LESSON 5

Blocking the Light

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Your shadow follows you everywhere. How is it formed? Is it always the same size or shape? Do you always have only one shadow?

INTRODUCTION

Light can pass through the vacuum of space. You know this because light from the Sun reaches Earth. You have observed during your experiments that light can travel through air and through water, some types of plastic, and glass. But can light travel through all types of matter? Does it pass through different types of matter in the same way? In this lesson, you will try to answer these questions.

OBJECTIVES FOR THIS LESSON

Observe what happens when light strikes different materials.

Investigate and explain the appearance and formation of shadows.

Getting Started

1. Have one member of your group collect the bag of objects.

2. Spread the contents of the bag out on a desk.

3. Examine the objects. Work with your group to sort the objects into groupings according to how they allow light to pass through them.

4. Create a table in your science notebook to list your groupings and record the objects in each grouping.

MATERIALS FOR LESSON 5

For you

- 1 copy of Student Sheet 5.1: Putting Objects in the Path of Light
- 1 copy of Student Sheet 5.2: Measuring Shadow Size

For you and your lab partner

- 1 assembled light stand
- 1 meterstick
- 1 white screen
- 2 plastic stands
- 1 black disk
- 1 craft stick
- Masking tape

For your group

- 1 bag containing samples of paper, plastic, cardboard, and other objects

Inquiry 5.1 Putting Objects in the Path of Light

PROCEDURE

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

2. Record your observations, measurements, and explanations on Student Sheet 5.1: Putting Objects in the Path of Light.

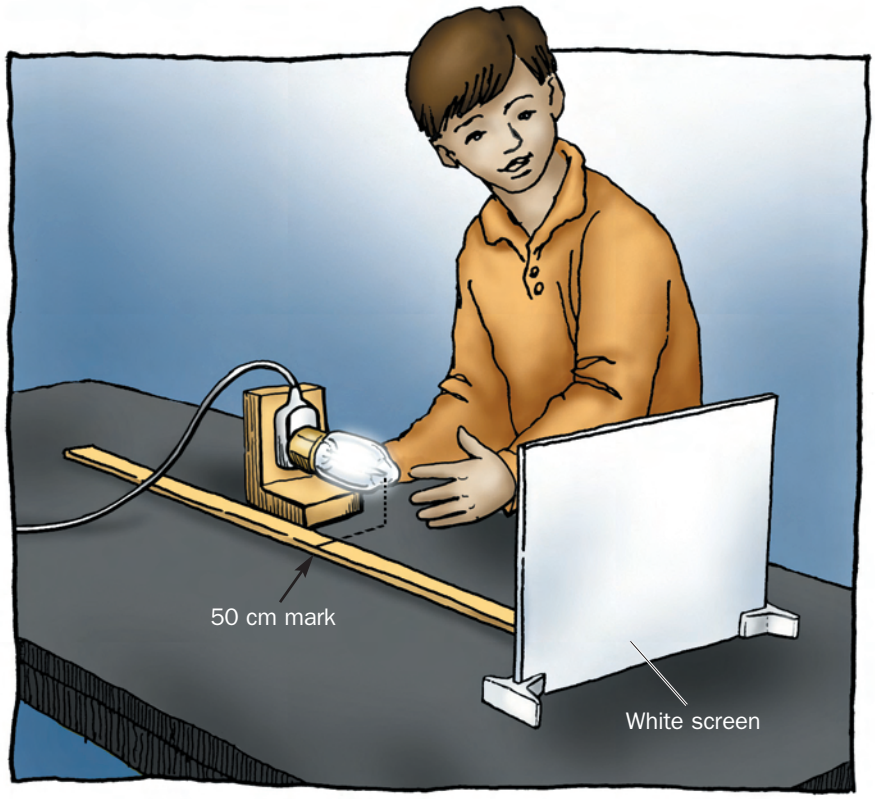

Figure 5.1 *Set up the screen. Place the lightbulb in a horizontal position. Put your hand between the screen and the lightbulb.*

3. Working with your partner, set up the screen. Place the light stand so the lightbulb is horizontal. Position the lightbulb so the tip of its filament is 50 cm away from the screen. Put your hand between the lightbulb and the screen (see Figure 5.1).

SAFETY TIP

Lightbulbs become hot very quickly and take many minutes to cool down. Make sure your lightbulb is cool before you handle it.

4. Switch on the lightbulb.

   A. What do you observe on the screen? Use words and/or a diagram to explain what you see.

5. Hold each object from "Getting Started" about 20 cm from the screen.

   B. For each object, describe what you see on the screen. Create a table to record your descriptions.

6. Discuss your observations with your partner.

   C. Explain what you observe.

   D. What do you think causes a shadow to form?

   E. Which of your objects produces the darkest shadows?

TRANSPARENT, TRANSLUCENT, AND OPAQUE

Substances that let light of certain wavelengths pass through them and can be clearly seen through are called transparent. Water, glass, and acetate sheets are transparent. Colored glass is also transparent—it allows some colors through but not others. Materials that let light pass through but cannot be clearly seen through are called translucent. These materials are said to diffuse, or scatter, light. Wax paper and frosted glass are two examples of translucent substances. Materials that do not let light pass through them are called opaque. Sometimes, thin samples of opaque materials (thin paper, for example) may be translucent in bright light.

All matter interacts in some way with light. Water, for example, is fairly transparent, but it does absorb and scatter some light. As a diver goes deeper into the sea, the color of the light from the Sun changes—it gets bluer and darker. Sunlight cannot penetrate the deepest part of the oceans.

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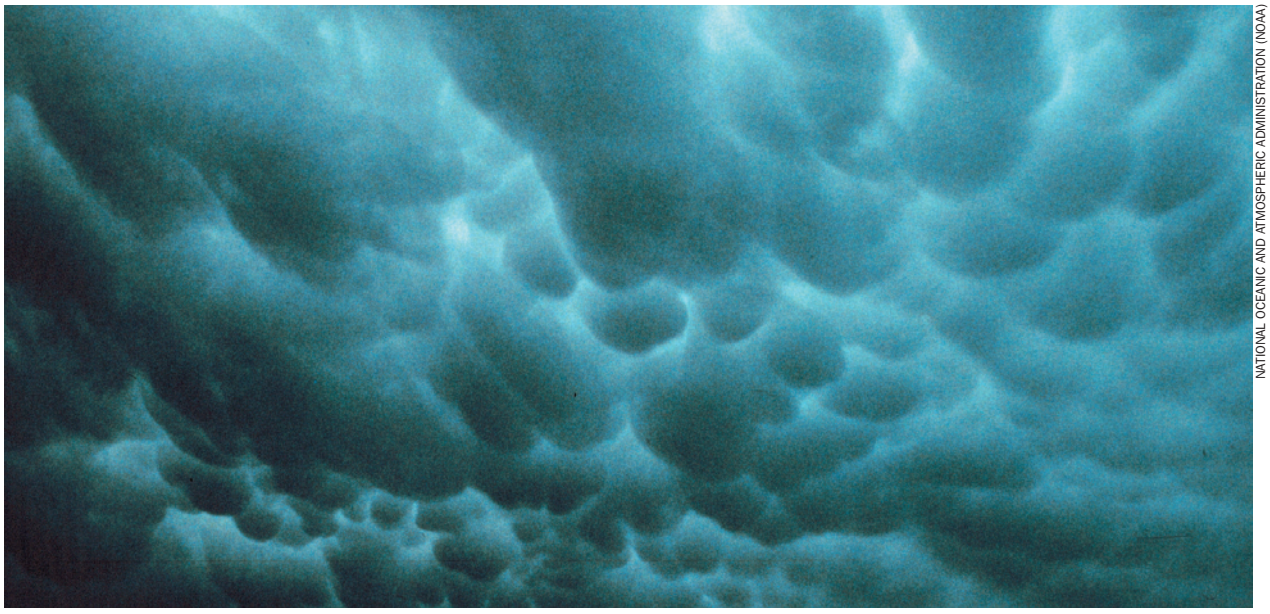
Water is considered transparent, but it does absorb and scatter some light. This is one reason why light does not reach the deepest part of the oceans. Submariners must carry their light with them.



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Clouds may allow light to pass through them, but you cannot see through them. They are translucent.

Inquiry 5.2
Measuring Shadow Size

PROCEDURE

1. You will be working with your partner. Record all your observations, measurements, and explanations on Student Sheet 5.2: Measuring Shadow Size.

2. Switch on the lightbulb.

A. Put your hand between the screen and the lightbulb and move your hand backward and forward between the lightbulb and the screen. Describe what you observe.

3. Attach the black disk to the craft stick (see Figure 5.2).

B. Measure and record the diameter of the disk.

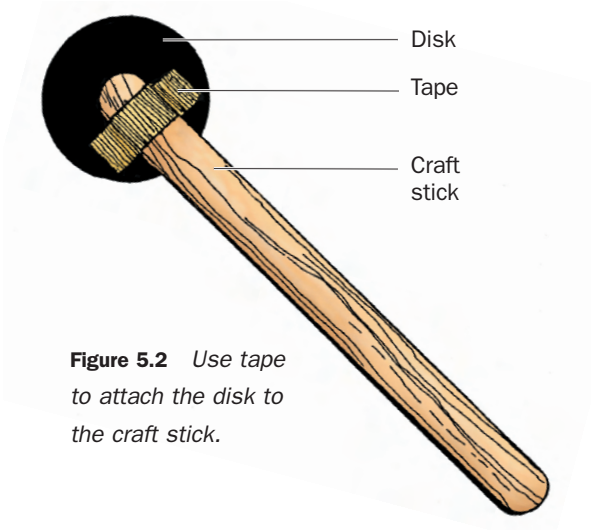


Figure 5.2 *Use tape to attach the disk to the craft stick.*

4. Use the disk to make a shadow on the screen. Hold the disk 20 cm from the screen.

C. Draw the shadow produced by the disk.

5. You are going to measure the size of the shadow made by the disk when it is placed at different distances from the screen. Start by measuring the diameter of the shadow produced when the disk is 20 cm from the screen. You should make at least five measurements of shadow diameter with the disk at different distances from the screen.

D. Design and draw a table for your results.

6. Place the disk at different distances from the screen that you have chosen to record and measure the diameter of the shadow produced each time (see Figure 5.3). Record your results in the table.

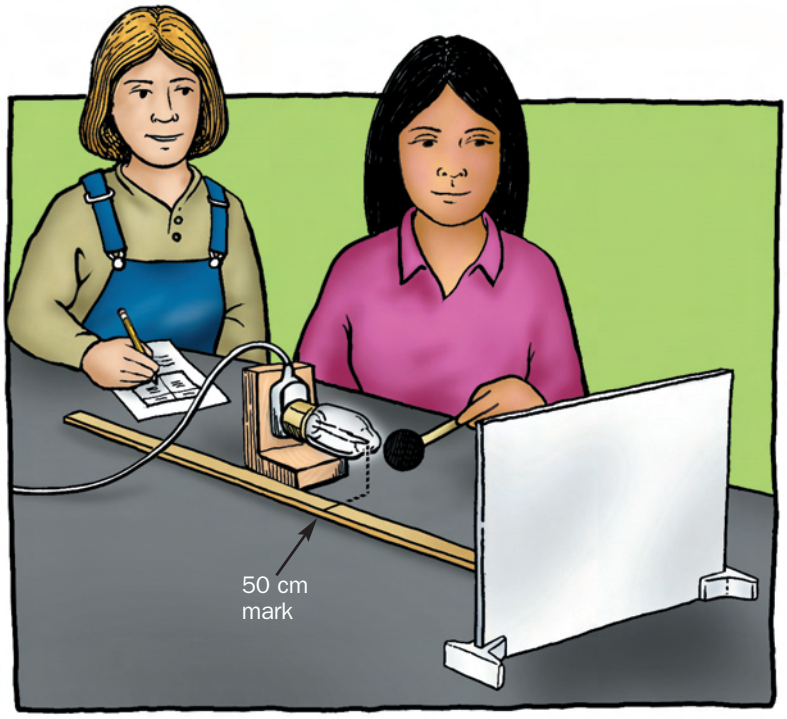


Figure 5.3 *Place the disk at different distances from the screen. Measure the diameter of the shadow the disk produces.*

E. Present your results as a graph.

F. Is there a relationship between the diameter of the shadow produced by the disk and the distance of the disk from the screen? Record your ideas.

G. Use a diagram to explain what you observed. Be prepared to draw your diagram for the class to discuss.

Inquiry 5.3
Comparing Shadows

PROCEDURE

1. Place the lightbulb in a vertical position, as shown in Figure 5.4. Use the disk to make a shadow on the screen. Record your responses for this inquiry in your notebook.

A. Draw a diagram of the shadow produced.

B. Describe how the shadow formed when the lightbulb was placed vertically differs from the shadow formed when the lightbulb was placed horizontally.

C. Have you ever seen a shadow like this before? If so, where?

2. After a class discussion about shadows, add labels to your diagram from A.

D. Draw a diagram that explains how fuzzy shadows are produced.

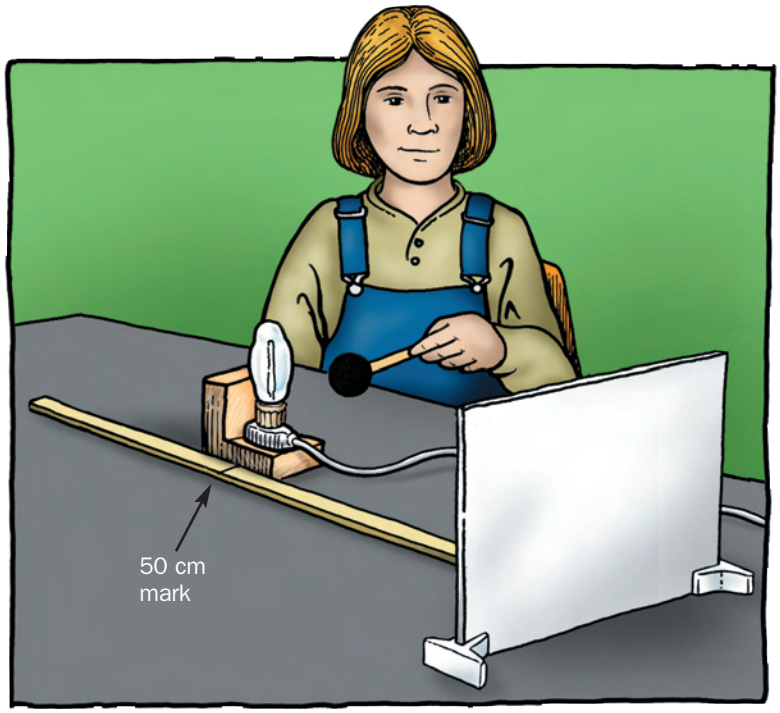
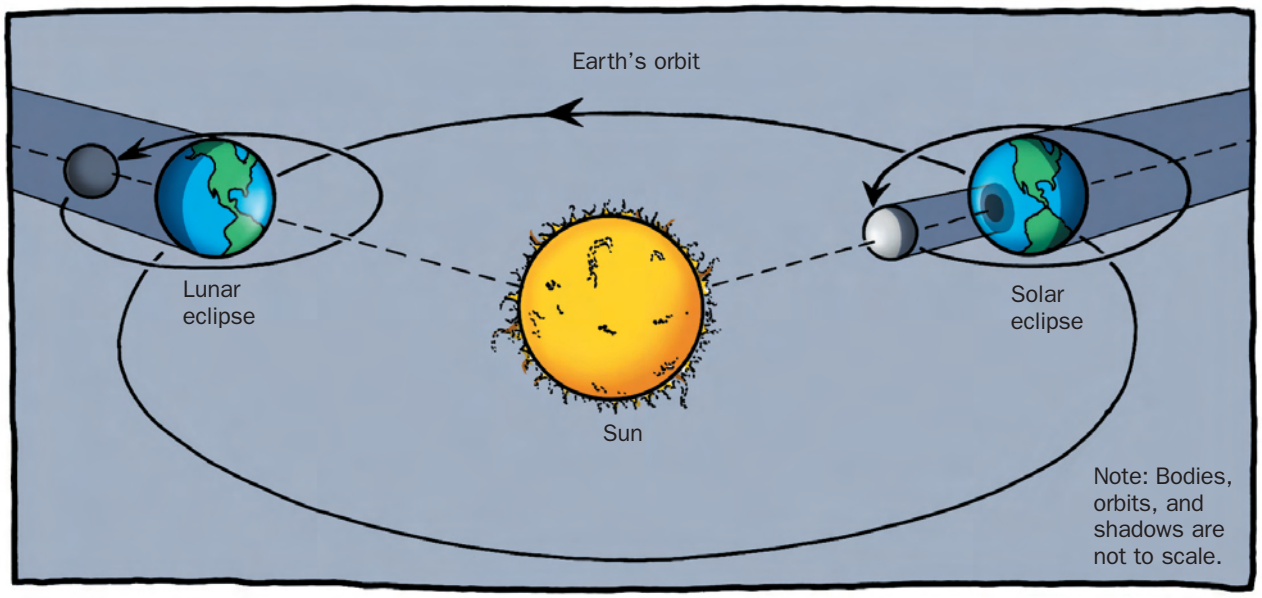


Figure 5.4 *Move the light stand so that the lightbulb is in a vertical position. Use the disk to make a shadow.*

ASTRONOMICAL SHADOWS

Shadows are areas of darkness that form behind an object when the object blocks a source of light. When shadows are formed on an astronomical scale, they are given a special name. They are called eclipses.

From Earth, two types of eclipses are visible to the naked eye—lunar eclipses and solar eclipses. A lunar eclipse occurs when Earth comes between the Sun and Moon and casts a shadow on the Moon. A solar eclipse happens when the Moon casts its shadow on Earth.



The shadows made by an eclipse have two regions, the umbra and penumbra. You may have observed these regions of a shadow in Inquiry 5.3. During a solar eclipse, the area under the umbra is in almost complete darkness. The area under the penumbra becomes about as dark as a dark, cloudy day.

A lunar eclipse in progress: a series of pictures taken at different times during an eclipse. You can see the shadow of Earth moving across the Moon's surface. Why in a total eclipse does the Moon look red? A later lesson will help you answer this question.

REFLECTING ON WHAT YOU'VE DONE

1. After discussing A–D with your group, record your responses in your notebook:

A. How are shadows produced?

B. What is the relationship between the size of a shadow on the screen and the distance of the screen from the object that produces the shadow?

C. What is the relationship between the size of a shadow on the screen and the distance of the object from the light source?

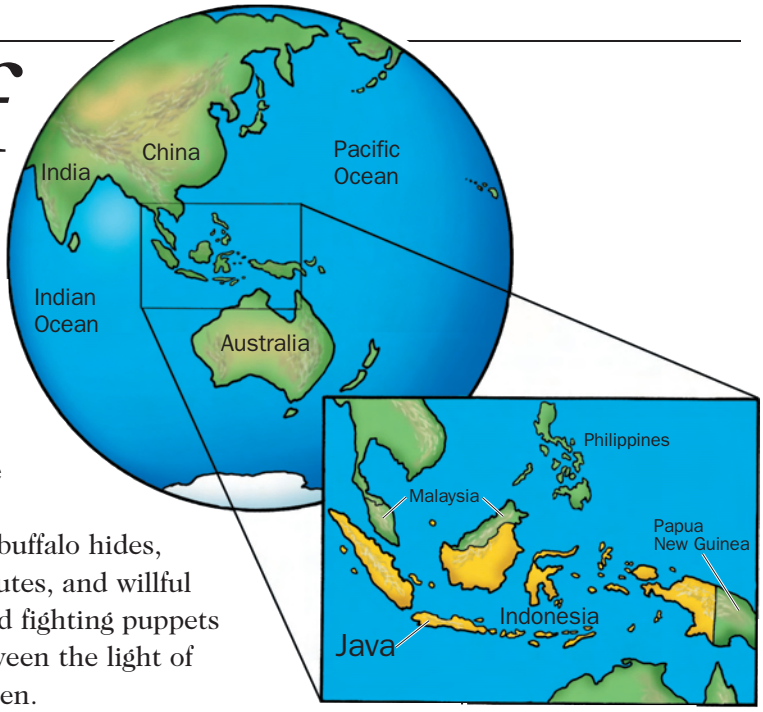
D. Which types of light sources produce the sharpest shadows?

2. Is it possible for an object to cast more than one shadow? You will need to share materials with other pairs and groups to help you answer this question.

E. Write a short paragraph about what you discovered.

3. Review the question bank cards generated in Lesson 1. Can you answer any more of them now? Identify those that you feel comfortable answering.

Theater of Shadows



Shadow puppet theater is a traditional form of entertainment in much of the archipelago that makes up Indonesia. Tamara first watched puppet masters at work on her home island of Java.

It began nearly one thousand years ago on the island nation of Indonesia. Shadow masters, called dalangs, traveled from village to village entertaining people with tales of love and war.

They used flat puppets, made of water buffalo hides, to play the parts of brave princes, evil brutes, and willful heroines. The shadows of the dancing and fighting puppets were created by placing the puppets between the light of an oil-burning lamp and a thin cloth screen.

The villagers looked forward to the dalang's visits. They gathered at the village square or temple yard at sunset to watch and listen. And that's just what they did—until dawn of the next day! To the people of Indonesia, the long plays were well worth it. The stories were morality tales that reminded the adults, and taught the children, about the nature of good and evil. And they believed that the puppets' shadows were their ancestors' spirits returning to Earth.

PHOTOS FROM THE PRIVATE COLLECTION OF TAMARA FIELDING AND TAMARA AND THE SHADOW THEATRE OF JAVA; WWW.INDONESIANSHADOWPLAY.COM

As a child in Indonesia, Tamara was fascinated by shadow puppet theater. Now she shares her enjoyment and knowledge of it with a new generation of youngsters.

The Magic and the Stories

Tamara Fielding was born in Indonesia on the island of Java. As a child, she was not supposed to go behind the dalang's screen to watch him perform. Only men and boys were allowed to do that. But young Tamara couldn't resist. She secretly crept behind the screen and watched the dalang work. His skillful and graceful performance amazed her. So did the beauty and fierceness of the puppets. From that early exposure, the "magic and the stories of shadow theater were locked inside me," says Tamara. And there they would stay for many years.

Tamara moved to Europe in her 20s. She studied drama and theater in Paris. Eventually, she came to the United States, where she continued her acting career. More years went by. Then one day, Tamara decided to dust off the shadow puppets that relatives had given her years before. She built a cloth screen and started moving the puppets in a way she remembered the dalang doing so long ago. The magic and the stories inside her began to come out.

Shadow Figures

Now Tamara has more than 400 puppets, or "shadow figures," as she calls them. She travels—not from village to village—but to universities, museums, and festivals sharing the stories and art of shadow theater.

Wearing a sarong and lace blouse with a flower in her hair, Tamara sits on the floor between the screen and the light. Unlike dalangs of old, she uses a 600-Watt halogen lamp to create her shadows. And most of her performances last less than an hour—not all night.

Today the shadow figures are as lively and powerful as ever. Like dalangs of old, Tamara creates the many voices of her characters. Her varied cast includes heroes, princesses, and animals, including monkeys, tigers, elephants, birds, and snakes.

With a single light source and a piece of cloth, the many dark shapes come alive. In the magical world of shadow theater, the shadows—magnificent, beautiful, and loathsome—take center stage. □

PHOTOS FROM THE PRIVATE COLLECTION OF TAMARA FIELDING AND TAMARA AND THE SHADOW THEATRE OF JAVA; WWW.INDONESIANSHADOWPLAY.COM

This traditional Indonesian play is about ancestors' spirits returning to Earth at night. The colors of these puppets are not visible. The audience sees only the puppets' shadows.