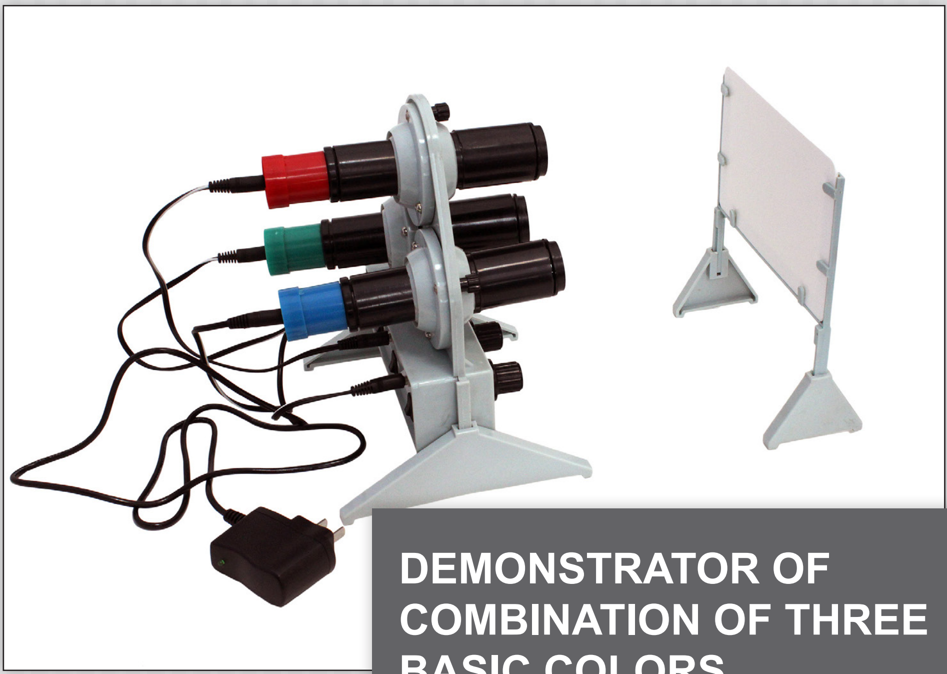
TEACHERS GUIDE



DEMONSTRATOR OF COMBINATION OF THREE BASIC COLORS

ITEM # 3559-30

LIGHT AND COLOR - DEMONSTRATION

Use to demonstrate color mixing and colored shadows. The 3 colored lights can be overlapped in any combination to show additive color mixing, complementary colors, color fatigue, and colored shadows. The 3 light sources (red, green, and blue) are easily installed in the base, and with just the turn of a knob, you and your students can experiment endlessly. Use the small white screen (included) for easy viewing, or project onto a larger screen or white wall for classroom demos.

Materials

- Construction paper (or butcher paper) in multiple colors (red, blue, green, cyan, magenta, yellow, black, other)
- pencil or other narrow object
- piece of paper with a small hole in the center
- color filters

Goals & Objectives

See page 8 for Next Generation Science Standards (NGSS)

INTRODUCTION

The spectrum of visible light consists of a broad swatch of wavelengths and frequencies along the electromagnetic spectrum. On the other hand, our perception of light is not based on a continuum so much as it is the result of the mixing of only a few colors that represent a much narrower selection of light wavelengths. Indeed, this color mixing is a bit more complex than the traditional color wheel that historically (and incorrectly) identifies red, yellow, and blue as the primary colors that mix to create orange, green, and purple.

The Demonstrator of Combination of Three Basic Colors makes exploring and experimenting with additive color mixing simple and accessible for everyone. Use the small screen (included) for individual or small group work, or project onto a white wall or larger screen to demonstrate concepts for the entire class. Address physics concepts such as wavelengths and the electromagnetic spectrum and connect the learning to concepts in biology such as sensory perception, anatomy and physiology of the eye and nervous system, and variation between individuals and species.

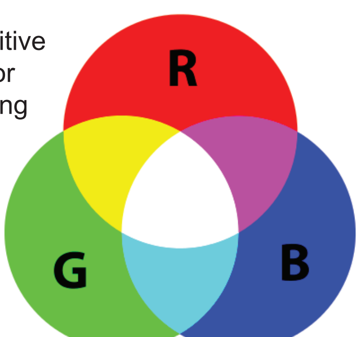
How It Works

The human nervous system senses light as it hits the retina at the back of eye. The retina is made up of light receptor cells (photoreceptors) called rods and cones. Rods do not recognize colors, and send messages to the brain regarding shape, lines, light and shadows. Cones are capable of distinguishing colored light. There are three kinds of cones. Each is activated by a narrow range of light wavelengths in either the red, green, or blue range. Different colors along the visible light spectrum activate the different cones in varying amounts sending combinations of messages to the brain such that humans can detect and distinguish between a very broad range and variety of colors.

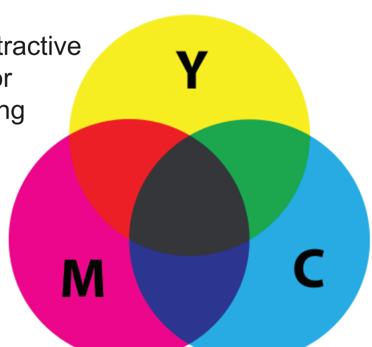
The Demonstrator of Combination of Three Basic Colors models the properties of additive color mixing that can be detected by the human eye. By mixing the three primary colors of red, green, and blue light, the Demonstrator can be used to create cyan light (green and blue), magenta light (blue and red), yellow light (red and green) and white light (red, green, and blue). By varying the intensity of each of the light sources, a broad range of additional colors can be created. This particular demonstrator works well in conjunction with the human eye, because it uses the primary colors that activate human cone photoreceptors. Other species, with different combinations of photoreceptors, would recognize the broadest mixing of colors with lights that matched their own photoreceptors. For example, some insect species would recognize additional color combinations if an ultraviolet light source was added.

Mixing different colors of light is known as additive color mixing. In contrast, subtractive color mixing creates different colors when additional colors of the spectrum are subtracted or absorbed by a medium, allowing a limited range of light to reflect off of the medium. The light that is reflected is the color detected by the eye. Primary colors for subtractive color mixing are cyan, magenta, and yellow. With the addition of black – or key – the CYMK color model is typically used for inks, paints and printing, including photographic printing.

Additive Color Mixing



Subtractive Color Mixing



ACTIVITIES

For younger students, focus on science practice skills such as predicting, making observations, and explaining at an age appropriate level. More complex physics, anatomy, and physiological concepts can be addressed using the same activities with middle school students and higher.
Use the small screen (included) for small groups or a larger screen or white wall for classroom demos. Dimming the lights is advised.

1 ***Getting Started:***
To begin color mixing exploration, allow students to see the colors on their own before overlapping the beams of light on the screen. Adjust the intensity of the light sources such that a white patch of light is in the middle of the overlapping circles. Play a little with the intensity of the lights to create different mixtures. Have students share their observations and any explanations for what they observe. Introduce terms such as primary colors, secondary colors, and complementary colors.

2 ***Shadows:***
Overlap the three beams of light to create one circle of white light. Use a pencil or other narrow object to create a shadow on the screen. Vary the distance of the pencil from the screen. Have students share their observations and any explanations. You may also choose to turn off one color beam at a time and make observations of the shadows with only two colors of lights. Have students discuss the explanations for their observations.

3 ***Experiment and Play:***
Have students explore color perception and light by experimenting and playing with additional concepts. Be sure to discuss observations and possible explanations. For example:

a *Color absorption:*
Project the colored light beams onto different colors of construction paper or butcher paper.

b *Color absorption II:*
Project the colored beams through different colors of plastic filters.

c *Pin hole:*
Project the lights through a hole in a piece of paper. Vary the distance of the hole from the light sources and the screen. Pay attention to the positions of the colors on the screen as compared to the positions of the light sources.
Which one is on top? Bottom? Right? Left?

ACTIVITIES

Activities continued

c *Color fatigue/After images:* Adjust the colored beams to create a triangle of colors with a patch of white in the center. Stare at the center of the white patch for 30-60 seconds. Be sure not to look away from the center! Turn off all of the light beams at exactly the same time and continue looking at the screen.

What do you see? What do you think would eventually happen to your vision if you were exposed to an environment with only blue light? Green? Red?

4 ***Subtractive color mixing:*** Use ink, paint, or food coloring (or other liquids with pigments that selectively absorb different wavelengths of visible light) to experiment with subtractive color mixing. Compare the results to additive color mixing with colored lights.

***Note**

It is always wise to DO an experiment ahead of time to be able to best present it to the class.

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HISTORY

Color mixing using primary colors has existed in art and art education for centuries. Historically, red, yellow, and blue were the primary colors used by artists and were mixed to create a range of additional colors. While the red, yellow, blue (RYB) color model has remained, to some extent in art, and to a greater extent as a misconception of how our eyes blend and perceive color, current color theory suggests that red, blue, and green (RGB) can be blended to create a much broader array of colors. This broader array of colors is, in part, due to the way that the human eye perceives light. In fact, modern painters who continue to use the RYB color model for mixing often supplement their palettes with additional colors, and others have switched over a different color mixing model altogether. Most televisions and computers rely on the RGB color model to create the broad array of colors displayed on their screens.

DISCUSSION

Additional Discussion and Real Life Applications

1. *The three color combinations of additive light mixing works well for humans who have three distinct types of color receptors (red, blue, and green) in the retina at the back of the eye. Many people who are color blind are born with one or more color photoreceptor types that do not function correctly. How would color mixing and color perception be different for someone whose eyes could not perceive one or more of the primary colors? Consider what the world and the light beams would look like for people with each type of missing photoreceptor. Is anyone in the class color blind? If they are willing to share, have them describe what they see in the color mixing investigations. This discussion can be extended by having students complete one or more tests for color blindness (a few online options can be found in the resources section of this guide). Connections can also be made to genetics and the concept of sex-linked traits.*

2. *What are some reasons that artists and early scientists may have considered red, yellow, and blue as the best primary colors for color mixing? Which colors did you learn as primary colors? How do your investigations with the red, green, and blue lights change or support your understanding of color mixing and color perception?*

3. *Some traditional secondary colors, such as purple and orange, are missing from the basic additive color mixing that creates cyan, magenta, and yellow. How can the RGB color mixing model be used to create orange or purple? What about brown? Gray? Test your predictions, if necessary.*

4. *Develop a model or description to demonstrate or explain how after images are created.*

GLOSSARY

Vocabulary:

- additive mixing
- complementary colors
- cones
- retina
- photoreceptors
- primary colors
- secondary colors
- subtractive mixing
- tristimulous theory of color perception
- visible light
- wavelengths

RESOURCES

Online color blindness tests and additional information

- http://www.color-blindness.com/color-blindness-tests/
- http://enchroma.com/test/instructions/
- http://colorvisiontesting.com/

Next Generation Science Standards

Students who demonstrate understanding can:

1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated.

1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science

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MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.