Student Name: _____ Date: _____

Using Microscopy to Get a Sense of Size and Scale

Engage: How big is big? How small is small?

Station A: What am I looking at?

In the space below, record what you think you may be looking at in each image.

Image	I think this is…because…
A	
B	
C	
D	
E	
F	

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Station B: Size Perception

For each item on the list below, indicate the size by placing an X in the box that is closest to your estimate of its size.

Object	< 1 nm	1 nm to 100 nm	100 nm to 1 µm	1 µm to 1 mm	1 mm to 1 cm	1 cm to 1 m	1 m to 10 m	> 10 m
Diameter of the nucleus of a Carbon atom								
Height of an average adult								
Diameter of a human blood cell								
Length of a postage stamp								
Diameter of a virus								
Width of human hair								
Length of soccer field								
Height of an elephant								
Length of grain of rice								
Wavelength of visible light								

Adapted from Tretter, T. R., Jones, M. G., Andre, T., Negishi, A., & Minogue, J. (2005). Conceptual Boundaries and Distances: Students' and Experts' Concepts of the Scale of Scientific Phenomena. Journal of Research in Science Teaching

Station C: Scale of the Universe (Scale)
Access the following resources to explore the scale of the universe.

a. https://www.nikon.com/about/sp/universcale/scale.htm
b. http://scaleofuniverse.com/powers-of-ten/
c. http://scaleofuniverse.com/

Discussion: How do you think scientists observe, measure, and study things that are too small to be seen with the naked eye?


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Explore: Van Leeuwenhoek Adventure

Antoni Van Leeuwenhoek, known as the father of microbiology, was the first scientist to observe and describe microorganisms. Influenced by the work of natural scientist Robert Hooke, who studied the microscopic world, Leeuwenhoek developed an interest in observing the natural microscopic world. Leeuwenhoek designed lenses and built microscopes which gave him the ability to magnify objects up to 200x. Van Leeuwenhoek made some of the first observations of the microscopic world, including the microscopic organisms which he referred to as "many very little living animalcules."

In this activity, you will do what Leeuwenhoek did!

Step #1: Obtain Samples

Group Members:

_____

_____

_____

Sample Information:

Date Obtained: _____ Source: _____

Notes: _____

_____

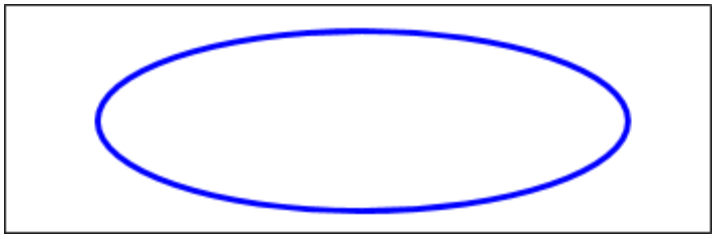
_____

Step #2: Prepare Samples

Student Name: _____ Date: _____

1. Place moss / lichen sample into a plastic Ziploc bag and add about 15 mL of spring water to the bag.
2. Allow the contents to sit overnight.

Step #3: Observe Samples

1. Use a wax pencil to draw an oval on one of the microscope slides. See set-up below.
2. 

3. Make sure the Ziploc bag is sealed and shake it vigorously to crumble the moss and/or lichens and mix it thoroughly into the water.

4. Using a plastic pipette, take up approximately 2-3 drops of the moss and/or lichens water mixture from the bag and place it in the oval of the microscope slide.

5. Use the microscope provided to observe your sample. In Table 1, record your observations and take pictures of what you see.

6. Use your electronic device to access the following resource, which provides information about organisms found in pond water.
   http://www.microscopy-uk.org.uk/ponddip/

7. To the best of your ability, identify the organisms in your images.

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Table 1: Pond Water Observations / Images

Reflection:

_____

_____

_____

_____

_____

_____

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Explain: Measuring Size, Converting Units, and Understanding Scale

Step #1: Metric System Review

Access Resource:
https://www.khanacademy.org/math/cc-fifth-grade-math/cc-5th-measurement-topic/cc-5th-unit-conversion/a/metric-units-of-length-review

Step #2: Measure, Convert, and Compare

1. Trace your left thumb in the space below. Using a ruler, measure the width of your thumb in centimeters (cm). How big is your thumb in meters? Millimeters? Micrometers?

Left Thumb Measurement	**Convert**	
	How wide is your thumb in meters (m)?	_____ m
_____ cm	In millimeters (mm)?	_____ mm
	In micrometers (µm)?	_____ µm

2. The period at the end of this sentence has a diameter of 0.5 mm. What is the diameter in meters? Centimeters? Micrometers?

Convert

a. What is the diameter in meters (m)? _____

b. In centimeters (cm)? _____

c. In micrometers (µm)? _____

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3. If you lined up periods side-by-side, how many would fit across the width of your thumb? Explain your thinking and support your answer with mathematical reasoning.

4. Indicate what unit of measurement (meter, centimeter, millimeter or micrometer) would be most appropriate to measure each of the objects listed below.

Object	Measurement
Length of an apple seed	
Diameter of a red blood cell	
Virus	
Thickness of a dime	
Length of your pencil	
Thickness of a strand of hair	
Diameter of a quarter	
Height of your desk	
Thickness of a coat of paint	
Length of a soccer field	

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Part III: Scale Bars and Magnification

One of the most common microorganisms found in pond water is the Daphnia. The image below, taken using a stereomicroscope, shows one of many species of Daphnia. Work with your team to determine the length and width of the Daphnia pictured below.

On the image, label where you will measure your length and width.
Include appropriate units for your measurements.
Provide an explanation.

 Figure 2. Cornell RET Summer 2018 Daphnia	Length: _____ Width: _____ Explain how you arrived at your answer.

Pair & Share

Find a partner. You must work with someone from another group. Discuss your approach. What was similar? What was different?

_____

_____

_____

A magnified object is a scaled image. When you look at an object under a microscope

Student Name: _____ Date: _____

you are seeing a larger version of the object. The object has been scaled up so that you can view it in greater detail. The degree to which it has been scaled up is the magnification. As you may have already noticed, the image in Figure 2 includes a scale bar. A scale bar is a line which corresponds to a certain measurement. Using the scale bar, you can calculate the magnification from the ratio of the scaled dimension to the actual dimension.

$$\text{Magnification} = \frac{\textit{Scaled Dimension}}{\textit{Actual Dimension}}$$

Using a ruler, measure the scale bar and record your answer in the space below. This value represents the scaled dimension. You will need to convert your units for consistency.

Scaled Dimension = _____ mm = _____ µm

The actual dimension is indicated by the scale bar on the image.

Actual Dimension = _____ µm

Calculate the magnification of the Daphnia.

Magnification Factor = _____

The magnification you calculated can be used to determine the actual size of the Daphnia. Using a ruler, measure the length and width of the Daphnia and record your answers in the space below.

Length = _____mm = _____µm

Width = _____mm = _____µm

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Next, divide your values by the magnification factor calculated above. These values represent the actual length and width of the Daphnia pictured in Figure 1.

Actual Length: _____ Actual Width: _____

Compare your results to your initial measurements of the length and width.

_____

_____

_____

Work with your group to determine the length and width of the Daphnia if it were magnified 1000x. Show your work in the space below. When you are finished, use your values to draw and cut out the scale model of the Daphnia.

Reflection: How can your scale model be improved?

_____

_____

_____

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Scale Bar and Magnification Practice:

For each image below, determine the magnification and the actual size of the organism (or part of the organism) indicated by the arrow.

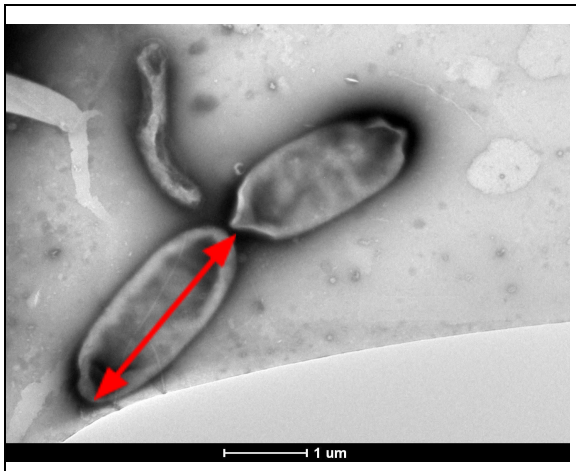

Figure 3. Cornell RET Summer 2018

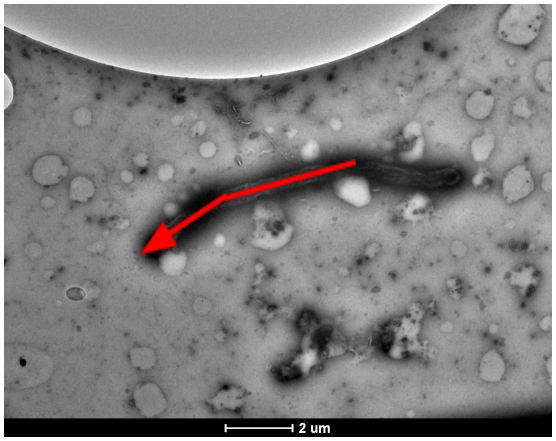

Figure 4. Cornell RET Summer 2018

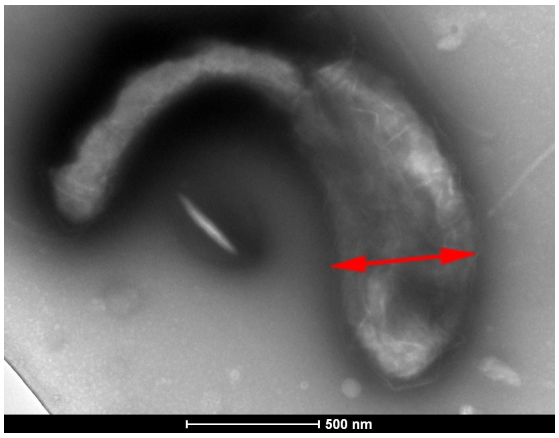

Figure 5. Cornell RET Summer 2018

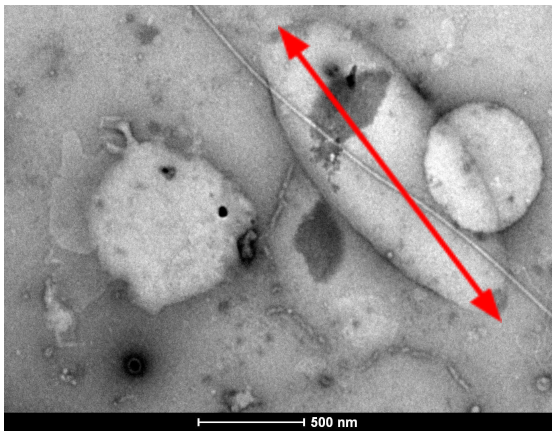

Figure 6. Cornell RET Summer 2018

Image	Actual Size	Magnification
Figure 3		
Figure 4		
Figure 5		
Figure 6		

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Take a closer look at the images in Figures 3 - 6. How are these images different from the ones you obtained in the Van Leeuwenhoek Adventure?

1. _____
   _____
   _____

2. _____
   _____
   _____

3. _____
   _____
   _____

What are some possible reasons for the difference in the images?

_____
_____
_____
_____
_____

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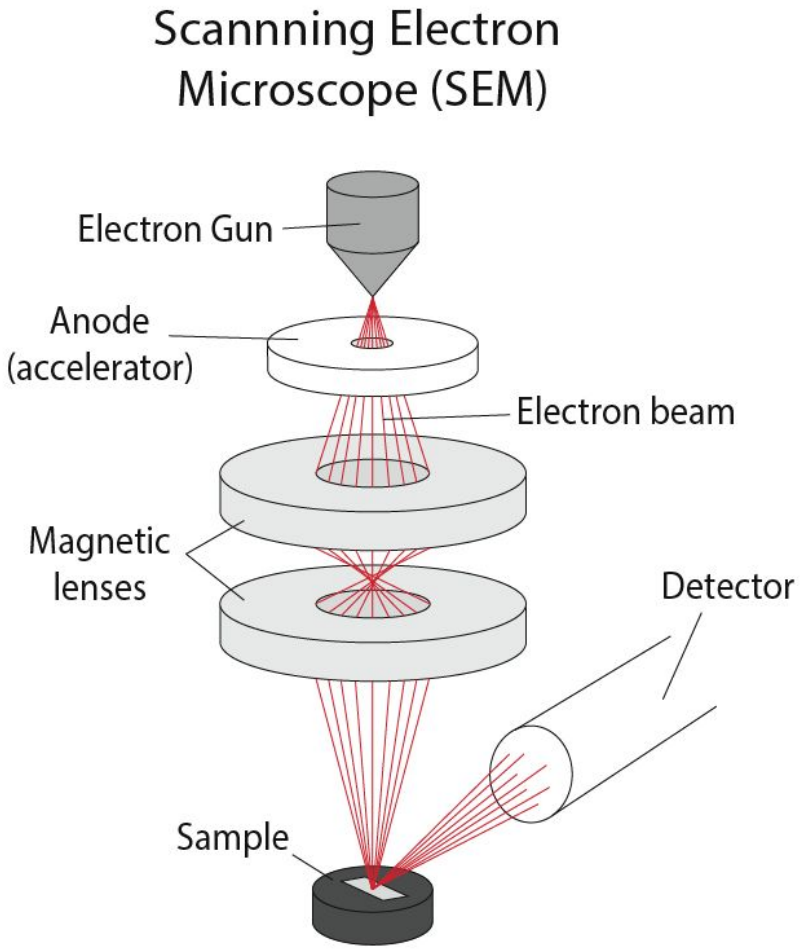
Elaborate: Scanning Electron Microscope

Part I: SEM Basics (Completed at home)

Access http://myscopeoutreach.org/2_howdoesansemworks.html to review the basics of an SEM microscope. Use the image below to take notes on the parts of an SEM and how each part functions.



SEM Schematic: Engineering Atoms – University of Cambridge

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Complete the graphic organizer below to highlight the similarities and differences between an optical microscope and a scanning electron microscope.

Optical Microscope	**Vs.**	**Scanning Electron Microscope (SEM)**
	Similarities	

1. What is the electron gun? Why is it important?
2. How are electrons condensed into an electron beam?
3. How do the sample and electrons interact?
4. What is the purpose of the deflector and detector?
5. How are images created?

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Part II: SEM Simulation Exploration (Adapted from MyScope Outreach)

Access: http://myscopeoutreach.org/virtualSEM_explore.html

I. Play with the simulation to experience using an SEM.
II. Kitchen Sponge Investigation – Find the Bacteria

Use the simulator to investigate the three samples of kitchen sponges at different magnifications.
For each sample, take pictures and save for all magnifications viewed.
Record your magnifications and observations in the Table below.

1. How was the unused sponge different from the other sponge samples?

2. As you increased the magnification on the used sponges, what do you see?

3. How many different types of bacteria are present on the sponge? Can you identify any?

4. How does the size of these microbes compare to the microorganisms you observed in your pond water samples?

III. Complete the Challenge: What do you see?
http://myscopeoutreach.org/whatDoYouSee.html

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Evaluate: Construct a Scale Model

Apply what you have learned about size, scale, and magnification to construct or draw a scale model of a microorganism magnified 5,000x.

Select one of the microorganisms from the images provided. If your image shows more than one organism, select one to work with.
Identify your microorganism.
Determine the measurements of the microorganism you selected.
Show your work for determining the actual size of the microorganism.
Show your work for determining the magnified size.
Construct a scale model of the microorganism magnified 5,000x.
On the back of your scale model, record five facts about the microorganism you selected.
Place your scale model on the magnified period to compare the sizes.
Complete reflection questions below.

Reflection Questions:

1. How does the size of your microorganism compare with the other microorganisms?

2. How does the size of your microorganism compare with the size of the period?

3. Look at the class mural, are most microbes bigger or smaller than the period you would see on a piece of paper?