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# Transition Pack for A Level Biology

**Get ready for A-level!**

**A guide to help you get ready for A-level Biology,  
including everything from topic guides to days out and  
online learning courses.**

**Commissioned by The PiXL Club Ltd. April 2016**

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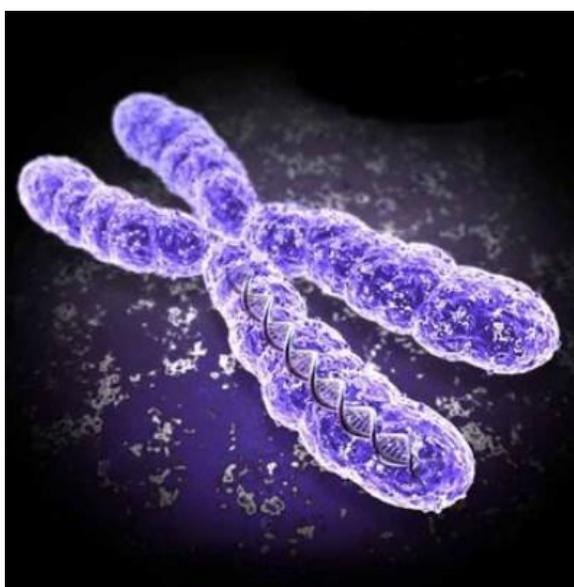
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# So you are considering A level Biology?

This pack contains a programme of activities and resources to prepare you to start A level in Biology in September. It is aimed to be used after you complete your GCSE throughout the remainder of the Summer term and over the Summer Holidays to ensure you are ready to start your course in September.



<https://www.distance-education-academy.com/wp-content/uploads/2013/06/biology-a-level-course.jpg>

Please hand work into Miss. Green ([green.j@kevi.org.uk](mailto:green.j@kevi.org.uk)), before you return to school in September.

## Task 1 - Pre-Knowledge Topics

A level Biology will use your knowledge from GCSE and build on this to help you understand new and more demanding ideas. Complete the following tasks to make sure your knowledge is up to date and you are ready to start studying:

### **DNA and the Genetic Code**

In living organisms nucleic acids (DNA and RNA have important roles and functions related to their properties. The sequence of bases in the DNA molecule determines the structure of proteins, including enzymes.

The double helix and its four bases store the information that is passed from generation to generation. The sequence of the base pairs adenine, thymine, cytosine and guanine tell ribosomes in the cytoplasm how to construct amino acids into polypeptides and produce every characteristic we see. DNA can mutate leading to diseases including cancer and sometimes anomalies in the genetic code are passed from parents to babies in disease such as cystic fibrosis, or can be developed in unborn foetuses such as Downs Syndrome.

Read the information on these websites (you could make notes if you wish):

<http://www.bbc.co.uk/education/guides/z36mmp3/revision>

<http://www.s-cool.co.uk/a-level/biology/dna-and-genetic-code>

And take a look at these videos:

<http://ed.ted.com/lessons/the-twisting-tale-of-dna-judith-hauck>

<http://ed.ted.com/lessons/where-do-genes-come-from-carl-zimmer>

### **Task:**

**Produce a wall display to put up in your classroom in September. You might make a poster or do this using PowerPoint or similar.**

Your display should use images, keywords and simple explanations to:

Define gene, chromosome, DNA and base pair

Describe the structure and function of DNA and RNA

Explain how DNA is copied in the body

Outline some of the problems that occur with DNA replication and what the consequences of this might be.

### **Evolution**

Transfer of genetic information from one generation to the next can ensure continuity of species or lead to variation within a species and possible formation of new species. Reproductive isolation can lead to accumulation of different genetic information in populations potentially leading to formation of new species (speciation). Sequencing projects have read the genomes of organisms ranging from microbes and plants to humans. This allows the sequences of the proteins that derive from the genetic code to be predicted. Gene technologies allow study and alteration of gene function in order to better understand organism function and to design new industrial and medical processes.

Read the information on these websites (you could make notes if you wish):

<https://www.bbc.co.uk/bitesize/guides/zcqbdxs/revision/1>

<http://www.s-cool.co.uk/a-level/biology/evolution>

And take a look at these videos:

<http://ed.ted.com/lessons/how-to-sequence-the-human-genome-mark-j-kiel>

<http://ed.ted.com/lessons/the-race-to-sequence-the-human-genome-tien-nguyen>

### **Task:**

**Produce a one page revision guide for an AS Biology student that recaps the key words and concepts in this topic.**

Your revision guide should:

Describe speciation

Explain what a genome is

Give examples of how this information has already been used to develop new treatments and technologies.

## **Cells**

The cell is a unifying concept in biology, you will come across it many times during your two years of A level study. Prokaryotic and eukaryotic cells can be distinguished on the basis of their structure and ultrastructure. In complex multicellular organisms cells are organised into tissues, tissues into organs and organs into systems. During the cell cycle genetic information is copied and passed to daughter cells. Daughter cells formed during mitosis have identical copies of genes while cells formed during meiosis are not genetically identical

Read the information on these websites (you could make notes if you wish):

<http://www.s-cool.co.uk/a-level/biology/cells-and-organelles>

<https://www.bbc.co.uk/bitesize/topics/z2s8v9q>

And take a look at these videos:

<https://www.youtube.com/watch?v=gcTuQpuJyD8>

<https://www.youtube.com/watch?v=L0k-enzoeOM>

<https://www.youtube.com/watch?v=qCLmR9-YY7o>

### **Task:**

**Produce a one page revision guide to share with your class in September summarising one of the following topics: Cells and Cell Ultrastructure, Prokaryotes and Eukaryotes, or Mitosis and Meiosis.**

Whichever topic you choose, your revision guide should include:

Key words and definitions

Clearly labelled diagrams

Short explanations of key ideas or processes.

## **Exchange and Transport**

Organisms need to exchange substances selectively with their environment and this takes place at exchange surfaces. Factors such as size or metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems. Substances are exchanged by passive or active transport across exchange surfaces. The structure of the plasma membrane enables control of the passage of substances into and out of cells

Read the information on these websites (you could make notes if you wish):

<http://www.s-cool.co.uk/a-level/biology/gas-exchange>

<http://www.s-cool.co.uk/a-level/biology/nutrition-and-digestion/revise-it/human-digestive-system>

And take a look at these videos:

<http://ed.ted.com/lessons/insights-into-cell-membranes-via-dish-detergent-ethan-perlstein>

<http://ed.ted.com/lessons/what-do-the-lungs-do-emma-bryce>

### **Task:**

**Create a poster or display to go in your classroom in September. Your poster should either: compare exchange surfaces in mammals and fish or compare exchange surfaces in the lungs and the intestines. You could use a Venn diagram to do this.**

Your poster should:

Describe diffusion, osmosis and active transport

Explain why oxygen and glucose need to be absorbed and waste products removed

Compare and contrast your chosen focus.

### **Biological Molecules**

Biological molecules are often polymers and are based on a small number of chemical elements. In living organisms carbohydrates, proteins, lipids, inorganic ions and water all have important roles and functions related to their properties. DNA determines the structure of proteins, including enzymes. Enzymes catalyse the reactions that determine structures and functions from cellular to whole-organism level. Enzymes are proteins with a mechanism of action and other properties determined by their tertiary structure. ATP provides the immediate source of energy for biological processes.

Read the information on these websites (you could make more Cornell notes if you wish):

<http://www.s-cool.co.uk/a-level/biology/biological-molecules-and-enzymes>

<https://www.bbc.co.uk/bitesize/guides/zcttv9q/revision/1>

And take a look at these videos:

<https://www.youtube.com/watch?v=H8WJ2KENIK0>

<http://ed.ted.com/lessons/activation-energy-kickstarting-chemical-reactions-vance-kite>

#### **Task:**

**Krabbe disease occurs when a person doesn't have a certain enzyme in their body. The disease effects the nervous system. Write a letter to a GP or a sufferer to explain what an enzyme is.**

Your letter should:

Describe the structure of an enzyme

Explain what enzymes do inside the body

### **Scientific and Investigative Skills**

As part of your A level you will complete a practical assessment. This will require you to carry out a series of practical activities as well as planning how to do them, analysing the results and evaluating the methods. This will require you to: use appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH), use appropriate instrumentation to record quantitative measurements, such as a colorimeter or photometer, use laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions, use of light microscope at high power and low power, including use of a graticule, produce scientific drawing from observation with annotations, use qualitative reagents to identify biological molecules, separate biological compounds using thin layer/paper chromatography or electrophoresis, safely and ethically use organisms, use microbiological aseptic techniques, including the use of agar plates and broth, safely use instruments for dissection of an animal organ, or plant organ, use sampling techniques in fieldwork.

#### **Task:**

**Produce a glossary for the following key words:**

accuracy, anomaly, calibration, causal link, chance, confounding variable, control experiment, control group, control variable, correlation, dependent variable, errors, evidence, fair test, hypothesis, independent, null hypothesis, precision, probability, protocol, random distribution, random error, raw data, reliability, systematic error, true value, validity, zero error,

# Task 2 – Maths skills for A-Level Biology

A level Biology will use some of your maths skills from GCSE maths and build on this to help you understand new and more demanding ideas. At least 10% of the questions on your final exam will require you to use some form of mathematical skill. Complete the following tasks to make sure your maths skills are up to date and you are ready to start studying:

## 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<sup>2</sup>), cubic metre (m<sup>3</sup>), 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 <sup>9</sup>	giga	G
10 <sup>6</sup>	mega	M
10 <sup>3</sup>	kilo	k
10 <sup>-2</sup>	centi	c
10 <sup>-3</sup>	milli	m
10 <sup>-6</sup>	micro	μ
10 <sup>-9</sup>	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  $9.0 \times 10^{-8}$  m and  $1.20 \times 10^{-7}$  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:

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

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

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.

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

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

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

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

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

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  $\mu\text{m}$  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  $\mu\text{l}$

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  $\mu\text{l}$

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<sup>2</sup>    0.03 cm<sup>2</sup>    0.0218 cm<sup>2</sup>    0.034 cm<sup>2</sup>

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,  $1.5 \times 10^7$  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  $3.72 \times 10^{13}$ .

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  $4.5 \times 10^{-7}$ .

#### 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  $4.7 \times 10^9$     c  $1.2 \times 10^{12}$     d  $7.96 \times 10^{-4}$

## 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:

$9.42 \times 10^{-5}$     $1.56 \times 10^8$

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  $5.90 \times 10^2$

**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 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  $\mu\text{m}$  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  $\mu\text{m}$ . Give your answer in  $\mu\text{m}^2$ .
- 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  $N_t = N_o \times 2^n$  where  $N_t$  = number after time  $t$ ,  $N_o$  = 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

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

where  $n$  = number of each species,  $N$  = grand total of all species, and  $D$  = diversity.

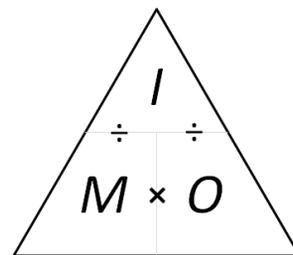
**Remember:** In this equation there is a part that needs to be done several times then summed, shown by the symbol  $\Sigma$ .

### 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:

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

#### 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 cm<sup>2</sup>. 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 dm<sup>3</sup> min<sup>-1</sup> 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  $\times 12$

b objective  $\times 40$  and eyepiece  $\times 15$

### 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.

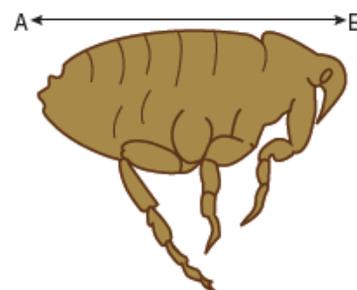
The image shows a flea which is 1.3 mm long. To calculate the magnification of the image, measure the image (or the scale bar if given) on the paper (in this example, the body length as indicated by the line A–B).

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

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

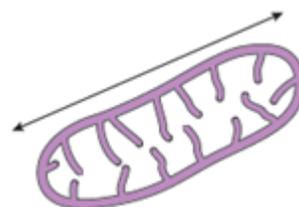
The magnification factor should therefore be written as  $\times 32.31$

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  $\mu\text{m}$  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.

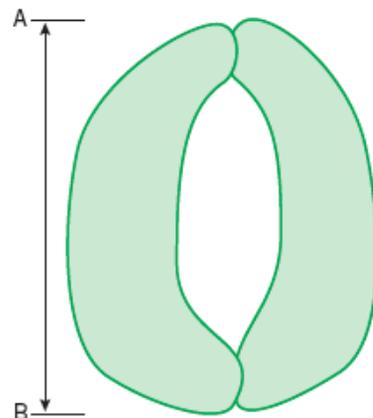
**Step 2:** Convert this measurement to units appropriate to the image. In this case you should use  $\mu\text{m}$  because it is a cell.

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:

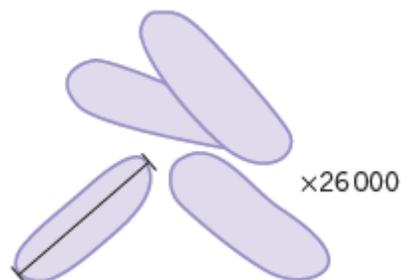
$$\text{real size} = \text{size of image} / \text{magnification} = 52\,000 / 5000 = 10.4$$

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 <sup>2</sup>
Energy transferred to primary consumers	2240 kJ/m <sup>2</sup>
Energy transferred to secondary consumers	480 kJ/m <sup>2</sup>

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

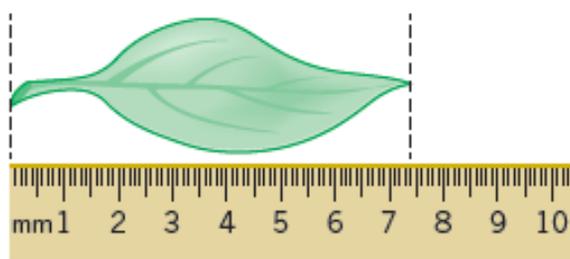
3 Convert the following mass changes as percentage changes.

Sucrose conc. / mol dm <sup>-3</sup>	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<sup>3</sup> 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 on the previous page, the absolute error is +/-0.5 mm.

The relative error is therefore:

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

### Practice question

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 <sup>3</sup> of liquid	0.5 cm <sup>3</sup> divisions		
Change in mass of 1.6 g	balance with 2 d.p.		