Ultraviolet Light Detecting Beads

UV-AST

What is ultraviolet light?

Ultraviolet ("UV") light is one of the frequencies of light that is given off by the sun. Ultraviolet light is not visible to the human eye; it is an invisible part of the "electromagnetic spectrum." Ultraviolet radiation, visible light and infrared energy are all given off by the sun.

The image below shows the electromagnetic spectrum, which includes ultraviolet, infrared and visible light along with other types of energy.

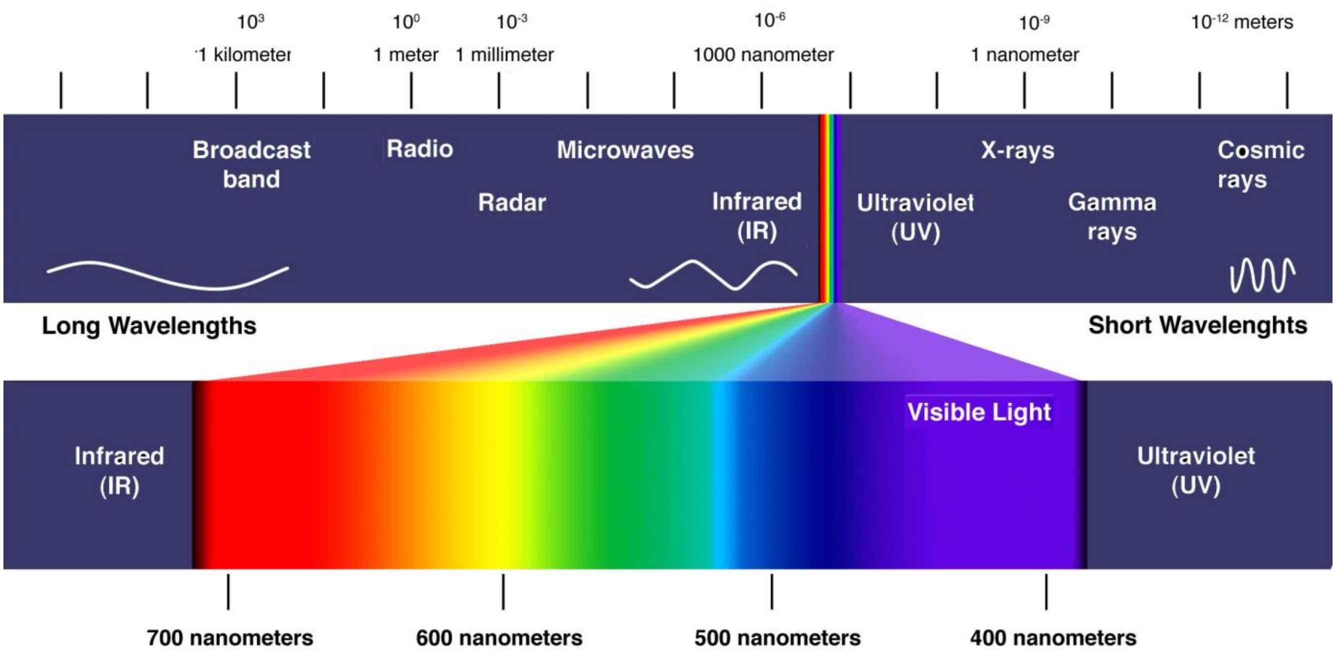


Image source: "Electromagnetic Spectrum"
https://en.wikipedia.org/wiki/Electromagnetic_spectrum

Over exposure to UV light can be harmful to many things—including humans. Its effects can be seen in faded furniture or paper, a sunburn, and a cracked rubber hose that has been left out in the sun.

How do the Ultraviolet Light Detecting Beads work?

Our UV-sensitive beads contain a unique pigment that changes color when exposed to ultraviolet light from the sun or other UV sources. The beads are not affected by visible light—they are chemically developed to *only* react to UV light and will remain white indoors or when shielded from UV light.

The electromagnetic radiation needed to affect a change in the color of the beads is between 360 and 300 nm in wavelength. This includes the high-energy part of UV Type A (400-320 nm) and the low energy part of UV Type B (320-280 nm).

Fluorescent type black lights (both traditional tubes and CFLs) work very well, as do most UV LED lights, but please note that incandescent black lights (the type used to make fluorescent paints glow) will not change the color of the beads nor will UV Type C (280-1 nm).

The Chemistry of Ultraviolet Light Detecting Beads

By Ron Perkins

The dye molecules in our 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, heat from the 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. The UV detecting beads remain one of the least expensive qualitative UV detectors available today. They cycle back and forth thousands of times.

NGSS Correlations

Our Ultraviolet Light Detecting Beads and these lesson ideas will support your students' understanding of these Next Generation Science Standards (NGSS):

Elementary

1-PS4-2
Students can conduct investigations showing evidence of illumination from an external source such as the Sun.

1-PS4-4
Electromagnetic Radiation Objects can be seen only when light is available to illuminate them.

Middle School

MS-PS4-1
Students can conduct investigations showing evidence that the amplitude of a wave is related to the energy in the wave.

MS-PS4-2
Students can use this tool to develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials.

High School

HS-PS4-5
Students can use UV Beads to conduct investigations on how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture energy.

HS-PS4-3
Students can use the UV Beads to evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described by a wave model.

HS-PS4-4
Students can explore the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation.

Suggested Science Idea(s)

1-PS4-2
UV light detectors can be made with these beads. Worn as a bracelet or zip pull, the beads will help students develop awareness of where and when UV light is present.

PS4.B
Objects can be seen only when light is available to illuminate them.

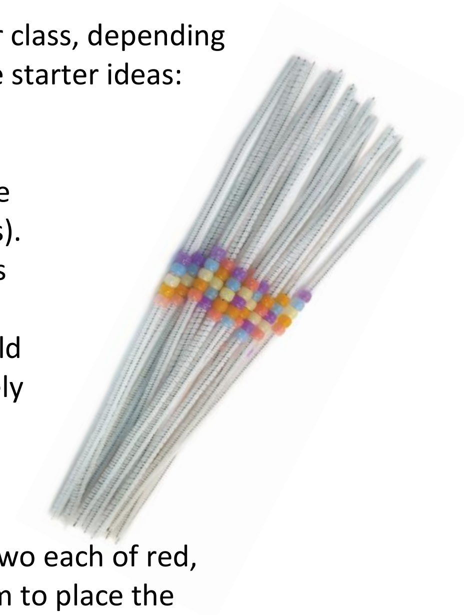
MS-PS4-1
Students can conduct investigations outside with the Outside Detector and make correlations to the Electromagnetic Spectrum and the amplitude of a wave is related to the energy in a wave.

MS-PS4-2
Students can use the beads to test different materials to see if the UV waves are being reflected, absorbed, or transmitted through various materials. Colored beads indicate that waves are transmitted.

HS-PS4-5
Students can use these UV Beads in experiments to support mathematical representations of UV light versus white light.

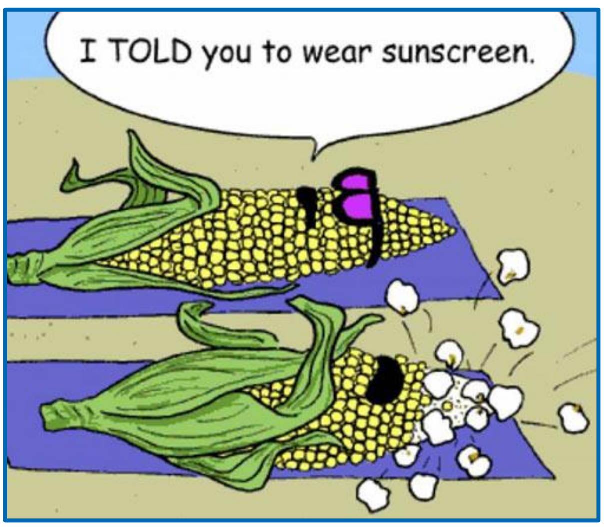
Classroom Activities

There are many ways to use the Ultraviolet Light Detecting Beads in your class, depending upon the time available and grade level of your students. Here are some starter ideas:



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

2. **Make a UV detecting bracelet.** To each student, distribute two each of red, yellow, orange, blue and purple UV detecting beads. Instruct them to place the beads onto a rawhide string (#UV-RAW), to create a pattern so that two beads of the same color are not next to each other. Your students can check their progress by exposing the beads to sunlight.



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 around sun safety and skin cancer prevention in their school.

3. **Test the effectiveness of sunblock.** By coating two pieces of overhead acetate with different levels of sun block, and placing a purple UV bead under each and then exposing the sheets to UV light, you can observe which bead changes most dramatically and determine if the SPF or brand of lotion actually affects the amount of UV light that passes through to your skin.

Seeing is believing!

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

4. Measure variations in the sun's UV light. Instruct students to compare the amount of UV light emitted from the sun on different colored beads and at different times of the day. You will find that the beads change color much faster at noon than in the late afternoon. As an added twist, 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.

5. Investigate UV absorption. Place different transparent filters between a UV light source and the beads—for instance, try eyeglasses, sunglasses or a UV-absorbing window film. Do they completely block the UV light or merely reduce its intensity? You will find that the front windshields of most cars block UV radiation, but the side windows usually don't have this built-in protection. Our UV Filter Set (FIL-235) offers many ways for students to experiment with UV light absorbing filters.

What wavelengths of light cause a color change?

Infrared 2500 - 700 nm	Visible 700 - 400 nm	UV-A 400 - 320 nm	UV-B 320 - 280 nm	UV-C 280 - 1 nm
Infrared light makes our skin feel warm and can be detected by certain animals such as rattlesnakes.	Visible light can be seen by our eyes. It includes all the colors of the visible rainbow.	Too much exposure to Ultraviolet A can result in the same damage as UV-B, but to a lesser degree.	Ultraviolet B light is needed for Vitamin D synthesis in our body, but is a major cause of reddening of the skin, sunburn, skin cancer, cataracts, suppression of the immune system, and photo-aging.	Ultraviolet C light is extremely dangerous, but completely absorbed by the ozone in the earth's atmosphere and does not reach the earth's surface.

Beads are white 2500 - 360 nm	Beads are colors 360 - 300 nm	Beads are white 300 - 1 nm

Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons.
For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

Please visit our website for more lesson ideas:

www.TeacherSource.com

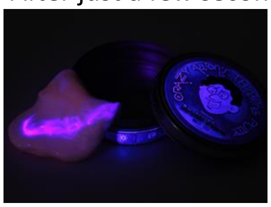
Check our blog for classroom-tested teaching plans on dozens of topics:

http://blog.TeacherSource.com

To extend your lesson, consider these Educational Innovations products:

UV Sensitive Putty (PUT-175)

After just a few seconds in the sun—or under the black light keychain (included)—this putty's icy WHITE



shimmer is transformed to a vibrant PURPLE. Take it outside and watch it react! Then tear it in half to see the unchanged color in the middle. This non-Newtonian substance can be bounced, stretched, pulled, and snapped. Always returns to its original white color and never dries out. Glows ORANGE in the dark.

Nature Print Paper (SPP-40)

This unique light-sensitive paper exposes in direct sunlight to create beautiful, permanent white-on-blue prints. Flat objects (such as leaves, photo negatives, coins, lace, etc.) placed on the paper block the sun and provide the subject for the print. Requires no photo equipment, darkroom or chemicals,

UV Outside Detector (UV-360)

Detector contains UV Detecting Beads inside of a clear plastic bottle preform. When the detector is shielded from UV radiation, the beads are white. When exposed to UV radiation (between 360 and 300 nm in wavelength), the beads turn purple. This detector can change color thousands of times.

UV Color Changing Nail Polish (NP-530, NP-540, NP-560)

This nail polish changes color when exposed to UV radiation. Away from sunlight, it returns to its original color! Try painting the polish on an index card or acetate to make a portable ultraviolet light detector.

UV Filter Set (FIL-235)

Set of two plastic disks. One absorbs UV-A Light, the other doesn't. Great for experimentation with our UV Beads!