

Preparation for studying A level and IB Biology



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Transition from GCSE to A level / IB Biology

Introduction

Moving from GCSE Science to A Level / IB can be a daunting leap. You'll be expected to remember a lot more facts, equations, and definitions, and you will need to learn new maths skills and develop confidence in applying what you already know to unfamiliar situations.

This booklet aims to give you a head start by helping you:

- to ensure you have a good knowledge of GCSE material
- to pre-learn some useful knowledge from the first topics of your A Level / IB course
- understand and practice some of the maths skills you'll need.

This booklet is divided into 3 sections

- Section 1 – ensuring a good knowledge and understanding of GCSE material
- Section 2 – maths skills required for A level / IB Biology
- Section 3 – preparing for the first A level / IB Biology topics

Complete section 1 first, sections 2 and 3 can be done in either order.

Learning objectives

After completing the booklet you should:

- have a good knowledge of GCSE Biology
- have knowledge of some of the material from the start of the A level / IB course
- be able to define practical science key terms
- be able to perform maths skills including:
 - converting between units, standard form, and prefixes
 - using significant figures
 - rearranging formulae
 - magnification calculations
 - calculating percentages, errors, and uncertainties
 - drawing and interpreting line graphs.

Section 1 – Ensuring good GCSE knowledge

WHAT TO DO

1. Use the following to ensure you have a good knowledge of the GCSE topics. A level Biology builds on knowledge from GCSE so it is important that you have a good knowledge and understanding of GCSE material before you start your A level / IB Biology course.

<https://www.senecalearning.com/en-GB/>

<https://www.bbc.co.uk/bitesize/examspecs/zpgcbk7>

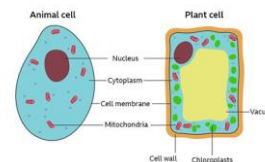
<https://www.freesciencelessons.co.uk/gcse-biology-paper-1/>

<https://www.physicsandmathstutor.com/biology-revision/>

2. Go over one topic at a time and then work through the tasks which follow.
3. Once you think you have a good knowledge of the GCSE materials work through some past papers to check you knowledge and understanding. These can be found on physicsandmaths tutor

<https://www.physicsandmathstutor.com/past-papers/gcse-biology/>

Activities to help consolidate GCSE knowledge



Activity 1 - Cells

1. Complete the table – you do not need to print the table you could draw a table

<u>Structure</u>	<u>Function</u>
Cell-surface membrane	
Chloroplast	
Cell vacuole	
Mitochondria	
Nucleus	
Cell wall	
Chromosome	
Ribosomes	

2. Draw the structure of a plant cell and an animal cell.

On each cell, add labels showing each of the structures in the table, if they exist.

Activity 2 – Photosynthesis and Respiration

Two of the most important reactions that take place in living things are photosynthesis and respiration. They both involve transfer of energy.

Copy and complete the table



	Photosynthesis	Aerobic Respiration
Which organisms carry out this process?		
Where in the organism does this process take place?		
Energy store at the beginning of the process	Sun	
Energy store at the end of the process		In cells
Reactants needed for the process		
Products of the process		
Overall word equation		
Balanced symbol equation for the overall process		

Which of the answers for aerobic respiration would be different for anaerobic respiration? Add these answers to the table in a different colour.

Activity 3 Principles of moving across boundaries

In biology, many processes involve moving substances across boundaries.

For the first 3 large boxes write a definition for the word in the box and then match the examples to the principle(s) involved. For each, give a brief description of why it is relevant.

Osmosis

Examples

Drinking a sports drink

Gas exchange in the lungs

Absorbing nutrients from the food in the body

Moving ions into a cell

The effect of salt on slugs

Penguins huddling together to keep warm

Diffusion

Potato pieces increase in mass when placed in water

Potato pieces decrease in mass when placed in very salty water

Active Transport

Cacti do not have large leaves.

Changing surface area or length

Activity 4 – Genetic Inheritance

Huntington's disease is an example of a disease where the mutation causing the disease is dominant.

h: normal (recessive)

H: mutation (dominant)

		Paternal alleles	
		H	h
Maternal alleles	h		
	h		

Cystic fibrosis is an example of a disease where the mutation causing the disease is recessive.

F: normal (recessive)

f: mutation (dominant)

		Paternal alleles	
		F	f
Maternal alleles	F		
	f		

For each of the Punnett squares:

1. Complete the diagrams to show the alleles for each child.
2. State which parent and child is:
 - healthy
 - has the disease
 - a carrier.

Activity 4 - continued

Each of the following statements is false. Re-write each one so that it becomes true.

1. The first Punnett square shows that one in every four children from this couple will have Huntington's disease.
2. The second Punnett square shows that there is a one in three chance that a child born to this couple will have cystic fibrosis.
3. All children of the second couple will either be carriers or suffer from cystic fibrosis.
4. The percentage of children who are sufferers on the diagram is the same as the percentage of children each couple will have who are sufferers.
5. Having one child who is born with cystic fibrosis means that the next three children will not have the disease.
6. A 50:50 chance is the same as a 0.25 probability.

Activity 5 - Analysing data

Biological investigations often result in large amounts of data being collected.

It is important to be able to analyse this data carefully in order to pick out trends.

A student investigated an area of moorland where succession was occurring. She used quadrats to measure the area covered by different plant species, bare ground and surface water every 10 metres along a transect. She also recorded the depth of soil at each quadrat. Her results are shown in the table.

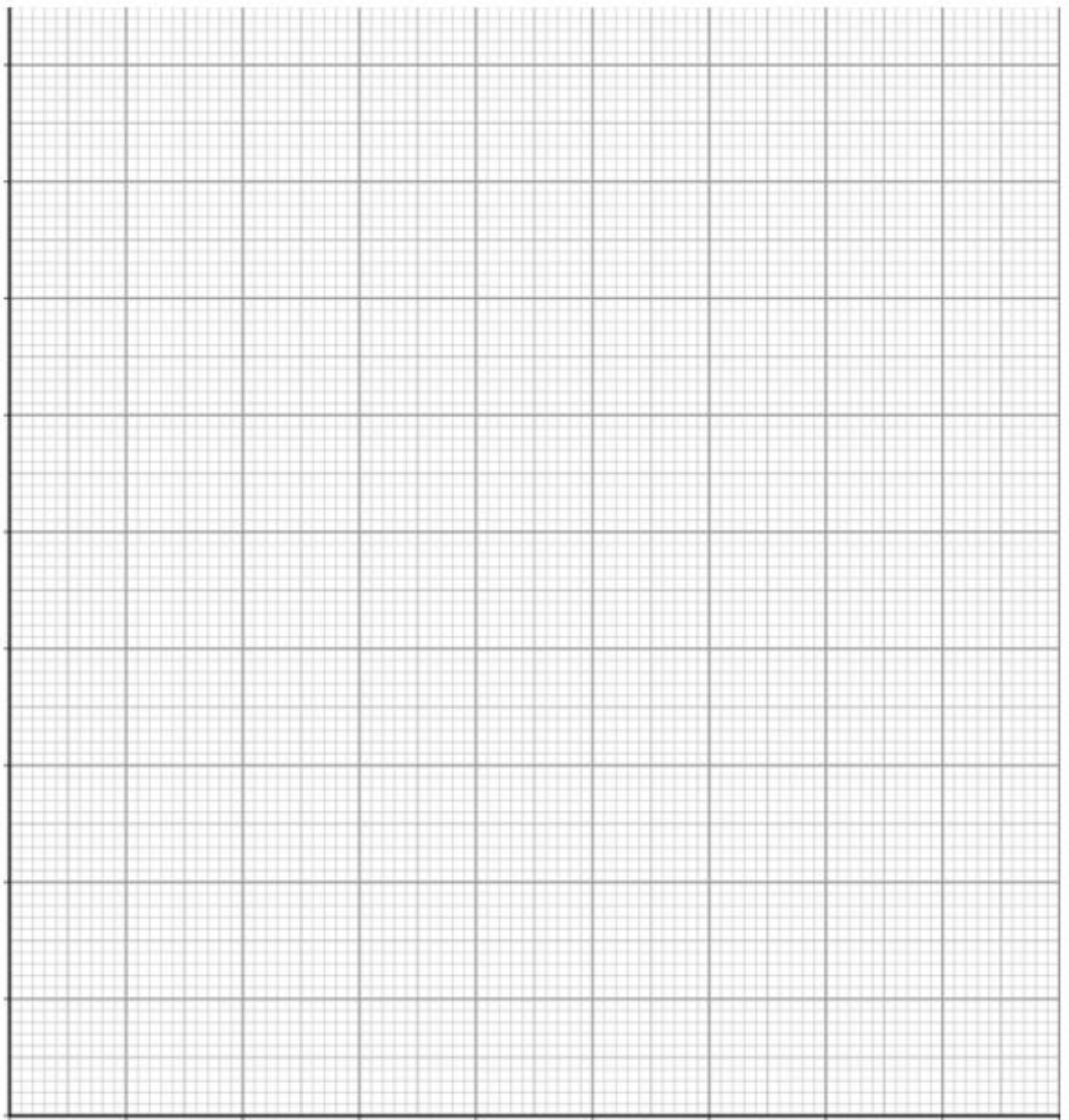
	Area covered in each quadrat A to E in cm ²				
	A	B	C	D	E
Bog moss	55	40	10	–	–
Bell heather	–	–	–	15	10
Sundew	10	5	–	–	–
Ling	–	–	–	15	20
Bilberry	–	–	–	15	25
Heath grass	–	–	30	10	5
Soft rush	–	30	20	5	5
Sheep's fescue	–	–	25	35	30
Bare ground	20	15	10	5	5
Surface water	15	10	5	–	–
Soil depth / cm	3.2	4.7	8.2	11.5	14.8

– indicates zero cover.

Calculate:

1. the mode area of soft rush in the sample
2. the mean soil depth
3. the median amount of bare ground in the sample.

Use the data from the table to plot a scatter graph of soil depth against the area covered by bare ground, soft rush and bog moss (use different colours or markers for each).



1. What conclusions does your graph suggest?
2. How confident are you in these conclusions?

Activity 6 – Analysing tables

Lung cancer, chronic bronchitis and coronary heart disease (CHD) are associated with smoking. Tables 1 and 2 give the total numbers of deaths from these diseases in the UK in 1974.

Table 1 Men

Age/years	Number of deaths (in thousands)		
	lung cancer	chronic bronchitis	coronary heart disease
35-64	11.5	4.2	31.7
65-74	12.6	8.5	33.3
75+	5.8	8.1	29.1
Total (35-75+)	29.9	20.8	94.1

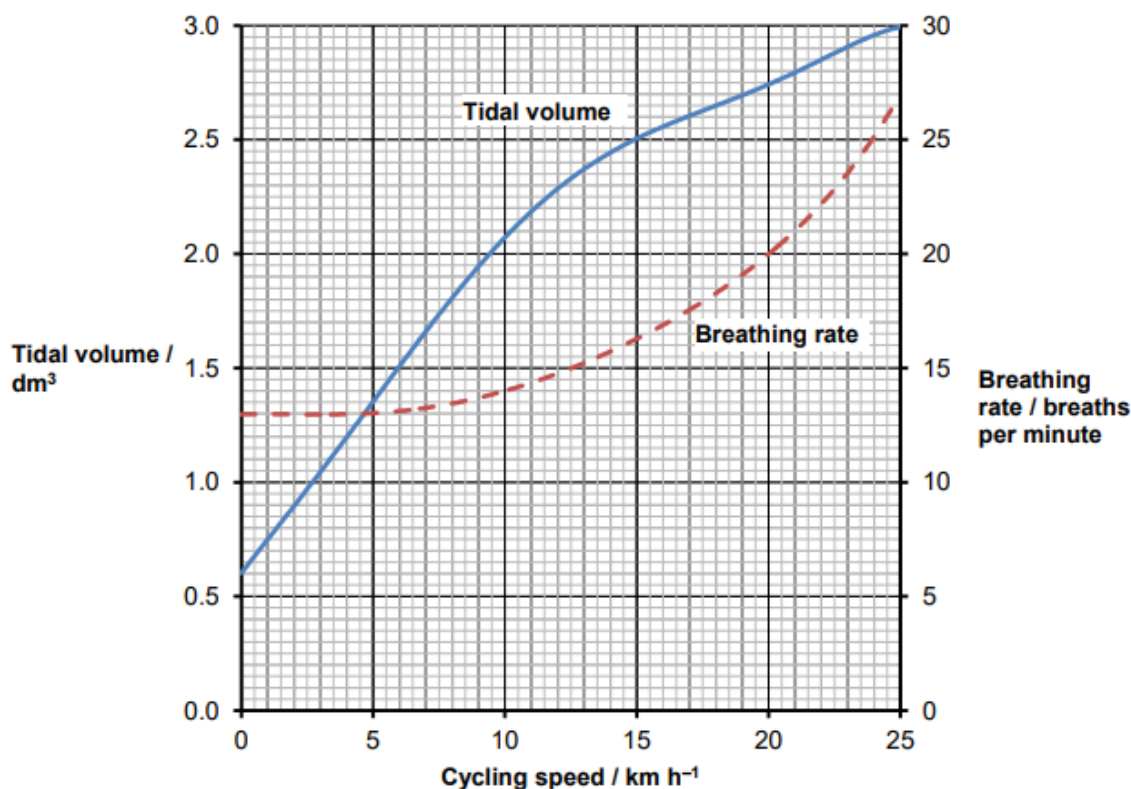
Table 2 Women

Age/years	Number of deaths (in thousands)		
	lung cancer	chronic bronchitis	coronary heart disease
35-64	3.2	1.3	8.4
65-74	2.6	1.9	18.2
75+	1.8	3.5	42.3
Total (35-75+)	7.6	6.7	68.9

1. Of the men who died aged 35-64 from one of these three causes, what percentage of them died of lung cancer?
2. What percentage of deaths from chronic bronchitis in women happened to women aged 65-74?
3. Deaths from lung cancer drop as people get older. Is there a bigger percentage difference for men or women from 35-64 to 75+?
4. What fraction of coronary heart disease deaths of men over 34 are in the 75+ bracket? What about for women?

Activity 7 – Analysing complex graphs

The volume of air breathed in and out of the lungs during each breath is called the tidal volume. The breathing rate and tidal volume were measured for a cyclist pedalling at different speeds. The graph shows the results.



1. What was the tidal volume when the cycling speed was 17 km h⁻¹ ?
2. What was the breathing rate when the cycling speed was 8 km h⁻¹ ?
3. What was the change in breathing rate when the cyclist changed from 10 to 20 km h⁻¹ ? Express this as a percentage.
4. At what speed did the breathing rate start to increase?
5. The tidal volume increased linearly with cycling speed up to about 10 km h⁻¹ . Calculate the increase in volume for each increase in speed of 1 km h⁻¹ .
6. For this initial linear section, what is the equation of the tidal volume Hint: use $y=mx + c$

Section 2 - Maths skills for A level / IB Biology

Maths skills are vitally important for A level and IB Biology. For A level students maths skills will make up 10% of the marks available in written exams. For extra help with maths skills for both A level and IB Biology visit the following website. You will find tutorials and quizzes.

<https://ocr.org.uk/subjects/science/maths-for-biology/>

What to do

Work through the tasks set out below. Once you have completed the practice questions check your answers.



1 Numbers and units

1.1 Units and prefixes

A key criterion for success in biological maths lies in the use of correct units and the management of numbers. The units scientists use are from the *Système Internationale* – the SI units. In biology, the most commonly used SI base units are metre (m), kilogram (kg), second (s), and mole (mol). Biologists also use SI derived units, such as square metre (m²), cubic metre (m³), degree Celsius (°C), and litre (l).

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 the table below.

Multiplication factor	Prefix	Symbol
10 ⁹	giga	G
10 ⁶	mega	M
10 ³	kilo	k
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n

Practice questions

- 1 A burger contains 4 500 000 J of energy. Write this in:
a kilojoules b megajoules.
- 2 HIV is a virus with a diameter of between 9.0×10^{-8} m and 1.20×10^{-7} m.
Write this range in nanometres.

1.2 Powers and indices

Ten squared = $10 \times 10 = 100$ and can be written as 10^2 . This is also called 'ten to the power of 2'.

Ten cubed is 'ten to the power of three' and can be written as $10^3 = 1000$.

The power is also called the index.

Fractions have negative indices:

one tenth = $10^{-1} = 1/10 = 0.1$

one hundredth = $10^{-2} = 1/100 = 0.01$

Any number to the power of 0 is equal to 1, for example, $29^0 = 1$.

If the index is 1, the value is unchanged, for example, $17^1 = 17$.

When multiplying powers of ten, you must *add* the indices.

So $100 \times 1000 = 100\,000$ is the same as $10^2 \times 10^3 = 10^{2+3} = 10^5$

When dividing powers of ten, you must *subtract* the indices.

So $100/1000 = 1/10 = 10^{-1}$ is the same as $10^2/10^3 = 10^{2-3} = 10^{-1}$

But you can only do this when the numbers with the indices are the same.

So $10^2 \times 2^3 = 100 \times 8 = 800$

And you can't do this when adding or subtracting.

$10^2 + 10^3 = 100 + 1000 = 1100$

$10^2 - 10^3 = 100 - 1000 = -900$

Remember: You can only add and subtract the indices when you are multiplying or dividing the numbers, not adding or subtracting them.

Practice questions

3 Calculate the following values. Give your answers using indices.

a $10^8 \times 10^3$

b $10^7 \times 10^2 \times 10^3$

c $10^3 + 10^3$

d $10^2 - 10^{-2}$

4 Calculate the following values. Give your answers with and without using indices.

a $10^5 \div 10^4$

b $10^3 \div 10^6$

c $10^2 \div 10^{-4}$

d $100^2 \div 10^2$

1.3 Converting units

When doing calculations, it is important to express your answer using sensible numbers. For example, an answer of 6230 μm would have been more meaningful expressed as 6.2 mm.

If you convert between units and round numbers properly, it allows quoted measurements to be understood within the scale of the observations.

To convert 488 889 m into km:

A kilo is 10^3 so you need to divide by this number, or move the decimal point three places to the left.

$$488\,889 \div 10^3 = 488.889 \text{ km}$$

However, suppose you are converting from mm to km: you need to go from 10^3 to 10^{-3} , or move the decimal point six places to the left.

333 mm is 0.000 333 km

Alternatively, if you want to convert from 333 mm to nm, you would have to go from 10^{-9} to 10^{-3} , or move the decimal point six places to the right.

333 mm is 333 000 000 nm

Practice question

5 Calculate the following conversions:

- | | |
|-------------------------------------|----------------------------|
| a 0.004 m into mm | b 130 000 ms into s |
| c 31.3 ml into μl | d 104 ng into mg |

6 Give the following values in a different unit 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 0.000 057 m | b 8 600 000 μl | c 68 000 ms | d 0.009 cm |
|----------------------|----------------------------------|--------------------|-------------------|

2 Decimals, standard form, and significant figures

2.1 Decimal numbers

A decimal number has a decimal point. Each figure *before* the point is a whole number, and the figures *after* the point represent fractions.

The number of decimal places is the number of figures *after* the decimal point. For example, the number 47.38 has 2 decimal places, and 47.380 is the same number to 3 decimal places.

In science, you must write your answer to a sensible number of decimal places.

Practice questions

- 1 New antibiotics are being tested. A student calculates the area of clear zones in Petri dishes in which the antibiotics have been used. List these in order from smallest to largest.
0.0214 cm² 0.03 cm² 0.0218 cm² 0.034 cm²
- 2 A student measures the heights of a number of different plants. List these in order from smallest to largest.
22.003 cm 22.25 cm 12.901 cm 12.03 cm 22 cm

2.2 Standard form

Sometimes biologists need to work with numbers that are very small, such as dimensions of organelles, or very large, such as populations of bacteria. In such cases, the use of scientific notation or standard form is very useful, because it allows the numbers to be written easily.

Standard form is expressing numbers in powers of ten, for example, 1.5×10^7 microorganisms.

Look at this worked example. The number of cells in the human body is approximately 37 200 000 000 000. To write this in standard form, follow these steps:

Step 1: Write down the smallest number between 1 and 10 that can be derived from the number to be converted. In this case it would be 3.72

Step 2: Write the number of times the decimal place will have to shift to expand this to the original number as powers of ten. On paper this can be done by hopping the decimal over each number like this:

6.3900000000

until the end of the number is reached.

In this example that requires 13 shifts, so the standard form should be written as 3.72×10^{13} .

For very small numbers the same rules apply, except that the decimal point has to hop backwards. For example, 0.000 000 45 would be written as 4.5×10^{-7} .

Practice questions

3 Change the following values to standard form.

a 3060 kJ

b 140 000 kg

c 0.000 18 m

d 0.000 004 m

4 Give the following numbers in standard form.

a 100

b 10 000

c 0.01

d 21 000 000

5 Give the following as decimals.

a 10^6

b 4.7×10^9

c 1.2×10^{12}

d 7.96×10^{-4}

2.3 Significant figures

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

7.88 25.4 741

Bigger and smaller numbers with 3 significant figures:

0.000 147 0.0147 0.245 39 400 96 200 000 (notice that the zeros before the figures and after the figures are *not* significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207 4050 1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^8

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:

590 (to 3.s.f.) or 5.90×10^2

Remember: For calculations, use the same number of figures as the data in the question with the lowest number of significant figures. It is not possible for the answer to be more accurate than the data in the question.

Practice question

6 Write the following numbers to i 2 s.f. and ii 3 s.f.

a 7644 g

b 27.54 m

c 4.3333 g

d $5.995 \times 10^2 \text{ cm}^3$

7 The average mass of oxygen produced by an oak tree is 11800 g per year.

Give this mass in standard form and quote your answer to 2 significant figures.

3 Working with formulae

It is often necessary to use a mathematical formula to calculate quantities. You may be tested on your ability to substitute numbers into formulae or to rearrange formulae to find specific values.

3.1 Substituting into formulae

Think about the data you are given in the question. Write down the equation and then think about how to get the data to substitute into the equation. Look at this worked example.

A cheek cell has a 0.06 mm diameter. Under a microscope it has a diameter 12 mm. What is the magnification?

$$\text{magnification} = \text{image size (mm)} \div \text{object size (mm)} \quad \text{or} \quad M = \frac{I}{O}$$

Substitute the values and calculate the answer:

$$M = 12 \text{ mm} / 0.06 \text{ mm} = 12 / 0.06 = 200$$

Answer: magnification = $\times 200$ (magnification has no units)

Sometimes an equation is more complicated and the steps need to be carried out in a certain order to succeed. A general principle applies here, usually known by the mnemonic BIDMAS. This stands for **B**rackets, **I**ndices (functions such as squaring or powers), **D**ivision, **M**ultiplication, **A**ddition, **S**ubtraction.

Practice questions

- 1 Calculate the magnification of a hair that has a width of 6.6 mm on a photograph. The hair is 165 μm wide.
- 2 Estimate the area of a leaf by treating it as a triangle with base 2 cm and height 9 cm.
- 3 Estimate the area of a cell by treating it as a circle with a diameter of 0.7 μm . Give your answer in μm^2 .
- 4 An *Amoeba* population starts with 24 cells. Calculate how many *Amoeba* cells would be present in the culture after 7 days if each cell divides once every 20 hours. Use the equation $N_t = N_0 \times 2^n$ where N_t = number after time t , N_0 = initial population, n = number of divisions in the given time t .
- 5 In a quadrat sample, an area was found to contain 96 aphids, 4 ladybirds, 22 grasshoppers, and 3 ground beetles. Calculate the diversity of the site using the equation $D = 1 - \sum \left(\frac{n}{N} \right)^2$ where n = number of each species, N = grand total of all species, and D = diversity.

Remember: In this equation there is a part that needs to be done several times then summed, shown by the symbol Σ .

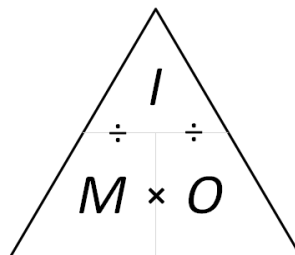
3.2 Rearranging formulae

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, the relationship between magnification, image size, and actual size of

specimens in micrographs usually uses the equation $M = \frac{I}{O}$,

where M is magnification, I is size of the image, and O = actual size of the object.

You can use the algebra you have learnt in Maths to rearrange equations, or you can use a triangle like the one shown.



Cover the quantity you want to find. This leaves you with either a fraction or a multiplication:

$$M = I \div O \qquad O = I \div M \qquad I = M \times O$$

Practice questions

- 6 A fat cell is 0.1 mm in diameter. Calculate the size of the diameter seen through a microscope with a magnification of $\times 50$.
- 7 A Petri dish shows a circular colony of bacteria with a cross-sectional area of 5.3 cm². Calculate the radius of this area.
- 8 In a photograph, a red blood cell is 14.5 mm in diameter. The magnification stated on the image is $\times 2000$. Calculate the real diameter of the red blood cell.
- 9 Rearrange the equation $34 = 2a/135 \times 100$ and find the value of a .
- 10 The cardiac output of a patient was found to be 2.5 dm³ min⁻¹ and their heart rate was 77 bpm. Calculate the stroke volume of the patient.

Use the equation: cardiac output = stroke volume $\times$ heart rate.

- 11 In a food chain, efficiency = $\frac{\text{biomass transferred}}{\text{biomass taken in}} \times 100$

A farmer fed 25 kg of grain to his chicken. The chicken gained weight with an efficiency of 0.84. Calculate the weight gained by the chicken.

4 Magnification

To look at small biological specimens you use a microscope to magnify the image that is observed. The microscope was developed in the 17th century. Anton van Leeuwenhoek used a single lens and Robert Hooke used two lenses. The lenses focus light from the specimen onto your retina to produce a magnified virtual image. The magnification at which observations are made depends on the lenses used.

4.1 Calculating the magnifying power of lenses

Lenses each have a magnifying power, defined as the number of times the image is larger than the real object. The magnifying power is written on the lens.

To find the magnification of the virtual image that you are observing, multiply the magnification powers of each lens used. For example, if the eyepiece lens is $\times 10$ and the objective lens is $\times 40$ the total magnification of the virtual image is $10 \times 40 = 400$.

Practice questions

- 1 Calculate the magnification of the virtual image produced by the following combinations of lenses:

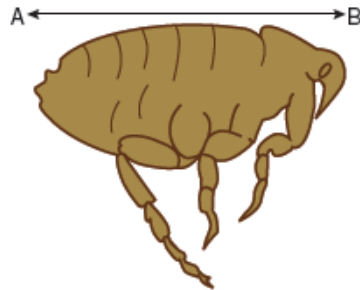
a objective $\times 10$ and eyepiece $\times 12$ $\times 15$	b objective $\times 40$ and eyepiece
--	---

4.2 Calculating the magnification of images

Drawings and photographs of biological specimens should always have a magnification factor stated. This indicates how much larger or smaller the image is compared with the real specimen.

The magnification is calculated by comparing the sizes of the image and the real specimen. Look at this worked example.

The image shows a flea which is 1.3 mm long. To calculate the magnification of the image, measure the image (or the scale bar if given) on the paper (in this example, the body length as indicated by the line A–B).



For this image, the length of the image is 42 mm and the length of the real specimen is 1.3 mm.

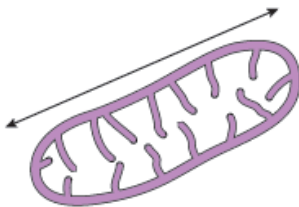
$$\text{magnification} = \frac{\text{length of image}}{\text{length of real specimen}} = 42/1.3 = 32.31$$

The magnification factor should therefore be written as $\times 32.31$

Remember: Use the same units. A common error is to mix units when performing these calculations. Begin each time by converting measurements to the same units for both the real specimen and the image.

Practice question

2 Calculate the magnification factor of a mitochondrion that is 1.5 μm long.



4.3 Calculating real dimensions

Magnification factors on images can be used to calculate the actual size of features shown on drawings and photographs of biological specimens. For example, in a photomicrograph of a cell, individual features can be measured if the magnification is stated. Look at this worked example.

The magnification factor for the image of the open stoma is $\times 5000$.

This can be used to find out the actual size of any part of the cell, for example, the length of one guard cell, measured from A to B.

Step 1: Measure the length of the guard cell as precisely as possible. In this example the image of the guard cell is 52 mm long.

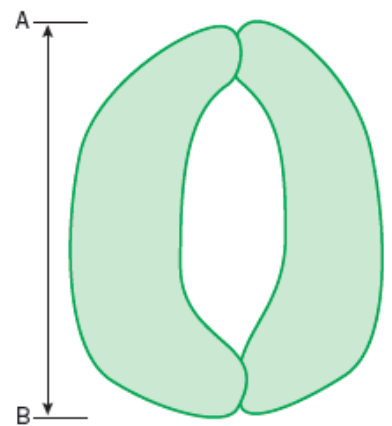
Step 2: Convert this measurement to units appropriate to the image. In this case you should use μm because it is a cell.

So the magnified image is $52 \times 1000 = 52\,000\ \mu\text{m}$

Step 3: Rearrange the magnification equation (see Topic 3.2) to get:

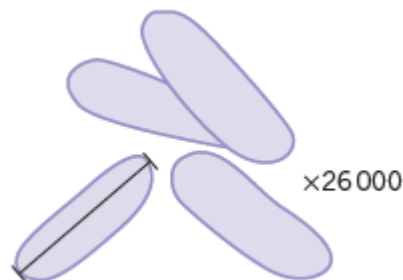
real size = size of image/magnification = $52\,000/5000 = 10.4$

So the real length of the guard cell is $10.4\ \mu\text{m}$.



Practice question

3 Use the magnification factor to determine the actual size of a bacterial cell.



5 Percentages and uncertainty

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

5.1 Calculating percentages as proportions

To work out a percentage, you must identify or calculate the total number using the equation:

$$\text{percentage} = \frac{\text{number you want as a percentage of total number}}{\text{total number}} \times 100\%$$

For example, 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:

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

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

Practice questions

- 1 The table below shows some data about energy absorbed by a tree in a year and how some of it is transferred.

Energy absorbed by the tree in a year	3 600 000 kJ/m ²
Energy transferred to primary consumers	2240 kJ/m ²
Energy transferred to secondary consumers	480 kJ/m ²

Calculate the percentage of energy absorbed by the tree that is transferred to
a primary consumers **b** secondary consumers.

- 2 One in 17 people in the UK has diabetes.

Calculate the percentage of the UK population that have diabetes.

5.2 Calculating the percentage change

When you work out an increase or a decrease as a percentage change, you must identify, or calculate, the total original amount:

$$\% \text{ increase} = \frac{\text{increase}}{\text{original amount}} \times 100$$

$$\% \text{ decrease} = \frac{\text{decrease}}{\text{original amount}} \times 100$$

Remember: When you calculate a percentage change, use the total *before* the increase or decrease, not the final total.

Practice questions

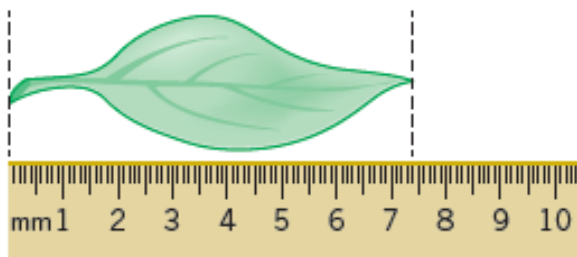
3. Convert the following mass changes as percentage changes.

Sucrose conc. / mol dm ⁻³	Initial mass / g	Final mass / g	Mass change / g	Percentage change in mass
0.9	1.79	1.06		
0.7	1.86	1.30		
0.5	1.95	1.70		
0.3	1.63	1.76		
0.1	1.82	2.55		

5.3 Measurement uncertainties

When you measure something, there will always be a small difference between the measured value and the true value. This may be because of the size of the scale divisions on your measuring equipment, or the difficulty of taking the measurement. This is called an uncertainty.

To estimate the uncertainty of a measurement with an instrument with a marked scale such as a ruler, a good rule of thumb is to let the uncertainty be equal to half the smallest division on the scale being used.



Using a ruler with a mm scale, the length of the leaf seems to be 74 mm. The smallest division is 1 mm, so the uncertainty is 0.5 mm.

The true length is therefore 74 mm $\pm$ 0.5 mm.

Practice question

- 4** Give the uncertainty for the following pieces of equipment:
- a** large measuring cylinder with 2 cm³ divisions
 - b** digital stopwatch timer measuring to the nearest hundredth of a second
 - c** thermometer with 0.1 °C divisions.

5.4 Calculating percentage uncertainties

The uncertainty is the range of possible error either side of the true value due to the scale being used, so the value recorded for the measurement = closest estimate $\pm$ uncertainty.

The difference between the true value and the maximum or minimum value is called the **absolute error**.

Once the absolute error has been established for a particular measurement, it is possible to express this as a percentage uncertainty or **relative error**. The calculation to use is:

$$\text{relative error} = \frac{\text{absolute error}}{\text{measured value}} \times 100\%$$

In the leaf example above, the absolute error is ± 0.5 mm.

The relative error is therefore:

$$0.5/74 \times 100\% = 0.7\%$$

Practice questions

5 Complete the table to show the missing values in the last two columns.

Measurement made	Equipment used	Absolute error	Relative error
Length of a fluid column in a respirometer is 6 mm	mm scale	0.5 mm	
Volume of a syringe is 12 cm ³ of liquid	0.5 cm ³ divisions		
Change in mass of 1.6 g	balance with 2 d.p.		

6 Scatter graphs and lines of best fit

The purpose of a scatter graph with a line of best fit is to allow visualisation of a trend in a set of data. The graph can be used to make calculations, such as rates, and also to judge the correlation between variables. It is easy to draw such a graph but also quite easy to make simple mistakes.

6.1 Plotting scatter graphs

The rules when plotting graphs are:

- Ensure that the graph occupies the majority of the space available:
 - In exams, this means more than half the space
 - Look for the largest number to help you decide the best scale
 - The scale should be based on 1, 2, or 5, or multiples of those numbers
- Ensure that the dependent variable that you measured is on the y -axis and the independent variable that you varied is on the x -axis
- Mark axes using a ruler and divide them clearly and equidistantly (i.e. 10, 20, 30, 40 not 10, 15, 20, 30, 45)
- Ensure that both axes have full titles and units are clearly labelled
- Plot the points accurately using sharp pencil 'x' marks so the exact position of the point is obvious
- Draw a neat best fit line, either a smooth curve or a ruled line. It does not have to pass through all the points. Move the ruler around aiming for:
 - as many points as possible on the line
 - the same number of points above and below the line
- If the line starts linear and then curves, be careful not to have a sharp corner where the two lines join. Your curve should be smooth
- Confine your line to the range of the points. Never extrapolate the line beyond the range within which you measured
- Add a clear, concise title.

Remember: Take care, use only pencil and check the positions of your points.

Practice questions

- 1** Use your calculated data in Topic 5.2 question 3 to plot a graph of % mass change against sucrose concentration.
- 2** For each of the tables of data:
 - a** Plot a scatter graph
 - b** Draw a line of best fit
 - c** Describe the correlation

Turbidity of casein samples at different pH	
pH	% transmission (blue light)
9.00	99
8.00	99
6.00	87
5.00	67
4.75	26
4.50	30
4.00	24
3.75	43
3.50	64

Sodium bicarbonate concentration / %	Rate of oxygen production by pondweed / mm³ s⁻¹
6.5	1.6
5.0	2.1
3.5	1.2
2.0	0.8
1.0	0.5
0.5	0.2

Answers to maths skills practice questions

1 Numbers and units

- 1 a 1 kJ = 1000 J, so 4 500 000 J = 4 500 000/1000 kJ = 4500 kJ
b 1 MJ = 1000 kJ, so 4500 kJ = 4.5 MJ
- 2 1 m = 10^9 nm (there are a billion nanometre in a metre)
 9.0×10^{-8} m = $9.0 \times 10^{-8} \times 10^9$ nm = $9.0 \times 10^{-8+9}$ nm = 9.0×10 nm = 90 nm
 1.20×10^{-7} m = $1.20 \times 10^{-7} \times 10^9$ nm = $1.20 \times 10^{-7+9}$ nm = 1.20×100 nm = 120 nm
Range = 90 nm to 120 nm
- 3 a 10^{11} b 10^{12}
c 1000 + 1000 = 2000 d 100 – 0.01 = 99.99
- 4 a 10^1 or 10 b 10^{-3} or 0.001
c 10^6 or 1 000 000 d $100^2 \div 100 = 100$ or 10^2
- 5 a 4 mm b 130 s
c 31 300 μ l d 0.000 104 mg
- 6 a 57 μ m b 8.6 L or 8.6 dm³
c 68 s d 0.09 mm

2 Decimals, standard form, and significant figures

- 3 0.0214 cm² 0.0218 cm² 0.03 cm² 0.034 cm²
- 4 12.03 cm 12.901 cm 22 cm 22.003 cm 22.25 cm
- 5 a 3.06×10^3 kJ b 1.4×10^5 kg
c 1.8×10^{-4} m d 4×10^{-6} m
- 4 a 1×10^2 b 1×10^4
c 1×10^{-2} d 2.1×10^7
- 5 Give the following as decimals.
a 1 000 000 b 4 700 000 000
c 1 200 000 000 000 d 0.000 796
- 6 a 7600 g / 7640 g b 28 m / 27.5 m
c 4.3 g / 4.33 g d 6.0×10^2 m / 5.00×10^2 m
- 7 1.2×10^4 g

3 Working with formulae

1. $M?$ $I = 6.6 \text{ mm}$ $O = 165 \mu\text{m}$

Change to same units: either both mm or both μm or both m: $165 \mu\text{m} = 0.165 \text{ mm}$

$$M = I/O = 6.6/0.165 = \times 40$$

2. $\text{Area} = 0.5 \times 2 \text{ cm} \times 9 \text{ cm} = 9 \text{ cm}^2$

3. $\text{Area} = \pi r^2 = \pi \times (0.7 \mu\text{m})^2 = \pi \times (0.7 \times 10^{-6} \text{ m}) \times (0.7 \times 10^{-6} \text{ m}) = 1.5 \mu\text{m}^2$

4. $N_0 = 24$

$$7 \text{ days} = 7 \times 24 \text{ hours} = 168 \text{ hours}$$

$$\text{so } n = 168 \div 20 = 8.4$$

$$Nt = 24 \times 28.4 = 8107 \text{ cells}$$

5. $N = 96 + 4 + 22 + 3 = 125 \text{ animals found}$

$$\text{so } D = 1 - \sum \left(\frac{n}{N} \right)^2$$

$$\text{inner brackets: } D = 1 - \left(\left(\frac{96}{125} \right)^2 + \left(\frac{4}{125} \right)^2 + \left(\frac{22}{125} \right)^2 + \left(\frac{3}{125} \right)^2 \right)$$

$$\text{indices: } D = 1 - (0.768^2 + 0.032^2 + 0.176^2 + 0.024^2)$$

$$\text{addition: } D = 1 - 0.6224 = 0.3776 = 0.38 \text{ (2.d.p.)}$$

6. $O = 0.1 \text{ mm}$ $I = ?$ $M = 50$ $I = M \times O = 50 \times 0.1 \text{ mm} = 5 \text{ mm}$

7. $\text{Area} = 5.3 \text{ cm}^2$ radius? $A = \pi r^2$

$$5.3 = \pi r^2 \quad r^2 = \frac{5.3}{\pi} = 1.687 \quad r = \sqrt{1.687} = 1.3 \text{ cm}$$

$$\text{Or } A = \pi r^2 \quad r^2 = \frac{A}{\pi} \quad r = \sqrt{\frac{A}{\pi}} \quad r = \sqrt{\frac{5.3}{\pi}} = 1.3 \text{ cm}$$

8. $25 \times 10^{-6} \text{ m}$ ($7.25 \mu\text{m}$)

$$9. a = \frac{\left(\frac{34}{100} \right) \times 135}{2} = 22.95$$

10. cardiac output = stroke volume $\times$ heart rate

$$\text{stroke volume} = \frac{2.7}{77} = 0.035 \text{ dm}^3$$

11. Substitute in the known values: $0.84 = \frac{\text{biomass transfer}}{25} \times 100$

$$\text{Rearrange the equation to give: biomass transfer} = \frac{0.84}{100} \times 25 = 0.21 \text{ kg}$$

4 Magnification

3. **a** $\times 120$ **b** $\times 600$

2. $\times 26\,000$

3. $0.88 \mu\text{m}$

5 Percentages and uncertainty

a $\frac{2240}{3600000} \times 100 = 0.06\%$ b $\frac{480}{3600000} \times 100 = 0.013\%$

2 5.88%

3

Sucrose conc. / mol dm^{-3}	Initial mass / g	Final mass / g	Mass change / g	Percentage change in mass
0.9	1.79	1.06	-0.73	-40.8%
0.7	1.86	1.30	-0.56	-30.1%
0.5	1.95	1.70	-0.25	-12.8%
0.3	1.63	1.76	+0.13	+8.0%
0.1	1.82	2.55	+0.73	+40.1%

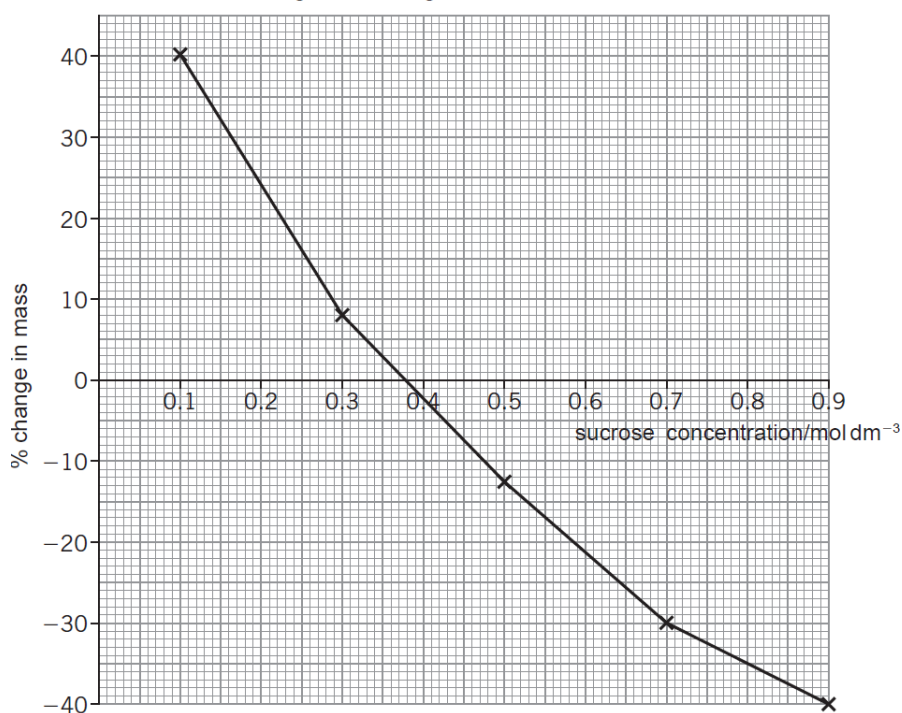
4 a 1 cm^3 b 0.005 s c $0.05 \text{ }^\circ\text{C}$

5

Measurement made	Equipment used	Absolute error	Relative error
Length of a fluid column in a respirometer is 6 mm	mm scale	0.5 mm	$\frac{0.5}{6} \times 100 = 8.3\%$
Volume of a syringe is 12 cm^3 of liquid	0.5 cm^3 divisions	0.25 cm^3	$\frac{0.25}{12} \times 100 = 2.1\%$
Change in mass of 1.6 g	balance with 2 d.p.	0.005 g	$\frac{0.005 \times 2}{1.6} \times 100 = 0.6\%$

6 Scatter graphs and lines of best fit

Change in mass against sucrose concentration



2 c Table 1: Strong correlation. Positive at the start. As light intensity increases, the increase in the rate of photosynthesis decreases (so the graph levels off).

Table 2: Strong correlation. Negative at the start. As time increases, the rate of the decrease of the concentration decreases (so the graph levels off).

Section 3 - Preparing for your first A level / IB topics

The work below will help you prepare for the first topics that will be covered at the start of the A level and IB courses. Use the following websites to help you.

<http://www.biologymad.com/master.html?http://www.biologymad.com/cells/cells.htm>

<https://www.bioknowledgey.info/12-ultrastructure-of-cells.html>

<https://ib.bioninja.com.au/standard-level/topic-1-cell-biology/12-ultrastructure-of-cells/eukaryotic-cells.html>

What to do

Work through the tasks as set out below for cell structure and biological molecules. Make sure you learn all this material carefully as you will be tested on this material at the start of your A level / IB course.

Cell structure

1. Draw a diagram to show the structure of a typical animal cell as seen with an electron microscope.

2. Add the following labels to your diagram;

- Nucleus
- Nucleolus
- Nuclear envelope
- Rough endoplasmic reticulum
- Smooth endoplasmic reticulum
- Golgi apparatus
- Ribosomes
- Mitochondria
- Lysosomes
- Plasma (cell surface membrane)
- Centrioles

3. Draw a diagram to show the structure of a typical plant cell as seen with an electron microscope.

4. Add the following labels to your diagram;

- Nucleus
- Nucleolus
- Nuclear envelope
- Rough endoplasmic reticulum
- Smooth endoplasmic reticulum
- Golgi apparatus
- Ribosomes
- Mitochondria
- Plasma (cell surface membrane)
- Chloroplast

5. Draw and complete a table like the one below. The descriptions of the structure and function do not have to be long, no more than a few lines but need to have the detail required for IB/A level Biology.

Organelle	Diagram	Description of structure	Function
Nucleus			

Organelle	Diagram	Description of structure	Function
Nucleolus			
Nuclear envelope			
Rough endoplasmic reticulum			
Smooth endoplasmic reticulum			
Golgi apparatus			
Ribosome			
Mitochondria			
Plasma (cell surface membrane)			
Chloroplast			
Centriole			
Lysosome			

6. Draw a table to show the differences and similarities between plant and animal cells. (Compare and contrast the structure of plant and animal cells)
7. Draw a diagram of a prokaryotic cell
8. Label the main features
9. Draw a table to compare the structure of prokaryotic cells and eukaryotic cells.
10. Learn all the material above for a test, make sure your revision is active e.g. make flash cards and / or mind maps.

During your first or second lesson in September you will be tested on your knowledge of the structure and function of prokaryotic and eukaryotic cells.

11. Read, make notes and answer questions in the CGP head start to A-Level biology book if you have access to one. This book (see page 39 for details) bridges the gap between GCSE and A level. This book, although designed for A-Level students, is also relevant to **IBH** and **IBS** students. The most relevant sections for the start of the course are sections 1, 2 and 9 but all sections will be relevant at some stage during the first year of the IB course. If you do not have access to this book use the links at the top of page 35 to make some notes on the topics at the start of the course.

Biological molecules

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What are monomers?	smaller units from which larger molecules are made
What are polymers?	molecules made from a large number of monomers joined together
What is a condensation reaction?	a reaction that joins two molecules together to form a chemical bond whilst eliminating of a molecule of water
What is a hydrolysis reaction?	a reaction that breaks a chemical bond between two molecules and involves the use of a water molecule
What is a monosaccharide?	monomers from which larger carbohydrates are made
How is a glycosidic bond formed?	a condensation reaction between two monosaccharides
Name the three main examples of polysaccharides	glycogen, starch, cellulose
Describe Benedict's test for reducing sugars	gently heat a solution of a food sample with an equal volume of Benedict's solution for five minutes, the solution turns orange/brown if reducing sugar is present
Name the two main groups of lipids	phospholipids, triglycerides (fats and oils)
Give four roles of lipids	source of energy, waterproofing, insulation, protection
What is an ester bond?	a bond formed by a condensation reaction between glycerol and a fatty acid
Describe the emulsion test for lipids	mix the sample with ethanol in a clean test tube, shake the sample, add water, shake the sample again, a cloudy white colour indicates that lipid is present
What are the monomers that make up proteins?	amino acids
Draw the structure of an amino acid	$ \begin{array}{c} \text{R} \\ \\ \text{H}_2\text{N} - \text{C} - \text{COOH} \\ \\ \text{H} \end{array} $
How is a peptide bond formed?	a condensation reaction between two amino acids
What is a polypeptide?	many amino acids joined together
Describe the biuret test for proteins	mix the sample with sodium hydroxide solution at room temperature, add very dilute copper(II) sulfate solution, mix gently, a purple colour indicates that peptide bonds are present
How does an enzyme affect a reaction?	it lowers the activation energy
Give five factors which can affect enzyme action	temperature, pH, enzyme concentration, substrate concentration, inhibitor concentration
What is a competitive inhibitor?	a molecule with a similar shape to the substrate, allowing it to occupy the active site of the enzyme
What is a non-competitive inhibitor?	a molecule that changes the shape of the enzyme by binding somewhere other than the active site.

Key terms used to describe measurements and results

You need to be confident about the definitions of terms that describe measurements and results in A Level Biology.

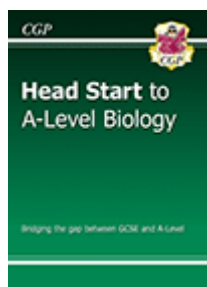
Learn the answers to the questions below, then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

Practical science key terms

When is a measurement valid?	when it measures what it is supposed to be measuring
When is a result accurate?	when it is close to the true value
What are precise results?	when repeat measurements are consistent/agree closely with each other
What is repeatability?	how precise repeated measurements are when they are taken by the <i>same</i> person, using the <i>same</i> equipment, under the <i>same</i> conditions
What is reproducibility?	how precise repeated measurements are when they are taken by <i>different</i> people, using <i>different</i> equipment
What is the uncertainty of a measurement?	the interval within which the true value is expected to lie
Define measurement error	the difference between a measured value and the true value
What type of error is caused by results varying around the true value in an unpredictable way?	random error
What is a systematic error?	a consistent difference between the measured values and true values
What does zero error mean?	a measuring instrument gives a false reading when the true value should be zero
Which variable is changed or selected by the investigator?	independent variable
What is a dependent variable?	a variable that is measured every time the independent variable is changed
Define a fair test	a test in which only the independent variable is allowed to affect the dependent variable
What are control variables?	variables that should be kept constant to avoid them affecting the dependent variable

A level and IB Biology text books

The book below bridges the gap between GCSE and A level Biology. It is also relevant for students studying IB Biology.



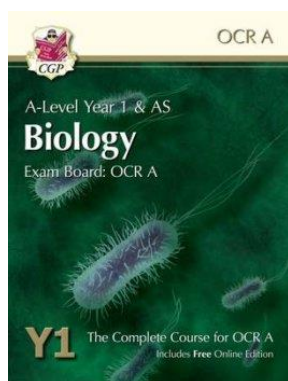
Head start to AS Biology

Book Details

- **Retail Price:** £4.95
- **ISBN:** 978 1 78294 279 5
- **Publisher:** CGP

Below is a selection of useful books for studying A level and IB Biology. You are **not expected to buy any of these books but you may find a CGP book useful.**

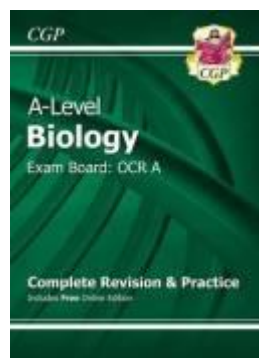
Useful books for A level Biology students during year 1



A-Level year 1 Biology - Exam board: OCR

Book Details

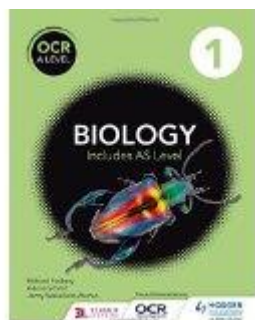
- **Price:** £19.99
- **ISBN:** 978-1782943204
- **Publisher:** CGP



A-Level Biology - Exam board: OCR the Revision Guide

Book Details

- **Price:** £19.99
- **ISBN:** 9781782942993
- **Publisher:** CGP

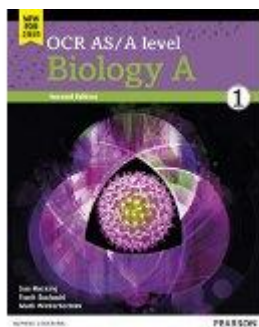


OCR A level Biology student book

You may wish to borrow a copy of this book from your local library before you start the course.

Book Details

- **ISBN:** 978-1471809156
- **Authors:** Adrian Schmit, Richard Fosbery
- **Publisher:** Hodder

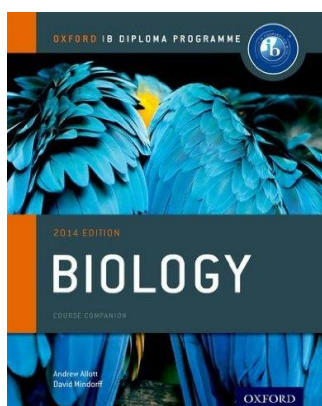


OCR AS/ A level Biology A

You will be issued with this text book in September. You may wish to borrow a copy of this book from your local library before you start the course.

- **ISBN:** 978-1447990796
- **Author:** Sue Hocking, Frank Sochacki
- **Publisher:** Pearson Education

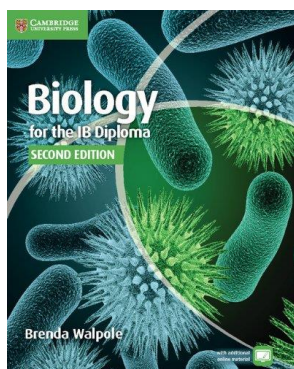
Useful books for IB Students



IB Biology Course Book 2014 edition: Oxford IB Diploma Programme (International Baccalaureate).

You will be issued with this book in September. You may wish to borrow a copy from your local library before the start of the course

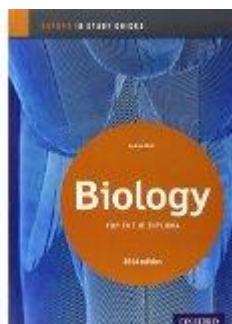
- **Publisher:** OUP Oxford;
- **ISBN-13:** 978-0198392118



Higher level biology for IB diploma

You may wish to borrow a copy of this book from your local library before the start of the course.

- **Publisher:** Cambridge university press;
- **ISBN-13:** 978-1107654600



Biology study guide for the IB diploma – 2014 edition

You may wish to borrow a copy of this book from your local library before the start of the course.

- **Publisher:** OUP;
- **ISBN-13:** 978-0198393511