Appendix V
Scientific Notation and the Metric System

I. Scientific notation.

Recall that in the mathematical expression "2^3" the number 2 is called the **base** and the number 3 is called the **exponent**. This expression is read as "two to the third power." To determine the number indicated by this expression, simply multiply the base (2) by itself the exponent (3) number of times. Hence,

$$2^3 = 2 \times 2 \times 2 = 8$$

Scientific notation is a concise, convenient way to express very large or very small numbers. The number 10 is used as the base. For example. . .

10^6	=	$10 \times 10 \times 10 \times 10 \times 10 \times 10$
10^{-6}	=	$\frac{1}{10 \times 10 \times 10 \times 10 \times 10 \times 10}$
2×10^6 =		$2(10 \times 10 \times 10 \times 10 \times 10 \times 10)$
3.6×10^{-6} =		$3.6 \times \frac{1}{10 \times 10 \times 10 \times 10 \times 10 \times 10}$

Of course, there are easier ways to calculate the actual number written in scientific notation besides multiplying everything out. Simply remember that the exponent designates the number of places to the right or the left one must move the decimal point to achieve the actual number.

When the exponent is positive, the decimal point moves to the right
When the exponent is negative, the decimal point moves to the left.

$1 \times 10^2 = 100$
$4.85 \times 10^3 = 4850$
$2.9 \times 10^{-4} = 0.00029$
$4.1 \times 10^{-3} = 0.0041$

Practice converting the following to and from scientific notation:

250 =
2550 =
40264100 =
0.00054 =
0.0021 =

4.54×10^{-6} = _____
5.2×10^3 = _____
1.33×10^8 = _____
99.4×10^4 = _____
22.1×10^{-5} = _____

II. Metric units of measurement

In scientific writing, it is proper to use ***Systeme International*** **(SI)** units of measurement. These include such internationally accepted units as the meter and the gram. The SI is commonly known as the **metric system**.

Now that you are an expert at scientific notation, it should be easy for you to convert from one metric unit to another. Several fundamental metric units of measure are listed in Table A5-1. Study these before you continue reading.

Table A5-1. Above, some common units of measure from the *Systeme International.* Below, the proper prefixes for fractions and multiples of the international units. Because you will be using these units and prefixes for the rest of your scientific career, you should learn them now.

International units of measure		
physical quantity	**name of unit**	**symbol**
length	**meter**	**m**
mass	**gram**	**g**
time	**second**	**s**
temperature	**Kelvin**	**K**
amount of substance	**mole (6.02×10^{23})**	**mol**

Fractions of international units			Multiples of international units		
fraction	**prefix**	**symbol**	**multiple**	**prefix**	**symbol**
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	μ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T

Thus, according to Table A5-1:

1 meter =	10^{2} cm	conversely, 1 cm =	10^{-2} m
	10^{3} mm	1 mm =	10^{-3} m
	10^{6} μm	1μm =	10^{-6} m
	10^{9} nm	1 nm =	10^{-9} m
	10^{10} Angstroms (Å)*	1 Å =	10^{-10} m
	10^{12} pm	1 pm =	10^{-12} m
	10^{-2} hm**	1 hm =	10^{2} m
	10^{-3} km	1 km =	10^{3} m

*An Angstrom is one several SI units bearing a special name not based on the word "meter.".
**A hectare is 100 square meters, and serves as the metric analog for an acre.

Converting from one unit to another is not difficult! Just remember to write down all units and cancel as you calculate. For example:

1. To convert 56 nm to meters, multiply: $56\ \text{nm} \times \frac{1\text{m}}{10^{9}\ \text{nm}} = 5.6 \times 10\text{-}8\ \text{m}$

2. To convert 2.45 cm to μm, multiply: $2.45\ \text{cm} \times \frac{1\text{m}}{10^{2}\ \text{cm}} \times \frac{10^{6}\ \text{m}}{1\ \text{m}} = 2.45 \times 10^{4}\ \mu\text{m}$

Try some yourself. Convert

1. 3.5 cm to m:

2. 5.3 mm to nm:

3. 3.12 nm to Angstroms:

4. 434.3 nm to m:

5. 34 μm to mm:

If you were educated in the United States or Great Britain, you are probably more familiar with the British system of measurement than you are with SI units. To help you relate to metric units more easily, we provide table A5-2, which lists conversions for several physical quantities commonly used in the biological sciences. Whenever necessary, refer to this table to convert laboratory data to SI units. This is especially important if you are writing a scientific paper.

Table A5-2. Conversion factors for some commonly used units of measure. Read the table as a matrix. For example, if you wish to convert feet to meters, go to the row labeled "foot" and look across to the column labeled "meter." In this example, 1 foot is equal to 0.3048 meters.

Physical Quantity:

distance	foot (ft)	inch (in)	meter (m)	centimeter(cm)
1 foot =	1.0	12.0	0.3048	30.48
1 inch =	0.0833	1.0	2.54×10^{-2}	2.54
1 meter =	3.28	39.37	1.0	1000
1 centimeter =	3.28×10^{-2}	0.3937	10^{-2}	1.0

mass	pound (lb)	ounce (oz)	kilogram (kg)	gram (g)
1 pound =	1.0	32.0	0.4536	453.6
1 ounce =	0.0625	1.0	2.836×10^{-2}	28.36
1 kilogram =	2.204	35.3	1.0	1000
1 gram =	2.204×10^{-3}	0.0353	0.001	1.0

volume	quart (qt)	fluid ounce(oz)	milliliter (ml)	cubic cm (cc)
quart =	1.0	32	943	943
fluid ounce =	3.125×10^{-2}	1.0	29.5	29.5
milliliter =	1.06×10^{-3}	3.392×10^{-2}	1.0	1.0
cubic centimeter =	1.06×10^{-3}	3.392×10^{-2}	1.0	1.0

temperature	Kelvin (^{o}K)	Farenheit (^{o}F)	Celsius (^{o}C)
1 ^{o}K =	1.0	9/5(^{o}K) - 459.7	^{o}K + 273.16
1 ^{o}F =	5/9(^{o}F) + 255.4	1.0	5/9(^{o}F - 32)
1 ^{o}C =	^{o}C - 273.16	9/5(^{o}C) + 32	1.0
note: absolute zero (^{o}K) = -273.16 ^{o}C			