LESSON 8

Where Does Color Come From?

CORBIS/ROYALTY-FREE

When people enjoy the fall colors, what are their eyes detecting?

INTRODUCTION

In the fall, hundreds of thousands of tourists from all over the world go to New England to enjoy the changing colors of the leaves. Color is very important to them, but then it is important to everyone. Whether you are shopping for new clothes or a car, following a marked trail in the woods, or waiting for a red light to turn green, color matters. Color provides you with a great deal of useful information about your environment. The universe would certainly be a dull place without it. So, what is color? Why do things appear to be colored? Where does color come from? When you see color, what exactly are you seeing? In this lesson and the four that follow, you will try to answer some of these questions as you investigate color.

OBJECTIVES FOR THIS LESSON

Investigate where color comes from.

Discuss the appearance of the visible spectrum.

Getting Started

1. Collect the plastic box of materials. Take out the flashlight and triangular prism. Wait until you do Inquiry 8.1 to divide the rest of the materials between the pairs in your group.

2. Hold the triangular prism close to your eye and look around the room. Look through the window and at the lights in the classroom. Make sure your partner gets a turn. Discuss with your partner where you have seen this effect before.

3. After your teacher has darkened the room, shine the flashlight through the prism onto the ceiling. Try holding the prism at different distances from the flashlight and turning the prism around in the beam of light. What do you observe?

4. Discuss your observations with your group and with the class.

MATERIALS FOR LESSON 8

For your group

- 1 ray box
- 1 ray box lid
- 1 60-W clear halogen lightbulb
- 1 extension cord
- 1 bulb holder
- 2 narrow-slit ray box masks
- 2 no-slit ray box masks

For you and your lab partner

- 1 triangular prism
- 1 flashlight
- 2 D-cell batteries
- 1 white screen
- 2 plastic stands
- 1 box of colored pencils

Inquiry 8.1
Using a Triangular Prism To Examine White Light

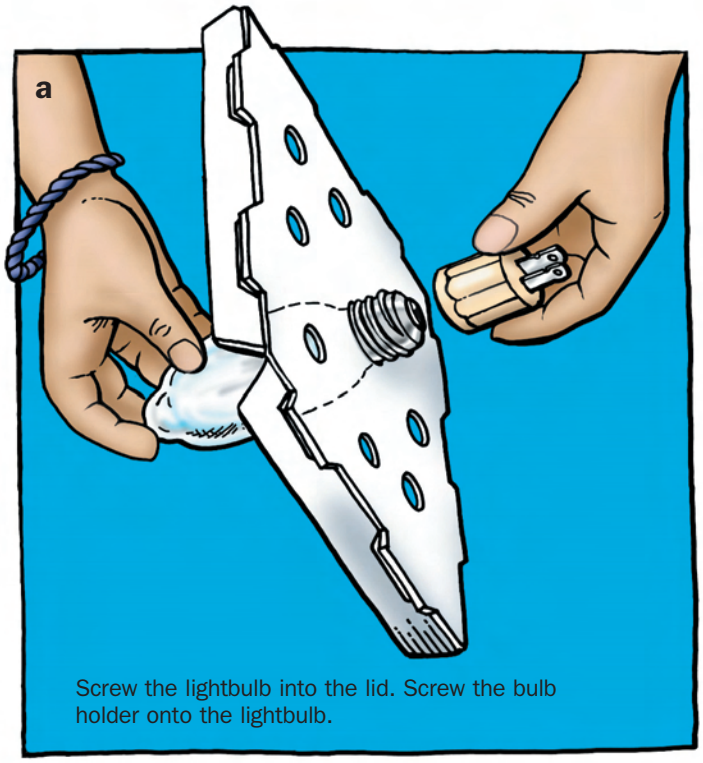
PROCEDURE

1. Record your responses for this inquiry in your science notebook. There is no student sheet for this lesson.

2. Watch as your teacher demonstrates how to set up the ray box, prism, and white screen. Use Figure 8.1 as a guide as you follow the instructions to construct your ray box set out in the diagrams labeled a–d.

SAFETY TIP

The lamp in the ray box gets hot. Allow it to cool for at least 5 minutes before handling the lightbulb.



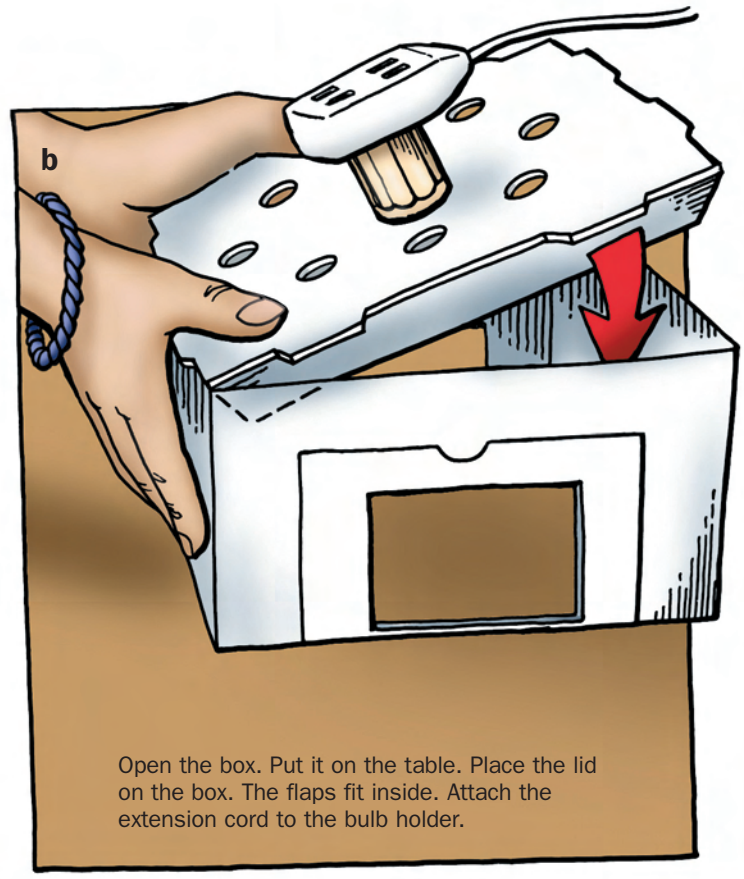
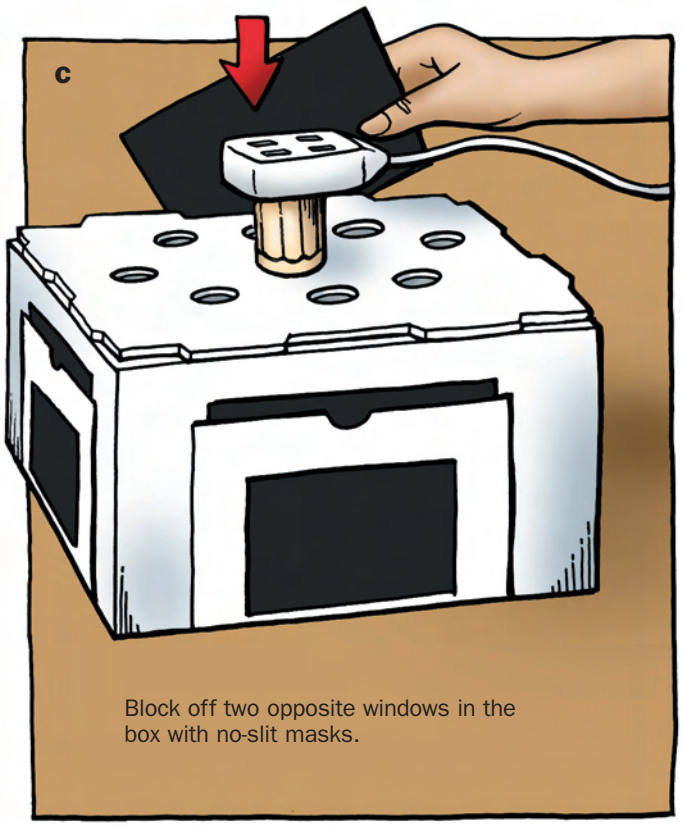
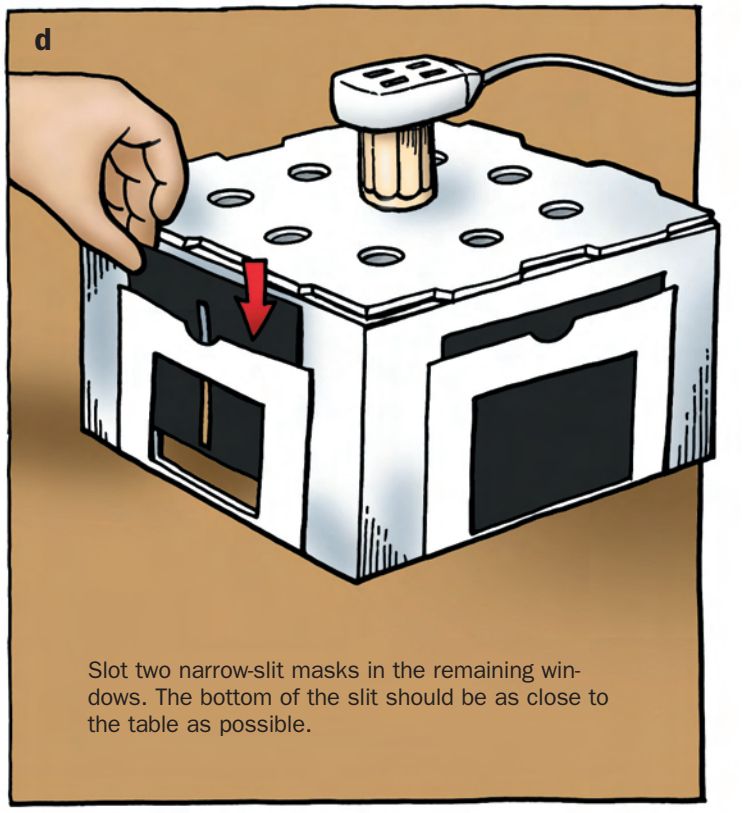


Figure 8.1 *Assembling the ray box. Two pairs can use each box.*

3. Place the triangular prism in the path of the light ray.

A. Draw what happens to the path of the light ray as it enters and leaves the prism.





SAFETY TIP

Turn off the ray box immediately after you finish using it. Allow the ray box to cool.

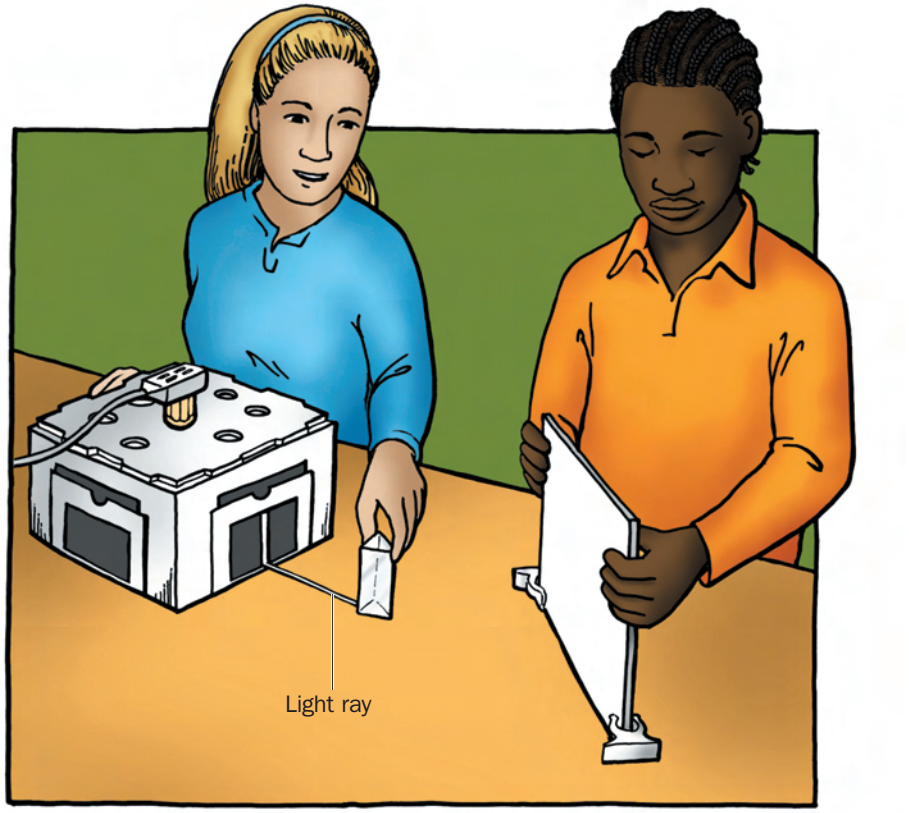


Figure 8.2 *Can you get the colors you observed in "Getting Started" to form on your screen?*

4. Attach the plastic stands to the white screen. Place the screen in the path of the light ray leaving the prism. Rotate the prism and, if necessary, move the screen (as shown in Figure 8.2) until you get the same colors you observed in "Getting Started."

B. Use colored pencils to draw what you see.

C. Write down the names of the colors in the order in which you observe them.

D. Can you get the colors to appear on the screen in a different sequence?

5. Where do you think the colors you observed came from? Discuss your ideas with your partner. Here are some questions to consider:

What happened to the light rays when they first entered the prism?

Did all the colors leave the prism at the same place?

What did the prism do to the white light?

E. Write a paragraph explaining where you think the colors came from.

REFLECTING ON WHAT YOU'VE DONE

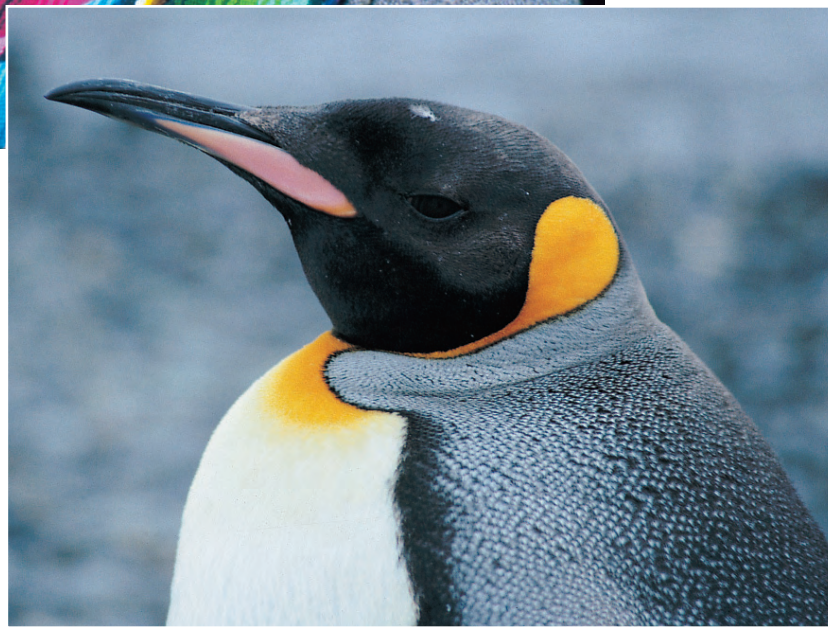
1. Scientists once thought that glass added colors to white light. What do you think of this hypothesis? How could you test it? Discuss this idea with your group. Be prepared to engage in a class discussion.

2. Read "The Impurity of White" and record your responses to A and B in your notebook.

A. What did Newton's experiments prove?

B. Write a paragraph summarizing his experiment.

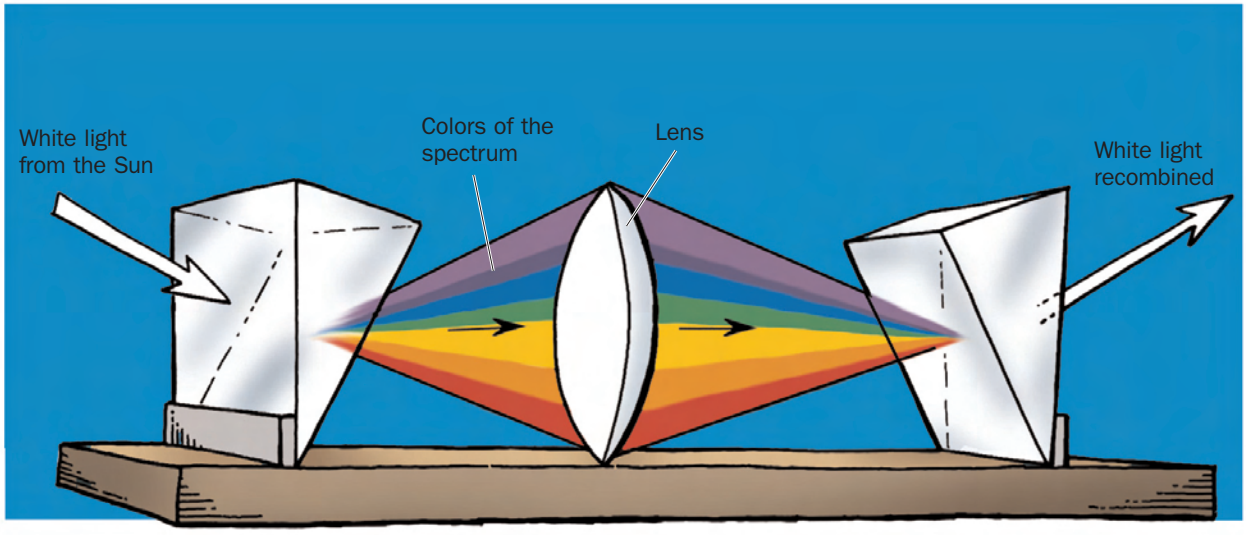
The Impurity of White



All color comes from light, whether it is the colored beak of a spectacular bird like this penguin or the bright colors of clothing. All things that are colored reflect some of the colors that make up white light.

For centuries the Western world had thought of white as the color of purity. The color white was associated with all that is pure and innocent. Along came a young English scientist, Isaac Newton (1642–1727), who changed people's ideas about the world of color forever. It was Newton who discovered in the 17th century that white light is not pure; it is a mixture of different colors.

Working in a darkened room, Newton experimented with a beam of light by allowing sunlight to shine into the room through a small hole in the wall. He then



Newton used prisms and a lens to recombine the colors in white light. Sunlight came in from the left, was split into its spectrum, and then was recombined using a lens and a second, identical, upside-down prism.

passed this beam of light through a glass prism. The result was a line of different colors, which he projected onto a white screen. But this part of his experiment was not new.

Many people had already observed that white light can produce a line of colors that is called a spectrum. For thousands of years, people observed how colors were produced when sunlight shone through crystals or droplets of water.

Everyone recognized these colors were the same as those found in rainbows. Most people believed that pure white light from the Sun was changed or contaminated in some way when it passed through the crystals or water. But on that day in 1666, Newton took his experiment one step further. And what he discovered turned people's ideas about the world of color upside down.

Recombining the Spectrum

"What would happen," Newton wondered, "if I used another prism but turned it upside down with respect to the first? Then the colors produced by the first prism would shine into the second one." He tried out his idea. He used two prisms and a lens, as shown here.

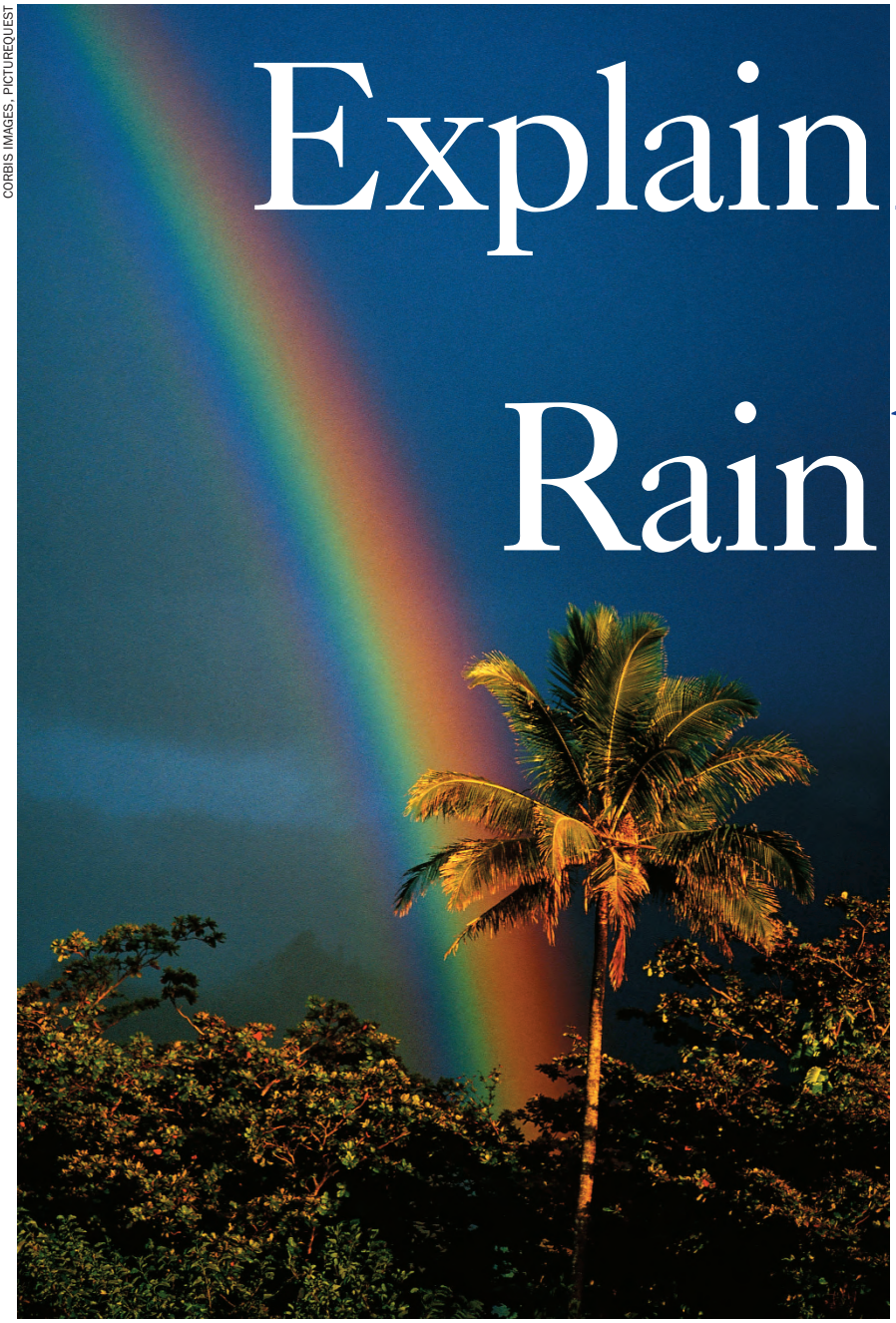
The first prism produced a colored spectrum. The lens then focused the spectrum onto a second, identical, upside-down prism. The spectrum left the second prism as a ray of white light. Newton could think of only one logical explanation. Instead of contaminating white light, the first prism split it into the different colors that make up white light. The second prism recombined those colors back into white light. White was not pure, but instead a mixture of color.

At the time many people found Newton's discovery very disturbing. It took quite a few years before they could accept that white was not a pure color. In fact, it was the least pure of all colors. At first, there was much opposition to his discovery. However, Newton's experiment was easily repeated. By the end of the 17th century, it was widely accepted that Newton's explanation of the spectrum produced by white light was the correct one. □

NORTHWIND PICTURE ARCHIVES

Newton used a glass prism and a beam of sunlight to produce a spectrum. Where did the colors in this spectrum come from?

Explaining a Rainbow



CORBIS IMAGES, PICTUREQUEST

White light is made up of the many colors of visible light—light we can see. A prism splits white light into these colors. It does this by bending the various colors of light at slightly different angles as they enter the prism. This causes the colors to spread out, splitting them apart.

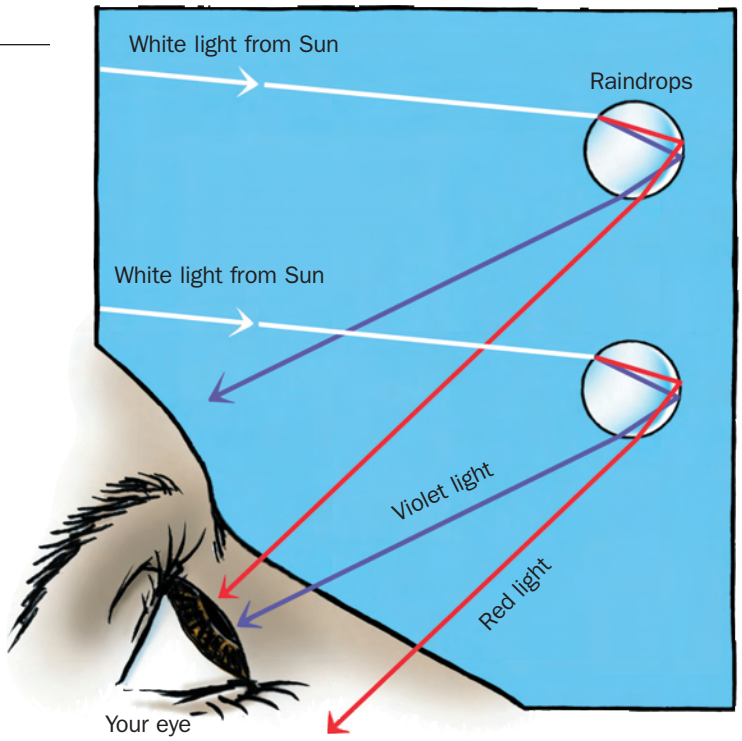
You have seen these colors before. They are the same ones that make up a rainbow. But a rainbow does not contain a prism, so how are the colors of a rainbow made?

A rainbow is not made from a single prism like the one you used, but a summer shower does contain billions of raindrops. As sunlight enters each drop, it bends, bounces off the back of the raindrop, and bends again when it leaves. As you can see from the illustration, bending the sunlight makes the white light split—just like a prism bends and splits white light. The raindrops that produce a rainbow behave a bit like billions of tiny prisms.

But why does a rainbow look like big bands of color? Inside each raindrop, each color of white light is bent a different amount. Because the raindrops are in different positions in the sky, they bend different colors to your eye. The appearance of the rainbow depends on the raindrops that make it up. Larger droplets separate the colors well, making the colors of the rainbow appear more distinct. When the droplets are very small, the colors can overlap and the rainbow becomes almost white and more difficult to see.

Although a rainbow appears to be an arc stretching across the sky, it actually forms a full circle. To an observer standing on Earth's surface, the rest of the circle is hidden below the horizon. There is no end to a rainbow!

Colored bows can be seen wherever sunlight strikes water droplets at certain angles. Many waterfalls produce rainbows in their spray. Sometimes bows of color ("dew bows") can be seen on early morning dew. □



Raindrops split white light into the colors that make it up. Raindrops in different positions send different colors to the eye of someone looking at the rainbow. Red light is seen from raindrops at an angle of 42 ° to the horizon, violet light from raindrops at an angle of 40 °. The other colors of the rainbow are seen at angles between 40 ° and 42 °. This is why rainbows are only visible to the observer as a narrow curved band in the sky. Using this diagram, think about what direction—up or down—you would have to look to see red light or violet light.

You don't need rain to make a rainbow. The spray from a waterfall can produce its own rainbow.

Which Colors Are in a Rainbow?

A rainbow has many colors. How many exactly? Some people suggest there are only seven: red, orange, yellow, green, blue, indigo, and violet. They even have a nonsense phrase to help them remember them—ROY G BIV. How many colors did you detect using your prism? Were there only seven? Could you see a greenish blue or a yellowish green? In fact, there are millions of colors in a rainbow. It's just that we have names for only a few of them!

Can you see in a rainbow or through a prism all the colors our eyes can perceive? Try looking for magenta or brown.