Title: Thinking with the Eyes

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Subject: Biology
Grade Level: 9th Grade Honors
Standards:
- SC.912.N.1.1: The practice of science
- SC.912.L.14.4: Compare and contrast structure and function of various types of microscopes.

Schedule: Two 40 minute class periods

Description:

This activity is divided into three parts. In this activity students will have the opportunity to calibrate the field of view of a microscope, explore the limit of human eye resolution and discover some of the tools have been invented in order to see things as small as an atom!

Objectives:

- Students will be able to state the difference between resolution and magnification.
- Students will be able to deduce the field of view on a light microscope.
- Students will be able to discuss the advantages and disadvantages of light and electron microscopes.
- Students will understand that more detailed information can be obtained from the use of microscopy tools.

Vocabulary:

- Magnification
- Resolution
- Field of view
- Light microscope
- Scanning electron microscope
- Transmission electron microscope

Materials:

- Optical light microscope
- Fine wire mesh
- Coarse wire mesh
- Ruler (with mm markings)
- Dollar bill
- Thread, hair, embryo slide, sand

Safety:

Always hold microscopes with two hands, holding the arm and base of the microscope. Store at low power, wrap cord around base and replace dust cover when finished.

Science Content for the Teacher:

Definitions

Magnification: how large the lens makes the object appear to the human eye
Resolution: the ability to distinguish between two objects

The right tools for the right job:

The smallest objects that the naked eye can see are about 0.1 mm long. That means that under the right conditions, you might be able to see an amoeba, a human egg, and a paramecium without using magnification. A magnifying glass can help you to see them more clearly, but you will not be able to make out the finer structures of the object.

Smaller cells are easily visible under a light microscope. It's even possible to make out some of the larger structures in the cell. Light microscopes take advantage of a series of lenses. However, the types of specimens viewed under a light microscope are limited by the wavelength of visible light (~500 nm).

To see anything smaller than 500 nm, you will need an electron microscope. Electron microscopes work by focusing a high-voltage beam of electrons onto or through an object, which deflects and absorbs a portion of the electrons. The most advanced electron microscopes can resolve molecules and even individual atoms.

Classroom Procedure:

Part I: Magnification with a light microscope
→Guiding Question: What is magnification and how do you know the relative size of an object when looking at an enlarged image?

- First have students look at an object from approximately two feet away. Now have students go to the back of the room and look at the same object. Ask the students why the object appears smaller when the distance between themselves and the object increases.

  Answer: The farther an object is away from your eyes, the smaller the angle it presents to your eyes. Math link: this is known as a subtended angle.

  In terms of resolution: Objects also dim with distance because the amount of light photons reaching your retina decreases as distance increases.

- Now, introduce students to the light microscope and pose the guiding question: What is magnification and how do you know the relative size of an object when looking at an enlarged image?

→Activity: Calculating the size of the field of view of a light microscope. By knowing the size of the field of view one can calculate the size of the object under the microscope.

- Step one: have students calibrate the microscope. This task can be completed by using a ruler with mm markings to measure the field of view for the three magnifications (4x, 10x, 40x). Have students place the ruler on the stage and record the calibration results.

Objective Lens	**Measurement**
4x	mm
10x	mm
40x	mm

- Once the students have calibrated the field of view, present students with a variety of objects so that they may calculate the size of the object.

Specimen	**4x**	**10x**	**40x**	**Estimated size**
Colored thread				
Human hair				
Grain of sand				
Stained chick embryo				

- Once students arrive at an estimated size have them compare values and discuss why discrepancies may have occurred.

Part
II: Human Eye Resolution
→Guiding Question: What is the smallest spacing that the unaided human eye can detect?

- What is resolution?
  Answer: the minimum distance observable between two objects. Resolution is the ability to distinguish between two separate points. Lower resolution means that

two points are a blur, rather than two individual points.

→Activity 1: Explore human eye resolution limitations using course and fine wire mesh.

- Have students refer to calibration data collected in Part I of the lesson.
- Distribute course wire mesh to students. Have them attempt to measure the spacing of the lines without the help of the microscope.
- Next, have the students confirm and compare their measurements using the light microscope (refer to calibrations).
- Now distribute the fine wire mesh. Instruct students to follow the same produces as they did with the coarse mesh.
- Next, distribute a teacher constructed mesh made by overlapping two fine wire mesh grids. **Note on preparation:** prepare using double sided sticky tape. Prepare the overlapping grids under the microscope next to a ruler. The lines should measure approximately 1/10 mm apart. Use your best judgment when preparing the slides.
- Again, follow the same procedure as with the single mesh grids. Note the spacing between the overlapping mesh will not be visible to the naked eye.

→Activity 2: Dollar Bill Dots

http://www.eeggs.com

- Distribute dollar bills to each student or have them bring their own to school.
- Ask the students to make detailed observations of the ink that is printed on the dollar bill.
- Next, instruct the students to look at the bill underneath the light microscope. Students will be surprised to see that what appears to be a solid line to the naked eye is actually composed of individual dots. U.S. History link: Why do you think the printing of money is so intricate? Answer: security and copyright concerns.

Part III: Light microscope advantages and disadvantages
→Guiding Question: What are the advantages of using a light microscope? What happens when a light microscope does not give the information you need?

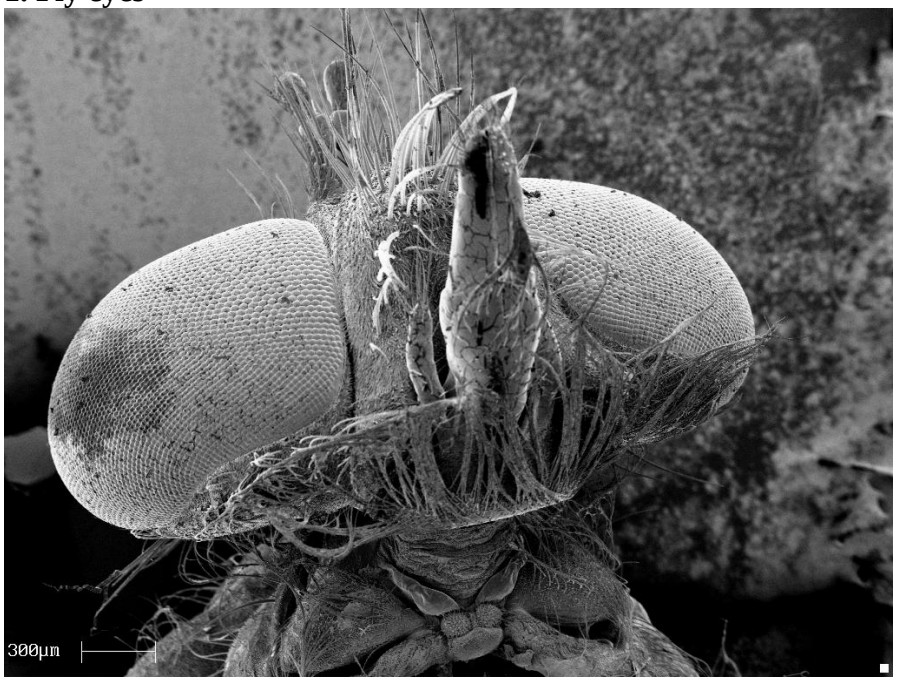
- Ask students to locate the endoplasmic reticulum in a stained animal cell. Students will soon be noting that they cannot find it!
- Now, the teacher can lead the discussion that light microscopes can only magnify and resolve images up to a certain point. After that limitations in visibility occur due to the nature of visible light (objects <500nm cannot be seen).
- Next, discuss the existence of tools that allow scientists to see objects that are not visible in the light microscope. Please see "science content for teacher" for a explanation of how electron microscopes work.
- Discuss with students the advantages and disadvantages of a light microscope verses an electron microscope.

ADVANTAGES OF USING A LIGHT MICROSCOPE	**ADVANTAGES OF USING AN ELECTRON MICROSCOPE**	**DISADVANTAGES OF USING A LIGHT MICROSCOPE**	**DISADVANTAGES OF USING AN ELECTRON MICROSCOPE**
Quick and easy sample prep, can use wet samples and it can "see" in color.	Extremely detailed magnification and resolution	Relatively low magnification and resolution	Very expensive and time consuming sample prep

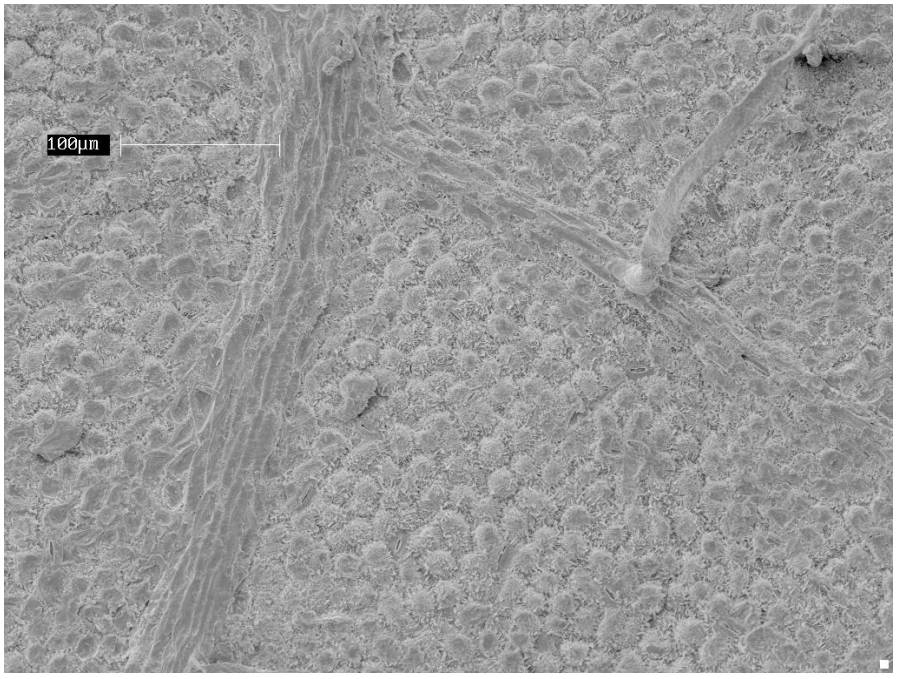
- Show SEM video found at the following link: http://www.youtube.com/watch?v=CR8D1esGWVg
- Finally, show images that were taken using the scanning electron microscope (SEM).

SEM IMAGES

1. Fly eyes



2. Underside of a leaf



Assessment:

- Students will be assessed by both whole and small group discussion.
- Students will be assessed on their ability to accurately calculate the field of view in a light microscope under various objectives.
- Students will be assessed by a written exercise prompting them to make connections between the size of an object and the appropriate tool (microscope) that needs to be used to view the object.

Acknowledgements:

- Mr. John Hunt, CCMR Cornell University, Optical Microscopy Facility Manager
- http://virtualurchin.stanford.edu/microscope.htm
- http://learn.genetics.utah.edu/content/begin/cells/scale/