

Names _____
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Introduction:

The purpose of this activity is to practice using the metric system. To conduct a scientific investigation, a researcher must be able to make accurate measurements. In today's exercise you will become familiar with metric system units and converting between large and small metric units. In each of the sections that follow, you will familiarize yourself with the appropriate metric units that scientists commonly use, and then you will take the measurements of some everyday objects.



The metric system is the standard system of measurement in the sciences, including biology, chemistry, and physics. It has tremendous advantages because all conversions, whether for volume, mass (weight), or length, are in units of ten. This ten-based system is similar to our monetary system, in which _____ cents equals a dime, and _____ dimes equals a dollar.

Standard Metric Units

The *International System of Measurement* (SI), commonly called the metric system, has been adopted as the official system of measurement by most countries. Unlike our traditional system of measurement (inch, foot, yard, mile), the metric system is based on standard units that can be easily converted by simply multiplying or dividing by ten. The standard metric unit for length is the meter. Gram is the standard unit of mass and liter the standard unit of volume. Temperature is measured in degrees Celsius (or Kelvin).

Figure 2.1

Standard units of the metric system

Measure	Unit	Example
Length	Meter (m)	Height of a typical door handle (1 m = approx. 39 inches)
Mass	Gram (g)	Mass of one dollar bill (1 g = 0.035 oz)
Volume	Liter (l)	Volume of large fast food soda (1 l = approximately 1 quart)
Temperature	Celsius (°C)	Water freezes at 0°C and boils at 100°C

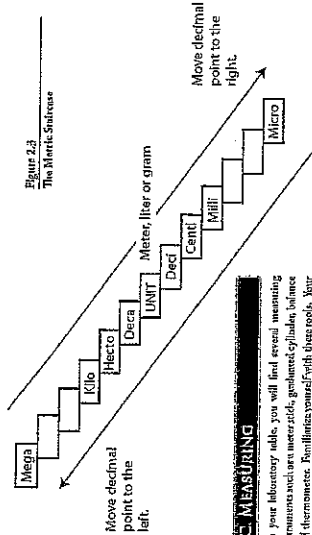
Figure 2.2 shows the metric units and their prefixes. Measurements are further expressed using a "superunit" prefix or subunit prefix. Superunits contain Greek prefixes to show multiples of the base unit, so they make the base unit larger. Latin prefixes, on the other hand, represent "subunits" that make the base unit smaller.

Figure 2.2
Common metric system prefixes and their values

Superunit	Prefix	Symbol	Value
	Kilo	K	1000.0
	Hecto	h	100.0
	Deca	da	10.0
Unit	Meter	m	1.0
	Gram	g	
	Liter	l	
Subunit	Deci	d	0.1
	Centi	c	0.01
	Milli	m	0.001
	Micro	μ	0.000001
	Nano	n	0.000000001

Metric Conversions

Conversions within the metric system can be made easily using a metric staircase. Each step of the staircase represents a ten-fold change in the value of the measure or a shift of the decimal point one place. Therefore, each step you move down the staircase represents multiplication by ten or a movement of the decimal one place to the right. Each step up the staircase represents a division by ten or the movement of the decimal point one place to the left. Two steps up or down the staircase represents a movement of the decimal point two places to the left or right and three steps up or down the staircase represents a movement of the decimal point three places to the left or right. If you have trouble, ask your instructor to demonstrate how to make conversions within the metric system using the staircase.



MEASURING

On your laboratory table, you will find several measuring instruments such as metersticks, graduated cylinders, balance and thermometers. Familiarize yourself with these tools. Your instructor will demonstrate how each is properly used.

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Background

Lab Activity: Measuring with Metric

Heed these rules:

1. You should always use **DECIMALS** (never fractions!) to express metric measurements.
For example: write 2.25 cm, **not** 2 ¼ cm
2. If a metric measurement is less than one, precede the decimal with a ZERO.
For example, *don't* write .55 mm, write 0.55 mm

Points will be deducted for incorrect format.

Practice converting Metric Units

Use the staircase diagram Figure 2.3 to convert the following metric units into new metric units.

8 meters = _____ mm

0.98 kg = _____ g

22.1 ml = _____ l

0.00003 m = _____ mm

10,900 cm = _____ m

57 mm = _____ cm

0.0034 mg = _____ g

0.98 kg = _____ mg

0.0087 l = _____ µl

349 ml = _____ µl

660 g = _____ mg

4590 µl = _____ ml

1. LENGTH

Metric units of length measurement *most commonly* used in biology include the meter (m), centimeter (cm), millimeter (mm), micrometer (µm), and nanometer (nm). See Table 2.1, below.

Unit	Meters	Centimeters	Millimeters	Relative Size
Meter (m)	1 m	100 cm	1000 mm	largest
Centimeter (cm)	0.01 (10 ⁻²) m	1 cm	10 mm	↓
Millimeter (mm)	0.001 (10 ⁻³) m	0.1 cm	1.0 mm	
Micrometer (µm)	0.000001 (10 ⁻⁶) m	0.0001 (10 ⁻⁴) cm	0.001 (10 ⁻³) mm	
Nanometer (nm)	0.000000001 (10 ⁻⁹) m	0.0000001 (10 ⁻⁷) cm	0.000001 (10 ⁻⁶) mm	smallest

How many cm are in a meter? _____

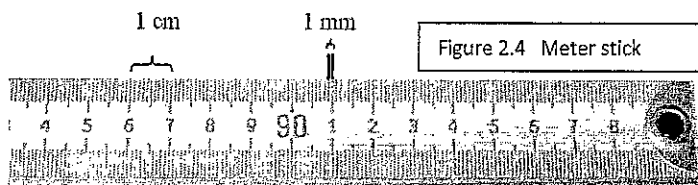
How many mm are in a centimeter? _____

How many µm are in a millimeter? _____

How many nm are in a micrometer? _____

Meter, Centimeter, and Millimeter

1. Obtain a meter stick. On the opposite side find the English measurement units of "inches". How many inches are in a meter? _____. Therefore, one meter is roughly equivalent to a *yard*.



2. Turn the meter stick over and observe the metric subdivisions (Fig. 2.4). How many centimeters are in a meter? _____

The prefix *centi-* means 100. How many cents (pennies) are in a dollar? _____

3. How many millimeters are in a centimeter? _____. The prefix *milli-* means a thousand. How many millimeters are in a meter? _____.

4. For measuring smaller objects, it is preferable to use a metric *ruler*, rather than a meter stick. Obtain a penny. Measure its diameter _____, then its width (thickness) _____.

5. Why is it preferable to measure a penny in millimeters rather than centimeters or meters?

Use a meter stick or a metric ruler to measure the following:

Width of classroom door opening (in meters) _____ m

Length of whiteboard (in meters) _____ m

Length of a dollar bill (in centimeters) _____ cm

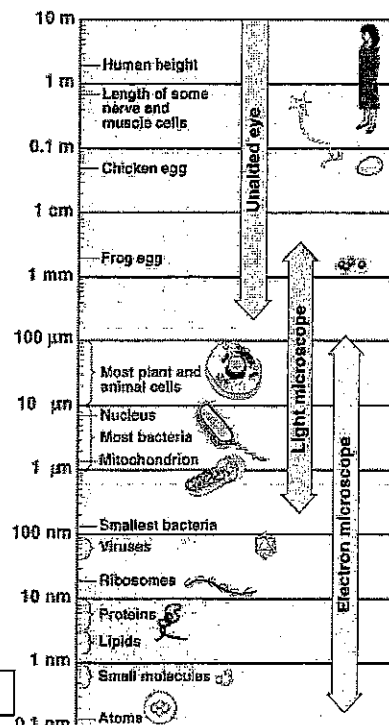
Width of your pen (in millimeters) _____ mm

Which of your fingernails is closest to 1 cm in width? _____

Millimeter, Micrometer, and Nanometer

As you will discover in upcoming laboratory exercises (using microscopes), the units micrometer (μm) and nanometer (nm) are useful in microscopy for measuring very tiny objects like cells or even viruses. Figure 2.5 shows that cells are generally much smaller than a millimeter (mm).

Figure 2.5 Measuring Small Objects

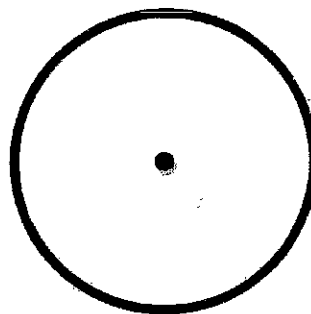


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Lab Activity: Measuring with Metric

Use a metric ruler marked in centimeters (cm) and millimeters (mm). Micrometers (μm) are not marked on the ruler, but remember that 1000 μm would fit in between each millimeter hashmark.

Figure 2.6 Measure the Circle



1. Measure the diameter of the circle (Fig 2.6). _____ mm
2. Now, calculate its diameter in micrometers: _____ μm
3. What is the diameter of the circle in nanometers? _____ nm

2. VOLUME

The basic unit of volume in the metric system is the **liter** (symbol is L or l). The most common derived unit used for *small* amounts of liquids is the **milliliter** (mL) (10^{-3} or 1/1000 of a liter). A typical individual bottle of spring water might hold 500 mL (half a liter) of liquid.

The volume of a milliliter is equal to the volume of a cube 1 centimeter per side. Sometimes these are expressed as **cc** (cubic centimeters) such as on the side of a medical syringe.

Another *even smaller* unit often used in the medical field is the **microliter** (μL) (10^{-6} or 1/1,000,000 of a liter). For example, you might expect to find 5 million red blood cells in a microliter of your blood.

1. Volume measurements can be related to those of length. Use a metric ruler to measure a wooden block. Record the measurements below.

Length = _____ cm width = _____ cm depth (height) = _____ cm

The volume (or space) occupied by the wooden block can be expressed in cubic centimeters (cc or cm^3) by multiplying L x W x H. Use your measurements to calculate this for the wooden block: _____

For the purposes of this activity, understand that $1 \text{ cm}^3 = 1 \text{ mL}$, so the wooden block has a volume of _____ mL.

2. In the biology laboratory, liquid volume is usually measured in milliliters, using an appropriately sized graduated cylinder. The measurement marks etched on the side are called "graduations".

When liquid is poured in, the top of the liquid forms a slight curve, called a "meniscus" (see Fig 2.7). The volume of the liquid should be read at the graduation closest to the **bottom of the meniscus**. For accuracy, you should read this (1) on a *flat lab surface*; (2) at *eye level* (crouch down).

How many milliliters of liquid is in the grad. cylinder in this picture? _____

Pro tip: Use as small a beaker or graduated cylinder as possible for your measurements. The smaller the vessel, the more accurate your measurement will be.

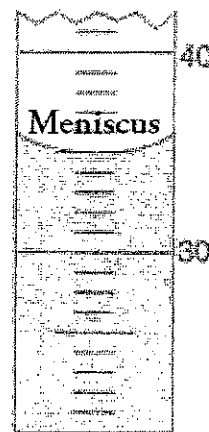


Figure 2.7 Meniscus

STATIONS 3-4

Volume Exercise 1: Practicing measurement accuracy.

At your lab table you should have a **glass bottle**, a **small plastic cup**, and a **test tube**. Find and record their volumes in the table below. *Hint: note that you have a faucet and sink to help with this task.*

Table 2.2:

Container	Measured volume
Volume of the bottle on your lab table	_____ mL
Volume of small cup on your lab table	_____ mL
Volume of test tube on your lab table	_____ mL

Volume Exercise 2: How many drops of water does it take to equal 1 mL?

To find out, fill a plastic pipette with tap water and count how many drops it takes to fill a small (10 mL) graduated cylinder to the 1 mL mark. *Don't forget to read the meniscus at eye level.*

From this information, you should be able to calculate how many mL each drop is, too!

Record below:

Drops per 1 mL = _____ mL per drop = _____

Volume Exercise 3: Measuring Volume by Displacement.

The volume of solid objects (like rocks, for example) can be obtained by measuring how much water they **displace** in a graduated cylinder. To measure the volume of an object using this method, first partially fill a graduated cylinder with water. Record the initial volume of water. Next, submerge the object completely under the water. Use extreme care when placing the object into the cylinder as to avoid breaking the glass. Then, record the new (final) volume of the liquid in the cylinder. The increase in the water's volume is equal to the object's volume.

Use a graduated cylinder and water to find the volumes of the following objects at your lab table:

Pebble = _____ mL Metal bolt = _____ mL

Volume Exercise 4: Using your meter stick, determine the VOLUME of either of the rectangular animal tanks in the classroom, in cm³ (cubic centimeters).

A) turtle tank b) bearded dragon tank (circle which tank you choose)

Show your measurements/calculations here (to the closest tenth decimal place):

Length = _____ cm width = _____ cm depth (height) = _____ cm

Volume = _____ cm³

Keeping in mind that each cubic centimeter is equivalent to a volume of 1 milliliter (mL), how many LITERS of water would the tank hold? _____ L

Lab Activity: Measuring with Metric

How many gallons (1 gallon = 3.7854 liters)? _____ gallons

Pro Tip: Very small volumes of water can be accurately measured using a *scale*, because each *milliliter* of water weighs 1 gram. To measure water this way, first put a small beaker on the scale, "zero" the scale by pressing the tare button (to "zero" it out). Be sure the readout shows a little "g" after the zero. If it says "N" the reading is not in grams. Now add the water to the beaker. Each gram that the scale reads equals 1 ml of water.

Answer this:

1. How many grams does 73 mL of pure water weigh?
2. What is the volume (mL) of 0.23 kg of pure water?

STATIONS 7-8

