Numbers and units

Working with numbers and units

Table 1 Divisions of some units of measurement

Division	Prefix	Length		Mass		Volume		Time	
one thousand millionth	nano	nanometre	nm	nanogram	ng	nanolitre	nl	nanosecond	ns
one millionth	micro	micrometre	μm	microgram	μg	microlitre	μl	microsecond	μs
one thousandth	milli	millimetre	mm	milligram	mg	millilitre	ml	millisecond	ms
one hundredth	centi	centimetre	cm						
whole unit		metre	m	gram	g	litre	dm^3	second	s
one thousand times	kilo	kilometre	km	kilogram	kg				

A key criterion for success in biological maths lies in the use of correct units and the management of numbers. The units we use are from the Système Internationale – the SI units. In biology, we most commonly use the SI base units metre (m), kilogram (kg), second (s) and mole (mol). Biologists also use SI derived units, such as square metre (m^2), cubic metre (m^3), degree Celsius (°C) and litre (dm^3). To accommodate the huge range of dimensions in our measurements they may be further modified using appropriate prefixes. For example, one thousandth of a second is a millisecond (ms). Some of these prefixes are illustrated in Table 1.

When doing calculations, it's also important to express your answer using sensible numbers. For example, Mike worked out an answer of 6230 μm. It would have been more meaningful for Mike to express that answer as 6.2 mm. If you convert between units and round numbers properly it allows quoted measurements to be understood within the relevant scale of the observations.

WORKED EXAMPLE

To convert between units on the nano-, micro-, milli- and kilo- scale divide or multiply by 1000.

If you divide (to make the number more sensible by making it smaller), then you look **down** Table 1 for the next unit (e.g. going from μm to mm).

If you multiply (making a number bigger to make it more sensible) then look **up** Table 1 to the next unit (e.g. going from m to mm).

An exception is converting to centimetres. A centimetre is one hundredth rather than one thousandth of a metre.

For example:

a) to convert 0.006 dm^3 into millilitres, you multiply by 1000 to give 6 ml

b) to convert 6000 μg into milligrams, you divide by 1000 to give 6 mg

c) to convert 6000 m into km, you divide by 1000 to give 6 km.

Take care when using cubed units. A metre cubed means a cube with each side length 1 m or 1000 mm. The cube of 1000 is $1000 \times 1000 \times 1000 = 1\,000\,000\,000$. So $1\ m^3 = 1\,000\,000\,000\ mm^3$. Therefore, to convert between volumes expressed as cubed distances, your conversion factor is 1 000 000 000, rather than just 1000.

This means that:

a) 5 000 000 mm^3 is equivalent to 0.005 m^3

b) 6 420 000 mm^3 is equivalent to 0.00642 m^3

c) 0.000 056 m^3 is equivalent to 56 000 mm^3

Similarly, when converting between squared units, we need to do the same thing. For example, imagine converting from m^2 to mm^2. One square metre is 1000 × 1000 = 1 000 000 mm^2. Therefore, to convert between areas, your conversion factor is 1 000 000, rather than just 1000.

WORKED EXAMPLE

Rounding

The rules for rounding are simple. Look at the figure to the right of the least significant figure you want to round to. If this figure is 5 or greater, round up. If this figure is less than 5, round down. For example:

a) 3.142 rounds to 3.14 (3 s.f.), rounds to 3.1 (2 s.f.) and rounds to 3 (1 s.f.).

b) 5.448 rounds to 5.45 (3 s.f.), rounds to 5.4 (2 s.f.) and rounds to 5 (1 s.f.).

REMEMBER:

Significant figures

The first significant figure in a number is the first digit that is not zero. In 2.34 it is 2 and there are three significant figures; in 0.0056 it is 5 and there are two significant figures.

SUMMARY QUESTIONS

1 Undertake the following conversions:

- **a** 0.0062 mm into μm
- **b** 7928 ml into dm^3
- **c** 213 ml into dm^3
- **d** 4 000 000 ns into s
- **e** 727 m into km
- **f** 0.002 km into mm.

REMEMBER:

Write down the units!

When you do a calculation, it is very easy to forget to give the units. A number on its own makes no sense, unless the reader knows what the units are!

Also, remember to put units only in headings in tables, **not** next to every figure entered.

2 Undertake the following conversions:

- **a** 1 000 000 000 mm^3 into m^3
- **b** 0.000 001 km^3 into m^3
- **c** 0.000 001 m^3 into mm^3.

3 Convert the following values so they make more sense to the reader. Choose the final units yourself. (Hint: make the final number as close in magnitude to zero as you can. For example, you would convert 1000 m into 1 km.)

- **a** 0.000 000 000 1 kg
- **b** 1 000 000 000 mg
- **c** 0.000 000 3 dm^3
- **d** 77 890 122 nm

4 Convert the following:

- **a** 1000 mm^2 into m^2
- **b** 0.6 m^2 into mm^2.

5 Round the following numbers:

- **a** 98.4478 to three significant figures
- **b** 1 298.444 444 4 to four significant figures
- **c** 5.555 55 to four significant figures
- **d** 0.358 to one significant figure
- **e** 0.000 464 8 to two significant figures.

REMEMBER:

Units

It is common to use cm^3 in place of ml in biology. These units are in fact the same measurement. Occasionally cc is used to mean ml or cm^3.

Percentages

Calculating percentages

A percentage is simply a fraction expressed as a decimal. It is an important thing to be able to calculate routinely, but is often incorrectly calculated in exams. These pages should allow you to practise!

WORKED EXAMPLE

Percentages as proportions

In a population the number of people who have brown hair was counted. The results showed that in the total population of 4600 people, 1800 people had brown hair.

The percentage of people with brown hair is found by calculating:

$$\frac{\text{number of people with brown hair}}{\text{total population}} \times 100$$

$$= \frac{1800}{4600} \times 100 = 39.1\%$$

Percentages as chance

In genetics predictions need to be expressed as a chance, which should always be a percentage.

Consider the monohybrid cross between two carriers of cystic fibrosis.

Parent	Male carrier		Female carrier	
Parent genotypes	Cc		Cc	
Possible gametes	C	c	C	c
F1 genotypes	CC	Cc	Cc	cc
F1 phenotypes	normal	normal (carrier)	normal (carrier)	sufferer

What is the chance of any baby born being a sufferer of cystic fibrosis?

Every birth carries a 1 in 4 chance so expressing this as a percentage:

$$\frac{\text{baby with cystic fibrosis}}{\text{all babies}} \times 100 = \frac{1}{4} \times 100 = 25\%$$

Percentage change

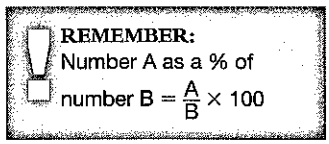
Percentage change is often used to describe osmosis experiments where samples (usually of potato tissue) gain and lose mass in different bathing solutions.

For example, a sample weighed 14.50 g at the start of the osmosis experiment and at the end it weighed 10.73 g.

The actual loss in mass = 14.50 g – 10.73 g = 3.77 g

$$\text{The percentage change} = \frac{\text{mass change}}{\text{starting mass}} \times 100 = -\frac{3.77}{14.50} \times 100 = -26\%$$

Note the use of the minus sign to indicate that this is a loss.



SUMMARY QUESTIONS

1 Calculate the values for the following situations.

a The chance of an albino child being born to two heterozygous people (albinism is recessive).

b The size of a population in which 67 of the people are left handed and with these people being 27% of the total.

c The percentage of plantains in a sample of 670 plants of which 34 are plantains.

2 Convert the following fractions to percentages.

a $\frac{1987}{10\,000}$

b $\frac{45}{71}$

c $\frac{3}{5}$

d $\frac{4500}{10^6}$

3 Convert the following decimals to percentages (you should do this without a calculator).

a 0.71

b 0.34

c 1.76

4 Convert the following common fraction ratios to percentages (you should do this without a calculator).

a $\frac{1}{2}$

b $\frac{1}{4}$

c $\frac{2}{3}$

5 Convert the following percentages to fractions (you should do this without a calculator).

a 75%

b 33.3%

c 25%

6 Convert the following mass changes to percentage changes and then plot a graph of % mass change against sucrose concentration.

Sucrose concentration/mol dm^{-3}	Initial mass/g	Final mass/g	Mass change/g	Percentage change in mass
0.1	1.82	2.55		
0.3	1.63	1.76		
0.5	1.95	1.70		
0.7	1.86	1.30		
0.9	1.79	1.06		