



Student Guide

Resolving Power – Seeing is Understanding

Introduction: In this activity, you will learn about light microscopes and their limitations in viewing small features and objects. In addition, you will explore more powerful imaging tools by understanding the principles of operation of electron and atomic force microscopes. As a culminating activity, you will solve a mystery using evidence and microscopes.

The light microscope has been a critical tool to allow researchers to see things at the microscopic level. It uses light beams and glass lenses to create a magnified image of an object. However, traditional light microscopes can't resolve objects smaller than about 500 nanometers (nm) or achieve magnifications more than ~10,000X. It's important to understand that these limitations are not due to flaws in the glass lenses or microscope design that could be corrected. Instead they are a fundamental outcome of optical physics – a result of the “size” of visible light (wavelength ~400 – 700 nm) and how it behaves as a wave. The electron microscope was developed when the wavelength became the limiting factor in light microscopes. Electrons have much shorter wavelengths, enabling better resolution down to the nanoscale. You will explore these more powerful imaging tools by accessing virtual ones online.

Part 1. Resolving Power

1. You will take a pretest to determine what you know about the mechanisms and resolving power of microscopes.
2. Next, read the page on resolving power and discuss the methods and abilities of the various scopes: <https://www.sciencelearn.org.nz/resources/495-magnification-and-resolution>.
3. You will access the virtual SEM and AFM. Your teacher will provide the links.
4. Have a class discussion about resolving power and the capabilities of the scopes.

Part 2. Solving the mystery: “Who Kidnapped Abigail?”

Task

Your favorite NCIS forensic specialist has gone missing. To help rescue Ms. Abigail, you need to identify several samples, using the tools in her lab. Some of these samples are identified with only one suspect, while others may implicate more than one source. Your task is to narrow the field of suspects and try to predict who may know the location of Abigail.

Tools: Optical microscopes, electron microscope, atomic force microscope. Your teacher may decide that the class will remotely access a Scanning Electron Microscope and/or an Atomic Force Microscope. This will allow live interaction with samples being viewed by these scopes.



Prefix Review

1 meter	= 1. m	$1 \times 10^0\text{m}$
1 millimeter	= 0.001 m	$1 \times 10^{-3}\text{m}$
1 micrometer	= 0.000001 m	$1 \times 10^{-6}\text{m}$
1 nanometer	= 0.000000001 m	$1 \times 10^{-9}\text{m}$

Can we go smaller? A hydrogen atom is 1/10 of a nanometer. **Think pico to femto.**

In Part 1, you explored resolving power and the capabilities of the microscopes that are the tools at your disposal. It will be up to you to decide which tool to use to examine evidence.

Activity:

Miss Abigail was last seen on the central staircase of NCIS, an area cleaned not long before, but frequented by many people. The NCIS forensic team has gathered evidence on the staircase. You have a list of suspects and clues (objects/materials) that are linked to each suspect. It is your job to examine these and decide who is guilty of kidnapping Ms. Abigail.

Your teacher will provide evidence to you that will point to 1 or 2 suspects. You have the list of suspects along with possible clues. It is your job to look at the clues collected in the stairwell to determine who has Abigail. You may need to use a light microscope to examine clues or more powerful microscopes. Your teacher will decide if you will use images of the objects or if you will remotely access specialized instruments to image samples.

Procedure:

- Examine and draw all the samples your group is given, and compare them to the clues from the AFM and SEM which have been provided as images. Or, you will remotely access specialized instruments to image specific samples.
- Are any of the samples that require an optical microscope to examine useful? Are there some samples that can't be used on the other scopes?
- Based on the clues found where Abigail was last seen, who do you think might have information about her whereabouts?
 - Defend your conclusion.
- What are the different strengths and weaknesses of the various instruments?
- What other samples or substances would you sample if given the chance?

Optional: Research how high tech imaging systems such as STM, AFM, SEM, and STEM have and are advancing the field of nanotechnology and/or forensic science. Prepare a short PowerPoint to present your results including what may occur in the future using these tools.

