LESSON **10**

Examining Spectra

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These students are using spectroscopes like the one you are going to make to observe different light sources.

INTRODUCTION

Electromagnetic radiation from the Sun provides Earth with light and heat. That same electromagnetic energy also provides scientists with information about the nature of the Sun itself. You have already discovered that white light, including light from the Sun, can be split into many colors or wavelengths. But did you know that by examining the spectrum of sunlight it is possible to determine what the Sun is made of. In fact, studying the spectrum produced by any object—whether a distant giant star or a tiny candle flame—can provide us with a great deal of useful information about it. The study of spectra (spectra is the plural of spectrum) is called spectroscopy. In this lesson, you build an instrument called a spectroscope. You will use your spectroscope to investigate spectra from different light sources.

OBJECTIVES FOR THIS LESSON

Build a spectroscope.

Use the spectroscope to examine light from different sources.

Discuss how spectroscopy is used.

Getting Started

1. Hold the small square of plastic by its edges. Take care not to get any fingerprints on its surface. Look through it at the lights in the classroom. Discuss your observations and the following questions with your partner:

What do you observe?

Have you seen anything similar to this before?

What does this piece of plastic do to white light?

2. Read "How the Piece of Plastic Separates Light."

HOW THE PIECE OF PLASTIC SEPARATES LIGHT

You have been given a piece of plastic called a diffraction grating. Look closely at its surface. It is covered by thousands of regularly spaced, parallel tiny scratches. These scratches bend light waves that pass through the plastic. This bending process is called diffraction. The amount a wave bends depends on its wavelength. This plastic diffraction grating can therefore be used to separate light made up of more than one wavelength—white light, for example. As the different wavelengths in a mixture of visible light bend by different amounts, they separate. These separated wavelengths can be seen as a spectrum of the different colors that make up the mixture.

MATERIALS FOR LESSON 10

For you

1 copy of Student Sheet 10.1: Using a Simple Spectroscope
1 cardboard tube
1 square of aluminum foil
1 square of black paper with a square hole

For you and your lab partner

1 pair of scissors
1 metric ruler
1 box of colored pencils
Masking tape

Inquiry 10.1
Using a Simple Spectroscope

PROCEDURE

1. One member of your group should collect the plastic box of materials. Divide the materials between the pairs in your group.

2. Each member of your group will make a spectroscope. Use Figure 10.1 as a guide as you follow the instructions to construct your spectroscope outlined in the diagrams labeled a–i.

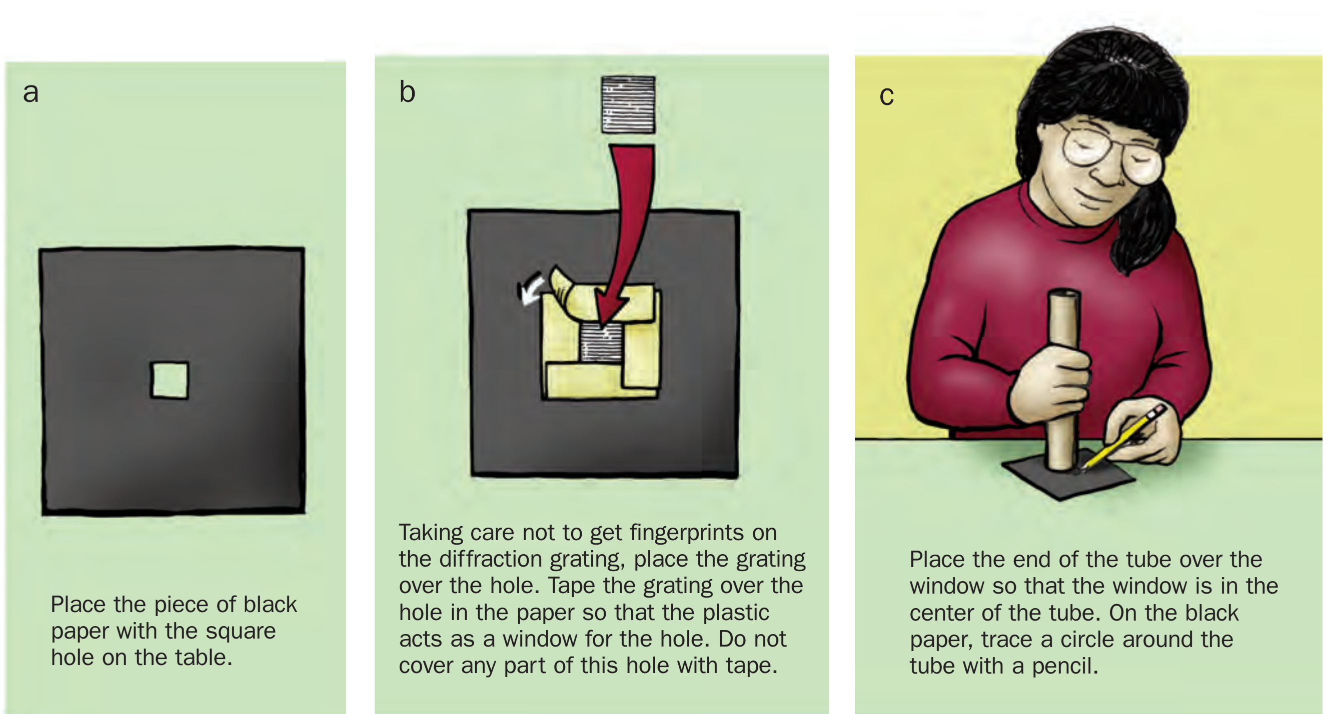
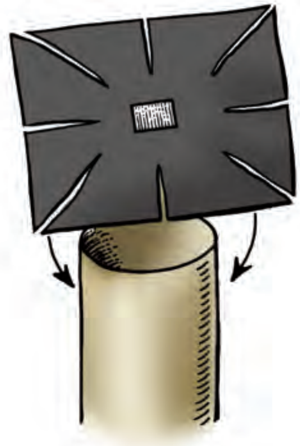


Figure 10.1 *Use these diagrams labeled a–i as a guide to help you construct your spectroscope.*

d

Carefully make cuts in the black paper from the edge of the paper inward to *just outside* the edge of the circle you have drawn.

e

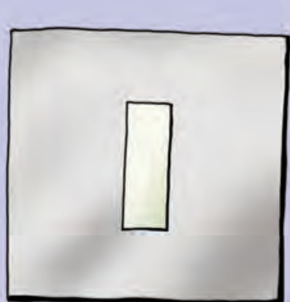


Turn the paper around so that the taped side (with the diffraction grating) faces the open end of the tube.

f

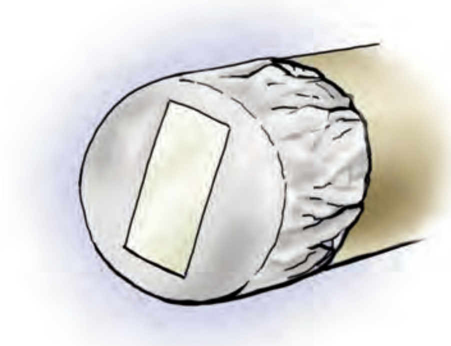
Make sure the diffraction grating window is centered over the opening of the tube. Keep the black paper as flat a possible over the end of the tube and tape it to the end of the tube as shown.

g



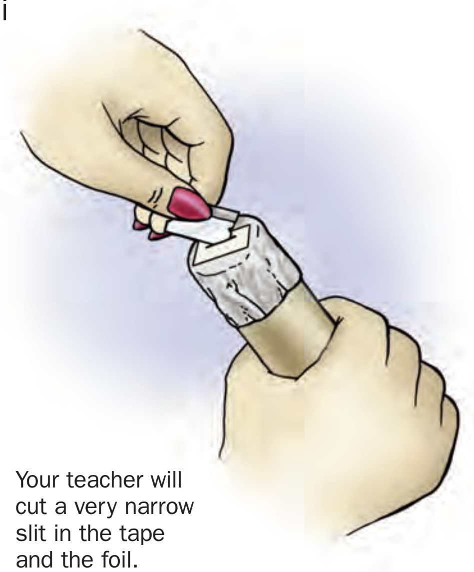
Cut a 3-cm length of masking tape. Stick it onto the center of the piece of aluminum foil.

h



Fold the aluminum foil over the other end of the tube. Make sure the tape on the foil faces out from the end of the tube and lies across the center of the tube. Get the foil as flat as possible. Take care not to tear the foil. DO NOT tape the aluminum foil in place.

i



Your teacher will cut a very narrow slit in the tape and the foil.

3. Your spectroscope is now complete. Compare it to the one in Figure 10.2.

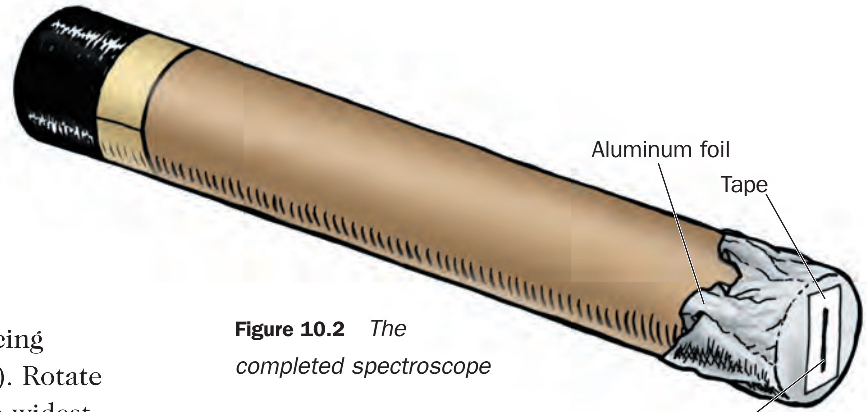


Figure 10.2 *The completed spectroscope*

4. Look through your spectroscope at daylight outside the window. The foil end of the tube should be facing the window (see Figure 10.3). Rotate the foil until you observe the widest spectrum.

A. Use colored pencils to record in the second column of Table 1 on Student Sheet 10.1: Using a Simple Spectroscope exactly what you observe through your spectroscope. Write any observations or comments you have in the third column of the table.

Figure 10.3 *Use your spectroscope to observe daylight.*

SAFETY TIP

Do not look directly at the Sun through your spectroscope, a telescope, or with your bare eyes. It could permanently damage your eyes.

SAFETY TIP

Do not touch any of these light sources. They get very hot and can cause painful burns.

5. Point your spectroscope at an incandescent lightbulb. Record the spectrum and your observations and comments in Table 1. Make sure you record exactly what you see.

6. Point your spectroscope at a fluorescent lightbulb. Look carefully at the spectrum. Record the spectrum and your observations and comments in Table 1. Discuss your observations with your group.

   B. Write a short paragraph comparing the spectra from these three light sources—daylight, incandescent lightbulb, and compact flourescent lightbulb.

7. Your teacher will show you a number of other light sources. Observe each carefully. Record their spectra and your observations and comments in the remaining rows of Table 1.

8. Don't dismantle your spectroscope. Write your name on it. You will be using it again in the next lesson.

REFLECTING ON WHAT YOU'VE DONE

1. Discuss with your group and then answer the following questions on the student sheet:

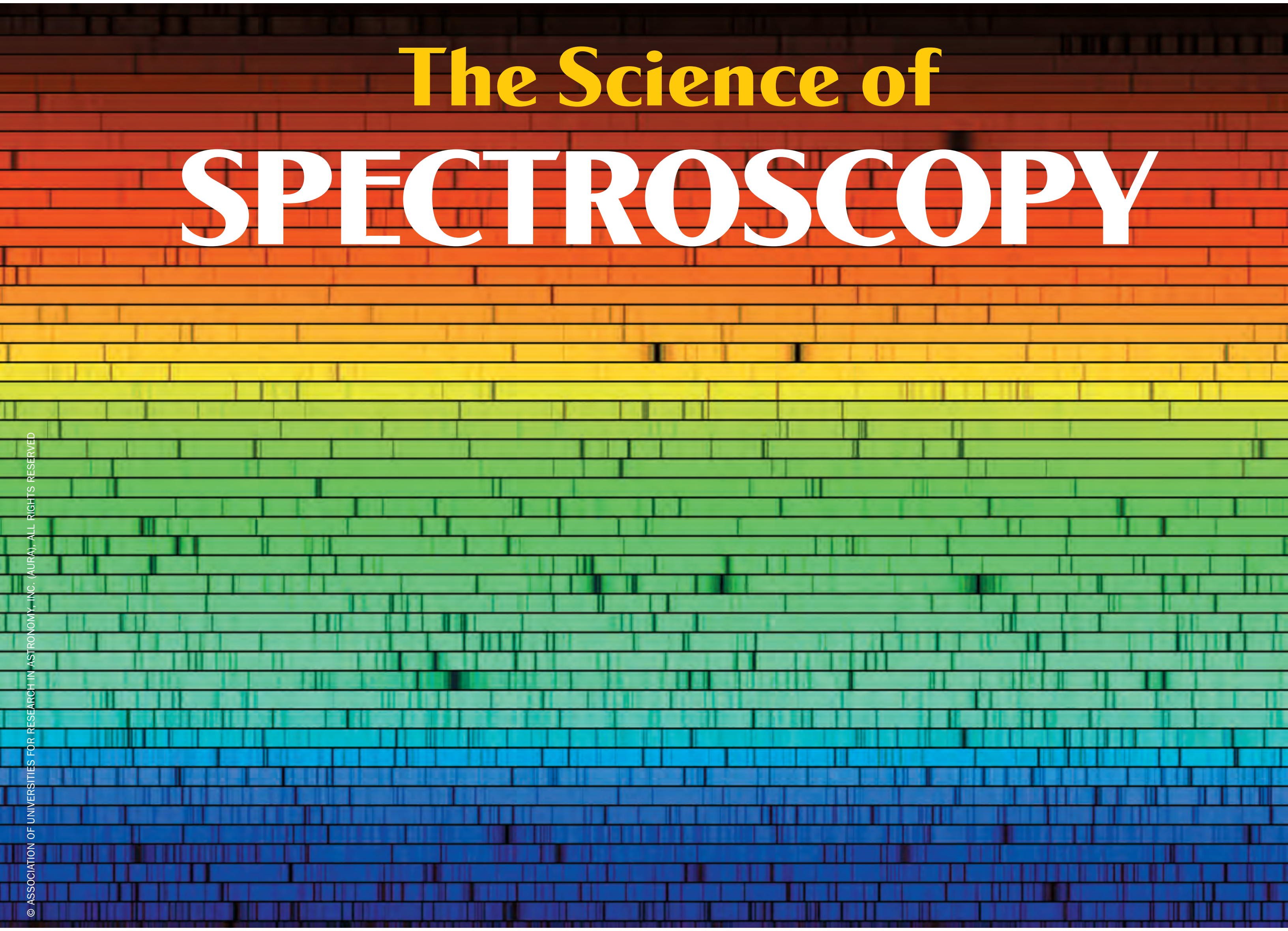
   A. What happens to light when it passes through your spectroscope?

   B. What can you now say about the spectra from various light sources?

   C. How could this information be useful?

2. Read more about how spectroscopes are used in "The Science of Spectroscopy."

The Science of SPECTROSCOPY



A closer look at the solar spectrum shows that it has may different wavelengths and also some gaps that show up as black lines. This spectrum reveals information about the composition of the Sun. This spectrum has been cut up and displayed this way so that it can fit on the page.

All matter consists of one or more chemical elements. When heated to a high enough temperature, all elements glow—they emit light. You may have noticed that various light sources have different colors when viewed with your eyes. For example, fluorescent tubes in your classroom look white, and neon tubes glow red. When you look at light emitted from one of these tubes through a spectroscope, you see the spectrum for that light source. This spectrum is an *emission* spectrum. Every element has a unique emission spectrum.

Substances may also absorb light. For example, if white light is shone through a gas, the gas will absorb some of the wavelengths of the light. If you look through a spectroscope at the spectrum leaving the gas, you will see dark lines where you would expect some of the

HTTP://IMAGINE.GSFC.NASA.GOV

At first glance, the spectrum of sunlight looks continuous.

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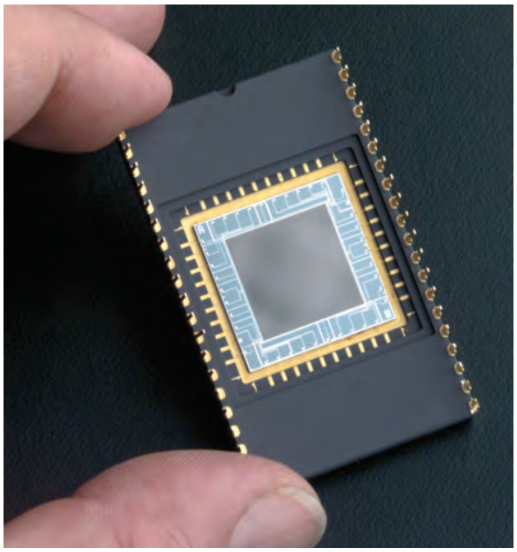

Light from distant stars can be very faint. Astronomers use sensitive electronic devices, similar to those found in video cameras, to record the spectra of dim distant objects.

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Spectroscopy is used by scientists to analyze the composition of unknown substances inside and beyond the laboratory. This scientist working at the South Pole is using a device called a spectrophotometer, which uses light to find out the composition and density of the ozone layer.

wavelengths should be. These wavelengths were absorbed by the gas. This spectrum is called an *absorption* spectrum. Different substances produce different emission and absorption spectra. Both types of spectra can be used to identify the composition of substances. The use of a spectroscope to analyze matter using its emission spectrum is called spectroscopy.

Spectroscopy is a useful tool for chemists. Just as a fingerprint can identify a person, a spectrum can identify a substance. Scientists use spectroscopy to find out the composition of substances.

Analyzing Stars

Spectroscopy has uses well beyond studying substances found on Earth and in its atmosphere. Astronomers can use a spectroscope attached to a telescope to determine the composition of the universe. Consider the spectrum of the closest star to Earth, the Sun. We often think of this glowing ball of gas as producing a continuous spectrum, running from red to violet.

But what happens when sunlight is passed through a sensitive spectroscope? More lines of color can be seen. Look closely at the picture behind the title. You will also see many dark lines. Some of these lines indicate that the gases in the outer layers of the Sun have absorbed some of the wavelengths in sunlight. The missing colors provide information on the composition of these gases.

Spectroscopy can provide information about stars beyond their composition. Astronomers can use this tool to estimate how hot stars or other objects are, and even how fast they are traveling. ☐