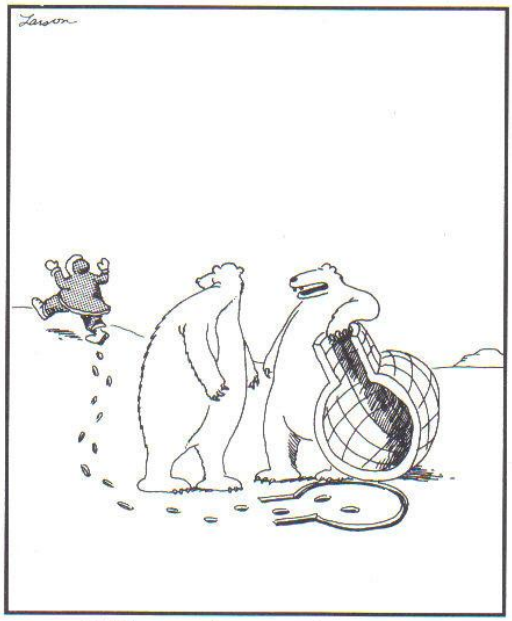
# *Bridging the Gap*

# BIOLOGY

# 2026




"I lift, you grab. … Was that concept just a little too complex, Carl?"

Welcome to the Berkhamsted School Biology Department. You have chosen to do an A-level subject that is both rewarding and interesting. It is an academically challenging subject which will require you to make a substantial leap in your understanding and skills learnt and applied at KS4. This may seem daunting but putting in the required level of effort in right from day one will mean success.

The pathway to success begins now. This pack is designed to get you up and running before the start of the academic year. There is a lot of information in this booklet and also some summer activities to do.

The following work set needs to be completed and submitted via email Your teachers wish to have access to this work before your first lesson.

You will submit 3 documents:

- Must submit a Reading log
- A short presentation inspired by your reading
- The Questions - at the end of this document

***Ensure that when this work is sent, each page is clearly labelled with your name (at the top of each page).***

***The document must have your name in the saved title.***

Due date: ***Monday 7th September 2026***

Email back to: **tpadfield@berkhamsted.com**

# 1. Summer Reading Log

***This is part of How Science Works. Scientists read and think and talk about ideas - hypotheses - evidence. They try things out - test their ideas - listen to each other.***

There are hundreds of good, popular science books around and background reading will definitely support you through the course. We want you to read a variety of books/journals/articles – whatever interests you! You don't have to read a whole book – start a chapter or two, make a note of your thoughts and you can come back to it later if you enjoy it!

As you read throughout the summer, complete the reading log on pages 5 - 6 making a brief note of what you found interesting and why. **You don't have to fill the entire log.** Reading suggestions are included below.

# Reading suggestions

If you are looking for journals, then here are three suggestions of how you can access some:

1) Biological Sciences Review Magazine:

https://my.dynamic-learning.co.uk/Default.aspx?cid=20918

Username: MagazineArchive9781471862410

And the password is: student

2) New Scientist:

**NEW SCIENTIST**

Username: library@newscientist.com

Password: castle

https://www.newscientist.com/

3) JSTOR

**JSTOR**

Username: berkhamsted

Password: researcher

http://www.jstor.org/

If you're interested in a longer read, or want to just delve into a few chapters (or even just one chapter!), there are lots of excellent books that the Biology staff have recommended (the library have a limited number of copies of these books for you to borrow):

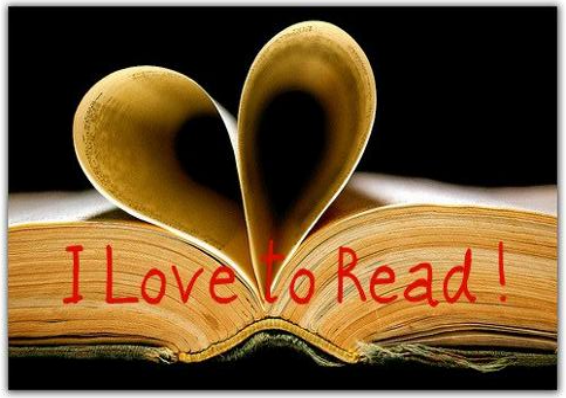
| | | |
|---|---|---|
| 1. | **Dawkins, Richard** | The greatest Show on Earth – *the evidence for evolution* |
| *2.* | **Shubin, Neil** | Your inner Fish: *the discovery of our 375 million year old ancestor* |
| 3. | **Gould, Stephen Jay** | The richness of life |
| 4. | **Forbes, Peter** | The gecko's foot: *how scientists are taking a leaf from nature's book* |
| *5.* | **Jones, Steve** | Y: *the descent of men* |
| *6.* | **Watson, James D** | Darwin**:** *the indelible stamp* |
| *7.* | **Hobhouse, Henry** | Seeds of change**:** *six plants that transformed Mankind* |
| 8. | **Ridley, Matt** | Nature via nurture: *genes, experience and what makes us human* |
| 9. | **Sykes, Brian** | The seven daughters of eve |
| 10. | **Reiss, Michael J** | Improving nature? |
| *11.* | **Postgate, J R** | Microbes and man |
| *12.* | **Carson, R** | Silent spring |
| *13.* | **Fortey, R A** | Life: an unauthorised biography. |
| *14.* | **Sigman, M** | *The Secret life of the Mind* |
| *15.* | **Mukherjee, S** | *The Gene – an intimate history.* |
| *16.* | **Yong, E** | *I Contain Multitudes.* |
| *17.* | **Godfrey-Smith, P** | *Other Minds.* |
| *18.* | **Enders, G** | *Gut.* |
| *19.* | **Lane, N** | The vital question |
| *20.* | **Lane, N** | Life Ascending |
| *21.* | **Parrington, J** | The Deeper Genome |
| *22.* | **Carey, N** | Junk DNA |
| *23.* | **Shapiro, B** | How to clone a mammoth |
| *24.* | **Criado Perez, C** | Invisible Women |
| *25.* | **Marchant, Jo** | Cure – A journey into the Science of mind over body |
| *26.* | **Rutherford, Adam** | Control – the dark history and troubling present of eugenics |
| *27.* | **Benjamin & McCallum** | A world without bees |
| *28.* | **Jones, Steve** | Coral: A pessimist in paradise |
| *29.* | **Jones, Steve** | Almost like a whale – the origin of species updated |
| *30.* | **Tree, Isabella** | Wilding – the return of nature to a British farm |
| *31.* | **Jebelli, Joe** | How the mind changed – a human history of our evolving brain |

**Please submit by Tuesday 2nd September (see the empty reading log on the next page – you can use this as a template for recording your reading log).**

**Also please submit a short (3-5 min) presentation that you will give to the class in September.**

**Email reading log and presentation to: tpadfield@berkhamsted.com**

# Year 12 Biology Summer Reading Log



Wider reading, beyond your specification, supported by active reflection on what you have read, is a key skill at A-level.

This will prepare you also for your Extended Project Qualification and, moreover, support your future UCAS Personal Statement.

| Date | Name of the book, magazine, journal you have read | What was the name of the article you read? | What did you find interesting? Explain why? |
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# 2. Summer written work

To be submitted by email to tpadfield@berkhamsted.com by Monday 7th Sept 2026

# Transition from GCSE to A Level

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 worksheet 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 and practice of some of the maths skills you'll need.

### Learning objectives

After completing these pages you should be able to:

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

# 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.

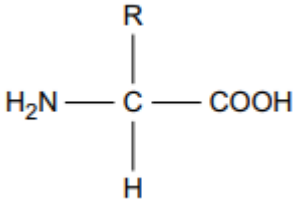
## Practical science key terms

| | |
|---|---|
| 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 |

#### *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 $9.0\times10^{-8}$ m and $1.20\times10^{-7}$ m.
Write this range in nanometres.

### 1.2 Powers and indices

Ten squared = 10 × 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 × 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.

$488\,889 \div 10^3 = 488.889$ 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 $cm^2$ 0.03 $cm^2$ 0.0218 $cm^2$ 0.034 $cm^2$

**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, $1.5\times10^{7}$ 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 $3.72\times10^{13}$.

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 $4.5\times10^{-7}$.

### *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** $4.7\times10^{9}$  **c** $1.2\times10^{12}$  **d** $7.96\times10^{-4}$

## 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:

$9.42\times10^{-5}$  $1.56\times10^{8}$

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 $5.90 \times 10^2$

**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 questions*

**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** $5.995 \times 10^2$ 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 = ×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 $t$.

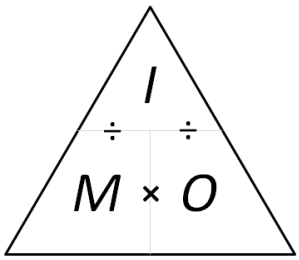
**5** In a quadrat sample, an area was found to contain 96 aphids, 4 ladybirds, 22 grasshoppers, and 3 ground beetles. Calculate the diversity of the site using the equation $D = 1 - \Sigma\left(\frac{n}{N}\right)^2$ *where* $n$ = number of each species, $N$ = grand total of all species, and $D$ = diversity.

**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:

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

### *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 ×50.

**7** A Petri dish shows a circular colony of bacteria with a cross-sectional area of 5.3 $cm^2$. 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 ×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 $dm^3\,min^{-1}$ and their heart rate was 77 bpm. Calculate the stroke volume of the patient.

Use the equation: cardiac output = stroke volume × 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 ×10 and the objective lens is ×40 the total magnification of the virtual image is 10 × 40 = 400.

## *Practice questions*

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

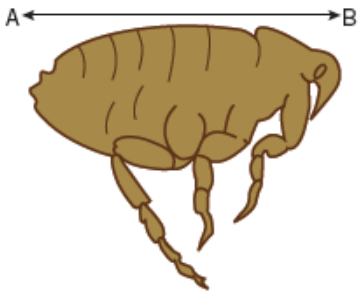
**a** objective ×10 and eyepiece ×12 **b** objective ×40 and eyepiece ×15

### 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.

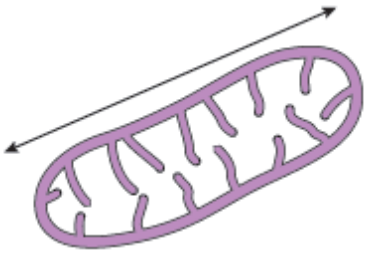
$$\text{magnification} = \frac{\text{length of image}}{\text{length of real specimen}} = 42/1.3 = 32.31$$

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.

## *Practice question*

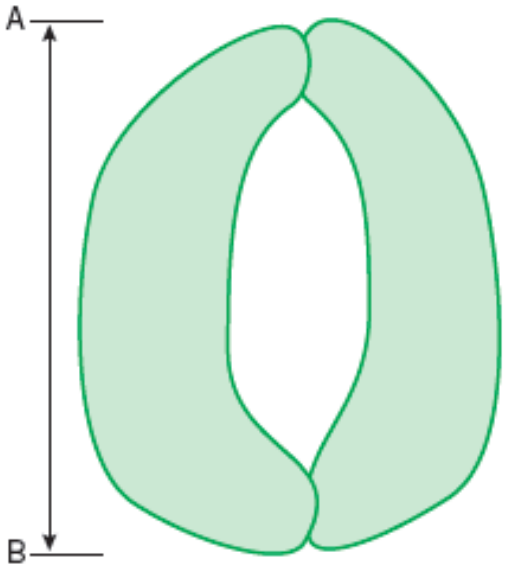
**2** Calculate the magnification factor of a mitochondrion that is 1.5 μm long.



### 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 ×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

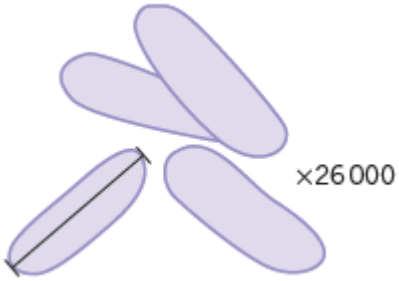
**Step 3:** Rearrange the magnification equation (see Topic 3.2) to get:

real size = size of image/magnification = 52 000/5000 = 10.4

So the real length of the guard cell is 10.4 μm.

## *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*

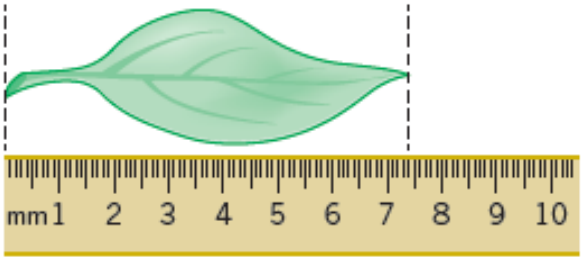
**3** Convert the following mass changes as percentage changes.

| 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 +/− 0.5 mm.

## *Practice question*

**4** Give the uncertainty for the following pieces of equipment:

**a** large measuring cylinder with 2 $cm^3$ 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 +/− 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 × 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.

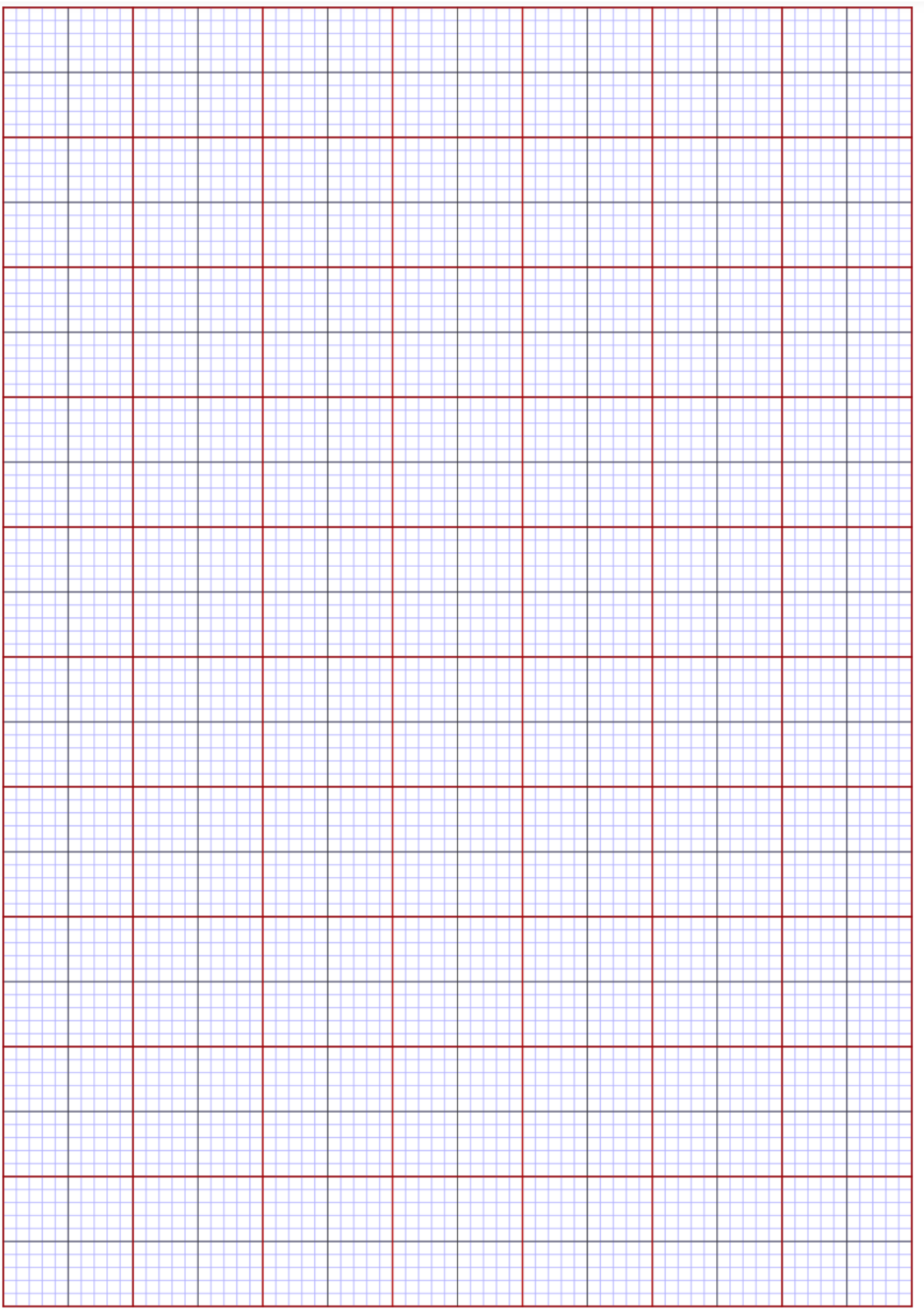
**2** For each of the tables of data:

**a** Plot a scatter graph

**b** Draw a line of best fit

**c** Describe the correlation

The final page of this document has a graph grid on it for you to complete your graph on.

| 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 / $mm^3\ s^{-1}$** |
|---|---|
| 6.5 | 1.6 |
| 5.0 | 2.1 |
| 3.5 | 1.2 |
| 2.0 | 0.8 |
| 1.0 | 0.5 |
| 0.5 | 0.2 |