

## APPENDIX C

# Metric System

The metric system is the most logical system of measurement yet developed. There is a standard unit for length called the meter, one for weight (mass) called the gram and one for volume called the liter. For each type of measurement, larger and smaller units are created using standard prefixes that are multiples of ten. Here is a list of the prefixes most often used in microbiology and their meanings.

PREFIX	MEANING
centi-	one Hundredth
milli-	one Thousandth
micro-	one Millionth
nano-	one Billionth

In order to get a better picture of what these prefixes mean, let's use the unit for length, the meter, as an example. There are one hundred centimeters (abbreviated cm) in a meter, there are one thousand millimeters (mm) in a meter, and so on. The following table summarizes all of these prefixes.

BASIC UNIT	ABBREV.	ONE METER WOULD EQUAL...	OR IN POWERS OF TEN...
Meter	m	1 m	
Centimeter	cm	1 m = 100 cm	= $10^2$ cm
Millimeter	mm	1 m = 1,000 mm	= $10^3$ mm
Micrometer	$\mu$ m	1 m = 1,000,000 $\mu$ m	= $10^6$ $\mu$ m
Nanometer	nm	1 m = 1,000,000,000 nm	= $10^9$ nm

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The same prefixes are used for all measurements. So there are not only 1000 millimeters in a meter, but also 1000 milligrams in a gram and 1000 milliliters in a liter. So how many micrograms are in a gram? If you said a million (or  $10^6$ ) give yourself a hug. If you weren't correct, give yourself a hug anyway.

To convert any measurement from one unit to another, you need to multiply it by a conversion factor. A conversion factor will always be equal to one. Whenever you multiply a measurement by one, the measurement will not change in value, and we don't want to change the value of our measurement, just the form it is in. Also the conversion factor will be a fraction. In order for a fraction to be equal to one, the numerator (top part) of the fraction should be equal to the denominator (bottom part) of the fraction. For example, one liter is equal to 1000 milliliters, so a fraction of one liter over 1000 milliliters would be equal to one. Look at the following example conversion factors. The numerator is always equal to the denominator, making the whole fraction equal to one.

$$\begin{array}{cccc} \frac{1 \text{ meter}}{100 \text{ cm}} & \frac{100 \text{ cm}}{1 \text{ meter}} & \frac{1000 \text{ mm}}{1 \text{ meter}} & \frac{1000 \text{ mm}}{100 \text{ cm}} \end{array}$$

Can you create a conversion factor with liters and microliters? Use the information above and remember that the numerator and denominator of your fraction should be equal to one another. One liter is equal to one million microliters, so if you answered with one liter over one million microliters or one million microliters over one liter, either answer would be a proper conversion factor.

Here is a basic, step-by-step method for making your own conversion factor. Of course, not just any conversion factor will do. We need one that will convert *from* the units we have, *to* the units we want. To make sure we don't make mistakes, we will do this one small step at a time.

1. Suppose we wanted to convert 3 meters into centimeters.

$$3 \text{ meters} = ? \text{ cm}$$

2. We would first write down 3 meters.

$$3 \text{ meters}$$

3. Then next to the original number, write a multiplication sign and a line for our future fraction.

$$3 \text{ meters } \times \underline{\hspace{2cm}}$$

4. Next we write the Unit we are converting *from* in the denominator.

$$3 \text{ meters } \times \frac{\underline{\hspace{2cm}}}{\text{meter}}$$

5. Then we write the Unit we are converting *to* in the numerator.

$$3 \text{ meters } \times \frac{\text{cm}}{\text{meter}}$$

6. Now, all we need to do to finish our conversion factor is to insert the proper numbers to keep the numerator equal to the denominator. Since 100 cm is equal to one meter, we would fill in the fraction as follows.

$$3 \text{ meters } \times \frac{100 \text{ cm}}{1 \text{ meter}}$$

7. Now meters cancels with meters, and the only units we are left with are centimeters (which is what we wanted).

$$3 \text{ meters } \times \frac{100 \text{ cm}}{1 \text{ meter}}$$

8. All that remains is the arithmetic of multiplying and dividing the numbers in our fractions. (This can be done long hand or with a calculator).

$$\frac{3 \times 100 \text{ cm}}{1}$$

9. In our example 3 times 100 equals 300 centimeters.

$$= 300 \text{ cm}$$

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Here is another example. See if you can follow along.

1. 2000 milligrams = ? grams Original problem
2. 2000 mg Write down what we have
3. 2000 mg x \_\_\_\_\_ Get ready for conversion
4. 2000 mg x  $\frac{\text{_____}}{\text{mg}}$  Copy unit coming *from*
5. 2000 mg x  $\frac{\text{gram}}{\text{mg}}$  Add unit we are going *to*
6. 2000 mg x  $\frac{1 \text{ gram}}{1000 \text{ mg}}$  One gram is equal to 1000 mg
7. 2000 ~~mg~~ x  $\frac{1 \text{ gram}}{1000 \text{ ~~mg~~}}$  Cancel like units (mg's)
8.  $\frac{2000 \times 1 \text{ gram}}{1000}$  Do arithmetic
9. = 2 grams Write (right) answer!

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This method of converting from one unit to another can be used for any measurement, including English/Metric conversions. In order to use the method, you just need to know how many of one unit is equal to how many of the other units so that you can create a conversion factor. Here are some equalities between English and metric systems.

	ENGLISH		METRIC
Mass (weight)	1 ounce	=	28 grams (gm)
Length	1 inch	=	2.5 centimeters (cm)
Volume	1.06 quarts	=	1 liter (l)

Let's try an example. Suppose you would like to convert 16 inches to centimeters.

1. 16 inches = ? cm
2. 16 inches
3. 16 inches x \_\_\_\_\_
4. 16 inches x  $\frac{\quad}{\text{inches}}$
5. 16 inches x  $\frac{\text{cm}}{\text{inches}}$
6. 16 inches x  $\frac{2.5 \text{ cm}}{1 \text{ inches}}$
7. 16 inches x  $\frac{2.5 \text{ cm}}{1 \text{ inches}}$
8.  $\frac{16 \times 2.5 \text{ cm}}{1}$
9. = 40 cm

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An advantage of using this method is that it requires a minimum of memorization. You will need to remember what the metric prefixes mean and you will need to remember the three English/Metric equalities listed above. With that information you can make any conversion. To make more complicated conversions like "2 feet equals how many meters", you simply string a series of conversions together. We may not know how many feet equal a meter, but we do know how many inches equal a foot, and we have memorized how many centimeters equal an inch and how many centimeters equal a meter. So we convert from one to the next as in the example below.

1.        2 feet = ? meters

2.        2 ft

3.        2 ft x \_\_\_\_\_

4.        2 ft x  $\frac{\text{_____}}{\text{ft}}$

5.        2 ft x  $\frac{\text{in}}{\text{ft}}$

6.        2 ft x  $\frac{12 \text{ in}}{1 \text{ ft}}$

B-3.     2 ft x  $\frac{12 \text{ in}}{1 \text{ ft}}$  x \_\_\_\_\_

B-4.     2 ft x  $\frac{12 \text{ in}}{1 \text{ ft}}$  x \_\_\_\_\_ in

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$$\text{B-5.} \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{\text{cm}}{\text{in}}$$

$$\text{B-6.} \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.5 \text{ cm}}{1 \text{ in}}$$

$$\text{C-3.} \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.5 \text{ cm}}{1 \text{ in}} \times \underline{\hspace{2cm}}$$

$$\text{C-4.} \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.5 \text{ cm}}{1 \text{ in}} \times \frac{\hspace{2cm}}{\text{cm}}$$

$$\text{C-5.} \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.5 \text{ cm}}{1 \text{ in}} \times \frac{\text{meter}}{\text{cm}}$$

$$\text{C-6.} \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.5 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ meter}}{100 \text{ cm}}$$

$$7. \quad 2 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.5 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ meter}}{100 \text{ cm}}$$

$$8. \quad \frac{2 \times 12 \times 2.5 \times 1 \text{ meters}}{1 \times 1 \times 100}$$

$$9. \quad = 0.6 \text{ meters}$$

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To really learn anything you need to do more than just read about it. You have to use it. On the following pages some sample problems have been provided for you to work with.

## Problems

a.  $10 \text{ grams} = ? \text{ milligrams}$

b.  $10 \text{ milligrams} = ? \text{ grams}$

c.  $13 \text{ mm} = ? \mu\text{m}$

d. 13 millimeters = ? inches

e. 6 feet = ? centimeters

f. 8,400 milligrams = ? ounces

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g. 1 cup = ? milliliters (Hint: 2 cups = pint; 2 pints = quart)

h. 3 pints = ? liters

i. 400 ml = ? pints

j. 4 fluid oz. = ? ml (Hint: 1 cup = 8 fluid oz.)