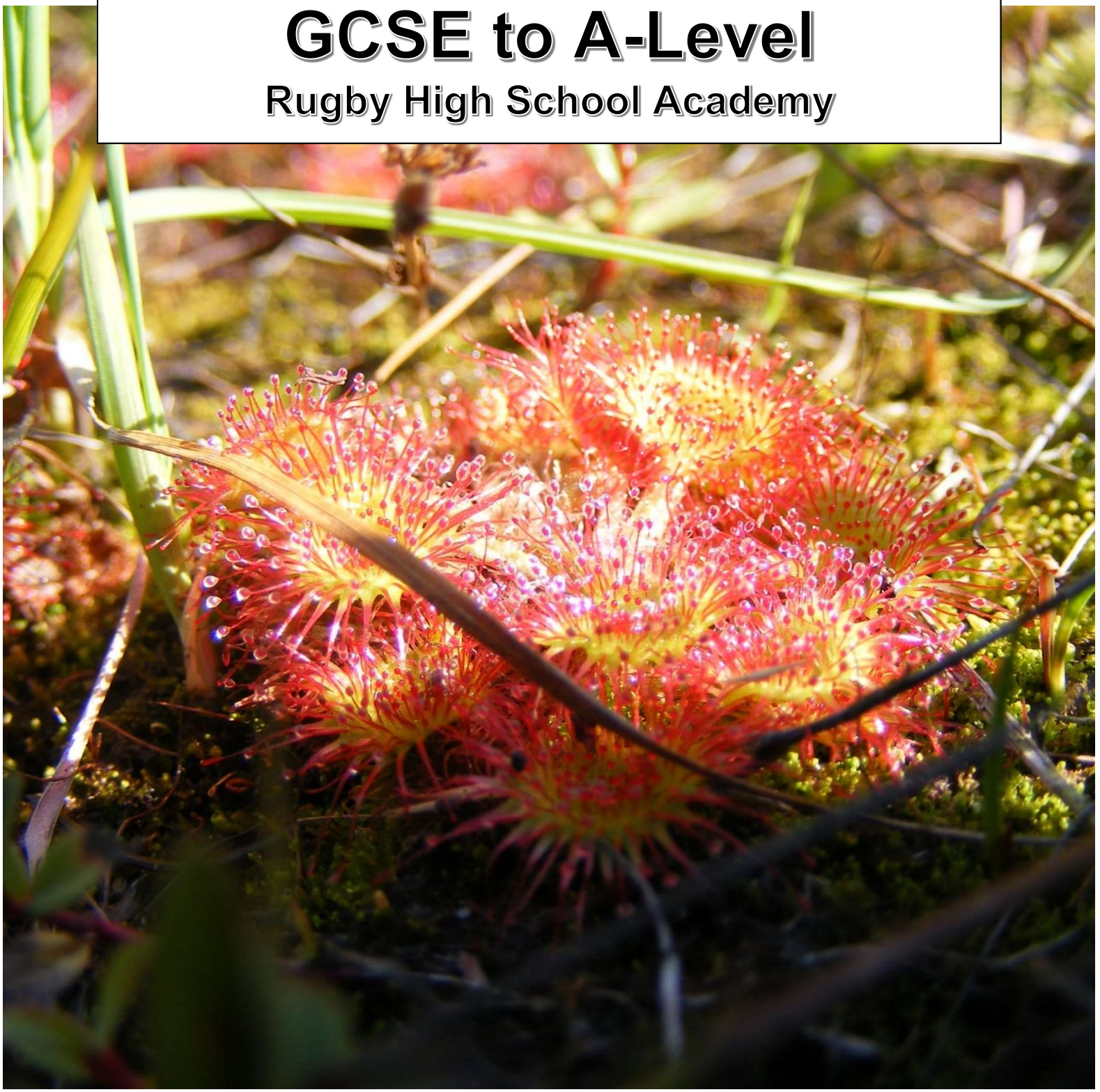
Biology

GCSE to A-Level

Rugby High School Academy



Name:

Moving from GCSE Science to A Level 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 pre-learn some useful knowledge from the first chapters of your A Level course
- understand some of the maths skills you will need.

Learning objectives

After completing the tasks, you should be able to:

- define practical science key terms
- recall the answers to the retrieval questions
- review the required 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.

Figure 1 Seneca

To do

1. ***Join the class on Seneca*** and work through the A-Level Taster assignment
2. ***Work your way through this sheet*** to aid in preparing to start your course in September.

   Self-assessment is an important tool in developing your ability to learn independently.
3. ***Review content from GCSE Biology.***

   A-level courses will develop further understanding in greater depth. Your GCSE knowledge is assumed so retaining and refreshing your understanding throughout the course will be beneficial. There will be a test comprising of GCSE-style questions in September.

<u>This test will take place at the start of the course and will last approximately 1 hour.</u>

Figure 2 GCSE Biology Paper 1 Content

Figure 3 GCSE Biology Paper 2 Content

4. Open University Study

Complete the **Tour of the Cell** prior to starting Biology in the autumn.
You are of course welcome to complete others – a selection is included below.

1. **Click on or scan** the QR code.
2. **Create an account** to be able to access all the quizzes that come with the course. It takes about 1 minute!
3. **Print the statement** of participation upon completion.
4. **Bring it** with you to Biology in September

These **courses are free** but the time you invest in them is priceless.

Figure 4 Tour of the cell

Figure 5 A students 6th Form Journey

Basic science: understanding numbers (12 hours)

Diagrams, charts, and graphs (5 hours)

Epidemiology: An introduction (7 hours)

Health and safety in the laboratory and field (1 hour)

Infection and Immunity (12 hours)

Introduction to Microscopy (3 hours)

Meiosis and Mitosis (8 hours)

Nutrition: Proteins (8 Hours)

Vaccination (14 hours)

What do genes do? (4 hours)

If you find Maths challenging then do this one as well BUT it will take you a long time!

Maths for Science and technology (24 hours)

Retrieval questions

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

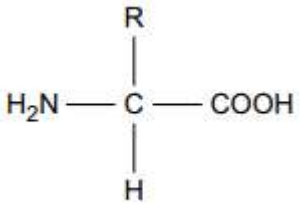
Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

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 *same* person, using the *same* equipment, under the *same* conditions
What is reproducibility?	how precise repeated measurements are when they are taken by *different* people, using *different* 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

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	
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.

Maths skills

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 (m^2), cubic metre (m^3), 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

1.2 Powers and indices

1. Ten squared = 10 × 10 = 100 and can be written as 10^2. This is also called 'ten to the power of 2'.
2. Ten cubed is 'ten to the power of three' and can be written as 10^3 = 1000.
3. The power is also called the index.
4. Fractions have negative indices:
    - one tenth = 10^{-1} = 1/10 = 0.1
    - one hundredth = 10^{-2} = 1/100 = 0.01
5. Any number to the power of 0 is equal to 1, for example, 29^0 = 1.
6. If the index is 1, the value is unchanged, for example, 17^1 = 17.
7. When multiplying powers of ten, you must *add* the indices.
    - So, 100 × 1000 = 100 000 is the same as $10^2 \times 10^3 = 10^{2+3} = 10^5$
8. When dividing powers of ten, you must *subtract* the indices.
    - So, 100/1000 = 1/10 = 10^{-1} is the same as $10^2/10^3 = 10^{2-3} = 10^{-1}$
9. But you can only do this when the numbers with the indices are the same.
    - So, $10^2 \times 2^3$ = 100 × 8 = 800
10. And you cannot 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.

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 ÷ 10^3 = 488.889 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

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.

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:

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}.

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.

2.4 Logarithmic scales

These are something that Biology students often struggle with. Watch this video by Miss Estruch to get the inside knowledge you need:

Figure 6 How to calculate Log and when to use it in A-level Biology

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:

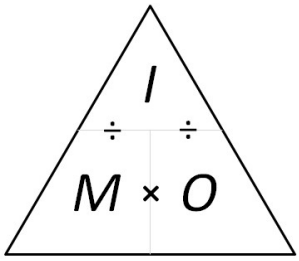
$$M = 12\ \text{mm}/0.06\ \text{mm} = 12/0.06 = 200$$

Answer: magnification = ×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.

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:

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

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.

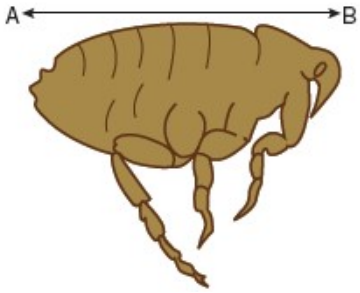
To find the magnification of the virtual image that you are observing, multiply the magnification powers of each lens used. For example, if the eyepiece lens is ×10 and the objective lens is ×40 the total magnification of the virtual image is 10 × 40 = 400.

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).

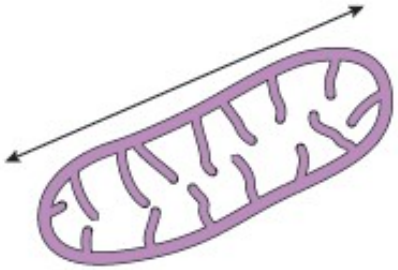


For this image, the length of the image is 42 mm and the length of the real specimen is 1.3 mm.

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

The magnification factor should therefore be written as ×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.



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 ×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 × 1000 = 52 000 µm

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 µm.

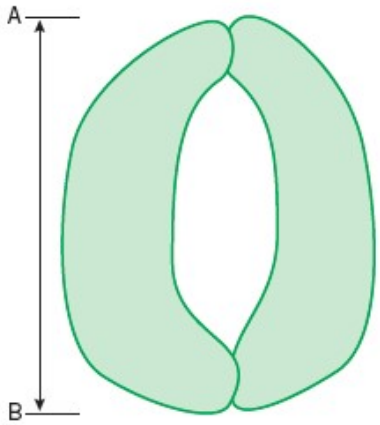


Figure 7 While you are here - please learn how to do a biological drawing!

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:

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

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

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:

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

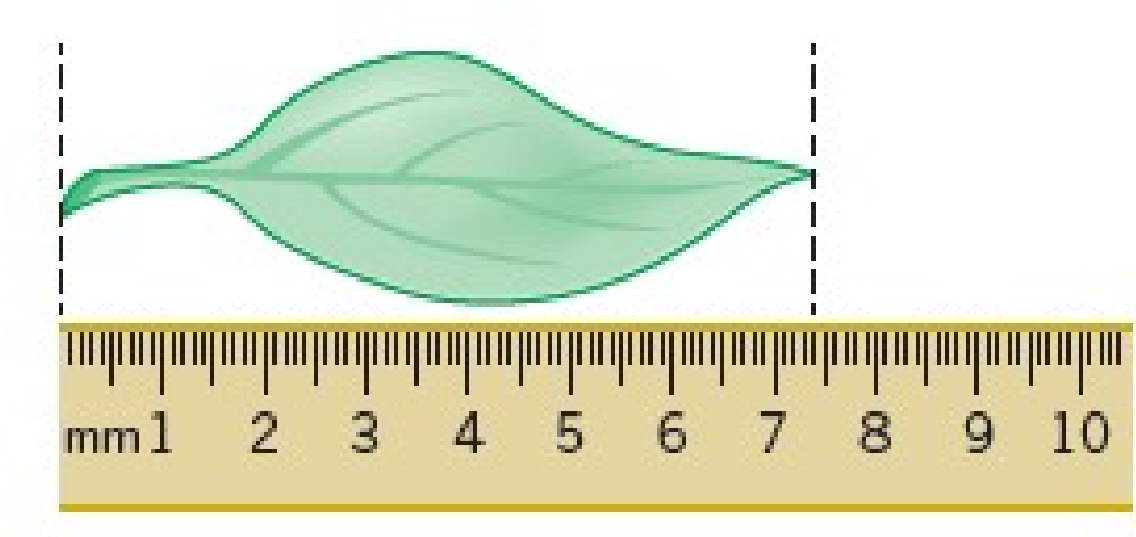
$$\%\ \text{decrease} = \frac{\text{decrease}}{\text{original amount}} \times 100$$

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

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.

However, when measuring length, **<u>two uncertainties</u>** must be included: the uncertainty of the placement of the zero of the ruler and the uncertainty of the point the measurement is taken from.

As both ends of the ruler have a ±0.5 scale division uncertainty, the measurement will have an uncertainty of ±1 division. The true length is therefore 74 mm +/− 1 mm.

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 +/− 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:

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

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.

Keep this booklet and add it to your folder for September

And now some fun…

A-LEVEL BIOLOGY PRACTICAL STUDY SUGGESTIONS

Stick this inside the front cover of your folder
Put your name CLEARLY on your folder

PRIOR TO EACH CHAPTER:

Pre-read the relevant section of the **textbook**.

Pre-read the relevant section of the **revision guide**.

Make basic notes prior to the lessons on the chapter:

- ***Annotate*** these during the lesson
- ***Focus*** on the learning and understanding, rather than the physical note-taking.
- ***Consider*** annotating and expanding on the revision guide directly in lessons, rather than writing all notes out from scratch.
  Beware that revision guides do not generally cover the content aimed at the highest grades.

Draw out (or photocopy) relevant diagrams prior to lessons:

- ***Annotate*** to understand the processes, rather than drawing the diagrams in the lesson.

Use Kerboodle to set the scene:

- ***Watch*** the animations
- ***Listen*** to the podcasts.

DURING EACH CHAPTER:

Consolidate class notes *after every lesson* using textbook or revision guide, or both.

Summarise notes into "cue cards".

Complete *all red* summary questions and *green* application questions from each chapter, as you go.

- ***Self-mark*** and make corrections using answers in the back of the book.
- ***Ask your teacher for help*** with any specific questions that you still do not understand, once corrected.

Look up video clips on YouTube on small sections. There are several links on Frog: "Mr Pollock" and the "Khan Academy" are good.

Use all interactive activities on Kerboodle *regularly*. These include:

- Animations
- Podcasts
- Webquests
- "On your Marks"
- Self-assessment multiple choice quizzes

AT THE END OF EACH CHAPTER (PRIOR TO TOPIC TEST):

Complete *every set* of Exam-style questions from the end of each chapter in the textbook. These are taken from actual past papers and are excellent exam-style practice.

Use the **Revision Question Booklets** and **Prepared Answer PowerPoints** on Frog. There are also resources on the AQA website.

Create mind maps and summary diagrams, for example:

- ***Prepare*** an A3 sheet showing how the light-dependent reaction is linked to the light-independent reaction of photosynthesis.
- ***Use*** the summaries at the start and end of each section of the textbook to guide you.

Draw up a *glossary of definitions* of all the key terms from the chapter.

"**Teach**" the chapter to one of your peers.

Review linked content in the specification:

- For example, when studying genetics in Yr 13, review Nucleic Acids from Year 12.
- There are hints in the textbook highlighting these synoptic areas (orange boxes).