Teacher's Preparatory Guide

Exploring Scientific Tools: Taking a Closer Look at Objects

Purpose:
For students to understand their world they often need to use tools to gather information. Some tools will help them see parts of their surrounding world that they would otherwise miss. These tools include magnifying glasses and microscopes. This lesson provides students an opportunity to learn how microscopes and lenses make small objects in our world visible. The lesson can be conducted as a learning center or as a teacher-led whole class instruction. These can be used along with other activities discussed in the book *Microscopes and Magnifying Lenses* by Janice VanCleave.[1]

Time required: two class periods

Level: General Science Elementary (Grades 4-5)

Teacher Background:
The *Big Ideas of Nanoscale Science and Engineering-A Guidebook for Secondary Teachers*[2] states that the degree to which we understand the world is limited, in part, by the tools available to investigate it, and the tools and instruments available to scientist determine what is accessible for them to observe and measure. One 21st century technology is nanoscale science and engineering. This technology is only possible because of the development of special tools some of which form images of nanostructures. Nanostructures are between 1 to 100 nanometers in one dimension (1×10^{-9} meter). For students to understand the importance of these special tools, this lesson gives them an opportunity to use tools to study a variety of everyday objects. The lesson begins laying the foundation for more advanced use of instruments and tools in middle and high school science.

A magnifying lens is made with a double convex lens or a lens thicker in the center than on its edges and curves outward on both sides. Light coming from an object is bent as it passes through a lens. Light through a magnifying lens bends or refracts depending on the focal distance which is the distance from the object being viewed to the magnifying lens. When you hold a magnifying glass close to an object, the light waves are widened before they are focused on your eyes, causing the object to appear large or magnified. If the magnifying glass is used to view a distant object, the object appears to be smaller and upside down. This effect is due to the image being beyond the focal point of the lens (See Figure 5).

The father of microscopy, Anton van Leeuwenhoek of Holland, taught himself new methods for grinding and polishing tiny lenses of great curvature which provide magnifications up to 270 diameters. This led to the building of his microscopes and the biological discoveries for which he is famous.

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The earliest microscopes consisted of a tube with a plate to place or hold the object at one end and a lens at the other end. The magnification was less than 10 diameters. Present day optical microscopes (use light to form an image) have changed very little from the middle of the 19^{th} century and can give magnifications up to 1250 diameters (magnification is 1250 times the original diameter) with ordinary light and up to 5000 with blue light.

A light microscope cannot be used to distinguish objects that are smaller than half the wavelength of visible light (around 200 to 400 nm). To see small particles, such as "nano" sized particles, scientist must use a different sort of illumination. The electron microscope was invented in the 1930s. Beams of electrons are focused on a sample and are absorbed or scattered by the samples' parts to form an image on an electron-sensitive plate. Electron microscopes make it possible to view objects as small as the diameter of an atom.

The development of tools and instruments such as the scanning probe microscope (SPM) and the scanning electron microscope (SEM) have rendered the nanoscale world accessible in ways impossible to imagine just a short time ago.

Vocabulary developed during the lesson include:

1. **Magnification** - How many times larger an object appears than it actually is.
2. **Hand lens** - A convex lens that is used to produce a magnified image of an object held in your hand.
3. **Compound Light Microscope** - A microscope with more than one lens and its own light source.
4. **Scanning Electron Microscope** - A type of electron microscope that images by scanning with a beam of electrons in a raster scan pattern.

Materials (Per Group):

- One box of clear plastic food wrap
- Clear drinking glass
- Rubber band to fit around drinking glass
- Empty plastic 1L drink bottle with lid
- (2) Tall olive jars with lids (one for oil, one for water)
- Paper towels
- One sheet of newspaper
- One sheet of lined notebook paper
- Two magnifying lenses with a 3 inch (7.5 cm) diameter (hand lens)
- Empty oatmeal cardboard carton (round)
- Scissors
- Compound light microscope (optional)
- Prepared slide(s) (optional, often come with microscopes or take borrow from life science class)
- Pictures of objects taken with regular camera (provided at end of lesson)
- Pictures taken with scanning electron microscope (provided at end of lesson)
- USB digital microscope such as Dinolite or Motic Ecoline (optional)

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Advance Preparation

Prepare enough materials for one learning center or enough materials for each group of students

1. Fill 1L container and tall olive jar with water and make sure that lids are tight. If possible you may want to seal the lids with tape.
2. Cut small squares of clear plastic food wrap that are large enough to go down into the clear drinking glass with some extra hanging out of the top.
3. Prepare the empty oatmeal box (Figures 1 and 2)by cutting a slit one inch form the top of the open end of the carton that is big enough for the handle of a hands lens to go through. Underneath this slit and one inch from the bottom of the carton cut a one inch square window. On the opposite side of the carton cut a 4 inch long slit that is just wide enough for a hands lens handle to move up and down. Start the slit two inches from the open end of the carton.

Figure 1

Figure 2

4. Print SEM pictures of objects on cardstock. Obtain samples of these objects that students can examine with a hand lens.
5. If using a learning center, you will need to prepare container and worksheets. Set up microscope with slides and instruction sheet. For Optional Activity: set up computer and USB digital microscope. See

Safety Information

Supervision of magnifying glasses, glass slides, glass containers, and optical microscopes will depend on age of students. Caution students about the use of glass objects.

Directions for the Activity

Learning Center: Materials will be placed into a container that can hold all materials. Students will be given Learning Center Worksheet which will guide them through the activities.

Teacher-led Whole Class Instruction:

- Ask the following question or place on the board- “Can you learn anything new about an object by taking a closer look?”
- Give the students a chance to respond.
- You may want to record their answer to return to at the end of the lesson.

Exploration 1

- Distribute some objects to students and have them describe their object. (They may also be asked to sketch their object.) Suggestions might include a penny, dime, or rock.

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- Distribute to each group or student a hand lens. Have students examine their object using the lens. Ask if the hand lens lets them see different things about their object. For example, if they use a penny or dime they might notice the worn ridges, the JS under the neck of the head of the dime, dirt on the coin, etc.
- Explain that a hand lens is a convex lens that is used to produce a magnified image of an object and they will be learning about how tools like a hand lens can be used to help see objects better.

Exploration 2

- Question: Does the shape of a lens affect its magnification? Have students place a sheet of plastic wrap on the inside of a clear plastic cup so that it touches the bottom and the extra plastic wrap hanging out of the top of the cup (Figure 3).

Figure 3

Figure 4

- Secure a rubber band around plastic wrap at top of cup.
- Pour about 2 inches (5 cm) of water into the lined cup. Place the cup on a sheet of newspaper. Direct students to look down through the water at the newspaper.
- Question: Does the size of the letters look the same through the water as they do without the water? There should not be any difference in the appearance of the letters.
- Remove the rubber band. Lift up the plastic wrap lining so that its bottom is about 1 inch above the bottom of the cup. Replace the rubber band to secure in place (Figure 4).
- Look through the water surface again and observe the printed letters.
- Question: Is there any difference in the size of the letters viewed through the water compared to the letters not covered by the cup of water. When the surface of the water becomes curved, it magnified the print. The shape of the water's surface caused the magnification. When the surface of the water is curved outward, the water acts like a convex lens (a lens that is thicker in the center than at the edges; it magnifies images of objects viewed through it). Light rays moving through the curved surface of the water lens are bent which produces an enlarged image of the object.

Exploration 3

- Distribute to each group:
  - one jar filled with water,
  - one jar filled with mineral oil, and
  - a sheet of notebook paper
- Place a jar on its side in the center of the notebook paper (lines parallel to the stuent) with its lid pointing toward the short side of the paper. Students will slowly roll the jar toward themselves. Try to make the lines viewed through the bottle of water line up with the lines on the sheet of paper. Count the number of spaces on the sheet of paper that fit into one space between the lines as viewed through the jar. Repeat this with the jar containing mineral oil.

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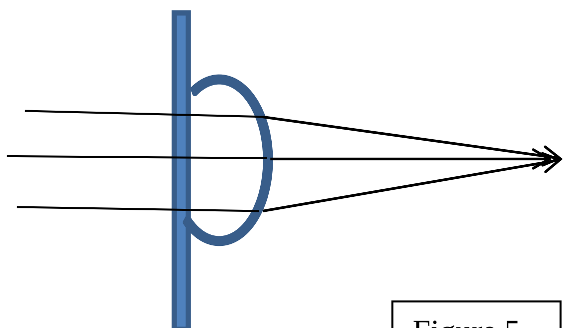
- Question: Do the lines on the paper look the same through the two jars? If not, how do they differ?
- The distance between the lines as viewed through the jar of water is twice that of the distance between the lines on the paper outside the jar. This indicates that the magnification (the enlargement of an object's image) due to the water and the glass of the jar is 2X. The expression 2 X means the image viewed through the magnifier is two times as large as the actual object.
- This magnification happens because you see the size of something because of how large an angle it makes on your eye. The larger the angle the larger the object looks. The curved water bends the light more at the edges than at the middle so the angle looks bigger to the eye. See Figure 5.

The larger the image the larger angle reflected light makes with the eye. This is used to help the brain know how large the object is.



Light bends more at the edges than at the center which makes the eye and brain think that the image is bigger than it is.

Figure 5

The image viewed through mineral oil is magnified even larger than the one using the jar of water. This happens because light passing through the air into the mineral oil in not refracted as much as it is when passing from air into water.

Exploration 4

- Question: What happens to an image when you look at it through two lenses?
- Distribute oatmeal box "microscopes". Instructions for making are included in the book *Microscopes and Magnifying Lenses*.
- Have the students place an object into the hole on the bottom so that the object lays in the center of the carton. Have students hold the handle of the top lens to keep it steady as they raise and lower the second lens. They will look through both lenses at the object.
- Question: Did the object look different as the bottom lens was raised and lowered? The image will become focused and un-focused and will appear larger and smaller as the lens is moved up and down.

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The image seen through the two lenses is similar to images viewed through a compound microscope (a microscope with two or more lenses). The lens closest to the eye acts like the microscope's eyepiece and the lens farther from the eye and closer to the object behaves similarly to the objective lens on a microscope.

Exploration 5

- Question: What are microscopes and how do they work?
- You may want your students to watch one of the videos in the resource section.
- Provide a light microscope and, if possible, a USB digital microscope (Dino-Lite Digital, ProScope, Motic Ecoline). Students will look at objects under the microscopes. If you use the USB digital microscopes, you may want them to look at the same object they examined with the hand lens in Exploration1.
- Question: Name some microscopes. Light, compound, digital, confocal, scanning tunneling, scanning electron, and atomic force are all examples of microscopes.
- Distribute worksheet for students to label the parts to an elementary compound microscope as you go over the function of each part.
- Show picture of a scanning electron microscope. Explain to students that these microscopes form an image of an object by using beams of tiny particles called electrons (it is not important that they understand what an electron is, but that the image is formed by something other than light). A compound microscope can magnify an object up to 1500 X and a scanning electron microscope can magnify an object up to 100,000 X. The SEM allows you to see objects that are too small to see with the compound microscope, including nanoscale objects.
- Distribute the scanning electron pictures, the objects that go with them, and hand lens. Have the student look at the objects using the hand lens and then try to match the objects to the correct scanning electron image. A suggestion is to put a number or letter on the pictures so that you can let the students check to see if they are correct.
- Wrap up the lesson by referring back to the original question and the student answers. See if they changed with the activity.

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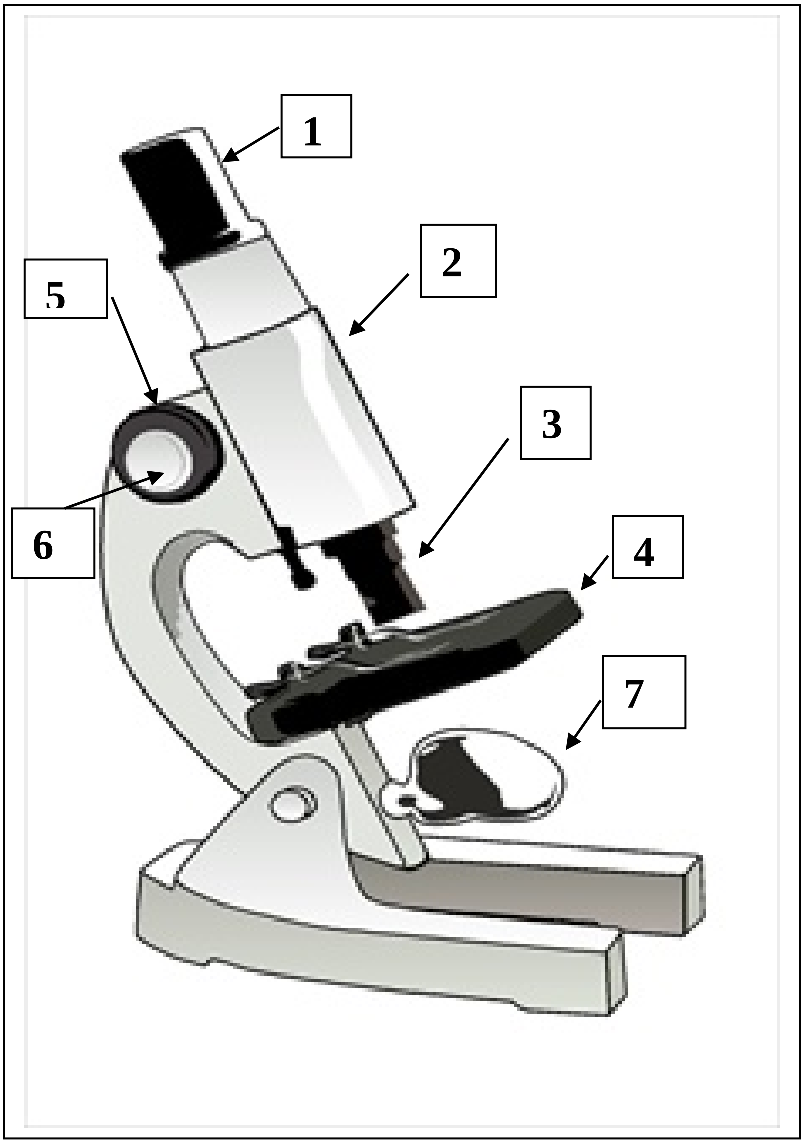
Student Worksheet (Answers in red)

Parts of a Microscope



Teacher Key
1. Eyepiece Lens
2. Body Tube
3. Objective lens
4. Stage
5. Coarse Adjustment Knob
6. Fine Adjustment Knob
7. Mirror

Identify the numbered part. Use the word bank below.

1. 2. 3. 4.

5. 6. 7.

Word Bank: Mirror, Coarse adjustment knob, Objective lens, Eyepiece lens, Body tube, Fine adjustment knob, Nose piece, Stage, Micrometer

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Learning Center Worksheet (answers in red):
Taking a Closer Look at Objects

Directions: Use the materials provided to complete the following. When finished put all materials back into container.

Question: Can you learn things about an object if you could see it better?

Exploration 1:

- Find the box OBJECTS FOR EXPLORATIONS 1 and 4. Take out one of the objects and lay it on your desk. Look at the object. Make a sketch of your object below. Then take out a hand lens (magnifying glass), look at the object with it, and sketch your object below.

Object without hand lens	Object with magnifying glass
Student Drawing	Student Drawing

- When using the hand lens did you see anything new about your object? ______ If yes what? ______Student Answers will vary______________________

Exploration 2:

- From the container take out plastic cups #1 and #2 and a sheet of newspaper.
- Place an inch of water inside each of the cups. Set cup #1 on the newspaper. Look down through the water in the cup at the words on the paper. Do the words on the newspaper look different when looked at through the cup? __No_______ If yes, how do they look different?

  ____

  __

- Place cup #2 on the paper. Look down through the water in the cup at the words on the paper. Do the words look different though the water in the cup? __Yes_______ If yes, how do they look different? ___The words look larger__________
- Do you see any difference in the cups? ___Yes___ If yes, what is different? _____________________the water in one cup is flat and in the other cup it is curved downward.
- Read the article *How Does a Magnifying Lens Work.* After reading the article, did that change what your thought about the cups and how they work? ___Yes____ If yes, how

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_____Explains that light going through a curved surface bends making the object look larger_________________

Exploration 3:

- Find the bottles that have Exploration 3 written on them and a sheet of notebook paper. Place the jar with water on its side in the center of the notebook paper with its lid pointing toward the side of the paper. Slowly roll the jar toward you. Try to make the lines viewed through the bottle of water line up with the lines on the sheet of paper. Write how many spaces on the paper fit into one space between the lines as viewed through the jar.

- Number of line_____Should be about two spaces to one space_______________

- Repeat step 6 with the jar filled with mineral oil. Did you count the same number of spaces as you did for the water bottle? __No____ If not, why do you think you did not? _________________________The more curved the surface the larger the image appears__________________

Exploration 4:

- Use the oatmeal box microscope. Take an object from OBJECTS FOR EXPLORATIONS 1 and 4 and place through the box sample opening on the bottom. Make sure the object is in the middle of the bottom. Look through the top of the box. Hold the handle of the top magnifying glass and move the bottom magnifying glass up and down with the handle. How does the image change when you are moving the lens up and down? The image will move in and out of focus

- Read the article *What is a Microscope* *http://www.kbears.com/sciences/microscopedefinition.html* or other website articles: http://www.explainthatstuff.com/microscopes.html http://www.brighthub.com/science/medical/articles/76213.aspx

- Fill out the Parts of a Microscope Worksheet.

Exploration 5:

- Go to where the microscope is set up. Follow the instructions for looking at slides under the microscope. Do you see things through the microscope on the slides that you cannot see on slides without a microscope?

  ____

- Optional: Get the same object that you used in Exploration 1 and look at it using the digital microscope attached to the computer. Do you see new details on this object that

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you did not see in Exploration 1?
____

- Get the bag labeled Objects and Pictures. Look at objects using a magnifying glass.
- Read the article from Hitachi, HTA *Science is Fun – All about electron microscopes http://www.inspirestemeducation.us/tools/science-is-fun/*
- The pictures that are included in the bag are scanning electron microscope images of the objects that you looked at in Step 12. They were made using the TM3000 Tabletop SEM from Hitachi. List the objects and then match the picture with the object. Write the picture number next to the object.

Object	Picture Number	Object	Picture Number
____________	____________	____________	____________
____________	____________	____________	____________
____________	____________	____________	____________

Cleanup:
Microscope will need to be covered and stored and materials used in learning center activity will need to be returned to container.

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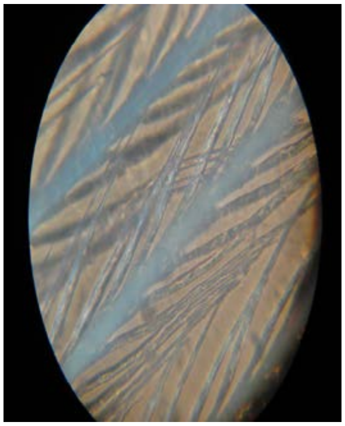
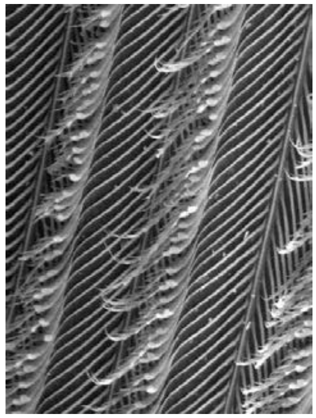
Assessment:

Taking a Closer Look at an Object Evaluation

1. Following is a set of pictures. Decide if the picture is of an image taken without any magnification, with magnifying glass, light microscope or scanning electron microscope. Write your choice below the picture.





Light Microscope   Scanning Electron Microscope   Without Microscope__

Picture sources: http://rhiraykhloe.deviantart.com/art/feathers-under-a-microscope-281684643

2. Define the following words.
Magnification How many times larger and object appears compared to its actual size
Magnifying Glass A convex lens used to make a magnified image of an object you hold.
Light Microscope A microscope with more than one lens and has its own light source.
Scanning Electron Microscope A microscope that creates images by scanning objects with a beam of electrons

References:

1. *Microscopes and Magnifying Lenses*, by Janice VanCleave. John Wiley & Sons, Inc., 1993.
2. *Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers, by Stevens, S., Sutherland, L., and Krajcik, J.. NSTA Press, 2009.*

Resources:
www.nnin.org/nnin_edu.html

To learn about magnifying glasses or microscopes

- http://science.pppst.com/microscopes.html Free PowerPoint presentations, lessons and games on microscopes
- http://science.kqed.org/quest/files/imp/304b_WorldsMostpowerfulMicroscope.pdf Worlds Most Powerful Microscope Teachers Guide
- http://chsstaff.vail.k12.az.us/~rathmanr/Teachers/Biology_Downloads_Quarter_1_files/Microscopes.pdf PowerPoint lesson on using a microscope
- http://sciencespot.net/Pages/classbio.html#micro – Micro Mania Lesson

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- http://www.wisc-online.com/Objects/ViewObject.aspx?ID=BIO905 Interactive Microscope Quiz
- http://www.tryengineering.org/lesson_detail.php?lesson=97 Be an Electron Scanning Microscope
- http://www.inspirestemeducation.us/Hitachi_STEM_resources_regarding_microscopes
- http://www.inspirestemeducation.us/tools/sem-101/How_and_SEM_microscope_works
- http://www.youtube.com/watch?v=zD21500u74VOK3A PowerPoint of microscope history, compound and electron microscope
- http://teachertube.com/viewVideo.php?title=Elementary_Microscopes&video_id=19051 Elementary microscopes
- http://video.google.com/videoplay?docid=-4584444570497215104 Microscope Tutorial
- http://www.youtube.com/watch?v=FvTrWridZss How Does a Microscope Work
- http://www.youtube.com/watch?v=H4Awx-sDmcs How to use the compound light microscope
- http://www.youtube.com/watch?v=X-w98KA8UqU How to use a microscope
- http://www.youtube.com/watch?v=gutJgViZf08 Explore the Tiny World Around You with the Blister Microscope
- http://www.Inspirestemeducation.us Hitachi, HTA's online resource for students and teachers.

National Science Education Standards

Grades K-4 Content Standard A: As a result of activities in grades K-4, all students should develop Abilities necessary to do scientific inquiry.

- Employ simple equipment and tools to gather data and extend the senses.

Grades 5-8 Content Standard A: As a result of activities in grades 5-8, all students should develop abilities necessary to do scientific inquiry.

- Use appropriate tools and techniques to gather, analyze, and interpret data.

Georgia Performance Standards

S4CS3 and S5CS3: Students will use tools and instruments for observing, measuring, and manipulating objects in scientific activities utilizing safe laboratory procedures.

Next Generation Science Standards

- 4-PS4-2 Develop a model to describe light reflecting from objects and entering the eye allows objects to be seen.
- 4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- 5-PS1-1 Develop a model to describe matter is made of particles too small to be seen.
- 5-PS1-3 Make observations and measurements to identify materials based on their properties.

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