LESSON 6

The Pinhole Camera

JEFF MCADAMS, PHOTOGRAPHER, COURTESY OF CAROLINA BIOLOGICAL SUPPLY COMPANY

This girl is viewing the world through a pinhole. How is her view different than what she would see using just her naked eye?

INTRODUCTION

You have collected evidence to support the hypothesis that light travels in straight lines. You have used this hypothesis to explain (using ray diagrams) how light spreads out from a source and how shadows are formed. In this lesson, you will construct a device called a pinhole camera. Your pinhole camera does not take photographs, but it will provide you with a surprising picture of the world. How is this picture produced? Can you explain the picture's appearance using a ray diagram? Does changing the design of the pinhole camera alter the picture it produces?

OBJECTIVES FOR THIS LESSON

Build a pinhole camera.

Observe how a pinhole camera works.

Use ray diagrams to explain how a pinhole camera works.

Getting Started

1. Have one member of your group collect the plastic box of materials. Divide the materials between the pairs in your group.

2. Wrap a piece of aluminum foil over one end of the narrow tube, folding it down the side of the tube (see Figure 6.1).

Figure 6.1 *Wrap the aluminum foil over the end of the narrow tube.*

MATERIALS FOR LESSON 6

For you

- 1 copy of Student Sheet 6.1: Looking Through Your Pinhole Camera
- 1 copy of Student Sheet 6.2: Modifying Your Pinhole Camera

For you and your lab partner

- 1 narrow cardboard tube
- 1 wide cardboard tube
- 2 pieces of aluminum foil
- 1 square of white plastic sheet
- 1 paper clip
- 2 rubber bands
- 1 piece of black paper
- Masking tape

For your group

- 1 transparency (or sheet of newsprint)
- 2 transparency markers or regular markers

3. Secure the foil in place by wrapping a rubber band around the foil and the tube as shown in Figure 6.2. Make sure the foil is smooth and flat. Take care—it tears easily!

4. Straighten the paper clip. Being very careful not to tear the foil, use the paperclip to make a single tiny hole in the center of the foil (see Figure 6.3).

5. Wrap the piece of white plastic sheet over one end of the wide tube. Make sure the sheet is as flat as possible. Use a rubber band to secure the sheet in place (see Figure 6.4).

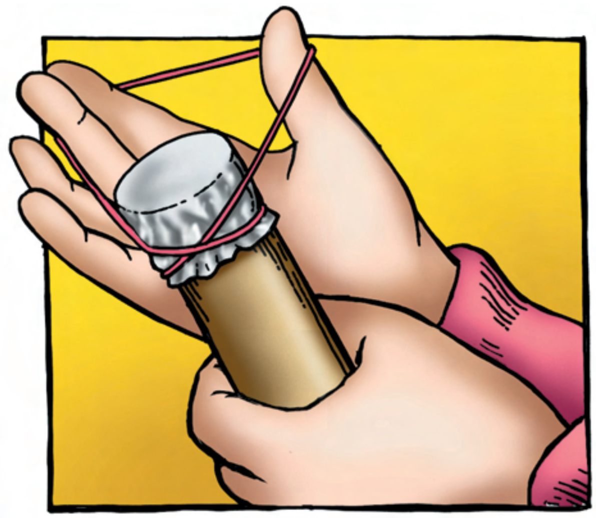


Figure 6.2 *Secure the foil by wrapping a rubber band around the foil and the tube.*

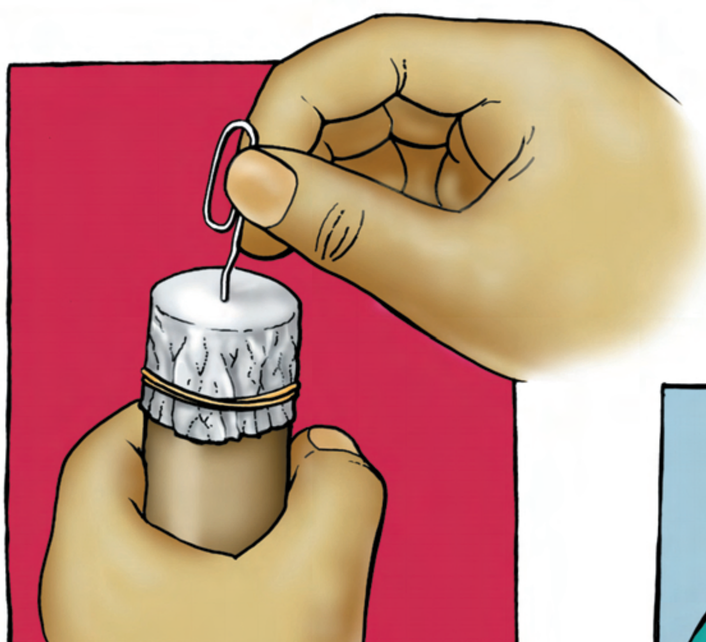


Figure 6.3 *Use a straightened paper clip to make a tiny hole in the center of the foil.*

Figure 6.4 *Make sure the white plastic sheet is flat before securing it with a rubber band.*

6. Slide the open end of the narrow tube inside the open end of the wide tube. Push the narrow tube about three-fourths of the way into the wide tube.

7. Roll the black paper so that it fits over the wide tube as shown in Figure 6.5. Use tape to attach the black paper to the white plastic end of the tube. Your pinhole camera is ready to use!

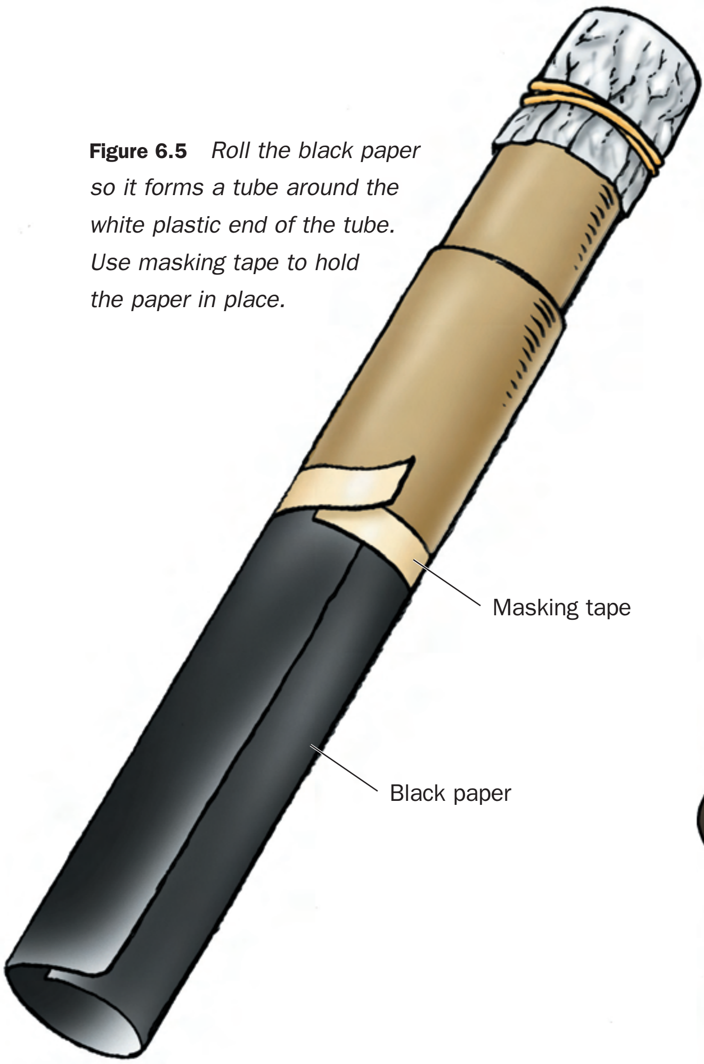


Figure 6.5 *Roll the black paper so it forms a tube around the white plastic end of the tube. Use masking tape to hold the paper in place.*

Inquiry 6.1
Looking Through Your Pinhole Camera

PROCEDURE

1. Record your predictions, observations, explanations, and diagrams for this inquiry on Student Sheet 6.1: Looking Through Your Pinhole Camera.

2. Your teacher has set out some lamps and other objects to look at through your pinhole camera. Choose an item to look at using your pinhole camera. Point the foil end of the camera at the object. Look through the white plastic end (see Figure 6.6).

   A. What do you observe on the white plastic?

   B. Compare what you observe through the pinhole camera with what you observe using only your eyes. What is the difference between the two views?

Figure 6.6 *Look through the white plastic end of your pinhole camera. The black paper will shade the white plastic from unwanted light.*

3. Look at other objects through the pinhole camera.

C. Which objects are easy to see on the white plastic?

D. Which objects are not easy to see?

E. Think about how light gets into the pinhole camera. Why do you think some objects are easier to see than others?

4. The picture on the white plastic of the pinhole camera is called an image. The white plastic acts as a screen on which the image forms. Discuss with your partner where else you may have seen an image formed on a screen.

5. Look at the diagram of the pinhole camera in Figure 6.7. The same diagram is on Student Sheet 6.1.

F. On the diagram on the student sheet, draw a line from the top of the object (Point A) that represents light leaving the object, passing through the pinhole, and forming an image on the screen. Next draw a line from Point B that represents light leaving the object, passing through the pinhole, and forming an image on the screen.

6. How does your diagram help you understand what is happening to light inside the pinhole camera? Discuss the following questions with your partner before answering them on the student sheet:

G. What happens to the rays of light from the object as they pass through the tiny hole?

H. How does your diagram help you explain the appearance of the image on the screen?

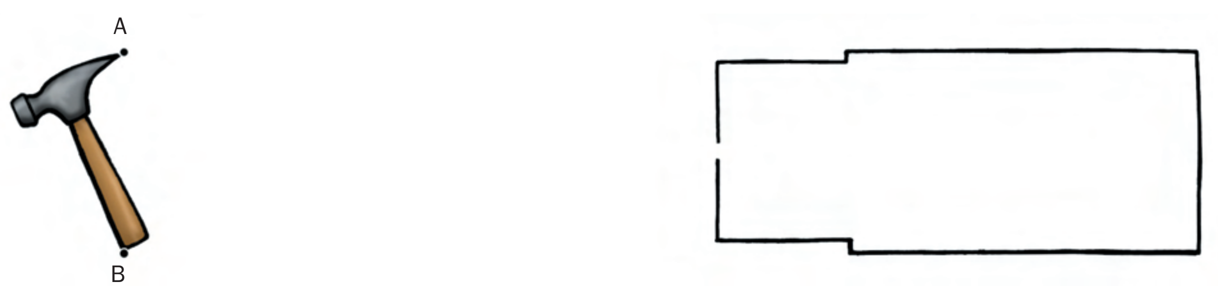


Figure 6.7 *Complete this diagram on the student sheet.*

Inquiry 6.2
Modifying Your Pinhole Camera

PROCEDURE

1. Working with your partner, you will now make changes in your camera and predict, observe, and explain how these changes affect how light behaves when it passes into your camera. Record your predictions, observations, explanations, and diagrams for this inquiry on Student Sheet 6.2: Modifying Your Pinhole Camera.

2. Predict what will happen to the image on the screen if you extend the length of the pinhole camera.

   A. Record your prediction.

3. Pull the narrow tube part of the way out of the wide tube so the camera is longer.

   B. Describe your observations.

   C. Draw a diagram that explains your observations.

4. Predict what will happen to the image on the screen if you double the diameter of the hole in the foil.

   D. Record your prediction. Test it, and record your observations and any explanations you have.

5. Predict what will happen to the image on the screen if you make more than one hole in the foil.

   E. Record your prediction. Test it, and record your observations. Be prepared to share your results with the class.

6. Discuss with other students in your group what you think is happening to light to produce the effect you observed in Step 5. On the transparency (or newsprint), draw a diagram that explains how light behaves when it passes into a pinhole camera with two holes. Be prepared to present your ideas and diagram to the class.

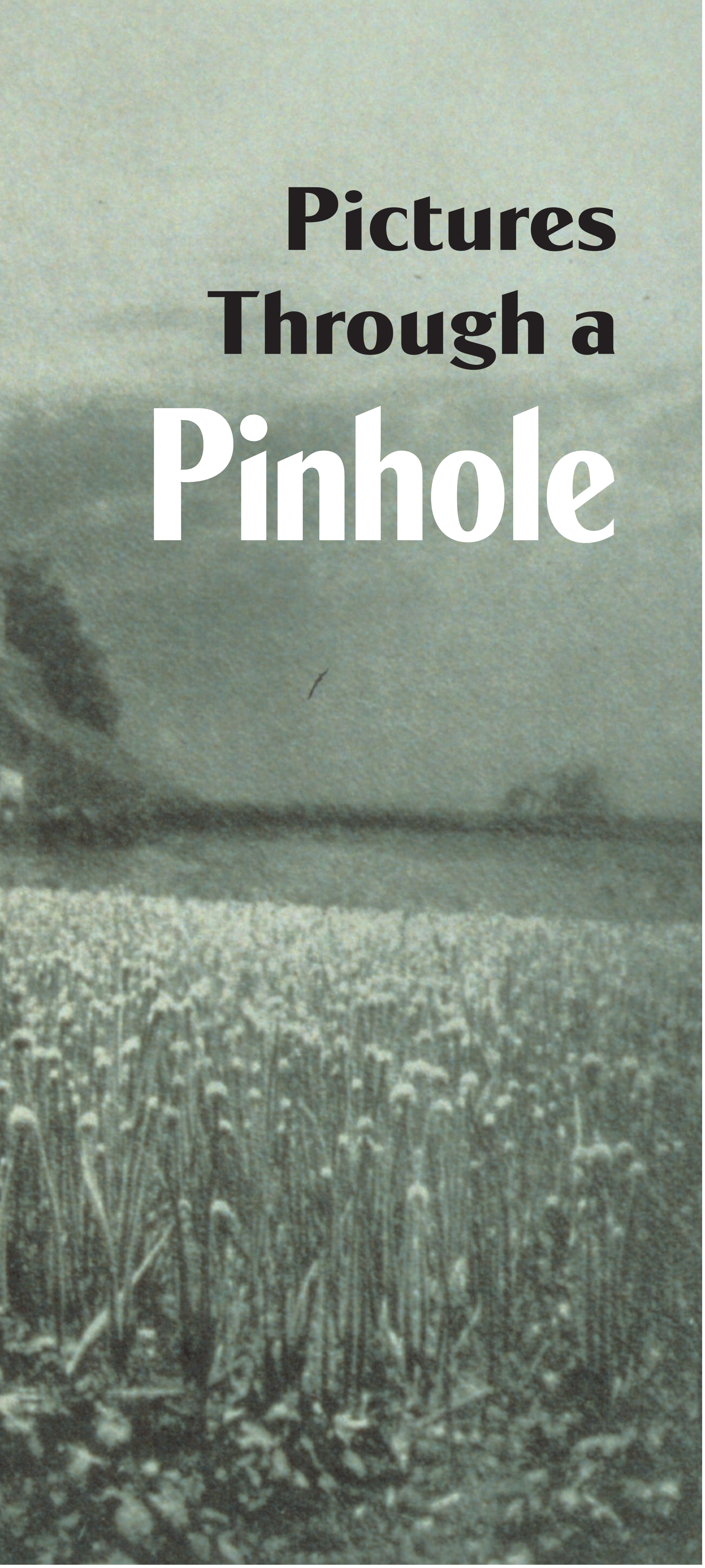
REFLECTING ON WHAT YOU'VE DONE

Discuss with other students in your group what a pinhole camera is and how it works. Listen to their explanations. Ask each other questions to determine whether you all understand what you have observed during the lesson.

A. Write a paragraph under A on Student Sheet 6.2, in your own words, that describes what a pinhole camera is and explains how it works. Be prepared to share your paragraph with the class.

This picture was taken using a pinhole camera. Although pictures taken with a pinhole camera often have a "soft" appearance, they have a very large depth of field. Notice how objects in the front of the picture and in the back of the picture are all equally in focus.

Pictures Through a Pinhole



COURTESY OF GEORGE EASTMAN HOUSE

What use is a camera without film? Not much, you might say. But the first cameras had no film. In fact, some of the earliest cameras were dark rooms with a small hole in one wall. (The word "camera" actually means "room.") These rooms were giant pinhole cameras. This type of pinhole camera was called a camera obscura.

A person sat inside the room and secretly observed an upside-down image of the outside world projected onto the wall opposite the hole. Artists often used a camera obscura to trace an outline of a landscape onto paper or canvas. Some artists had portable camera obscuras—and lots of servants to carry them about! Other artists made smaller versions. Still others added lenses to the cameras to focus the light in order to make a bigger and brighter picture.

Pinhole Cameras and Photography

The invention of photography in the early 19th century meant that a camera could reproduce an image and make a picture automatically. However, the design of a modern camera remains similar to that of a pinhole camera. New parts have been added, but a modern camera still basically consists of a box with a hole in it.

Some photographers still use pinhole cameras (with photographic film, but no lenses) to take photographs. Pictures taken with pinhole cameras often have a "soft" appearance, that is, the images are not sharply defined. However, they have a very large depth of field. This means that objects in the front of the picture and in the back of the picture are all equally in focus.

Because only a small amount of light enters the pinhole, a pinhole camera requires very bright light or a long exposure time. (Exposure time is the length of time the light is allowed to fall on the film.) Modern cameras use a larger hole (or aperture) and lenses to collect and focus more light. This allows pictures to be taken under dimmer conditions. Modern cameras also use short exposure times—usually hundredths of a second. This allows the camera to take clear photos of moving objects. But the larger aperture possible with modern cameras has some drawbacks. Look at the photo of chickens taken with a modern camera. Are the near and far objects equally in focus?

When using a large aperture and a lens, a camera has a much smaller depth of field than a pinhole camera. This results in a photograph in which only some of the objects are in focus.

Pinhole Cameras and Science

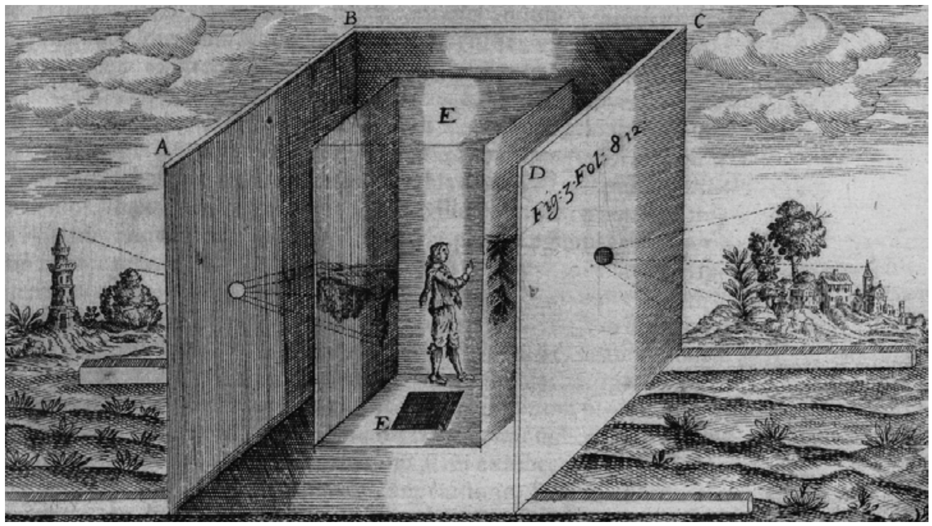
Pinhole cameras are useful scientific instruments. In the 4th century B.C., the philosopher Aristotle used a pinhole in a leaf to observe eclipses of the Sun. We still use pinholes to look at an image of the Sun without damaging our eyes. (Find out more about this method before trying it out!)

COURTESY WALPOLE GALLERY, LONDON

This painting is by the aptly named artist, Canaletto. He used a camera obscura to make exact drawings from which he produced many detailed paintings, some showing the famous canals of his hometown of Venice, Italy.

Some satellites designed to look at distant stars are equipped with versions of the pinhole camera. Scientists and engineers often use pinhole cameras to observe and take photographs of very bright images. Rocket designers use them to photograph the behavior of brightly burning hot gases inside rocket engines. Physicists studying the process by which the Sun releases energy use them to photograph gases heated up (by lasers) to temperatures similar to the surface of the Sun.

The pinhole camera may be an old invention, but it still has a lot of new uses. □



GERNSHEIM COLLECTION, HARRY RANSOM HUMANITIES RESEARCH CENTER, THE UNIVERSITY OF TEXAS AT AUSTIN

Camera obscuras were small rooms or very large boxes, some big enough to stand inside. This giant camera was used by an artist in the 17th century. It was supposed to be portable—if you had the servants to carry it around.

KENT KNUDSON/PHOTO LINK/PHOTODISC/PICTUREQUEST

When using a modern camera with a lens and a large aperture only some of the objects can be brought into focus. In this photograph, only some of the chickens are in focus.