1A. Writing very large and very small numbers

Very large or small numbers can be written by using **powers**. For example 100 can be written as 10^2 where the "2" is the power. 10^2 is the same as writing 10 x 10. In biology it is most common to use 10 as the base. But it is also possible to use 2 or any other number. For example $2^2 = 4$; $2^3 = 8$ and so on.

10	= 10	= just one ten	= 10^1
100	= 10 x 10	= 2 tens multiplied together	= 10^2
1 000	= 10 x 10 x 10	= 3 tens multiplied together	= 10^3
10 000	= 10 x 10 x 10 x 10	= 4 tens multiplied together	= 10^4
100 000	= 10 x 10 x 10 x 10 x 10	= 5 tens multiplied together	= 10^5
1 000 000	= 10 x 10 x 10 x 10 x 10 x 10	= 6 tens multiplied together	= 10^6

The use of negative powers sometimes seems less intuitive. Here you need to remember that, for example,

0.01 is the same as $\frac{1}{100}$ which is the same as $\frac{1}{10^2}$ which is the same as 10^{-2}.

0.1	= $\frac{1}{10}$	= $\frac{1}{10^1}$	= 10^{-1}
0.01	= $\frac{1}{100}$	= $\frac{1}{10^2}$	= 10^{-2}
0.001	= $\frac{1}{1000}$	= $\frac{1}{10^3}$	= 10^{-3}
0.0001	= $\frac{1}{10000}$	= $\frac{1}{10^4}$	= 10^{-4}

Standard form, consists of an integer or decimal multiplied by a power of ten. So for example 2000 is the same as 2 x 1000 which is the same as 2 x 10^3.

Standard form isn't the only way of writing large or small numbers, sometimes it's useful to write in scientific notation (which is any number multiplied by a power of ten).

Every time you divide this by 10…

… you need to multiply this by a power of ten.

2000. = 200.0 x 10^1
= 20.00 x 10^2
= 2.000 x 10^3 This is "standard form" or standard scientific notation

In principle I could keep going if I wanted to:
= 0.2 x 10^4
= 0.02 x 10^5

For small numbers, take for example
0.0066
= 0.066 x 10^{-1}
= 0.66 x 10^{-2}
= 6.6 x 10^{-3} This is the "standard form" but I could keep going if I wished…
= 66 x 10^{-4}
= 660 x 10^{-5} and so on.

Every time you multiply this by 10…

… you need to divide this by a power of ten.

1B. Using Prefixes

Prefixes are even more of a shorthand than standard form. The prefixes in bold in the table are the ones that are most relevant for biology.

Factor	Prefix	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	**giga**	**G**
10^{6}	**mega**	**M**
10^{3}	**kilo**	**k**
10^{2}	hecto	h
10^{1}	deca	da

Factor	Prefix	Symbol
10^{-1}	**deci**	**d**
10^{-2}	**centi**	**c**
10^{-3}	**milli**	**m**
10^{-6}	**micro**	**μ**
10^{-9}	**nano**	**n**
10^{-12}	**pico**	**p**
10^{-15}	**femto**	**f**
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

To convert standard form to to a number with the symbol for a prefix means that you need to change the power so that it is a multiple of three. Then you can just substitute the appropriate prefix.

Example 1.1 Use a prefix to write a large or small number

	689 000 g		689 000 g
	= 689 x 1000 g	OR	= 0.689 x 1 000 000 g
rewrite in scientific notation	= 689 x 10^3 g	OR	= 0.689 x 10^6 g
substitute "k" for "10^3" or "M" for "10^6")	= 689 kg (kilograms)		= 0.689 Mg (megagrams)

Generally speaking, it is up to you to decide which prefix is most appropriate.

Example 1.2

	0.00098 m		0.00098 m
rewrite in scientific notation	= 0.98 x 10^{-3} m	OR	= 980 x 10^{-6} m
substitute "m" for "10^{-3}" or "μ" for "10^{-6}"	= 0.98 mm (millimetres)		= 980 μm (micrometres)

Exercises

(1) Convert the following to standard form.

784 000 000 g	
867 000 m	
9 600 s	
0.0044 g	
0.000 078 m	
0.000 00086 s	

(2) Write the following in standard form and then with an appropriate prefix.

	in standard form	with prefix
10 140 000 s		
8 500 m		
9 750 000 g		
0.005 92 m		
0.000 003 g		
0.000 000 21 s		

(3) Put the following numbers in order from smallest to largest.

A 88.2×10^{-4}
B 2.8×10^{-3}
C 3.4×10^{-4}

(4) Which of these are equivalent?
A: 92×10^{4} B: 92×10^{-4} C: 9.2×10^{-3} D: 9.2×10^{-4} E: 9.2×10^{3}

(5) The organism with the largest known genome size is Polychaos dubium (an amoeba) with 670 000 000 000 base pairs. Write this in standard form.

(6) Fill in the blanks: 0.00089 = _____ $\times 10^{-1}$

= _____ $\times 10^{-2}$

= _____ $\times 10^{-3}$

= _____ $\times 10^{-4}$

= _____ $\times 10^{-5}$

= _____ $\times 10^{-6}$

0.00089 g = _____ mg = _____ µg

(7) Syringe filters are used to sterilise small volumes of drug solution. A filter with pore diameter 0.45 µm is attached to the end of a syringe and the solution passed through. Which of the following would pass through the filter?
(a) E.coli: diameter 1.3×10^{-6} m
(b) Influenza virus: diameter 1×10^{-7} m
(c) Human blood cell: diameter 9×10^{-6} m
(d) Ribosome: diameter 2×10^{-8} m

(8) Rewrite the following measurements with the prefix shown.

(a) 9×10^{-6} m = ____ mm (b) 8.6×10^{-1} m = ____ mm (c) 3.08×10^{-8} m = ____ µm

(9) Rewrite the following measurements with the prefix shown.

(a) 204 nL = ____ µL (b) 84.5 nL = ____ µL (c) 908 mL = ____ µL

Answers

(1)

784 000 000 g	7.84×10^{8} g
867 000 m	8.67×10^{5} m
9 600 s	9.6×10^{3} s
0.0044 g	4.4×10^{-3} g
0.000 078 m	7.8×10^{-5} m
0.000 00086 s	8.6×10^{-7} s

(2)

	in scientific notation	with prefix
10 140 000 s	10.14×10^{6} s	10.14 Ms
8 500 m	8.5×10^{3} m	8.5 ks
9 750 000 g	9.75×10^{6} g	9.75 Mg
0.005 92 m	5.92×10^{-3} m	5.92 mm
0.000 003 g	3×10^{-6} g	3 µg
0.000 000 21 s	0.21×10^{-6} s	0.21 µs

(3) C < B < A

A $88.2 \times 10^{-4} = 8.82 \times 10^{-3}$

B 2.8×10^{-3}

C $3.4 \times 10^{-4} = 0.34 \times 10^{-3}$

(4) Correct answers were B and C

(5) 6.7×10^{11}

(6) $0.00089 = 0.0089 \times 10^{-1}$ (move the decimal place by one position)

$= 0.089 \times 10^{-2}$ (and again….)

$= 0.89 \times 10^{-3}$

$= 8.9 \times 10^{-4}$

$= 89 \times 10^{-5}$

$= 890 \times 10^{-6}$

0.00089 g =0.89 mg =890 µg

(7) (b) and (d)

(8) (a) 9×10^{-6} m = 0.009 mm (b) 8.6×10^{-1} m = 860 mm (c) 3.08×10^{-8} m =308 µm

(9) (a) 204 nL = 0.204 µL (b) 84.5 nL = 0.0845µL (c) 908 mL =908 000 µL