Transition to A-level Biology Work

Hello Year 11, and welcome to the transition work for A-level Biology. In order for you to consolidate what you have learnt in Year 11 and ease your transition into Year 12 Biology you will need to complete the following pack.

The pack is divided into the following sections:

Section titles	**Sets of practice questions**
Maths	7
Biological molecules	5
Cell structure	3
DNA and protein synthesis	4

Once you have answered the questions for a particular section you should make a set of flashcards to help you memorise what you learnt in the sections. These can either be physical flashcards, or I would recommend the program 'Anki' as an excellent app that you can download onto your phone or computer https://apps.ankiweb.net/

The answers to the questions should be completed either as a typed document or hand-written and saved in a safe place, with the title of the section clearly visible.

To do this work properly including the time taken for testing yourself using flashcards you should expect to spend between 10 and 12 hours work on this pack.

If you have any question please contact Dr Fisher at dawn.fisher@paddington-academy.org

Good luck!

Section 1: Maths

Units

*Whatever you're investigating in Biology, **units** are important. Without them, a measurement just doesn't make sense. Sometimes you might need to change between units, so knowing how to do a conversion is a pretty useful skill to have.*

Here Are Some Common Units You Might See

Height and Length

1 kilometre = 1000 metres
1 metre = 100 centimetres
1 centimetre = 10 millimetres
1 millimetre = 1000 micrometres

kilometres (km)
metres (m)
centimetres (cm)
millimetres (mm)
micrometres (μm)

Area

square metres (m^2)
square centimetres (cm^2)

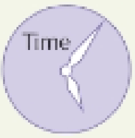
1 square metre = 10 000 square centimetres

kilograms (kg)
grams (g)
milligrams (mg)
micrograms (μg)

1 kilogram = 1000 grams
1 gram = 1000 milligrams
1 milligram = 1000 micrograms

cubic decimetres (dm^3)
cubic centimetres (cm^3)
microlitres (μl)

1 cubic decimetre = 1000 cubic centimetres
1 cubic centimetre = 1000 microlitres



hours (h)
minutes (min)
seconds (s)
milliseconds (ms)

1 hour = 60 minutes
1 minute = 60 seconds
1 second = 1000 milliseconds

You Might Need To Convert Between Units

Knowing how different units are related to each other can come in useful if you need to swap from one to the other. You just have to remember the number you have to multiply or divide by (the **conversion factor**).

When you're converting between units of length, mass or time:

- To convert from a **bigger** unit to a **smaller** unit, you need to **multiply** by the conversion factor.
- To convert from a **smaller** unit to a **bigger** unit, you need to **divide** by the conversion factor.

E.g. from m to cm: 2 m × 100 = 200 cm

Centimetres are smaller than metres, so this needs to be a multiplication.

1 m = 100 cm, so the conversion factor is 100.

E.g. from g to kg: 5000 g ÷ 1000 = 5 kg

Kilograms are bigger than grams, so this needs to be a division.

1 kg = 1000 g, so the conversion factor is 1000.

Area and Volume Are Trickier To Convert

Watch your step now... 1 m = 100 cm **does not** mean that 1 m^2 = 100 cm^2.
The easiest way to convert between units of area or **volume** is to remember that if a unit is **squared** or **cubed**, then you should do the **same** to the standard conversion factor.

1) To convert between units of area, follow this rule:

If the area units are **squared**, you should **square** the conversion factor.

The units are square metres.

E.g. from m^2 to cm^2: 5 m^2 × 10 000 = 50 000 cm^2

The conversion factor for m to cm is 100, so the conversion factor for m^2 to cm^2 is 100^2.
100 × 100 = 10 000

Units

2) To convert between units of volume, follow this rule:

If the volume units are **cubed**, you should **cube** the conversion factor.

The units are cubic decimetres.

E.g. from dm^3 to cm^3: $9\ dm^3 \times 1000 = 9000\ cm^3$

1 dm = 10 cm, so the conversion factor for dm^3 to cm^3 is 10^3. $10 \times 10 \times 10 = 1000$

Bernard's attempt to convert his horse into a tea towel was surprisingly successful.

Worked Example

A plant produces 5.4 cm^3 of oxygen in one hour.

Assuming that the rate of production is constant, how much oxygen does the plant produce per minute? Give your answer in $mm^3\ min^{-1}$.

The little '−1' just means 'per'. So $mm^3\ min^{-1}$ means mm^3 per minute. Sometimes units can get a bit more complicated, e.g. $cm^3\ g^{-1}\ hr^{-1}$ means cm^3 per gram per hour.

1 ***Work out the volume produced in one minute.***

1 hour = 60 minutes, so 5.4 cm^3 is produced in 60 minutes.

Divide by 60 to work out how much is produced per minute. → $5.4 \div 60 = \mathbf{0.09\ cm^3\ min^{-1}}$

0.09 cm^3 of oxygen is produced in one minute.

2 ***Work out the volume conversion factor.***

1 cm = 10 mm, so the conversion factor from cm to mm is **10**.

The units in the question are **cubic**, so the conversion factor needs to be **cubed** too. → The conversion factor = 10^3 = **1000**

3 ***Work out whether to multiply or divide.***

Millimetres are a **smaller** measurement than centimetres, so you are going from a **bigger** unit to a **smaller** unit. That means you need to **multiply** by the conversion factor.

4 ***Multiply the volume in cm^3 by the conversion factor to find the answer.***

$0.09\ cm^3\ min^{-1} \times 1000 = \mathbf{90\ mm^3\ min^{-1}}$

Don't forget to use the new units for your answer.

Practice Questions

Q1 Convert the following:

a) 42 kg to grams. b) 5 m^3 to cubic centimetres. c) 2000 cm^2 to square metres.

Q2 The body of a locust is 7.1 cm long and its mass is 1.8 g.

a) What is its length in metres? b) What is its mass in milligrams?

Q3 An adult human's kidneys process approximately 1200 cm^3 of blood every minute.

a) What is this volume in cubic decimetres?

b) How much blood is processed by the kidneys every second? Give your answer in mm^3.

I asked my gran about units and she taught me how to crochet...

A simple trick for perfectly converted units is to always check your answer — the number of small units should always be greater than the number of big units. If it's the other way round, you've probably gone the wrong way.

Standard Form

*Standard form is useful for writing **very big** or **very small** numbers in a **simpler** way.*

Standard Form Gets **Rid** of Some **0s**

Very big or **very small** numbers can have **loads of zeros** (e.g. 640 000 000 or 0.000000015), but writing them in standard form can be more convenient. It converts the number into one **between 1 and 10**.

The decimal point **moves**, and the zeros are represented by a **power of 10**. For example...

The number of bacteria in a culture is estimated to be 1 000 000.

1 000 000 can be written in standard form like this: 1×10^6

10^6 is a shorter way of writing $10 \times 10 \times 10 \times 10 \times 10 \times 10$.

The decimal place is moved left to after the 1.

A bacterium is 0.0017 mm long.

0.0017 can be written in standard form like this: 1.7×10^{-3}

If this small number is negative, it means that the number is less than 1.

The decimal place is moved to between the 1 and 7.

Numbers in Standard Form Need to be Written in an **Exact Form**

Numbers in standard form will always look like this:

$$A \times 10^n$$

This number (A) is always between **1** and **10**.

This (n) is the **number of places** the **decimal point** moves. n is positive for big numbers, and negative for numbers smaller than 1.

To write a number in standard form, you just have to **count** how many places the decimal point has moved. You also need to know which **direction** it has moved in.

1) If the decimal point has been moved to the **left**, n should be **positive**. For example:

$$14\,800 = 1.48 \times 10^4$$

The decimal point has moved four places, so $n = 4$.

The decimal point has moved to the left, so n is positive.

2) If the decimal point has been moved to the **right**, n should be **negative**. For example:

$$0.000072 = 7.2 \times 10^{-5}$$

The decimal point has moved five places, so $n = 5$.

The decimal point has moved to the right, so n is negative.

Your calculator might display a number in standard form like this: 7.986 ^{15}

This is the same as $\mathbf{7.986 \times 10^{15}}$.

It is **definitely not** the same as 7.986^{15} — the '**× 10**' bit is really important, so don't forget to include it when you're writing the number down.

"...or, for just £9.99, you can upgrade to premium form... and I'll even throw in this pen."

Standard Form

Worked Example

A patient has been prescribed a daily dose of 0.0004 grams of a drug.

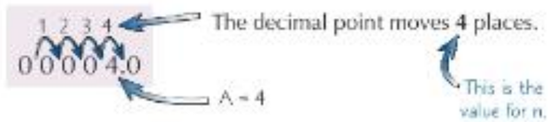
a) **Write this dose in standard form.**

b) **The tablets that the hospital stocks each contain 8×10^{-5} grams of the drug. How many tablets should the patient be given each day?**

1 ***For part a), count the number of places that the decimal point has to move.***

You want to write 0.0004 in the form $A \times 10^n$.

To make 'A' a number between 1 and 10, you need to place the decimal point **after** the first digit that **isn't a 0**.



2 ***Work out whether n should be positive or negative.***

It's a number smaller than 1 and the decimal point has moved to the **right**, so n should be **negative**.

$0.0004 = \mathbf{4 \times 10^{-4}}$

3 ***For part b), write 8×10^{-5} as an ordinary number.***

$n = -5$, so the decimal point has been moved **5 places** to the **right**.

To get the normal number, you need to move the decimal point **back 5 places** to the **left**.

8 is the same as 8.0 — it's just written without the decimal point.

5 4 3 2 1

$8 \times 10^{-5} = 0.00008$

4 ***Divide the number of grams in the dose by the number of grams in each tablet to get the answer.***

The patient has been prescribed **0.0004 grams** of the drug.

You've worked out that there are **0.00008 grams** of drug in each tablet.

$0.0004 \div 0.00008 =$ **5 tablets**

Practice Questions

Q1 Copy and complete the table on the right.

Ordinary Number	84 100			0.000022
Standard Form		5.412×10^4	7.46×10^9	

Q2 The total amount of light energy converted to chemical energy by a plant in a year is 2.53×10^7 Jm^{-2}.

a) Write this amount as an ordinary number.

b) The plant loses 9.8×10^6 Jm^{-2} of the energy through respiration. How much energy does it have left? Give your answer in standard form.

I thought a standard form asks for your name and date of birth...

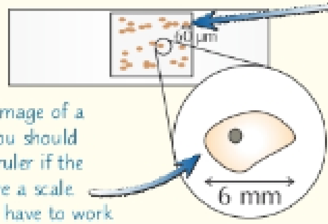
Don't let standard form bother you — it's really just there to save you writing down a bunch of zeros. If you're doing a calculation with numbers in standard form, just write out the numbers in their ordinary form and work with them. Easy.

Magnification

Even when looking down a microscope, you can't escape from equations...

Magnification is How Large an Image is Compared to the Object's Real Size

We all know that microscopes produce a magnified image of a sample.
Magnification is how much bigger the **image** is than the **real thing**.



Cells are usually between 1 and 100 µm long (1 µm = 0.001 mm).

If you're given an image of a cell in an exam, you should measure it with a ruler if the image doesn't have a scale. Sometimes you'll then have to work out its actual size using a scale.

The actual size of the cell is 60 µm and the magnified image measures 6 mm. So the image is **100 times bigger** than the cell — the magnification is **× 100.**

Calculate the Magnification Using This Equation

The **equation** for working out the magnification is:

$$\text{magnification} = \frac{\text{size of image}}{\text{size of real object}}$$

Both of these measurements should have the same units. If they don't, you'll need to do a conversion. See pages 8-9 for a reminder.

When dealing with microscopes the **units** can get pretty tiny.
Here are some common units you might use:

To convert:	Unit	How many millimetres it is:	To convert:
	Millimetre (mm)	1 mm	
÷ 1000	Micrometre (µm)	0.001 mm	× 1000
÷ 1000	Nanometre (nm)	0.000001 mm	× 1000

To convert from a smaller unit to a larger unit, divide by the conversion factor. To convert from a larger unit to a smaller unit, multiply by the conversion factor.

Worked Example 1

A rhinovirus particle is 0.023 µm in diameter.
Its magnified image produced by a microscope is 0.0345 mm.
What is the magnification of the microscope?

1. ***Make sure the measurement are in the same units.***

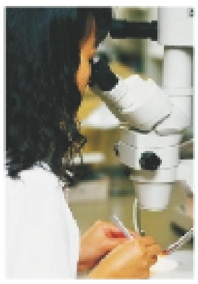
   Change 0.0345 mm into micrometres.
   1 mm = 1000 µm

   0.0345 mm × 1000 = **34.5 µm**

2. ***Use the equation to work out the magnification.***

   The size of the image. → 34.5 µm
   The size of the real rhinovirus particle. → 0.023 µm

$$\frac{34.5\ \mu m}{0.023\ \mu m} = \times\ 1500$$



Having mastered the magnification equation, Meridith took her knitting to a whole new level.

Magnification

Worked Example 2

The diameter of a capillary is 8 μm. Charlie examines the capillary under a × 50 microscope lens.
What is the diameter of the capillary in the magnified image in millimetres?

1. ***Rearrange the equation.***

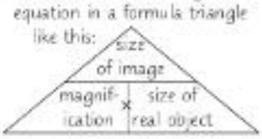
The question asks about the diameter of the capillary in the **image**.
So rearrange the equation to get 'size of image' by itself.

$$\text{magnification} \times \textbf{size of real object} = \frac{\text{size of image}}{\cancel{\text{size of real object}}} \times \cancel{\textbf{size of real object}}$$

Multiply both sides of the equation by 'size of real object' — on this side it's cancelled out.

magnification × size of real object = size of image

You can also write the magnification equation in a formula triangle like this:



You can use the triangle to help you rearrange the equation. All you do is put your finger over the bit you want and read off the formula. E.g. if you want the size of the image, you put your finger over that and it leaves behind magnification × size of real object.

2. ***Use the equation to work out the size of the image.***

The diameter of the capillary is **8 μm**.
The magnification is **× 50**.

50 × 8 μm = **400 μm**

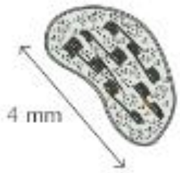
The units for the real object are the same as the units of the image.

3. ***Convert the answer from μm to millimetres.***

Divide by 1000 to get millimetres. → 400 μm ÷ 1000 = **0.4 mm**

Practice Questions

Q1 In a microscope image, a chloroplast's length measures 4 mm.
Its real length is 10 μm.
What is the magnification?

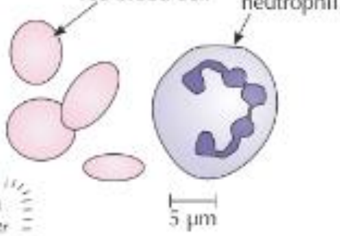


Q2 A virus has a diameter of 0.12 μm.

a) In a microscope image, the virus has a diameter of 6 mm. What is the magnification of the microscope?

b) The same virus is examined with a × 15 000 microscope lens.
What is the diameter of the magnified image? Give your answer in millimetres.

Q3 Laura examined a blood smear with a × 400 microscope lens.
A diagram of her observation is on the right.



a) The observed diameter of the labelled red blood cell was 2.8 mm.
What was its real diameter? Give your answer in micrometers (μm).

b) What magnification should Laura use to get an image of the labelled red blood cell that is 4 mm in diameter?
Give your answer to the nearest hundred.

c) Use the scale underneath the diagram to estimate the real diameter of a neutrophil to the nearest micrometer.

You'll need a ruler to answer Q3 c).

It's time to put another equation under the microscope...

Knowing the magnification equation is an easy way to pick up marks if it turns up in your exam. Just remember to keep an eye on the units you're using — the image and the real object need to have the same units for the calculation to work.

Magnification

Worked Example 2

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Multiply both sides of the equation by 'size of real object' — on this side it's cancelled out.

magnification × **size of real object** = size of image / ~~size of real object~~ × **~~size of real object~~**

magnification × size of real object = size of image

2 ***Use the equation to work out the size of the image.***

The diameter of the capillary is **8 µm**.
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50 × 8 µm = **400 µm**

The units for the real object are the same as the units of the image.

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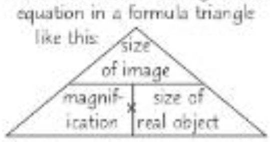

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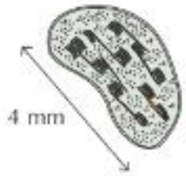

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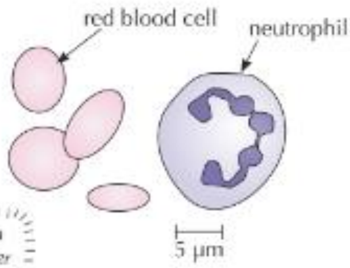

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c) Use the scale underneath the diagram to estimate the real diameter of a neutrophil to the nearest micrometer.

You'll need a ruler to answer Q3 c)

It's time to put another equation under the microscope...

Knowing the magnification equation is an easy way to pick up marks if it turns up in your exam. Just remember to keep an eye on the units you're using — the image and the real object need to have the same units for the calculation to work.

Tables of Data

***Tables** are all over the place in Biology. Make sure you know how to use them...*

Tables Show Data in Rows and Columns

This is a **simple table**:

The **top row** has headings showing what's recorded in each column.

In this table, each row tells you about a **different person**.

This row is for a person who weighs 85 kg and is 1.82 m tall.

Weight / kg	Height / m
70	1.58
53	1.54
85	1.82
61	1.59

Rows go from side to side.

Columns go up and down.

This is a **frequency table**:

Frequency tables show the **number of times** something occurs.

The first column gives the **values** or **names** of the different pieces of data.

Flower colour	Tally	Frequency
Red	III	3
White	IIII IIII II	12
Purple	IIII IIII	9

The data is recorded with **tally marks**. Each mark represents one piece of data.

The tally marks are added up to get the **frequency**.

5 results are written as IIII, not IIIII. This makes it easier to keep track of the numbers.

This is a **two-way table**:

Two-way tables have labels **down the side** as well as along the **top**. They are useful when there are two things that you're interested in.

	Number of Cases			
Hospital	Jan	Feb	Mar	Total
A	4	9	2	15
B	10	4	1	15
Total	14	13	3	30

Two-way tables normally show **frequencies**. This table shows the number of cases in two different hospitals over three months.

Two-way tables often have a **total** row and/or column. Lots of statistical calculations need you to use the total, so including these can be really useful.

Raw data (the set of individual bits of information) is really difficult to work with — tables are a great way of summarising it.

Look at both sets of labels to see what a number means. This is the number of cases in Hospital B in January.

Be Careful with the Units

If you're reading from a table...

1) Make sure you **read all the labels** on a table carefully before you start using it. It saves a lot of trouble later on.
2) Read **down** or **across** from the relevant heading to find the entry you're looking for, paying attention to the **units**.

If you're drawing a table...

Amount of maths in Biology lesson / %	Length of fingernails chewed off / cm
20	0.2
40	0.3
95	0.6

1) Remember to include a clear heading for each row and/or column.
2) Include the units in the headings for any data that needs them, rather than writing them over and over in the table. Make sure all the information in a row/column is in the same units.

Your data should be recorded to a consistent number of decimal places.

Tables of Data

Worked Example

A biologist investigating the diversity of fish species in two different habitats recorded the data in the table on the right.

a) How many fish from species D were observed in the river habitat?

b) How many fish did the biologist count in the lake habitat altogether?

	Number of fish of each species				
Habitat	A	B	C	D	E
Lake	0	1	6	14	1
River	1	9	3	2	5

1 ***For part a), find the row showing the data for the river habitat.***

	Number of fish of each species				
Habitat	A	B	C	D	E
Lake	0	1	6	14	1
River	1	9	3	2	5

This row shows the number of each fish species in the river.

2 ***Read across the row until you reach the column showing the number of fish from species D.***

	Number of fish of each species				
Habitat	A	B	C	D	E
Lake	0	1	6	14	1
River	1	9	3	2	5

This column shows the number of fish from species D.

The number of fish from species D in the river is the number where the row and the column meet.

2 fish from species D were observed in the river habitat.

3 ***For part b), add up the number of fish from each species to get the total number that the biologist counted in the lake.***

	Number of fish of each species				
Habitat	A	B	C	D	E
Lake	0	1	6	14	1
River	1	9	3	2	5

$0 + 1 + 6 + 14 + 1 = 22$

22 fish were counted in the lake habitat.

Practice Question

Q1 Iman was investigating the effect of temperature on seedling growth rate. Some of her results are shown in the table below.

a) On day 20, the mean height of the seedlings grown at 20 °C was 32 mm, the mean height of the seedlings grown at 10 °C was 15 mm and the mean height of seedlings grown at 15 °C was 22 mm.
Copy the table and add in this missing data.

b) How much did the mean height of seedlings grown at 20 °C change between day 10 and day 15?

c) What was the difference between the mean height of seedlings grown at 15 °C and those grown at 10 °C on day 15?

	Mean seedling height / mm		
Day	10 °C	15 °C	20 °C
5	4	5	7
10	7	13	16
15	12	15	25
20			

I can't keep up with your two-way tables...

Tables crop up a lot as they're a nice, simple way of showing data, so make sure you know your stuff. If you need to draw one, label it up clearly. And whether you're reading from a table or drawing one, be careful with the units.

Ratios

***Ratios** help you to compare numbers in different groups...*

Ratios are a Way of **Comparing Quantities**

To write a ratio, you just need to write the number of one thing compared to the number of another thing, separated by a **colon**.

Here, for every **two squares** there are **seven circles**. So, the ratio of squares to circles is **2 : 7**.

Now, for every **two squares** there are **eight circles**. So, the ratio of squares to circles is **2 : 8**. However, ratios should be written in their **simplest form**, so this would be written as **1 : 4**.

Ratios don't just have to contain two numbers — they can contain as many numbers as there are categories. The ratio of the shapes below would be written as **1 : 5 : 7**.

Ratios can be used in biology to compare lots of different types of quantities.

For example, you can compare the surface area of an animal to its volume — this is called the surface area to volume ratio (see page 20). A ratio of 2 : 1 would mean an animal's surface area is twice as large as its volume.

Write Ratios in Their **Simplest Form**

Ratios are always written:

$$x : y$$

A colon separates one quantity from the other.

x and y stand for the quantities of each thing, for example, the surface area of an animal related to its volume.

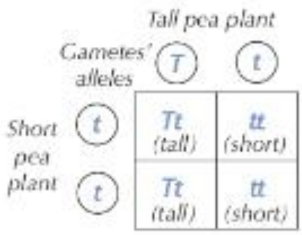
They are more helpful when written in their **simplest form**.

There are two ways to simplify ratios. These are shown in the examples below.

Worked Example 1

The genetic diagram on the right shows the results of a cross between a tall pea plant (with alleles Tt) and a short pea plant (with alleles tt).

What is the ratio (written in its simplest form) of tall pea plants to short pea plants in the offspring?



1 ***Put the numbers into a ratio.***

Count up all the possible genotypes for tall pea plants — Tt.
Then count up all the possible genotypes for short pea plants — tt.
This means the ratio in the offspring is 2 tall pea plants to 2 short pea plants, which is **2 : 2**.

2 ***Simplify the ratio.***

To get the ratio in its simplest form, divide each side by the same number until you reach the smallest whole number possible on one side.

÷ 2 (2 : 2 → 1 : 1) ÷ 2

So the ratio of tall pea plants to short pea plants is **1 : 1**.

Ratios

Worked Example 2

The table on the right shows body mass index (BMI) data split up for males (M) and females (F) in two cities. Those with a BMI of over 30 are obese.

Calculate the ratio of obese males to obese females in City A. Give your answer in the form 1 : *n*.

	City A		City B	
BMI	% F	% M	% F	% M
30 or under	76	77	74	78
Over 30	24	23	26	22

Be careful when you use ratios to compare numbers. If you're comparing results from groups that aren't the same size, make sure that the numbers have been turned into percentages first *(see p. 26).*

1 ***Find the numbers that you need for the ratio.***

First, find the right information in the table.
You've been told that a BMI of over 30 is obese, so you want the percentage of females and the percentage of males in City A that have a BMI over 30.

	City A		City B	
BMI	% F	% M	% F	% M
30 or under	76	77	74	78
Over 30	24	23	26	22

Use these numbers to make your ratio.
Make sure you get the ratio the right way round — the question asks for the ratio of males to females.
So, the ratio of obese males to obese females is **23 : 24**.

2 ***Simplify the ratio.***

You might have noticed that this ratio doesn't simplify easily — you can't divide each side by the same number to get whole numbers.

Instead the question asks you to simplify the first number to 1. This means that the second number will become a decimal.

÷ 23 (23 : 24) ÷ 23
1 : 1.04

To get 1 on the left-hand side, divide both sides by 23.

So the ratio of obese males to obese females is **1 : 1.04**.

Practice Questions

Q1 A cross between two pea plants resulted in 36 plants with smooth seeds and 12 plants with wrinkled seeds. Write the ratio of smooth seeds to wrinkled seeds in the form *n* : 1.

Q2 Two students were investigating the nutritional value of different types of chocolate bar. Their results are shown in the table on the right.

a) Calculate the ratio of saturated fat to total fat for chocolate bar A.

b) Calculate the ratio of total fat to sugars for chocolate bar C.

	Nutritional Information per 100g			
Bar	Total fat / g	Saturated fat / g	Total carbohydrate / g	Sugars / g
A	30	15	59	56
B	27	15	55	54
C	45	27	24	12

Q3 Dylan is measuring his lung volume. A spirometer trace shows that the volume of air he takes in during one breath (his tidal volume) is 0.4 dm^3 and the maximum volume of air he can breathe in (his vital capacity) is 2.6 dm^3.
What is the ratio of Dylan's tidal volume to his vital capacity? Give your answer in the form 1 : *n*.

Q4 The rate of an enzyme-controlled reaction at 20 °C is found to be 0.29 $\mu mol\,dm^{-3}s^{-1}$.
The same reaction was repeated at 30 °C and the rate was found to be 0.52 $\mu mol\,dm^{-3}s^{-1}$.
Write the ratio of the rate of reaction at 30 °C to the rate of reaction at 20 °C in the form *n* : 1.

The ratio of maths questions I like to those I don't is 1 : 1000...

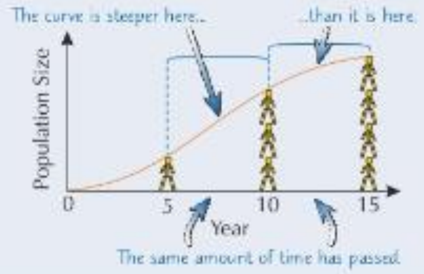
Ratios are just another way of comparing numbers, so don't let the colon throw you off. This stuff could pick you up a few extra marks, so make sure you understand what's going on. Practise simplifying ratios both ways, just in case.

Rates and Gradients

*Rates are pretty important in Biology and come up a lot — you've probably heard of breathing rate, growth rate or rate of reaction. Rate is simply a **measure** of how much something is changing over **time**.*

A Bigger Change Over Time Means a Faster Rate

If you plot your results on a graph with time on the x-axis, the **steepness** of the line (or curve) shows how fast the rate is. Just look at this:



The population increases **more** between years 5 and 10 than between years 10 and 15.

There is more growth over the same amount of time.

So the **rate** of population growth is higher between years 5 and 10.

Do This Calculation to Work Out the Rate

You might need to calculate a rate from a **table**. If so, you just need to use this equation:

$$\text{rate} = \frac{\text{change in dependent variable}}{\text{time taken for change}}$$

The dependent variable is the variable that's measured — e.g. height.

The change is a positive number if it's an increase, or a negative number if it's a decrease (which will give a negative value for the rate).

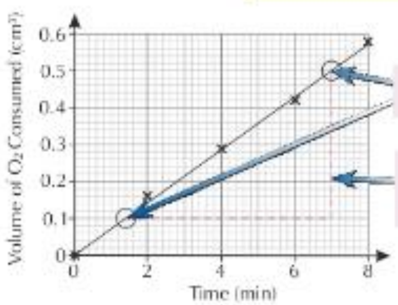
You might have to work out the difference between two values for each of these bits.

To calculate the rate from a **line graph** or a **line of best fit**, you need to work out the **gradient** of the line. The gradient is a value that tells you how **steep** the line is. You find it like this:

$$\text{rate} = \text{gradient} = \frac{\text{change in } y}{\text{change in } x}$$

This is the change in the y-axis (the dependent variable).

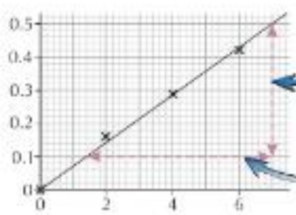
This is the change in the x-axis, which is the time taken for the change.



Pick two points on the line that are easy to read.

Then draw a vertical line down from one point and a horizontal line across from the other to make a **triangle**.

Try to make your triangle at least half the size of the graph.



The vertical side of the triangle is the change in y.
So here, it's 0.5 – 0.1 = **0.4 cm³**.

The horizontal side of the triangle is the change in x.
So here, it's 7.0 – 1.4 = **5.6 minutes**.

The growth rate of Bruno's ears was beginning to become a concern.

Rates and Gradients

Plug the Values into the *Formula*

You've now got the two values you need to plug into the gradient formula.

$$\text{rate} = \text{gradient} = \frac{0.4}{5.6} = \mathbf{0.07}$$

Rates always need to have **units**, and these are always:

$$\text{units} = \frac{\text{units of the dependent variable}}{\text{units of time}}$$

Here they're $cm^3\ min^{-1}$, so the rate is **0.07 $cm^3\ min^{-1}$**.

This means that the volume of O_2 consumed is increasing at a rate of 0.07 cm^3 per minute.

You might also see these units written as cm^3/min — they both mean cm^3 per minute.

Worked Example 1

The number of people living in a village in Cumbria was recorded every ten years as part of a 40 year study.

a) **What was the population growth rate between 1960 and 1970?**

b) **Was this higher or lower than the average population growth rate over the course of the study?**

Population	1114	1237	1882	2795	4909
Year	1950	1960	1970	1980	1990

1. ***To answer part a), work out the change in the population (the change in y).***

   In 1960, the population was 1237.
   In 1970, the population was 1882.

   1882 – 1237 = **645 people**

   If the population was decreasing, the change would be a negative number.

Population	1114	1237	1882	2795	4909
Year	1950	1960	1970	1980	1990

2. ***Work out the change in time (the change in x).***

   The difference in the two dates is **10 years**.

3. ***Divide the change in the population by the time taken for the change to get the rate.***

   645 people ÷ 10 years = **65 people year^{-1}**

   Don't forget to include the units for the rate. You can include the units throughout your calculation to help you work it out.

   The exact answer is 64.5, but you can't have 0.5 of a person so round the answer to the nearest whole number.

4. ***To answer part b), repeat steps 1-3 to calculate the population growth rate across the full 40 years.***

   3795 people ÷ 40 years = **95 people year^{-1}**

   The change in the population (4909 – 1114 = 3795).

   The number of years taken for the change.

   Now you can compare the two growth rates.

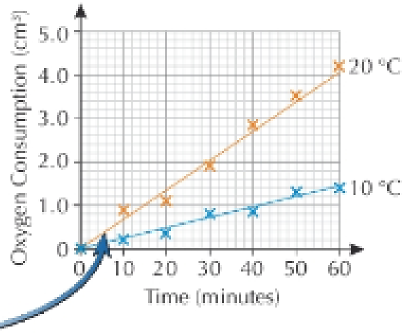
   95 is **bigger** than 65, so the population growth rate between 1960 and 1970 was **lower** than the population growth rate across the whole study.

Rates and Gradients

Worked Example 2

Janet was investigating the effect of temperature on the respiration rate of germinating seeds. She used oxygen consumption as a measure of respiration. Her results are shown in the graph on the right.

Calculate the rate of oxygen consumption for seeds germinating at 20 °C.

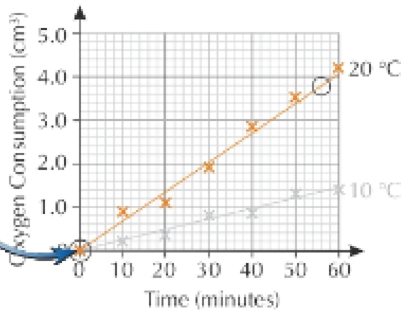


1 ***Find the line you need to look at.***

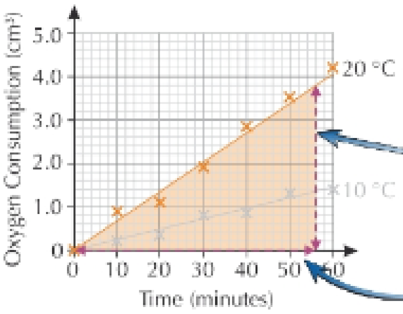
The question asks about seeds germinating at 20 °C, so you need to look at the orange line.

2 ***Find two points on the line that are easy to read.***

If the line goes through 0 on both axes (the origin), you can use that as one point — it will make the next step a bit easier.



You want to use points that have a clear *x* and *y* value, so use points where the line crosses both grid lines at once if you can.



3 ***Make a triangle using the two points. Then work out the length of its side and base.***

The scale on the *y*-axis means that every small square is worth 0.2 cm³.

So the **height** of the triangle is: 3.8 – 0 = **3.8 cm³**

The scale on the *x*-axis means that every small square is worth 2 minutes.

So the **base** of the triangle is: 56 – 0 = **56 minutes**

0 makes a nice easy calculation.

4 ***Use the equation to find the rate of oxygen consumption.***

The rate is equal to the **gradient** of the line. So put the values from step 3 into this equation:

$$\text{gradient} = \frac{\text{change in } y}{\text{change in } x}$$

This is the height of the triangle.

This is the base of the triangle.

rate = gradient = 3.8 cm³ ÷ 56 minutes = **0.068 cm³ min⁻¹ (to 2 s.f.)**

Round your answer to a sensible value.

Don't forget to include the units — it'll always be one unit over the other for rate.

Rates and Gradients

Practice Questions

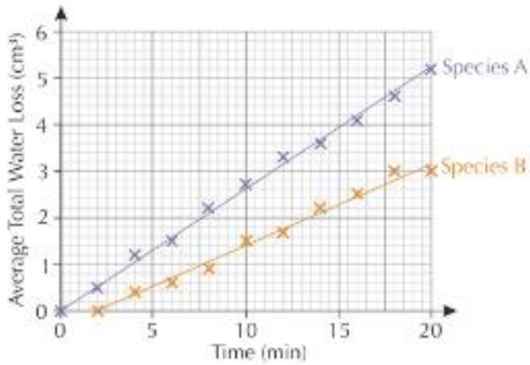
Q1 Josie was investigating the rate at which amylase breaks down starch. She used the concentration of maltose as a measure of how the reaction was progressing. Her results are shown in the table below.

a) The rate of reaction can be found by calculating the rate at which maltose is produced by the reaction.
Write down the units for the rate of reaction.

b) Calculate the rate of reaction for the first 20 minutes of the experiment.

Time / minutes	0	5	10	15	20	25
Maltose Concentration / $g\,\mu l^{-1}$	0.0	5.2	10.7	15.6	19.1	25.2

Q2 An investigation into transpiration rate was carried out using two different plant species. The average total water loss per 100 g for each species was recorded every two minutes. The results are shown in the graph on the right.



a) Which plant species had a faster transpiration rate? Explain your answer.

b) Use the graph to calculate the transpiration rate for Species B.

Q3 Kyle was investigating the effect of auxin concentration on plant growth.
He removed the tips from three different shoots and coated each with a different concentration of auxin.
The table on the right shows a summary of his results.

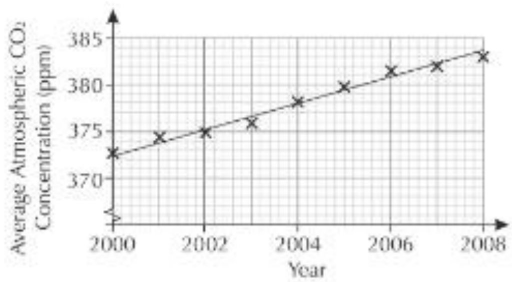
a) What was the average growth rate for Shoot 1? Give your answer in mm $hour^{-1}$.

You might need to work out a rate in different units to the units given in the data. It's okay though — just convert each value before you pop it into the equation. There's more about converting units on pages 8-9.

b) Which shoot had the highest growth rate?

	Height / cm		
Days of growth	Shoot 1	Shoot 2	Shoot 3
0	1.2	3.2	3.5
5	1.8	4.9	4.1
10	2.6	7.0	4.9
15	4.2	9.2	6.0
20	5.9	11.6	6.9
25	8.2	13.9	7.1
30	9.9	16.3	8.2

Q4 The graph on the right shows the average atmospheric CO_2 concentration in a forest, recorded over a period of 8 years.
At what rate did the CO_2 concentration increase?



My rate of learning about graphs is at an all-time high...

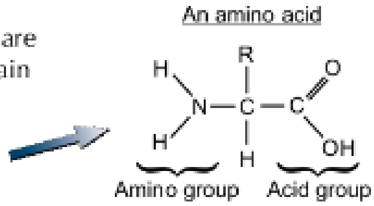
Being able to calculate a rate can come in really handy, so keep practising until you can do it blindfolded, at night, upside down... you get the picture. Just make sure to always include the units, or your answer won't make much sense.

Section 2: Biological Molecules

Proteins

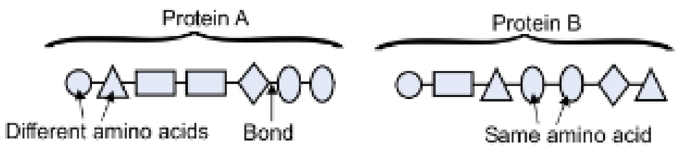
Proteins are Made of Amino Acids

Proteins are composed of long chains of **amino acids**. There are **twenty different** amino acids used in proteins. They all contain carbon, hydrogen, oxygen and nitrogen, and some contain sulfur. All have the **same structure** as the one in the diagram but **R** can be one of twenty different chemical groups.



Proteins are Held Together by Peptide Bonds

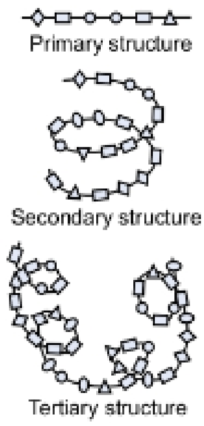
1) The chains of amino acids are attached to each other by **strong peptide bonds**.
2) The amino acids can be arranged in any sequence and proteins can be up to **several hundred** amino acids long.
3) The number of different proteins that are possible is almost unimaginable. Consider that there are several thousand ways of arranging a chain of just three amino acids, with each combination forming a different protein. Add one more amino acid to the chain and the number of possibilities leaps into the hundreds of thousands.
4) It's the **order** of the amino acids in a protein that determines its **structure** and it's the structure of a protein that determines **how it works**.



(N.B. Each different shape represents a different amino acid.)

Each Protein has its Own Special Shape

1) The order in which the amino acids are arranged in a protein chain is called the **primary structure**.
2) Some chains **coil up** or **fold** into pleats that are held together by weak forces of chemical attraction called **hydrogen bonds**. The coils and pleats are the **secondary structure** of a protein.
3) Some proteins (especially enzymes) have a **tertiary structure**. The coiled chain of amino acids is folded into a **ball** that's held together by a mixture of weak chemical bonds (e.g. hydrogen bonds) and stronger bonds (e.g. disulfide bonds).
4) If the protein has a roughly spherical shape it's called a **globular protein** (e.g. enzymes are classed as globular proteins).



The name's Bond. Peptide Bond...

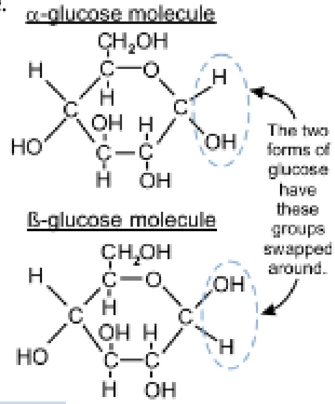
1) What is the primary structure of a protein?
2) What type of bond holds together the secondary structure of a protein?

Carbohydrates

Carbohydrates Contain Three Elements

Carbohydrates contain **carbon**, **hydrogen** and **oxygen**. There are several types of carbohydrate, e.g. sugars, starch and cellulose.

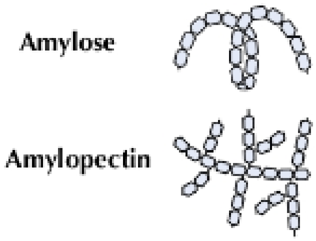
1) Sugars are **small**, **water-soluble** molecules that taste sweet.
2) They're divided into two groups: **monosaccharides** (pronounced: mono-sack-a-rides) and **disaccharides** (die-sack-a-rides).
3) Monosaccharides are the single units from which all the other carbohydrates are built. **Glucose** and **fructose** are both monosaccharides. Glucose has two forms — **alpha** (α) and **beta** (ß).
4) Disaccharides are formed when **two monosaccharides** are joined together by a chemical reaction. A molecule of **water** is also formed (so it's called a **condensation reaction**).



GLUCOSE + GLUCOSE → MALTOSE (a disaccharide) + WATER
GLUCOSE + FRUCTOSE → SUCROSE (a disaccharide) + WATER

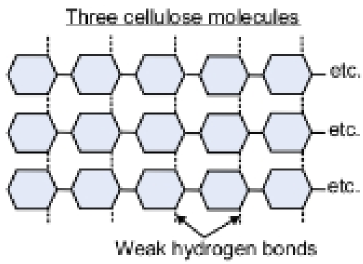
Starch is a Polysaccharide

Polysaccharides are **polymers** — large molecules made up of **monomers** (smaller units). The monomers of polysaccharides are **monosaccharides**. **Starch** molecules are made up of two different polysaccharides — **amylose** and **amylopectin**, which are polymers of glucose. The insoluble, compact starch molecules are an ideal way of **storing glucose**. Starch is **only** found in plant cells.



Cellulose is Also a Polysaccharide

1) Like starch, cellulose is a polymer of glucose, but the **bonding** between the glucose units is different.
2) As a result, the cellulose molecules are **long** and **straight**.
3) Several cellulose molecules can lie side by side to form **microfibrils**.
4) The molecules are held together by many weak **hydrogen bonds**.
5) Cellulose is only found in plant cells.
6) The microfibrils **strengthen** the plant cell wall.



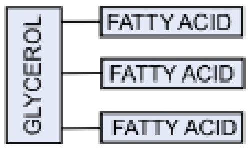
A poly-sack-a-ride — a bunch of kids on a helter skelter...

1) Name two monosaccharides.
2) Which disaccharide is composed of two molecules of glucose?
3) Name two polysaccharides.

Lipids

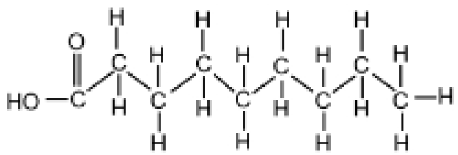
Lipids** Contain **Carbon**, **Hydrogen** and **Oxygen

Lipids are **oils** and **fats**. Plant oils and animal fats are mostly made up of a group of lipids called **triglycerides**. A triglyceride consists of a molecule of **glycerol** with **three fatty acids** attached to it.

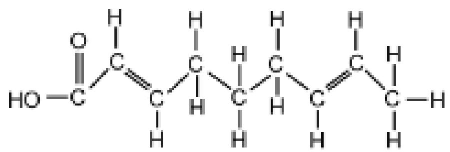


A **triglyceride**

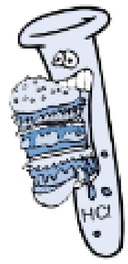
A fatty acid molecule is a long chain of **carbon atoms** with an **acid group** (-COOH) at one end. **Hydrogen atoms** are attached to the carbon atoms. If every carbon atom in the chain is joined by a **single bond**, we say that the fatty acid is **saturated**. If one or more of the bonds is a **double bond**, it's said to be **unsaturated**. A fatty acid with many double bonds is **polyunsaturated**.



Saturated fatty acid



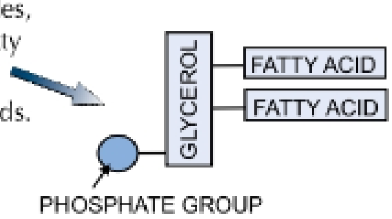
Unsaturated fatty acid



Phospholipids** are a **Special** Type of **Lipid

Phospholipids (pronounced: foss-foe-lip-id) are like triglycerides, but instead of having three fatty acid chains, they have **two** fatty acid chains and a **phosphate** group.

Cell membranes are made from a **double layer** of phospholipids.



Acid chain and the phospholipids — sounds like a punk band...

1) Which elements are fatty acids composed of?
2) What's the difference between saturated fatty acids and unsaturated fatty acids?
3) What's the difference between triglycerides and phospholipids?

Enzymes

Enzymes Help to **Speed up Biochemical Reactions**

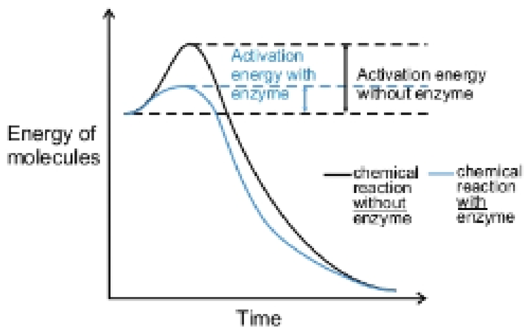
1) In a living cell, thousands of **biochemical reactions** take place every second. The sum of these reactions is called **metabolism**. A single chain of these reactions is called a **metabolic pathway**.
2) Without enzymes, these reactions would take place very **slowly** at normal body temperature.

> 1) Enzymes are **biological catalysts**.
> 2) They **increase** the **rate** (speed) of reactions.

How do Enzymes **Act** as **Catalysts**?

1) Even reactions that release energy require an **input of energy** to get them going, e.g. the gas from a Bunsen burner doesn't burn until you provide heat energy from a match.
2) This input energy is called the **activation energy**. A reaction that needs a high activation energy can't start at a low temperature of 37 °C (i.e. body temperature).
3) Enzymes **reduce** the activation energy.

> This graph shows the activation energies of a reaction **with** and **without** an enzyme:



Enzymes are **Proteins**

1) All enzymes are **globular proteins** (because they're roughly spherical).
2) It's the order of amino acids in an enzyme that determines its **structure**, and so how it works.
3) Enzymes can be involved in **breaking down** molecules or **building** molecules. For example:
   - **Digestive enzymes** are important in the digestive system, where they help to break down food into smaller molecules, e.g. carbohydrases break down carbohydrates.
   - Enzymes involved in **DNA replication** help to build molecules, e.g. DNA polymerase.

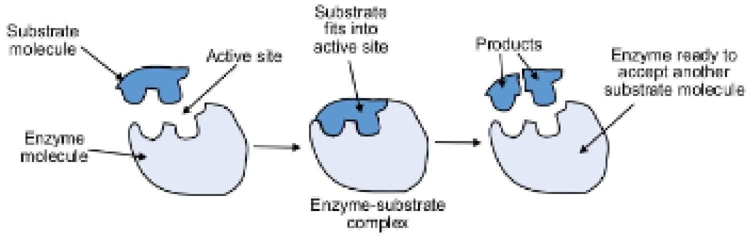
I could really use a catalyst to help me write this gag...

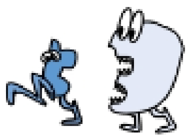
1) What is the function of enzymes?
2) What is activation energy?
3) What do digestive enzymes do?

Enzymes

Enzymes have an **Active Site**

1) A substance that's acted upon by an enzyme is called its **substrate**.
2) The **active site** is a region on the surface of the enzyme molecule where a substrate molecule can attach itself. It's where the catalysed reaction takes place.
3) The shape of the substrate molecule and the shape of the active site are **complementary**, i.e. they fit each other.
4) Almost as soon as the **enzyme-substrate complex** has formed, the products of the reaction are released and the enzyme is ready to accept another substrate molecule.





Enzymes are **Specific**

1) An enzyme usually catalyses one **specific** chemical reaction.
2) The substrate molecule must be the **correct shape** to fit into the active site.
3) **Only one substrate** will be the correct shape to fit, so each enzyme only catalyses one specific reaction.
4) Anything that **changes** the shape of the active site will **affect** how well the enzyme works.

The **Effect** of **Temperature** on **Enzyme Activity**

As temperature **increases**, enzyme reactions become **faster**, because the molecules have more **energy**. However, at high temperatures the atoms of the enzyme molecule vibrate more rapidly and **break** the weak bonds that hold the **tertiary structure** together. The **shape** of the active site **changes** and the substrate can no longer fit in. The enzyme is said to be **denatured**.

The **Effect** of **pH** on **Enzyme Activity**

Acids and **alkalis** can denature enzymes. Hydrogen ions (H^+) in acids and hydroxyl ions (OH^-) in alkalis disrupt the **weak bonds** and change the shape of the active site.

Lonely enzyme seeking complementary substrate...

1) Why are enzymes described as 'specific'?
2) Explain why a denatured enzyme will not function.
3) Describe the effect of pH on enzyme activity.

Section 3: Cell Structure

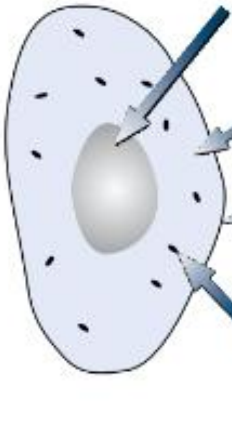
Eukaryotic and Prokaryotic Cells

Organisms can be *Prokaryotes* or *Eukaryotes*

1) **Prokaryotic** (pronounced like this: pro-carry-ot-ick) organisms are prokaryotic cells (i.e. they're **single-celled** organisms) and **eukaryotic** (you-carry-ot-ick) organisms are made up of eukaryotic cells.
2) Both types of cells contain **organelles**. Organelles are parts of cells — each one has a **specific function**.

Eukaryotic cells are **complex** and include all **animal** and **plant** cells.
Prokaryotic cells are **smaller** and **simpler**, e.g. **bacteria**.

4 organelles **animal** and **plant** cells have in **common**:



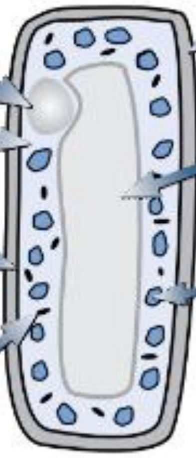
Nucleus contains genetic material (DNA) that controls what the cell **does**.

Cytoplasm contains enzymes that speed up biochemical reactions.

Cell-surface membrane holds the cell together and controls what goes **in** and **out**.

Mitochondria are where glucose and oxygen are used in **respiration** to provide a source of **energy** for the cell.

3 extras that **only plant cells** have:



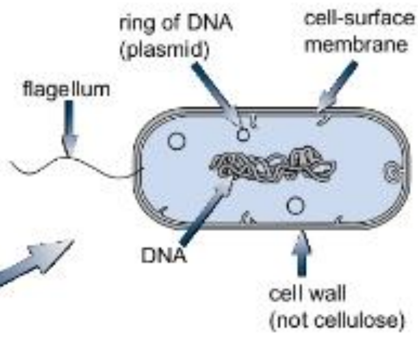
Rigid cell wall made of **cellulose**, gives the cell support.

Vacuole contains **cell sap**, a weak solution of sugar and salts.

Chloroplasts contain **chlorophyll** for **photosynthesis**. They're found in the **green** parts of plants, e.g. leaves and stem.

Bacterial Cells are *Prokaryotic*

1) Prokaryotes like bacteria are roughly a **tenth the size** of eukaryotic cells.
2) Prokaryotic cells **don't contain** a nucleus, mitochondria or chloroplasts.
3) As they **don't** have a nucleus, their **DNA floats freely** in the **cytoplasm**. Some prokaryotes also have **rings of DNA** called **plasmids**.
4) Some prokaryotes have a **flagellum** which **rotates** and allows the cell to **move**.
5) The diagram shows a bacterial cell as seen under an **electron microscope** (see next page).



Bacterial cheerleaders — they never stop swirling their flagella...

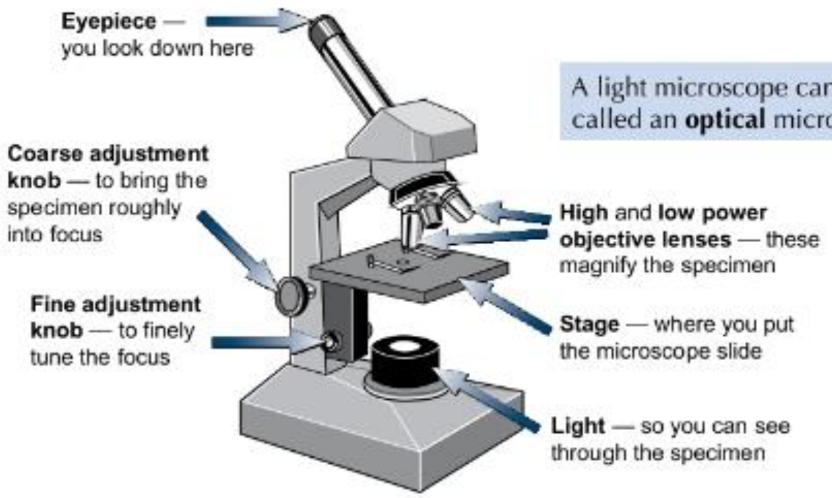
1) Give an example of a prokaryotic cell.
2) Name four organelles that plant and animals cells both have.
3) What is the function of mitochondria?

Microscopes

*You Can **See Cell Structure** with a **Light Microscope***

A **light microscope** can magnify up to 1500 times and allows you to see individual animal and plant cells along with the organelles inside them.

1) If the cells have been **stained** you can see the dark-coloured **nucleus** surrounded by lighter-coloured **cytoplasm**.
2) Tiny **mitochondria** and the black line of the **cell membrane** are also visible.
3) In plant cells, the **cell wall**, **chloroplasts** and the **vacuole** can be seen.



A light microscope can also be called an **optical** microscope.

Electron Microscopes** have a **Greater Magnification

1) The detailed **ultrastructure** of cells was revealed in the 1950s when the **electron microscope** was invented.
2) An electron microscope can **magnify** objects more than 500 000 times and, more importantly, it allows **greater detail** to be seen than a light microscope. For example, it allows you to see the detailed **structures inside organelles** such as mitochondria and chloroplasts.
3) The image that's recorded is called an **electron micrograph**.

I put a slide on the stage and then slid straight off the edge...

1) Name three things visible with a light microscope in both animal and plant cells.
2) Which type of microscope must be used to show the detailed ultrastructure of a cell?
3) What is the image recorded by an electron microscope called?

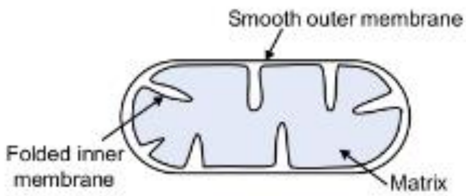
Functions of the Nucleus, Mitochondria and Cell Wall

Nucleus

1) The **nucleus** is the control centre of the cell.
2) It contains **DNA** (deoxyribonucleic acid): the coded information needed for **making proteins**.
3) During **cell division** the chromosomes carrying the long DNA molecules coil up, becoming shorter and thicker and visible with a light microscope.
4) Electron micrographs show that there's a **double membrane** around the nucleus.

Mitochondria

Mitochondria are about the size of bacteria, so they can be seen with a light microscope, but you need an electron microscope to see any of the detail.
Each mitochondrion has a **smooth outer membrane** and a **folded inner membrane**:



A **mitochondrion**

Their job is to capture the energy in glucose in a form that the cell can use.
To do this **aerobic respiration** takes place inside the mitochondria.

Word equation: GLUCOSE + OXYGEN → CARBON DIOXIDE + WATER + (ENERGY)

The energy released by respiration ends up in molecules of **ATP** (adenosine triphosphate). ATP is used in the cell to provide the energy for **muscle contraction**, **active transport** (called active uptake in some text books) and **building large molecules** from small ones, as well as many other processes.

Cell Wall — Plants

1) The plant cell wall is relatively rigid and provides **support** for the cell.
2) It mainly consists of bundles of long, straight **cellulose molecules**.
3) The cellulose molecules lay side by side to form **microfibrils**.

Doctor, doctor my DNA is getting shorter and thicker...*

1) Which organelle acts as the control centre of the cell?
2) In which organelle does aerobic respiration occur?
3) Describe the membranes of a mitochondrion.
4) What is the word equation for aerobic respiration?
5) Name the molecule used to provide energy for processes in the cell.
6) Name the molecule that is found in bundles in plant cell walls.

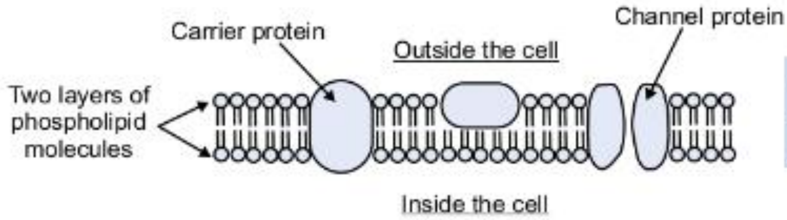
*...that's the least of your worries — you're going to divide soon.

Cell Membranes

Structure of the Cell-Surface Membrane

The **cell-surface membrane** is the very thin structure around an individual cell.

1) Electron micrographs show that the cell-surface membrane consists of a double layer of **phospholipid** molecules tightly packed together.
2) Bigger **protein molecules** are embedded in the phospholipid molecules.
3) Some proteins go **all the way through** the membrane and some only go **halfway**.
4) Membranes surrounding the **organelles** inside cells have the **same** structure.



Cell-surface membranes can also be called **plasma membranes**.

Do I Really have to Know this Much Detail?

1) The answer is "Yes". Once you're familiar with the molecular structure of the membrane you can explain how the membrane **controls** the passage of substances **in** and **out** of the cell.
2) Because the membrane only allows certain substances through it, it's described as being **partially permeable**.

Substances Pass Through Membranes by Four Methods

1 Diffusion

1) The particles of liquids and gases are constantly **moving about**. This movement causes the particles to spread from an area of **higher** concentration to an area of **lower** concentration.
2) Particles will **diffuse** through the cell membrane as long as they are small enough to pass through the very small gaps **between** the phospholipid molecules. Water, oxygen and **carbon dioxide** molecules can do this.
3) The cell **doesn't** need to provide any energy for this process.

The difference in concentration is sometimes called a **concentration gradient**, e.g. a big difference in concentration is a big concentration gradient.

2 Osmosis

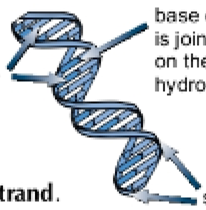
1) **Osmosis** is the diffusion of **water** molecules across a partially permeable membrane from a region of **higher concentration** of water molecules to a region of **lower concentration** of water molecules. The cell **doesn't** need to provide energy.
2) The concentration of water molecules is also referred to as the **water potential**. At AS and A-level, you tend to talk about water moving from a region of **higher water potential** to a region of **lower water potential**.

Section 4: DNA and protein synthesis

DNA and Protein Synthesis

DNA is Made Up of Nucleotides Containing Bases

1) **DNA** is a **double helix** (a double-stranded spiral). Each of the two DNA strands is made up of lots of small molecules called **nucleotides**.
2) Each **nucleotide** contains a part called a **base**. DNA has just **four** different bases.
3) These bases are: **adenine** (**A**), **cytosine** (**C**), **guanine** (**G**) and **thymine** (**T**).
4) Each base forms **hydrogen bonds** to a base **on the other strand**. This keeps the two DNA strands **tightly wound** together.
5) The bases **always** join up in the **same way**.



Adenine (**A**) always joins up with **thymine** (**T**), and **cytosine** (**C**) always joins up with **guanine** (**G**).

These pairs of bases are called **complementary bases**. They join together because they **complement** each other in shape — this is called **complementary base pairing**.

Proteins are Made by Reading the Code in DNA

1) **DNA** controls the production of **proteins** (**protein synthesis**) in a cell.
2) A **section of DNA** that codes for a particular **protein** is called a **gene**.
3) Proteins are made up of **chains** of **amino acids**. Each different protein has its own particular **number** and **order** of amino acids.
4) This gives each protein a different **shape**, which means each protein can have a different **function**.
5) It's the **order** of the **bases** in a **gene** that decides the order of **amino acids** in a **protein**.
6) Each gene contains a **different sequence** of **bases** — which is what allows it to code for a **unique protein**.

'**Codes for**' just means '**contains the instructions for**'.

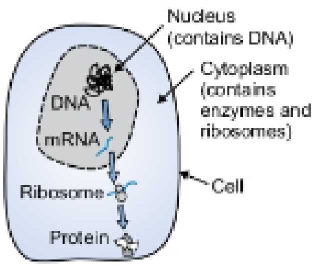
Pro-teen synthesis — supporting youth electronic music-making...

1) What is the name given to the double-stranded structure of DNA?
2) How many different bases are there in DNA?
3) Give the names of the bases in DNA.
4) How do the strands of DNA stay together?
5) What is complementary base pairing?
6) What is a gene?
7) What determines the order of amino acids in a protein?

RNA and Protein Synthesis

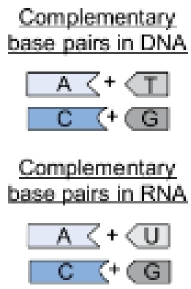
RNA *is Needed to Make* ***Proteins***

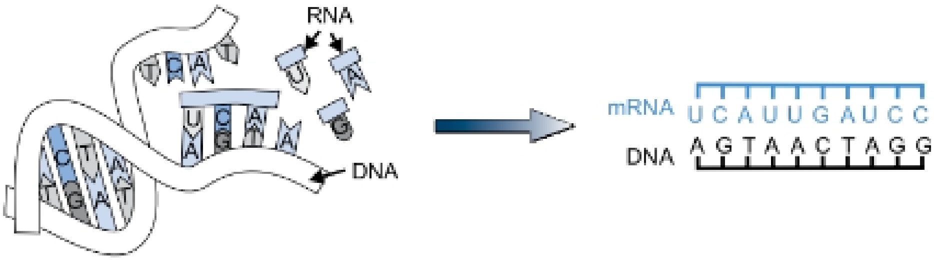
1) DNA molecules (and so genes) are found in the **nucleus** of a cell, but they can't move out of the nucleus because they're very **large**.
2) Protein synthesis happens in the **cytoplasm** at organelles called **ribosomes**.
3) So when a cell **needs** a particular protein, a **copy** of the gene that codes for it is made in the nucleus. This copy is **smaller** than DNA so it can move in to the cytoplasm, where it can be used to make the protein.
4) The copy of the gene is made from a molecule called **messenger RNA** (mRNA).



DNA *is Used as a* ***Template*** *to Make an* ***mRNA*** *Molecule*

1) The DNA in the gene acts as a **template**.
2) RNA, like DNA, is made up of **nucleotides**, which each have a **base**.
3) The bases on RNA nucleotides line up next to their **complementary** bases on the DNA template.
   - In RNA, there's **no thymine** (**T**), so the base **uracil** (**U**) binds to any **adenine** (**A**) in the DNA instead.
   - Once the bases on the **RNA** nucleotides have **paired up** with the bases on the **DNA** strand, the RNA nucleotides join together to make an **mRNA molecule**.
4) Eventually, a **whole copy** of the gene is made and the **sequence** (order) of **bases** in the mRNA copy is complementary to the sequence of bases in the DNA template.





Complimentary RNA — oh, you do look dashing Mr Ribo Some...

1) Why does a copy of a gene need to be made for protein synthesis?
2) What does the 'm' in mRNA stand for?
3) In RNA, which base is complementary to adenine?
4) Give the mRNA sequence that would be complementary to the DNA sequence: ATTGCGCA

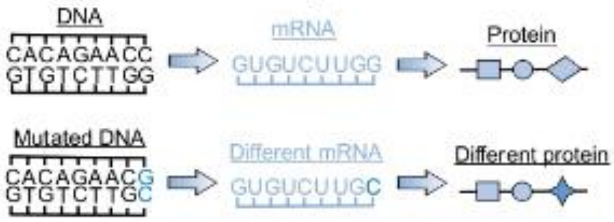
Mutations

The **Order** of **Bases** Determines the **Order** of **Amino Acids**

Three bases in a row (a **triplet**, e.g. GCT) codes for **one amino acid** — this is called the **genetic code**. **Different amino acids** are coded for by **different triplets**, e.g. TAT = tyrosine, AGT = serine. The **order of the bases** (and so triplets) in the DNA of a gene determines the order of bases in its mRNA copy, and that determines the **order of amino acids** in a protein:

Mutations Change the **Order of Bases** in **DNA**

1) **Mutations** are changes to the **base** sequence (order) of DNA.
2) For example, one base can be **substituted** (swapped) for another one. This can cause the base triplet to **change**. E.g. if C is substituted for A, GCT becomes GAT.
3) So mutations can change the **amino acids** in the protein that the gene codes for.
4) A change in the amino acids can cause a **different protein** to be produced. Sometimes the different protein can be **harmful** (see below).



Mutations happen **spontaneously** (randomly), but how **frequently** they happen can be increased by **mutagenic agents** — factors that increase mutations, e.g. UV radiation in sunlight.

Mutations can be **Harmful**

1) Mutations can cause **cancer** because **cell division** is controlled by **proteins**. If mutations occur in the **genes** for these proteins, they can **alter** the proteins so they **no longer work**. This can lead to **uncontrolled cell division**, and the development of a **tumour** (cancer).
2) Mutations also cause **genetic disorders** — mutations that result in **altered** genes and proteins can be **inherited** (passed on from your parents), e.g. cystic fibrosis.

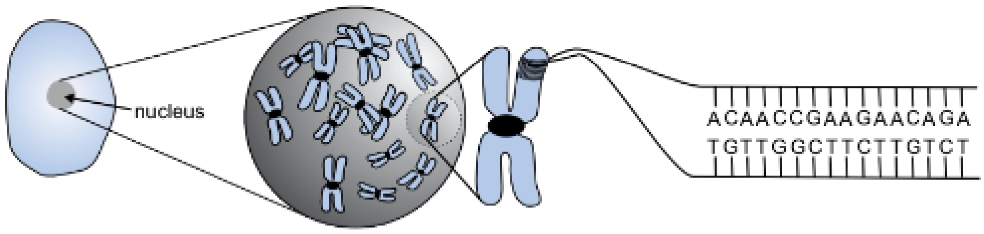
DoNAtello, LeAmino... it's the Teenage Mutant Protein Makers...

1) How many bases code for one amino acid?
2) What are mutations?
3) What do mutagenic agents do?

Chromosomes

DNA is Found on Chromosomes

DNA is found in the **nucleus** of **eukaryotic cells**. It has to be **wound up** into chromosomes to fit in. Each human chromosome contains between a couple of hundred and a few thousand genes.

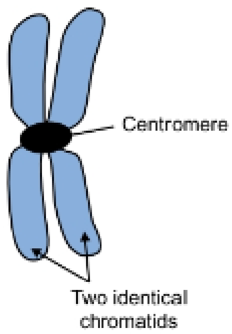


Homologous Pairs

Humans have **23 homologous pairs** of chromosomes (46 in total), e.g. two number 1s, two number 2s, two number 3s, etc. One from each pair comes from your mother and one comes from your father. Both chromosomes in a pair are the **same size** and carry the **same genes** (which is why they're called **homologous pairs**). But they usually have **different alleles** (different versions of the genes).

Chromosomes are Often Shown as X-Shaped

In loads of books chromosomes are shown as **X-shaped**. An X-shaped chromosome is actually **one chromosome** attached to an **identical copy** of itself. Don't get it confused with a homologous pair of chromosomes. They're only X-shaped just after the DNA has been **replicated** (e.g. in cell division). Each side of the X is referred to as a **chromatid** and the bit in the middle where they're attached is called the **centromere**.



It's in his DNA, D, D, D, DNA...

1) Where is DNA found in a eukaryotic cell?
2) How many homologous pairs of chromosomes do human cells have?
3) Are homologous pairs of chromosomes identical? Explain your answer.
4) What is a chromatid?
5) What is the name of the region where two identical chromatids are joined?