ACTIVITY 4

Color Filters and Light

OBJECTIVES

Students add to their understanding of subtractive color mixing by investigating the effect of filters on the color of light.

The students

- shine white light through color filters and observe how the color of the light changes
- predict and then observe the effects of passing white light through different combinations of color filters
- compare this process with the process of mixing pigments

SCHEDULE

About 60 minutes

VOCABULARY

filter

MATERIALS

For each student

1	Activity Sheet 4, Parts A and B

For each team of two

2	batteries, D-cell
1	flashlight
1 sht	paper, white

For the class

3 shts	acetate, blue
1 sht	acetate, frosted
3 shts	acetate, green
4 shts	acetate, orange
3 shts	acetate, red
4 shts	acetate, violet
3 shts	acetate, yellow
6	bags, plastic, reclosable
1 pair	scissors*
1 roll	tape, masking

*provided by the teacher

PREPARATION

1. Make a copy of Activity Sheet 4, Parts A and B, for each student.
2. Install batteries into flashlights, and check to see that all of the flashlights work properly.
3. Cut the sheet of frosted acetate into squares 5 cm × 5 cm (about 2 in. × 2 in.), one square per flashlight. Tape a frosted acetate square over the working end of each flashlight so that the lamp is completely covered by the square. Make sure that the tape does not obstruct any of the light.
4. Cut the sheets of blue, green, orange, red, violet, and yellow acetate into pieces 10 cm × 12.5 cm (about 4 in. × 5 in.). These pieces of acetate will now be referred to as color filters. Note that you will probably not use all of the pieces that you cut in this activity. Return all extra pieces to the kit.
5. Each team of two will need a working flashlight with a piece of frosted acetate taped over one end, a sheet of white paper, and six color filters (one each of blue, green, orange, red, violet, and yellow).

BACKGROUND INFORMATION

A ***filter*** is a substance or device that prevents certain things from passing through it while allowing certain other things to pass. Color filters allow only certain colors of light to pass through them by absorbing all the rest. When white light shines on a red filter, for example, the orange, yellow, green, blue, and violet components of the light are absorbed by the filter, allowing only the red component of the light to pass through to the other side of the filter.

A pure filter allows only a single color of light to pass through it. Like pigments, however, most filters are not pure—they allow more than one color through. For example, most yellow filters also allow some red, orange, and green light to pass through them, but our eyes see a mixture of yellow, red, and green light as simply yellow. Likewise, a blue filter allows some violet and green as well as blue light to pass, but our eyes perceive the mixture as blue.

Overlapping different color filters (placing one on top or in front of another) is a lot like mixing different food colorings in that new colors are formed by the process of subtractive color mixing. Each color filter that is added subtracts certain colors from the colors of light that strike it. For example, if the blue and yellow filters mentioned above were overlapped, the yellow filter would absorb the blue and violet light that passed through the blue filter, allowing only the green through.

The frosted acetate is used in this activity to diffuse the light from the flashlight, making the light intensity more uniform.

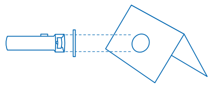
▼ Activity Sheet 4, Part A

Color Filters and Light

1. Fold the sheet of white paper in half so that it stands up by itself in the shape of an upside-down V. You will use this as a screen to shine light on.

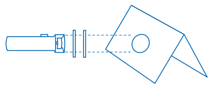
2. Choose a color filter and predict what you will see when you shine light through it. Record your prediction in the chart. Then place the filter in front of the flashlight and shine the light on the screen. Record your results. Repeat for the remaining five filters.

Filter Color	Prediction	Results
red	Predictions	red
orange	will vary.	orange
yellow		yellow
green		green
blue		blue
violet		violet



3. Use two filters for this step. For each combination of filters, predict what color light you will see. Record your prediction. Then place both filters in front of the flashlight and shine the light on the screen. Record your results.

Filter Color	Prediction	Results
red + yellow	Predictions	red-orange
yellow + blue	will vary.	green
blue + red		violet
green + red		green
blue + green		turquoise
green + yellow		green
There are		
over 15		
possibilities.		

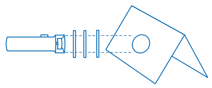


▼ Activity Sheet 4, Part B

Color Filters and Light

4. Use three filters for this step. For each combination of filters, predict what color light you will see. Record your prediction. Then place the three filters in front of the flashlight and shine the light on the screen. Record your results.

Filter Color	Prediction	Results
g+b+y	Predictions	blue-green
r+v+b	will vary.	dark violet
g+v+b		green
r+b+g		green
r+b+y		red
o+b+g		green
There are		
over 20		
possibilities.		



Guiding the Activity

Additional Information

1 Write the word *filter* on the board. Ask the students, **What do you think a filter is? Can you give an example?**

*A **filter** is something that lets certain things through but blocks others. An example is a wire mesh sieve that allows sand and pebbles to fall through, but holds back—or filters out—larger stones. Another example is a kitchen strainer used to drain the water from spaghetti or vegetables.*

Tell the students that in this activity they will observe what happens when white light passes through color filters.

2 Hold up several of the color filters. Ask, **What do you think these objects filter out or allow through?**

Each one filters out certain colors of light and allows other colors to pass through.

What does the red filter block and what does it let through?

It lets red light through but blocks (absorbs) other colors of light. Some students may know or guess that it actually lets through some other colors in addition to red (such as orange and violet).

3 Divide the class into teams of two. Distribute a copy of **Activity Sheet 4, Parts A and B,** to each student. Go over the instructions on the activity sheets with the students.

Distribute a sheet of white paper, a flashlight with a piece of frosted acetate taped to it, and a set of filters (blue, green, orange, red, violet, and yellow) to each team of students.

Demonstrate how to position the flashlight and filters and how to fold the sheet of white paper in half so that it can set up as a paper screen (see Figure 4-1).

Tell students to predict what will happen when the white light from their flashlights shines through each individual color filter. Have them record their predictions on the activity sheets.

4 Darken the room. Allow about 15 minutes for the students to experiment with each of the six filters and to complete the chart at the top of their activity sheets.

Tell students that only single filters should be used at this point; combinations of filters will be tested shortly.

Guiding the Activity

Additional Information

5 After about 15 minutes, turn on the classroom lights and begin a discussion of the students' results. Ask, **What happened when you shined white light from the flashlight through a blue filter? Why? What happened to the other colors that make up the white light?**

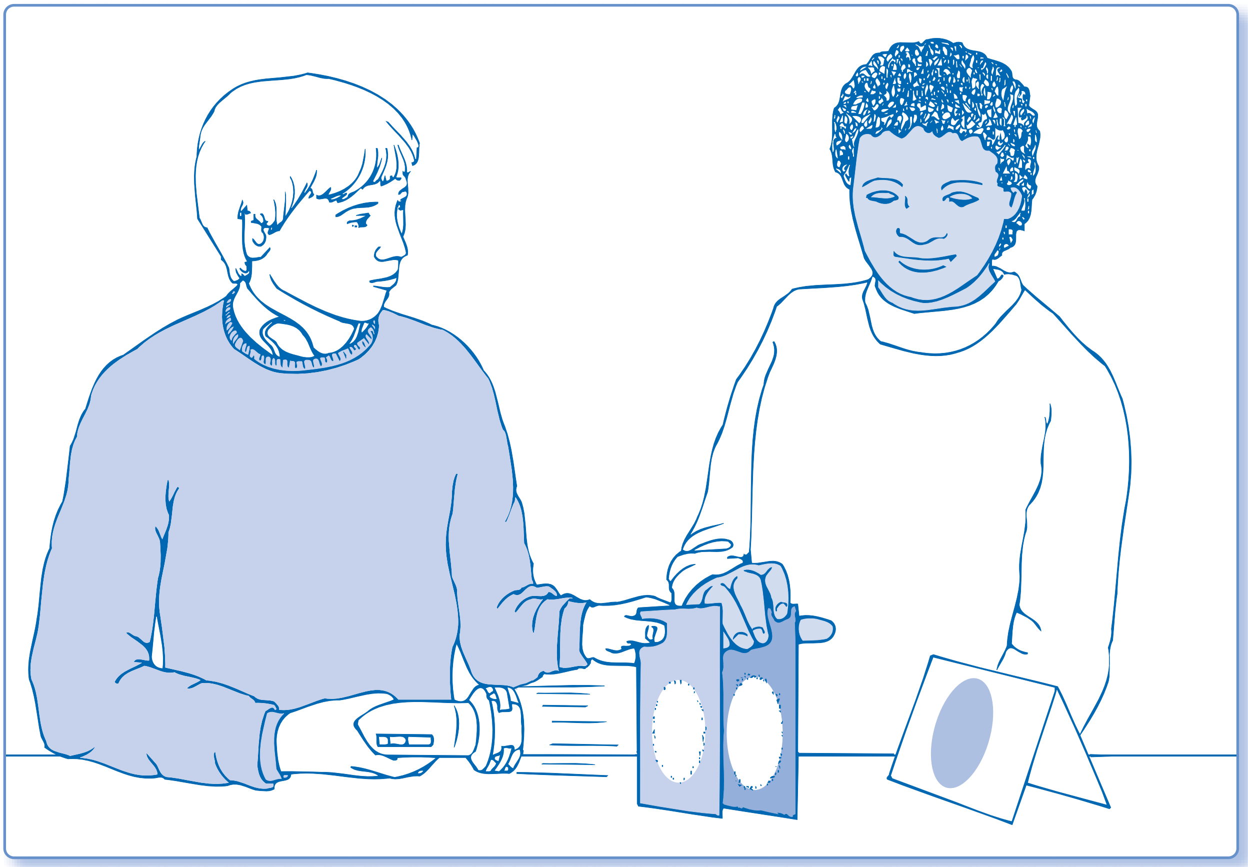
The light that passed through the blue filter was blue because all the other colors were filtered out, or absorbed, by the blue filter.

Ask, **What do you predict will happen when you shine your flashlight through two overlapping color filters?**

Answers may vary.

Remind students to record their predictions in the second chart on their activity sheets.

6 Darken the room again. Allow about 15 minutes for the students to experiment with combinations of two overlapped filters. Tell them to record their results on their activity sheets.



▲ ***Figure 4-1.*** *Which colors of light will pass through the filters?*

Guiding the Activity

Additional Information

7 After about 15 minutes, turn on the classroom lights and ask, **What happened to the light when you overlapped two filters? Does the light change color when you add filters? Does it get brighter or dimmer? Why?**

The light changes color because each added filter absorbs additional colors of light. The intensity of the light decreases (the light gets dimmer) because each color removed diminishes the total amount of light that gets through the filters and hits the paper screen.

Ask, **What do you predict will happen if you shine light though three overlapping color filters?**

Have students record their predictions in the third chart on their activity sheets.

8 Darken the room once again so the students can test their three-filter combinations. Remind them to record their results.

9 When students have finished testing their three-filter combinations, instruct them to overlap all six filters at one time and to observe what happens to the light.

No light is able to pass through all six filters.

Ask, **Why doesn't any light get through to the screen?**

Every color of light in the spectrum has been absorbed by one or more of the color filters.

10 Turn on the classroom lights. Ask, **Do the results you obtained overlapping filters remind you of anything else you have examined recently?**

The students should recognize that overlapping the filters formed new colors in a manner similar to what they observed when mixing water colored with pigments.

Ask, **Did you notice any differences between the results obtained using overlapping filters and the results obtained by mixing colored water? How would you explain these differences?**

Students may come up with a variety of responses.

One remarkable difference is that combining red and yellow filters results in essentially red light, not the expected orange. This is because a yellow filter can allow a large amount of red and green light to pass through it and still look yellow, whereas the red filter is much more effective at blocking out other colors. Similarly, overlapping green and yellow filters yields a much darker green than students might expect after their pigment-mixing experiments.

REINFORCEMENT

Prepare three glasses of water: To one, add 10 drops of red food coloring; to a second, add 10 drops of blue food coloring; and to a third, add 10 drops of yellow food coloring. Show students that colored water acts like a filter, changing the color of the light that passes through it. Have students experiment to see whether overlapping colored liquids yields the same results as overlapping filters. Then challenge them to find ways in which the two processes differ and to explain why. For example, overlapping glasses of red and yellow colored water results in very orange light, while overlapping red and yellow filters results in very red light. This is because red food coloring allows more orange light to pass through than the red filters do.

Assessment Opportunity

This Reinforcement also may be used as an ongoing assessment of students' understanding of science concepts and skills.

SCIENCE JOURNALS

Have students place their completed activity sheets in their science journals.

CLEANUP

Leave the squares of frosted acetate taped to the flashlights for use in Activity 5. Place the color filters into the plastic, reclosable bags, one color per bag. Return the flashlights, paper screens, color filters, and roll of masking tape to the kit.

Connections

Science Challenge

Ask students to find out what the words *transparent, translucent,* and *opaque* mean and to give examples of materials that can be described in these terms. (Transparent materials allow light to pass directly through them; objects can be seen clearly through transparent materials. Translucent materials allow light to pass through them but scatter it in all directions; objects cannot be seen clearly through translucent materials. Opaque materials do not allow any light to pass through them; objects cannot be seen at all through opaque materials.)

Science Extension

Pose the following question to the class: If sunlight is white light, and air has no color, why does the sky look blue during the day and red, orange, or pink at sunrise and sunset? Give students some time to think about and discuss the question, then have them do the following activity in teams. Fill a drinking glass or other tall, clear container with water. Hold a sheet of white paper behind the container, and shine a flashlight directly at the container from the other side. Students will see white light shining on the paper. Next have students add about half a teaspoon of milk to the water, mix it thoroughly, and then shine the flashlight at it from the side again. This time, the cloudy water in the container and the light shining on the paper will be reddish orange. Also have students shine the light down into the container from above and note the bluish-grey color of the cloudy water. Repeat your original question, and ask students to use their observations to try to answer it, at least partly. (Air in the atmosphere contains billions of tiny dust particles. When sunlight hits these particles, it bounces off them and scatters. Blue and violet light waves scatter the most, orange and red waves the least. When the sun is higher in the sky during the day, less light is scattered and more blue light reaches our eyes, making the sky appear blue. When the sun is low in the sky at sunrise or sunset, most of the blue light is scattered and primarily red and orange light color the sky. This phenomenon also explains why spectacular sunsets often occur after a volcanic eruption releases ash and dust into the atmosphere.)

Science and the Arts

Suggest that students find out how stained glass windows are made for churches, homes, and public buildings. Students might enjoy making a model of a stained glass window by cutting out sections of a sheet of black oak tag, leaving areas between the cut-out sections to represent the leading that holds a stained glass window together, then gluing pieces of tissue paper over the cut-out sections and coloring them with marking pens. Have students hang their completed windows against the classroom window so they can observe the amounts and colors of light that pass through the sections.

Science, Technology, and Society

Ask students whether they have ever seen a store window covered with a transparent, yellow window shade. Ask them why such shades are used. (to keep materials in the display from being faded and discolored by sunlight) Explain that the shades act as filters to screen out some of the sun's rays but still allow people to view the display without distorting its colors too much. Let students test the fading power of sunlight by hanging a brightly colored strip of fabric in a sunny place, putting an identical strip in a dark place, and comparing the color of the strips every week for a month or two.