Jalen Powell
Bio 103

# `Lab B: Metrics

Adapted from ©Lumen Learning, Biology 1 Lab Manual

Metrics:

## Introduction

Measurements in science use **metric** units. The metric system was developed in France in 1791 so that scientists had a common unit for research comparisons. In 1960 the metric system became the basis for the International System of Units (**SI** units). The basic units of these measurements for the metric system are listed in the chart below.

| Unit | Metric Measure | Abbreviation |
|---|---|---|
| Length | Meter | m |
| Volume | Liter | L |
| Mass | Gram | g |
| Temperature | Celsius | °C |

Larger or smaller units are created by adding prefixes to the terms above. The metric system is based on units of 10, so conversions from one unit to another are relatively easy and can be completed by moving a decimal point either adding or subtracting zeros.

| Prefix | Symbol | Multiplier | Notation |
|---|---|---|---|
| pico | p | 0.000000000001 | $10^{-12}$ |
| nano | n | 0.000000001 | $10^{-9}$ |
| micro | μ | 0.000001 | $10^{-6}$ |
| milli | m | 0.001 | $10^{-3}$ |
| centi | c | 0.01 | $10^{-2}$ |
| deci | d | 0.1 | $10^{-1}$ |
| Base unit | g, m, or L | 1 | $10^{0}$ |

| Prefix | Symbol | Multiplier | Notation |
|---|---|---|---|
| deka | da | 10 | $10^1$ |
| hecto | h | 100 | $10^2$ |
| kilo | k | 1000 | $10^3$ |
| mega | M | 1000000 | $10^6$ |

The chart on the previous page had some common metric prefixes from smallest to largest. Remember that the base unit, like a gram or a meter, is the same as $10^0$ or 1.

## NOW IT'S TIME TO PRACTICE!

Make the following metric conversions:

1. 1 meter = 100 centimeters = 1000 millimeters
2. 56.2 millimeters = 0.0562 meters = 5.62 centimeters
3. 13 kilometers = 0.013 meters = 0.0013 decimeters
4. 16 ml = 16000 µl 2. 7 g = 7000 mg
5. 9 µl = 0.00000900 L 4. 2.3 µl = 0.0023 mL
6. 32 mm = 32000000 nm 6. 19 m = 0.0190 km
7. 28 m = 0.0280 km 8. 400 ml = 0.400 L
8. 2 kg = 2.00x10^6 mg 10. 82 cm = 0.000820 km

## Part 1: Length and Area

Length is measured with a metric ruler, a meter stick, or a measuring tape. The basic unit of length is **meters**. Examine intervals marked on the metric rulers. You should see centimeter and millimeter divisions. Use a ruler or measuring tape to make the following measurements making sure to include units.

1. Length of a book 22.9 cm.
2. Width of the book 15.2 cm.
3. Area of the book 348.08 cm.
   (Area = length × width)
4. Length of yourself, or another person 186.40 cm.
5. Diameter of a penny 0.01905 m.
6. Measurement of object of your choice _____.
   Height of Playstation 5 40 cm.

**LAB QUESTION**

**What are some potential sources of error in your measurements?**

Some possible errors that can be made while measuring objects are numbers and significant figures.

## Part 2: Volume

Volume is the space occupied by an object. Units of volume are cubed (i.e. three dimensional) units of length. The **liter** (L) is the basic metric unit of volume.

1. Measure and pour 25 mL water into a 50 mL graduated cylinder. Notice how the water is curved. This is called the **meniscus** and is due to surface tension and adhesion of water molecules to the sides of the cylinder. When measuring liquids in a cylinder always get eye level with the meniscus and read the volume at the lowest level of the curve.
2. Fill a glass test tube with water. Use your graduated cylinders to measure the volume of the test tube in milliliters: 5 mL.
3. Convert this volume to liters: 0.005 L.

**LAB QUESTION**

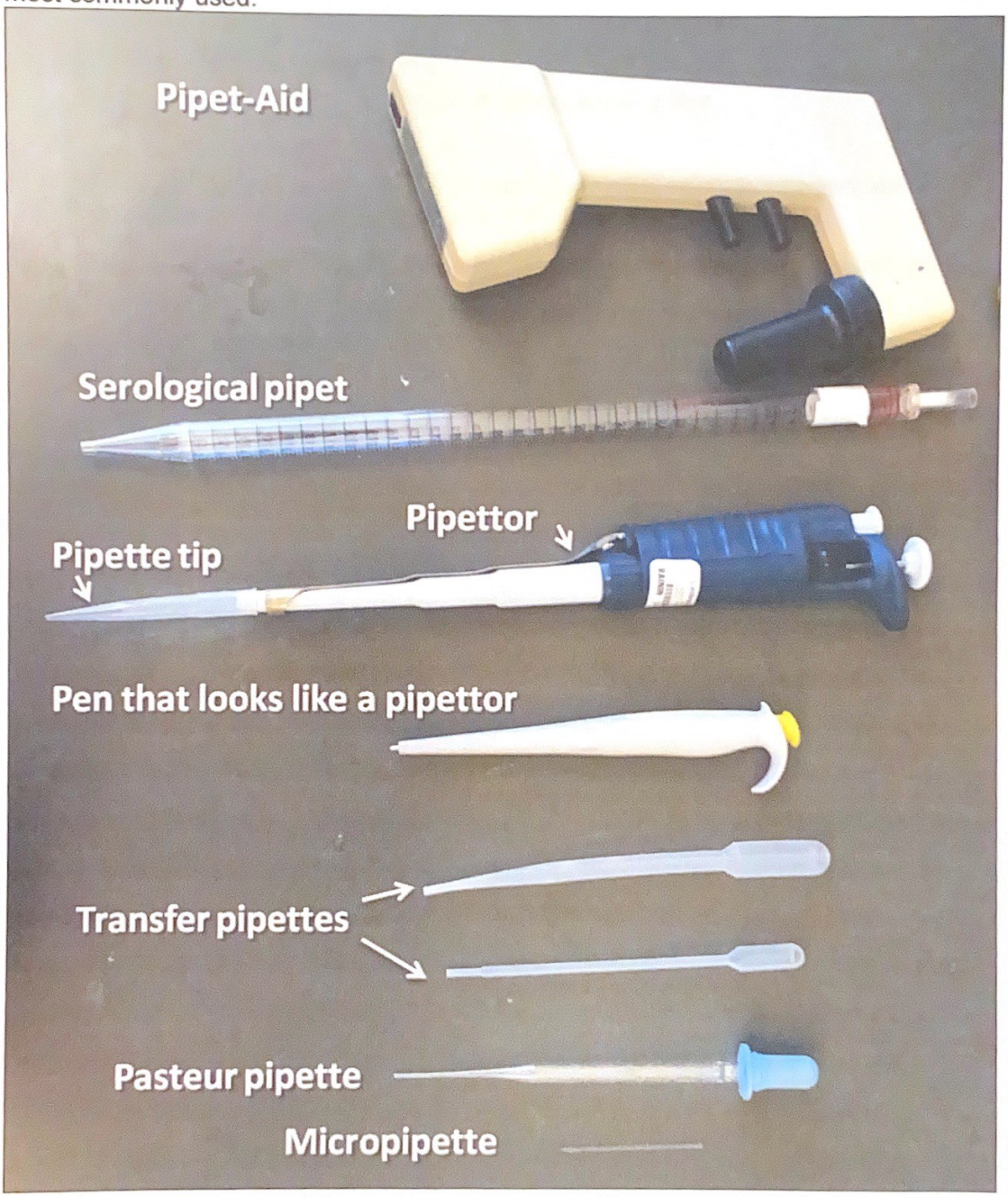
What are some potential sources of error in your measurements?

A potential source of error can be the small amount of water left in the test tube or reading the meniscus line incorrectly.

## Part 3: Pipetting

Pipetting is a way to accurately measure and transfer small amounts of liquids.

There are several different types of pipets, below are some examples of some of the most commonly used:



Micropipettes are used to measure the volume of extremely small amounts of liquids. They are commonly used by researchers, hospital lab technicians, and by scientists in the food and drug industries. Micropipettes measure microliters (µl).

1. How many microliters are there in a milliliter? 5 µ / mL
2. How many milliliters are in a liter? 1,000 mL / L
3. Therefore, there are 1,000,000 microliters are in a liter.

Micropipettes come in many sizes. For example, a p200 micropipette can pipette up to 200 µl while a p1000 can pipette up to 1000 µl, or 1 ml, of liquid.

When choosing what instrument to use when measuring volume, it is important to keep in mind the different ways the instrument dispenses volume. There are 2 major differences, we commonly see: To Contain (TC) or To Dispense (TD).

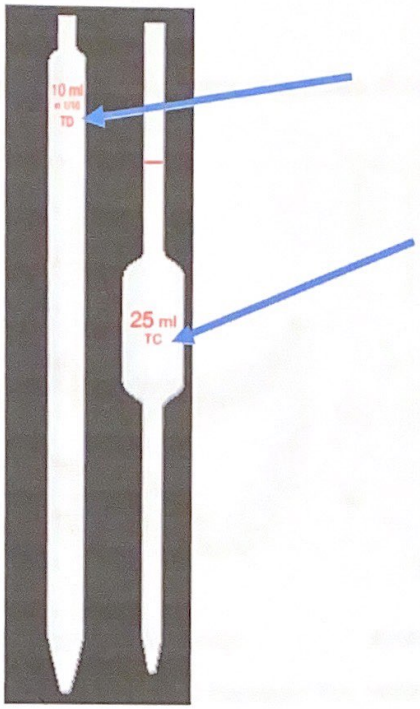
## TC vs TD

- TC= To Contain

TC glassware is used to make solutions.
If a liquid fills a TC glassware piece to a 50 mL line, then 50 mL of liquid is present.
However, if that liquid is poured into another container, less than 50 mL will be present.
This is because liquid is lost by sticking to the sides of the glassware.
Examples: Volumetric Flask, Beaker, Erlenmeyer Flask, transfer pipet

- TD= To Dispense

This glassware is used to deliver liquids
TD glassware accounts for leftover droplets on the glassware when pouring or dispensing.
If 50 mL is dispensed or poured from a TD glassware, 50 mL of liquid will be dispensed, because the calibration of the instrument accounts for the leftover drops that remain.
Examples: Volumetric Pipet, Buret, Graduated Cylinder
The type of dispensing is indicated on the instrument by the manufacturer:




Why are the differences between TC and TD important?

The differences are important because both are used to gain accurate measurements of liquid. One is more accurate than the other. TC is for correct measurement while being contained. TD is for dispensing the correct amount without leftovers.

## Part 4: Mass

The **gram** is the basic metric unit of mass. Below are some examples of scales and balances:

**Scale Balance**


**Electronic Balance**


**Analytical Balance**

The biggest major difference is the precision of each to measure the mass of a substance/ object. A scale balance measure mass by comparing it to a known weight. The electronic balance is limited by its readability. It can measure the mass of an object up to two significant figures so if it measures an apple for instance it could weigh 172.33g, measuring the same apple on an analytical scale you will see it weighs 172.3341g. The precision is greater when using the analytical balance.

It is useful to know the weight of common items; you can use that knowledge to estimate the most practical unit to measure the mass of another item. For instance, a nickel weighs about 5 grams. Knowing that, what is the best likely unit to measure the mass of a carrot?

I believe grams is the best unit of measurement for a carrot.

## Part 5: Temperature

Scientists measure temperature in degrees Celsius (C), this is sometimes called centigrade. Celsius scale, or centigrade scale, is a temperature scale that is based on the freezing point of water at 0°C and the boiling point of water at 100°C. Fahrenheit scale is a temperature scale that is based on the freezing point of water at 32°F and the boiling point of water at 212°F.The formula for conversion is (32°F − 32) × 5/9 = 0°C. Here are some typical temperatures:

- 25ºC room temperature
- 37ºC human body temperature
- 75ºC hot coffee

Convert the following temperatures from Celsius to Fahrenheit, and from Fahrenheit to Celsius:

1. 25ºC 77 ºF
2. 38ºC 100 ºF 100.4F
3. 16º 60.8 ºF
4. 84ºF 28.9 ºC
5. 32ºF 0 ºC
6. 100ºF 37.8 ºC