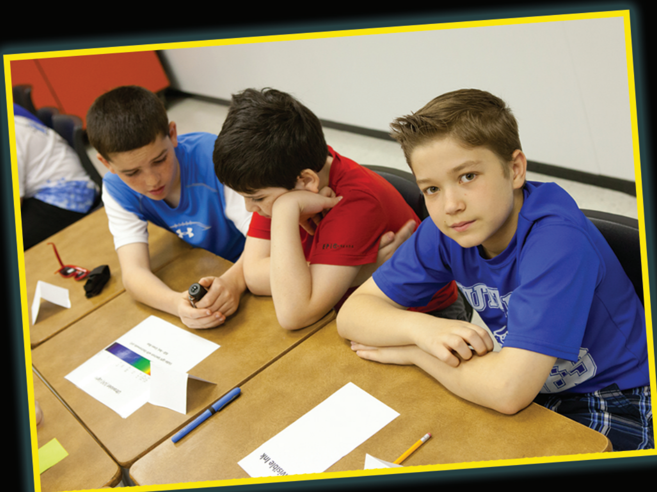
UV BEADS

Help your kids learn about ultraviolet light and its effects by experimenting with plastic
beads that are sensitive to UV rays.

Under UV-free light the beads are milky white.
But their color shines through when
kids let them bask in the sun or under lightbulbs that emit UV light in the proper range.
Let your students experiment with the effects different materials have on the transmission of UV radiation. Then, use their observations as a jumping point to talk about how energy originates from the sun, the health effects of UV radiation, or even global warming.



How Do UV Beads Work?
Most UV radiation is blocked by the ozone layer of Earth's atmosphere, but enough still gets through to the Earth's surface to support life. It's invisible, but we can see, and feel, its effects everywhere. UV light warms the planet, stimulates vitamin D production in humans and animals, helps insects navigate in the night, and is used to sterilize equipment in biology and medical labs. It also causes sunburn, damages our eyes, and fades fabric and plastic.

UV-sensitive beads are a reliable detector of this type of radiation. They contain a chemical dye with a unique molecular structure that changes when exposed to UV light. The more UV, the more intense the color. Once you remove UV exposure, they slowly change to white again. This process can be repeated thousands of times.

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In the following activity, students will be given the opportunity to explore UV radiation using these special beads. In doing so, they will test the ability of various materials to block or transmit UV radiation and the degree to which exposure occurs.

Learning Objectives

After this activity, students should understand that:

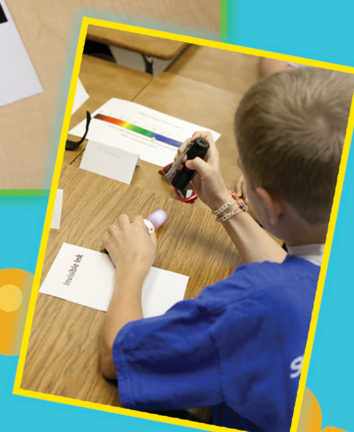
1. The sun produces light in a broad spectrum of wavelengths, including invisible UV light
2. UV light is both beneficial and harmful
3. Earth's atmosphere provides significant, but not complete, protection from UV radiation
4. There are ways to detect UV radiation and protect against the damage it can cause

MATERIALS

- 1 of each available color of UV-sensitive beads or 5 random beads per participant
- 1 pipe cleaner or ribbon per participant
- 1 worksheet per participant
- A selection of materials for experimentation, like water, sunscreen, orange pill bottles, sunglasses, fabric, etc. (see worksheet)

MATERIALS

- Sandwich bags
- Permanent markers
- A source of UV light at the proper wavelengths (300-360 nm), either natural or manmade
- Paper towels



Grade Level
3–12

Time Requirement
30–45 minutes

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PROCEDURE

1. Discuss UV radiation with your students using the information above and in the fact sheets below. Show them where UV light falls on the electromagnetic spectrum chart. Reinforce the concept that UV is a form of light that cannot be detected by the naked eye, but it is emitted by the sun and some other stars, as well as some types of lightbulbs.Discuss other types of invisible electromagnetic rays, like x-rays, microwave radiation, and radio waves.

2. Distribute a set of beads, a pipe cleaner or length of ribbon, and a worksheet to your students. Have them string their beads and tie the ends of their pipe cleaner or ribbon as you explain how the beads work.

3. Ask the students to become the scientist as they experiment with their beads. Provide them with eithe a specific set of materials or a selection to choose from. Using their worksheets, students should make predictions about what will happen when they expose their beads to UV under the protection of their various materials.

4. As your students test their beads by exposing them to the sun or a manmade UV light source, have them record the reactions of the beads to the exposure. Are they still white or are they faintly colored or brightly colored? How long did it take for them to change? How quickly do they go back to white? (To test sunscreen, coat the outside of a sandwich bag with the lotion and place the beads in the bag before exposure.)

5. When students are done, discuss their results and how they varied, the accuracy of their predictions, and what they learned about the materials they tested. Continue your discussion about UV light in the context of your classroom. Experimenting with UV beads can launch discussions about the sun as our most basic energy source, the electromagnetic spectrum, how we use UV and other types of light to do work, why we need sunlight for health, how to avoid the harmful effects of UV light, the ozone layer and global warming, and a host of other subjects.

Example materials: water, sunscreen, paper, sun glasses, eye glasses, regular plastic in various colors, orange plastic medicine bottles, a window, a windshield, the brim of a cap, fabrics in various colors and weights.

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EXPLORATORY WORKSHEET

You be the scientist! Experiment with your beads by protecting them with the different materials your teacher has provided. First, make a prediction about how your beads will react when you shield them with each material. Will they remain white because the rays are blocked? Will they turn a faint color because some rays will pass through the barrier? Or will they turn an intense color because many rays will pass through?

Next, place your beads behind each barrier and expose them to UV light. Record your observations of how their color changes—or not. As you work, consider when you might or might not want to expose yourself to UV light and how you can protect yourself when its effects could be harmful.

Material	Prediction	Observations	Conclusions

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EXPLORATORY QUESTIONS

(USE ADDITIONAL PAPER AS NEEDED)

At what time day are you most at risk from exposure to UV radiation exposure?

At what time of day are you at least risk?

In what season are you at most risk from UV radiation? Are you at risk any other season of the year?

Which of the materials you tested today were most effective at restrictin the transmission of UV radiation? Which were least effective?

What do you think made the difference?

What can you do to protect yourself from UV radiation during outside activities?

Based on what you have learned, what type of lightbulb do you think is used in tanning beds? Or reptile cages? How do you think they work? How do you they compare to natural sunlight?

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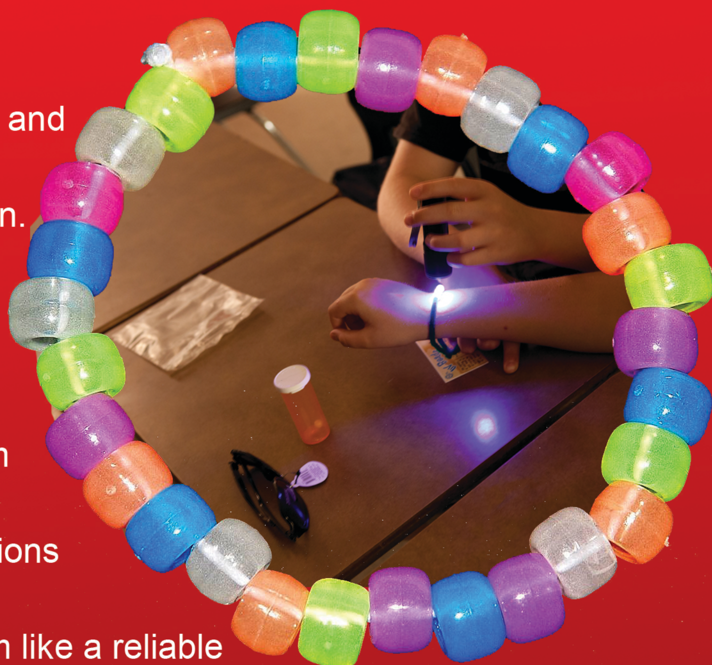
There are many ways to use UV beads in your class or at home, depending upon the time available and grade level of your students. Here are some ideas.

A Great Inquiry Lesson!
Give each of your students five white beads on a pipe cleaner to take home (use different colored beads). Don't tell them what to expect. Do tell them that their homework is to determine what makes the beads special. They should write down their observations and at least two questions they would like to explore further. This is an excellent way to guarantee a lively discussion during the next class session!

Make a UV-Detecting Bracelet
Pass out two each of red, yellow, orange, blue, and purple beads to each student. Have them place the beads onto a string to create a pattern. Your students can check their progress by exposing the beads to sunlight or a proper UV bulb.



Tell students to wear their bracelets (or tie them to a backpack) and monitor their UV exposure for the next few days. What observations \can they make about the amount of time they spend in sunlight? Does the bracelet seem like a reliable UV detector? As a class, develop a list of possible ways these beads could be used to promote awareness concerning unprotected exposure to the sun safety and the possible long-term consequences.

Which Lotion Is Right for You?
Test the effectiveness of different brands or SPS levels of sunblock and suntanning lotion. Have students coat clear sandwich bags with the selected lotions. (Don't forget to label them!) Place the same color bead in each bag and expose them to UV light. Observe which beads change the most dramatically to determine which brands or SPF levels actually affect the amount of UV light that passes through to your skin. This experiment can also be done with lip balms, hand lotions, and even sunglasses that promise UV protection. Do they deliver?

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If time permits, show your students a brief video of UV beads "in action." An international sunscreen company used UV beads to create a commercial that emphasized how well their sunscreen products block UV rays. The video is available at http://vimeo.com/36033383.

Measuring Variations in the Sun's UV Light

Instruct students to compare the amount of UV light emitted from the sun on different colored beads at different times of the day. Then take your beads outside at the same time of the day but under different weather conditions. Does cloud cover change the amount of UV light you are exposed to? What about rainy or cold weather? Encourage students to make and test their hypotheses about what makes the beads change colors.

Investigating UV Absorption

Place contrasting filters between a UV light source and the beads—for instance, try eyeglasses versus sunglasses, transparent versus colored medicine bottles, lipstick versus lipbalm with sunscreen, or car windshields versus side windows. How do the items compare? What is the difference between them? Do they block UV light? How well? For example, students should discover that the front windshields of most cars block UV radiation, but side windows (usually) don't have this built-in protection. Discuss why manufacturers choose to provide UV protection in their products and if that protection works.

Science 'n Art

Combine science, technology, and the arts with your UV beads. Assign your students the task of designing a UV bead mosaic using a cross-stitch-style grid to mark the placement of each colored bead in the design. This can be done by hand or on a computer. Students then use their pattern to create a real mosaic by gluing or stitching their beads to fabric or paper. (Stitching will guarantee a longer life for the project.) Display the finished pieces in a place that gets sunlight part of the day. Students can observe how the mosaics change under different weather conditions and how the designs appear and disappear throughout the day.

Going Beyond the Beads

The ozone layer provides protection to plants and animals by acting as a filter for UV radiation. Some scientists hypothesize that chlorofluorocarbon gasses released from aerosol propellants are damaging the ozone layer and placing life on Earth at greater risk of UV exposure. Ask your students to research this issue and prepare a paper or an in-class resentation that explores this pros and cons of this controversy or takes a position on the issue.

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UV FACTS

Solar Energy

All energy on the earth originates from sunlight. Our sun primarily emits UV in the areas above the surface and in the sun's extremely hot atmosphere, called the corona, where where most intense solar activity occurs. Because our ozone layer blocks many UV frequencies from

Astronomical observation reveal that hot objects in space emit UV radiation, and extremely hot stars emit even more UV than our sun does. Most of its electromagnetic emissions peak in the range that is visible to our eyes, what we perceive as light. Creatures on planets with a star that has peak emissions in the UV range would have different eyes than ours, ones sensitive to UV, and they would see their world differently than humans would.

The Electromagnetic Spectrum and UV Light

UV light is electromagnetic radiation with a wavelength shorter than visible light but longer than x-rays, in the range between 400 nm and 10 nm. It is an invisible part of the electromagnetic spectrum, which includes ultraviolet, infrared, and visible light, along with other types of energy. It is named ultraviolet because its frequency is higher than the one humans identify as the color violet. Though UV frequencies are invisible to humans, near-UV is visible to a number of insects and birds.

Although we cannot see UV radiation, most people are aware of its effects on the skin, like suntan and sunburn. Outside the deep oceans, life on Earth is possible only because of the protection provided by our atmosphere, primarily the ozone layer, which filters out nearly all short-range and most mid-range UV.

UV light has many effects on human health, both beneficial and damaging. It causes long-term skin damage, eye damage, and cancer. However, UV stimulation in the skin is crucial to the formation of vitamin D. It has many other benefits to humans, other animals, and plants, as well.

The effects of UV radiation are not limited to living things. It is also evident in faded furniture, fabrics, printed products, or the cracked rubber hose that has been left lying in the sun. Plastics are noticeably susceptible to UV deterioration, which is why we often see bleached and brittle objects set out for curbside pick-up, particularly those dyed red.

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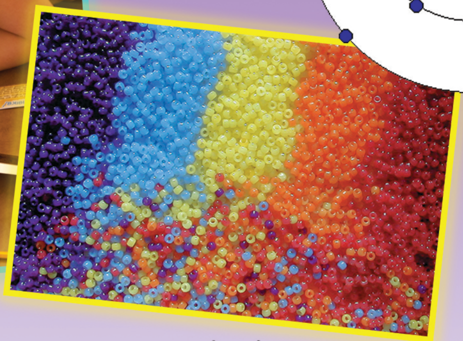
The Chemistry of Ultraviolet Light Detecting Beads
By Ron Perkins
NASA

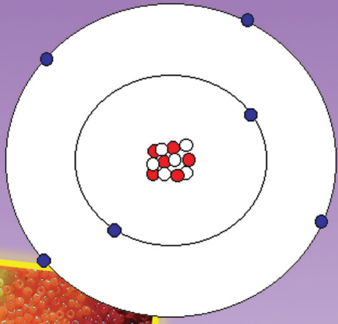
The dye molecules in Ultraviolet Light Detecting Beads consist of two large, planar, conjugated systems that are orthogonal to one another. No resonance occurs between two orthogonal parts of a molecule. Imagine two planes at right angles to one another, connected by a carbon atom. When high energy UV light excites the central carbon atom, the two smaller planar conjugated parts form one large conjugated planar molecule. Initially neither of the two planar conjugated parts of the molecule is large enough to absorb visible light and the dye remains colorless.

When excited with UV radiation, the resulting larger planar conjugated molecule absorbs certain wavelengths of visible light resulting in a color. The longer the conjugated chain, the longer the wavelength of light absorbed by the molecule. By changing the size of the two conjugated sections of the molecule, different dye colors can be produced. Heat from the surroundings provides the activation energy needed to return the planar form of the molecule back to its lower energy orthogonal colorless structure.

Although UV light is needed to excite the molecule to form the high-energy planar structure, ambient heat from the immediate surroundings provides the activation energy to change the molecule back to its colorless structure. If colored beads are placed in liquid nitrogen, they will not have enough activation energy to return to the colorless form.

UV detecting beads remain one of the least expensive qualitative UV detectors available today. They cycle back and forth 50,000 times.





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