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Thinking Small – Worksheet

Part 1

How small is small?

Instructions: Answer the questions below ***independently*** *unless otherwise directed.*

1. Define small. What is small to you? What is the smallest thing you own?

2. Look around the room and write down the smallest item that you can see.

3. So then, what is smaller than small? What is the smallest thing you know about but can't see? Brainstorm ***with your group*** and write your ideas below.

4. If you can't see the things you wrote about above, then how do you know they exist? Brainstorm ***with your group*** and write your ideas below.

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Can you put the items on the cards in order by size?
Instructions: ***With your group*** *, complete the card sort by arranging the objects on the cards in order or largest to smallest, then answer the questions below. When you are done, fill in the chart to check your work.*

5. Which item did you identify as the smallest? Why? Which item did you identify as the largest? Why?

6. Were there any items that were tough to place? Why?

Check your work! Look through the Scale of the Universe (https://htwins.net/scale2/) to check the order of your card sort. Find the objects on the computer program and record their size below in the chart.

CHART FOR SCALE OF THE UNIVERSE

Rank Largest to Smallest	Object	Size in Scientific Notation (Click on the Object)
1 (Largest)		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17 (Smallest)		

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Part 2

How do we measure small things?

Instructions: Read the segment below and ***independently*** *complete the conversions that follow. Check answers with your group before moving on to Part 3.*

Reading Segment

How do scientists measure objects? Scientists use the International System of Units (SI). In the chart below are the base units for measurements we will make frequently. To measure quantities, scientists use specialized equipment. You will be measuring primarily the physical quantities below.

Physical Quantity Measured	Base SI Unit	Symbol
Temperature	Kelvin	K
Mass	Kilogram	kg
Volume	Liter	L
Length	Meter	m
Time	Second	s

Scientists also need to convert between units of measurement. For example, a scientist may ask for 400 ml (milliliters) instead of 0.4 L of a liquid, or they may ask for 20 mg (milligrams) instead of 0.020 g (grams). Knowing how to convert between units is very important. Using the table below let's practice a couple of unit conversions.

Prefix	Symbol	Multiplication factor		
exa	**E**	10^{18}	=	1 000 000 000 000 000 000
peta	**P**	10^{15}	=	1 000 000 000 000 000
tera	**T**	10^{12}	=	1 000 000 000 000
giga	**G**	10^{9}	=	1 000 000 000
mega	**M**	10^{6}	=	1 000 000
kilo	**k**	10^{3}	=	1 000
hecto	h	10^{2}	=	100
deca	da	10^{1}	=	10
deci	d	10^{-1}	=	0.1
centi	c	10^{-2}	=	0.01
milli	**m**	10^{-3}	=	0.001
micro	**µ**	10^{-6}	=	0.000 001
nano	**n**	10^{-9}	=	0.000 000 001
pico	**p**	10^{-12}	=	0.000 000 000 001
femto	**f**	10^{-15}	=	0.000 000 000 000 001
atto	**a**	10^{-18}	=	0.000 000 000 000 000 001

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1. Convert 25 microliters into liters.
   _________L
2. Convert 0.357 liters into milliliters.
   _______mL
3. Convert 37 centimeters into meters.
   _______m
4. Convert 78 milligrams into grams.
   ________g
5. Convert 48 nanometers into meters.
   _______m
6. Convert 5 grams into milligrams.
   _________m

Part 3

Practicing Taking Measurements

Instructions: Complete the three challenges below with your group. Make sure all measurements go on this worksheet.

Measuring Mass (grams) and Volume (Liters) in science uses a special set of equipment. In this activity, we will use scales, beakers, graduated cylinders, plastic pipettes, and micropipettes. When measuring volume in science it is extremely important to measure accurately. Therefore, we must think about what equipment we must use to get the best measurement.

Challenge 1 (Measuring Mass)

How do we measure mass? Examine your scale and think about the following questions: What do you see on your scale? What are the different units your scale can measure in? What unit will we use to measure? How do you know your scale is set to that unit?

Taring your scale: When we weigh materials, we often need to put them in a container in order to weight them. However, we don't want to count the weight of the container when we are measuring the mass of the material. To negate the weight of the container, place an empty container on the scale and press the "tare" button. Let's practice!

1. **Weigh 3 grams of salt.** Which object is closest in size to your pile of salt? A loaf of bread, a cell phone, a ping pong ball, a pencil eraser, or the tip of a pencil?
2. **Weigh 15 grams of salt.** Which object is closest in size to your pile of salt? A loaf of bread, a cell phone, a ping pong ball, a pencil eraser, or the tip of a pencil?
3. Now that you are a professional, explain in writing what you do when using a scale to measure the mass of your substance below.

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Challenge 2 (Measuring Volume)

In science we need to be accurate in our measurements. That means choosing the right size tools that will give us the most accurate measurement. Using graduated cylinders of various sizes to measure the different volumes, select the best one, and measure the volume. Record what size graduated cylinder you used and explain why you selected that size.

- 7 mL:
- 15 mL:
- 28 mL:
- 57 mL:
- 93 mL:

Challenge 3 (Measuring Volume Using Micropipettes)

Sometimes you need to measure volumes that are too small to use a graduated cylinder. What would we do then? For example, how would we measure 2μL? 15μL? 25μL? To measure these volumes, we will need to use special tools called *micropipettes*. Follow the three steps below to learn about and use your micropipette

Step 1: To introduce micro-pipetting, watch the video, Lab Skills: Micropipetting Basics (https://www.youtube.com/watch?v=22Y34316nZs) and answer the following questions:

1. What is the role of the “plunger”?
2. Can you measure 500μL on a P200? Why or why not?
3. How often should you reuse a pipette tip?

4. When measuring liquids, do you push the plunger to the first or second stop before inserting it into the liquid

5. True or False: your micropipette tip should touch the bottom of the liquid container to get the best measurement.

6. True or False: you should remove the tip once you are done by grabbing it with a gloved hand.

Step 2: Practice using your pipette to measure the liquid amounts below. Remember to set the micropipette for the amount you want to measure and get a clean tip before you measure! All measurements should go into the labelled "liquid waste" beaker

- 25 μLs red water
- 70 μLs blue water
- 103 μLs red water
- 141 μLs blue water

Step 3: Reflection Questions

7. When do you think researchers use micropipettes? When in this class do you think we will use micropipettes?

8. What is the hardest part of using the micropipette?

9. If you were teaching your friend how to use a micropipette for the first time, what do you think is important for them to know?

Part 4

What about the things we can't see? How do we measure things that are too small to be seen?

Scientists can't always use scales, graduated cylinders, and micropipettes to see and measure materials. Sometimes those objects and particles are just too small to see or measure without specialized equipment like microscopes. You learned about the electromagnetic spectrum in your physics class last year! Analyze the figure below with your partner. What can you tell me about light waves, wavelengths, frequencies, and some technological applications at different wavelengths?

So how do scientists use microscopy to see and manipulate very tiny objects? Let's watch a segment of Mysteries of the Unseen World (from 21:38 - 35:00 https://www.youtube.com/watch?v=OzFvGx6DZOs)
As you watch this segment, record the answers to the questions below.

I. Compound Microscope:

1. How does a compound microscope work to visualize small creatures?

2. What are the limitations of a compound microscope? Why?

II. Scanning Electron Microscopy:

3. How does Scanning Electron Microscopy (SEM) work to allow us to see items smaller than visible light?

4. What are some examples of things you can see with a Scanning Electron Microscope?

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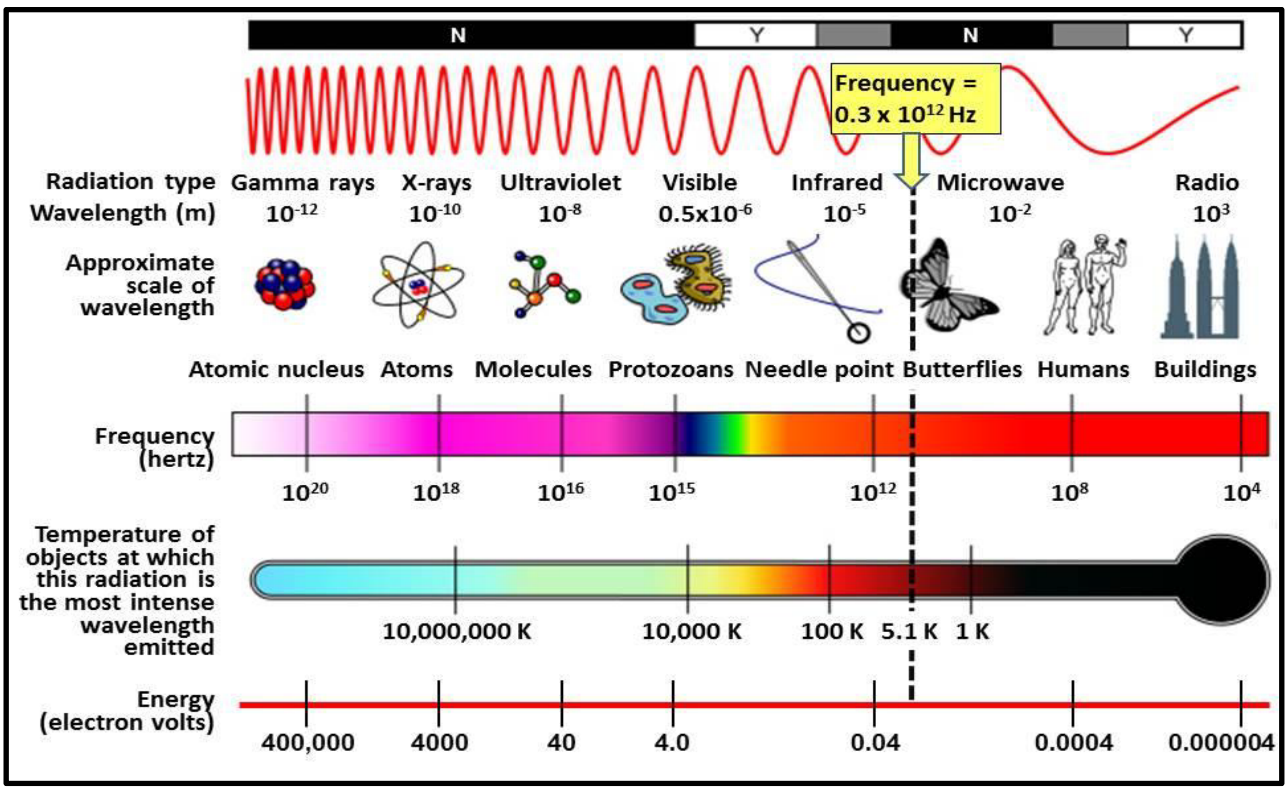
III. Nanoworld:

5. What is special about the…

   a. Lotus Flower:

   b. Gecko's Feet:

   c. Spider Silk:



6. How would you describe the nanoworld?

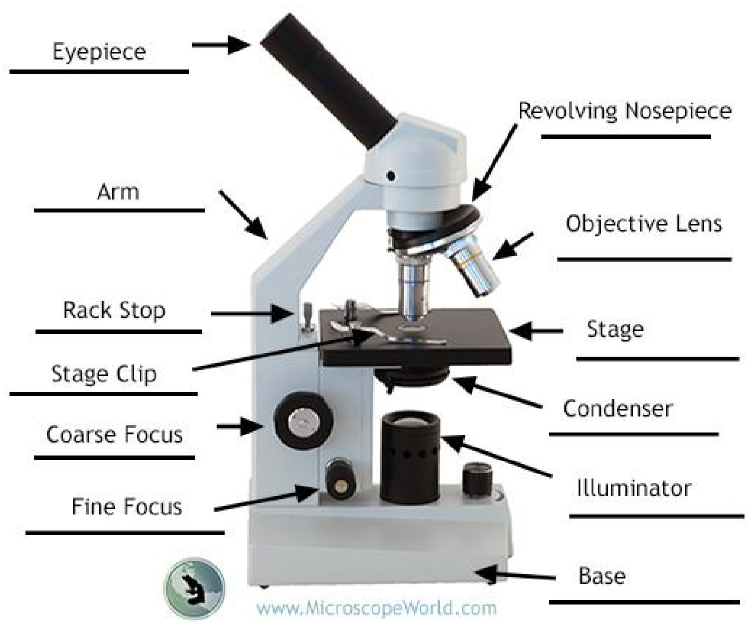
7. Why do you think the nanoworld is the new frontier?

8. What can our most advanced microscopes do?

Part 5

Focusing on the Small Things!

In this activity, you will use the Compound Light Microscope. Light microscopes use both objective lenses and eyepiece lenses to help magnify objects so that you can see them. Microscopes have been used in Biology since Antonie van Leeuwenhoek (1632–1724) first used them, although his microscope was much simpler. The image to the right will help us review the parts of the microscope. Before we use it in class though, let's review some basic information.



1. How do we carry the microscope?

2. What steps do you take to use the objective lenses to find your object of interest?

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Now try it yourself! Select one of the organisms on the slides before you and practice visualizing them at different powers. Draw what you see below:

4X 10X 40X

Now that you are good at finding an organism in a fixed slide, let's see if you can find any organisms in a drop of pond water on a wet slide! To do so place one drop of pond water on your clean slide. Carefully place the coverslip on top of it, and then move your slide onto the stage! Draw what you saw in the pond water below!