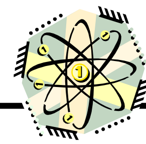
Intradisciplinary Connections

See pages 31-32 for the complete wording of the Texas Essential Knowledge & Skills addressed in this learning experience.



Physical Science

- Interactions of matter and energy
- Transfer of energy

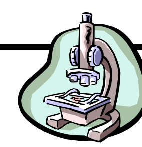
Properties, Patterns, & Systems

History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

Science and Technology

- Understandings about science and technology
- Abilities of technological design



Life Science

- Structure and function in living systems
- Regulation and behavior

Overview of Learning Experiences

TEKS	**6.5** The student knows that systems may combine with other systems to form a larger system. The student is expected to: (A) identify and describe a system that results from the combination of two or more systems (B) describe how the properties of a system are different from the properties of its parts. ***To read complete TEKS student expectations for 6.5 and 6.6, see page 31-32.***
Engage	✦ Students hypothesize on the function of an object that is actually a picture of a very unusual simple microscope invented by Anton Von Leeuwenhoek. ✦ Students observe, describe, and record properties and magnifying power of baggie and water drop magnifiers in their science journal.
Explore	✦ Students manipulate various lenses to classify them by their ability to magnify. ✦ Students combine lenses in a system that results in a more powerful magnifier. ✦ Students design a system used to measure magnification strength of a lens.
Explain	✦ Students relate the shape of a lens to its ability to magnify. ✦ Students communicate the parts and functions of a self-designed compound magnifying system, and a system used to measure its magnifying power. ✦ Students demonstrate proficiency in focusing the microscope and preparing slides. ✦ Students relate the changes in the image of the letter "b" under the microscope to the changes that occur in light rays as they pass through a lens.
Elaborate	✦ Students investigate eyes as optical systems during a sheep's eye dissection and construction of a baseball model of the eye. ✦ Students investigate cameras as optical systems, and construct a pinhole viewer. ✦ Students compare the structures and functions in eyes and cameras, using a Venn diagram.
Evaluate	**SUMMATIVE ASSESSMENT** ✦ Students are assessed by a rubric score on a set performance tasks including lab safety, proficient use of the microscope, a completed student journal on optical systems, and the development of an individual student product on the optical system of their choice.

ENGAGE

1. Review with students the information on "My Science Journal" page. Show students an overhead picture of Leeuwenhoek's simple, paddle-like microscope, and ask them to draw it in their journals, and write a hypothesis about what the object might be used for. After a few guesses, reveal that it was a microscope from the 1600's invented by Anton Von Leeuwenhoek, who was the first person to make an optical system that was powerful enough to clearly observe microscopic protists and bacteria. How did he develop such a powerful simple microscope with a single lens? What properties make a lens able to be a powerful magnifier and able to form clear images? Students will compare the magnification properties of a baggie lens, and a water drop lens to discover which properties make a lens a more powerful magnifier and able to form clear images.

MATERIALS (details p. 25)

For the class:
- ☐ Transparency of Leeuwenhoek's microscope

For each group:
- ☐ water
- ☐ clear plastic wrap
- ☐ baggies
- ☐ letter "b" on white paper, Master A
- ☐ trays

For each student:
- ☐ student journal
- ☐ *My Science Journal*, Master B

ENGAGE

2. Baggie Lens

Hand out a water-filled baggies for each pair of students. Ask one student to hold the baggie in front of their face while the other student observes, then squeeze the bag gently in different areas to see if the image of the person's face changes as the shape of the bag changes. After both partners have had a turn, students should place the baggie over the "b"s, and determine if it also magnifies letters. Ask students to place the water baggies in a tray on the table, and complete drawings and descriptions of each observation in their journals.

Questioning Strategies

- How did your partner's face look behind the water-filled baggie? (magnified, but stretched and out of proportion)
- Are both sides of the baggie curved? *(Convex - slightly curved out in the middle)*
- *What properties of the baggie make it useful as a lens? (Tranparent and curved)*
- *Did the baggy magnify the b? (a little)*

The introduction of historical examples will help students see the scientific enterprise as more philosophical, social, and human. Middle-school students can thereby develop a better understanding of scientific inquiry and the interactions between science and society. In general, teachers should not assume that students have an accurate conception of the nature of science in either contemporary or historical contexts.

National Science Education Standards, p. 170

ENGAGE

3. Water Drop Lens

1. Ask students to place a piece of wax paper over a strip of paper with a row of "b"s. Before they begin, they will need to design a chart in their journal to record the appearance of the letter "b"s and the drop shape as they add more water to each drop.
2. After placing one drop of water on the wax paper over the first "b", they should observe the letter from above the water drop, and draw it in their chart. The side view of the water drop shape should also be included for each water drop size recorded.
3. Students should skip to the next "b", and make their next water drop. They need to make this drop bigger by squeezing two drops into the area over the "b." The same observation and recoding procedure describe in Step 2 should be followed. It is important for them to draw the shape of the water drop from the side each time. The cohesive forces of water will hold the drops together until 3 or 4 drops have been added, and then the drop will spread out. It may be interesting for them to test this "drop", too.

Questioning Strategies

- Describe the "b" under the single water drop.(The single drop magnified more than the bigger drops, and the "b" looked clear.)
- What is the shape of the single water drop? *(Curved into a round dome on the top surface and flat on the bottom surface)*
- *Compare the shape of the larger drops with the first drop. (The larger drops were flatter and less domed than the first drop.)*
- *Did you observe a pattern in the magnification properties as the drops became larger? (The larger and flatter the drops became, the less they magnified.)*
- *What shape would you recommend for a lens to use as a magnifier?(Very curved, convex)*

Sample chart

Water Drop Lenses

Number of drops	Draw "b" under drop	Draw drop shape
1		
2		
3		
4		

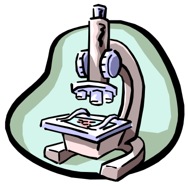
To develop understanding of the history and nature of science, teachers of science can use the actual experience of student investigations, case studies, and historical vignettes.

National Science Education Standards, p. 170

Historical Vignette
Leeuwenhoek's Secret

Leeuwenhoek was a fabric or textile merchant in the 1600's. He and other textile merchants used little "glass pearls" to examine the quality of fabrics. The "glass pearl" became a scientific tool when Leeuwenhoek moved from observing fabrics to other natural objects with it. His quest for increasing magnification led him to grind down the tiny "glass beads" into smaller and more strongly curved lenses. The lenses were so small and hard to handle that he had to fix them between two drilled paddle-like sheets, and put the object he was viewing on the tip of a moveable screw so he could focus it.

ENGAGE



My Science Journal (See Master B)
Scope It Out!

Scientists use journals to write down information about their observations and experiments. The following suggestions will help you complete an interesting and informative journal to show what you have learned about magnifying systems:

1. Dedicate **one** notebook for your journal. A composition book is the best choice because pages can't be torn out easily.

2. Write your first and last name on the cover of the journal.

3. The first page should be titled "Table of Contents." This can be filled in after each of your journal entries have been completed.

4. You may use only the front of each page for journal entries.

5. Skip to the third page of your journal. Number the upper right hand corner of each page, beginning with number 1, until you reach the end.

6. Each journal entry page should be dated, and should have a title to help remind you of the science concept experienced. Labeled drawings of your experiences are important observations!

7. Each journal entry should **explain what you know** or **why you think something happened**. Here are some sentences starters to try:

I wonder if…
I wonder why…
This relates to…
What if…
This observation reminds me of…
I was really surprised when…
During the discussion, I wondered…
My inference about our data is…

EXPLORE

During his lifetime in the 1600's, Leeuwenhoek spent much of his time grinding small pieces of glass into lenses for his tiny 1" by 2" microscopes. He observed everything from pond water to the bacteria on his teeth and made some very surprising discoveries.

He discovered a tiny world of living organisms that he named "wee beasties," living in pond and ditch water, and even tinier bacteria that live in tooth plaque. Many scientists of this period did not readily accept his drawings and descriptions of these microorganisms. They didn't believe an unknown Dutch fabric merchant could make microscopes that were clearer and more powerful than the ones they were trying to develop by combining two lenses to make a compound microscope. In this learning experience, students will discover that the quest to develop a clear, powerful magnifying system using two lenses took patience and perseverance.

1. Ask students to work with a partner to explore the variety of lenses and magnifiers in their tray.
2. Challenge teams to discover the combination of lenses that form the clearest and most powerful magnifying system. (They may also use the baggie or water drop lenses.)
3. Teams must make a visual that shows a **labeled diagram** of their magnifying system, explains the **steps used to make and operate it**, and **explains the system of measurement** used to determine its magnification power. A variety of materials are provided for students to use – rulers, graph paper, and lined paper. Students may observe pond water if they can devise a method to contain it in the magnifying system.

EXPLORE

Materials (details p. 25)

For the class:
☐ transparency of convex and concave lens

For each group:
☐ hand lenses
☐ large hand magnifiers
☐ loupes
☐ variety of convex lenses
☐ variety of concave lenses
☐ magnifying boxes
☐ transparent cm rulers
☐ graph paper
☐ pond water
☐ lined college ruled paper
☐ baggie, and water drop lens from the explore activity
☐ chart paper

For each student:
☐ student journal

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach conclusions that we currently take for granted.

National Science Education Standards, p.171

EXPLAIN

A. Discuss the results of the initial tests of the lenses or magnifiers on the rulers, graph paper, and lined paper.

1. Students should have discovered that convex lenses were good magnifiers, but concave lenses were not. (Discuss the properties of each type of lens as a review.) Did their predictions agree with the results?
2. The second task was to determine which of the lenses used was the most powerful magnifier. Ask students to describe the test used, and the method of measurement.
3. The third task was to try combinations of two lenses or magnifiers to increase the magnification of the ruler, lined paper, or graph paper.

Materials (details p. 26)

For each group:
- ☐ hand lenses
- ☐ loupes
- ☐ variety of convex lenses
- ☐ variety of concave lenses
- ☐ magnifying boxes
- ☐ graph paper
- ☐ lined college ruled paper
- ☐ baggie, and water drop lens from the explore activity

For each student:
- ☐ student journal

EXPLAIN

Questioning Strategies

Which lenses were magnifiers? (*convex lenses)*

- How can you tell which is a concave and which is a convex lens? (*A convex is thicker in the middle, and a concave lens caves in the middle.)*
- *What was your group's strongest magnifier? (The most curved convex lens)*
- Hold a magnifier over notebook paper.
- How many lines can be seen in the lens? 1
- How many lines can be seen outside of the lens? (Two*, so the magnification of the lens is 2x. This means that the image of the lines viewed through the lens looks two times larger than they really are.*
- Demonstrate and describe the combination of lenses that your group found to be the most powerful magnifying system.

B. Show students a picture of another early microscope made by Robert Hooke in the late 1600's. Explain that his microscope was powerful enough to observe cells. He coined the term "cell" after seeing tiny boxes that looked like the cells or tiny rooms that monks used for living quarters in monasteries.

Questioning Strategies

- How many lenses does Hooke's microscope have? (*2)*
- *How many lenses did your combination of magnifiers have? (2)*
- What is a microscope with two lenses called? (*A compound microscope)*
- How do we figure out the magnification if there are two lenses, one above the other, just like our combination of magnifiers? (Multiply *the magnification of the top lens times the magnification of the bottom lens)*
- What is the magnification of a compound microscope if the top lens near our eye, called the eyepiece lens, magnifies 2x, and the lens closest to the newsprint, called the objective lens, magnifies 10x? *(2 x 10 = 20x)(It makes objects look 20 times larger than they really are)*
- What else did Hooke add to his microscope? (*A mirror and an oil lamp)*
- Why is this an improvement over Leeuwenhoek's paddle microscope that had to be held up to a candle? *(Hooke could use his microscope when it was dark because he had an oil lamp to supply light for viewing objects. Hooke also added a stand, so he didn't have to hold the microscope and the specimen at the same time.)*

MATERIALS (details p. 26)

For the class:
- ☐ transparency of Hooke's microscope
- ☐ transparency of compound microscope

For each group:
- ☐ water
- ☐ slides
- ☐ droppers
- ☐ letter "b" on white paper
- ☐ compound microscopes

For each student:
- ☐ student journal

EXPLAIN

EXPLAIN

C. Show students a modern compound light microscope.

Questioning Strategies

- How is it similar to Hooke's microscope? *(It has two lenses, its own light source, and a stand)*
- How is it different? *(The light source is an electric lamp, it has a stage to put the slides on, and clips to hold the slide, it has a rotating nosepiece with objectives)*
- Show a microscope diagram transparency to familiarize students with the parts they will need to recognize during the focusing lesson. **They do not need to memorize the parts of the microscope!** The parts that students need to recognize are bolded in the focusing lesson below.

D. Focusing the Microscope

Demonstrate the steps below for students to follow when they view their slides:

1. Place the slide on the **stage** so that the object to be viewed is directly over the hole in the stage. Make sure the **clips** are placed carefully over the ends of the slide.
2. Turn on the **lamp**. Turn the **diaphragm** so the largest hole is directly under the hole or **aperture**. Raise the microscope from the back so they can see how the diaphragm rotates to allow control of how much light can enter the microscope.
3. Rotate the nosepiece so that it is on the **low power** objective. The low power objective has 10x written on the side. It will click into place.
4. Look at the slide on the stage as you carefully turn the **coarse adjustment knob** until the **nosepiece** is as close as it can get to the slide. Always begin focusing on low power, and look from the side, (not through the eyepiece), while lowering the nosepiece to prevent accidents.

EXPLAIN

5. Look into the eyepiece with both eyes open. Slowly rotate the coarse adjustment knob, which raises the nosepiece. The object on the slide will slowly come into focus.
6. Use the fine adjustment knob to sharpen the image.
7. To view the object on high power, simply rotate the nosepiece to the high power objective. Do not touch either of the adjustment knobs before changing to high power, because this will cause you to lose your focus.
8. Once the high power objective clicks into place, you may use only the fine focus knob to sharpen the image. **Do not use the coarse adjustment knob on high power**! It might cause the objective lens to hit the slide.

Place a prepared slide on the microscope, and ask for student volunteers who would like to try the focusing steps on the demonstration microscope. Ask other students to observe the volunteers carefully, so helpful suggestions might be discussed after the demonstrations.

Provide each pair of students with a microscope. The Power of Magnification student data sheet should be completed first, as they look at the objective lenses on their microscopes.

Explain how to make a wet and dry mount slide, using the letter "b" from newsprint. The steps will also be listed on the student sheet, in case they need to refer back to the steps.

E. Preparing Wet and Dry Mount Slides

A dry mount slide is simply placing an object on a slide, and covering it with a cover slip. No water is added, hence the name dry mount. Adding a drop of water to the specimen before the adding the cover slip makes a wet mount slide. Wet mount slides hold the specimen in place, and are useful for living organisms.

EXPLAIN

Demonstrate how to make the letter "b" slide before students begin their microscope work.

Preparing a Wet Mount Slide of the Letter "b"

1. Cut out a lower case letter e from a piece of newspaper. Place it on the middle of the slide, making sure it is right side up so you can read it.
2. Squeeze a drop of water on the e with a pipette or dropper.
3. Hold the cover slip between your fingers, and set one side down on the edge of the drop of water. Slowly lower the cover slip so that it spreads the water out into a thin film and prevents the formation of bubbles.
4. Hold the prepared slide by the edges to prevent smudges.

Students should also be aware of microscope care and safety rules before using the microscope. Discuss these rules before they handle expensive microscopes.

F. Microscope Care and Safety

A microscope is an expensive piece of lab equipment, and must be handled with care:

1. Always use two hands to pick up and carry the microscope. Hold the arm with one hand, and support the base with your other hand.
2. Use lens paper provided by your teacher to clean the lenses on the microscope. Paper towels, tissue, or cloth could scratch the lens. Avoid touching the lens to prevent smudges.
3. When you are finished using the microscope, store it properly to prevent damage.
4. Rotate the nosepiece so the **low power** objective is over the aperture or hole. Use the coarse adjustment knob to roll the nosepiece as close to the stage as possible, and then cover the microscope with a dust cover.

Questioning Strategies

- How did the "b" appear when you looked at it on the slide? *(It looked right side up.)*
- What did you predict the "b" image would look like when viewed under the microscope? *(A "p" because that would be the b flipped upside down.)*
- What happened to the image of the letter "b" when it was viewed under the microscope*? (It was a "q" because it was reversed and flipped upside down by the lenses.)*

The Letter "b":

On Slide

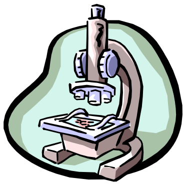
b

Under Scope

q

EXPLAIN

EXPLAIN



Scope It Out! (See Master C)

Student Data Sheet

Calculating the Power of Magnification of a Compound Microscope

A compound microscope has two or three objective lenses, so it has the ability to change the magnification of the image you are viewing. You will need to write the power of magnification under any microscope drawings made after observing specimens. To determine the power of magnification, follow the steps below.

1. Look at the markings 10x on the eyepiece. The x stands for "times" and the number tells you how much the image is increased. If you could look through just the eyepiece alone, it would magnify the object **10 times** larger than it is in real life.

2. Look at the markings 4x on the smallest objective. That tells you that the lens magnifies the object 4 times larger than it is in real life. The medium size objective is usually 10x, and the third objective is usually 40x or 43x. If your microscope only has two objective lenses, the small one is called low power, and usually magnifies 10x, and the larger one is called high power, and either magnifies 40x or 43x.

3. To determine the power of magnification, **multiply** the power of the eyepiece times the power of the objective lens that is over the hole or aperture. If the smallest objective (4x) is over the hole, and the eyepiece is 10x, we would calculate magnification by saying 4 x 10 is 40x. In other words, looking at an image under low power combined with the magnification power of the eyepiece makes it look 40 times larger than its actual size.

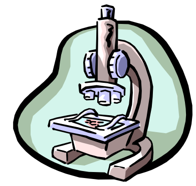
Practice calculating the power of magnification in the following exercises:

Eyepiece	Objective lens	Power of Magnification
10x	4x	
10x	10x	
10x	40x	
10x	43x	

a. How do you calculate the power of magnification?

____

EXPLAIN



Microscope Basics (See Master D)

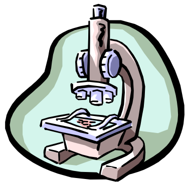
Focusing the Microscope

1. Place the slide on the **stage** so that the object to be viewed is directly over the hole in the stage. Make sure the **clips** are placed carefully over the ends of the slide.
2. Turn on the **lamp**. Turn the **diaphragm** so the largest hole is directly under the hole or **aperture**. Raise the microscope from the back so they can see how the diaphragm rotates to allow control of how much light can enter the microscope.
3. Rotate the nosepiece so that it is on the **low power** objective. The low power objective has 10x written on the side. It will click into place.
4. Look at the slide on the stage as you carefully turn the **coarse adjustment knob** until the **nosepiece** is as close as it can get to the slide. Always begin focusing on low power, and look from the side, (not through the eyepiece), while lowering the nosepiece to prevent accidents.
5. Look into the eyepiece with both eyes open. Slowly rotate the coarse adjustment knob, which raises the nosepiece. The object on the slide will slowly come into focus.
6. Use the fine adjustment knob to sharpen the image.
7. To view the object on high power, simply rotate the nosepiece to the high power objective. Do not touch either of the adjustment knobs before changing to high power, because this will cause you to lose your focus.
8. Once the high power objective clicks into place, you may use only the fine focus knob to sharpen the image. **Do not use the coarse adjustment knob on high power**! It might cause the objective lens to hit the slide.

Preparing Wet and Dry Mount Slides

1. A dry mount slide is simply placing an object on a slide, and covering it with a cover slip. No water is added, hence the name dry mount.

2. Adding a drop of water to the specimen before the adding the cover slip makes a wet mount slide. Wet mount slides hold the specimen in place and are useful for living organisms.



Scoping Out a "b" (See Masters E-F)

Student Data Sheet

Question: How does a microscope change the letter "b"?
Prediction: I think that the letter "b" will look like a ______ under the microscope.

Materials: microscope, droppers, slides, coverslips, newsprint

Procedure:

1. Prepare a wet mount slide of the letter "b".
2. Cut out a lower case letter e from a piece of newspaper. Place it on the middle of the slide; making sure it is right side up so you can read it.
3. Squeeze a drop of water on the e with a pipette or dropper.
4. Hold the cover slip between your fingers, and set one side down on the edge of the drop of water. Slowly lower the cover slip so that it spreads the water out into a thin film and prevents the formation of bubbles.
5. Hold the prepared slide by the edges to prevent smudges.
6. Place the stage on the slide do that the "b" is directly over the hole in the stage. When you look at the "b" directly, not through the eyepiece, it should be right side up.
7. Turn on the lamp. Turn the diaphragm so the largest hole is directly under the aperture.
8. Rotate the nosepiece so that it is on the **low power** objective. It will click into place. Look at the slide on the stage as you carefully turn the coarse adjustment knob until the nosepiece is as close as it can get to the aperture. Always begin focusing on low power, and look from the side, (not through the eyepiece), while lowering the nosepiece to prevent accidents.
9. Look into the eyepiece with both eyes open. Slowly rotate the coarse adjustment knob, which raises the nosepiece. The "b" will slowly come into focus.
10. Use the fine adjustment knob to sharpen the image. To view the "b" on high power, simply rotate the nosepiece to the high power objective. Do not touch either of the adjustment knobs before changing to high power, because this will cause you to lose your focus. Once the high power objective clicks into place, you may use only the fine focus knob to sharpen the image. **Do not use the coarse adjustment knob on high power**!

EXPLAIN

11. Rotate the nosepiece back to the 10x objective, and complete the activities below:
    A. The circles mean "drawings as viewed through a microscope."
    B. Calculate the magnification on low power, and write it on the line under each circle in front of the x.
    B. Draw a picture of what the "b" looks like under low power in the left hand circle below. Then rotate the slide 180 degrees and draw a picture of what you see in the right hand circle.

______x ______x

Right side up Upside down

Turn the slide right side up again, and move the slide as directed in the chart below.

Direction to Move the "b" Slide	**Direction the "b" Appears to Move**
Move slide to the right	
Move slide to the left	
Move slide away from you	
Move slide toward you	

How is the letter "b" changed when it is observed under a compound microscope?

____

____

____

ELABORATE

Students investigate other optical systems, such as eyes and cameras.

A. Students observe the demonstration model of the dissected sheep's eye, and observe a transparency of the parts of the human eye to compare the eyes in structure. Students should draw a diagram of the eye in their journals, and also make observations in words.

B. Emphasize the importance of taking care of our eyes in and out of the science classroom. What are some dangers to eyes out of the classroom? What are some dangers to eyes inside the science classroom? After someone mentions chemicals, show students an eye safety model of a raw egg coming in contact with 1 M HCl in a **glass** petri dish on the overhead projector. The egg is "cooked" by the acid immediately, and can't be changed back to its former raw state by flushing with water. What could the acid do to living eye tissue? The demonstration and an inference about the importance of wearing eye protection should be included in student journals.

C. Students make models of the human eye to investigate how its parts work together to form an optical system that is used in combination with all other optical systems.

The human eye is the most important optical system, because without sight it would be impossible for us to visually observe any of the other optical systems. The instructions for constructing the eye are on page 20. After making the model, students should do research to find out the functions of each part of the eyeball model.

C. Students will also investigate the camera as an optical system, and compare it's structures and functions to the parts of the eye they have studied.

Materials (details p. 26)

For each group of students:
- ☐ hollow plastic baseballs
- ☐ blue/brown felt
- ☐ scissors
- ☐ markers
- ☐ clear plastic wrap
- ☐ glue
- ☐ baggie
- ☐ clear hair gel
- ☐ clear marble
- ☐ tape
- ☐ foil
- ☐ straws
- ☐ used disposable cameras
- ☐ plastic cup
- ☐ wax paper
- ☐ rubber band
- ☐ pushpin

For the teacher:
- ☐drill to cut ball
- ☐ sheep's eye for dissection
- ☐ scalpel
- ☐ dissecting tray
- ☐ transparency of human eye
- ☐ raw egg
- ☐ dropper of HCl
- ☐ goggles
- ☐ **glass** petri dish

ELABORATE

Have students look directly into their partner's eyes, and observe the tiny black pupil that allows light to enter the eye. They should continue to observe their partner's eyes as you dim the lights in the room. Wait a few seconds, ask students to carefully observe for any changes in the pupil, and turn the lights back on. Most students are very surprised by the rapid changes in pupil size in response to light changes.

Questioning Strategies

- What did you observe when the lights were dimmed? (*The pupils got bigger*)
- What did you observe when the lights were turned back on? (*The pupils shrank quickly.)*
- Why would low light cause the pupil to dilate or get bigger? (*So more light could enter the eye, and the person could see objects more clearly in the dark.)*
- Why would bright light cause the pupil to shrink? *(So less light could enter the eyes, and the eyes would be protected from too much light.)*

2. Students should also observe the aperture of a camera, and compare its job to the tiny muscles in the iris that regulate the size of the pupil to regulate light entering the camera.

What do we have to use when we take pictures in the dark or indoors away from natural light? (*We have to artificially supply enough light to reflect off the object and into the camera, so a flash must be used.*)
Used box cameras and models of eyes, or eye posters should be available for students to compare parts and processes of eyes and cameras.

ELABORATE

ELABORATE

3. Students construct a simple pinhole viewer out of cup, wax paper, rubber band, and a pushpin following these steps.

a. Punch a small hole in the center of the bottom of the cup with the pushpin.
b. Tightly stretch a piece of wax paper over the top of the cup, and secure it with a rubber band.
c. Aim the viewer at a lamp in an otherwise darkened room. (Do Not Aim the Viewer at the Sun!)
d. Look at the wax paper, and record what you see in your journal.

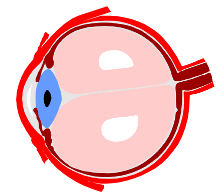
Questioning Strategies

- How is a pinhole viewer like an eye? *(It has a hole like the pupil to let light in, and the image is formed on wax paper, like an image is formed on the retina.)*
- How is the image formed by a pinhole viewer different from the image formed by an eye*?(The pinhole viewer does not have a convex lens to flip the image, but is able to make an upside down image on the wax paper screen the hole isolates a few rays reflecting off the object being viewed. The upper light rays continue in a straight line and hit the bottom of the wax paper screen, and the lower rays hit the top of the screen, which causes an upside down image to form.)*

4. Demonstrate how to take apart one of the disposable cameras. Using the dissected camera and your group's eye model, complete the Venn diagram (Master K) comparing the eye to a camera.

ELABORATE

The Eye – A Magnificent Optical System (See Master G)



Materials: hollow plastic baseballs, clear plastic wrap, clear marble, blue or brown felt, glue, tape, scissors, fold-over-top baggie, straw, drill to cut ball, clear hair gel, foil, markers

Procedure:

1. Your teacher has sliced the baseballs in half for you, and has cut circular holes in the center of each of the halves.
2. Cut a circle of blue or brown felt a little larger than the hole in the center of the ball. This is the **iris**, or colored part of the eye. Cut a hole in the middle for the **pupil**, where light enters the eye.
3. Glue around the edges of the felt, and glue it on the inside of the ball in the center of the pre-cut hole.
4. Cut a circle of clear plastic wrap about the size of the felt, and glue on the outside of the felt to represent the **cornea**.
5. Fill the baggie $\frac{3}{4}$'s full of hair gel to represent the **vitreous humor** fluid inside the eyeball, and tape edges to form an oval that will fit in the ball.
6. Glue the clear marble in the center of the oval for the **lens**.
7. Line the half of the ball that has a tiny hole cut in the center with foil to represent the **retina**. **Rods** (black) and **cones** (color) can be drawn on the retina in marker.
8. Insert a 3" piece of straw through the hole and foil lining to represent the **optic nerve**.
9. Place the baggie inside the first half of the baseball, making sure the lens is behind the pupil.
10. Tape the half with the straw optic nerve to the first half to complete the eyeball.

Research the parts of the eye that are in bold print, and prepare a key for the eyeball that tells the job or function of each part.

Explain why the eye can be considered an optical system.____________________________
____
____

EVALUATE

Student learning about the history, characteristics, and use of optical systems is enhanced and assessed by further research, and the development of an individual student product from the choices listed below:

1. A functional compound microscope model
2. A functional pinhole camera
3. A 3-D model of the eye, with a key describing the reason for choosing each material to represent each part of the eye. (It must use different materials than the class eye model.)
4. An illustrated big book explaining the early history of the microscope, and how it's discovery helped in the development of the germ theory
5. Scientific research and investigation to discover if the protists found in Texas pond water are similar to the protists Leeuwenhoek found in Dutch pond water.
6. An alternate product that is approved by the teacher.

Students will be assessed using rubrics:

Rubric A assesses the following:

- ☐ Lab skills, safety, and participation
- ☐ Performance assessment on proficient microscope use
- ☐ The completion of an informative, illustrated journal of the Scope It Out experiences.

Rubric B assesses the following:

- ☐ The quality of the research and completed product, and on the presentation of the product to the class.

Materials

For each student:

☐ completed journal
☐ assessment rubrics A and B, Masters

EVALUATE

Scope It Out (See Master H-I)

Performance Assessment

Scoring Rubric A

Task	Criteria	
1. Lab Skills, Safety, and Participation	Selects and uses appropriate equipment with care and proficiency. Listens attentively, and stays actively involved in an organized approach.	4
	Uncertain about equipment selection, but uses equipment carefully. Listens to instructions and stays involved, but may wait for others to lead.	3
	Is not familiar with use of equipment, so chooses inappropriate equipment, but does not abuse equipment. Distracted during instructions, so must rely on others for directions.	2
	Uses equipment improperly, and is haphazard and disorganized. Is distracted during instructions, and needs constant reminders to stay on task.	1
	Does not use equipment or abuses equipment. Is disruptive during instructions and activity.	0
2. Proficient and Safe Use of the Microscope	Understands the functions of the parts of the microscope needed for focusing. Is skilled and efficient at focusing on low and high power. Handles the microscope with great care.	4
	Understands most of the functions of the parts of the microscope needed for focusing. Is efficient at focusing on low and high power. Handles the microscope with care.	3
	Understands some of the functions of the parts of the microscope needed for focusing. Can focus on low and high power after minimal prompting. Handles the microscope with care, but may need reminders.	2
	Understands few of the functions of the parts of the microscope needed for focusing. Can focus on low and high power with repeated prompting. Needs to review rules for safe handling of the microscope.	1
	Understands few of the functions of the parts of the microscope needed for focusing. Unable to focus on low and high power even with repeated prompting. Handles the microscope carelessly.	0
3. Scope It Out Science Journal	Contains very detailed entries and labeled drawings that clearly communicate each learning experience, no omissions. Asks astute questions, and makes relevant inferences and connections with optical systems concepts. Very neat and well organized.	4

	Contains detailed entries and labeled drawings that communicate each learning experience, with one omission. Asks relevant questions, and makes inferences and connections with optical systems concepts. Neat and organized.	3
	Contains fairly detailed entries and drawings, with two omissions. Asks questions, and makes some inferences and connections with optical systems concepts. Neat, but may need to spend more time organizing entries.	2
	Contains some entries and drawings, with three omissions. Asks few questions, and makes few inferences and connections with optical systems concepts. May need to spend more time on neatness and organizing entries.	1
	Contains minimal entries and drawings, with four or more omissions. Makes no inferences or connections with optical systems concepts. Needs to spend more time on neatness and organizing entries.	0

Scope It Out (See Master J)
Performance Assessment
Scoring Rubric B

Research	Product Design	Application	Presentation
4 Research is accurate, clear, and very detailed.	4 Creative design & use of materials.	4 A clear, unique application of concepts through explanation, construction, or illustrations	4 Explanations are accurate, clear, and very detailed. Entertaining and creative!
3 Research is accurate, clear, and fairly detailed.	3 Good choice of design and materials.	3 A clear application of concepts through explanation, construction, or illustrations	3 Explanations are accurate, clear, and fairly detailed. Creative!
2 Research is limited in scope. More preparation needed.	2 Design and use of materials are similar to previous activities.	2 A partial application of concepts through explanation, construction, or illustrations.	2 Explanations are limited but accurate, and are somewhat clear. More preparation needed.
1 Very little research is attempted.	1 The product is incomplete.	1 Product is not an application of concepts.	1 Explanations are limited, unclear, and inaccurate

Materials Detail Sheet

ENGAGE

For the class:

☐ Transparency of Leeuwenhoek's microscope

For each group:

☐ water
☐ clear plastic wrap
☐ baggies
☐ letter "b" on white paper, Master A
☐ trays

For each student:

☐ student journal
☐ *My Science Journal*, Master B

EXPLORE

For the class:

☐ transparency of convex and concave lens

For each group:

☐ hand lenses
☐ large hand magnifiers
☐ loupes
☐ variety of convex lenses
☐ variety of concave lenses
☐ magnifying boxes
☐ transparent cm rulers
☐ graph paper
☐ pond water
☐ lined college ruled paper
☐ baggie, and water drop lens from the explore activity
☐ chart paper

Materials Detail Sheet

For each student:
☐ student journal

EXPLAIN

For the class:
☐ Transparency of Hooke's microscope
☐ Transparency of compound microscope

For each group:
☐ water
☐ slides
☐ droppers
☐ letter "b" on white paper
☐ compound microscopes
☐ hand lenses
☐ loupes
☐ variety of convex lenses
☐ variety of concave lenses
☐ magnifying boxes
☐ graph paper
☐ lined college ruled paper
☐ baggie, and water drop lens from the explore activity

For each student:
☐ student journal

ELABORATE

For each group of students:
☐ hollow plastic baseballs
☐ blue/brown felt
☐ scissors
☐ markers
☐ clear plastic wrap
☐ glue

Materials Detail Sheet

☐ baggie
☐ clear hair gel
☐ clear marble
☐ tape
☐ foil
☐ straws
☐ used disposable cameras
☐ plastic cup
☐ wax paper
☐ rubber band
☐ Venn diagram, Master K
☐ pushpin

For the teacher:
☐ drill to cut ball
☐ sheep's eye for dissection
☐ scalpel
☐ dissecting tray
☐ transparency of human eye
☐ raw egg
☐ dropper of HCl
☐ goggles
☐ **glass** petri dish

EVALUATE
For each student:
☐ completed journal
☐ assessment rubric

Background Information for Teachers

The study of light is called optics. An optical system has parts that collect light and change it by refraction (bending) or reflection (bouncing) before it reaches our eyes to create an image that might look very different than the actual object it represents. Light can be collected, directed, and used to create images in optical systems such as lenses, mirrors, cameras, telescopes, and microscopes. One of the most complex optical systems is the eye itself, which must be used in combination with any other optical system if we are to see an image.

In the early history of optics, scientists had to first discover the properties of light and lenses before they could use them together as a system to "see" objects that were previously invisible to the human eye. Prior to the 1600's, people were unaware that hosts of microorganisms, such as disease-causing bacteria and protists, even existed. Anton von Leeuwenhoek and Robert Hooke were pioneers in the development of the microscope, which means "to see the small" in Greek. To make very small objects visible, Leeuwenhoek and Hooke discovered that they could construct lenses to make objects appear bigger by changing the direction of light before it reached the observer's eye.

Many optical systems use a lens to bend light. Light travels in parallel waves until it passes through the lens and is bent. The bent waves end up meeting at a certain distance from the lens. The place where the rays meet forms an image. A clear, focused image only occurs at a spot called the focal point. The image can still be seen if it is a little closer or farther away from the lens, but it will look blurry because it is out of focus. Each time we use an optical system, we are combining two optical systems, because our eyes themselves are optical systems.

The human eye is a very complex sense organ that allows us to see objects that reflect light. Light enters the eye through a tiny opening called the pupil after it passes through the clear protective covering called the cornea. The size of the pupil is regulated by the ring of muscles in the iris, which controls the amount of light that can enter the eye. The light then passes through a convex lens, which focuses the light on to the light-sensitive retina at the back of the eye. After passing through the convex lens, the image is that is focused on the retina is flipped upside down. The retina contains photoreceptor cells that create nerve impulses when stimulated by light. These nerve impulses are carried from the retina to the optic nerve, which carries the impulse or message to the brain. The brain interprets the message to allow us to "see" the image, and flips it right side up. Human eyes, however, can only detect objects that are within their resolving power. To see and study the world of microorganisms, we need the magnifying power of a microscope.

National Science Education Standards - History and Nature of Science
The introduction of historical examples will help students see the scientific enterprise as more philosophical, social, and human. Middle-school students can thereby develop a better understanding of scientific inquiry and the interactions between science and society. In general, teachers should not assume that students have an accurate conception of the nature of science in either contemporary or historical contexts. (*National Science Education Standards, p. 170)*

To develop understanding of the history and nature of science, teachers of science can use the actual experience of student investigations, case studies, and historical vignettes. (*National Science Education Standards, p. 170)*

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach conclusions that we currently take for granted. *(National Science Education Standards, p. 171)*

National Science Education Standards – Life Science

Students in grades 5-8 also have the fine-motor skills to work with a light microscope and can interpret accurately what they see, enhancing their introduction to cells and microorganisms and establishing a foundation for developing understanding of molecular biology at the high school level. *(National Science Education Standards, p. 155)*

Middle school students are in a period of development that "lends itself to human biology." They can develop the understanding that the body has organs that function together to maintain life. Teachers should introduce the general idea of structure-function in the context of human organ systems working together. Other, more specific and concrete examples, such as the hand, (or the eye) can be used to develop a specific understanding of structure-function in living systems. *(National Science Education Standards, p. 156)*

Benchmarks for Science Literacy

In contrast to many of the other historical episodes, the study of germ theory is one worth trying in middle school. The science needed can be developed during these grades. The story of Pasteur's discovery that microbes can cause disease is straightforward, the role played by microscopes in making germs in diseased tissues visible follows nicely from students own microscopic observation, and the implications for sanitary practice and disease prevention are things that students routinely encounter. (*Benchmarks for Science Literacy, p. 257)*

Targeted Texas Essential Knowledge & Skills

Science TEKS

6.1 The student conducts field and laboratory investigations using safe, environmentally appropriate and ethical practices. The student is expected to:
(A) demonstrate safe practices during field and laboratory investigations

6.2 The student uses scientific inquiry methods during field and laboratory investigations. The student is expected to:
(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology
(B) collect data by observing and measuring direct and indirect evidence
(C) analyze and interpret information to construct reasonable explanations from direct and indirect evidence
(D) communicate valid conclusions
(E) construct simple graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate information

6.3 The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:
(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information
(C) represent the natural world using models and identify their limitations
(D) evaluate the impact of research on scientific thought, society, and the environment
(E) connect Grade 6 science concepts with the history of science and contributions of scientists

6.4 The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to:
(A) collect, analyze, and record information to explain a phenomenon using tools including beakers, petri dishes, meter sticks, graduated cylinders, weather

instruments, hot plates, dissecting equipment, test tubes, safety goggles, spring scales, balances, microscopes, telescopes, thermometers, calculators, field equipment, computers, computer probes, timing devices, magnets, and compasses

6.5 The student knows that systems may combine with other systems to form a larger system. The student is expected to:

(A) identify and describe a system that results form the combination of two or more systems such as in the solar system
(B) describe how the properties of a system are different from the properties of its parts.

6.10 The student knows the relationship between structure and function in living systems. The student is expected to:

(A) differentiate between structure and function
(B) identify how structure complements function at different levels of organization including organs, organ systems, organisms, and populations.

6.12 The student knows that the responses of organisms are caused by internal or external stimuli. The student is expected to:

(B) identify responses in organisms to external stimuli such as the presence or absence of light

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Fun Science Gallery- A Glass-Sphere Microscope
http://www.funsci.com/fun3_en/usph/usph.htm

History of the Microscope
http://www.microscopy-uk.org.uk/intro/histo.html

How to Use a Microscope Properly
http://shs.westport.k12.ct.us/mjvl/biology/microscope/microscope.htm

How to Build a Microscope
http://www.brooklyn.cuny.edu/bc/ahp/CellBio/SBAM/SBAM.Microscopes.html

Human Vision
http://www.brooklyn.cuny.edu/bc/ahp/CellBio/SBAM/SBAM.Vision.html

The Physics Classroom
http://www.glenbrook.k12.il.us/gbssci/phys/Class/refln/u13l2d.html