

FILTERING LIGHT

grades 6–12

Objective

Show how color filters selectively block some colors of light and not others to demonstrate how color filters are used in creating astronomical images.

Introduction

Astronomers use electronic cameras called CCDs to create digital astronomical images. However, a CCD cannot determine the color of the light that strikes it. To take color pictures, CCDs must be equipped with color filters.

Color filters block certain wavelengths of light and let others pass through. For example, a green filter blocks all wavelengths except green light. To create color pictures, a CCD takes three separate pictures of the same object using red, blue, and green filters. These pictures are then combined to create a single color image. Astronomers assign a color to each pixel of the final image according to its brightness when observed through each of the different filters. All the astronomical color pictures that we see in magazines and books come from three separate images that are added together.

Background Reading for Educators

Digital Images: The Universe Exposed!, available at

https://www.amnh.org/content/download/1898/25301/file/du_x03_digital.pdf

Developed with the generous support of
The Charles Hayden Foundation



Materials

Styrofoam plate

5 Green M&M's, 5 Red M&M's,
5 Brown M&M's

Red cellophane

Green cellophane

Black-and-white photograph

(Preferably a black-and-white landscape
such as an Ansel Adams picture)

Magazines containing color
photographs

Index card

Scissors

Tape

Procedure

Part One: Thinking in Colors

- 1] Hold up a black-and-white photograph and have your students describe the image. The image you select should contain nothing more than black, white, and shades of gray.
Ask: What colors do you think would comprise the picture if we could insert colors? Why do you think the camera did not detect these colors?
- 2] Place a styrofoam plate on the table and put the M&M's on the plate. Arrange the red colors on the left, the brown colors in the middle, and the green colors on the right.
- 3] The students should think of the M&M's as different wavelengths of light coming from the Sun. The CCD cameras used by astronomers cannot distinguish these colors unless they use filters.
Ask: If you took a picture of the M&M's with a camera using black and white film, would all of the M&M's appear the same color?
Explain: Each colored M&M would appear gray.

Part Two: Observing with Filters

- 4] Take the red cellophane and place it over the plate. It is important to double up on the cellophane paper to ensure that it is strong enough. You will notice that red M&M's are visibly red and the green M&M's and brown M&M's appear black.

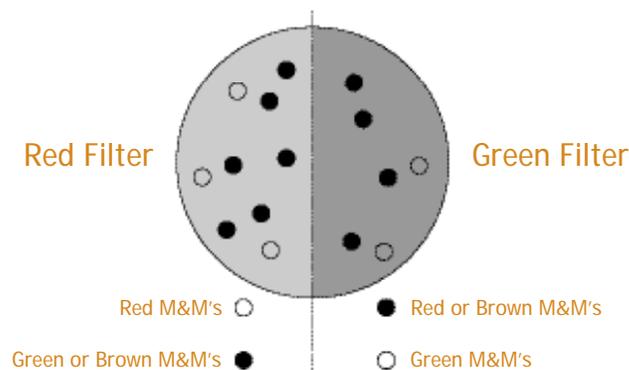
Ask: What color are the M&M's?

Explain: A red filter allows only red light to pass through, so you can get a bright image only of the red M&M's; the others appear black.

- 5] Repeat step 4 with the green cellophane paper.

Ask: Why can't you see the red M&M's anymore?

Explain: Color filters allow you to see just one color at a time. You could find the red M&M's even with a black-and-white camera, because the red filter would make all the other colors appear black.



- 6] Tape the two filters together so that the red filter covers half of the plate and the green filter covers the other half. Tape the red/green filters to the bottom of the plate. Roll the M&M's back and forth and notice how the green are visible only when they are under the green filter, the red are visible only under the red filter, and the color of the brown M&M's is never distinguishable.

Explain: Pictures taken from space are often made with three filters: a red one, a green one, and a blue one. If each color of M&M's represented a different wavelength of light from the Sun, we could pick out the red, blue, and green wavelengths using color filters. Astronomers take three pictures through different filters, and by measuring the intensity of the light visible through each filter, they find out the brightness of each color in the image. They then combine this information to make a single color image.

Part Three: Looking Around with Filters

In advance of this activity, have the students bring in a magazine of their choice, preferably one with bright colors in it. Have each student take two index cards and cut out a 2-inch square in each one. Distribute a piece of red cellophane and green cellophane to each student.

- 8] Have each student tape a piece of red cellophane to one of the index cards (so that it is in front of the square) and a piece of green cellophane to the other index card. They can double or triple the cellophane if it lets through too much light.
- 9] Have the students flip through their magazine looking at the pictures with their filter windows. They should look through the magazine with the red filter, then with the green filter, then with no filter at all.
- 10] Invite the students to look around the room using the red filter, then the green filter. Be sure to have them look at the light bulb. If a student in the class is wearing a brightly colored shirt or sweater have the students look at the clothing through their filters.
- 11] Engage the class in a general discussion about what they noticed about the room and the magazine as they looked at it with the filters.
Ask: Why was the light bulb visible through every filter? Which parts of a photo were darkened by each filter? Why?
Explain: You can look at the same picture in a magazine with different filters and find which parts are red, blue, green, or a mixture of different colors. By observing how bright or dark different parts of the picture are through each filter, you can piece together the colors of the entire picture. This is how astronomers make astronomical images. Light bulbs appear bright through every color filter because white light is a mixture of every color of light.