

WHITE LIGHT AND COLORED LIGHT

grades K-5

Objective

This activity offers two simple ways to demonstrate that white light is made of different colors of light mixed together. The first uses special glasses to reveal the colors that make up white light. The second involves spinning a colorful top to blend different colors into white. Together, these activities can be thought of as taking white light apart and putting it back together again.

Introduction

The Sun, the stars, and a light bulb are all sources of “white” light. But what is white light?

What we see as white light is actually a combination of all visible colors of light mixed together. Astronomers spread starlight into a rainbow or spectrum to study the specific colors of light it contains. The colors hidden in white starlight can reveal what the star is made of and how hot it is.

The tool astronomers use to spread light into a spectrum is called a spectroscope. But many things, such as glass prisms and water droplets, can also separate white light into a rainbow of colors. After it rains, there are often lots of water droplets in the air. White sunlight passing through these droplets is spread apart into its component colors, creating a rainbow.

In this activity, you will view the rainbow of colors contained in white light by using a pair of “Rainbow Glasses” that separate white light into a spectrum.



SAFETY NOTE

These glasses do NOT protect your eyes from the Sun. NEVER LOOK AT THE SUN!

Background Reading for Educators

Light: Its Secrets Revealed, available at
http://www.amnh.org/education/resources/rfl/pdf/du_x01_light.pdf

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Materials

Rainbow Glasses

(paper glasses containing a diffraction grating). One pair is included free with this guide. You can order more from www.sciencekit.com, catalog #69751-06, \$3.95 for pkg/6

Possible white light sources:

Incandescent light bulb

Flashlight

String of clear holiday lights

Fluorescent light bulbs

Procedure

Part One: Separating White Light into Colors

- 1] Set up a few different kinds of white light sources in a room. The best rainbows come from the smallest points of light; for example, a single holiday light or a small, bright flashlight. (If you only have large bulbs, you can make a point source by looking at the light through a tiny hole punched in a piece of heavy or dark paper.)
- 2] Turn on a light and instruct the students to put on their glasses, or pass around the pair that is included in your activity manual.
Ask: What do you see?
- 3] Have the students look at the light source with the glasses on and notice what the rainbows they see look like.
Ask: Are the colors always arranged in the same order (red, orange, yellow, green, blue, indigo, and violet)? Is the same color always closest to the light source?
- 4] Look through the glasses at different light sources, noticing that the rainbows are not present when the lights are turned off.
- 5] To conclude, you can have the students draw their own pictures of the rainbows that they saw in the prism glasses.
Ask: Where did the colors in the rainbows come from?
Explain: These colors were already there, hidden in the white light, and the glasses separated them out into their individual colors. Raindrops work the same way, separating sunlight into the colors we see in rainbows in the sky. These colors are actually contained in sunlight all the time, but we cannot see them because they are usually mixed together into white. Introduce Part Two of the activity by explaining that you will show how you can make white light from different colors by mixing them together.

- 6] You may want to look at light sources that do not show a complete spectrum, such as fluorescent lights or colored holiday lights.

Ask: Do these lights contain a mixture of colors, too? Is the entire rainbow present when looking at the colored holiday lights, or are some colors missing?

Explain: Fluorescent lights contain just a handful of specific colors, not a continuous rainbow. Since fluorescent bulbs are so large, you will need to close one eye and look through a small hole punched in a piece of paper to see a clear spectrum. You should see narrow stripes of specific colors, not a continuous rainbow.



Teacher's Note: Refraction, Diffraction, and Diffraction Gratings

These glasses contain a series of very narrow lines called a diffraction grating. Though the effect is similar to looking through a glass prism, they actually work very differently.

Light can be bent in two different ways: by refraction and diffraction. Refraction occurs when light enters and exits transparent materials such as glass and water. Diffraction occurs when light bends around objects as it passes by them.

Both refraction and diffraction can be used to spread light into a spectrum. Refraction produces a spectrum because shorter wavelengths bend at sharper angles than longer wavelengths. Creating a spectrum through diffraction is more complicated. When light passes through a series of tiny slits or grooves called a diffraction grating, light fans out from each slit. The light waves from neighboring slits overlap and interact with each other, creating an interference pattern. Though the process is very different, the result is similar to refraction: white light is spread out into a spectrum according to wavelength.

Part Two: Blending Colors into White Light

In the previous activity, you took white light and broke it up to show it is made of all the colors in the rainbow. Now you will put that rainbow back together again to get white.

White, in scientific terms, means the combination of all the light in the visible spectrum. When our eyes see “white” we are actually seeing the colors of the visible spectrum combined. Because of the way our eyes work, every color of the spectrum need not be present for light to look white. Televisions and computer monitors create “white” light by mixing just three colors. In this experiment, you will mix six colors of light to get white.

Materials

Color wheel (p.6)

Scissors

Flat toothpicks

Index cards or other heavy paper

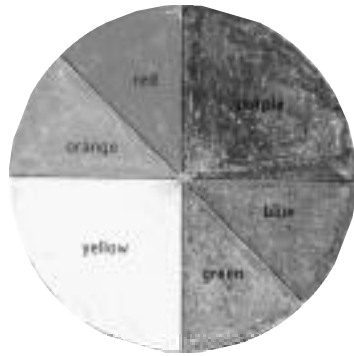
Liquid glue

Crayola crayons in standard red, orange, yellow, green, blue, and violet (purple).

Optional: simple gyroscope for demonstration. A small gyroscope can be ordered from www.sciencekit.com, catalog #62020-00, \$6.25.

Procedure

- 1] Photocopy the page containing the color wheel diagram and instructions (pg. 6) and give each student a copy. For younger children, read the instructions aloud as they make their tops.
- 2] Spinning the tops should make the colors blend into white.
Ask: Where did the white color come from, and where did the colors go?
Explain: White light is a mixture of different colors of light. (Remind them what they saw with the rainbow glasses.)
- 3] For a dramatic demonstration, put the color wheel on a simple gyroscope (you will have to cut a slit in the color wheel from the edge to the center) and then spin the gyroscope while the color wheel is on it. This will allow the wheel to spin much faster than possible with a toothpick, and it will go for at least 15 seconds—enough time for students to get a good view of the “white” wheel.



Finished color wheel.

- 4] Use the second color wheel to let children experiment with mixing colors. They can make a second top from this wheel, after filling it in with colors of their own choice. Suggest that some use just two colors in alternating wedges to see what happens when they are combined. Red and blue will make purple. Red, blue, and green should be nearly white. And red and green will make yellow! (Yellow appears between red and green on a spectrum, and your eye combines them into yellow.) Explain: When you spin the top, your eye mixes together the colored light it receives from each part of the top. Note that this is a different kind of color mixing than mixing paint, or drawing with all the crayons on top of each other, which would make brown or black. Only mixing colored light together makes white.



Teacher's Note: Additive and Subtractive Color Mixing

Mixing light is different from mixing paint or pigments. For instance, if you tried to mix the same colors used in this experiment by drawing with all six crayons on top of each other, the result would be muddy brown or black, not white. The reason for this is that colors can be mixed in two different ways—by adding them, or subtracting them.

Pigments such as those in crayons gain their color by subtracting colors from white light. If you shine white light on a red crayon, it reflects only the red light in the spectrum and absorbs the rest. A green crayon reflects the green light in white light and absorbs the red light. If you draw with both colors on top of each other, the red pigment absorbs the green light, the green pigment absorbs the red light, and neither gets reflected, creating a dark color.

But when you mix colored light, you are adding, not subtracting colors. If you add all the colors together, you will get white light.

Even though your color wheel top uses pigments, not colored light bulbs, the effect is additive, not subtractive, because the different colors of light reflected by the top are mixed together by your eye. This effect depends on an optical illusion called persistence of vision. When your eye sees something, the image persists for a fleeting moment even after the light stops coming.

Blending Colors into White Light

COLOR WHEELS

- 1 Color in the wheel.
- 2 Glue the wheel onto an index card or heavy paper. This will make the wheel sturdy and easier to spin.
- 3 Cut the color wheel out.
- 4 Break a flat toothpick in half. Poke one half through the center of the color wheel.
- 5 For a stronger top, glue the toothpick to the wheel by placing a drop of glue around the center hole.
- 6 Spin the top on a table, desk, or the floor.

