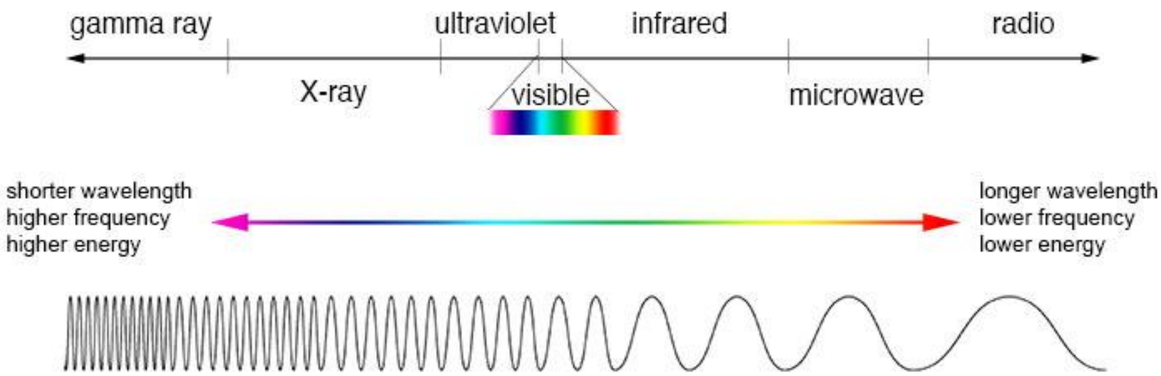
The UV Challenge

Ultraviolet (UV) light energy is part of the electromagnetic spectrum produced by the Sun.



UV light has a shorter wavelength and higher energy than the visible light seen by our eyes (however, some insect and animal eyes can see UV light). Although the lenses in our eyes absorb much of the UV light in the sky, the cells in the retinas of our eyes are very sensitive to UV light energy, which is why we should never look directly at the Sun. UV light also causes tanning in skin, but too much will cause sunburn and may lead to skin cancer. You may also notice chemical and physical changes occurring in household objects exposed to UV light; for example, pictures and clothing will fade, and a rubber water hose can develop leaks after long exposure to UV light.

UV-sensitive beads become colored when briefly exposed to UV light. The beads change color because UV light energy causes dye molecules in the beads to change shape so that they absorb some of the visible light that we can see. When the beads are removed from the UV light, the dye molecules in the beads gradually change back to normal and the beads lose their color and become clear. This process is similar to what happens when light reaches the rod and cone cells in the retinas of our eyes. These cells also contain dye molecules whose properties are changed by the light, and they **[The cells or the molecules?]** cause chemical signals to be sent through the optic nerve to the brain, where the image of the object we are looking at is created. The sensitivity of our cone cells to different energies of light results in the colors we see.

Please review the safety precautions in *Handy Health Guide to Your Eyes*. Do not look directly at sunlight or at laser-pointer light. You should you shine laser pointers toward others' eyes or at shiny surfaces or mirrors that can reflect into your or others' eyes. **[Students should not be using laser pointers in middle school. Please revise this activity to avoid use of lasers.]**

The Challenge

Your teacher will give you six clear UV beads that will change into a different color when exposed to UV light. Place them in the small plastic container. **[It would be helpful to have a materials list in this packet.]** Working individually, with a partner, or in small groups **[Of how many students?]**, make predictions about what will cause the beads to change color, conduct experimental tests of your predictions, and discuss your results. After you have conducted the experiments, discuss as a class what you observed.

Variables (different conditions)	Prediction: Will the beads become colored when exposed to light?	Describe the experimental test of your prediction (hypothesis)
When illuminated by • sunlight • a fluorescent light • a LED or computer screen • a green laser light • a red laser light • a blue laser light		
Beads in water exposed to the light sources (place water in container with beads)		
Beads behind sunglasses exposed to the light sources (bring sunglasses from home)		
Beads covered with sunscreen exposed to the light sources (bring sunscreen from home)		

1. What do your observations tell you about the nature of light from these sources? What do your observations tell you about what blocks UV light and prevents it from reaching the beads?

2. Were there any observations that you could not explain? List these and discuss with your partner/group and then with the class.

3. Why do people use sunscreen and sunglasses? Did they protect the beads from UV light? How can you determine if the time of exposure to UV light makes a difference? Discuss with other members of your group, and prepare to discuss your research in class.

Now, place the beads on the string and tie the ends to form a bracelet. You may keep the bracelet—wear it to alert you to when you are exposed to UV light!

Sunglasses or sunscreens: Protecting the public

You are employed by a company hired by *Consumer Reports* to test the sunglasses or sunscreens for UV light protection. Your company must check and verify whether their UV protection ratings are appropriate.

1. You and your company must develop procedures for testing the UV protection ratings.

2. After testing is completed, each company will publish the data and the procedures used to assure the public and *Consumer Reports* that appropriate UV safeguards are being used.

3. Work with your group to design tests. Write them in a form or a report suitable for the public to understand.

4. Present your plan to the class, obtain their suggestions, and then revise your plan.

Spin a Color Wheel

The sunlight that we perceive as white is actually a mixture of light energies (colors) that can be separated (diffracted) by a prism. Early scientists thought that the prism was adding color to white light, but the physicist Isaac Newton proved this to be wrong by showing that the colors formed by shining light through a prism could be recombined to form white light.

Can you think of how he might have done this? (Discuss with others, and then read about how Newton did the experiment at *www.webexhibits.org/colorart/bh.html*.)

The light-sensitive rod and cone cells in our eyes can distinguish light energies perceived as red, green, and blue, so we see them as separate colors. However, if the colors are being replaced by each other, our brain mixes the signals from our eyes instead of keeping them separate. What do you think we see then?

You can answer this question by conducting an experiment to mix colors using a color wheel.

Cut out the wheel found at *http://cdn.bigshotcamera.com/images/fun/buildables/colorwheel/color_wheel.pdf*.

Trim the edges of the cardstock and carefully poke a pencil (other similar object) through the center.

Spin the color wheel. What happens to the colors when you spin the wheel slowly? What happens as you spin the wheel faster?

Find and Measure Your Blind Spot

The region of the retina to which the optic nerve is connected has no photoreceptor cells (rods and cones), so it does not sense light. This is the *blind spot***.** You don't notice this in everyday life, because one eye “fills in” for the other. However, you can detect the blind spot by using just one eye. To detect the blind spot, copy the filled in square and circle below onto a card or piece of white paper, so they are 3 or 4 inches apart.

Hold the card or paper at arm's length and cover one eye with your hand. Focus on the filled in square with your open eye, but notice that you can also see the circle. Slowly move the card or paper toward you. Notice that the circle disappears! This is because an image of the image of the circle is projected by your lens onto your blind spot, where it is not visible. Repeat using the other eye to find its blind spot.

What happened when the circle disappeared? Did you see anything where the circle had been? No; when the circle disappeared, you saw a plain white background that matched the rest of the sheet of paper. This is because your brain "filled in" for the blind spot—your eye didn't send any information about that part of the paper, so the brain just made the "hole" match the rest. Try the experiment again with a piece of colored paper. When the circle disappears, the brain will fill in whatever color matches the rest of the paper.

You can measure the size of your blind spot with some simple arithmetic and geometry, as described at *http://faculty.washington.edu/chudler/blindspot.html*.

Cow Eye Dissection

General guidelines and detailed instructions are provided below. Also review this useful web link: *www.exploratorium.edu/learning_studio/cow_eye/video_big_all.html*. **It is important that all students wear gloves and safety goggles to avoid exposure to the fixative!**

The cow eyes provided are generally free of fat and muscle, although a small amount of muscle has been left so you can understand how the eye is held in the socket and moves. This can best be described by the teacer.

Describe external features of the eye—the muscles, cornea, sclera, and optic nerve protruding from the rear of the eye that connects to the brain.

The sclera has been incised to enable you to easily cut the eye in half, but you should be careful not to squeeze it tightly. The clear jelly in the eye is the *vitreous humor* that helps nourish the various tissues. It is transparent to light.

Take the front half of the eyeball and flip it inside out, and pop out the lens. It is cloudy because of the fixative. Normally, it is clear and can be used to focus light, just as the Grow Lens. **[What is a Grow Lens?]** Locate the *iris*, the dark membrane on which the lens sits. Use the wooden tool **[Again, would be helpful to have a materials list.]** to remove the iris as one piece and examine the *pupil* (the hole in the middle). Human eyes have round pupils, but a cow's pupil is oval-shaped. Why? (Ovals increase the area of vision. A cow's eyes are located on the sides of its head, so it needs a wider vision area. Human eyes are on the front of the skull, so we already have a range of about 180 degrees.)

Examine the *cornea*, a thick, translucent tissue. A cow's cornea has seven or eight layers of material, but human eyes have three to five layers. Why? (The cow needs these extra layers of protection because it spends so much time grazing close to the ground, where its eyes could be damaged by grass, sticks, or other objects.)

Turn to the back half of the eyeball and locate the retina. Dislodge the retina with the wooden tool and locate where it is attached to the optic nerve (the blind spot). It is at this point that the connections from the rod and cone cells are made. Note the pigmented surface (*tapetum lucidum*) behind the retina that helps reflect and amplify light. This is present in animals that must use vision to see in low light. Humans do not have this.

When finished, place all the tissues in the ziplock bag and dispose of them appropriately. Wash the instruments, then remove your gloves and wash your hands.

Safety Guidelines

Cow eyes
The cow eyes may be purchased from Carolina Biological or from a local butcher. The former will be preserved in Carolina Biological Perfect Solution, whose safety data sheet can be found at *www.carolina.com/teacher-resources/Document/msds-specimens-in-carolinas-perfect-solution/tr-msds-specinpsghs.tr*. Students and teachers handling these eyes should wear impermeable gloves and eye protection. When finished, place waste materials in a plastic bag, close the bag, and then put into the trash.

General rules
Students should be told to wash their hands after using laboratory materials.
Keep hands away from eyes, mouthm and face when handling preserved specimens.

Eye protection
All persons must wear safety glasses.

Students should report to the teacher any personal injury (e.g., burn, scratch, cut) or liquid on the skin or clothing.