apply a coat of sunscreen (spf 5 or 8) to the plastic with a paintbrush or sponge.
 - ▼ Canister 9. Repeat the instructions for the previous canister using an spf 30 sunscreen.





5. Tell students to let their canister sit for five minutes in the sunlight- either outdoors or in a sunny window.
6. While waiting for the results to appear, conduct a whole group discussion to have the students predict what might happen to the beads in each of the canisters. Prompt with questions if necessary, such as:
 - ▼ What do you think will happen to your beads? Why?
 - ▼ Will the same thing happen to everyone else's beads?
 - ▼ What colors do you predict they will become? What makes you say that?
7. After five minutes, have students check the canisters one at a time and record the results on Worksheet 1 (at end of this section). Before checking they will need to move the canister to the shade and look quickly. The response time of the beads is very rapid. If the beads are not examined in the shade immediately and if the students look too slowly, the results will not be valid.
8. Each group should enter their results on a student worksheet (Page 44).

Teaching Tip

Ensure that all students have a chance to observe the results in each of the canisters. Only one student need fill out the worksheet, however. Others may also do so if you prefer.



DISCUSSION & REFLECTION

The point of this exploration is to think further about the Sun's energy.

Have each group discuss their observations amongst themselves for two or three minutes, and perhaps choose a spokesperson for the entire class discussion, if necessary.

Bring the groups together, and discuss the basic findings, and what caused them. Prompt with questions such as:

- ▼ In which of the canisters did the beads change color?
- ▼ Did they all change to the same colors?
- ▼ Why do you suppose that certain beads changed color and not others?
- ▼ Look at the results from the different canisters, and compare two, now three canisters. What do you notice? How do the color changes in each of the canisters compare? For example, is white cloth different from black cloth in changing the amount of UV radiation that reaches the beads? Which materials best blocked ultra-violet radiation?

LESSON ADAPTATIONS

For students who know about other planets, ask them to speculate about how much of the Sun's power reaches them. Ask about visible light, heat, and UV radiation. You may want to mention here the other forms of solar energy discussed in the Science Overview (including gamma, X-rays, infrared and radio waves).

Prompt with study questions or research topics such as:

- ▼ How would the Sun's energy be different on different planets such as Mercury or Pluto?
- ▼ What features of the other planets make them different from Earth? Why are those features important when we think about light, heat, and UV radiation?

To make this lesson more relevant to students' knowledge of biology in the early grades:

- ▼ Explain how insects use their ability to sense ultra-violet radiation. Butterflies and bees see ultraviolet light as a distinct color that makes certain markings on flowers very vivid to them and guides them to the nectar tubes.





CURRICULUM CONNECTIONS

- ▼ *Health:* Invite the school nurse or dermatologist to talk with students about the importance of using sunscreen to protect their skin from ultra-violet light.

ASSESSMENT

Ultra-violet beads offer third and fourth graders a fine opportunity to develop a scientific investigation or fair test. Ask your students to design their own tests to show how the beads respond under different conditions.

The following list outlines some useful expectations on how to assess such investigations.

Exemplary:

- ▼ Students plan controlled investigations of predictions with a rationale based on scientific thinking.
- ▼ Students repeat procedures to confirm observations.
- ▼ Students apply measurement to represent their ideas.
- ▼ Students select appropriate charts and graphs to record and then interpret their findings.
- ▼ Students make conclusions that relate their findings to scientific thinking and propose further questions for investigation.

Emerging

- ▼ Students make predictions that guide the formation of fair testing procedures.
- ▼ Students defend their procedures and rationale for selecting them.
- ▼ Students carry out fair tests, knowing why they are fair.
- ▼ Students select and make appropriate measurements.
- ▼ Students complete a chart or graph to record and help interpret their findings.
- ▼ Students draw conclusions and attempt to relate their findings to scientific thinking.

Formative

- ▼ Students describe what they expect to happen when something is changed and support that idea with some scientific thinking.
- ▼ Students use suitable equipment to make and record adequate and relevant observations.
- ▼ Students record what they find and compare it to what they expected.
- ▼ Students make appropriate measurements.



INTERNET RESOURCES & REFERENCES

UV Detection beads can be purchased from Educational Innovations Inc. (1-888-912-7474) or online at www.teachersource.com.





WORKSHEET 1

Record observations of UV beads in film canisters.

CANISTER	START COLOR	END COLOR
Canister 1. (control) on the ground with nothing over it	_____	_____
Canister 2. covered with a white piece of cloth	_____	_____
Canister 3. covered with a black piece of cloth	_____	_____
Canister 4. covered with sunglasses	_____	_____
Canister 5. covered with a baseball cap	_____	_____
Canister 6. filled with water	_____	_____
Canister 7. covered with plastic wrap	_____	_____
Canister 8. covered with plastic wrap and a coat of sunscreen (spf 5 or 8)	_____	_____
Canister 9. covered with plastic wrap and a coat of sunscreen (spf 30)	_____	_____