MODULE m8

How Does It Work?

INTRODUCTION

Module 8 contains five inquiries that facilitate exploration and explanation of how some of the practical applications of optics influence the day to day lives of students:

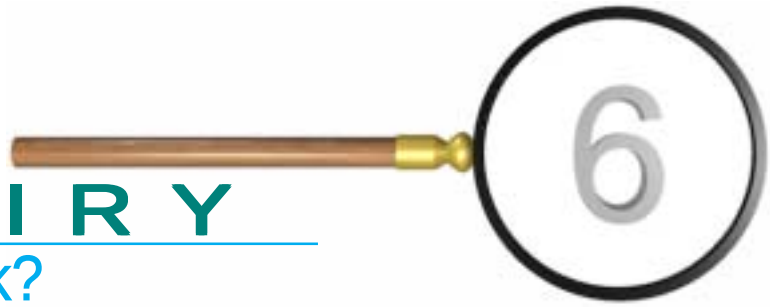
Inquiry 6: Cameras and Photography
Students investigate making and using pinhole cameras. Suggestions for ways to investigate the history of cameras and photography in are also provided.

Inquiry 7: Lighthouses
There is a brief history of how lenses are used in lighthouses. There are also several suggestions on how to link the study of lighthouses with science, art, math and language arts.

Inquiry 8: Binoculars, Periscopes, and Kaleidoscopes
There is information on how various optical instruments work. Included are discussions of binoculars, periscopes and kaleidoscopes. Information on how to make some of these optical instruments is included.

Inquiry 9: 3D Images and Holograms
The principles behind 3D images and holograms are explained. Students are also encouraged to investigate some of the current applications of holograms.

Inquiry 10: Project Ideas for Light and Optics
Extensions to the activities are provided as well as enrichment opportunities for students who wish to learn more. Also included, are instructions for making periscopes and kaleidoscopes.



INQUIRY

How Does It Work?
Cameras and Photography

Pinhole images have been seen since the time of Aristotle. What he saw were images and shapes flickering through the tiny holes made between several leaves overlapping. Pinhole photography is the capturing of those images and shapes onto film using no lens. A tiny hole replaces the lens. Light passes through the hole and an image is formed on the back wall of the camera. The image is upside down because light travels in straight lines and therefore crosses at the hole. If looking at an outdoor scene, the sky is at the bottom and the ground at the top. Pinhole cameras can be small or large. They can be made of seashells, oatmeal boxes, film canisters, soda cans or any size box. Even cars and rooms in large buildings have been used as pinhole cameras. In the Renaissance and later centuries the pinhole was mainly used for scientific purposes in astronomy. However, as time went by the pinhole image (often called a *camera obscura*) was used more and more as a drawing aid for artists and painters.

Make a Pinhole Camera. A simple device called a pinhole camera is an easy and safe way to view the Sun. It involves projecting an image of the sun through a tiny hole onto a white sheet of paper. Students should be closely monitored while making pinhole cameras so they do not look directly a the sun.

Students will need a sunny day, a partner and two pieces of white paper. Have students follow theses directions:

1. Punch a hole in the center of one piece of paper. Go outside, hold the paper up, and aim the hole at the sun. DO NOT LOOK AT THE SUN!
2. Move the other piece of white paper back and forth until the image of the sun is on the paper and is in focus (the clearest image of the sun you can see). What you are seeing is not just a dot of light, but an actual image of the sun.
3. Experiment by making the pinhole larger or smaller. Record in your Science Notebook what happens to the image of the sun.
4. What happens if you punch 2 holes in the piece of paper? Or, try bending your paper so that the images from the 2 holes are placed one on top of another. Record your observations and compare them with other students. Write a paragraph about your experience. Include possible uses for a pinhole camera.

Research. Students can be encouraged to find out more about cameras and photography by researching some of the following topics.

- **Magic Lanterns** were once considered the most famous and entertaining inventions in history. The early form of the magic lantern is considered the forerunner of our current day slide projector or overhead projector.

- **Daguerreotypes** were pictures on metal. These were the first quality photographs but they could not be reproduced.

- **Calotypes** were the first type of photographs that produced a negative picture on paper; the lights of the image were recorded as darks, and the darks as lights.

- In 1888, Thomas Edison created an apparatus that he called a **kinetoscope** which means "Moving View." The invention consisted of photographing continuously a series of pictures occurring at intervals greater than eight per second. The images were recorded in a continuous spiral on a cylinder plate in the same manner as sound was recorded on the phonograph. In groups, students could study the life of Thomas Edison and report on some of the inventions he patented during his lifetime and note the creative way he attempted to answer his own questions about the world around him.

- In 1900 the **Brownie Camera,** which was made for children to use, sold for $1.00. The intention was to make cameras available to as many people as possible. The Box Brownie contained a roll of film with 100 exposures. Once the film was used, the camera and the film were sent back to Kodak where the film was developed and new film was put into the camera.

- In 1947 the **Polaroid Land Camera** produced instant pictures within 60 seconds, and became one of the most popular cameras of all times. Have students research and find out how these instant cameras operate. Polaroid film and cameras are still being manufactured and have undergone many changes since the original instant camera. Here is the story of how Edward Land got the idea for the instant camera:

  Edward Land was taking pictures of his family on vacation in the southwest. His young daughter asked, "Why do we have to wait to see the pictures?" and Land thought to himself, "good question!" He later sketched out some of his ideas and experimented with them after he returned to his lab in Boston. The Polaroid camera and the science of instant photography emerged soon thereafter.

- **Motion Picture Cameras**: Thomas Edison and George Eastman from Kodak worked together to produce the first motion pictures. Students could conduct research about this partnership to answer the question: "Was it the partnership of the two men that facilitated the invention?"

- Students can research the history of movies and movie technology. Encourage them to include how films are being restored because the film itself deteriorates and how movies have changed over time.

- A **photocopier** is an invention that has made our lives more convenient. The term "xerography" comes from two Greek words meaning dry writing. Chester F. Carlson in 1938 first invented this technique which gave rise in 1959 to the first office copier produced by Xerox. Photocopiers today use lenses, mirrors, color filters, lamps, and toners of magenta, cyan, yellow and black to reproduce images.

- Some students are already familiar with the **video camera** and **digital camera** technology. Students could use newspapers to research the cost and features of various types of video cameras and digital cameras. They could then design an ad that would encourage consumers to purchase a particular type of camera.

INQUIRY 7

How Does It Work?
Lighthouses

The first great lighthouse was built on an island in the harbor of Alexandria, Egypt. The Pharos tower, built around 280 BC, was 450 feet high, and the light produced by a fire kept blazing on its roof, could be seen from as far away as 29 miles out in the Mediterranean. Sailors needed the Pharos light because the city of Alexandria was on the flat Nile Delta. There were no mountains or other natural features to help them find the city. Ancient peoples built fires on hills and mountainsides to bring sailors home from the sea. The Pharos tower attracted sailors from far distances and, as a result, Alexandria became one of the busiest ports in the world.

How did sailors navigate over long distances in earlier times? By day, it was best to remain in sight of the land. That way the sailors could identify features of the land. Most of the travel was local because sailors knew their own waters well and could spot where the water swirled around hidden rocks. At night, however, the open ocean was a better place to be in order to avoid underwater reefs and rugged coastlines. The light from the stars and the moon helped them to navigate.

An open fire produced the light that emanated from early lighthouses. Wind direction would cause the light to be bright or less bright on the side facing the sea. Heavy rains created problems that were solved by using covered lanterns or enclosing lanterns with glazing. As a result the light was greatly reduced, especially if the keeper did not keep the glazing clean. Fuel for the fire was wood and forests were often destroyed to keep the light burning. After AD 1500 coal was used in lighthouses. This method was effective at producing light except when blown by the wind, because the fire became hot enough to melt the grate holding the coal. However, coal-burning lighthouses continued to be used well into the 19th century. Some lighthouses used oil lamps, which consisted of small containers filled with oil and a floating wick. Later a cresset, a stone bowl containing oil and a fixed wick, was used. The type of oil preferred was sperm whale oil. Petroleum oil or kerosene was used around the 1870's in regular lamps. In the early 1900's the incandescent oil vapor lamp came into use. This lamp produced a bright light that was used with the Fresnel lens. Electric generators were used until 1875 to provide electricity for the lighthouses until power lines could be run.

Many different materials were used to construct lighthouses, for example, stone, iron, wood and iron, bricks, limestone, and concrete. By 1820, the United States had 55 coastal and harbor lighthouses. The lighting system used at the time was the Argand lamp that consisted of a lens and a parabolic reflector. By 1850, however, the government authorized use of the multiprismed lens invented in France by Augustin Fresnel in 1822 (see Historical Vignette, Module 2, Activity 5). Fresnel lenses are shaped like a beehive, with concentric rings of prisms around a lens that acts as a magnifier. All of these features focus scattered light from a lamp or bulb into a tight beam. In the 19th century, each lens cost $12,000 plus shipping costs from France. The lenses were ranked in six "orders." The order of the lens was determined by the distance of the flame from the lens, known as the focal distance. The weakest, ranked sixth, was used to light lakes and harbors. The largest, first-order lens, made up of over 1000 prisms, stood 10-12 feet tall, measured 6 feet in circumference and weighed up to 3 tons. When these lenses were mounted at 100 feet above sea level the light could be seen for up to 18 miles at sea.

The study of lighthouses in the classroom is an excellent way to integrate social studies, science, art, math and language arts into the curriculum. Below are some suggestions for studying lighthouses:

K-W-L Chart: Students, in cooperative groups, create a K-W-L chart on lighthouses. After they have created their charts, have them plan how they will answer their questions. Encourage students to answer the questions and share with the rest of the group.

Art. Have students work in cooperative groups to design and draw what they think a lighthouse looks like. Encourage them to put as much detail into their drawing as possible and discuss features that they think are necessary to create a working facility. This will entail some research on the student's part on different types of lighthouses.

Parabolic Reflector Model. Parabolic reflectors were used to increase the amount of light produced by a light source in lighthouses. They were made out of curved metal, usually copper, and coated with a silvery compound. Provide students with cardboard, candles or a flashlight, aluminum foil, aluminum pie plates, lenses and other items needed for them to design a parabolic reflector that could concentrate and increase the amount of light coming from a candle or a flashlight. Have them design a model, draw their model and then create a working model.

Diorama. Have students design a diorama showing what a lighthouse and surrounding area would look light along the Florida coast or along the California or Oregon coast. (Generally speaking, lighthouses found on the Pacific coastline were not very tall because of the rocky terrain, whereas the ones found along southeast coastline were usually quite tall.)

Poetry. Lighthouses have been the inspiration for many poems. Three poems about lighthouses follow. After you read them, have students write a poem with a lighthouse as the theme or have students find other poems about lighthouses.

The Lighthouse

by Henry Wadsworth Longfellow

The rocky ledge runs far into the sea,
and on its outer point, some miles away,
the lighthouse lifts its massive masonry,
A pillar of fire by night, of cloud by day.

Even at this distance I can see the tides,
Upheaving, break unheard along its base,
A speechless wrath, that rises and subsides
in the white tip and tremor of the face.

And as the evening darkens, lo! how bright,
through the deep purple of the twilight air,
Beams forth the sudden radiance of its light,
with strange, unearthly splendor in the glare!

No one alone: from each projecting cape
And perilous reef along the ocean's verge,
Starts into life a dim, gigantic shape,
Holding its lantern o'er the restless surge.

Like the great giant Christopher it stands
Upon the brink of the tempestuous wave,
Wading far out among the rocks and sands,
The night o'er taken mariner to save.

And the great ships sail outward and return
Bending and bowing o'er the billowy swells,
And ever joyful, as they see it burn
They wave their silent welcome and farewells.

They come forth from the darkness, and their sails
Gleam for a moment only in the blaze,
And eager faces, as the light unveils
Gaze at the tower, and vanish while they gaze.

The mariner remembers when a child,
on his first voyage, he saw it fade and sink
And when returning from adventures wild,
He saw it rise again o'er ocean's brink.

Steadfast, serene, immovable, the same,
Year after year, through all the silent night
Burns on forevermore that quenchless flame,
Shines on that inextinguishable light!

It sees the ocean to its bosum clasp
The rocks and sea-sand with the kiss of peace:
It sees the wild winds lift it in their grasp,
And hold it up, and shake it like a fleece.

The startled waves leap over it; the storm
Smites it with all the scourges of the rain,
And steadily against its solid form
press the great shoulders of the hurricane.

The sea-bird wheeling round it, with the din
of wings and winds and solitary cries,
Blinded and maddened by the light within,
Dashes himself against the glare, and dies.

A new Prometheus, chained upon the rock,
Still grasping in his hand the fire of love,
it does not hear the cry, nor heed the shock,
but hails the mariner with words of love.

"Sail on!" it says: "sail on, ye stately ships!
And with your floating bridge the ocean span;
Be mine to guard this light from all eclipse.
Be yours to bring man neared unto man.

THE DIAMOND BY THE SEA

Like a ruby in an antique brooch with sentiment untold,
The gem in the tower glistens with beauty to behold!
Its glow reflects where sea meets sand in sapphire rivulets
That trickle down with the ebbing tide to the ocean's treasure chest.

The jewel on the horizon worn with dignity and grace
has romance and security wrapped up in its embrace
Beneath the sky of topaz shining brilliantly
the lighthouse is the brightest gem - The Diamond by the Sea.

-unknown–

THE LIGHTHOUSE LULLABYE

Lay down your head and close your eyes
and rest your weary soul,
For the lighthouse shines through fog, and rain,
and night as black as coal!

Though winds are lashing and waves are crashing
on coral reefs below,
The beacons calls and beckons all
with its majestic beam aglow.

When stars are out and seas are calm
and eventide draws nigh -
The seafarer rocks in a cradle of waves
to The Lighthouse Lullabye.

- unknown -

Design a Game. The light keepers on many of the earlier lighthouses often remained isolated for long periods of time. Students in cooperative groups could make a list of things that a light keeper might do to for entertainment. Have students share their ideas and design a game or an activity for a child their age that was a child of a lightkeeper. Students could then play the games and imagine what it would be like to live in a lighthouse. Students design a list of all of the items they would need to bring with them for an extended stay at a lighthouse. Rooms were small so they would only be able to take one suitcase.

Writing. Have students write a story about life in a lighthouse. What would they miss most? What would meals be like? How would they get to school?

Life Science. Many light keepers or their wives became involved in gardening to beautify the lighthouse. Have students design and draw a plan that would beautify the lighthouse grounds. Encourage students to consider conditions plants would have to tolerate in order to fluorish. Students may wish to include vegetable gardens, however they would have to find varieties of vegetables that suit the environment.

Art and History. Lighthouses along coastlines were often used as “daymarks.” A daymark is a landmark used during the day by sailors. Lighthouses along some coastlines were identical in design. Therefore, they had to be painted in different ways so that they could be used as daymarks. Have students draw several lighthouses of the same design and color them in ways that would be visible from far away. Once these are completed display them in class. Students will be surprised at the variations.

Reading. Read the book *The Wreckers* (ISBN: 0-440-41545-4) by Iain Lawrence as an extension of their studies of lighthouses. This is the story of a boy and his father who become shipwrecked in a village populated by wreckers. Located on the English coast, the village is populated by villagers who feed and clothe themselves with what they could salvage from shipwrecks.

Geography. Have students research the geography and history of the lighthouses along the Florida Coast. Students could take a map of Florida and locate the lighthouses that still exist on the map. Many of these lighthouses are open for tours and belong to the National Parks Service. Have students plan a trip to one of the open lighthouses close to them and calculate how much money the trip would cost.

Because the Florida Keys were one of the most dangerous sea lanes and many ships wrecked in the narrow strait between the Gulf Stream and the Florida Reef, the area became a prosperous resource for "wreckers" and pirates. Wreckers were individuals who recovered the cargo from wrecked ships and sold it at auction. This was a legitimate business at the time, but there were also "mooncussers" who illegally tried to have ships wreck for salvage and profit.

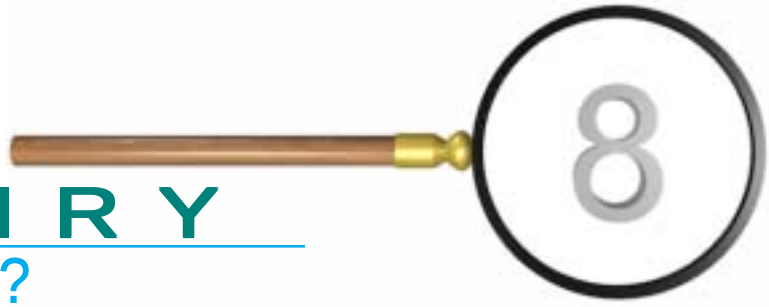
Journal Writing. Light keepers usually kept a journal or log documenting the events of the day. Have students pretend they are keeping a log and record some of the things they might encounter during a two-week stay at a lighthouse. What ships did they see? What did they do? Have students discuss in small groups the kinds of things they could write about before they begin.

Research. There are Fresnel lenses found in other things beside lighthouses, have students find out some of them and be able to explain how they help us. For example, Fresnel lenses are now created out of plastic and are used for solar energy collection.

Models. Using print and electronic media, students design a model or draw a picture of a lighthouse that exists somewhere in the United States. The name of the lighthouse, its location and the date it was constructed should be on this project. Encourage students to research the type of light or lens used and to include historical information such as whether it has been moved due to coastal erosion, if the lighthouse is part of the National Parks system, or if the lighthouse was also a residence.

Current Issues. Even though many lighthouses are not currently operational, there are conservationists who believe these should be preserved. In some locations, erosion has caused the land on which the structures rest to become unstable. Divide students into groups to debate whether or not lighthouses should be preserved, restored, or moved to another location. Students should justify their ideas and opinions with facts.

Reading/Social Studies. Read *A Light in the Storm* by Karen Hesse (ISBN 0-590-56733-0). This is a Civil War diary of a young woman who is part of a family responsible for the lighthouse on Fenwick Island, Delaware. This story not only provides a literature connection to light and optics and can enhance study of the life during the Civil War.



INQUIRY

How Does It Work?
Binoculars, Periscopes, and Kaleidoscopes

Binoculars, periscopes, and kaleidoscopes use mirrors, lenses, and/or prisms. Learning about these optical instruments can enhance your students' study of light and optics. This activity introduces each of these instruments and provides instructions for constructing models.

How do binoculars work?

Binoculars are used to make distant objects look larger. Binoculars are really just two refracting telescopes joined together with a hinge. Soon after telescopes were invented, people started to fasten two of the long tubes together to make binoculars. These long binoculars were heavy and difficult to handle. Since it was difficult to keep these tubes parallel to one another, the image seen was often doubled.

Around 1900 a German physicist named Ernst Abbe made a pair of binoculars using prisms that reflected the incoming light twice. This meant that it was possible to make a shorter instrument.. By using two prisms the image appeared rightside up.

Binoculars are found in three designs: 6x30, 7x50, and 8x30. The first number tells the magnification of the binoculars and the second number gives the diameter of the objective lens in millimeters. When using binoculars, you look at an object and light reflects off the object and enters the front of the binoculars through the objective lens. This forms an image that is upside down and reversed. Prisms correct the image before we see it through the magnifying eyepiece lenses.

Life Science. Encourage students to use binoculars to observe birds. They can record some of the following features used for the identification of birds. The shape and color of the eyes, feet, color of the plumage, shape of the head, shape of the tail feathers, and beak shape and color. They should record in their Science Notebooks some of these features, sketch what they observe, or both. Using guidebooks for the identification of birds and bird observation may turn in to a life-long hobby.

What is a Periscope?

Periscopes are instruments that allow the viewing of objects that are not in the direct line of vision. Periscopes found in submarines have tubes that may be up to 30 feet long. Tanks also contain periscopes that allow people inside of a tank to view the surrounding area while remaining protected. With the development of fiber optics, periscopes have been developed that allow doctors to view inside the human body without having to use major surgery. These types of periscopes are called endoscopes or cystoscopes and are very useful in medicine.

The construction of periscopes by your students will allow them to experiment with mirrors and the correct placement of them in the container, whether they use a tube or a milk carton. Students will have fun looking around corners.

MATERIALS:

- ❑ One or two empty quart-sized cardboard milk or juice containers (one for a short periscope and two for a long one)
- ❑ Two small rectangular mirrors, mirror paper or mylar*
- ❑ Tape
- ❑ Scissors or a craft knife.

* Transparency film on black construction paper works like a mirror and the materials are accessible and inexpensive.

Following are two sets of instructions; the first is more discovery-oriented and the second set of instructions are more prescriptive:

Procedure I

1. Place students in cooperative groups of 2-3 students.
2. Discussing, experimenting with the mirrors, and perhaps drawing their periscope design should be encouraged before actually constructing the periscope.
3. Help students discover the angles at which the two mirrors must be placed in order for them to use their periscope. This periscope reflects light two times before it reaches their eyes.

Procedure II

1. Cut the tops off of two milk cartons.
2. Cut a hole about 5 cm in diameter in one side of each carton near the bottom.
3. Tape a mirror, tilted at a 45-degree angle, in the bottom of each carton, with the shiny side facing the hole.
4. Tape the two cartons together so that the holes are on opposite sides of the periscope. In other words, where you look into the periscope is on the opposite side of the tube from the hole where light is coming in.

Students answer the following questions in their Science Notebooks:

1. What do you see when you look into the periscope?
2. How could you use your periscope?
3. Have you ever seen a periscope used? Or, have you seen another instrument that works like a periscope? Describe where you have seen a similar instrument.
4. How can you improve upon the design of your periscope?

What is a Kaleidoscope? It is really all done with mirrors.

The kaleidoscope was invented by Sir David Brewster about 1816 and patented in 1817. It was sold mainly as a toy, but has practical uses as well.

A kaleidoscope uses the image-forming properties of combined inclined mirrors. Depending on the number of mirrors and the angle between them, the kaleidoscope will produce multiple symmetrical patterns.

A simple kaleidoscope is made of two thin, wedge-shaped mirror strips touching along a common edge or a single sheet of bright aluminum bent to an angle of 45 or 60 degrees. The mirrors are enclosed in a tube with a viewing eyehole at one end. At the other end is a thin, flat box that can be rotated. This flat box is made from two glass disks, the outer one ground to act as a diffusing screen. In this box are pieces of colored glass or beads. When the box is turned or tapped, the objects inside tumble into different groups and when the diffusing screen is illuminated by natural or artificial light, six or eight different symmetrical images appear. The number of combinations and patterns is without limit.

There are five different types of kaleidoscopes. The ***Chamber Kaleidoscope*** has an enclosed object case with free-tumbling jewels, glass, beads or other objects. The ***Liquid Chamberscope*** has an object case filled with liquid (usually glycerin) in which the jewels, glass beads or other objects float. The ***Wheel Scope*** has one or more wheels at its objective end that may contain glass, translucent rocks like agates, pressed flowers, beads, jewels other objects. The ***Refillable Scope*** features a removable object chamber. The contents of this chamber can be changed and users can experiment with their own assortment of colors and objects. The ***Teleidoscope*** uses mirrors and lenses alone. Anything that is viewed is multiplied.

Following are directions for making kaleidoscopes using a Pringles can or a paper towel roll.

Pringles Can Kaleidoscope

MATERIALS:

- ☐ Pringles can
- ☐ Nail and hammer
- ☐ Scissors
- ☐ Compass
- ☐ Transparency film
- ☐ Black construction paper
- ☐ File folder
- ☐ Glue
- ☐ Pen and ruler

Pringles Can Kaleidoscope

1. Make a hole in the center of the metal bottom of the Pringles can with the hammer and nail. With the point of the scissors or other object, expand the hole to a 1.5 cm diameter. This will be the eyehole of the kaleidoscope so it is important that there are no sharp edges.

2. Cut out a 4 cm square of transparency film. Glue the transparency square over the eyehole of the kaleidoscope.

3. Cut from the file folder three 7.5 cm x 19.5 cm strips. Do the same with the black construction paper and the transparency film.

4. Glue the strips together in the following order: file folder, black construction paper, then transparency film. You should now have 3 sets of layered strips. The transparency on top of the black paper should provide a mirror-like surface.

5. Place each set of strips into the open end of the can, edge to edge, with the mirror surfaces facing the center of the can. Looking into the can, the top edges of the strips should form an equilateral triangle.

6. Cut 2 strips from the file folder (23 cm x 1.5 cm). Fold one strip in half the long way. Glue the folded strip along the long edge of the unfolded strip.

7. Glue the combined strips around and along the inside edge of the open end of the can above the mirrors. The folded strip should be closest to the mirrors. Let the glue dry.

8. Cut a circle of transparency film with a diameter of 7.5 cm (the same diameter as the opening of the can).

9. Place the transparency circle inside the open end of the can with its edge against ledge created by the folded strip. Glue circle in place with rubber cement.

10. Place various objects (beads, shells, gemstones, etc.) on top of the transparency circle. Place lid of can back on.

11. Your kaleidoscope is done! Look through the eyehole while turning the can and see the kaleidoscopic show.

Paper Towel Roll Kaleidoscope

MATERIALS:

- ☐ Paper towel roll
- ☐ Scissors
- ☐ Masking tape
- ☐ Compass
- ☐ Pen
- ☐ Ruler
- ☐ Glue
- ☐ Black construction paper
- ☐ Transparency film
- ☐ File Folder

1. Trace the top of the paper towel roll on the folder. Using a compass, draw a circle 1.5 cm larger around the circle you traced. Cut out the larger circle.

2. Make a hole about 1.5 cm in diameter in the center of the circle. This will be the eyehole for the kaleidoscope.

3. Make small cuts around the outer edge of circle from the edge to the traced line. The cuts should be made about every 1.5 cm around the circle. The cuts will form little tabs around the edge of the circle.

4. Cut out a piece of transparency film large enough to cover the eyehole. Glue it over the eyehole.

5. Place the circle on the one end of the roll with the transparency piece facing inside the roll. Fold down the tabs all around the outside of the roll. Secure it to the roll with masking tape.

6. Cut from the file folder three 6.5 cm x 27 cm strips. Do the same with the black construction paper and the transparency film.

7. Glue the strips together in the following order: file folder, black construction paper, then transparency. You should now have 3 sets of layered strips. The transparency film on top of the black paper will provide a mirror-like surface.

8. Place the strips side by side, mirrored surface down, on top of your work surface. Put masking tape across the strips at the top and bottom.

9. Fold the connected strips to form a three sided column 27 cm long with the mirrored surface facing inside. Tape around the column to hold it together. Looking into the column, the top edges of the strips should form an equilateral triangle. Place the column into the open end of the tube.

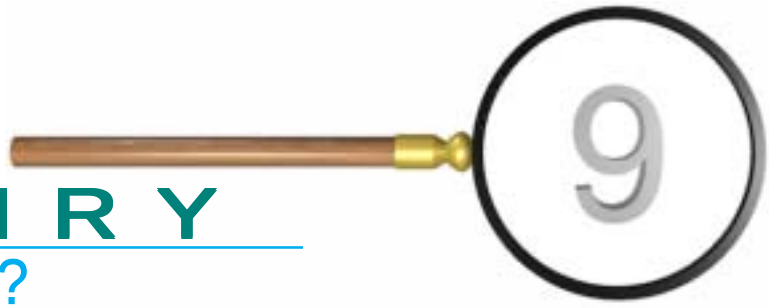
10. Cut out two circles from the transparency film using the directions in steps 1 and 4. You should now have two circles of transparency film with 1.5 cm tabs around it.

11. Fold back the tabs of one of the transparency circles then place it into the open end of the tube so the circle is touching the mirrored column and the tabs are facing out. Secure the circle to the tube with tape.

12. Place your choice of colorful objects (beads, gems, rocks, etc.) into the open end of the tube.

13. Now place the other transparency circle over the open end of the tube. Fold down the tabs all around the outside of the roll. Secure it to the roll with masking tape.

14. Your kaleidoscope is done! Look through the eyehole while turning the tube and see the kaleidoscopic show.



INQUIRY

How Does It Work?
3D Images and Holograms

Three-dimensional Images

Stereoscopic or 3D photography works because it is able to recreate the illusion of depth. Our eyes are about two and a half inches apart, so each eye sees something different. If you view two photographs that are taken the same distance apart with a stereoscope, then you will be able to see depth.

To show how your eyes see things different, hold your finger about a foot from your nose and close one eye, then reopen it and close the other. Your finger will appear to jump from side to side.

The principles of three dimensional or 3D images were known even before photography was invented. Charles Wheatstone experimented with stereoscopic drawings of simple objects in 1832. After the discovery of photography a few years later, the two principles were combined and stereoscope viewers were made. They became a very popular form of home entertainment. In 1844 a technique for taking stereoscopic photographs was demonstrated in Germany, and David Brewster developed a much smaller and simpler viewer that used prismatic lenses in Scotland. Stereoscope viewers were used to look at cards called stereographs. A stereograph is a twin photograph with two images mounted side by side. Each picture is taken from a slightly different viewpoint that is equal to the spacing of the eyes. When looked at through the stereoscope viewer, the picture appears as a three-dimensional image.

Anaglyph images are the type of 3D images with which students are most familiar. Louis Ducas Du Hauron, a French scientist, patented this method of stereoscopic photography in 1891. A pair of images taken from slightly different points is color corrected and superimposed so that one image is offset slightly from the other. Typically the image for the left eye is printed in red ink and the right eye image is printed in green ink. When observed with the naked eye, the image looks overlapping, doubled and blurry. However, when viewed through a pair of glasses with different colored lenses, the image appears to be 3-dimensional. The glasses used to view these objects are usually red and blue with the red lens covering the left eye and the blue or sometimes green lens covering the right eye.

The stereoscope is considered a form of mass media. This instrument allowed many people to "travel" to far off lands without leaving home. Some things that particularly interested people were the pyramids and tombs of ancient Egypt, the sights of New York, Chicago and San Francisco, and the abbeys and countryside of Europe. The great events of the day also found their way into stereo slides. Among these were the building of the Panama Canal, War World I, the Johnstown Flood, and the San Francisco earthquake. The Chicago World's Fair of 1892 and the St. Louis World's Fair of 1904 could be enjoyed even by those who could not be there. Have students design a series of stereoscope programs that show a current or historical event. Discuss why the depiction of events was more important around the turn of the century.

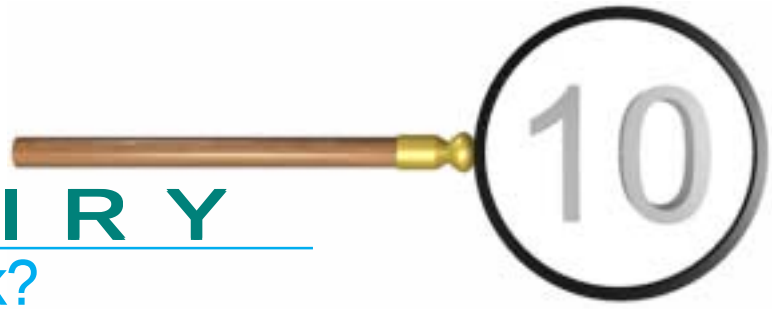
Holograms

The method of making three-dimensional photographic images *without* a lens is called holography and the images are called holograms. A British physicist, Dennis Gabor, developed theories involved with holography in 1947. However, the first production of holograms did not take place until the 1960's when laser technology became available.

Holography has very little in common with regular photography. Holograms contain information about the size, shape, brightness and contrast of the object being recorded. Lasers are used to produce holograms because their light is one color and highly directional. Holograms record images of light waves emitted from a laser as they are reflected off an object. This hologram when lighted and viewed under ordinary light, presents a three-dimensional re-creation of the original object.

Today holograms are used in security applications, commercial and consumer applications, and promotional pieces. Holograms are used to protect financial documents, credit cards, tamper-evident stickers, and on paper money. The reason for using holograms is that they are difficult to copy. Some commercial/consumer applications would include greeting cards, collectibles, trading cards, packaging and displays. Promotional pieces would include T-shirts, tags on merchandise, stickers and key chains.

Activity. In cooperative groups have students create a list of all of the places they have seen holograms. Compile a class list after each group has completed their group list. Ask students to comment on the reasons why these are used. It is said that, in the very near future, holograms will be broadcast over television. Have students discuss and write about this would change television? How would their favorite TV program change if this happened?



INQUIRY

How Does It Work?
Project Ideas

The following ideas can be used during the study of optics as extensions to the activities or as the main focus for your unit.

Research. Assign to pairs of students one of the following vision problems or diseases:

- Nearsightedness
- Farsightedness
- Astigmatism
- Color blindness
- Macular degeneration
- Retinitis pigmentosa
- Cataracts

Each student pair finds and presents answers to the following questions:

1. What causes this vision problem or disease?
2. How different parts of the eye are affected?
3. How can this vision problem or disease be helped by technology, devices or surgical procedures?
4. How does each device or procedure work to change the affected parts of the eye to enhance better vision?

Once students have completed their research, have them prepare a poster, pamphlet, or other form of presentation that explains to others the causes and treatment of the problem or disease they investigated.

Research/Interview. Students research how eyeglasses or contact lenses are made and how they are designed to correct various vision problems. Encourage students to report on changes in the design of contact lenses and materials used to make them since the first ones were made available to the public (for example, the evolution of hard contact lenses, soft contact lenses, disposable lenses, or bifocal contact lenses). Students could conduct an interview with an optician or opthamologist to find out more about the fitting of contact lenses and the problems they encounter.

Model Design. Students design models that illustrate the similarities and differences between the human eye and devices that use lenses, such as cameras, microscopes and telescopes.

Timeline. To integrate history and the study of optics, students research and prepare a timeline large enough to be displayed in the classroom on the history of lenses, the history of optical instruments, or the history of basic theories involving light and its properties. Refer to the *Science, Optics & You* Timeline at http://micro.magnet.fsu.edu/optics/timeline/index.html

Scientist Trading Cards. Students design a *Famous Scientist Trading Card* (adapted from Biology Biography activities by Nora C. Doerder). The Scientists Cards are colorful, collectible cards in the following format:

Front of the Card:
- Photograph or portrait
- Name of Scientist
- Time Period
- Most significant contribution
- Awards and Honors
- Areas of Study

Back of the Card:
- Stats: Basic biographical information
- A quote
- A picture related to this person's work.

Scientist Scrapbook. Students work in groups to prepare a Famous Scientist Scrapbook (adapted from Biology Biography activities by Nora C. Doerder). The scrapbook can have a colorful cover to serve as an introduction to the scientist and the contributions he/she made to the study of optics, color and light, physics, or photomicroscopy. The cover can be illustrated with a picture or portrait of the scientist and pictures relating to the scientist's work. The following are some suggested scrapbook entries:

1. A personal timeline for the scientist. Display the high points of your scientist's personal and professional life and include at least five events.
2. A birth announcement and birth certificate. Create a certificate and appropriate information.
3. A letter written by the person as a young man/woman revealing information to a friend about his/her interests.
4. A letter of recommendation for this person to a college from a high school teacher.
5. A speech or essay written by this person on the topic "Advice to Young People Who Want to Succeed in Science."

6. A letter of introduction from the scientist to the class. A letter written by a student appearing to be from the scientist as if he/she were alive today.
7. A newspaper article reporting and explaining important events in which this person was involved.
8. A script for a radio commercial featuring this person and their work.
9. A color advertisement about this person and their work.

Research: Scientists Related to the Study of Optics.

General Optics: Ali Alhazen, Roger Bacon, Johannes Kepler, Hans Lippershey, Galileo Galilei, Francesco Grimaldi, Willebrod Snell, Rene Descartes, Pierre Fermat, Robert Hooke, Isaac Newton, Christaan Huygens, Thomas Young, Joseph Von Fraunhoffer, Augustin Fresnell, Christian Doppler, Michael Faraday, Jean Foucault, Albert Einstein.

Microscopy: Hans Jansen, Robert Hooke, Karl Friederich Gauss, Antonie Van Leeuwenhoek, Christaan Hyygens, Joseph Jackson Lister, Zacharias Jansen, Carl Zeiss**.**

Refer to the *Science, Optics & You* Timeline at http://micro.magnet.fsu.edu/optics/timeline/index.html