MODULE m5

SHADOWS

INTRODUCTION

Module 5, Shadows, contains two activities. Students will be exploring how shadows are made and how to manipulate light to create shadows. These activities build upon the activities in previous modules particularly drawing upon the concepts of transparent, translucent, and opaque materials.

Activity 11: Investigating Shadows
Activity 12: Shadows in Action: The Shadowbox Theater

In Activity 11, Investigating Shadows, students will study the relationship between the size of a shadow and the size of an object as well as how distances between the light, the object and the screen affect the shadow that is produced.

For Activity 12, students will be making shadowboxes and manipulating light and shadow to create special effects. The Shadowbox Theater is a device that can be used at any time with any unit of study. Students can incorporate what they are learning as they study light and optics with other content areas.

The following interactive web-based tutorials can be used to enhance this module, explain difficult concepts, and enrich the classroom experience: The Shadowbox Theatre, Measuring With Shadows, Eclipse of the Moon, and Solar Eclipse,
http://micro.magnet.fsu.edu/optics/tutorials/index.html

ACTIVITY 11

Investigating Shadows

In this activity students will be exploring some of the features of shadows and shadow making. The concepts of transparent, translucent and opaque were introduced to the students in Module 4, Activity 10, but it would be a worthwhile activity for students to create a KWL chart about shadows (see Module 1, Activity 2). Students can create this chart in their Science Notebook as individuals or on butcher or chart paper as a group. Some of the students may know more about shadows than others, and the KWL chart enables them to examine what they already know, what they are curious about and, finally, what they have learned.

A shadow is a dark outline or image cast by an object that blocks light. A shadow forms when light hits an opaque object (anything that does not let light through). When light strikes opaque objects it is blocked. Everywhere else, the light continues in a straight path until it bounces off the ground or wall behind the object. The result is a dark patch, or shadow, with the same outline as the object surrounded by light.

Students will investigate the relationship between the size of a shadow and the size of an object and also how the distances between the light, the object and the screen (or ground or wall) affect the shadow that is produced. They will also investigate why an object can produce several differently shaped shadows. Students will be asked to record information in their Science Notebooks about what they observe.

MATERIALS:

- ❑ Flashlight
- ❑ Scissors
- ❑ White paper or poster board
- ❑ Ruler or measuring tape
- ❑ Objects to use to produce shadows (some that are translucent, some that are opaque, and some that are transparent).
- ❑ Science Notebooks
- ❑ Graph paper

WHAT WILL THE STUDENTS DO?

Students will be doing a lot of exploring in this activity. They will use the Student Page to guide them while they are exploring and their Science Notebook to record answers to questions that are asked while doing these manipulations.

Students begin by creating a KWL chart, either individually or in groups. Encourage students to write down anything that they want to know about shadows in the W (What I Want To Learn) column of their KWL charts, and if they find the answer to their question while experimenting, to write the answer down in L (What I Learned) column of their KWL chart.

1. The first part of the activity involves a brief trip outside. Working in pairs, one student will stand in the sunlight and the other will draw a sketch of the shadow that is formed. Have students make two shadows shadows and sketch them, one with the person facing the sun, and the other with the person's shoulder facing the sun. Students will then discuss how the shadows are alike and how they are different.

2. Returning to the classroom, students will take an object and use it to make a shadow by illuminating it with a flashlight. They will follow the directions on the student page and discover how to change the length or direction of the shadow.

3. Students will now choose a 2-dimensional object and a 3-dimensional object and compare the shape of the shadow with the shape of the object and the size of the object with the size of the shadow.

EXTENSIONS:

Narrative writing.

Each of us has studied how light produces shadows.

Before you begin writing, think about a time when the shadow of an object might have frightened you.

Now write a story about this experience and why the shadow frightened you.

Reading and Writing. Read aloud *Shadow* by Marcia Brown (ISBN 0-689-71875-6). Based on stories told by African storytellers and tribal leaders, *Shadow* is a rich story of how shadows can become part of our cultural heritage. Use this book to encourage students to write their own stories about shadows. It can also be a starting point for looking for other stories about shadows that are specific to certain cultures.

Art and Reading. Show students *William and the Magic Ring* (Museum of Fine Arts, Boston, Catalog 1-800-225-5592, ISBN 0-87846-467-0). This is an excellent demonstration to use before completing Activity 12, by projecting paper cutouts to produce shadows. It also is a good way to start a writing activity since it is a story about a boy who imagines an animal battle just by looking at his window shade.

Photo Fakery. The camera was invented in 1839 and as early as the 1840s and 1850s, photographers were manipulating images. Photographs were a new way to convey messages to family and friends. This new medium also became a way for people to get firsthand looks at historical figures and events. Sometimes photographs were "faked" by inserting one image onto another photograph to communicate a certain message. In order to determine whether a photo has been manipulated, experts look first at light and shadows. With your students, look at photographs and determine where the light is coming from. If you can, find photographs that have been changed (for example, putting one person's image on another person's body) and have students look at the light and shadows and figure out if the photo has been changed. A good source of information on this subject is *Photo Fakery: The History and Techniques of Photographic Deception and Manipulation* by Dino A. Brugioni (ISBN 1574881663).

HISTORICAL VIGNETTE: LEWIS H. LATIMER (1848-1928)

Lewis H. Latimer was born in Chelsea, Massachusetts in 1848. As a young man, Lewis Latimer learned mechanical drawing while working for a Boston patent office. In 1880 Hiram Maxim of the U.S. Electric Lighting Company hired him to help develop a commercial electric lamp. In 1882, Latimer invented a device for efficiently manufacturing the carbon filaments used in electric lamps and shared a patent for the "Maxim electric lamp." He also patented a threaded wooden socket for light bulbs and supervised the installation of electric streetlights in New York City, Philadelphia, Montreal and London.

Lewis Latimer assisted Alexander Graham Bell in preparing the application for his telephone patent. In 1918 he became one of the 28 charter members of Thomas Edison's elite research team, "Edison's Pioneers." While working for Edison, Latimer wrote *Incandescent Electric Lighting,* the first engineering handbook on lighting systems. He was the only African-American in this prestigious, highly selective group.

Cooperative Learning Research Activity. Divide students into groups of three or four and give each group a different type of light to research. In groups each member could have a certain responsibility such as researching how the particular light works, researching the inventor and the year the light was patented, researching the use of their particular type of light, and illustrating or making a model of the of light. Groups could present their information to the rest of the class. Types of lights could include incandescent, fluorescent, neon, halogen, mercury vapor, sodium vapor or infrared lights.

Florida History. Thomas Edison made his home for part of his life in Ft. Myers, Florida. He originally came to Florida because he believed that carbonized bamboo would make a good filament for his newly-invented light bulb. He became a very good friend of Henry Ford and they lived in Ft. Myers in adjoining homes. Have students imagine what a conversation between Henry Ford and Thomas Edison might have sounded like. They often sat together, joking and laughing and visiting with other famous men and women of their time. Students could role-play using a written script and share their ideas with the class.

Art and History. Thomas Edison and his wife, Mina, constructed a walkway of stepping-stones, each one placed in the garden after someone visited their Florida home. Have students design a walkway. Each stone should have on it the name of the person who visited, the date of the visit, and a word or two to describe the visit. Students can either use the time period in which Thomas Edison constructed his walkway or choose another time period. For example, another historical vignette in the *Science, Optics and You* materials is one that features Galileo Galilei. Have students imagine who Galileo might have spoken with to discuss his astronomical theories and have them create a walkway based on those famous scientific figures.

ARTIST VIGNETTE: JOHN MIERS (1758-1821)

One form of preserving images is the creation of silhouettes. The development of silhouettes has been linked to that of outline drawing and shadow painting. It is said that this art form first appeared in France and Spain in the cave murals of Stone Age people. Tracing the outline of an object's shadow and then filling the drawing in with a flat color made the drawings realistic. Ancient Greek and Roman painters drew silhouette outlines of a person's shadow cast by sunlight as well as by candlelight or lamplight.

Silhouette techniques became popular in Europe during the eighteenth century. Many people collected silhouettes, especially well known people. These shadow portraits were painted on different materials such as plaster, wax, and paper and were elaborately framed.

One of the most famous silhouette artists was John Miers. He has been called one of the finest and most widely known profilists in the history of art, and was one of the few artists that painted silhouettes on plaster. A native of Leeds in northern England, Miers sold paints as did his

father, but by 1781 he expanded his business to include painting coaches, gilding, and making profiles. He was so successful in making silhouettes that in 1791 he opened a studio, employed several artists and had a very good business. He continued making silhouettes of famous people until 1800.

Activity. Students create a silhouette of a friend in the classroom. There are several ways to create one. One is to paste dark paper cut to a person's profile on a light background. Then there is hollow-cut, which involves the opposite color combinations. The student will cut out the likeness from the center of white paper and place it on a background of black paper or black fabric. Materials needed are paper, pen and a light source. Seat the student sideways in a chair positioned against a blank wall. Position a light a few feet from the wall so that it creates a shadow. Tape tracing paper on the wall and trace the outline. Place the profile on black paper and use scissors to cut it out of both sheets. Mount the black silhouette on light-colored paper.

Activity 11

Investigating Shadows

A shadow is a dark outline or image cast by an object that blocks light. It is formed when light hits an opaque object (anything that does not let light through). Everywhere else, the light continues in a straight path until it bounces off the ground or wall behind the object. The result is a dark patch, or shadow, with the same outline as the object surrounded by light.

In this activity you will explore some of the features of shadows and how to make shadows. You will also be investigating how the size of a shadow and the size of the object that produced the shadow are related. You will find answers to some questions such as: Why can an object produce several differently-shaped shadows? You will also be investigating how the distances between the light, the object, and the screen (wall or ground) affect the shadow that is produced. Record all of your observations and data in your Science Notebook.

Materials:

- ❑ Flashlight
- ❑ Scissors
- ❑ White paper or poster board
- ❑ Ruler or measuring tape
- ❑ Objects that will produce shadows
- ❑ Science Notebook
- ❑ Graph paper

Prepare a K-W-L chart in your Science Notebook. Use the first column (K) to place things that you already know about shadows. In the second column (W) write down any questions that you want to find out about shadows during this activity. In the final column (L) write down what you learned about shadows after doing this activity.

Keep your Science Notebook open and answer questions as you can or record any data that you may collect.

Investigation # 1: Outdoor Shadow Activity

1. Find a partner, go outside and measure his or her height. One of you will make the shadow and the other will draw what the shadow looks like.

2. Have your partner stand facing the sun and draw the shadow that is created. Then answer the following questions in your Science Notebook.

   How was the shadow made?

   What is the length of the shadow?

   How does this compare with the height of your partner?

   What affects the height and position of the shadow?

   Does the shadow give an accurate picture of the shape of your partner's body? Explain why or why not.

3. Draw your partner's shadow again, but this time have your partner turn with his or her shoulder facing the sun. Compare the two drawings you made and write a paragraph about how they are alike and how they are different.

Investigation #2: Changing the length of shadows

1. Choose several objects from around the room (books, papers, or items that your teacher has provided). Choose one thing that you can see through and one object that you cannot see through.

2. Darken the classroom so that you can use your flashlight to create shadows. Take the object you can see through and your flashlight and produce a shadow.

   What does the shadow look like?

   Can you change the length of the shadow? How?

3. Use your flashlight to form a shadow using the object that you cannot see through.

   What does the shadow look like?

   How is it similar to the shadow you made in #2 above? How is it different?

Investigation #3: Comparing Shapes and Shadows.

1. Choose a two-dimensional (flat) object and use your flashlight to produce a shadow.

2. Then choose an object that is three-dimensional and use your flashlight to produce a shadow. Answer the following questions in your Science Notebook.

   How are the shadows produced by these objects alike?

   How are the shadows produced by these objects different?

3. Find a three-dimensional object and try to create three different shadows from the same object. Draw them in your Science Notebook.

4. List any questions you still have about shadows in your Science Notebook and suggest ways that you can answer the question.

INVESTIGATION #4: WHAT AFFECTS THE SIZE OF A SHADOW?

1. Use the materials in *Science, Optics & You* to answer the question, "What affects the size of a shadow?"

2. In your Science Notebook, write your plan for answering the question. Then, share your plan with a classmate and then put your plan into action!

3. Write a description of how your plan worked in your Science Notebook and answer your original question, "What affects the size of a shadow?"

ACTIVITY 12

Shadows in Action: The Shadowbox Theater

A shadowbox theater can be used with any unit of study that you are conducting in your classroom, not just with light and optics. However, once students reach a level of understanding of how the theater works and how light and shadows can be manipulated, the shadowbox theater (and its variations) can be an alternative way for students to share what they have learned. Students will discover that making and using their theaters is easier if they identify a few variables and how to manipulate them. [A variable is something being changed in an experiment.] Some variables are: the type of material or paper that is used as a screen for the shadowbox; how far away or close the puppet is; how carefully students cut out the puppets; how dark or light the room is; and what kind of light source students are using (a broad beam of light or a concentrated beam of light).

Although you do not have to use the word “variable,” the concept of manipulating parts of an experiment one at a time is consistent with how science is done in real-world situations. Part of the scientific process of asking and answering questions is learning to manipulate one variable at a time. This ensures that students will be able to analyze their data and draw viable conclusions. They will quickly discover that manipulating more than one variable at a time leads to confusion and questionable results.

The more students experiment with the shadowbox and puppets, the more variables they will identify and the more questions they will have. Encourage students to write down all their questions in their Science Notebooks. Have them compare ideas with other students and present their ideas to one another.

Materials:

- ☐ Shoeboxes or other small cardboard boxes
- ☐ Craft or Popsicle sticks
- ☐ Scissors
- ☐ Construction paper
- ☐ Flashlights or other light sources
- ☐ White paper
- ☐ Transparent tape
- ☐ Various art supplies to decorate the boxes

This could be a teacher-guided activity or students could work independently using the student page as a guide. It is helpful to have a previously made shadowbox to serve as a model for your students.

Ahead of time: If you wish to have your students perform for other classes, you will need to schedule classroom visits ahead of time. Older students could perform for younger students while explaining to them how the shadow puppets work.

Ahead of time: you will also need to accumulate a collection of boxes so that you will have all of your materials ready when you want to begin the activity.

What will the students do?

Students will construct shadowboxes and demonstrate that they can perform a play by manipulating light, shadows, and puppets. After creating their shadowbox theaters, students will answer questions in their science notebooks about the science of shadow making.

1. Students cut a hole about 13 centimeters square in the bottom of a shoebox. The square hole should be close to the short end of the box. This will provide an area to conceal the hands of the puppeteer.

2. Tape a piece of translucent white paper over the hole to serve as the screen. Copy paper, butcher paper, newsprint, or wax paper will work. Encourage students to try a variety of papers to determine which make the best screen.

3. Students decorate their boxes using crayons, markers, paint, or paper cutouts.

4. Students make up a story or choose a story that they are reading to perform, deciding on the characters for their story and cutting out silhouette puppets from construction paper. Students tape craft sticks to the puppets to serve as handles.

5. To perform, students shine a flashlight into the box in a darkened room and manipulate the puppets so that their shadows are cast on the screen.

6. Students will experiment with the effects of placing the puppets at different distances from the screen and of turning the puppets at different angles to the light source.

EXTENSIONS:

Poetry. Read aloud the poem, *My Shadow,* by Robert Louis Stevenson. Discuss the poem with students. Encourage them to propose some scenarios as to what Stevenson was doing when he got the idea for the poem.

I have a little shadow that goes in and out with me,
And what can be the use of him is more that I can see.
He is very, very like me from the heels up to the head;
And I see him jump before me, when I jump into my bed.

The funniest thing about him is the way he likes to grow –
Not at all like proper children, which is always very slow;
For he sometimes shoots up taller like an india-rubber ball.
And he sometimes goes so little that there's none of him at all.

Writing. Have students write a poem about their shadows. Students can use a word that starts with each letter of the word shadow to start each line of the poem, for example:

S*kinny is my shadow when the sun is low,*
H*appy is my shadow when I run and play,*
A*ngry is my shadow when I go away.*

Narrative writing.

In the story of Peter Pan, Peter loses his shadow. Pretend that your shadow runs away from you.

Think about the adventures that your shadow has.

Now write a short story telling what happened to your shadow.

Mathematics. Have students measure their shadows outside at different times of the day. Students can compare differences between their heights and the lengths of their shadows. Then have students graph the data that they collect. Students should be able to explain why the type of graph that they chose was most suited to displaying their data. Challenge students to explain why the lengths of their shadows vary. If your students are ready for a discussion about the rotation of the earth, have them model how the earth's rotation affects the length of their shadows.

Earth science. During a lunar eclipse, the round shadow of the Earth slowly covers the moon. Using a light source and various sized balls, challenge students to discover and demonstrate how a lunar eclipse occurs. This activity can lead to a study of the moon and the discoveries of Galileo Galilei (see the Historical Vignette & Activity: Galileo Galilei & the Moon). It would also be a source for a shadowbox theater play.

Reading. Read aloud *Henry in Shadowland* by Laszlo Varvasovzsky (ISBN 0-87923-785-6). This story about a boy who becomes involved with the characters that he has created for a shadowbox theater could spark the imagination of students before they begin this activity.

Geography. Have students research the shadow puppet theatres of Java, Bali and Thailand. Shadow puppet theatres have been part of the folk culture for centuries. The shadow puppet theatre is considered the strongest traditional theatre form in Southeast Asia and thousands of puppeteers are still active producing elaborate shows.

HISTORICAL VIGNETTE: GALILEO GALILEI

This vignette is written to be read aloud to students:

Galileo Galilei was a very famous scientist, mathematician, astronomer, philosopher and physicist. He lived from 1564 to 1642 in Italy. He was the first to use a telescope to explore and map the stars, planets and the moon. Galileo kept careful notes and made beautiful drawings of his observations. The moon particularly fascinated Galileo. Using a telescope (shown below), he was the first to discover what the surface of the moon looks like. Here is a description of the moon in Galileo's own words:

> *It is a beautiful thing and most gratifying to the sight to behold the body of the moon. The moon is not robed in a smooth and polished surface but is in fact rough and uneven covered everywhere, just like the earth's surface with huge prominences, deep valleys, and chasms.*

Galileo collected all of his writings and published them in a book called *The Starry Messenger.* His book became the most famous and important source of information for many years about the moon, planets, sun and stars.

Activity. Read aloud the Caldecott Award-winning book, *Starry Messenger, Galileo Galilei* by Peter Sís (ISBN #0-374-37191-1), a fascinating and beautifully illustrated book. Descriptions are given of the many and varied discoveries of Galileo and excerpts of his writing are included.

ARTIST VIGNETTE: ETIENNE DE SILHOUETTE

A silhouette is an outline or profile drawing of a person or thing filled with a solid color. A silhouette looks very much like a shadow. During the 1700s in Europe, a French government official named Etienne de Silhouette started cutting paper shadow portraits of his friends and family. He would cast a shadow of his subject on a piece of paper using a candle. He would then trace the shadow profile and then cut it out using black paper. Soon shadow portraits became very popular and were named after him.

Silhouette portraits became popular in America during the 1800s. George Washington's granddaughter made a silhouette portrait of her grandfather that still exists. She made it by tracing his shadow cast on the wall of his home using sunlight.

Silhouette portraits continued to be popular until the early 1900s. Many famous people including most of the first presidents of the United States have had their silhouette portraits made. Because of silhouette portraits, we are still able to see what men and women who were important to American history looked like. Silhouette portraits have helped us remember those who have lived long ago.

Activity. After reading aloud the vignette, ask students to think about why George Washington's granddaughter made a silhouette portrait of her grandfather. The discussion will certainly touch on having something to remember him by. Ask students to think about a favorite family member, friend, or pet that they would like to always remember. Suggest that they make a silhouette portrait. Students can practice making portraits in class. Students can even make albums containing portraits of several persons. For each portrait, students can write biographical information and a story about the person or pet.

Activity 12

Shadows in Action: The Shadowbox Theater

When the sun shines, shadows can be seen on the ground or a wall, creating an outline of any object that blocks the light. Shadows are so common that you probably do not pay much attention to them. However, there is much to discover if you observe shadows and experiment with making your own. A fun way to learn about shadows is to make a shadowbox theater and shadow puppets.

Shadowbox theaters were very popular in Europe during the 1800s and early 1900s. They are still popular in the Indonesian Islands of Bali and Java where very elaborate shadow puppet shows are performed. Follow these directions to make your own shadowbox theater.

Materials:

- ☐ Shoeboxes or other small cardboard boxes
- ☐ Craft or Popsicle sticks
- ☐ Scissors
- ☐ Construction paper
- ☐ Flashlights or other light sources
- ☐ Different types of translucent paper
- ☐ Transparent tape
- ☐ Various art supplies to decorate the boxes

1. Stand the shoebox on its end. Cut a square hole at the top end of the bottom of

the box. This is where the screen will be. The hole should be about 13 centimeters square (13 cm X 13 cm).

2. Cut out a piece of translucent paper just a little bit bigger than the hole you made. Tape or glue the paper on the inside of the box covering the hole. This will be the screen for your theater. Your theater is ready. If you like, use paint, crayons, markers, or paper cutouts to decorate your theater.

3. Now you need a story and puppets. You can make up a story or choose a story that you know. Decide on the characters and what you want the characters to do and say. Draw an outline of the characters on construction paper, making sure that your puppets are small enough to fit on your screen.

4. Carefully cut out your shadow puppets. Tape the puppets to craft or Popsicle sticks so that you have a handle.

5. Shine a flashlight into the box in a darkened room. (You may want to place the flashlight on a pile of books or work with a partner.) Move your puppets in the box between the light and the screen. The puppets will appear as shadows to your audience.

6. Experiment with placing the puppets at different distances from the screen. Turn the puppets in different directions to get interesting effects. For example, can you make the shadows darker, sharper, bigger, or smaller?

Now, on with the show!

After you have performed a show and watched a show, answer the following

questions in your Science Notebook.

What did you do to produce the sharpest image on the screen?

What was the most difficult thing about making your shadowbox theater?

How could you improve upon your design?

Which type of translucent paper would you use to design a new screen for a shadowbox theater?

Student SELF-CHECK

Module 2: Light and Lenses

Now that you have completed Module 5, answer the questions below in your Science Notebook as a self-check to see if you need more practice.

1. Which type of object would produce the best shadow, a transparent, translucent or opaque one?

2. Will a shadow look the same size at different times of the day? Why or why not.

3. What happens to the size of a shadow as the object is brought closer to a flashlight?

4. Which instrument would you use to see stars?

5. Explain how you can make a shadow darker and sharper if you are using a flat object and a flashlight.