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the science of MICROBES

Activity: Tools of Magnification

from *The Science of Microbes Teacher's Guide*

by Nancy P. Moreno, Ph.D., Barbara Z. Tharp, M.S., Deanne B. Erdmann, M.S., Sonia Rahmati Clayton, Ph.D., and James P. Denk, M.A.

RESOURCES

Free, online presentations of each activity, downloadable activities in PDF format, and annotated slide sets for classroom use are available at www.bioedonline.org/ or www.k8science.org/.

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HIV virus particle. L. Howard, C. Daghlian, Dartmouth College.

INTRODUCTION

Microbial Challenges

Infectious diseases have plagued humans throughout history. Sometimes, they even have shaped history. Ancient plagues, the Black Death of the Middle Ages, and the "Spanish flu" pandemic of 1918 are but a few examples.

Epidemics and pandemics always have had major social and economic impacts on affected populations, but in our current interconnected world, the outcomes can be truly global. Consider the SARS outbreak of early 2003. This epidemic demonstrated that new infectious diseases are just a plane trip away, as the disease was spread rapidly to Canada, the U.S. and Europe by air travelers. Even though the SARS outbreak was relatively short-lived and geographically contained, fear inspired by the epidemic led to travel restrictions and the closing of schools, stores, factories and airports. The economic loss to Asian countries was estimated at $18 billion.

The HIV/AIDS viral epidemic, particularly in Africa, illustrates the economic and social effects of a prolonged and widespread infection. The disproportionate loss of the most economically productive individuals within the population has reduced workforces and economic growth in many countries, especially those with high infection rates. This affects the health care, education, and political stability of these nations. In the southern regions of Africa, where the infection rate is highest, life expectancy has plummeted in a single decade, from 62 years in 1990–95 to 48 years in 2000–05. By 2003, 12 million children under the age of 18 were orphaned by HIV/AIDS in this region.

> For an emerging disease to become established, at least two events must occur: 1) the infectious agent has to be introduced into a vulnerable population, and 2) the agent has to have the ability to spread readily from person to person and cause disease. The infection also must be able to sustain itself within the population and continue to infect more people.

Despite significant advances in infectious disease research and treatment, control and eradication of diseases are slowed by the following challenges.

- The emergence of new infectious diseases
- An increase in the incidence or geographical distribution of old infectious diseases
- The re-emergence of old infectious diseases
- The potential for intentional introduction of infectious agents by bioterrorists
- The increasing resistance of pathogens to current antimicrobial drugs
- Breakdowns in public health systems

Baylor College of Medicine, Department of Molecular Virology and Microbiology, www.bcm.edu/molvir/.

Using Cooperative Groups In The Classroom

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides organized group interaction and enables students to share ideas and to learn from one another. Students in such an environment are more likely to take responsibility for their own learning. Cooperative groups enable the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. Materials must be managed, investigations conducted, results recorded, and clean-up directed and carried out. Each student must have a specific role, or chaos may result.

The Teaming Up! model* provides an efficient system for cooperative learning. Four "jobs" entail specific duties. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities so that each student has a chance to experience all roles. For groups with fewer than four students, job assignments can be combined.

Once a model for learning is established in the classroom, students are able to conduct science activities in an organized and effective manner. Suggested job titles and duties follow.

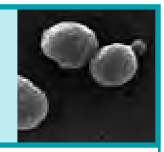
Principal Investigator
- Reads the directions
- Asks the questions
- Checks the work

Maintenance Director
- Follows the safety rules
- Directs the cleanup
- Asks others to help

Reporter
- Records observations and results
- Explains the results
- Tells the teacher when the group is finished

Materials Manager
- Picks up the materials
- Uses the equipment
- Returns the materials

* Jones, R.M. 1990. *Teaming Up!* LaPorte, Texas: ITGROUP.



Streptococcus pneumoniae bacteria. CDC\9996 J. Carr, R. Facklam.

Overview

Students will use water drops and hand lenses to begin the exploration of magnification, and will be introduced to the microscope.

TIME

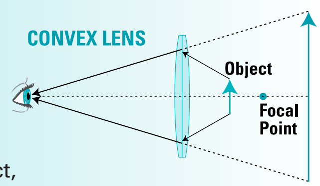
Setup: 10 minutes
Activity: 45 minutes

T O O L S   O F

Magnification

Scientific progress often is tied to the development of new tools and technologies. For example, until magnifying lenses were developed, people were able to see only as much of the world as their naked eyes would allow. The development of high quality magnifiers and microscopes opened up the world of cells and microorganisms for exploration by generations of scientists.

With an object closer to a lens than the focal point, the light rays diverge, giving the viewer the illusion that he or she is seeing a larger object, farther away, in the same orientation.



The word "lens" comes from the Latin word for lentil, because early magnifiers resembled lentil beans in shape.

Lenses are made of transparent materials and have one or two curved surfaces. They work by refraction, which means that the pathway of light is altered as it passes from one clear material, such as air, into another, such as glass. Magnifying glasses are single lenses that are convex on both sides. The compound light, or optical, microscope uses two magnifying lenses in series to make things appear much larger to the eye than would be possible with a single lens. The simplest compound microscopes consist of tubes with lenses at each end. Objects can be magnified up to 2,000 times using a high quality compound microscope.

The invention of the transmission electron microscope (TEM) in the mid-20th Century made it possible to view objects even tinier than cells, such as viruses. This type of microscope magnifies objects up to two million times by passing a beam of electrons through a very thin specimen and recording changes in the electron beam.

Zacharias Janssen is credited with developing the first compound microscope around 1595. But in 1665, scientist Robert Hooke was the first to use such an instrument to observe the division of plant tissues into tiny compartments, which he termed "cellulae," or cells. Inspired by the work of Hooke, Anton van Leeuwenhoek, a Dutch inventor, used simple (one lens) microscopes to describe bacteria and protists. Van Leeuwenhoek's well-made microscopes magnified objects more than 200 times and allowed him to make very detailed observations.

MATERIALS

Per Group of Students (see Setup)

- 4 hand lenses or magnifiers
- 4 index cards (or similarly sized sections of cardstock)
- 4 pairs of scissors
- 4 pieces of newsprint, about 2 cm x 10 cm each. Select pieces that have newsprint on one side only so that print will not show through under the microscope.

Continued

SCIENCE EDUCATION CONTENT STANDARDS

Grades 5–8

Inquiry

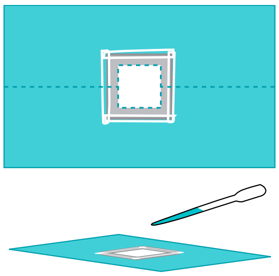
- Use appropriate tools and techniques to gather, analyze and interpret data.

Science and Technology

- Science and technology are reciprocal. Technology provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable.

Cynthia Goldsmith, M.S., a CDC research biologist, is shown working at a transmission electron microscope (TEM). Ms. Goldsmith's work has repeatedly played a key role in the rapid identification of emerging disease-causing microbes, including hantavirus, Nipah virus, and SARS coronavirus. CDC\3511 J. Gathany.

WATER DROP MAGNIFIER



Students will create a magnifier by placing a drop of water over a small square of wax paper.

TEACHING RESOURCES

Further information about magnification, refraction, microscopes and microscopy, including free, downloadable PowerPoint slides for classroom use, is available at www.BioEdOnline.org/. Look under the Presentations and Slide Sets pull-down menus for Lab Techniques on Light Microscopy.

EXTENSION

Allow students to bring in their own samples of materials to observe using wet mounts under the microscope.

- 4 pipettes or droppers
- 4 plastic cover slips
- 4 plastic or glass microscope slides
- 4 rulers (measurements in cm)
- Microscope (any kind)
- Other objects to observe, such as a leaf, coin, dollar bill, etc.
- Set of colored pencils or markers
- Sheet of wax paper (6 cm in length)
- Small container of tap water
- Transparent tape

Per Student

- Copies of the stuudent sheets

SETUP

Make copies of the student sheets. Place materials for each group on trays in a central location.

Before allowing students to carry microscopes to their work areas, demonstrate how to hold a microscope by placing one hand on the microscope stand (arm) and the other under the base (foot).

Have students work in groups of four.

SAFETY ISSUES

Follow all district and school science laboratory safety procedures. It is good laboratory practice to have students wash hands before and after any investigations.

PROCEDURE

Part 1. Lenses & Magnification

1. Hold up a magnifier or hand lens. Ask students, *How many of you have used something like this? What can it be used for?* (Lenses can be used to focus light on a single point, and also are used in eyeglasses, cameras, etc.) Tell students they will be using hand lenses to make observations.
2. Distribute materials to each team of students. Direct students to observe each item on the tray using the hand lens. Ask, *Did you observe anything on any of the objects that you have never noticed before?* Let students report their observations informally.
3. Tell students to use a hand lens to observe the newsprint and draw what they observe on their student sheets.
4. Next, have each student make a magnifier following these steps.
   - Fold index cards in half lengthwise (see Water Drop Magnifier, left sidebar).
   - Cut an opening about 2 cm long and 1 cm wide in the center of the card. Open the card (opening will be 2 cm x 2 cm).
   - Cut a 3-cm x 3-cm square of wax paper.
   - Place wax paper over the opening and secure it with tape.
5. Direct students to observe the newsprint through the wax paper window. Next, have students place a single drop of water (using a pipette or dropper) in the center of the wax paper window, and observe the newsprint through the water drop. Have students draw their observations as before.
6. Discuss students' observations. Ask, *What happened when you looked at the newsprint through wax paper?* (no change) *Through the water drop?* (print was magnified) *Are there any similarities between the magnifier and the drop?* (clear, transparent, curved surface) Help students understand that the magnifier lens and the water drop shared similar characteristics. If students need additional clarification, have them observe the newsprint through a glass or plastic slide, which is flat. The slide will not magnify (or shrink) the image, because the surface is not curved.

Part 2. Microscopes

1. Ask, *What could we use to magnify the materials further?* Distribute the microscopes and allow groups to examine them for a few minutes. Then ask, *Where is the lens? Is there more than one lens?* (yes, in the eyepiece and at the bases of the objectives) Ask, *What do you notice*

about the lenses? Students should note the curvature of the lens and the "X" markings on the sides of the eyepiece and objective. Ask, *What does "X" usually mean in mathematics?* (multiplication or "times") Explain that the bottom lens number (on the objective in use) and the top lens number (on the eyepiece) are multiplied to indicate the total number of times a specimen is magnified when observed. For example, an eyepiece of 10x with an objective of 4x will magnify an image 40 times (10 x 4 = 40).

2. If students are not familiar with microscopes, help them locate the basic parts. For example, tell students, *One part of the microscope is called the stage. It is similar to a stage for a performance. Can you find it? What about the arm?* Have students use *The Compound Microscope* sheet to find the eyepiece, objectives, coarse and fine focus knobs, arm, stage, and light source of their microscopes.

   Many microscopes also have a condenser to intensify the light and a diaphragm aperture to adjust the amount of light passing from the light source up through the object. Encourage students to examine the microscope and propose the function of each part.

3. Finally, have students create a temporary slide, called a "wet mount." Instruct students to cut out a 1-cm x 1-cm piece of newsprint, and to put the piece of newsprint in the center of a clean microscope slide. Have students place a drop of water on the paper, cover the drop gently with a cover slip and then place the slide on the microscope stage. If the stage has clips, have students place the clips over the slide to hold it in place.

   If the microscope has a light source, make sure the light is aimed up through the paper. Initially, the diaphragm should be adjusted to its largest opening. If the image is too bright (seems "washed out") when viewed, help students reduce the amount of light by partially closing the diaphragm.

   Note: Low-power "dissecting-type" microscopes may not have a light source below the stage.

4. Direct students to move the lowest power objective into place above the print material (not all microscopes have multiple objectives) and to use the coarse focus knob to lower the tip of the objective until it is just above the coverslip. Students should look through the eyepiece and use the coarse focus knob (depending on the microscope) to move the objective gradually upwards until the printing on the paper comes into view.

   Remind students that the object sample will come into focus when the objective is very close to the stage. Tell students to use the fine focus knob to sharpen the appearance of the image, and use caution not to break the coverslip. Each student should have an opportunity to adjust and focus the microscope.

5. Have students draw their observations of the newsprint on the *Magnification Observations* sheet. Some students may wish to study the newsprint at a higher magnification by first centering the object in the field of view, then gently rotating the middle objective into position and adjusting the focus using the fine focus knob only.

6. Discuss students' observations or have them answer the following questions in their science notebooks. Ask, *Which tool provided the greatest magnification? What did all of the tools have in common? What were the differences between each of the tools?*

SPECIAL MICROSCOPES

Scientists use a variety of high-powered microscopes to study the surface and internal structure of a sample, and to measure the size of things too tiny to see with light microscopes.

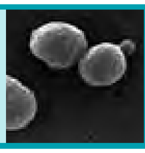
TEM image of *Legionella pneumophila* bacterium (causes Legionnaire's disease). CDC/7306.

A transmission electron microscope (TEM) uses an electron beam that passes through a specimen, enabling the interior of an object to be observed (see image above).

A scanning electron microscope (SEM) uses electrons to image the surface of an object (see image below).

SEM image of *Legionella pneumophila.* CDC\6640 B. Fields.

For more information, see the reading activity, "A Powerful Tool" at BioEd Online.



Streptococcus pneumoniae bacteria. CDC\9996 J. Carr, R. Facklam.

Magnification Observations

Observation 1

Tool Used ______________________ Magnification (if known) ______________________

Notes and Observations ______________________

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Observation 2

Tool Used ______________________ Magnification (if known) ______________________

Notes and Observations ______________________

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Observation 3

Tool Used ______________________ Magnification (if known) ______________________

Notes and Observations ______________________

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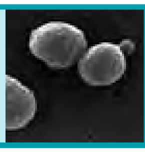
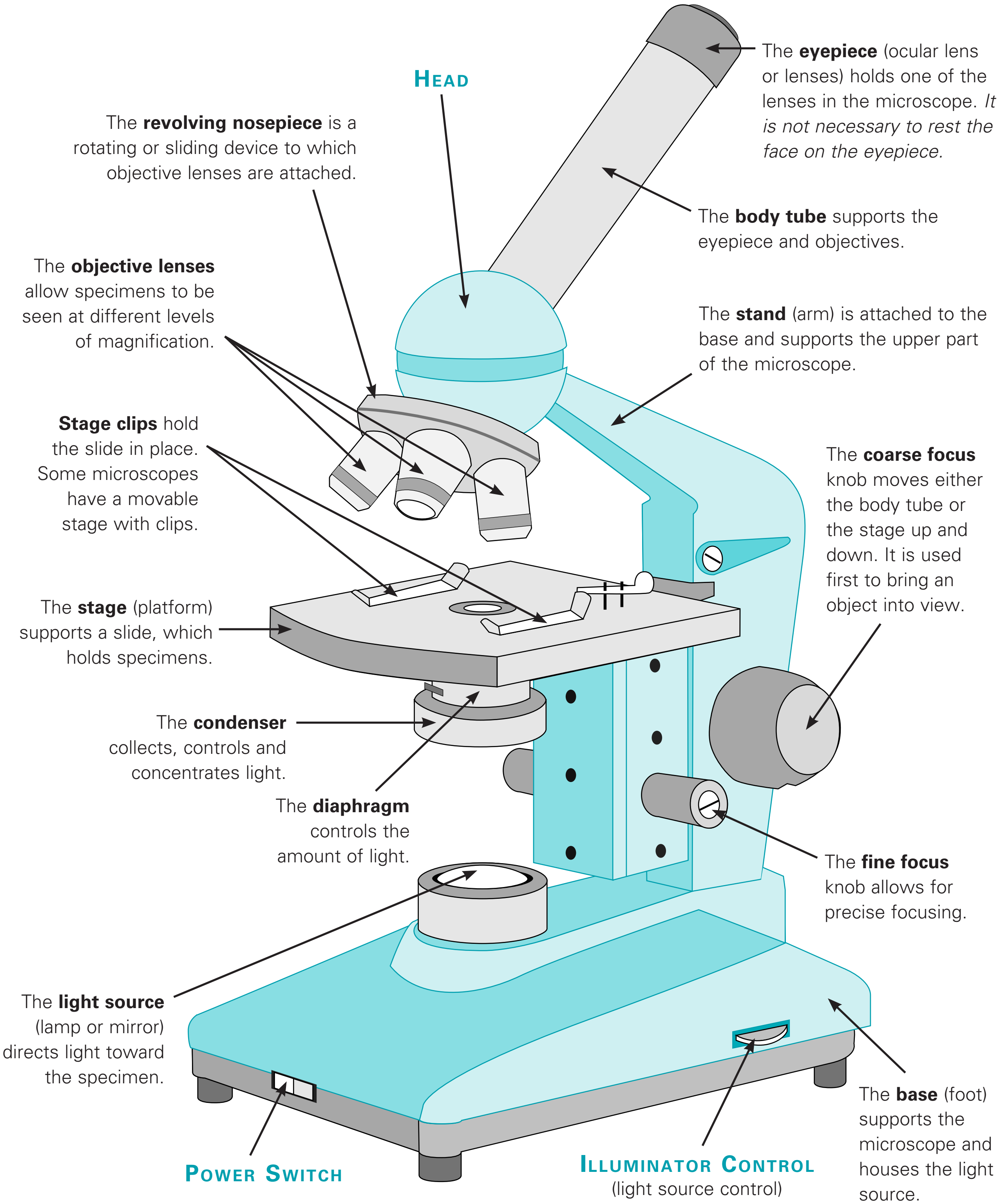


Streptococcus pneumoniae bacteria. CDC\9996 J. Carr, R. Facklam.

The Compound Microscope

When you look through a microscope, lenses make what you are looking at appear larger. For example, a 10-power lens (10x) makes objects appear ten times larger than their actual size. With the right combination of lenses, a very good compound light microscope can magnify objects as much as 2,000 times (2000x).



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