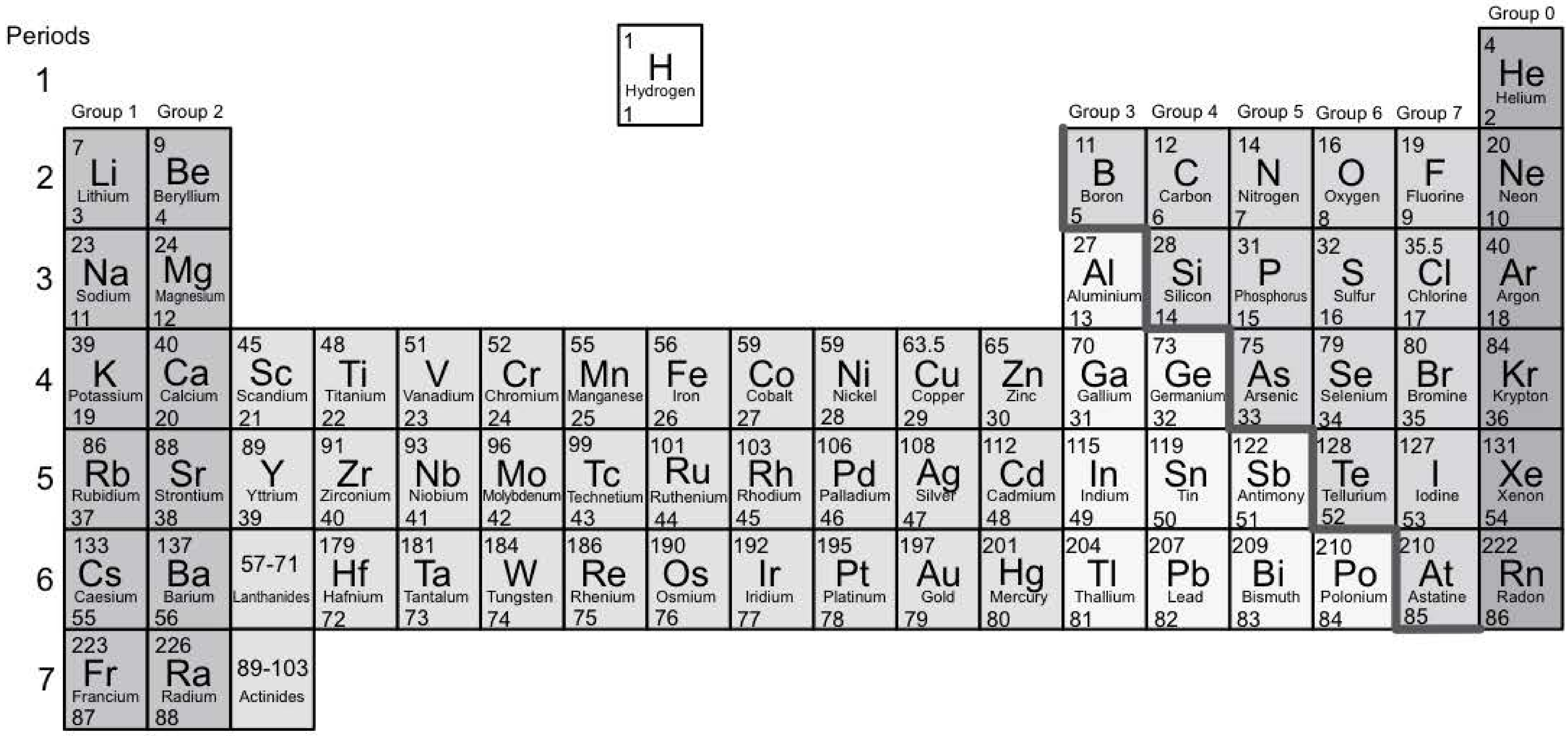
CGP

Key Stage Three
Science
Higher Level

The Study Guide

Written by Paddy Gannon

The Periodic Table



Periods	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1								1 H Hydrogen 1										4 He Helium 2
2	7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
3	23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
4	39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
5	86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	57-71 Lanthanides	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	223 Fr Francium 87	226 Ra Radium 88	89-103 Actinides															

Useful Physics Symbols and Units

	Quantity	Symbol	Standard Units	Formula
1	Energy		joules, J, kilojoules, kJ, kilowatt-hours, kWh	
2	Distance	d	metres, m	
3	Power		watts, W, kilowatts, kW	
4	Speed	s	metres/sec, m/s	s = d/t
5	Time	t	seconds, s	
6	Force	F	newtons, N	
7	Moment	M	newton metres, Nm	M = F×d
8	Pressure	P	pascals, Pa (N/m^2)	P = F/A
9	Area	A	metres^2, m^2	Area = length × width
10	Frequency		hertz, Hz	
11	Resistance		ohms, Ω	
12	Current		amperes, A	
13	Potential difference		volts, V	
14	Mass	m	kilograms, kg	
15	Weight (a force)	W	newtons, N	W = m×g
16	Gravitational field strength	g	newtons/kilogram, N/kg	

It's another great book from CGP...

This book has everything you need to get your head around Science at KS3 (ages 11-14) — every topic is explained in a clear, straightforward style.

Bursting with practice questions, helpful diagrams and top revision tips and tricks, it's ideal if you're working at a higher level. Really, what more could you want?!

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Our sole aim here at CGP is to produce the highest quality books — carefully written, immaculately presented and dangerously close to being funny.

Then we work our socks off to get them out to you
— at the cheapest possible prices.

Contents

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Section 8 — Energy and Matter

Section 9 — Forces and Motion

Section 10 — Waves

Section 11 — Electricity and Magnetism

Section 12 — The Earth and Beyond

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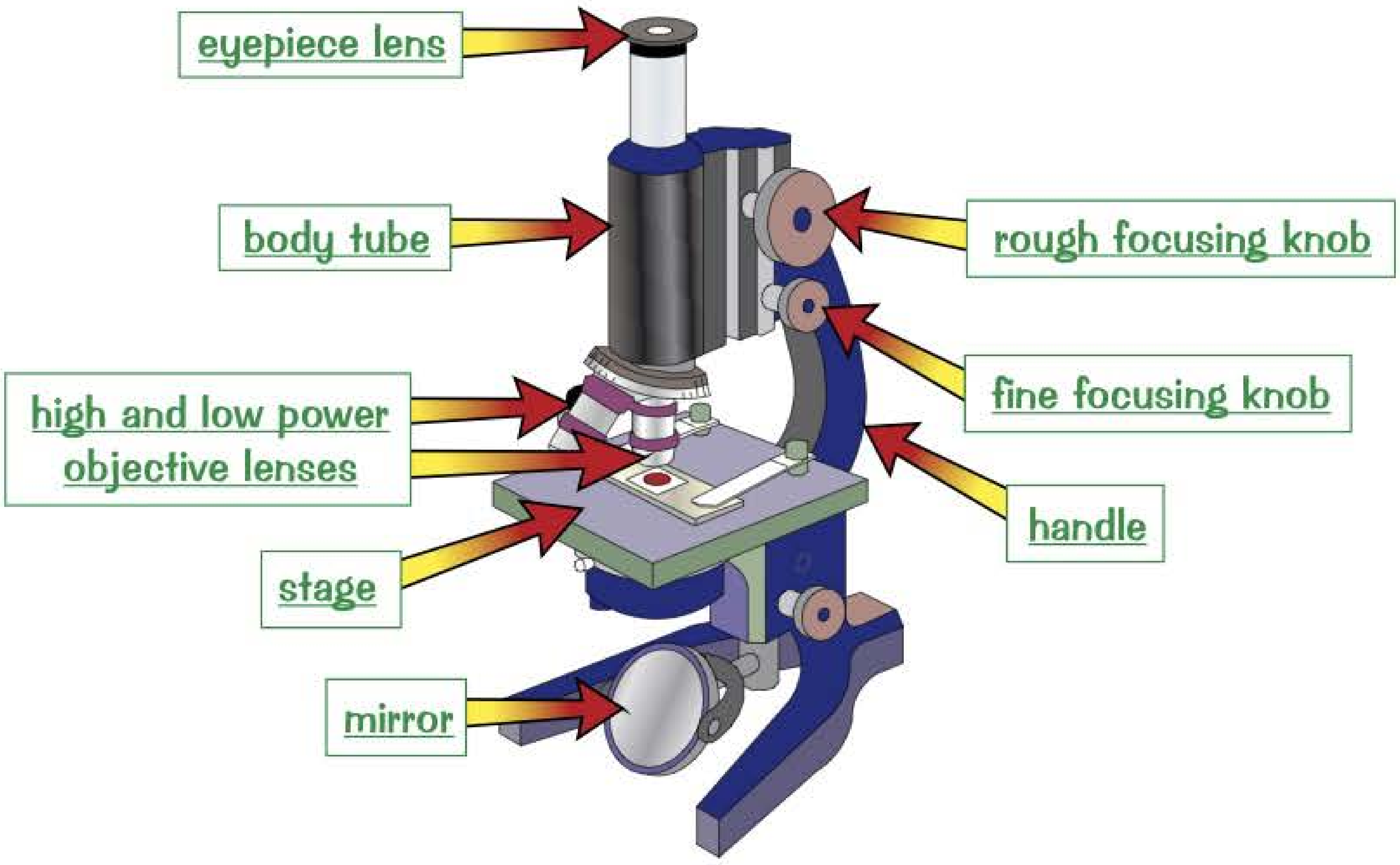
The Microscope

A microscope is used for looking at objects that are too small to see with the naked eye. The lenses in the microscope magnify objects (make them look bigger) so that you can see them. It's magical stuff...

Learn the Different Parts of a Microscope

Here are some of the main parts of a light microscope — make sure you can identify them.



Follow These Easy Steps to Using a Light Microscope

1) Carry your microscope by the handle.
2) Place it near a lamp or a window, and angle the mirror so light shines up through the hole in the stage.
3) Clip a slide onto the stage. The slide should have the object(s) you want to look at stuck to it.
4) Select the lowest powered objective lens.

Don't reflect direct sunlight into the microscope — it could damage your eyes.

5) Turn the rough focusing knob to move the objective lens down to just above the slide.
6) Look down the eyepiece lens and adjust the focus using the fine focusing knob.
7) Keep adjusting until you get a clear image of whatever's on the slide.

DON'T BREAK THE SLIDE

Always turn the fine focusing knob so that the objective lens is moving away from the slide — so the lens and slide don't crash together.

8) If you need to see the slide with greater magnification, switch to a higher powered objective lens (a longer one).
9) Now refocus the microscope (repeat steps 5 to 7).

Microscopes — useful for looking at onions...

Teachers love getting you to look at onions under the microscope. Not a whole one mind, just the slimy skin between the onion layers (yuk). A microscope lets you see all the tiny building blocks (called cells) that the onion skin is made up of. It's, um, more interesting than it sounds. There's more on cells on the next page.

Cells

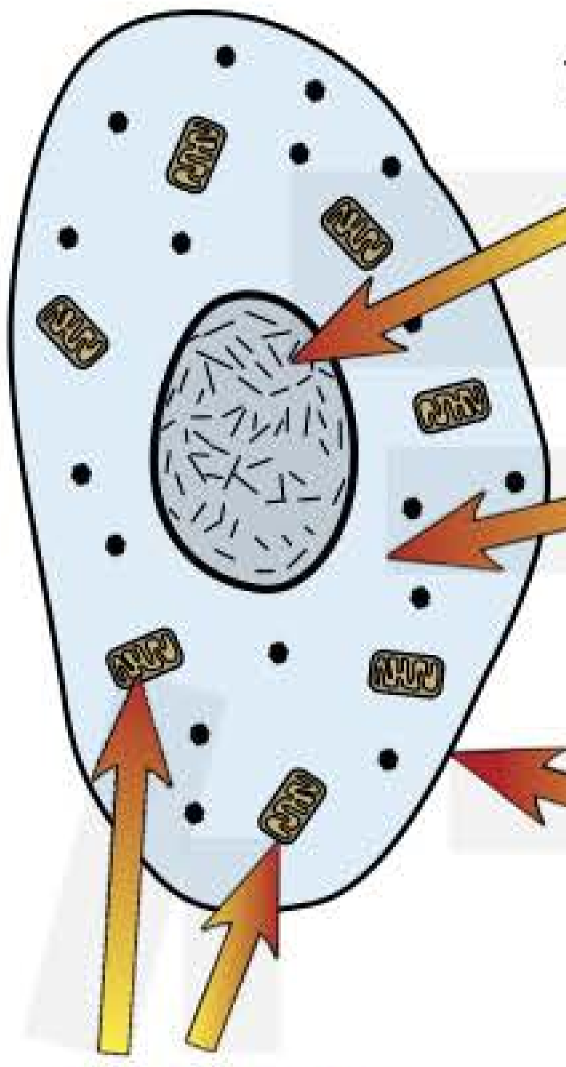
This page is about what living things are made of. Be prepared to find out that you're quite similar to a plant.

Living Things are Made of Cells

1) Another word for a living thing is an organism. All organisms are made up of tiny building blocks known as cells.
2) Cells can be seen through a microscope (see previous page) — but it helps if you stain them first (using a coloured dye).

Animal and Plant Cells Have Similarities and Differences

An Animal Cell



BOTH have:

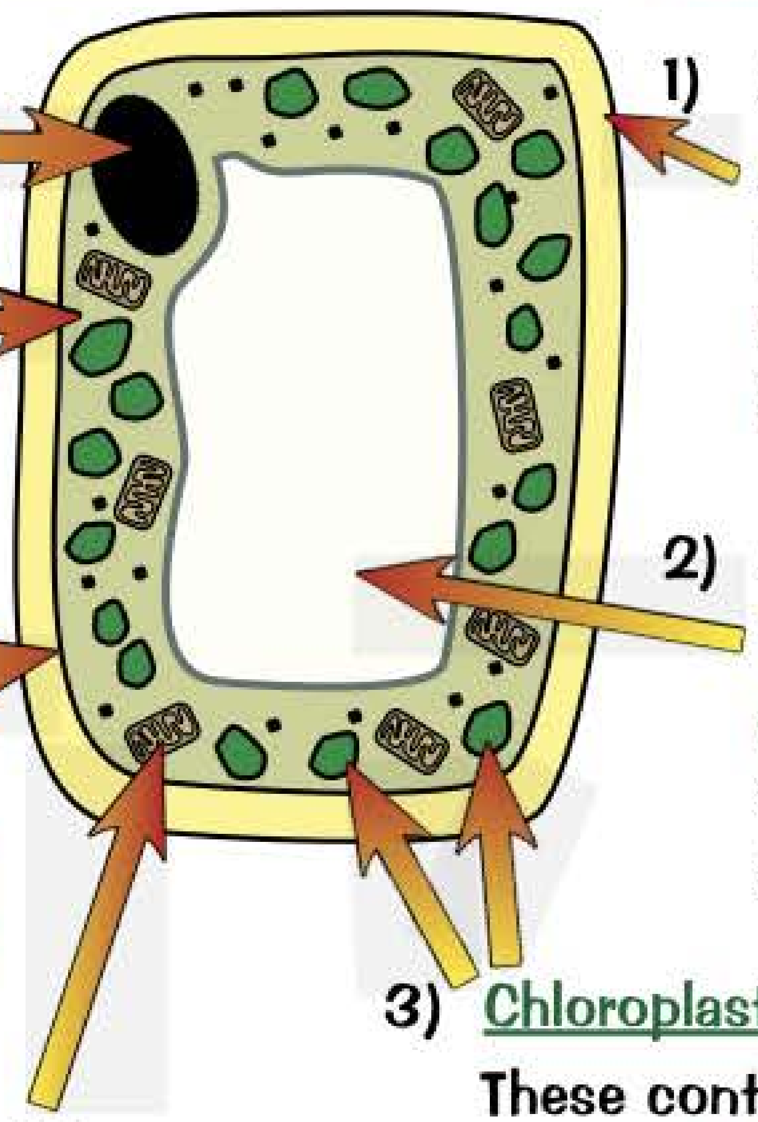
1) A **Nucleus**: This controls what the cell does.

2) **Cytoplasm**: This is a jelly-like stuff where most chemical reactions happen.

3) A **Cell Membrane**: This is a thin skin around the cell — it holds the cell together and also controls what goes in and out.

4) **Mitochondria**: These are tiny structures inside the cell where most of the reactions for aerobic respiration (see page 4) take place. Respiration releases energy for the cell.

A Plant Cell



ONLY PLANTS have:

1) A **Cell Wall**: A rigid outer coating made of cellulose — it gives support to the cell.

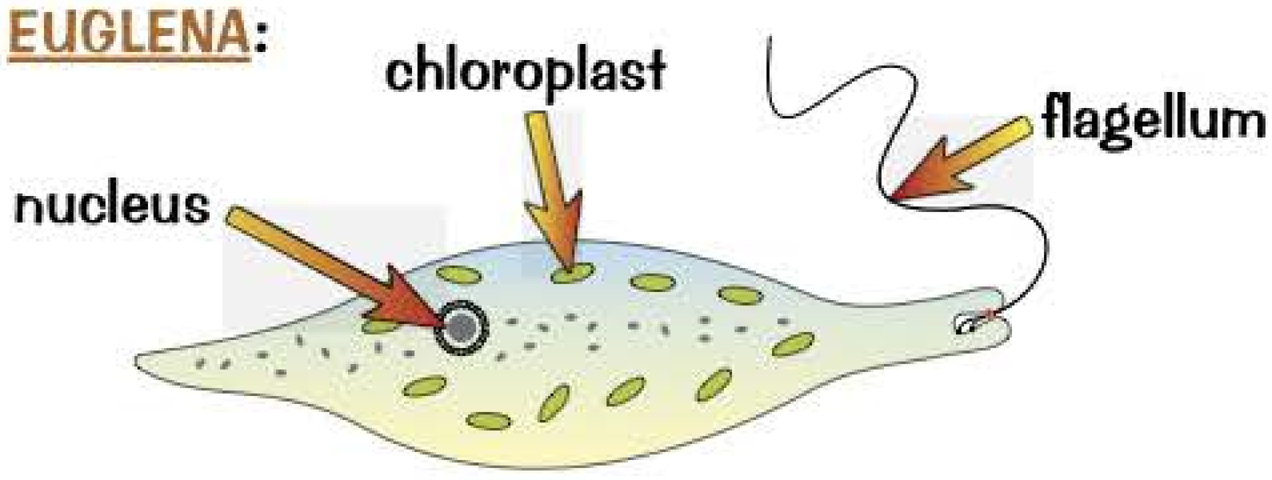
2) A **Vacuole**: This is filled with cell sap — a weak solution of sugar and salts.

3) **Chloroplasts**: These contain chlorophyll used for photosynthesis (see p. 19). Photosynthesis makes food for the plant.

Some Living Things are Unicellular

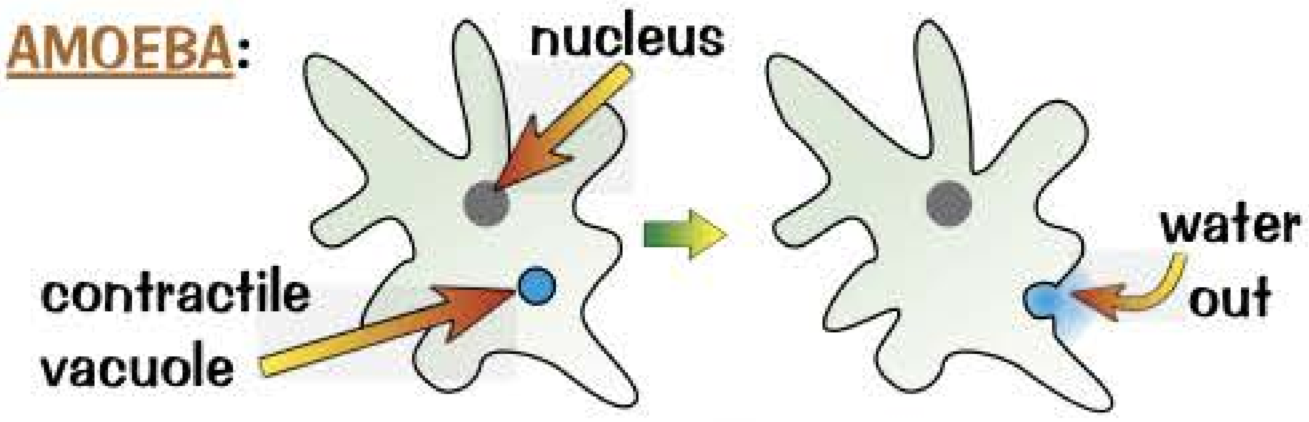
1) Animals and plants are made up of lots of cells. They're multicellular organisms.
2) But many living things are made up of only one cell — these are called unicellular organisms. Unicellular organisms have adaptations to help them survive in the environment they live in, e.g.

EUGLENA:



Euglena live in water. They have a tail-like structure called a flagellum to help them swim.

AMOEBA:



Some amoeba also live in water. They use a contractile vacuole to collect any excess water inside them and squeeze it out at the cell membrane.

Cells — they're great for locking things up...

You need to learn what all the bits and pieces in animal and plant cells look like, so you can identify them under a microscope. Have a go at drawing the top two cells above for yourself and then labelling them.

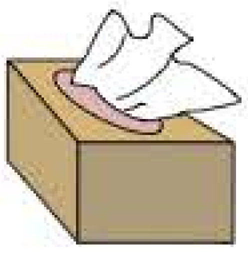
Cell Organisation

Cells are organised. They write all their appointments down in a little diary and never forget your birthday.

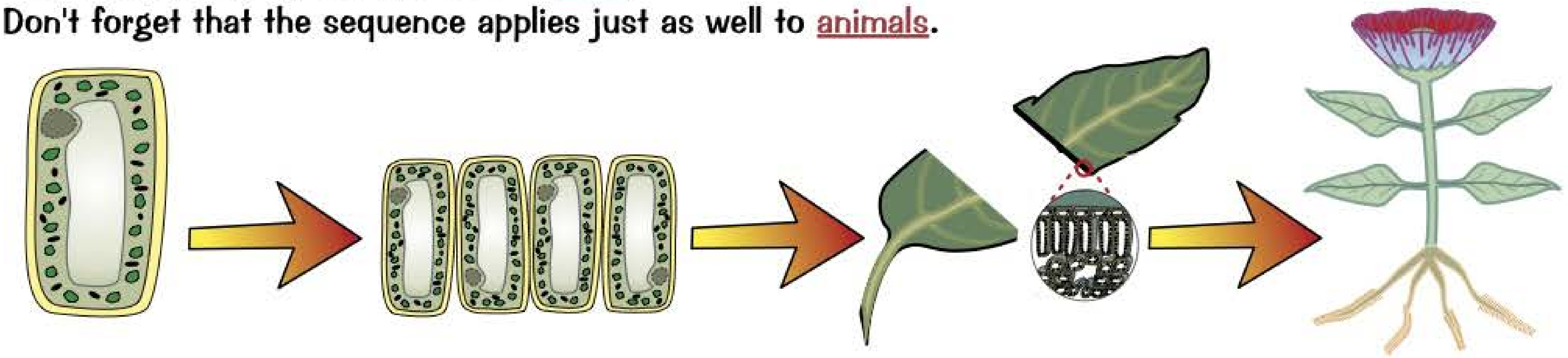
Learn How Cells are Organised

In organisms with lots of cells (like animals and plants), the cells are organised into groups. Here's how:

A group of similar cells come together to make a tissue.
A group of different tissues work together to make an organ.
A group of organs work together to make an organ system.
A multicellular organism is usually made up of several organ systems.



Here's a rather jolly example from a plant.
Don't forget that the sequence applies just as well to animals.



palisade CELLS...

...make up palisade TISSUE...

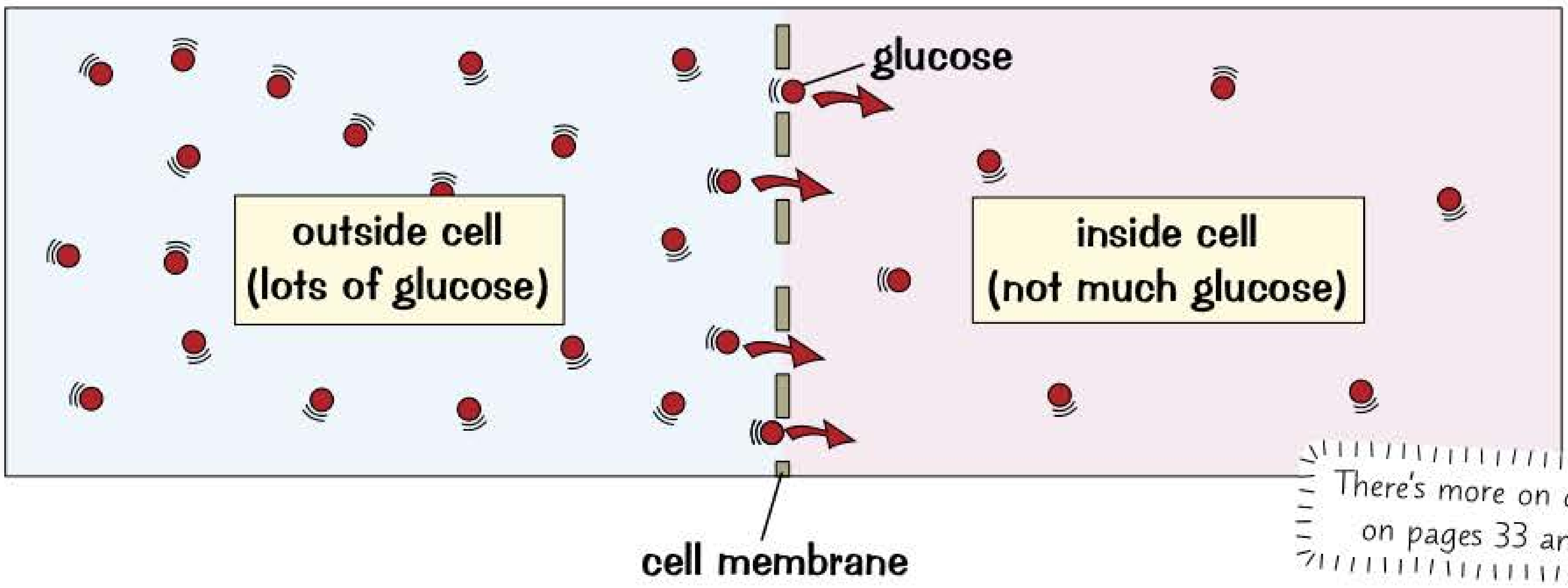
...which, with other tissues, makes up a leaf (an ORGAN)...

...which, with more leaves and other organs, makes up the shoot system (an ORGAN SYSTEM). Various organ systems make up a full plant (an ORGANISM).

A palisade cell is just the name for a particular type of plant cell.

Stuff Moves Into and Out of Cells by Diffusion

1) Cells need things like glucose (a sugar) and oxygen to survive.
They also need to get rid of waste products, like carbon dioxide.
2) These materials all move into or out of cells by a process called diffusion.
3) Diffusion is where a substance moves from an area of high concentration (where there's lots of it) to an area of low concentration (where there's less of it) — just like glucose in this diagram...



There's more on diffusion on pages 33 and 75.

Get organised — learn this page...

Remember: cells → tissues → organs → organ systems → organisms. You need to get your head around diffusion too — it comes up all the time in KS3 science, so it's worth getting to grips with now.

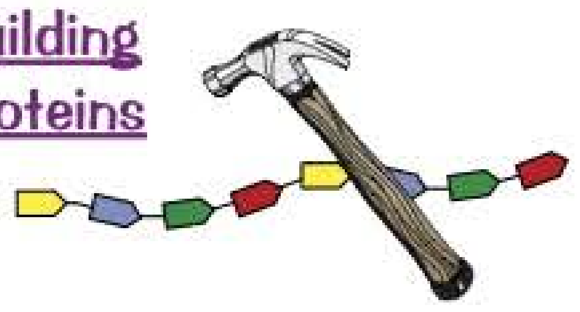
Respiration

As life processes go, this is the big one — respiration. Without it, you'd be well and truly stuck.

Respiration is a Chemical Reaction

1) Respiration happens in every cell of every living organism.
2) Respiration is the process of releasing energy from glucose (a sugar).
3) The energy released by respiration is used for all the other chemical reactions that keep you alive. For example, the reactions involved in:

building proteins



muscle contraction

keeping warm

Aerobic Respiration Needs Plenty of Oxygen

1) Aerobic respiration is respiration using oxygen. It takes place in the mitochondria (see page 2) of animal and plant cells.
2) In aerobic respiration, glucose and oxygen react to produce carbon dioxide and water. This reaction releases lots of energy. Here's a word equation to show what happens in the reaction — learn it:

glucose + oxygen → carbon dioxide + water + ENERGY

These are the reactants. These are the products.

There's more on chemical reactions and word equations on pages 48 and 51.

Anaerobic Respiration Takes Place Without Oxygen

1) Anaerobic respiration is respiration without oxygen.
2) Anaerobic respiration is less efficient than aerobic respiration, so it releases less energy.
3) Because of this, anaerobic respiration usually only happens when cells can't get enough oxygen.

E.g. when you exercise, your body can't always get enough oxygen to your muscle cells. So they start to respire anaerobically.

Anaerobic Respiration is Different in Different Organisms

1) In humans, anaerobic respiration produces a substance called lactic acid: **glucose → lactic acid + ENERGY**

   Lactic acid can build up in your muscles during exercise and can be painful.

2) In microorganisms like yeast, anaerobic respiration produces carbon dioxide and ethanol (alcohol): **glucose → carbon dioxide + ethanol + ENERGY**

   When anaerobic respiration produces ethanol, it's called fermentation. Fermentation is the process used to make beer.

Respiration — it's energetic stuff, innit...

It can be quite tricky to get your head around the idea of respiration, but it just means releasing energy from glucose. Aerobic respiration does this with oxygen, while anaerobic respiration does it without. Sorted.

Section Summary

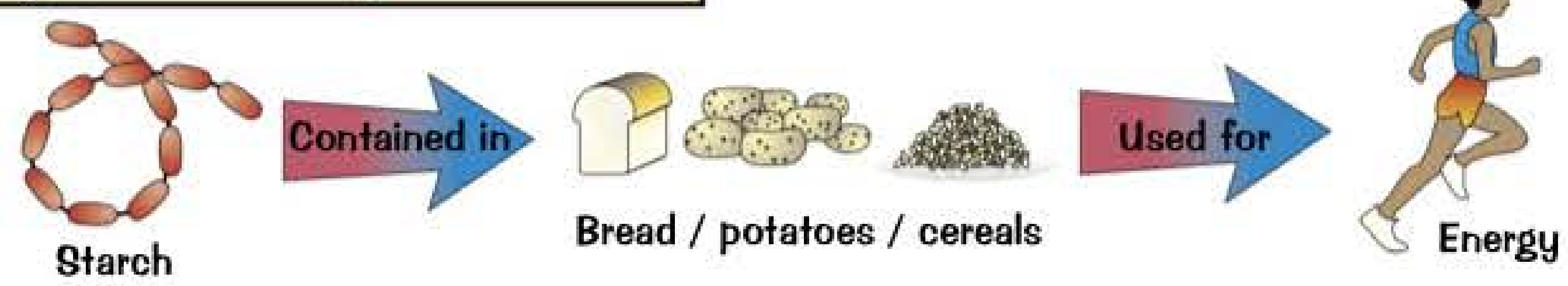
Welcome to your very first Section Summary. It's full of questions written especially for finding out what you actually know — and, more importantly, what you don't. Here's what you have to do... 1) Go through the whole lot of these Section Summary questions and try to answer them. 2) Look up the answers to any you can't do and try to really learn them (hint: the answers are all somewhere in Section 1). 3) Try all the questions again to see if you can answer more than you could before. 4) Keep going till you get them all right.

1) What part of a microscope do you clip your slide onto?
2) What do the focusing knobs on a microscope do?
3) Why should you always move the objective lens away from the slide when you're focusing a microscope?
4) What is an organism?
5) What instrument would you use to look at a cell? What can you do to help see cells?
6) Name four parts that both plant cells and animal cells have. Say what they all do.
7) Name three parts of a cell that only plant cells have.
8) Give an example of a unicellular organism and say how it's adapted to its environment.
9) Explain the meaning of: a) tissue b) organ c) organ system. Give an example of each.
10) What is diffusion?
11) Give two examples of substances that move into or out of cells by diffusion.
12) What's the name of the process that goes on in every cell, releasing energy?
13) What is the energy released by this process used for? Give three examples.
14) What is aerobic respiration? Where does it take place in plant and animal cells?
15) Write down the word equation for aerobic respiration.
16) Give two differences between aerobic respiration and anaerobic respiration in humans. When might humans respire anaerobically?
17) What are the products of anaerobic respiration in yeast?
18) What is fermentation? What can fermentation be used to make?

Nutrition

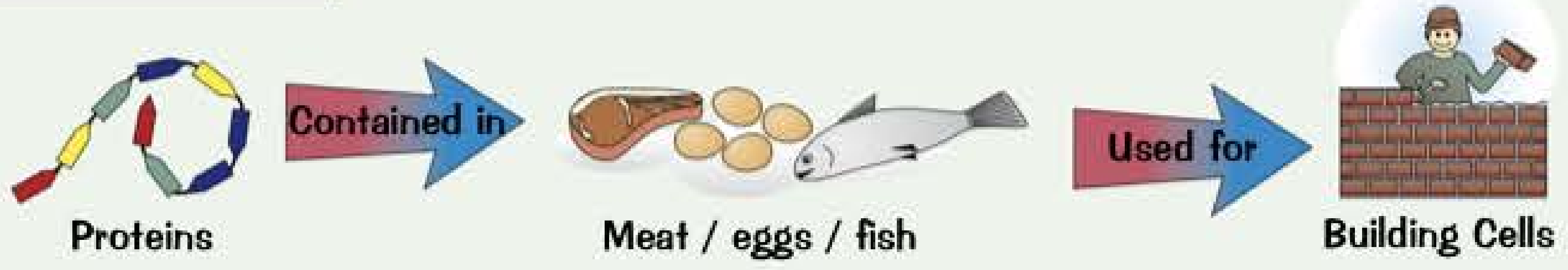
Nutrition is what you eat — and what you eat is really important for your health.
A balanced diet will have the right amount of the five nutrients listed below, as well as fibre and water.

1) Carbohydrates



These are like fuel for your body. Active or growing folk need lots of carbohydrate.

2) Proteins



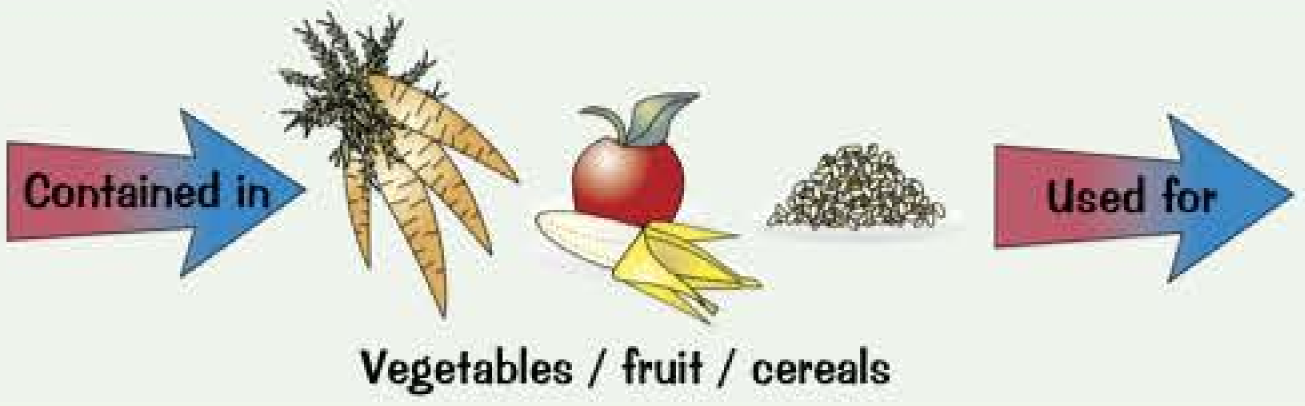
Proteins are vital for growth and to repair damaged areas.

3) Lipids (Fats and Oils)

Lipids act as a store of energy — which you use if your body runs out of carbohydrates.

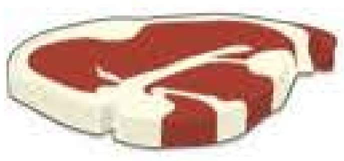
4) Vitamins

E.g. A B_1 B_2
C D E

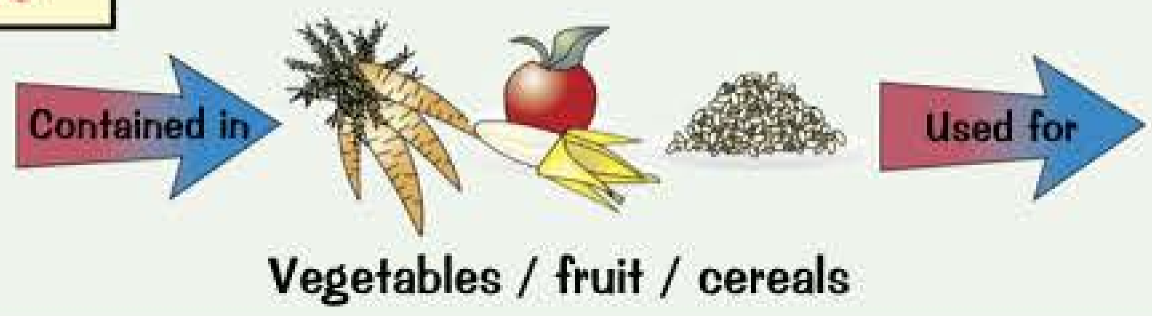


Vitamins are only needed in very small amounts — they keep many vital processes happening.

5) Minerals

E.g. —	Iron	Calcium	Sodium
Found in —			
Needed for –	Blood	Teeth/Bones	Nerves

Fibre



Fibre helps food move through your digestive system.

Water

About 75% of your body is water and all chemical reactions (e.g. digestion), take place in water – it's well important!

Obviously we only had gruel when I was a lad... sob ...sob...

Five types of nutrient, what you find them in and what they're for. And then there's fibre and water too. Learn each section and test yourself with the only method that works — covering the page and jotting it down.

More on Nutrition

Your body needs energy all the time. Even when you're asleep your body is using energy just to keep you alive. You get the energy your body needs from carbohydrates and fats in your diet.

Different People Have Different Energy Requirements

1) The amount of energy you need each day depends on your body mass ("weight") and level of activity.
2) The heavier and the more active you are, the more energy you will need.

You Can Work Out Your Daily Basic Energy Requirement...

1) Every cell (see page 2) in the body needs energy. So the bigger you are, the more cells you have, and the more energy you'll need.
2) You also need energy to move, and it takes more energy to move a bigger mass.
3) For every kg of body mass, you need 5.4 kJ of energy every hour. This is the basic energy requirement (BER) needed to maintain essential bodily functions.

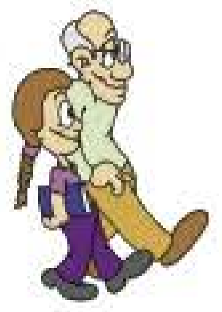
A kJ is a unit of energy.

You calculate it like this: Daily BER (kJ/day) = 5.4 × 24 hours × body mass (kg)

E.g. a 60 kg person requires 5.4 × 24 × 60 = 7776 kJ/day

...and How Much Extra Energy You Need for Your Activities

1) The more active you are the more energy you will need.
2) For example, a 60 kg person will use about 400 kJ walking for half an hour but 1500 kJ running for half an hour.
3) To find out how much energy you need in a day you have to add together your daily BER and the extra energy you use in your activities.



400 kJ

1500 kJ

An Unbalanced Diet Can Cause Health Problems

Obesity

1) If you take in more energy from your diet than you use, your body will store the extra energy as fat — so you will put on weight.
2) If you weigh over 20% more than the recommended weight for your height, then you are classed as obese.
3) Obesity can lead to health problems such as high blood pressure and heart disease.

Starvation and Deficiency Diseases

1) Some people don't get enough food to eat — this is starvation.
2) The effects of starvation include slow growth (in children), being more likely to get infections, and irregular periods in women.
3) Some people don't get enough vitamins or minerals — this can cause deficiency diseases. For example, a lack of vitamin C can cause scurvy, a deficiency disease that causes problems with the skin, joints and gums.

Summon up the energy to learn this page...

You should be able to work out how much energy a person needs in a day. Also, make sure you understand about the health problems that can be caused from eating too much or too little food.

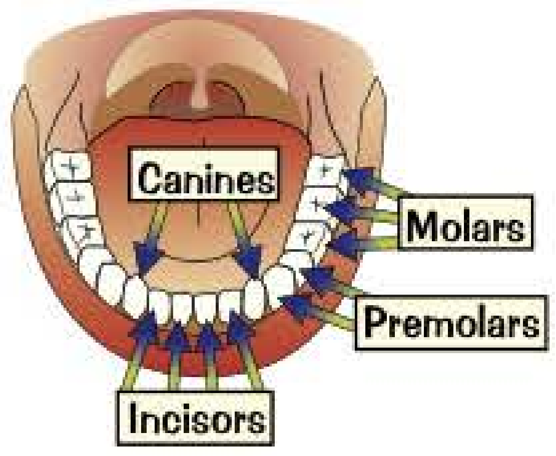
Digestion

Digestion's fab. The body breaks down almost all the food we shove into our mouths, so we can use the nutrients it contains. But it's not easy — lots of different organs have to work together to get the job done.

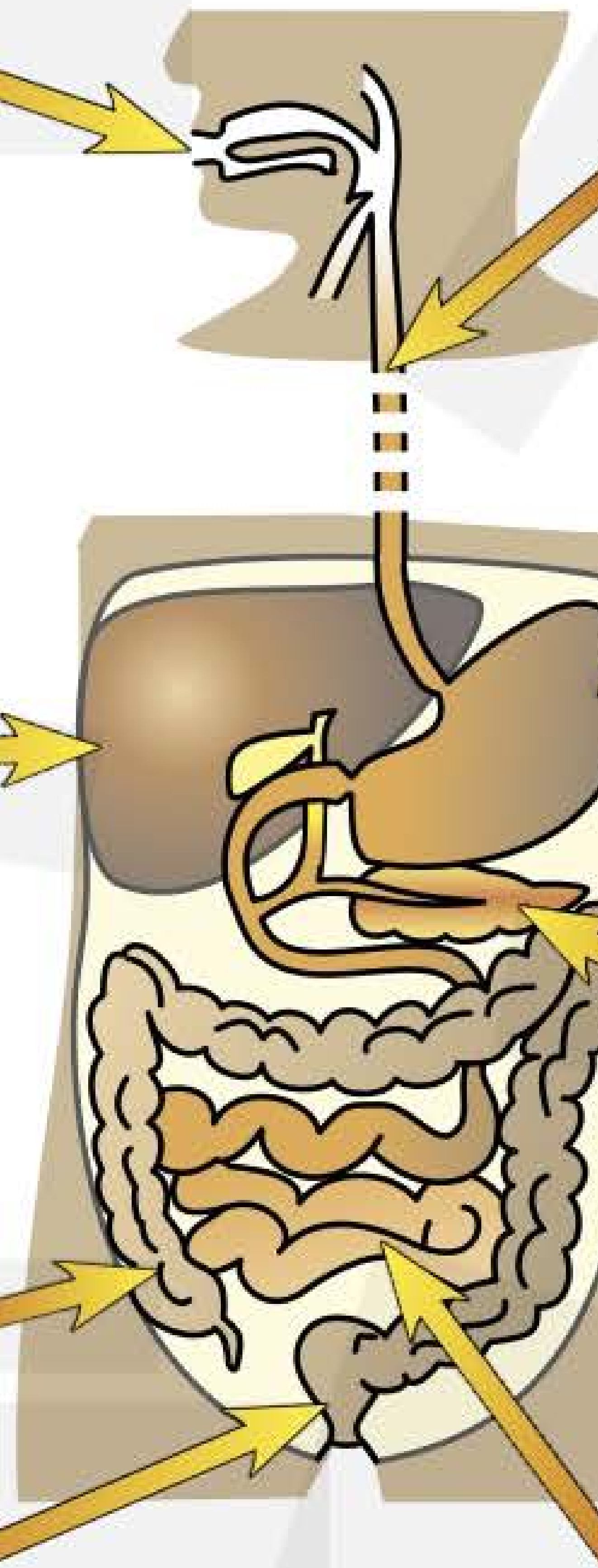
Digestion is All About Breaking Down Food

There are two steps to this. The first is quick, the second isn't:

1) Breaking down the food MECHANICALLY, e.g. chewing with teeth:
2) Breaking down the food CHEMICALLY — with the help of proteins called enzymes. Enzymes are biological catalysts — this means they speed up the rate of chemical reactions in the body.



Eight Bits of The Alimentary Canal



1) Mouth

Digestion starts here where the teeth have a good old chew and mix the food with saliva. Saliva contains an enzyme (called amylase) that breaks down carbohydrates.

2) Oesophagus

(Food pipe) Links the mouth to the stomach.

3) Stomach

1) Here the food mixes with protease enzymes which digest proteins. The stomach contains muscular tissue to move the stomach wall and churn up food.
2) Hydrochloric acid is present to kill harmful bacteria and give a low pH for the enzymes to work.

4) Liver

The liver makes bile, which breaks fats into tiny droplets (emulsification). It's also alkaline to give the right pH for the enzymes in the small intestine.

5) Pancreas

The pancreas contains glandular tissue, which makes three enzymes:

1) PROTease digests PROTein.
2) CARBOHYDRAse digests CARBOHYDRAtes.
3) LIPase digests LIPids — i.e. fats.

6) Small intestine

1) This produces more enzymes to further digest proteins, carbohydrates and fats.
2) Food is also absorbed through the gut wall into the blood, which then takes it around the body to wherever it's needed.

7) Large intestine

Here water is absorbed — so we don't all shrivel up.

8) Rectum

Food usually contains some materials that we can't digest. This undigested food is stored as faeces. Here the digestion story ends when it plops out of the anus — egestion.

The alimentary canal — don't try to float a boat down it...

As a first step you need to memorise the headings — including each of the eight bits of the alimentary canal. Then there's just the small matter of learning all the details that go with them. Get an image in your head of the whole page and gradually learn the details as you scribble on. It'll get easier the more you practise.

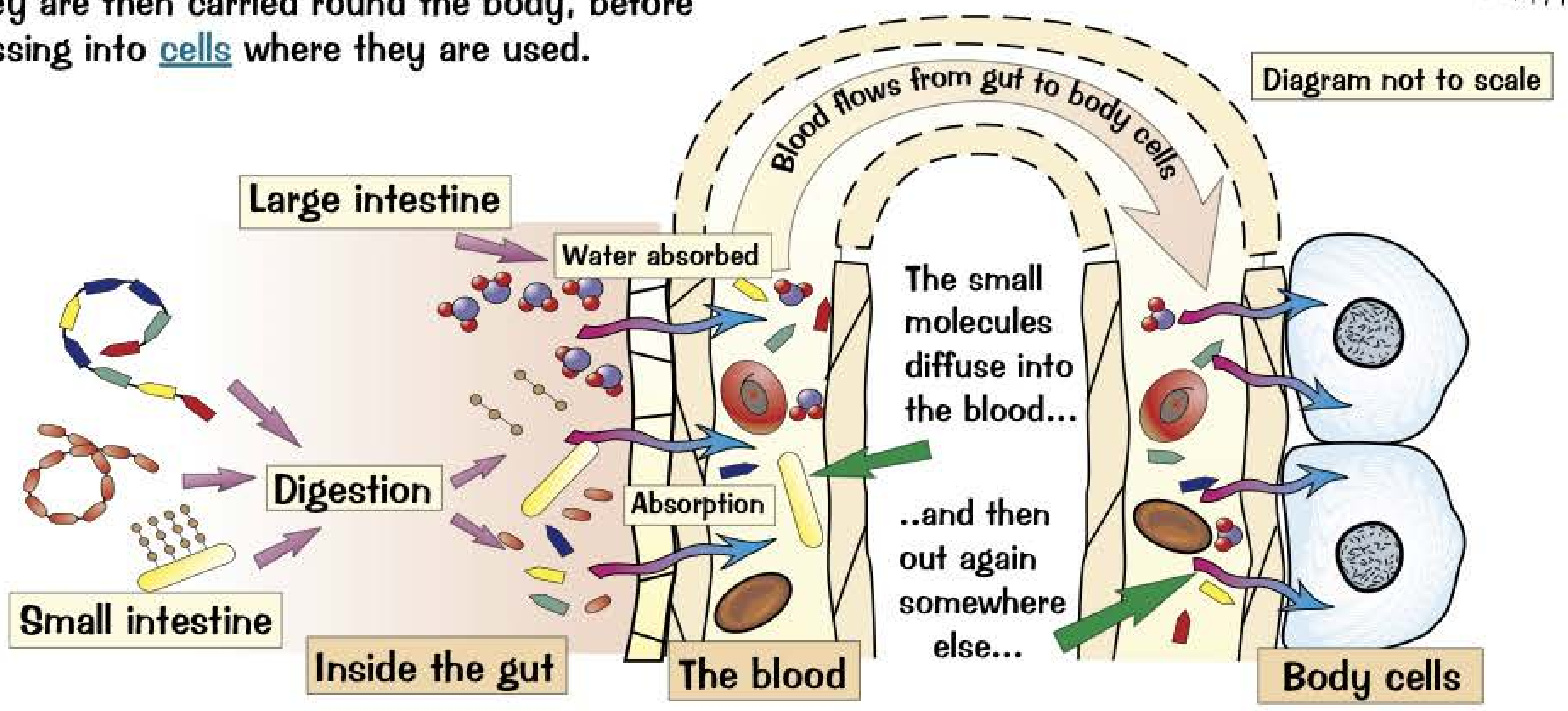
More on Digestion

Well would you believe it? There's more to learn about digestion.

Absorption of Food Molecules

1) Big, insoluble food molecules can't pass through the gut wall.
2) So enzymes are used to break up the big molecules into smaller, soluble ones.
3) These small molecules can pass through the gut wall into the blood. They are then carried round the body, before passing into cells where they are used.

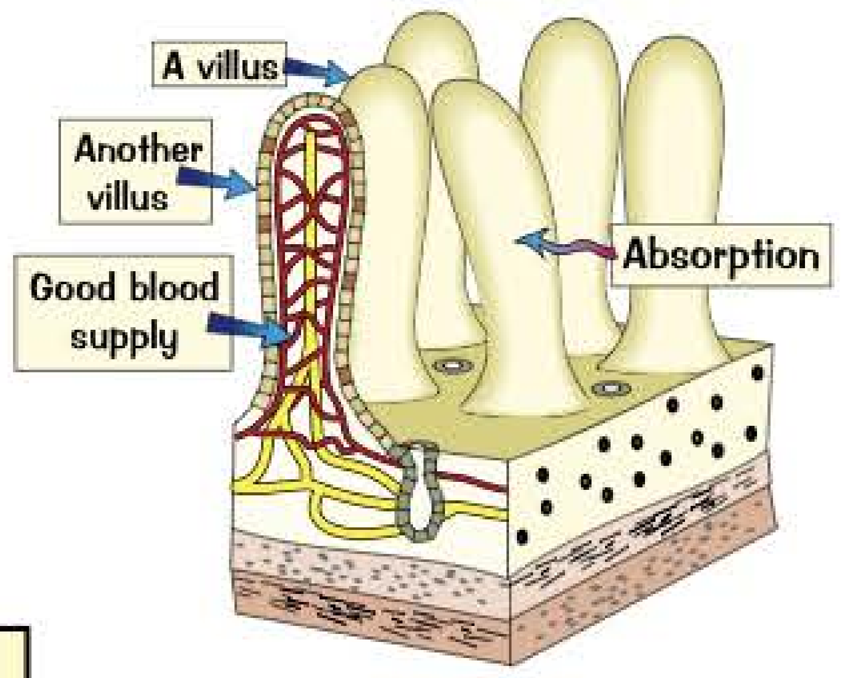
'Insoluble' means 'won't dissolve'. 'Soluble' means 'will dissolve'. See page 39 for more.



The Small Intestine is Covered with Millions of Villi

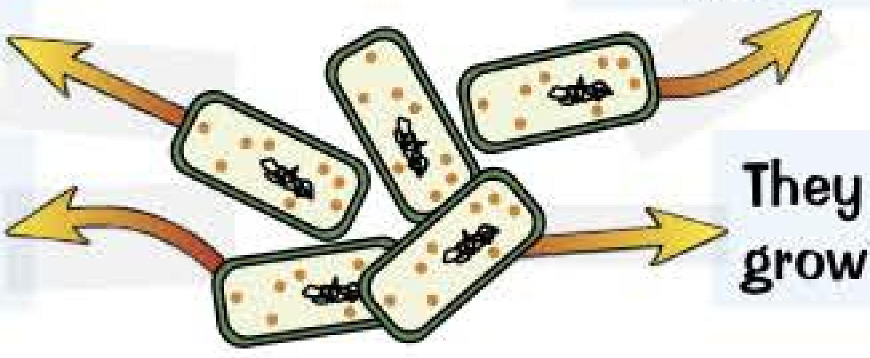
1) Food molecules are absorbed into the blood in the small intestine.
2) The small intestine is lined with tiny finger-like projections called VILLI.
3) Villi are perfect for absorbing food because:
   - They have a thin outer layer of cells.
   - They have a good blood supply.
   - They provide a large surface area for absorption.

Villi is the plural of villus — i.e. it's one villus but two (or more) villi.



Bacteria are Really Important in the Gut

1) Bacteria are unicellular organisms (see page 2).
2) There are about 100 trillion bacterial cells in the alimentary canal. That's loads.
3) Most of these are in the end part of the small intestine and in the large intestine.
4) Some types of bacteria can make you really ill if they get into your body, but the bacteria found naturally in your gut actually do a lot of good:



They produce enzymes that help to digest food.

They produce useful hormones.

They make useful vitamins, e.g. vitamin K.

They reduce the possibility of harmful bacteria growing in your intestines and making you ill.

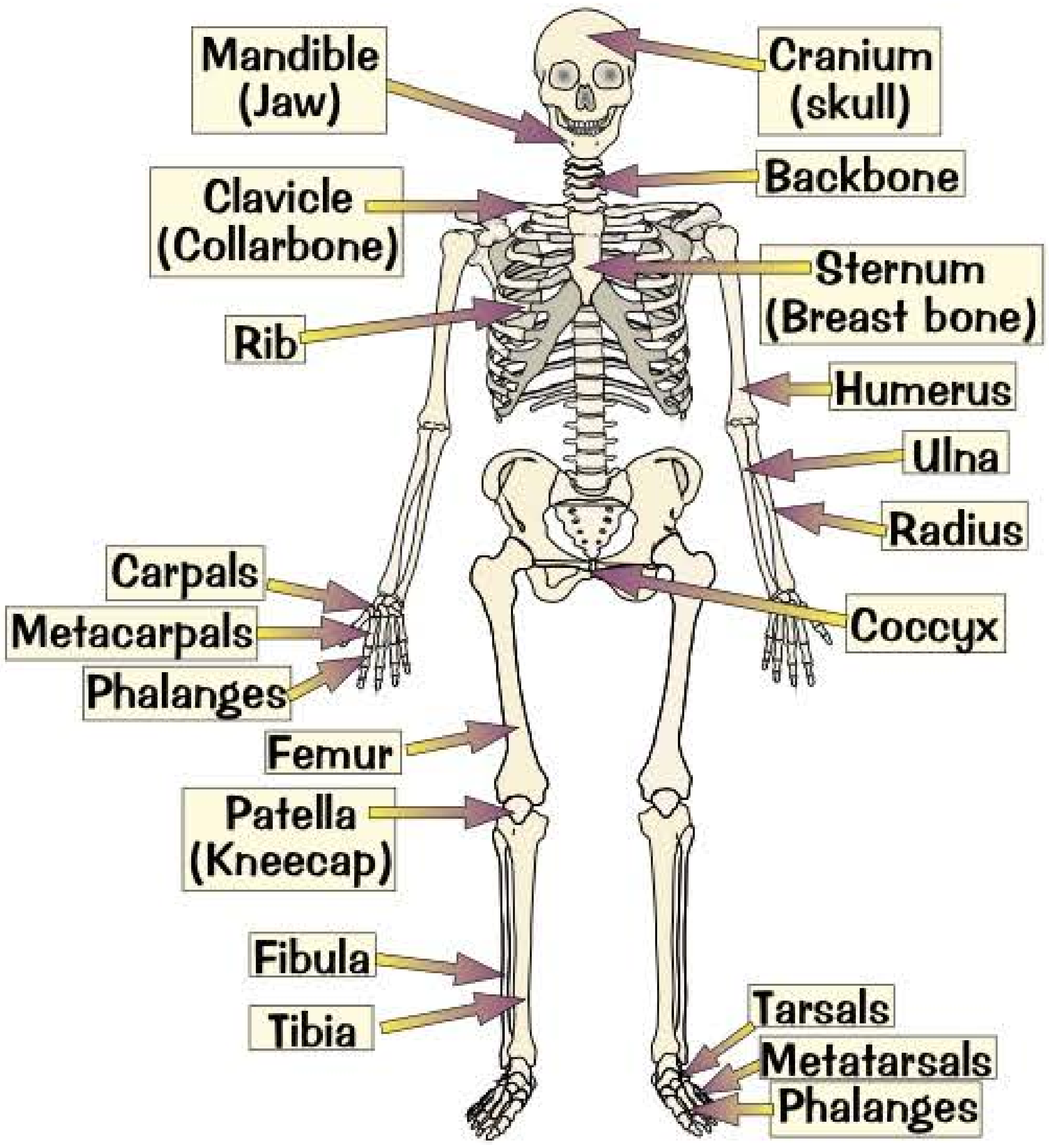
Just like convicts, food can't pass through walls...

As well as just looking pretty, the diagrams on this page are really important for helping you understand how food is broken down and absorbed — so make sure you look at them properly and absorb the information. :)

The Skeleton and Muscles

The human skeletal system is made up of 206 bones and the muscular system has around 640 muscles. Together these systems are really important for allowing you to move around.

The Skeletal System



Bones are made from different types of tissue:

- The outer layer of bone is made from really strong and hard tissue — this makes bones rigid (they can't bend).
- The inner layer is made from more spongy tissue, but it's still strong.

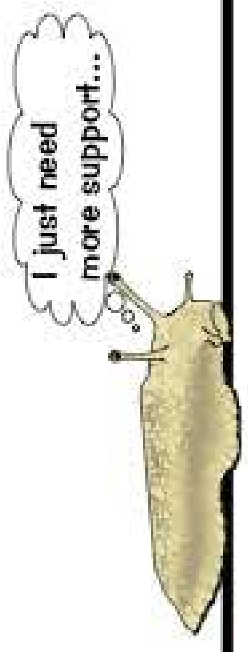
The skeletal system has four main functions:

1) Protection

Bone is rigid and tough so it can protect delicate organs — in particular the brain.

2) Support

1) The skeleton provides a rigid frame for the rest of the body to kind of hang off — kind of like a custom made coat-hanger.
2) All the soft tissues are supported by the skeleton — this allows us to stand up.



3) Production of Blood Cells

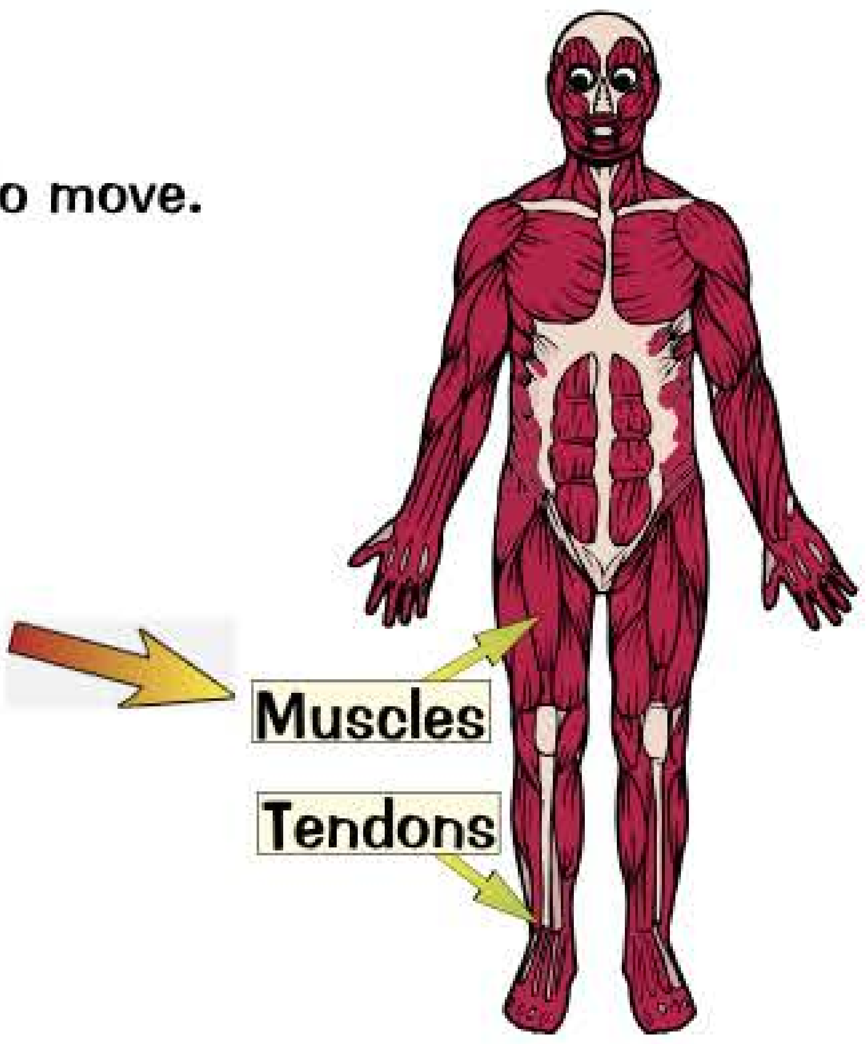
1) Many bones have a soft tissue called bone marrow in the middle of them.
2) Bone marrow produces red blood cells (which carry oxygen around the body) and white blood cells (which help to protect the body from infection).

4) Movement

1) Muscles are attached to bones (see below).
2) The action of muscles allows the skeleton to move.
3) Joints (e.g. the knees and elbows) also allow the skeleton to move.

The Muscular System

1) Muscles are attached to bones via tough bands called tendons.
2) When a muscle contracts it applies a force to the bone it's attached to, which makes the bone move.
3) Muscles are found in pairs round a joint (see the next page).

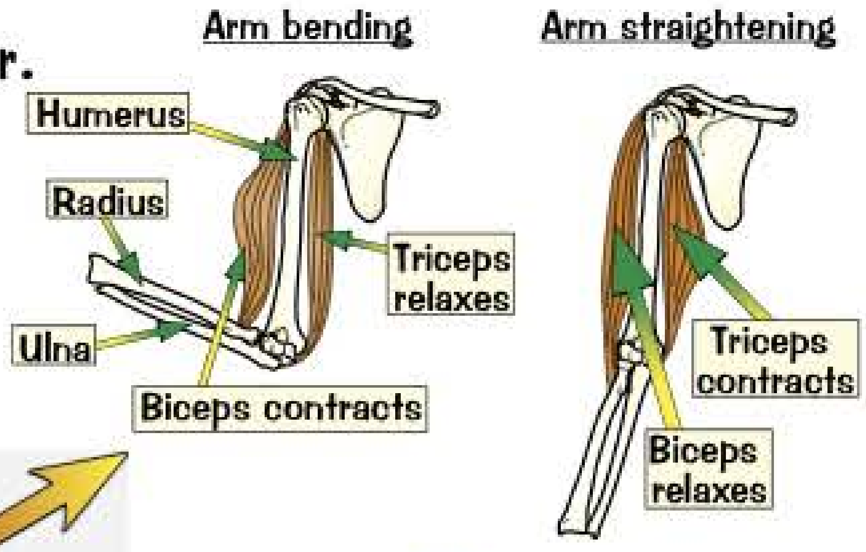


A body without bones? Ever seen a tent without poles...

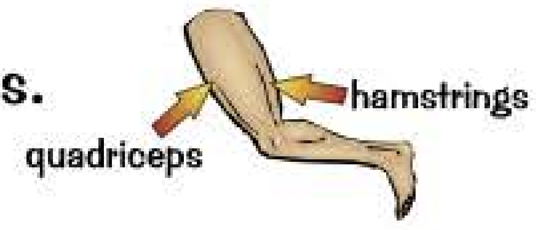
Lots of bone-tinglingly exciting facts to learn here. You don't need to learn the names of all those bones — much more important than the names are what the bones and muscles actually do. The skeletal system has four main functions — you know what to do, cover up the page and see if you can scribble them all down.

How Muscles Work

Antagonistic Muscles Work in Pairs



1) Antagonistic muscles are pairs of muscles that work against each other.
2) One muscle contracts (shortens) while the other one relaxes (lengthens) and vice versa.
3) They are attached to bones with tendons. This allows them to pull on the bone, which then acts like a lever (see below).
4) One muscle pulls the bone in one direction and the other pulls it in the opposite direction — causing movement at the joint.
5) The biceps and triceps muscles in the arm are examples of antagonistic muscles. So are the hamstrings and quadriceps in the legs.



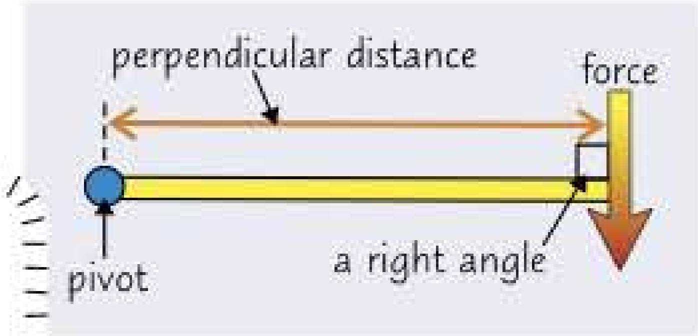
You Can Measure the Force Applied by a Muscle

Let's look at a muscle in the arm as an example:

The study of forces acting on the body is called biomechanics.

Start By Calculating the Moment

1) A pivot is the point around which a rotation happens. A lever is a bar attached to a pivot.
2) When a force acts on something that has a pivot, it creates a "turning effect" known as a moment (see page 82).
3) The arm works as a lever with the elbow as a pivot. This means when a force acts on the arm there's a moment.
4) To calculate the size of a moment, you can use this equation:

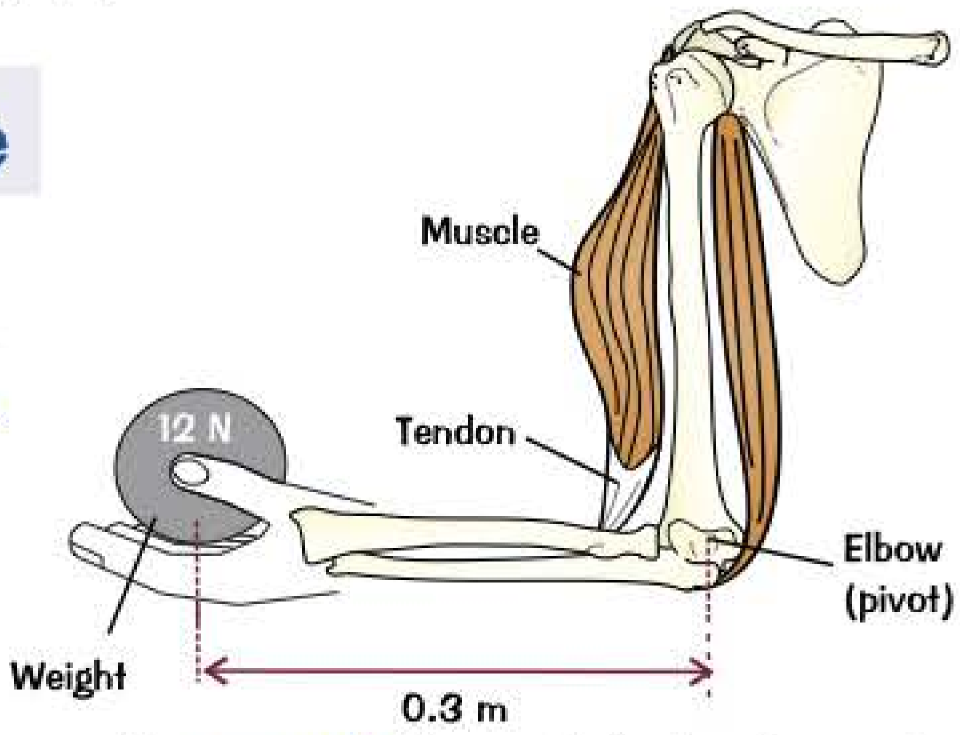


'Perpendicular distance' is the distance at a right angle from the pivot to the line of force.

$$\text{Moment} = \text{force} \times \text{perpendicular distance}$$

In newton metres (Nm) In newtons (N) In metres (m)

5) In the diagram here, the weight (a force) in the hand is creating a moment.
6) The weight has a force of 12 N. It is 0.3 m away from the pivot (the elbow). So using the equation above, the moment of the weight is 12 × 0.3 = 3.6 Nm.



7) But the weight is not the only thing applying a force to the arm — the muscle is applying a force to counteract the moment of the weight and keep the arm still. For the arm to stay still, the moment of the muscle has to be the same as the moment of the weight (but acting in the opposite direction).

Now Work Out The Force Applied By the Muscle

You can rearrange the equation above to calculate the force applied by the muscle:

$$\text{Force} = \text{moment} \div \text{perpendicular distance}$$

In newtons (N) In newton metres (Nm) In metres (m)

In the example above, the weight has a moment of 3.6 Nm, so the muscle must also have a moment of 3.6 Nm.

The distance between the muscle and the pivot (elbow) is 0.05 m. So the force applied by the muscle is 3.6 ÷ 0.05 = 72 N.

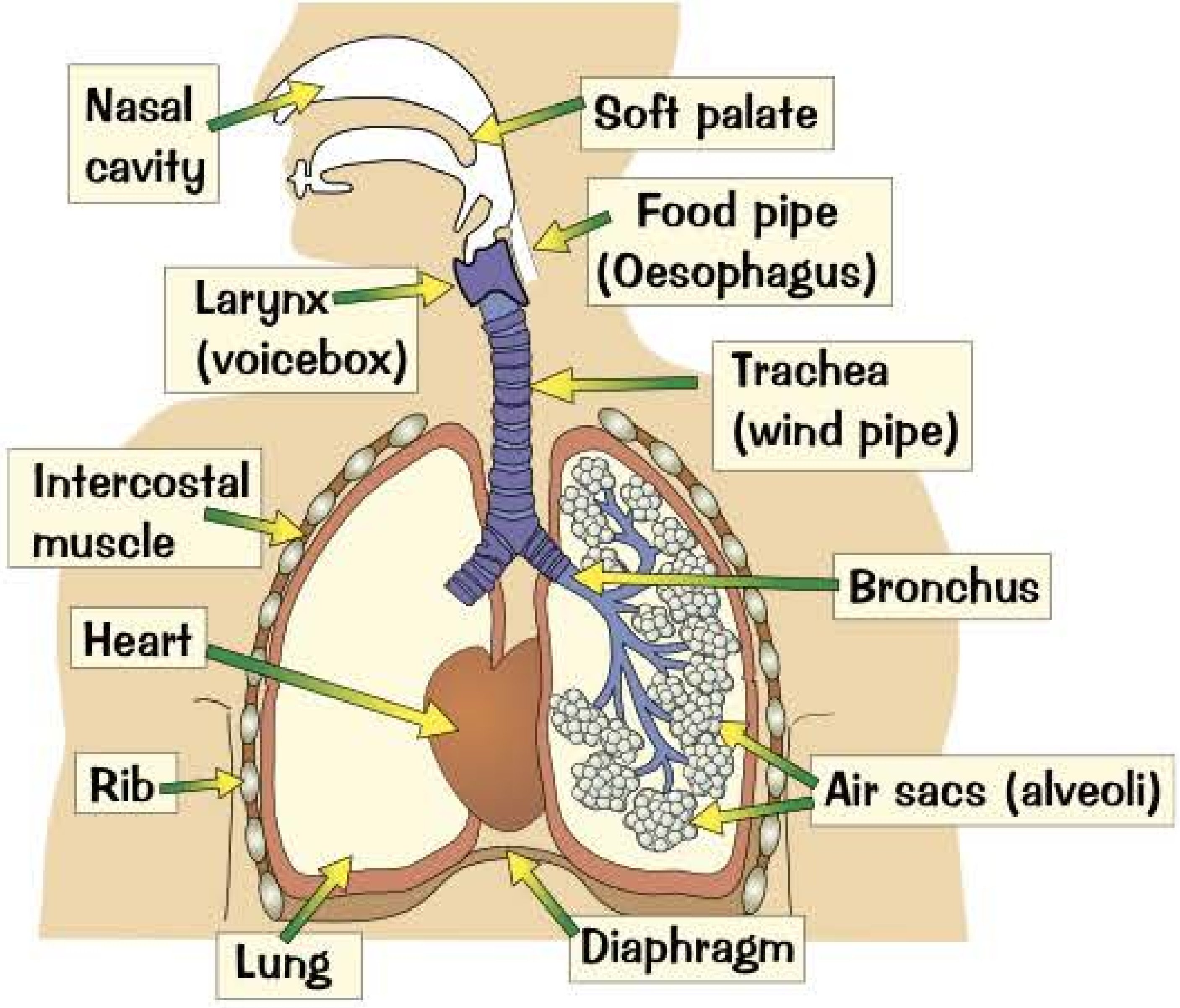
Hang on a moment... what?

All this talk of forces and levers and moments can be pretty tricky to get your head around. But stick with it — you'll really impress your teacher with your super science knowledge if you can explain how muscles work.

Gas Exchange

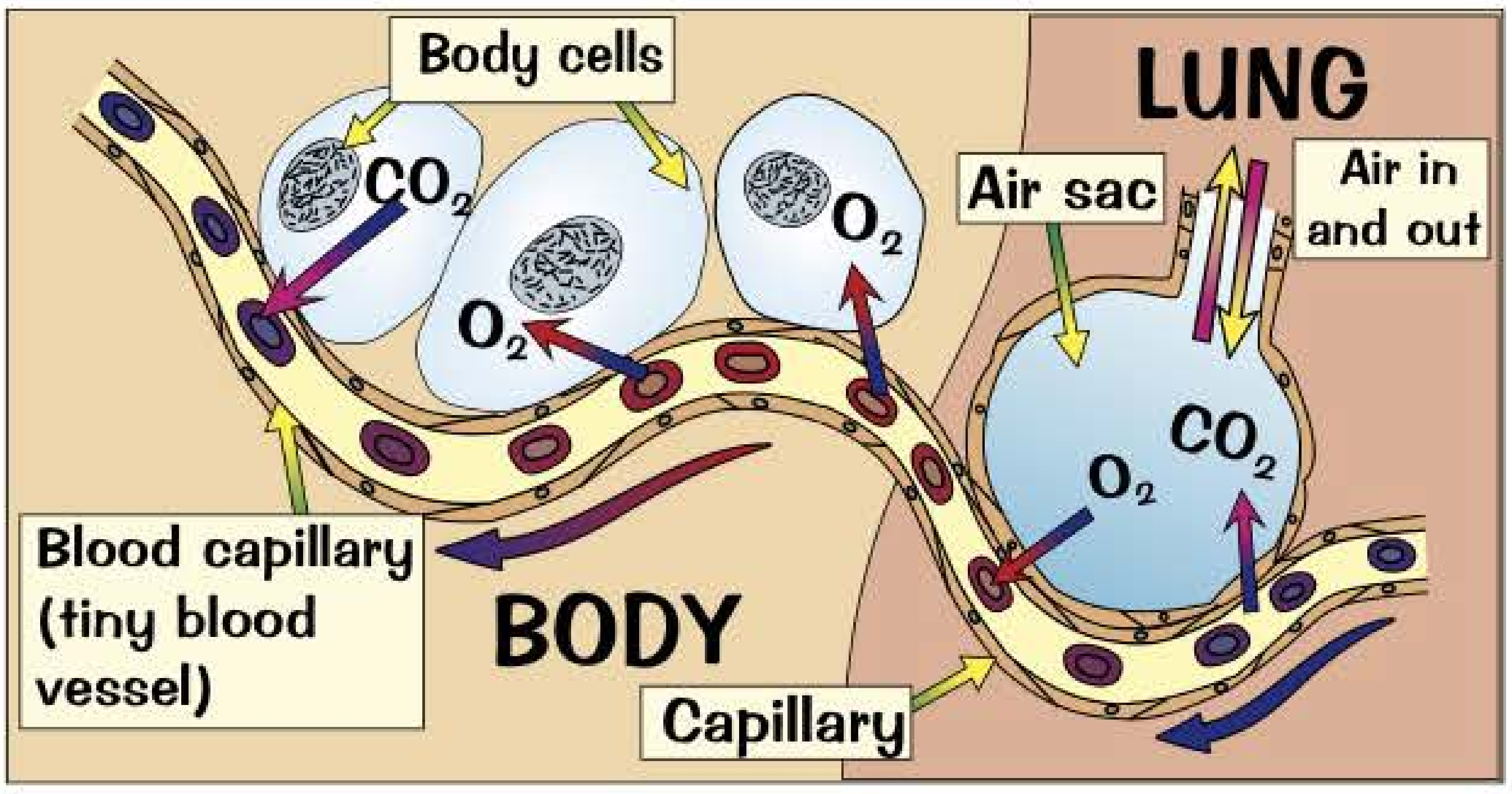
You need to get oxygen from the air into your bloodstream. You also need to get rid of the carbon dioxide that's in your bloodstream. Funnily enough, this exchange of gases happens in your gas exchange system.

Learn These Structures in the Gas Exchange System



1) The lungs are like big pink sponges. They're protected by the ribcage.
2) The diaphragm is a muscle that sits underneath the ribcage. It moves up when it relaxes and down when it contracts. This movement helps to get air in and out of your lungs (see next page).
3) The air that you breathe in goes through the trachea. This splits into two tubes called 'bronchi' (each one is 'a bronchus'), one going to each lung.
4) The bronchi split into smaller tubes called bronchioles.
5) The bronchioles end at small air sacs in the lungs called alveoli. These are where gas exchange takes place.

Gas Exchange Happens in the Lungs



1) Air is inhaled into the lungs.
2) Some of the oxygen in the inhaled air passes into the bloodstream to be used in respiration (see page 4).
3) Carbon dioxide is a waste product of respiration. In the lungs it passes out of the blood and is then breathed out.
4) The gases pass into or out of the bloodstream by diffusion — where a substance moves from where there's lots of it to where there's less of it — see page 3.
5) The lungs are well adapted for gas exchange:
   1) They're moist.
   2) They have a good blood supply.
   3) The alveoli (air sacs) give the lungs a big inside surface area.

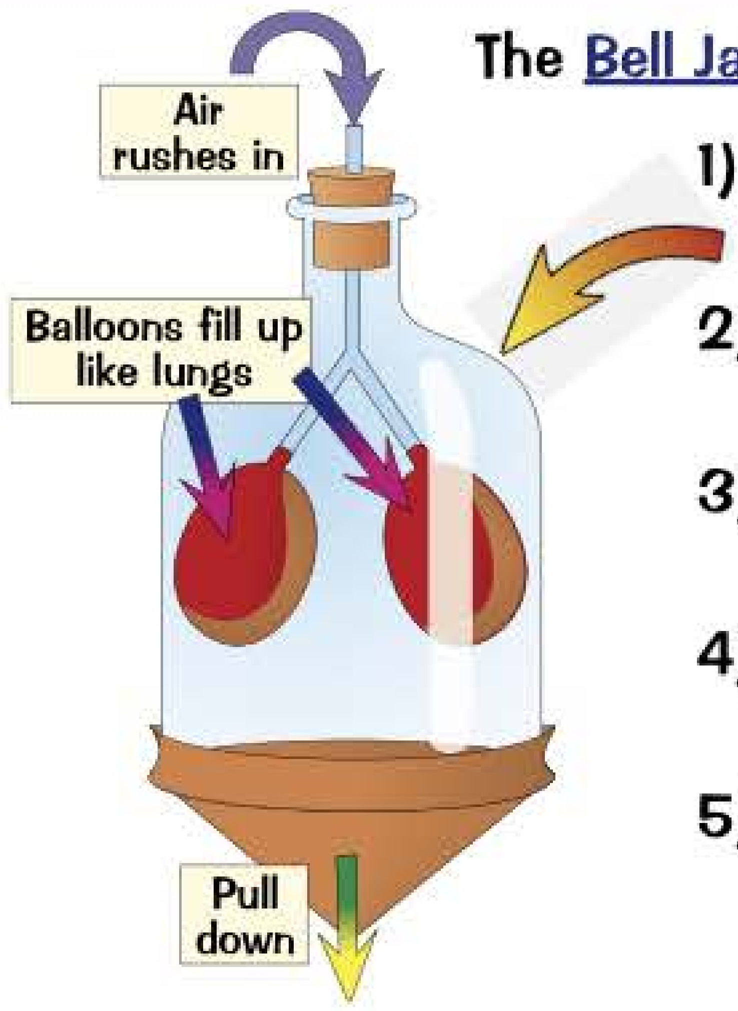
I love ribs — spare ones are my favourite though…

There are a couple of quite detailed diagrams here which need learning. Sooner or later you're expected to learn all the structures in the gas exchange system and what they do, so you may as well start now.

Breathing

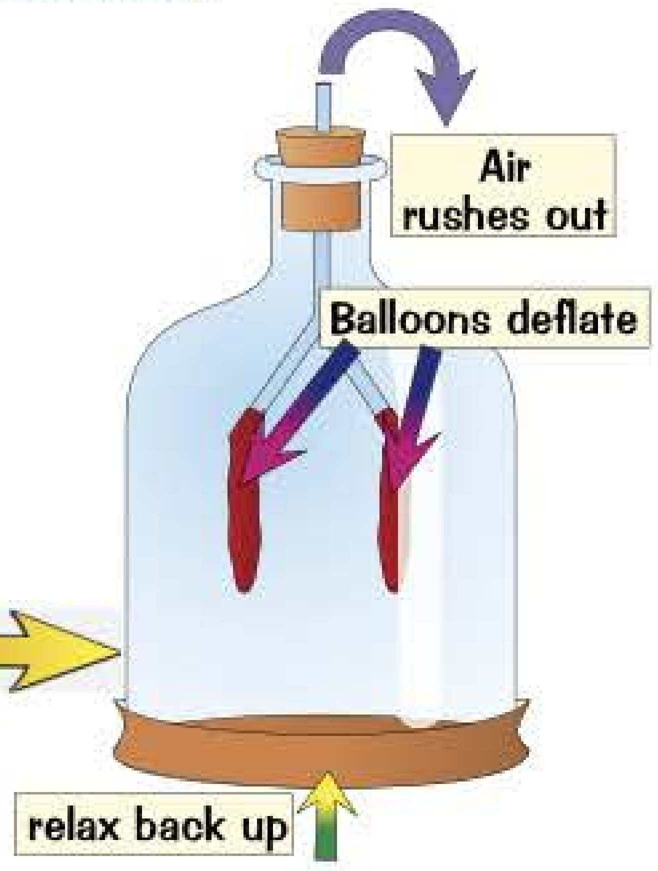
Breathing is how the air gets in and out of your lungs. It's definitely a useful skill.

The Mechanism of Breathing



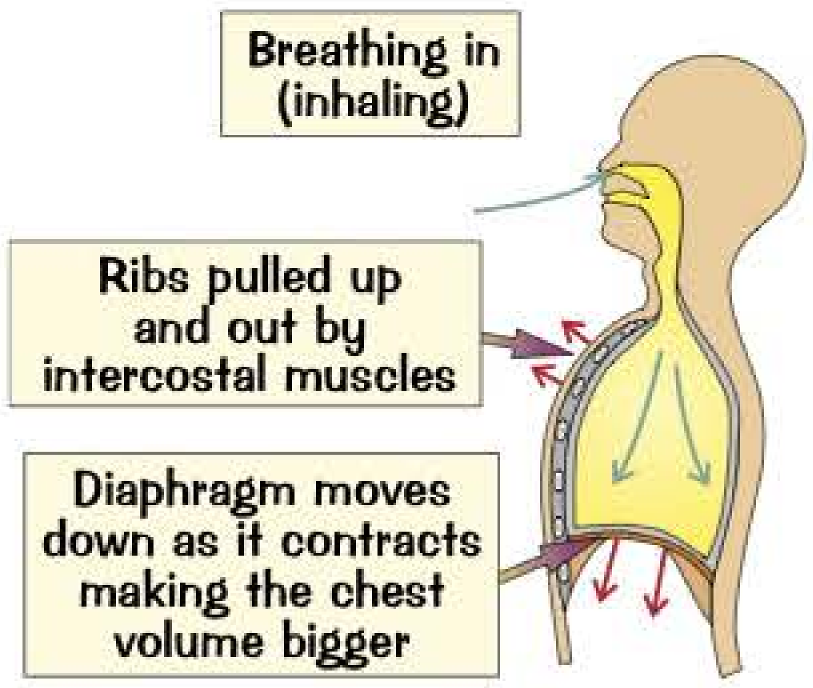
The Bell Jar demonstration shows us what's going on when you breathe:

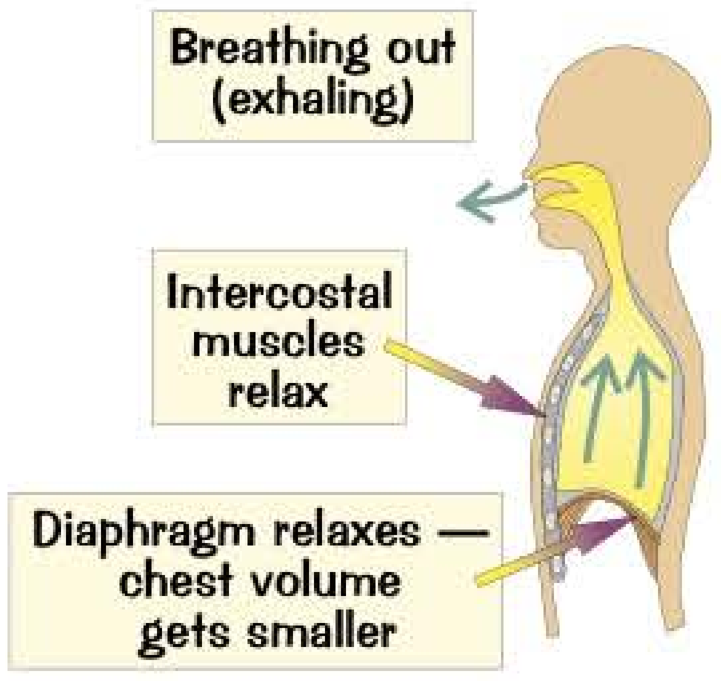
1) First you pull the rubber sheet down — like it's your diaphragm.
2) This increases the volume inside the bell jar, which decreases the pressure.
3) The drop in pressure causes air to rush into the balloons — this is like breathing in.
4) Let go of the rubber sheet — this is like relaxing your diaphragm.
5) The volume in the jar gets smaller. This increases the pressure, so air rushes out. Cool, innit...



Inhaling and Exhaling is Breathing In and Out

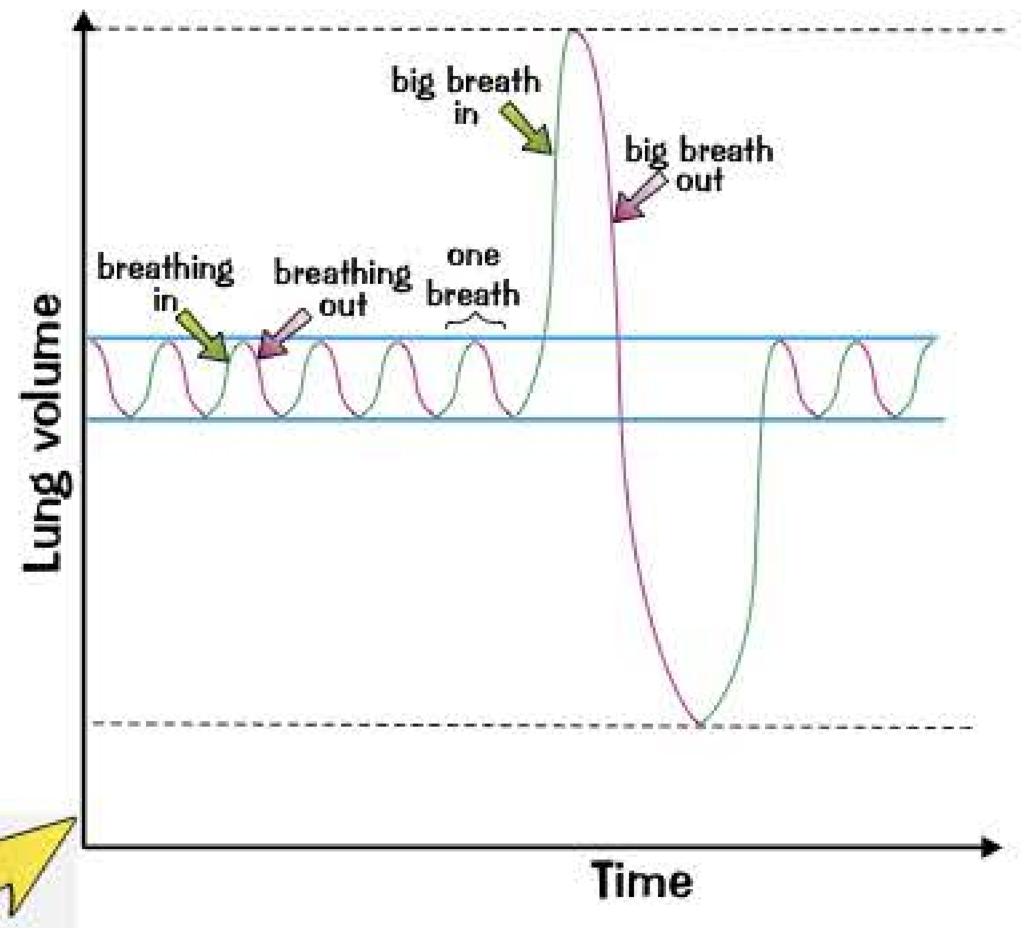
1) The chest cavity is like a bell jar.
2) When you breathe in, the diaphragm moves down and the ribs move up. This increases the volume of the chest cavity, which decreases the pressure. So air rushes in to fill the lungs.
3) When the diaphragm moves up and the ribs move down, air rushes out.





Lung Volume Can Be Measured

1) Lung volume is the amount of air you can breathe into your lungs in a single breath.
2) Lung volume is different for different people. For example, taller people tend to have a bigger lung volume than shorter people. And some diseases may reduce a person's lung volume.
3) Lung volume can be measured using a machine called a spirometer.
4) To use a spirometer, a person breathes into the machine (through a tube) for a few minutes. The volume of air that is breathed in and out is measured and plotted on a graph (called a spirogram) like this one...



Now take a deep breath and learn these facts...

Well, if ever you wanted to know how you breathe in and out, now you know. Learn how breathing works — use that bell jar demo to help you understand what goes on in your actual lungs. Make sure you know how lung volume can be measured too. You'll be acing all things breathing in no time at all.

Exercise, Asthma and Smoking

Exercise, asthma and smoking can all affect your gas exchange system and the way in which you breathe.

Exercise

1) When you exercise, your muscles need more oxygen and glucose so they can respire and release energy (see page 4) to keep you going.
2) During exercise, your breathing rate and depth of breathing increase so you can get more oxygen into your blood.
3) If you exercise regularly, the muscles that you use to breathe (the diaphragm and intercostal muscles) will get stronger.
4) This means that your chest cavity can open up more when you breathe in, so you can get more air into your lungs.
5) Over time, regular exercise can also cause an increase in the number and size of the small blood vessels in your lungs and in the number of alveoli. This means gas exchange becomes more efficient.

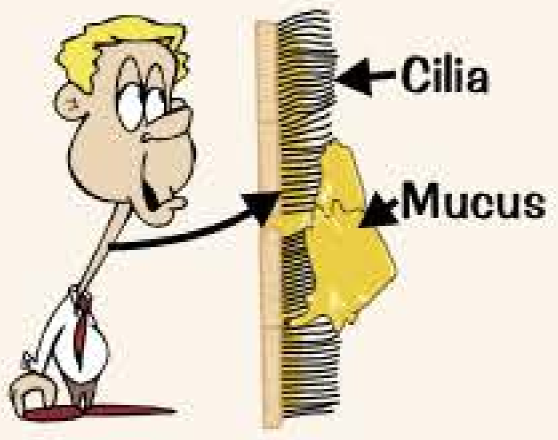
Asthma

1) People with asthma (asthmatics) have lungs that are too sensitive to certain things (e.g. pet hair, pollen, dust, smoke...).
2) If an asthmatic breathes these things in, the muscles around their bronchioles contract. This narrows the airways.
3) The lining of the airways becomes inflamed and fluid builds up in the airways, making it hard to breathe (an asthma attack).
4) Symptoms of an attack are:
   - difficulty breathing,
   - wheezing,
   - a tight chest.
5) When symptoms appear, sufferers can use an inhaler containing drugs that open up the airways.

Smoking

1) Cigarette smoke contains four main things: carbon monoxide, nicotine, tar and particulates.
2) Tar in particular is really bad for you:

- Tar covers the cilia (little hairs) on the lining of the airways.
- The damaged cilia can't get rid of mucus properly.
- The mucus sticks to the airways, making you cough more — this is known as smoker's cough.
- The damage builds up and can eventually lead to bronchitis (a disease that inflames the lining of the bronchi) and emphysema (a disease that destroys the air sacs in the lungs). Both these diseases make it difficult to breathe.
- And there's more... tar contains carcinogens (substances that can cause cancer). Smoking causes cancer of the lung, throat and mouth.



This page is just breathtaking...

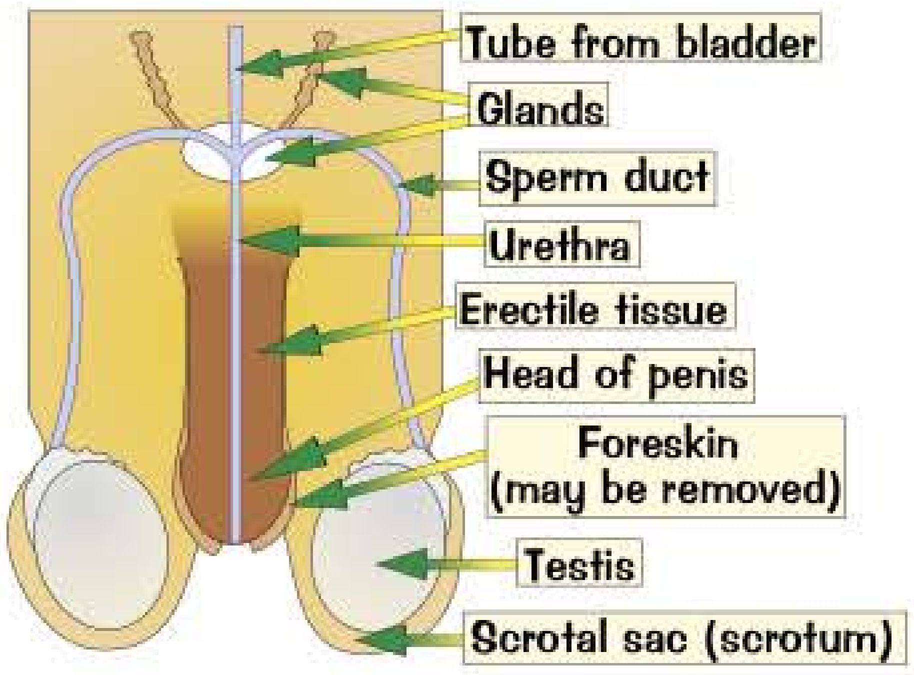
So there you have it — three different things that have an impact on the gas exchange system. Make sure you know them all. Cover up the page and see how much you can write down about each one. If you're struggling, then re-read the page and try again (and again and again...) until you're confident you know it.

Human Reproductive Systems

Like all mammals, humans have different boy bits and girl bits that allow us to reproduce. No giggling now.

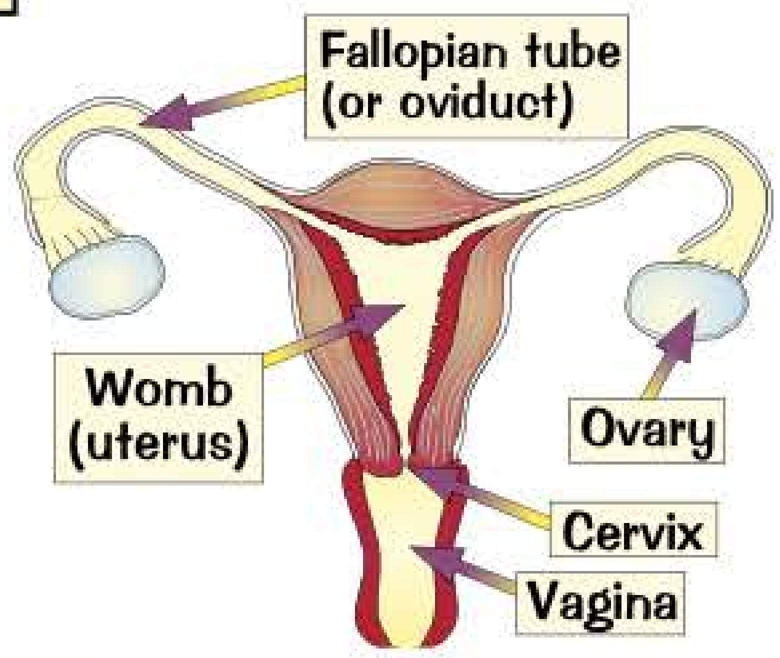
The Male Reproductive System

1) Sperm are the male sex cells or 'gametes'.
2) Sperm are made in the testes after puberty.
3) Sperm mix with a liquid to make semen, which is ejaculated from the penis during sexual intercourse.



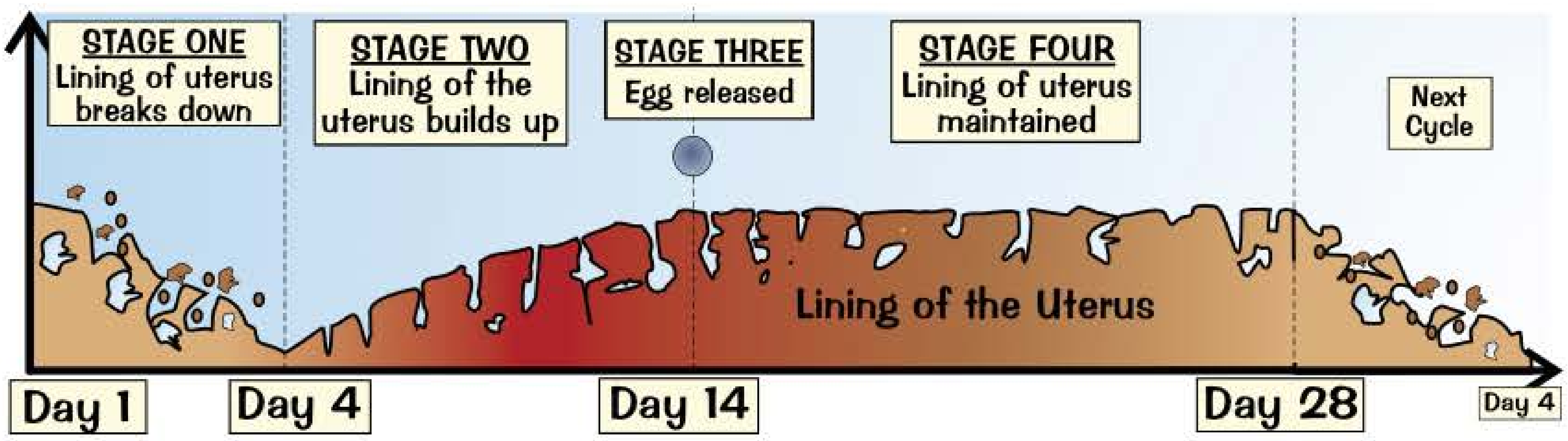
The Female Reproductive System

1) An egg is a female sex cell or 'gamete'.
2) One of the two ovaries releases an egg every 28 days.
3) It passes into the fallopian tube (or oviduct) where it may meet sperm, which has entered the vagina during sexual intercourse (sometimes known as copulation).
4) If it isn't fertilised by sperm (see next page), the egg will die after about a day and pass out of the vagina.



The Menstrual Cycle Takes 28 Days

1) From the age of puberty females undergo a monthly sequence of events which are collectively known as the MENSTRUAL CYCLE.
2) This involves the body preparing the uterus (womb) in case it receives a fertilised egg.
3) If this doesn't happen, then the egg and uterus lining break down and are lost from the body through the vagina over a period of three to four days, usually.
4) The cycle has four main stages — they are summarised in the diagram and table below:



Day	What happens...
1	BLEEDING STARTS as the lining of the uterus (the womb) breaks down and passes out of the vagina — this is what's known as "having a PERIOD".
4	The lining of the uterus starts to build up again. It thickens into a spongy layer full of blood vessels ready for IMPLANTATION. (See next page.)
14	An egg is released from the ovaries of the female, so this is the MOST LIKELY time in which a female may become pregnant. (This day may vary from one woman to the next.)
28	The wall remains thick awaiting the arrival of a fertilised egg. If this doesn't happen then this lining breaks down, passing out of the vagina. Then the whole cycle starts again.

The end of the cycle depends on whether the egg's fertilised...

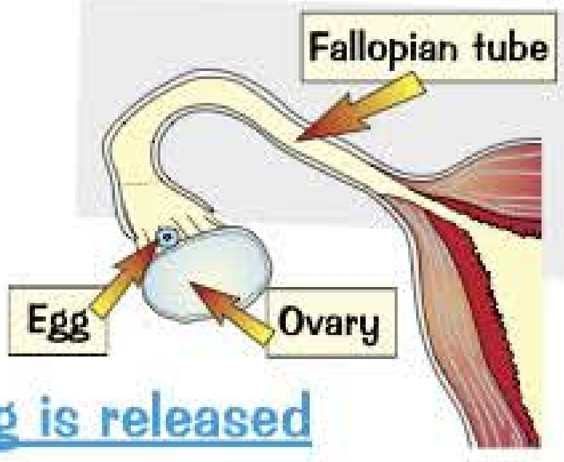
There are quite a few details to learn here. Make sure you know all the bits and bobs in the male and female reproductive systems, plus exactly what all the four stages of the menstrual cycle are and when they occur.

Having a Baby

Once Dad's sperm has fertilised Mum's egg, an embryo forms, the gestation period passes, a baby is born.

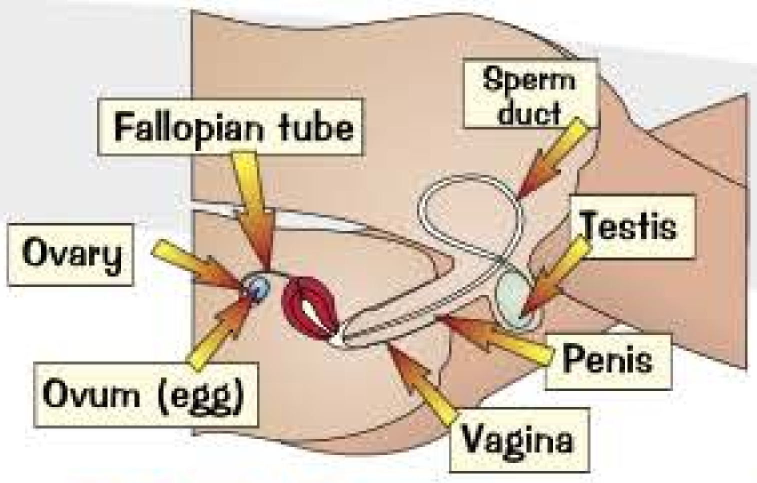
Fertilisation and Development

1) Ovulation



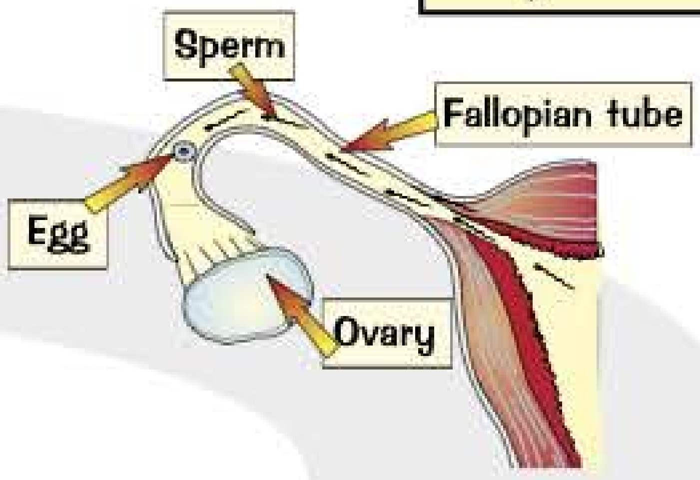
An egg is released from an ovary (around day 14).

2) Copulation



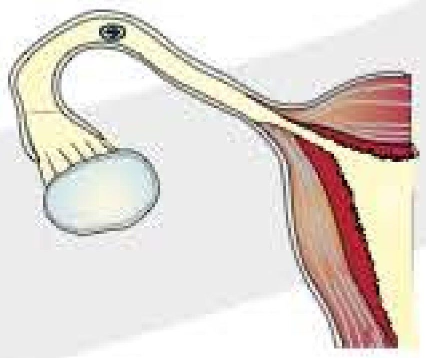
Millions of sperm are released from the penis into the vagina during intercourse.

3) Fertilisation



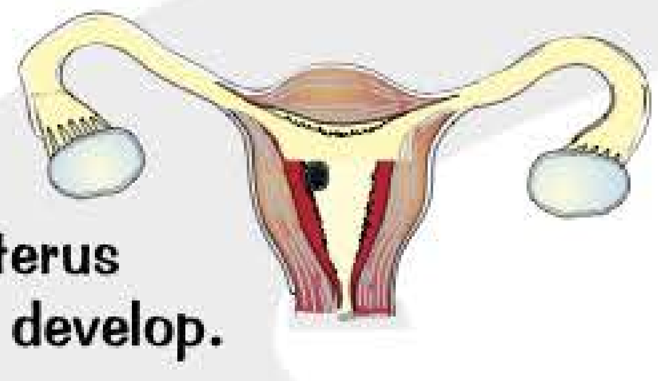
The egg is fertilised when the nuclei of the egg and sperm join — the fertilised egg is called a ZYGOTE.

4) Cell Division



24 HOURS after fertilisation the fertilised egg divides into two. After about 4 DAYS the egg has divided into 32 cells. It's now called an EMBRYO.

5) Implantation



About one week after fertilisation, the embryo starts to embed (implant) itself into the wall of the uterus and the placenta begins to develop.

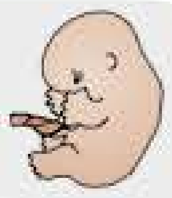
The Embryo Develops During Gestation

Start here

At 1 Month

The embryo is 6 mm long and has a brain, heart, eyes, ears and legs.

At 9 Weeks



The body is about 25 mm long and is completely formed — it's now called a FOETUS.

At 3 Months

The foetus is 54 mm long and looks much more like a baby.

At 5 Months

It's now about 160 mm long. It kicks and its pesky finger nails can be felt.

At 7 Months

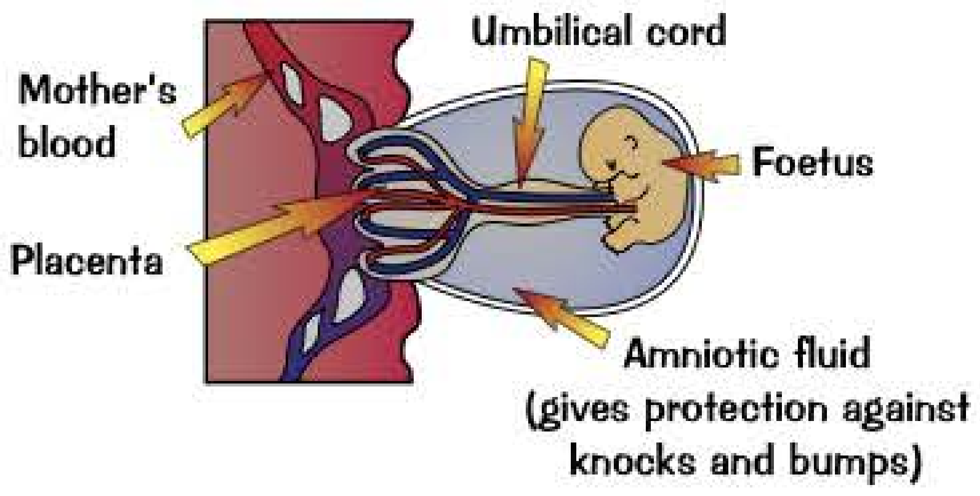
The foetus is 370 mm long and is 'VIABLE'. This means it would have a fair chance of surviving if it were born at this stage.

At 39 weeks

The baby is about 520 mm long. It's fully developed and ready to be BORN.

The Mother's Lifestyle During Pregnancy is Important

1) The placenta lets the blood of the foetus and mother get very close to allow exchange of food, oxygen and wastes.
2) If the mother smokes, drinks alcohol or takes other drugs while she is pregnant, harmful chemicals in her blood can cross the placenta and affect the foetus. For example, the foetus may not develop properly and could have health problems after it's born.



Health and Drugs

Good health is a situation where you're fine and dandy both physically and mentally.
Recreational drugs can have serious negative effects on your health.

Health is More Than Just the Absence of Disease

Good health means having BOTH of these:

1) A healthy body that's all working properly with no diseases.
2) A healthy mental state where you're able to cope with the ups and downs of life.

You should look after your body by eating a balanced diet, doing enough exercise and not abusing drugs.

Drugs

1) A drug is anything that affects the way the body works.
   E.g. They may raise the heart rate or cause blurred vision.
2) There are LEGAL DRUGS and ILLEGAL DRUGS.
   Aspirin, caffeine and antibiotics are examples of legal drugs.
   Cannabis, speed and ecstasy are examples of illegal drugs.
3) RECREATIONAL DRUGS are drugs used for enjoyment, rather than as medicine. They can be legal or illegal.
4) Drugs can affect life processes. For example, drugs that affect the brain are likely to affect movement and sensitivity. And drugs that affect the liver and kidneys will most likely affect excretion (as these are the organs that process waste).

7 Life Processes

Movement — moving parts of the body.
Reproduction — producing offspring.
Sensitivity — responding and reacting.
Nutrition — getting food to stay alive.
Excretion — getting rid of waste.
Respiration — releasing energy from food.
Growth — getting to adult size.

Solvents

1) Solvents are found in most homes — in things like paints, aerosols and glues.
2) They're drugs because they cause hallucinations, which are illusions of the mind.
   Solvents usually have a severe effect on behaviour and character.
3) They also cause serious damage to the lungs, the brain, liver and kidneys.

Alcohol

1) Alcohol is found in beers, wines and spirits. It's illegal to buy it under the age of 18.
2) It's a depressant, which means it decreases the activity of the brain and slows down responses.
3) It's a poison which affects the brain and liver leading to various health problems, e.g. cirrhosis (liver disease).
4) It impairs judgement which can lead to accidents. It's also very addictive.

Illegal Drugs — Dangerous, Addictive and Life-Wrecking

1) Ecstasy and LSD are hallucinogens. Ecstasy can give the feeling of boundless energy which can lead to overheating, dehydration and sometimes DEATH.
2) Heroin and Morphine were developed as painkillers. However they turned out to be highly addictive. They can both cause severe degeneration of a person's life.
3) Amphetamine (speed) and Methedrine are stimulants. They give a feeling of boundless energy. However, users quickly become psychologically dependent on the drug (i.e. they think they need them), so behaviour and character deteriorate.
4) Barbiturates are depressants. They slow down the nervous system and therefore slow down reaction time. They can help sleeping but they're seriously habit-forming.

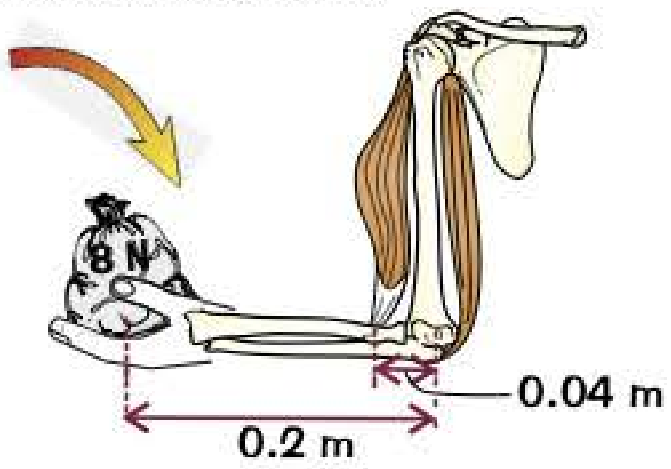
Drugs aren't harmless fun — they're a slippery slope...

There are lots of details here. Make sure you know how different recreational drugs can affect behaviour, health and life processes. And above all else, make sure you realise the dangers of illegal drugs. Learn it well.

Section Summary

Well, there's certainly some stuff in Section 2 — all you ever wanted to know about human beings, and a good deal more besides I should think. Now what you've got to do is make sure you learn it all. And here again for your delectation and enjoyment I have prepared some more of those splendid questions. I didn't say exciting questions — just splendid. Remember, you have to keep coming back to these questions time and time again, to see how many of them you can do. All they do is test the basic simple facts.
OK then — let's see how much you've learnt so far...

1) Name all five nutrients in a balanced diet.
2) Say what each nutrient is important for in the body.
3) For each of the five nutrients, give three examples of foods that contain them.
4) Apart from the five nutrients, give two things that are needed in a balanced diet and explain why they're needed.
5) Give two things that affect how much energy a person needs each day.
6)* Sonia has a body mass of 54 kg. What is her daily basic energy requirement?
7) What is obesity? How is it caused?
8) What health problems can be caused by getting too little food?
9) What does digestion do?
10) Name eight main bits of the alimentary canal.
11) Say what goes on in each of the eight bits.
12) Why can't big molecules pass through gut walls? What has to happen to them first?
13) What are villi? What is their function (job) and how are they well-suited to it?
14) Give four reasons why the bacteria found naturally in your digestive system are good news.
15) Give four functions of the skeleton.
16) What are antagonistic muscles?
17) Explain in terms of "muscle contraction" how you can move your arm up and down.
18) What is a moment? What two pieces of information do you need to be able to calculate one?
19)* Calculate the force applied by the muscle to keep the arm still in this diagram.



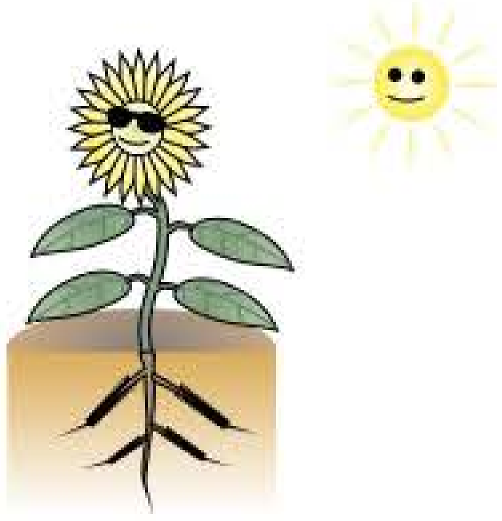
20) Sketch the human gas exchange system and label all the important structures.
21) What gases are exchanged in the lungs when air is breathed in? Where does each gas move from and to?
22) Give three ways in which the lungs are well-adapted for gas exchange.
23) Explain how we breathe air in and out.
24) How can lung volume be measured?
25) How does exercise affect the gas exchange system?
26) What happens in the gas exchange system when someone has an asthma attack?
27) What are the symptoms of an asthma attack?
28) Give two ways in which smoking affects the gas exchange system.
29) What are the male sex cells called? Where are they made?
30) And what are the female sex cells called? Where are they made?
31) Outline the four main stages of the menstrual cycle and say when they happen.
32) What exactly is fertilisation?
33) List five things which must happen before a human embryo can start to develop.
34) Describe what an embryo looks like at:
    1 month, 9 weeks, 3 months, 5 months, 7 months, 39 weeks.
35) Explain why it's not a good idea for a woman to smoke while she's pregnant.
36) What does being healthy mean?
37) What are drugs? What is meant by a 'recreational' drug?
38) Name three legal drugs and three illegal drugs. (Steer clear pal.)
39) Name one recreational drug and explain how it affects life processes.

*Answers on page 108.

Plant Nutrition

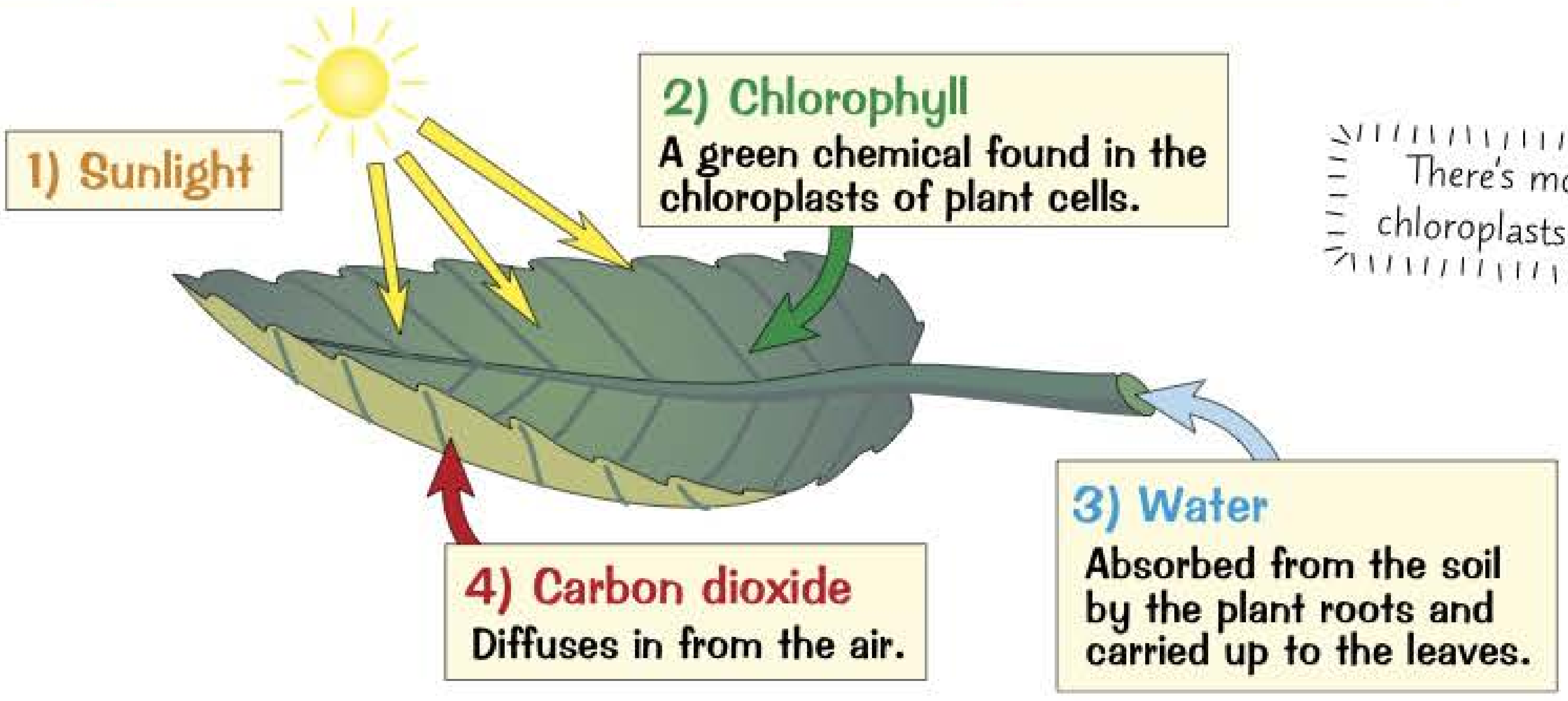
THINK about this: plants make their own food — it's a nice trick if you can do it.

Photosynthesis Makes Food From Sunlight



1) Photosynthesis is a chemical process which takes place in every green plant.
2) Photosynthesis basically produces food — in the form of glucose (a carbohydrate).
3) The plant can then use the glucose to increase its biomass — i.e. to grow.
4) Photosynthesis happens in all the green bits of a plant but mainly in the leaves.

Four Things are Needed for Photosynthesis...



There's more on chloroplasts on p.2.

Chlorophyll absorbs sunlight and uses the energy to convert carbon dioxide and water into glucose. Oxygen is also produced. This word equation summarises what happens during photosynthesis. Learn it:

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose} + \text{Oxygen}$$

These are the reactants.

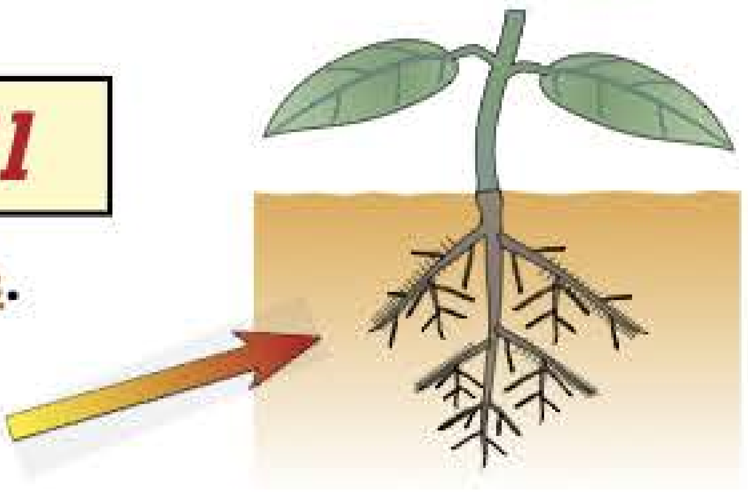
These are the products.

Leaves are Adapted for Efficient Photosynthesis

Leaves are really good at carrying out photosynthesis. Here's why...

1) Leaves are broad, so there's a big surface area for absorbing light.
2) Most of the chloroplasts are found in cells near the top of the leaf, where they can get the most light.
3) The underside of the leaf is covered in tiny holes called stomata. These holes allow carbon dioxide to diffuse (move) into the leaf from the air. They also allow oxygen to diffuse out. Air spaces inside the leaf allow carbon dioxide to move easily between the leaf cells.
4) Leaves also contain a network of veins, which deliver water to the leaf cells and take away glucose.

Plants Also Need Minerals from the Soil



1) Plants grow using the food they make themselves in photosynthesis. But to keep healthy they also need mineral nutrients from the soil.
2) Plants absorb these minerals through their roots (along with water).

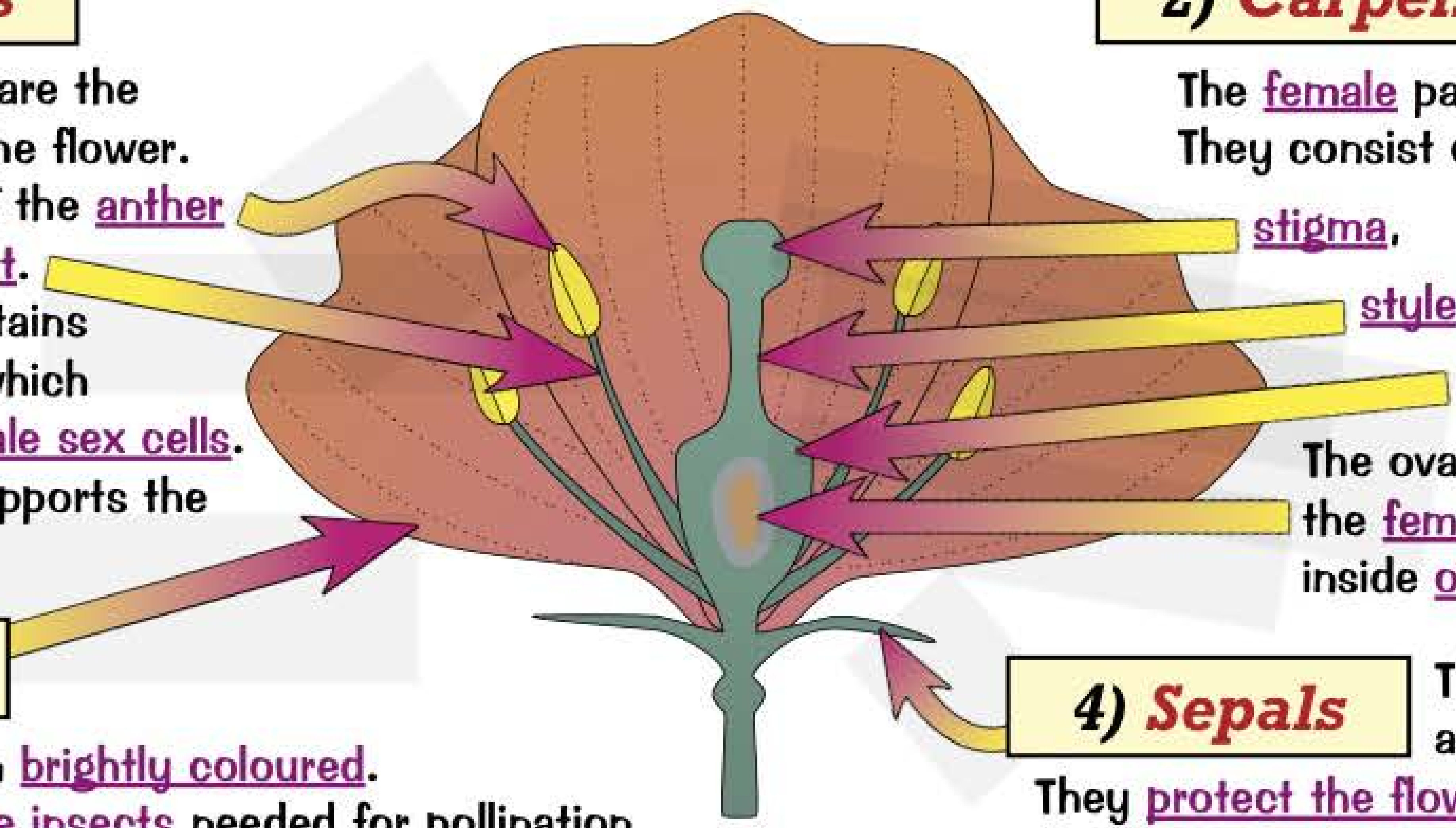
Hmm, it's all clever stuff — just make sure you learn it...

Remember, plants don't get food from the soil — they make it themselves using photosynthesis. They do get water and tiny amounts of the minerals they need to stay healthy from the soil. Got that? Sorted.

Plant Reproduction

Just like humans, plants reproduce (make babies). This page is all about how plant reproduction starts.

The Flower Contains the Reproductive Organs



1) Stamens

The sta-men-s are the male parts of the flower. They consist of the anther and the filament. The anther contains pollen grains, which produce the male sex cells. The filament supports the anther.

2) Carpels

The female parts of the flower. They consist of the stigma, style and ovary. The ovary contains the female sex cells inside ovules.

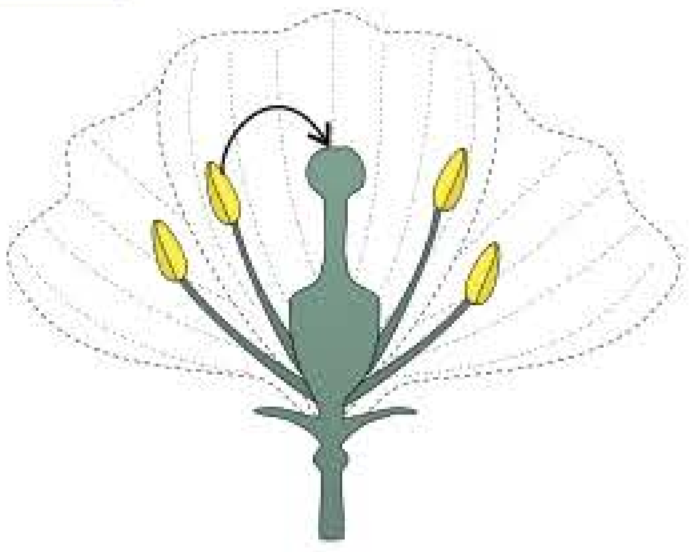
3) Petals

These are often brightly coloured. They attract the insects needed for pollination.

4) Sepals

These are green and leaf-like. They protect the flower in the bud. They're found below the main petals.

"Pollination" is Getting Pollen to the Stigma



1) To make a seed (which will eventually grow into a new plant) the male and female sex cells must "meet up".
2) To do this, the pollen grains must get from a stamen to a stigma. This can happen in two ways:

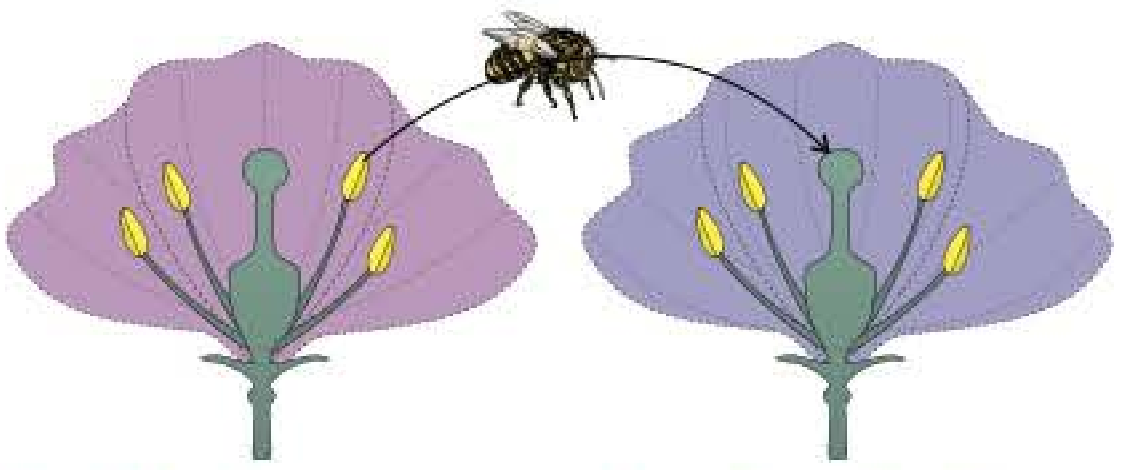
1) Self Pollination

— pollen is transferred from stamen to stigma on the SAME PLANT.

2) Cross Pollination

— pollen is transferred from the stamen of one plant to the stigma of a DIFFERENT PLANT. Cross pollination can involve...

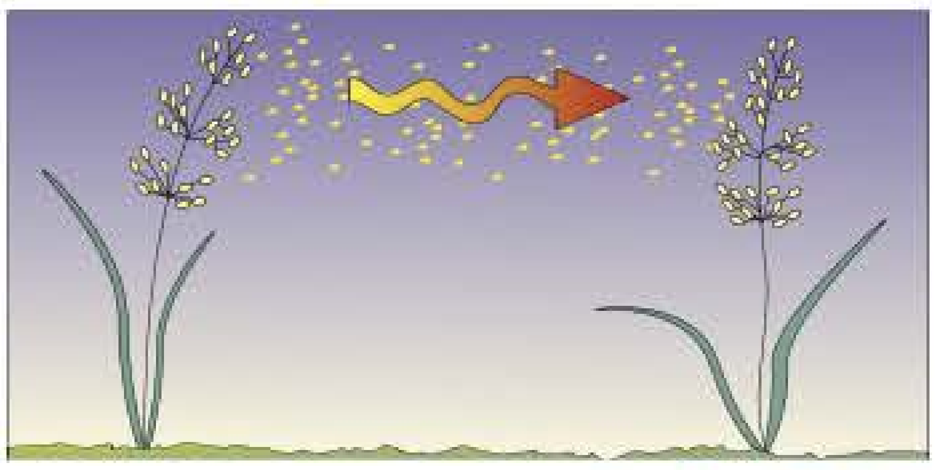
...Insect Pollination



Plant features that help insect pollination:

1) Bright coloured petals.
2) Scented flowers with nectaries (glands that produce a sugary liquid for insects to feed on).
3) Sticky stigma to take the pollen off the insect as it goes from plant to plant to feed in the nectaries.

...Wind Pollination



Features of plants that use wind pollination:

1) Usually small dull petals on the flower.
2) No scent or nectaries.
3) Long filaments hang the anthers outside the flower so a lot of pollen is blown away.
4) Stigmas are feathery to catch pollen as it's carried past in the wind.

There are no "B"s in wind pollination — bzzzz bzzz...

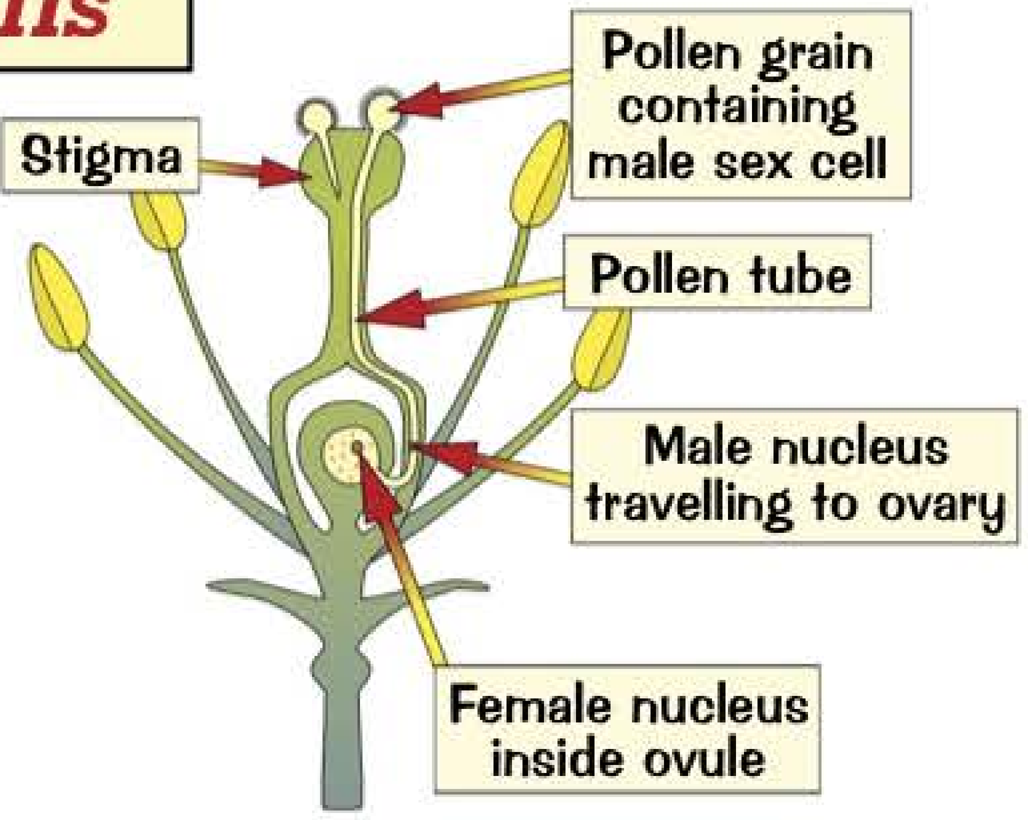
All those bits of a flower to learn and then the "ins and outs" of pollination. Make sure you know it all before you move on to the next page or you'll be in a pretty pickle. And not the edible kind either...

Fertilisation and Seed Formation

Here it is, the long awaited sequel to Plant Reproduction — or what happens after a flower is pollinated.

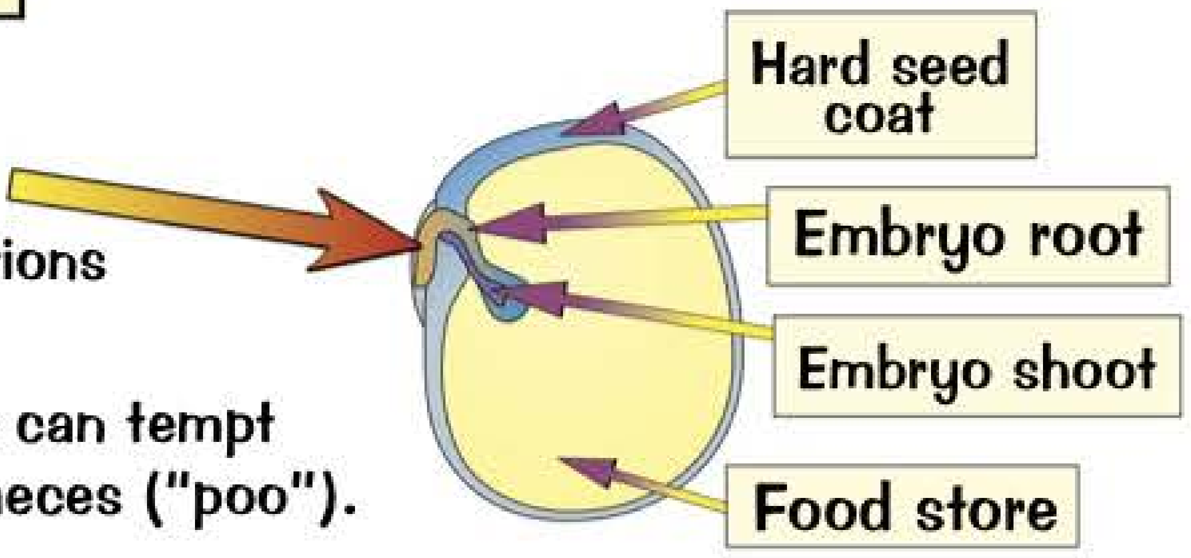
Fertilisation is the Joining of Sex Cells

1) Pollen is the plant equivalent of human sperm.
2) Pollen grains land on a ripe stigma with help from insects or the wind (see previous page).
3) A pollen tube then grows out of a pollen grain, down through the style to the ovary.
4) The nucleus from a male sex cell moves down the tube to join with a female sex cell inside an ovule. Fertilisation is when the two nuclei join.



Seeds are Formed From Ovules

1) After fertilisation, the ovule develops into a seed. Each seed contains a dormant (inactive) embryo plant.
2) The embryo has a food store which it uses when conditions are right — i.e. it starts to grow or "germinate".
3) The ovary develops into a fruit around the seed. Fruits can tempt animals to eat them and so scatter the seeds in their faeces ("poo").



Seed Dispersal is Scattering Seeds

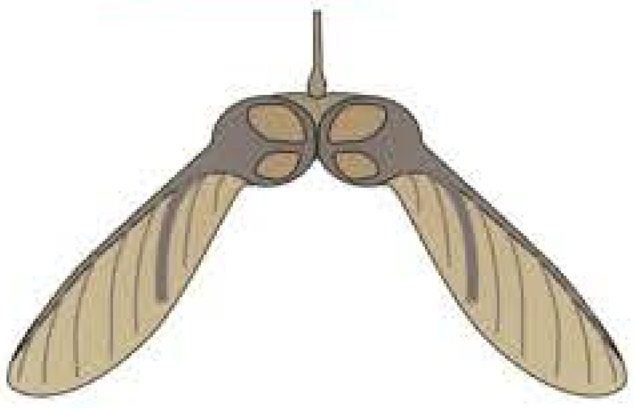
Seeds are dispersed or spread out so that they can grow without too much competition from each other. Here are some ways in which the seed can be dispersed:

1) Wind dispersal

Dandelion fruit.

Parachutes catch the wind.

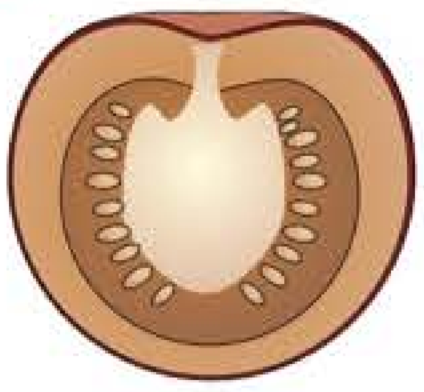
Sycamore fruit.



Wings help it fly away from the parent tree.

2) Animal dispersal

Tomato fruit.



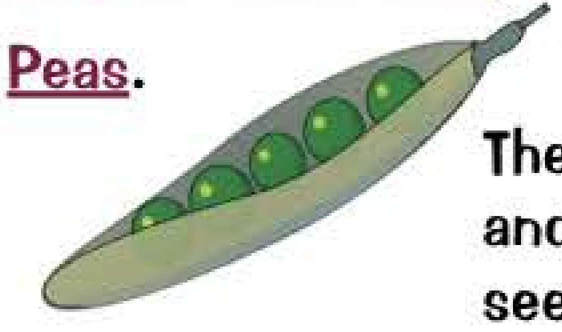
Fruit gets eaten. Seeds come out in the animals' droppings.

Burdock fruit.

Hooks catch animals' coats.

3) Explosions

Peas.



The pods dry out and flick the seed out.

4) Drop and Roll

The heavy fruit falls down from the tree. It splits when it hits the ground and the seeds roll out.

Horse Chestnut fruit.

The seeds then tend to be further dispersed by animals.

What has a hazelnut in every bite — Squirrel poo...

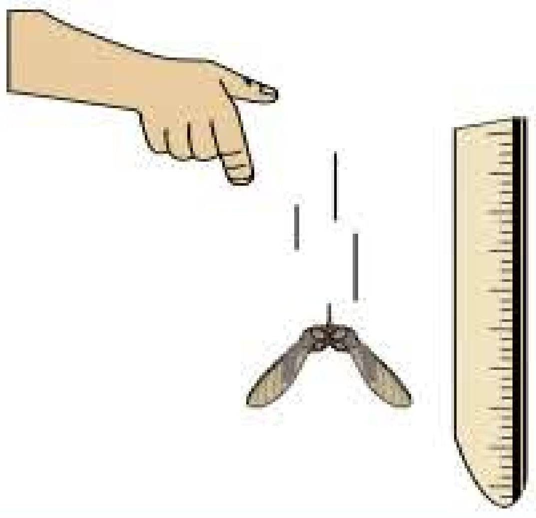
Phew, what a palaver. It all starts with pretty flowers which lead to pollination, then fertilisation. That leads on to seed development, and then the business of dispersal. Eventually, the seeds will grow into new plants far away from their parents. It makes your head hurt just thinking about it. You do need to learn it though.

Investigating Seed Dispersal Mechanisms

At last, a little bit of science in action. Roll up your sleeves and let's get started.

You Can Investigate Seed Dispersal by Dropping Fruit

You can investigate how well different seeds disperse from the comfort of your own classroom. It's easiest to investigate the wind and drop and roll dispersal mechanisms.



Here's what you have to do.

1) Get yourself some fruit (containing seeds). You could compare ones with different dispersal mechanisms, e.g. sycamore fruit and horse chestnut fruit.
2) Decide on a fixed height to drop the fruit from.
3) Drop the fruit one at a time from this height, directly above a set point on the ground.
4) Using a tape measure, measure and record how far along the ground the seeds have been dispersed.

Do this at least three times for each type of seed and then find the average distance each type travels or 'disperses' when dropped.

Seed Type	Distance Dispersed (c		
Sycamore	20	25	
Horse Chestnut			

Make Sure it's a Fair Test

So that you can make a fair comparison between the distances travelled by different seed types, you need to keep the following the same each time you do the experiment:

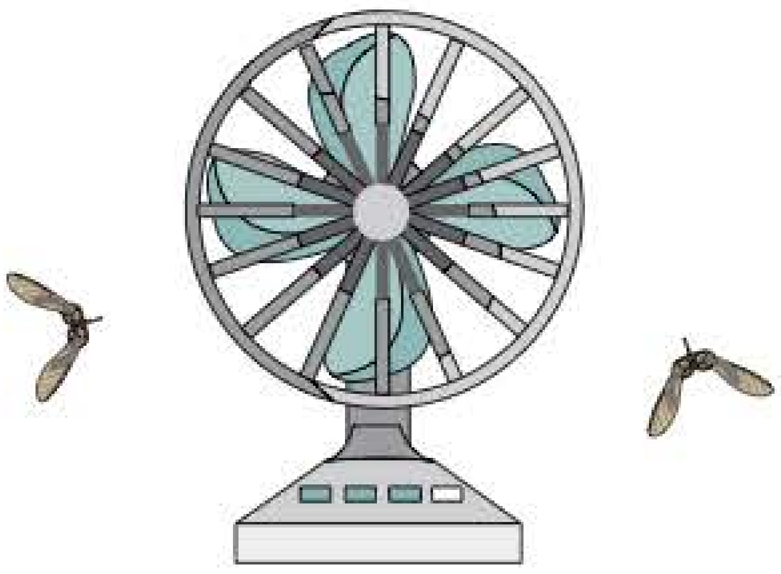
- the person dropping the fruit,
- the height the fruit are dropped from,
- the place you're doing the experiment (stay away from doors and windows that might cause draughts).

This is called "controlling the variables".

Use a Fan to Investigate the "Wind Factor"

Many seed dispersal mechanisms are affected by the wind. The special shape of sycamore fruit helps the wind to catch the fruit and carry the seeds far away from the parent sycamore tree.

You can investigate just how much the wind affects seed dispersal by introducing an electric fan into the experiment above. Here's how:



1) Set up the fan a fixed distance from the person dropping the fruit.
2) Switch the fan on — it needs to be set to the same speed for every fruit you drop. This makes sure the experiment will be a fair test.
3) Drop the fruit as before and measure how far along the ground the seeds travel.

You should find that the sycamore seeds travel much further in windy conditions (i.e. when the fan is switched on). This might not be the case for every seed type though.

I've got a pea shooter — is that a seed dispersal mechanism?

Ahh, the things you get up to in science lessons. You can also investigate how much the shape of sycamore fruit helps the seeds to disperse — just cut the wings off and repeat the experiment in front of the fan.

Dependence on Other Organisms

It probably won't surprise you to learn that organisms depend on other organisms for their survival.

Organisms in an Ecosystem are Interdependent

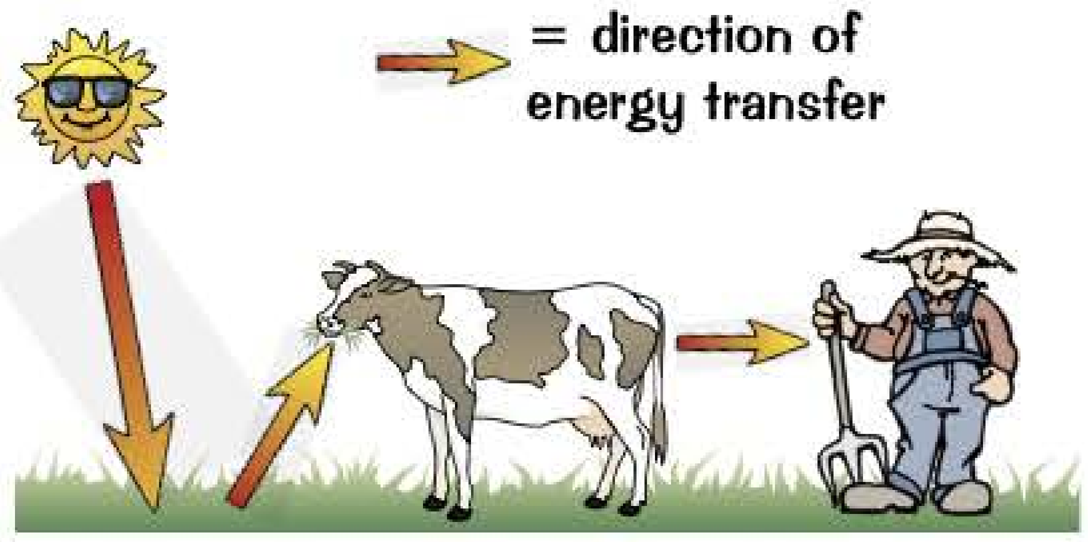
1) An ecosystem is all the living organisms in one area, plus their environment.
2) The organisms in an ecosystem are interdependent — they need each other to survive.

Almost All Living Things Depend on Plants

Almost all life on Earth depends on plants. Without them, we just wouldn't be here. Here's why...

Plants Capture the Sun's Energy

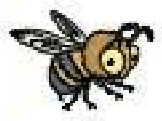
1) Almost all energy on Earth comes from the Sun.
2) Plants use some of the Sun's energy to make food during photosynthesis (see page 19). They then use this food to build "organic molecules" (things like carbohydrates and proteins), which become part of the plants' cells.
3) These organic molecules store the Sun's energy. The energy gets passed on from plants to animals when animals eat the plants. It gets passed on again when these animals are eaten by other animals.
4) Only plants, algae (seaweeds) and some bacteria are able to carry out photosynthesis. So nearly all living things rely on plants to capture and store the Sun's energy.



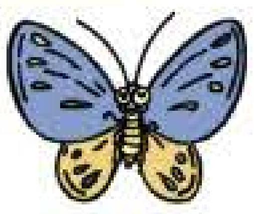
Plants Release Oxygen and Take in Carbon Dioxide

1) All living things respire (see page 4).
2) When plants and animals respire, they take in oxygen (O_2) from the atmosphere and release carbon dioxide (CO_2).
3) When plants photosynthesise, they do the opposite — they release oxygen and take in carbon dioxide.
4) So photosynthesis helps make sure there's always plenty of oxygen around for respiration. It also helps to stop the carbon dioxide level in the atmosphere from getting too high. This is an example of organisms affecting their environment.

Many Plants Depend on Insects in Order to Reproduce



1) Many plants depend on insects to pollinate them (see page 20).
2) Without insects like bees, moths and butterflies, these plants would struggle to reproduce.
3) This would obviously be bad for the plants, but it would be bad for humans too. Many of our crop plants need to be pollinated by insects in order to produce the fruit, nuts and seeds that we eat.
4) So we depend on insects to pollinate our crops and ensure our food supply.



We're all just one big happy family...

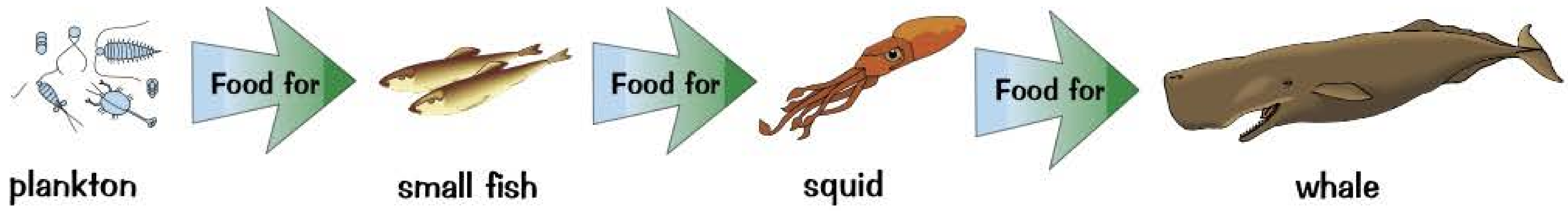
Remember, the organisms in an ecosystem are interdependent — we depend on plants for all our energy and to produce the oxygen we use up in respiration. And many plants depend on insects to pollinate them.

Food Chains and Food Webs

Organisms depend on each other to survive. Mainly this means that they depend on each other for food.

Food Chains Show What is Eaten by What

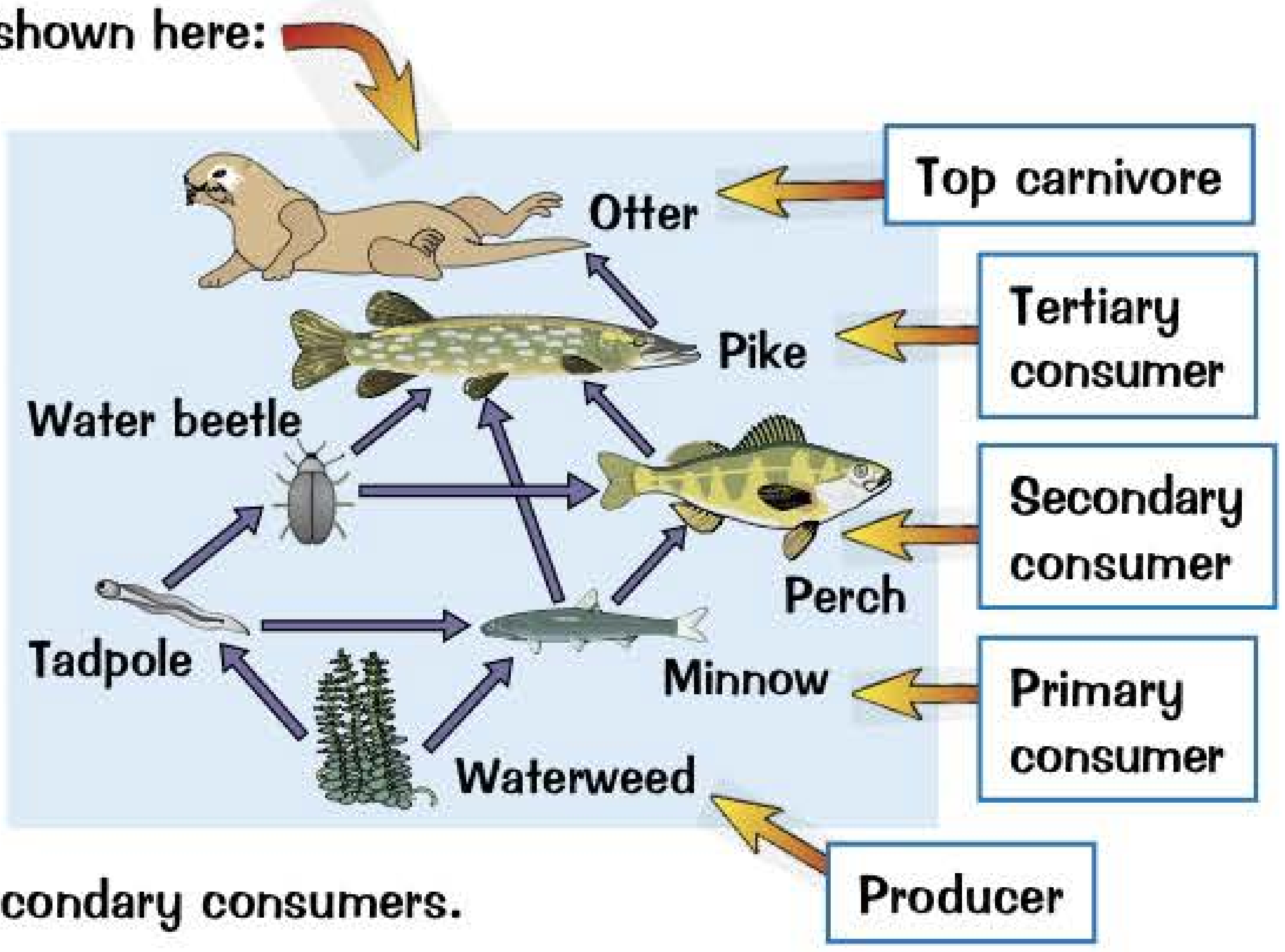
1) The organisms in a food chain are usually in the same ecosystem.



2) The arrows show what is eaten by what — i.e. "food for". (Plankton is food for small fish, etc.)
3) The arrows also show the direction of energy flow.

Food Webs and Their Tremendous Terminology

Food webs contain many interlinked food chains as shown here:
Learn these nine bits of terminology:



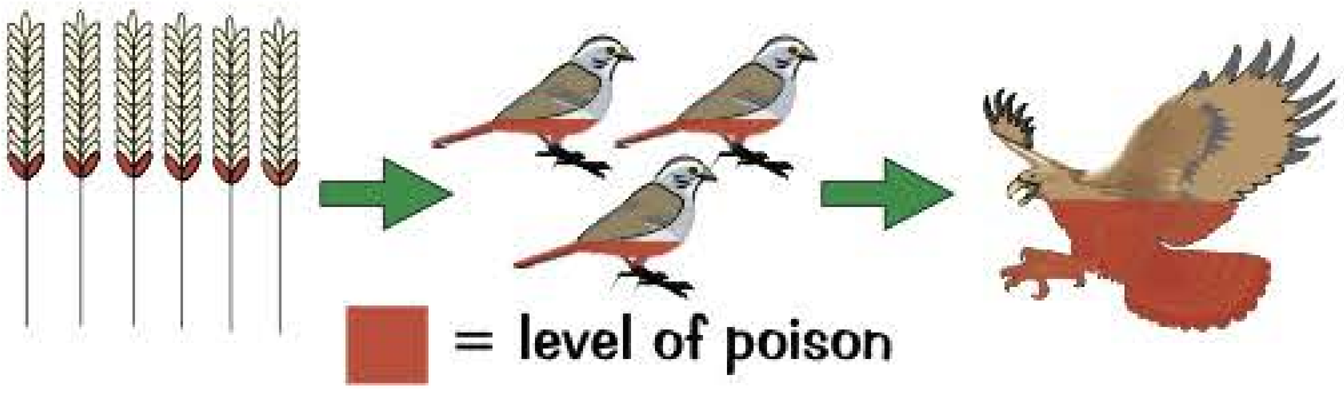
1) PRODUCER — all plants are producers. They store energy from the Sun.
2) HERBIVORE — an animal that only eats plants, e.g. tadpoles, rabbits, caterpillars, aphids.
3) CONSUMER — all animals are consumers. (All plants are not, because they're producers.)
4) PRIMARY CONSUMER — an animal that eats producers (plants).
5) SECONDARY CONSUMER — an animal that eats primary consumers.
6) TERTIARY CONSUMER — an animal that eats secondary consumers.
7) CARNIVORE — eats only animals, never plants.
8) TOP CARNIVORE — is not eaten by anything else.
9) OMNIVORE — eats both plants and animals.

The organisms in a food web are all interdependent — so a change in one organism can easily affect others.

Example — What happens if the minnows are removed?

1) Who will get eaten LESS? The tadpoles, as there are no minnows there to eat them.
2) Who will get eaten MORE? a) Water beetles (by perch who'll get hungry without minnows).
b) Waterweeds (since the numbers of tadpoles will increase).

Poisons Build Up as They are Passed Along a Food Chain



Toxic materials (poisons) can sometimes get into food chains and harm the organisms involved. Organisms higher up the food chain (usually the top carnivores) are likely to be the worst affected as the toxins accumulate (build up) as they are passed along.

Learn about Food Webs — but don't get tangled up...

Once you've learnt everything on this page, you can practise this typical food web question: "If the number of otters decreased, give one reason why the number of water beetles might a) decrease b) increase".*

*Answers on page 108.

Section Summary

Green plants are ace aren't they? What I really like about them is that they're all so clean and fresh — human and animal biology always seems to end up so gory with all sorts of gruesome diagrams and horrid diseases. But plants have such simple lives — they just seem to "go with the flow", with no apparent discomfort and no worries — and let's face it, it's a nice trick if you can do it.

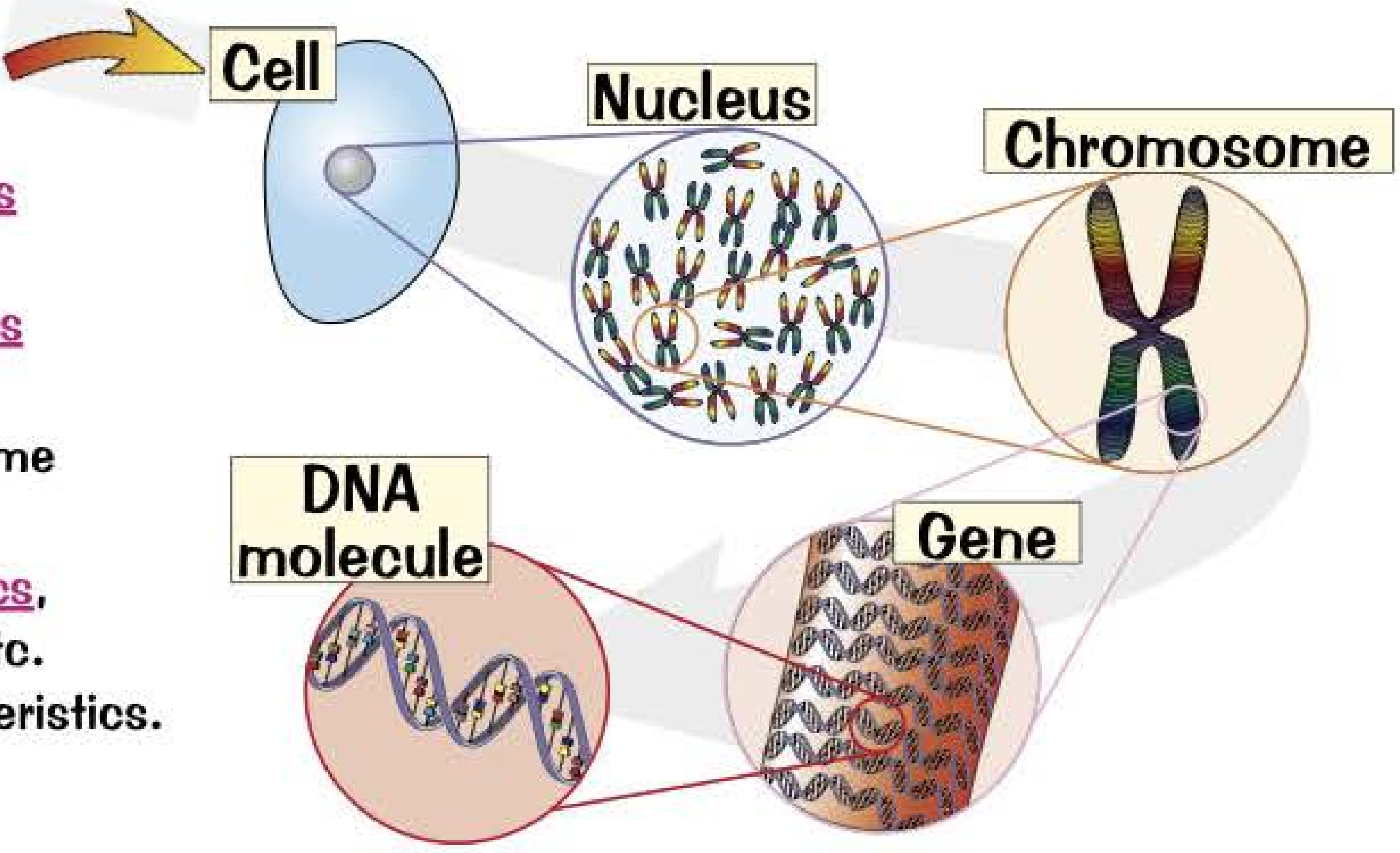
Alas nature conspired to give humans an altogether more "challenging" experience on this little blue-green planet of ours — and somehow that's ended up with you needing to know the answers to all these questions. Hmmm, it's a funny old world isn't it — when you think about it from that angle...
Anyway, here they are. Off you go then...

1) What is made during photosynthesis?
2) What do plants do with glucose?
3) What are the four things needed for photosynthesis to happen?
4) Write out the word equation for photosynthesis.
5) What is the by-product made in photosynthesis, which is needed by animals?
6) Apart from water, what do plants need from the soil?
7) What are the four main parts of a flower? Say what each part actually does.
8) What is pollination? What are the two types of pollination?
9) What is the difference between insect pollination and wind pollination?
10) Give three features of: a) an insect pollinated plant, b) a wind pollinated plant.
11) What is fertilisation? How does the male sex cell nucleus get from the stigma to the ovary?
12) What does an ovule develop into after fertilisation?
13) What does the ovary eventually develop into?
14) Give another name for seed dispersal.
15) Give four ways in which seeds can be dispersed.
Give an example of a fruit that disperses seeds in each of these ways.
16) Describe how you could investigate the seed dispersal mechanism of a sycamore tree.
How could you investigate the effect of wind on this dispersal mechanism?
17) What is an ecosystem?
18) Explain why most living things rely on plants for energy.
19) What else do living things rely on plants for?
20) What do many plants rely on insects for? How does this affect us humans?
21) What is a food chain? And a food web?
22) Give good definitions for all of the following terms:
a) producer b) herbivore c) consumer
d) primary consumer e) secondary consumer f) tertiary consumer
g) carnivore h) top carnivore i) omnivore.
23) What happens to poisons as they are passed along a food chain?

DNA and Inheritance

DNA's brilliant stuff — it's like your body's own instruction manual. When you're being made, you get bits of DNA from your mum and bits from your dad — this is how you inherit characteristics.

Chromosomes, DNA and Genes



1) Most cells in your body have a nucleus. The nucleus contains chromosomes.
2) Chromosomes are long, coiled up lengths of a molecule called DNA.
3) DNA is a long list of chemical instructions on how to build an organism.
4) A gene is a short section of a chromosome (and so a short section of DNA).
5) Genes control many of our characteristics, e.g. hair colour, eye colour, hairiness, etc. Different genes control different characteristics.
6) Genes work in pairs — one will usually be dominant over the other.

We Inherit Characteristics From Our Parents

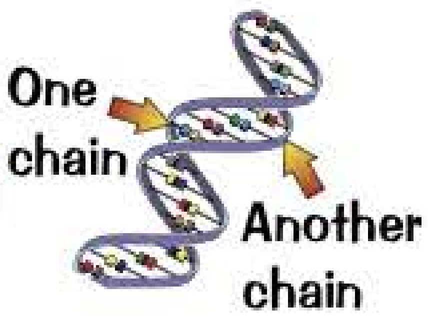
1) Human body cells have 46 chromosomes (23 pairs).
2) Sperm and egg cells carry only 23 chromosomes.

3) During reproduction, when an egg is fertilised, the nucleus of the egg fuses with the nucleus of the sperm.
4) This means that the fertilised egg contains 23 matched pairs of chromosomes. It has one copy of each gene from the mother and one from the father.
5) Since genes control characteristics, the fertilised egg develops into an embryo with a mixture of the parents' characteristics. This is how you 'inherit' your parents' characteristics.
6) The process by which genes are passed down from parents to their offspring is called heredity.

A characteristic passed on in this way is called a 'hereditary' characteristic.

The Structure of DNA Was Only Worked Out Recently

1) Scientists struggled for decades to work out the structure of DNA.
2) Crick and Watson were the first scientists to build a model of DNA — they did it in 1953.
3) They used data from other scientists, Wilkins and Franklin, to help them understand the structure of the molecule. This included X-ray data showing that DNA is a double helix — a spiral made of two chains wound together.
4) By putting all the information together, Crick and Watson were able to build a model showing what DNA looks like.



DNA? I get all my genes from Topshop...

I can see three main headings, sixteen numbered points and two important diagrams — and they all need learning. Sitting down and challenging yourself to repeat the main details from this page really isn't that hard. If you're struggling with any bits you can re-read the page, then cover it back up and try again.

Variation

This page is all about differences between organisms — both big, obvious differences, like those between a tree and a cow, and less obvious differences, like people having different blood groups.

Different Species Have Different Genes

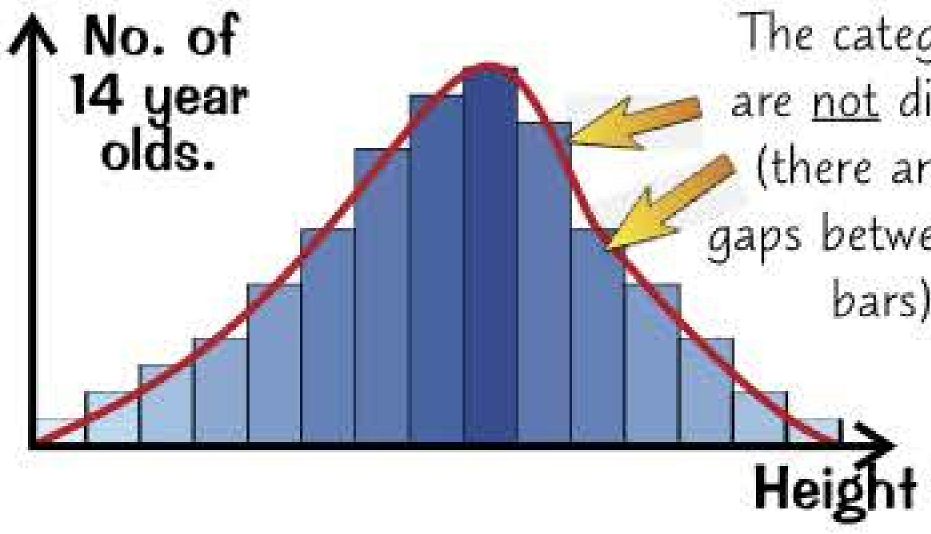
1) All living things in the world are different — we say that they show VARIATION.
2) A human, a cow, a dandelion and a tree all look different because they're different species. These differences between species occur because their genes are very different.
3) But you also see variation within a species, i.e. plants or animals that have basically the same genes will also show differences between them, e.g. skin colour, height, flower size, etc. Any difference is known as a characteristic feature.
4) Characteristic features can be inherited (come from your parents via genes) or they can be environmental (caused by your surroundings).

Continuous and Discontinuous Variation

Variation within a species can either be classed as continuous or discontinuous.

Continuous Variation — the feature can vary over a range of values

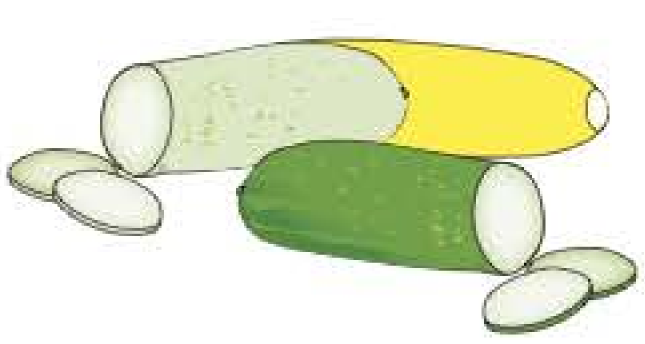
1) Examples of this are things like height, weight, skin colour, intelligence, leaf area, etc. where the feature can have any value at all — within a certain range. If you did a survey of kids' heights you could plot the results on a chart like the one opposite (the heights would be collected into groups to give the bars).
2) The smooth distribution curve drawn on afterwards (the red line) shows much better the continuous way that values for height actually vary.



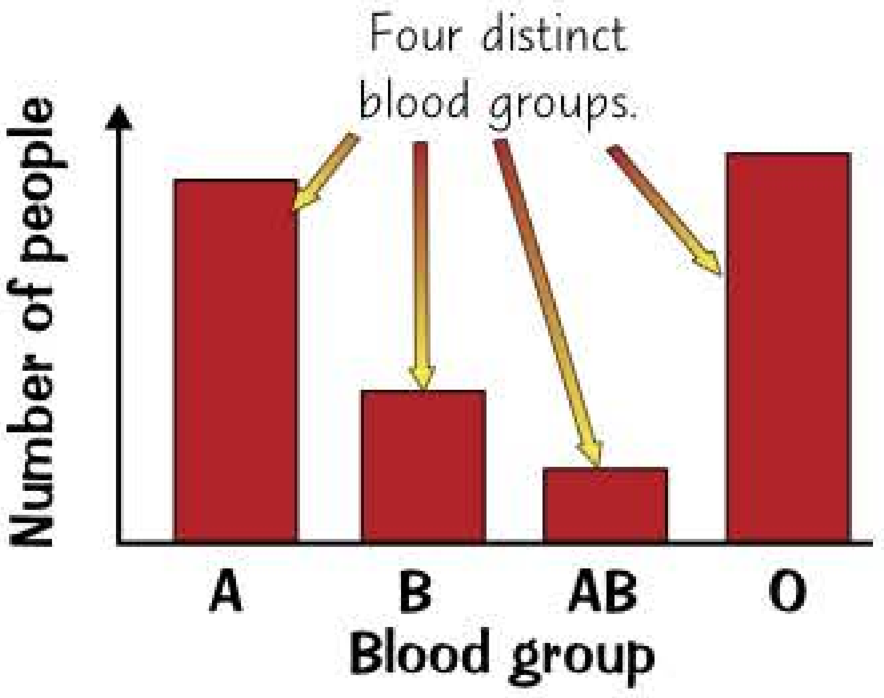
The categories are not distinct (there are no gaps between the bars).

Discontinuous Variation — the feature can only take certain values

1) An example of this is a person's blood group, where there are just four distinct options, NOT a whole continuous range.



2) Another example is the colour of a courgette. A courgette is either yellow, light green or dark green — there's no range of values.



Variationvariationvariation — guess what type of variation that is...

Don't let the fancy word "variation" put you off. People seem to think it must mean something really complicated. It doesn't. It just means "differences" (between any living things). You can have variation (differences) between different species, and you can also have variation (differences) within one species.

Natural Selection and Survival

It's OK to be different — that's what our parents are always trying to tell us. In nature, being different can be really important. Having a different characteristic to other organisms can determine whether an organism (and its future generations) are likely to survive in the long run or not. It's serious stuff.

Variation Leads to Natural Selection

1) Organisms show variation because of differences in their genes (see previous page).
2) Organisms also have to compete for the resources they need in order to survive and reproduce, e.g. food, water and shelter. They have to compete with other members of their own species, as well as organisms from other species.

FOR EXAMPLE...

...this red squirrel...

...has to compete with other red squirrels (members of its own species)...

...as well as grey squirrels (a different species), in order to get food.

3) Organisms with characteristics that make them better at competing are more likely to survive and reproduce. This means they're more likely to pass on the genes for their useful characteristics to the next generation.
4) Organisms that are less successful competitors are usually the first to die — possibly before they've had a chance to reproduce. This means their genes and less useful characteristics won't be passed on to any offspring.
5) So, over time, the gene for a useful characteristic will become more common.
6) This process in which a characteristic gradually becomes more (or less) common in a population is known as natural selection.

A population is all the organisms of one species that live in the same ecosystem.

Giraffes Have Long Necks Due to Natural Selection

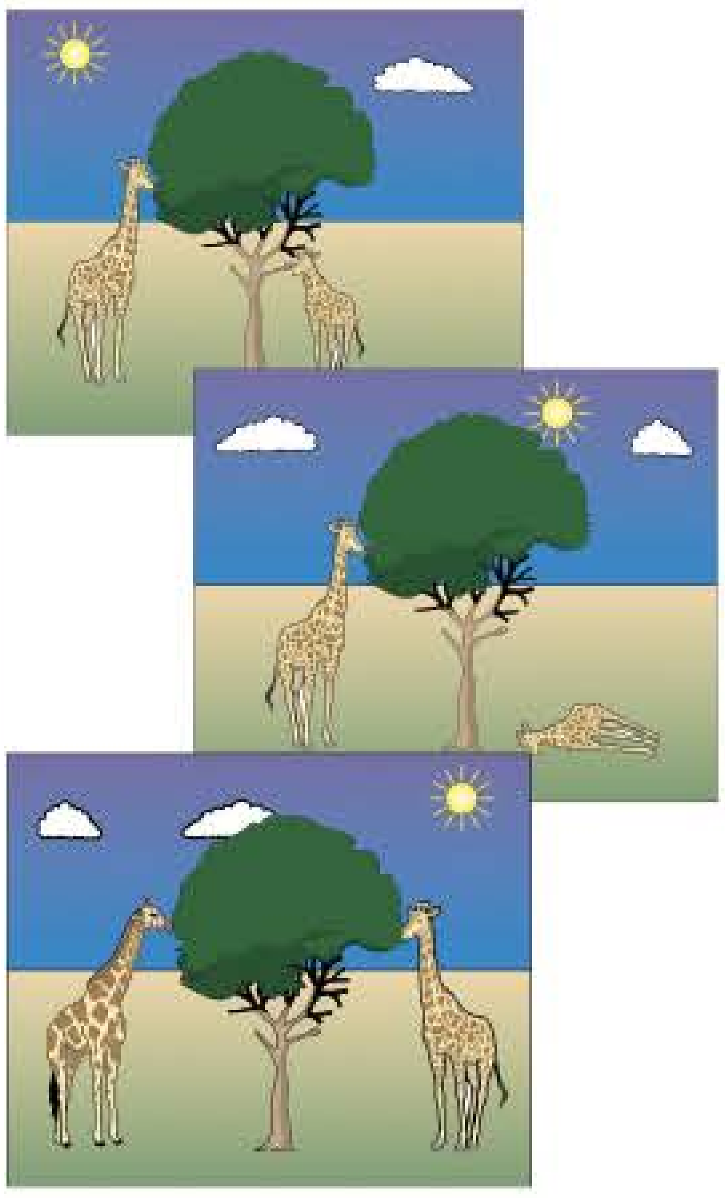
Are you sitting comfortably...

Once upon a time there was a group of animals munching leaves from a tree. Unfortunately the population was high and food was running short. Soon all the leaves on the lower parts of the trees were gone and the animals started to get hungry — some even died. Except, that is, for a couple of animals which happened to have slightly longer necks than normal. This meant that they could compete better for food — they could reach just that bit higher, to the juicy and yummy leaves higher up the trees.

They survived that year, unlike a lot of animals, and had lots of babies.

The babies also had longer necks, and could eventually reach up the tree for the juicy yummy leaves.

It soon got to a situation where most of the animals in the population had long necks...



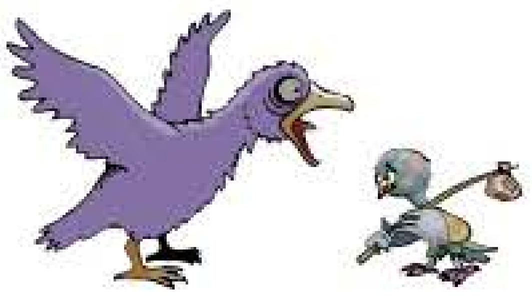
Survival of the Giraffe — a tall story...

Make sure you get the gist of this. Only those who are born with features that make them great at competing in the world they live in will survive and produce offspring — the sick and the inept all die off very quickly. Just be glad you're a human and live in the time and the place that you do!

Extinction and Preserving Species

Organisms that can't compete don't survive for long. It's a cruel world out there.

Many Species Are at Risk of Becoming Extinct



1) Many organisms survive because they are well-adapted for competing in their environment.
2) But if the environment changes in some way, some organisms may struggle to compete successfully for the resources they need to survive and reproduce.
3) If this happens to a whole species, then that species is at risk of becoming extinct. Extinct means that there are none of them left at all (like the woolly mammoth).
4) Species at risk of becoming extinct are called endangered species.

Humans Can Suffer When Species Become Extinct

1) Humans rely on plants and animals for food.
2) We also use them to make clothing, medicines, fuel, etc.
3) We need to protect the organisms we already use in this way. We also need to make sure organisms we haven't discovered yet don't become extinct before we find them — or we might miss out on new sources of useful products.
4) Ecosystems are complex. If one species becomes extinct, this can have a knock-on effect for other organisms — including us.
5) That's why it's important for us to maintain the planet's biodiversity — the variety of species that live on Earth.

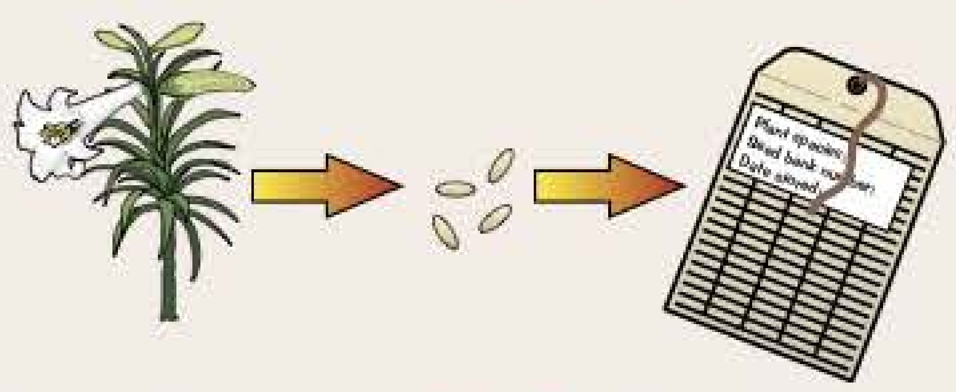
There are probably loads of species we don't know about, e.g. in unexplored rainforests and deep in the ocean.

Gene Banks May Help to Prevent Extinction

1) A gene bank is basically a store of the genes of different species.
2) This means that if a species becomes endangered or even extinct, it may be possible to create new members of that species. So gene banks could be a way of maintaining biodiversity in the future.
3) Genes are stored differently for plants and animals. For example:

PLANTS

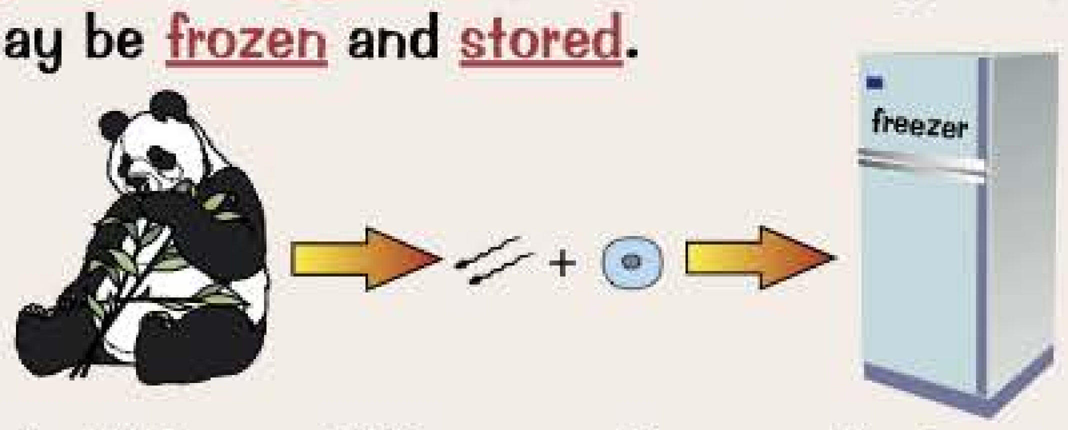
Seeds (which contain genes) can be collected from plants and stored in seed banks.



If the plants become extinct in the wild, new plants can be grown from the seeds kept in storage.

ANIMALS

Sperm and egg cells (which contain genes) may be frozen and stored.



Scientists could then use these cells to create new animal embryos in the future.

Gene banks aren't the only way to maintain biodiversity. It's much better to try to stop species becoming extinct in the first place, e.g. by preventing the destruction of habitats (the areas where organisms live).

My bank balance is two seeds and an egg...

You need to understand how environmental changes can put species at risk of extinction. Also, make sure you understand why it's so important to maintain biodiversity and how gene banks may help to do this.

Section Summary

Section 4 is fairly basic stuff really, but there are one or two fancy words which might cause you quite a bit of grief until you've made the effort to learn exactly what they mean: "DNA" is just a list of instructions for how any living creature is put together; "variation" just means "differences", etc., etc.

These questions aren't the easiest you could find, but they test exactly what you know and find out exactly what you don't. You need to be able to answer them all, because all they do is test the basic facts.
You must practise these questions over and over again until you can just sail through them.

1) Where do you find chromosomes?
2) What are chromosomes made of?
3) What is a gene? What do genes control?
4) How many chromosomes do humans have in each body cell?
5) How many chromosomes are there in human sperm cells? How about in human egg cells?
6) What happens at fertilisation?
7) What does heredity mean?
8) Name the two scientists who first built a model of DNA.
Name the other two scientists whose data helped them.
9) Describe the structure of a DNA molecule.
10) What does variation mean?
11) Why do different species look different?
12) What is a characteristic feature?
13) What is continuous variation? Give three examples.
14) What is discontinuous variation? Give two examples.
15) Give one way in which a graph showing continuous variation would differ from a graph showing discontinuous variation.
16) Why is it important that organisms are good at competing for the things they need?
17) Why are genes for useful characteristics likely to become more common in a population over time?
What is this process called?
18) How did giraffes end up with very long necks?
19) Why could it be bad news for an organism if its environment changes?
20) What does extinct mean?
21) What does endangered mean?
22) What is biodiversity? Why is it important for us to maintain the planet's biodiversity?
23) What is a gene bank? What are they used for?
24) What part of a plant may be stored in a gene bank? What about an animal?

Solids, Liquids and Gases

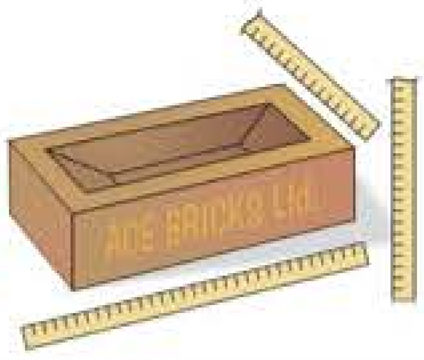
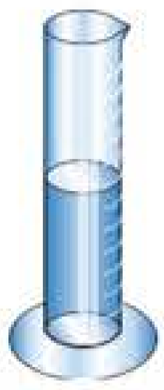
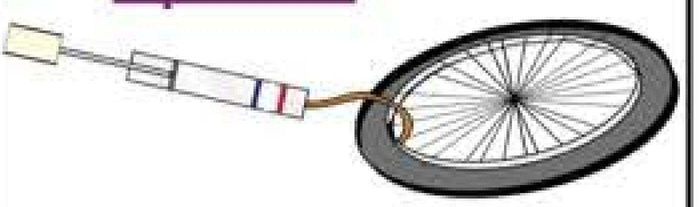
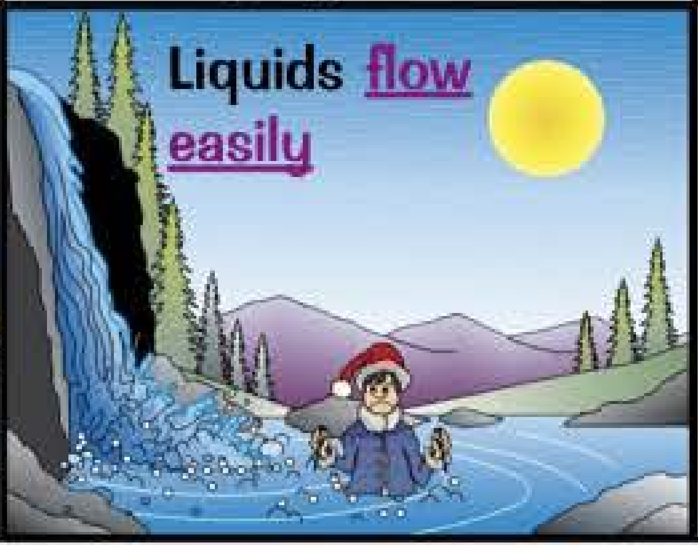
The first page in this section is all about states of matter and there are only three you need to know.

The Three States of Matter — Solid, Liquid and Gas

1) Materials come in three different forms — solids, liquids and gases.
2) These are called the Three States of Matter.
3) All materials are made up of tiny particles.
4) Which state you get (solid, liquid or gas) depends on how strongly the particles stick together.
How well they stick together depends on three things:
   a) the material b) the temperature c) the pressure.

Solids, Liquids and Gases Have Different Properties

1) We can recognise solids, liquids and gases by their different properties.
2) A property of a substance is just a way of saying how it behaves.

Property	Solids	Liquids	Gases
Volume This is how much space something takes up.	Solids have a definite volume 	Liquids have a definite volume 	Gases have no definite volume — they always fill the container they're in 
Shape	 Solids have a definite shape	 Liquids match the shape of the container	Gases become the same shape as the container 
Density This is how heavy something is for its size.	Solids usually have a high density (heavy for their size) 	Liquids usually have medium density 	Gases have a very low density 
Compressibility This is how much you can squash something.	 Solids are not easily squashed	 Liquids are not easily squashed	Gases are easily squashed 
Ease of Flow	Solids don't flow 	Liquids flow easily 	Gases flow easily 

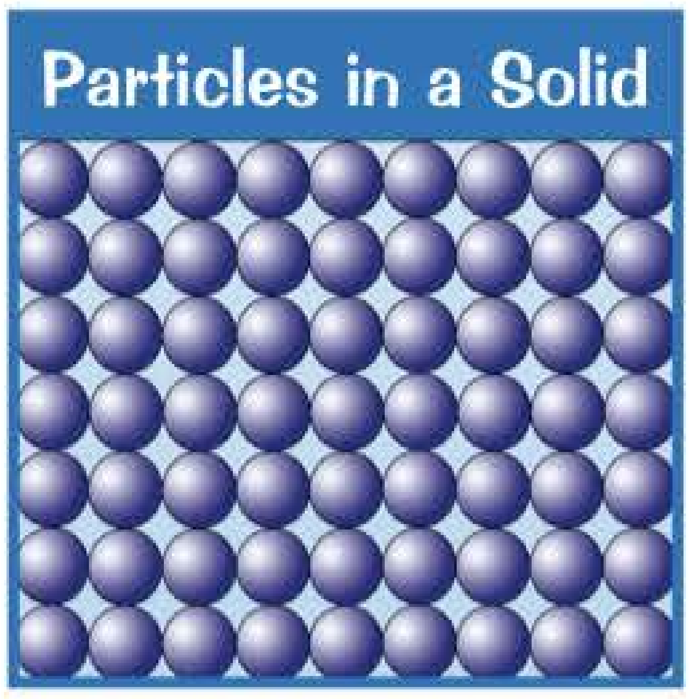
The Three States — do they really matter....

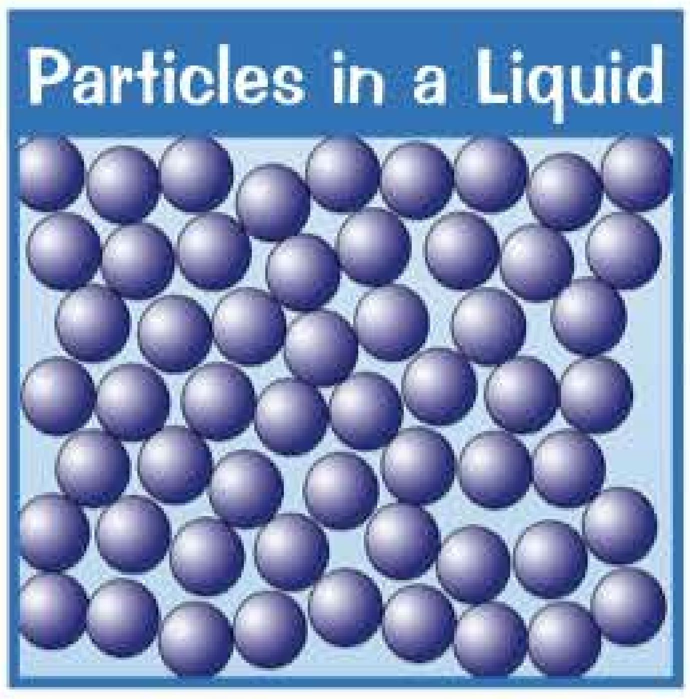
Solids, liquids and gases — you must learn all those numbered points and the properties of all three. When you think you know it, cover the page and scribble it all down from memory. That soon shows what you really know — and what you don't. Keep trying till you can do it.

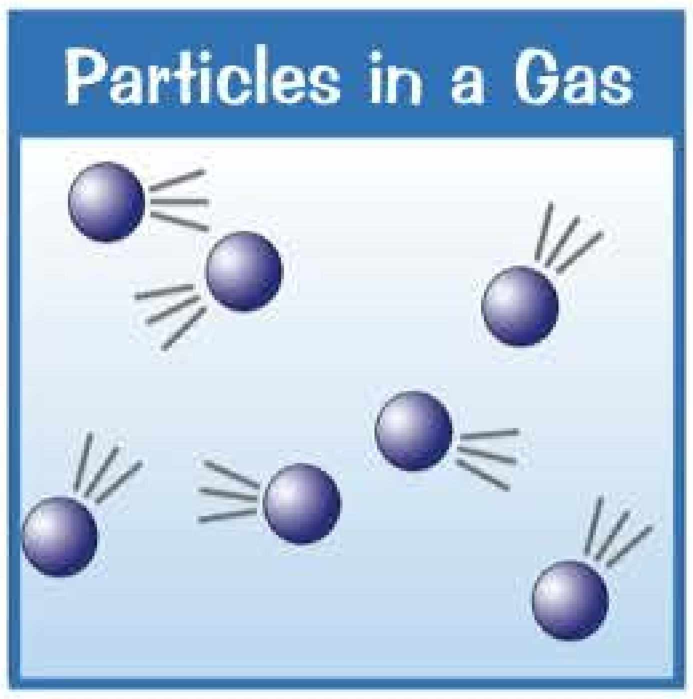
Particle Theory

Particle theory — sounds pretty fancy. But actually it's pretty straightforward.

1) The particles in a substance stay the same whether it's a solid, a liquid or a gas.
2) What changes is the arrangement of the particles and their energy.

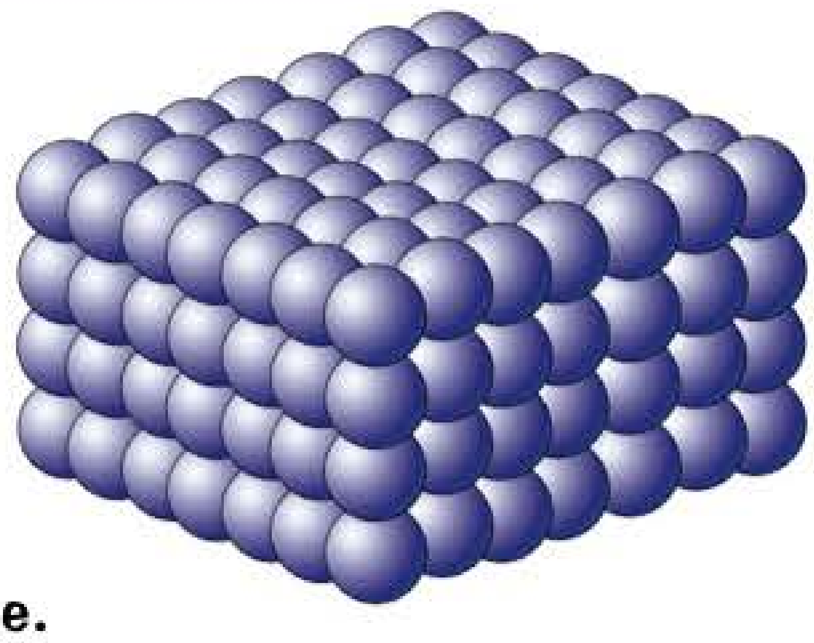

Particles in a Solid


Particles in a Liquid


Particles in a Gas

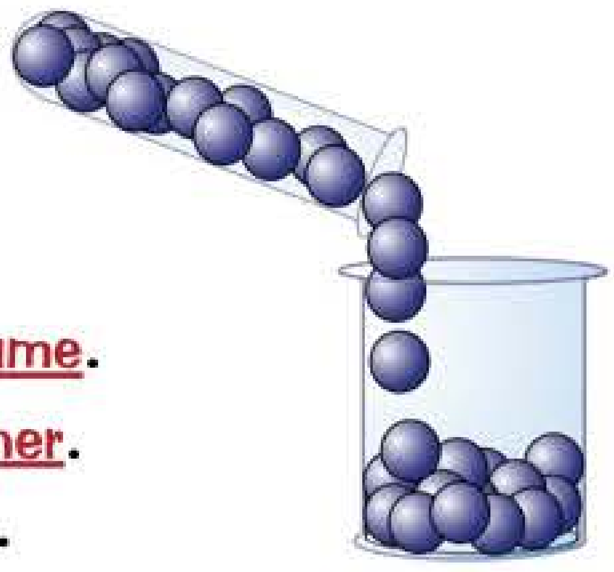
3) This particle theory explains all the different properties of solids, liquids and gases...

Solids — Particles are Held Very Tightly Together



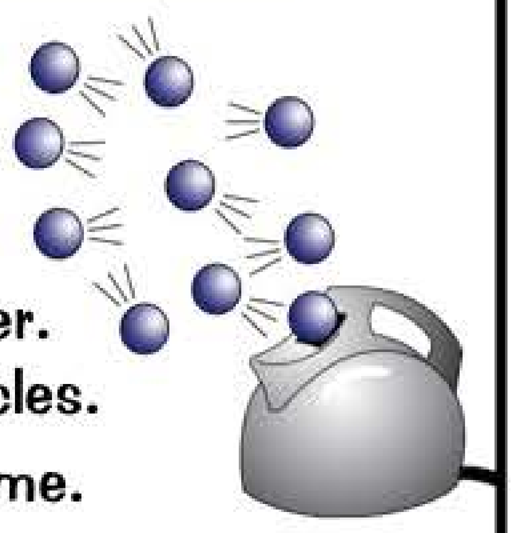
1) There are strong forces of attraction between particles.
2) The particles are held closely in fixed positions in a very regular arrangement. But they do vibrate to and fro.
3) The particles don't move from their positions, so all solids keep a definite shape and volume, and can't flow like liquids.
4) Solids can't easily be compressed because the particles are already packed very closely together.
5) Solids are usually dense, as there are lots of particles in a small volume.

Liquids — Particles are Close Together But They Can Move



1) There are some forces of attraction between the particles.
2) The particles are close, but free to move past each other — and they do stick together. The particles are constantly moving in all directions.
3) Liquids don't keep a definite shape and can form puddles. They flow and fill the bottom of a container. But they do keep the same volume.
4) Liquids won't compress easily because the particles are packed closely together.
5) Liquids are quite dense, as there are quite a lot of particles in a small volume.

Gases — Particles are Far Apart and Whizz About a Lot



1) There are very weak forces of attraction between the particles.
2) The particles are far apart and free to move quickly in all directions.
3) The particles move fast, and so collide with each other and the container.
4) Gases don't keep a definite shape or volume and will always expand to fill any container. Gases can be compressed easily because there's a lot of free space between the particles.
5) Gases all have very low densities, because there are not many particles in a large volume.

Phew, Particle Theory — particle-ularly gripping stuff...

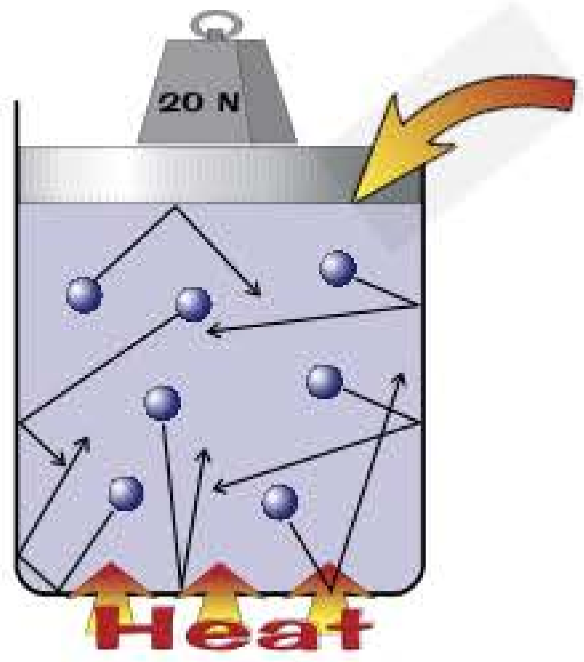
It's pretty clever the way you can explain all the differences between solids, liquids and gases with a page full of snooker balls. Anyway, that's the easy bit. The not-so-easy bit is making sure you understand it.

More Particle Theory

Particle theory can be used to explain all sorts of exciting things, like, erm, gas pressure and diffusion. I say exciting. I may be exaggerating just a teensy tiny bit...

Gas Pressure is Due to Particles Hitting a Surface

Increasing the Temperature Increases Pressure



1) When you increase the temperature, it makes the particles move faster.
2) This has two effects:

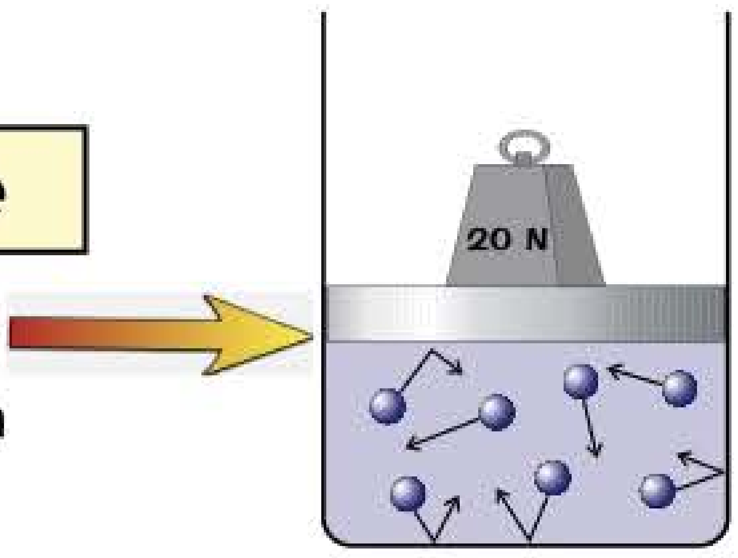
a) They hit the walls harder.
b) They hit more often.

3) Both these things increase the pressure.

Increasing the temperature will only increase the pressure if the volume stays the same.

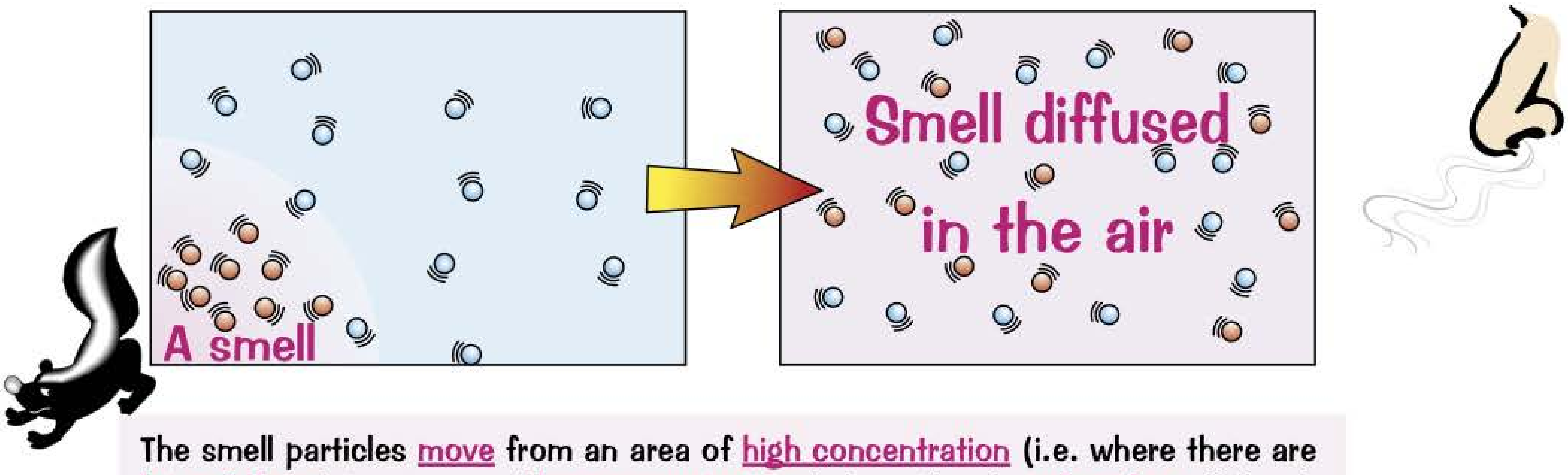
Reducing the Volume Increases Pressure

1) If you reduce the volume it makes the pressure increase.
2) This is because when the particles are squashed up into a smaller space they'll hit the walls more often.



Diffusion is Just Particles Spreading Out

1) Particles "want" to spread out — this is called diffusion.
An example is when a smell spreads slowly through a room.



The smell particles move from an area of high concentration (i.e. where there are lots of them) to an area of low concentration (where there's only a few of them).

2) Diffusion is slow because the smell particles keep bumping into air particles, which stops them making forward progress and often sends them off in a completely different direction — it's a bit like trying to run blindfold through a herd of frisky bullocks. As you do.

Let the information on this page diffuse into your mind...

...you know — move from where there's a high concentration of information (this page) to where there's a low concentration (err... your mind). To be honest though, you're going to need to be a bit more active when it comes to learning this page. You know the drill by now. Look, cover and scribble it all down.

Physical Changes

Physical changes don't change the particles — just their arrangement or their energy.

Changes of State

— i.e. changing from one state of matter to another.

① When a solid is heated, its particles gain more energy.

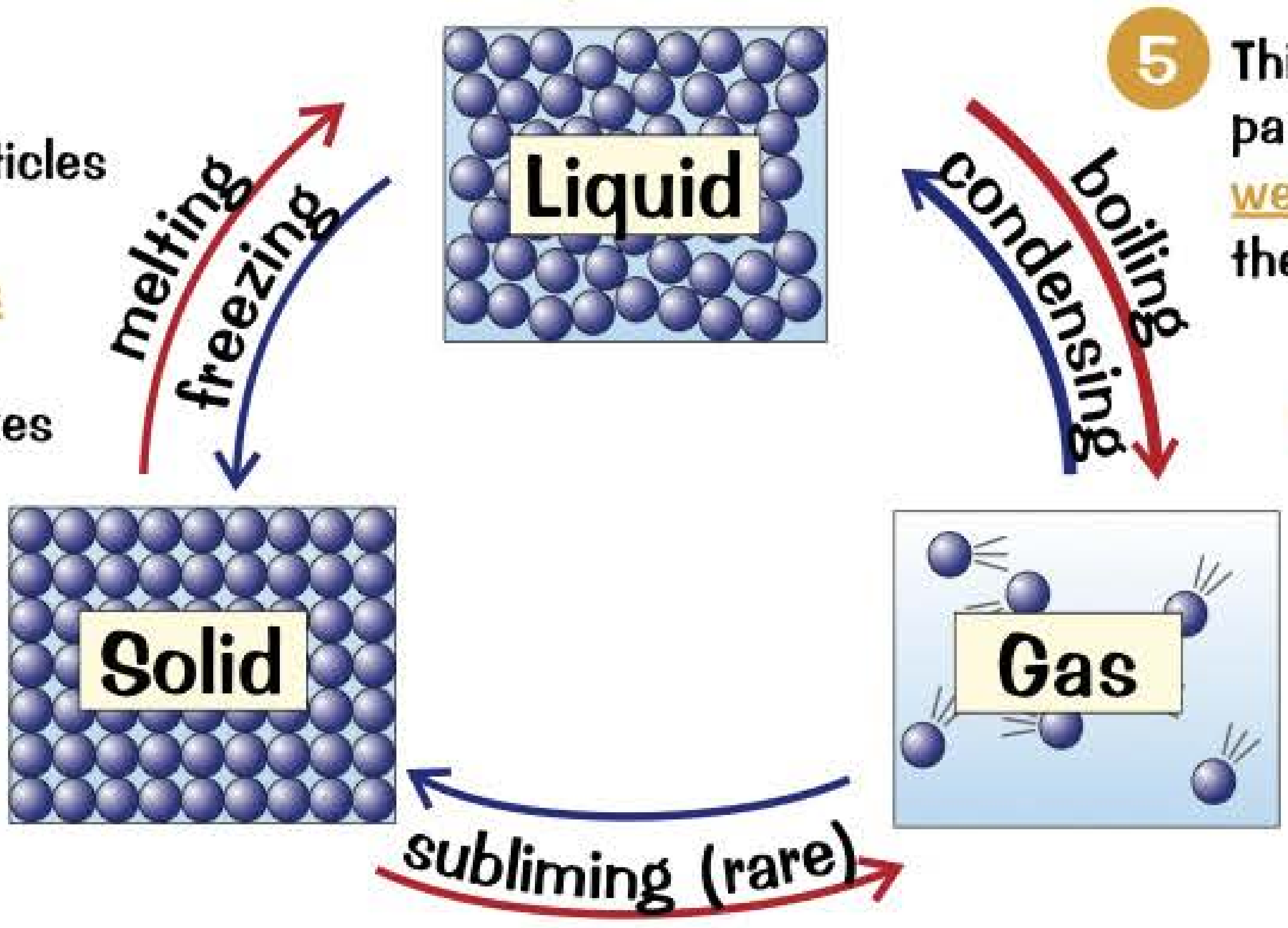
② This makes the particles move more which weakens the forces that hold the solid together. This makes the solid expand.

③ At a certain temperature, the particles have enough energy to break free from their positions. This is called melting and the solid turns into a liquid.

④ When a liquid is heated, again the particles get even more energy.

⑤ This energy makes the particles move faster which weakens the forces holding the liquid together.

⑥ At a certain temperature, the particles have enough energy to break the forces. This is called boiling and the liquid turns into a gas.



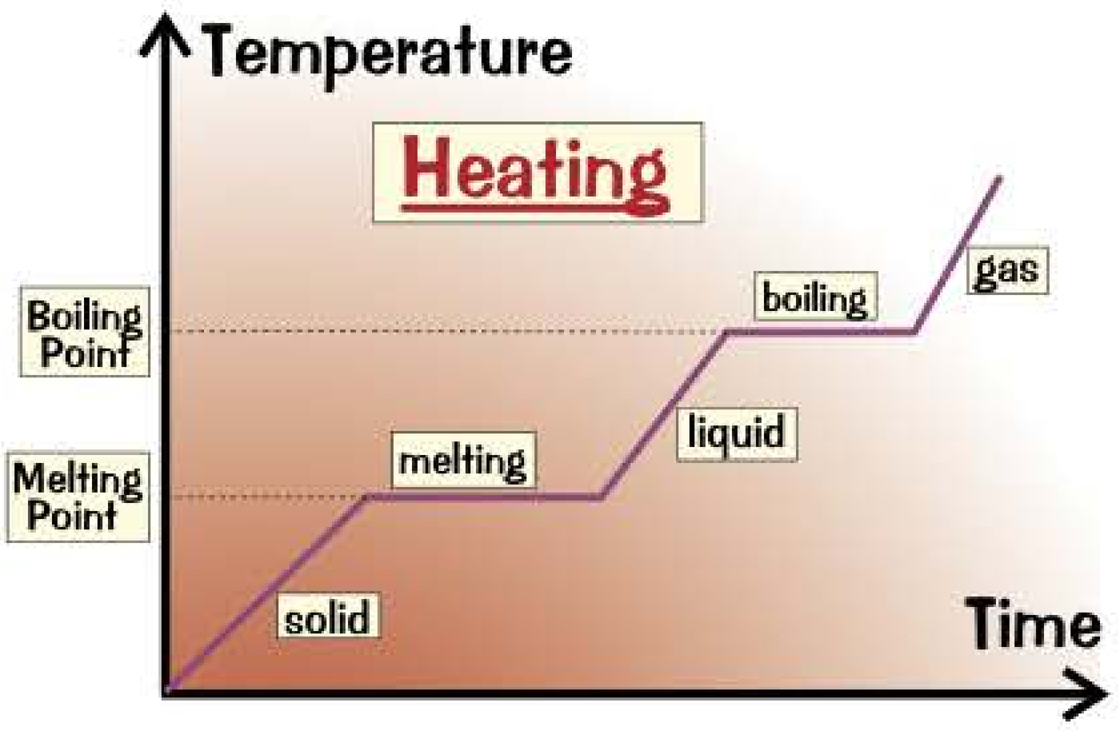
A Red Arrow means energy is supplied

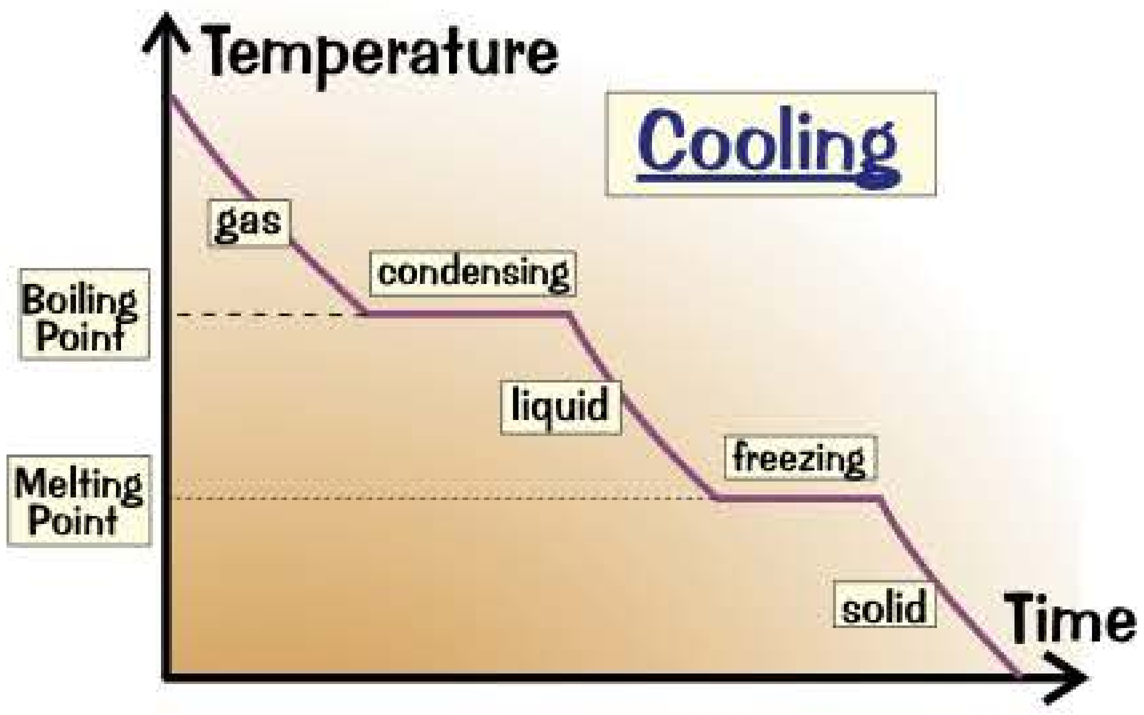
A Blue Arrow means energy is given out

A change of state doesn't involve a change in mass (see page 74), only a change in energy.

Heating and Cooling Curves have Flat Bits

Heating and cooling curves show the energy changes that happen when a substance changes state:





1) When a substance is melting or boiling, all the energy supplied from heating is used to weaken the forces between particles rather than raising the temperature — hence the flat bits on the heating graph.

2) When a substance is cooled, the cooling graph will show flat bits at the condensing and freezing points.

3) This is because the forces between particles get stronger when a gas condenses or when a liquid freezes — and energy is given out. This means that the temperature doesn't go down until all the substance has changed state.

Phew — another page of jostling snooker balls...

So the reason your ice cream melts is because the little snooker balls of ice cream take in energy, which means they can break free from their positions and become a liquid. Not that my ice creams last that long.

Atoms and Elements

If you've ever wondered what everything is made of, then the simple answer is atoms.

You Need to Know About Atoms...

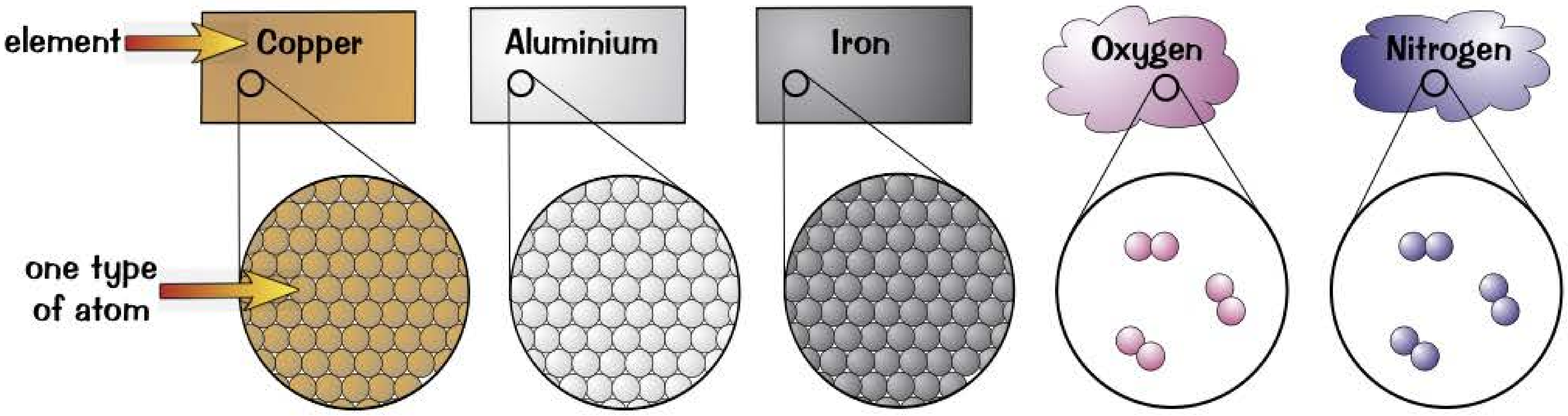
1) Atoms are a type of tiny, tiny, particle.
2) They're so small that you can't see them directly.
So for a long time, no one knew much about them.
3) Dalton was the first modern scientist to try to explain things about atoms.
According to the Dalton model:

- All matter is made up of atoms.
- There are different types of atom.
- Each element (see below) contains a different type.

Scientists now know a lot more about atoms — but luckily, this is all you need to learn for Key Stage 3.

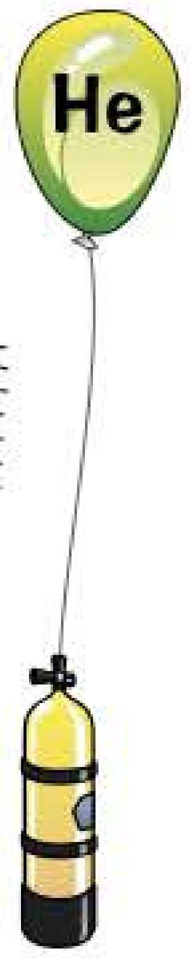
...and Elements

1) An element is a substance that contains only one type of atom.
2) Quite a lot of everyday substances are elements:



3) All of these elements have different properties.
For example, copper is a soft, bendy metal. Oxygen is a colourless gas.

All Elements Have a Name and a Symbol



1) There are over 100 different elements and writing their names out each time you wanted to mention one would take ages.
2) So each element has a symbol — usually of one or two letters.

Some symbols make sense (like O for oxygen) but others are based on Latin, so are a bit weird — like Fe for iron.

Examples:

Oxygen has the symbol O.
Carbon has the symbol C.
Helium has the symbol He.
Iron has the symbol Fe.

3) You can see the symbol for each element on the periodic table (see next page).

It's elemental, my dear Watson...

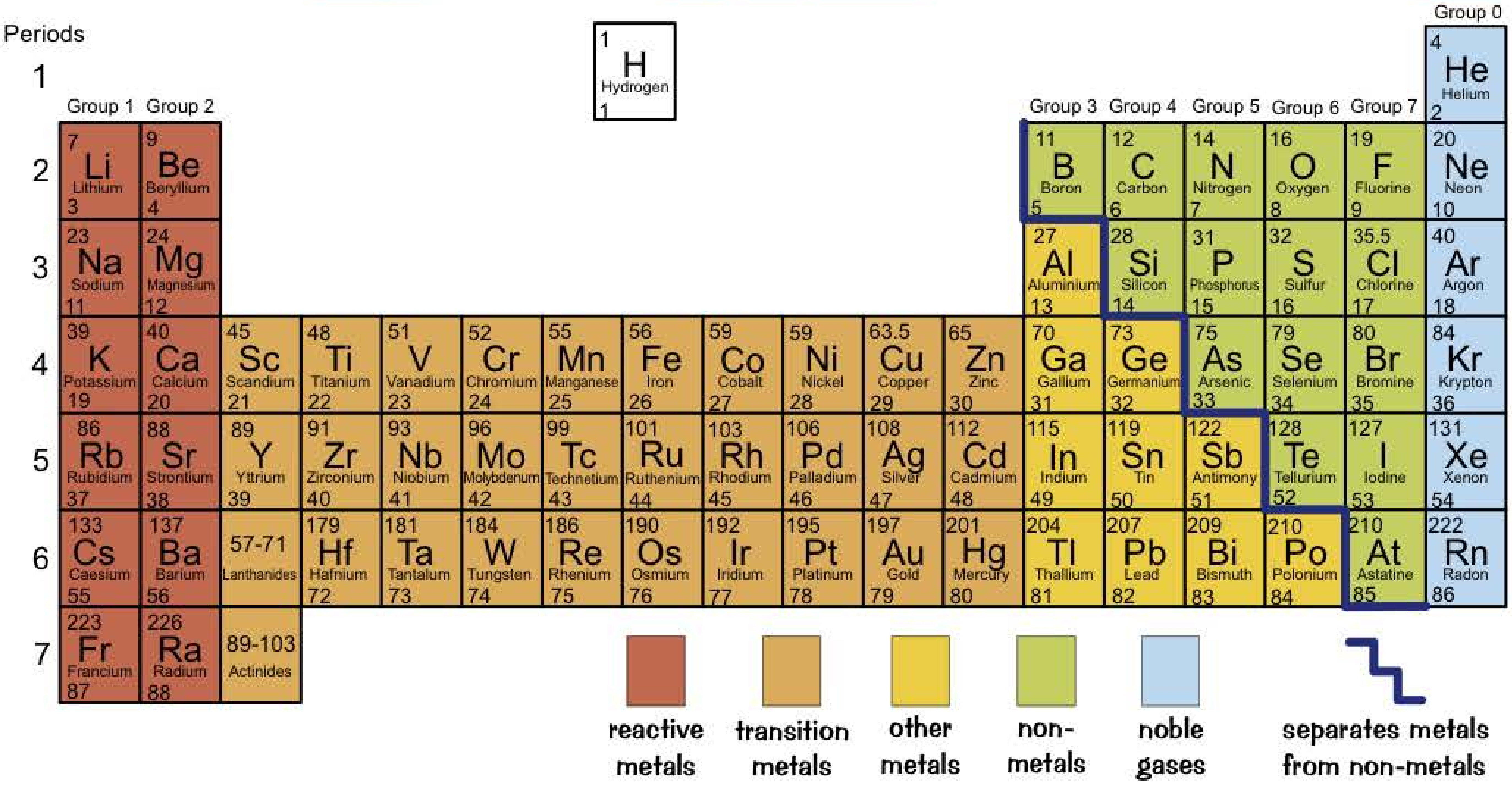
Atoms — you can't see them, but these tiny little footballs are absolutely everywhere. Understanding atoms and elements is pretty fundamental to the whole of chemistry — so make absolutely certain you've learnt this page before you even think about moving on to the next one.

The Periodic Table

How can you find out what all those chemical symbols mean? Step forth the periodic table...

The Periodic Table Lists All the Elements

1) The periodic table shows all the elements we have discovered.
2) The first version of the table was put together by a scientist called Mendeleev. It's thanks to Mendeleev that elements with very similar properties are arranged into vertical columns in the table.
3) The vertical columns are called groups.
4) The horizontal rows are called periods.
5) If you know the properties of one element in a group, you can predict the properties of other elements in that group. E.g. Group 1 elements are all soft, shiny metals, which react in a similar way with water.



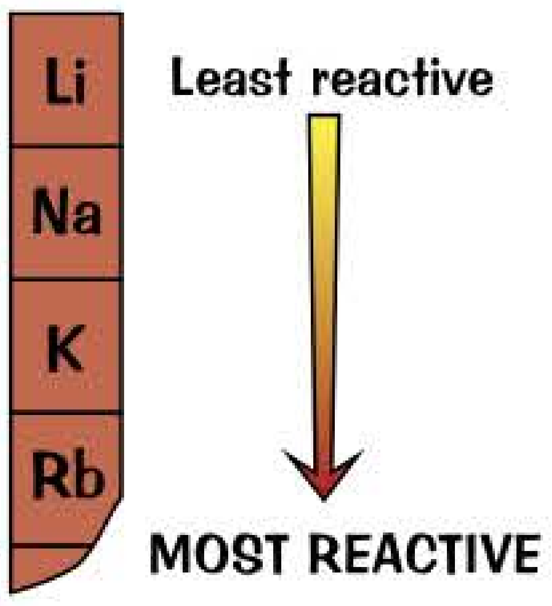
Periods	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1								1 **H** Hydrogen 1										4 **He** Helium 2
2	7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
3	23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
4	39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
5	86 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	99 **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
6	133 **Cs** Caesium 55	137 **Ba** Barium 56	57-71 Lanthanides	179 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	210 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
7	223 **Fr** Francium 87	226 **Ra** Radium 88	89-103 Actinides															

🟥 reactive metals
🟧 transition metals
🟨 other metals
🟩 non-metals
🟦 noble gases
separates metals from non-metals

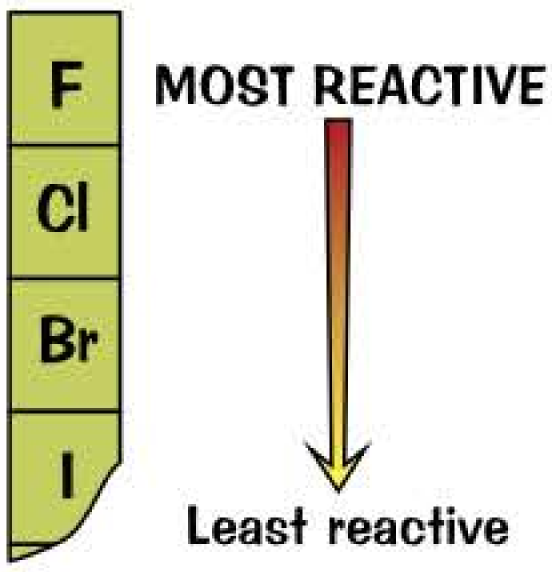
You Can Use the Periodic Table to Predict Patterns in Reactions

1) In a chemical reaction, elements combine to form new substances (see next page).
2) An element that's dead keen to combine with other elements is said to be very reactive. Group 1, 2 and 7 elements are all pretty reactive.
3) Group 0 elements (the "noble gases") are all extremely unreactive. They almost never take part in any chemical reactions.
4) You can use the periodic table to predict patterns in chemical reactions. For example...

The Group 1 metals get MORE reactive as you go down the group. You can see this by the way the Group 1 metals react with water. When lithium (Li) reacts with water, it fizzes. When rubidium (Rb) reacts with water, it explodes. This is because rubidium is much more reactive than lithium.



The non-metals in Group 7 behave in the opposite way to the metals in Group 1. They get LESS reactive as you go down the group.



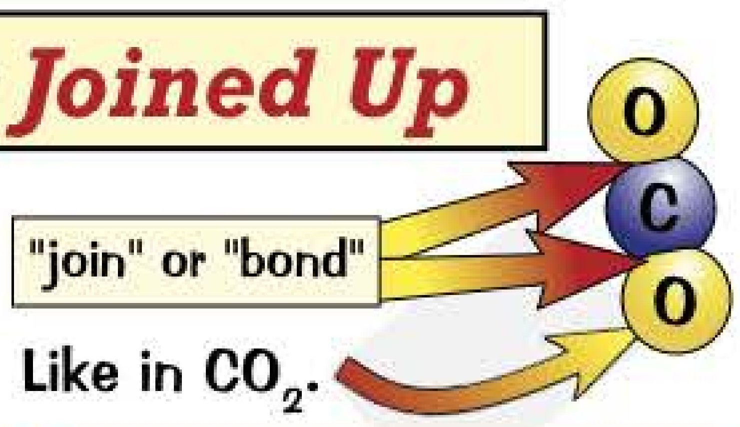
Group 1 metals — always spoiling for a fight...

So... the periodic table is made up of groups and periods. All the elements in a group have similar properties.

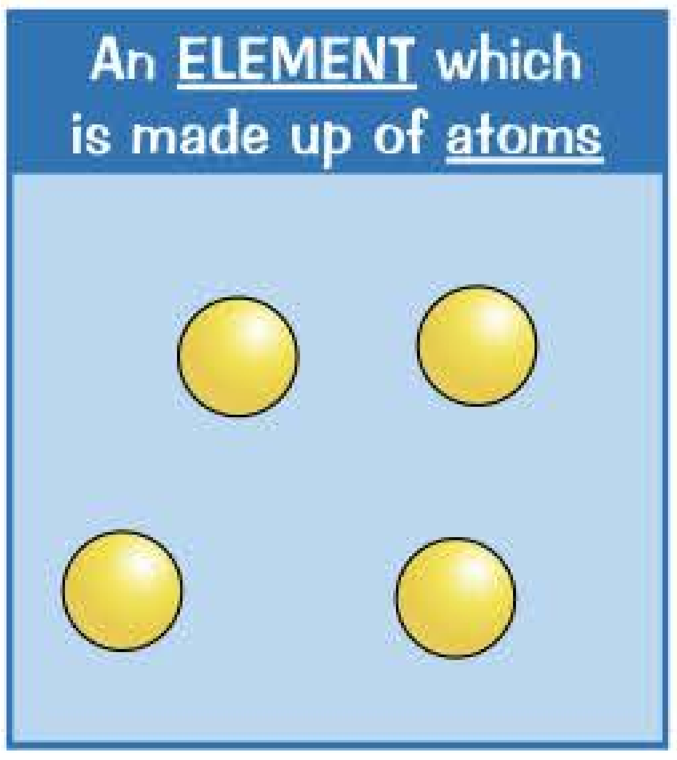
Compounds

It'd be pretty boring if we only had elements to play with,
but luckily compounds give us all sorts of exciting materials...

Compounds Contain Two or More Elements Joined Up

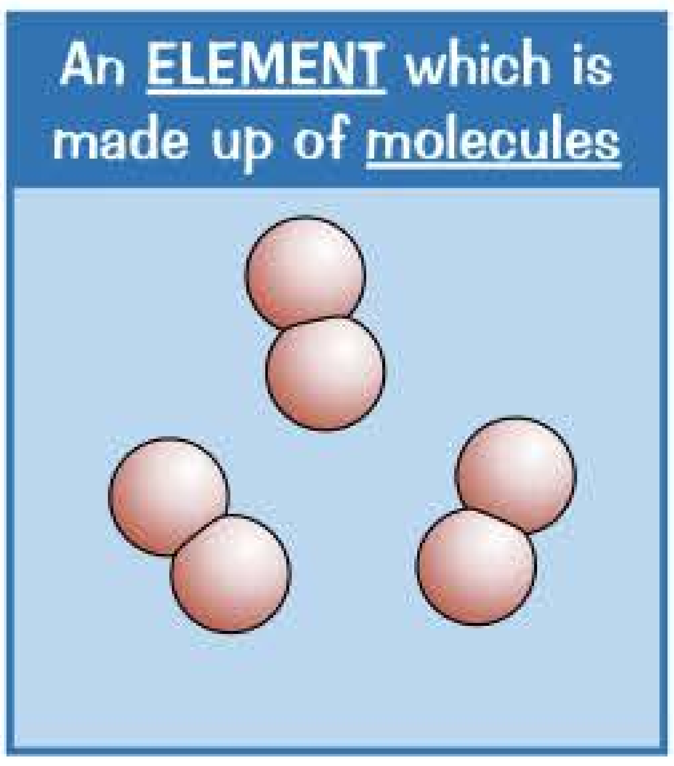


1) When two or more atoms join together, a molecule is made. The "join" is known as a chemical bond.
2) Compounds are formed when atoms from different elements join together. Like in CO_2.



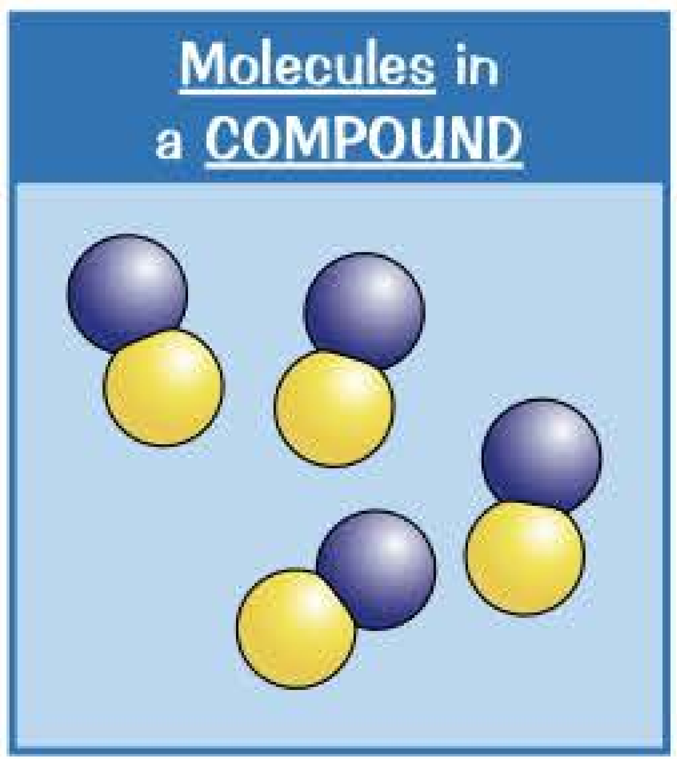
An ELEMENT which is made up of atoms

The atoms are all the same and not joined up — it must be an element.



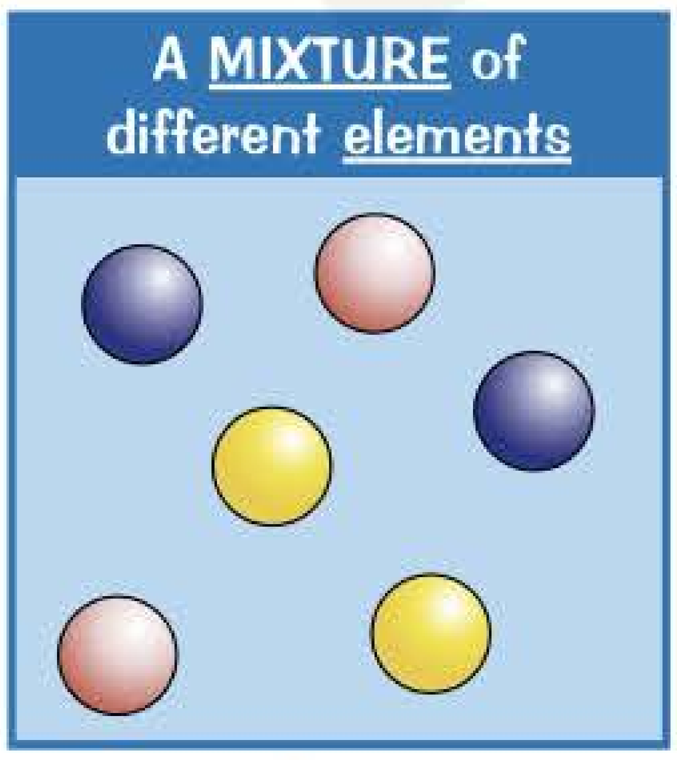
An ELEMENT which is made up of molecules

The atoms are joined, but there's still only one type, so it's still an element.



Molecules in a COMPOUND

Here we have different atoms joined together — that's a compound alright.



A MIXTURE of different elements

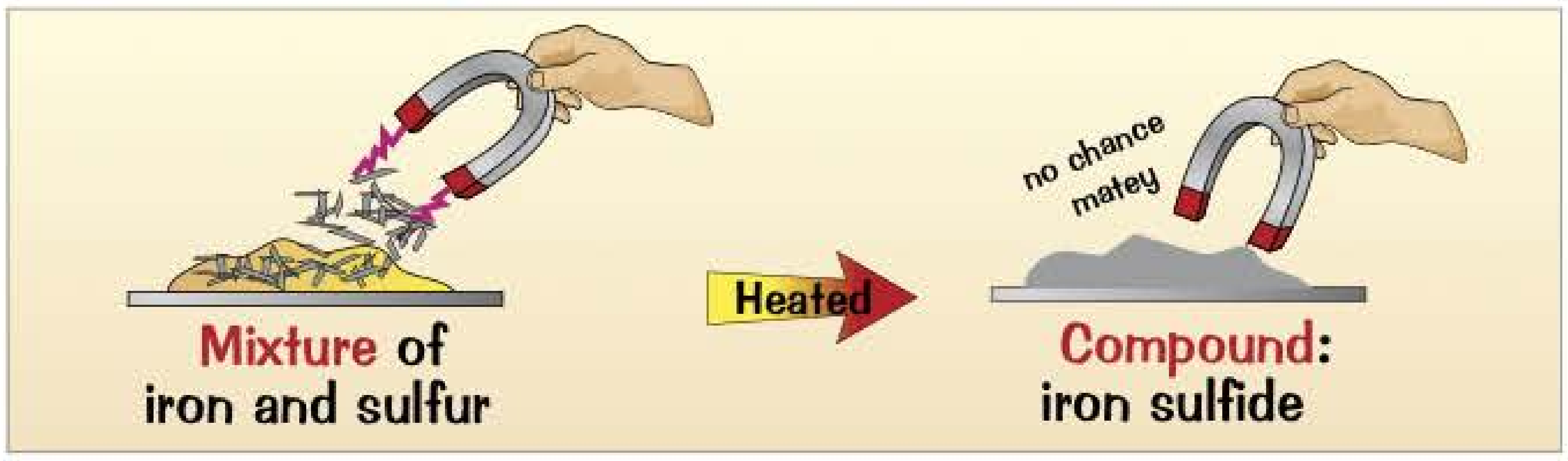
This is not a compound because the elements aren't joined up — it's a mixture.

Compounds are Formed from Chemical Reactions

1) A chemical reaction involves chemicals (called the reactants) combining together or splitting apart to form one or more new substances (called the products).
2) When a new compound is synthesised (made), elements combine.
3) The new compounds produced by any chemical reaction are always totally different from the original elements (or reactants). The classic example of this is iron reacting with sulfur as shown below:

Iron is magnetic.
It reacts with sulfur
to make iron sulfide,
a totally new substance
which is not magnetic.

These equations show what happens in the reaction:



Word equation: Iron + Sulfur $\xrightarrow{\text{Heated}}$ Iron Sulfide

In symbols: $Fe + S \xrightarrow{\text{Heated}} FeS$

4) When elements undergo a chemical reaction like the one above, the products will always have a chemical formula — e.g. H_2O for water or FeS for iron sulfide.
5) Compounds can be split up back into their original elements but it won't just happen by itself — you have to supply a lot of energy to make the reaction go in reverse.

Remember, every element has a name and a symbol. See p. 35 for more.

Learn about Compounds — and try and make it stick...

They really do like seeing if you know the difference between elements and compounds (and mixtures — see page 39 for more on these). Make sure you do. You'll also need to learn what happens in chemical reactions. It's not that tricky — but you do have to learn all the picky details on this page good 'n' proper.

Naming Compounds

When elements combine to make a compound, their names change slightly. Learn the Two Simple Rules.

Naming Compounds — Two Simple Rules

Rule 1: When two different elements combine the ending is usually "something -ide".

$NaCl$	Formula	MgO
Sodium and Chlorine	Elements present	Magnesium and Oxygen
give: SODIUM CHLORIDE	Name of Compound	give: MAGNESIUM OXIDE

And in just the same way:	Sulfur changes to Sulfide	Bromine changes to Bromide
	Iodine changes to Iodide	Fluorine changes to Fluoride

Rule 2: When three or more different elements combine — and one of them is oxygen — the ending will usually be "something -ate".

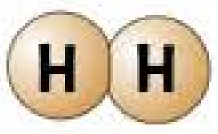
$CuSO_4$	Formula	$CaCO_3$
1 Copper, 1 Sulfur, 4 Oxygens	Elements present	1 Calcium, 1 Carbon, 3 Oxygens
COPPER SULFATE	Name of Compound	CALCIUM CARBONATE

And in just the same way:	Sodium + Carbon + 3 Oxygens makes:	SODIUM CARBONATE
	Potassium + Sulfur + 4 Oxygens makes:	POTASSIUM SULFATE
	Ammonia + Nitrogen + 3 Oxygens makes:	AMMONIUM NITRATE

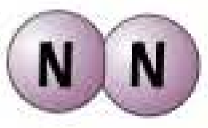
If Two Identical Elements Combine, it's Not a Compound

Identical atoms of the same element are often found combined.
This doesn't make them a compound though — in fact, their name doesn't even change.

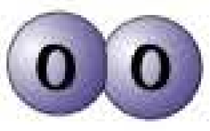
H_2 = Hydrogen



N_2 = Nitrogen

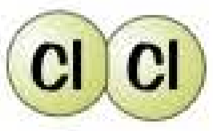


O_2 = Oxygen

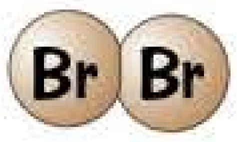


F_2 = Fluorine

Cl_2 =Chlorine



Br_2 = Bromine



These are all elements with two atoms, not compounds. They're almost never found as single atoms in nature.

-ides and -ates — it's the game of the name, pal...

Naming compounds can get very tricky of course, but for KS3 you'll do just fine learning those two simple rules. When you have, work out the names of these three:

1) Sodium joined with fluorine 2) Two iodines joined up 3) Calcium with sulfur and oxygen.*

*Answers on page 108.

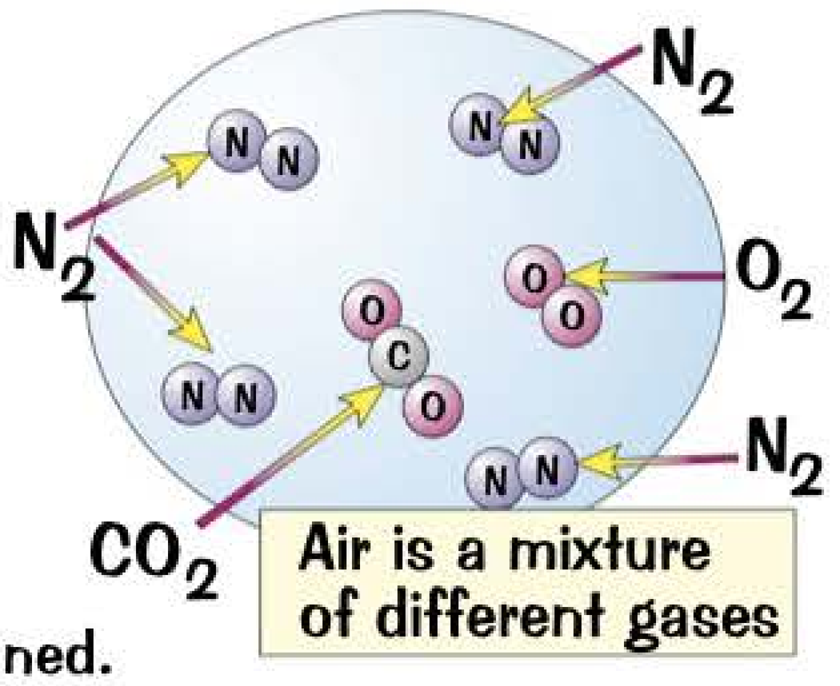
Mixtures

Mixtures in chemistry are like cake mix in the kitchen — all the components are mushed up together, but you can still pick out the raisins if you really want. You'll need to learn the technical terms too though...

Mixtures are Substances That are NOT Chemically Joined Up

1) A pure substance is made up of only one type of element OR only one type of compound. It can't be separated into anything simpler without a chemical reaction.

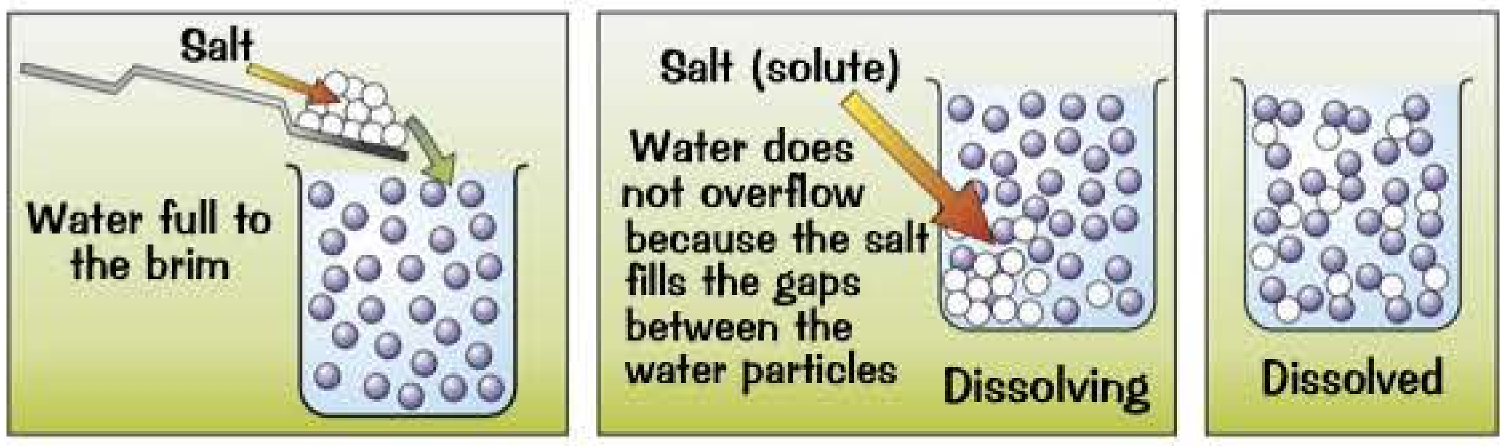
   E.g. pure water is made up of H_2O molecules only. These molecules can't be separated into H and O atoms without a chemical reaction.



Air is a mixture of different gases

2) A mixture contains two or more different substances. These substances aren't chemically joined up — so, if you're clever, you can separate them very easily using physical methods (i.e. without a chemical reaction). See pages 40-41 for more.
3) Sea water and air are good examples of mixtures — they contain several different substances which aren't chemically combined.
4) A mixture has the properties of its constituent parts (i.e. the parts it's made from).

Dissolving isn't Disappearing

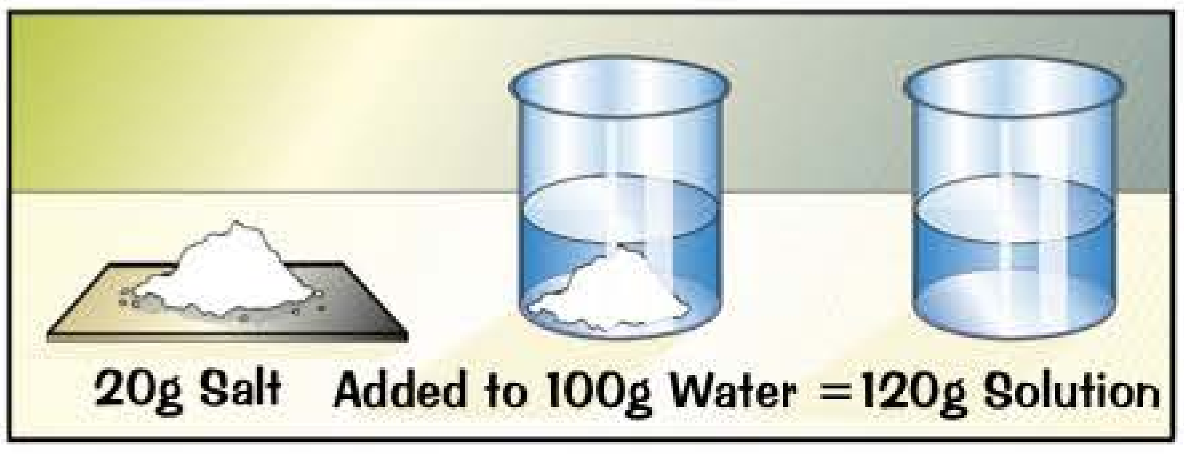


1) Dissolving is a common way mixtures are made.
2) When you add a solid (the solute) to a liquid (the solvent) the bonds holding the solute particles together sometimes break.
3) The solute particles then mix with the particles in the liquid forming a solution.

   Learn these seven definitions:

   1) Solute – is the solid being dissolved.
   2) Solvent – is the liquid it's dissolving into.
   3) Solution – is a mixture of a solute and a solvent that does not separate out.
   4) Soluble – means it WILL dissolve.
   5) Insoluble – means it will NOT dissolve.
   6) Saturated – a solution that won't dissolve any more solute at that temperature.
   7) Solubility – a measure of how much solute will dissolve.

4) Remember, when salt dissolves it hasn't vanished — it's still there — no mass is lost.
5) If you evaporated off the solvent (the water), you'd see the solute (the salt) again.



Solubility Increases with Temperature

1) At higher temperatures more solute will dissolve in the solvent because particles move faster.
2) However some solutes won't dissolve in certain solvents. E.g. salt won't dissolve in petrol.

I said nothing disappears — just don't ask Derren Brown...

Learn the three main headings on this page till you can write them down from memory. Then learn the stuff underneath them, including the diagrams. Cover the page and write it all down.

Separating Mixtures

There are all sorts of ways you can separate mixtures. You've got to know four of them.

Mixtures Can be Separated Using Physical Methods

There are four separation techniques you need to be familiar with.

1) FILTRATION 2) EVAPORATION 3) CHROMATOGRAPHY 4) DISTILLATION (see next page).

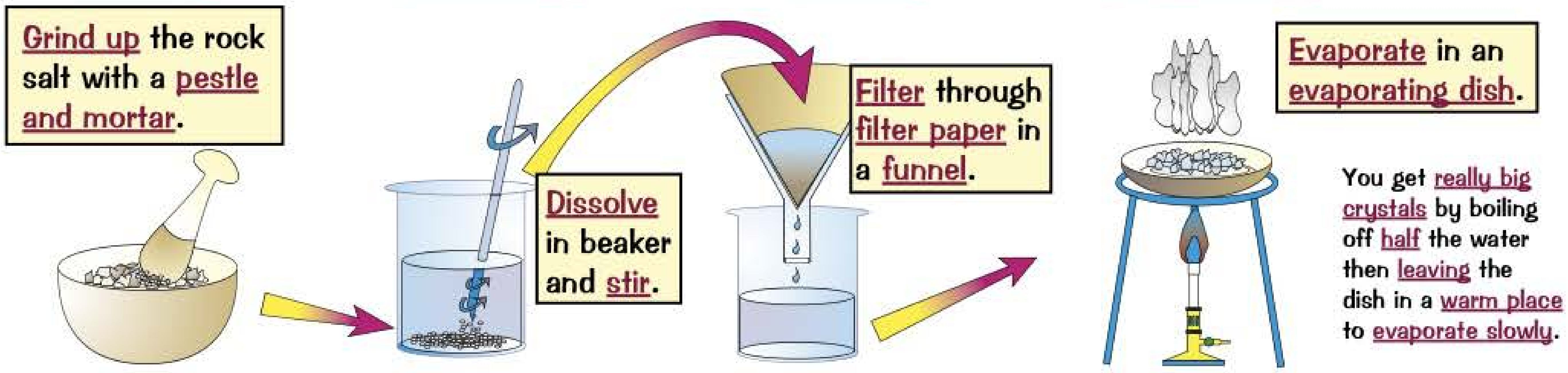
All four make use of the different properties of the constituent parts to separate them out.

Filtration and Evaporation — *E.g. for the Separation of Rock Salt*

1) Rock Salt is simply a mixture of salt and sand (they spread it on the roads in winter).
2) Salt and sand are both compounds — but salt dissolves in water and sand doesn't. This vital difference in their physical properties gives us a great way to separate them.

You Need to Learn the Four Steps of the Method:

1) Grinding 2) Dissolving 3) Filtering 4) Evaporating



Grind up the rock salt with a pestle and mortar.

Dissolve in beaker and stir.

Filter through filter paper in a funnel.

Evaporate in an evaporating dish.

You get really big crystals by boiling off half the water then leaving the dish in a warm place to evaporate slowly.

- The sand doesn't dissolve (it's insoluble) so it stays as big grains and obviously these won't fit through the tiny holes in the filter paper — so it collects on the filter paper.
- The salt is dissolved in solution so it does go through — and when the water's evaporated, the salt forms as crystals in the evaporating dish. This is called crystallisation. (Surprise surprise.)

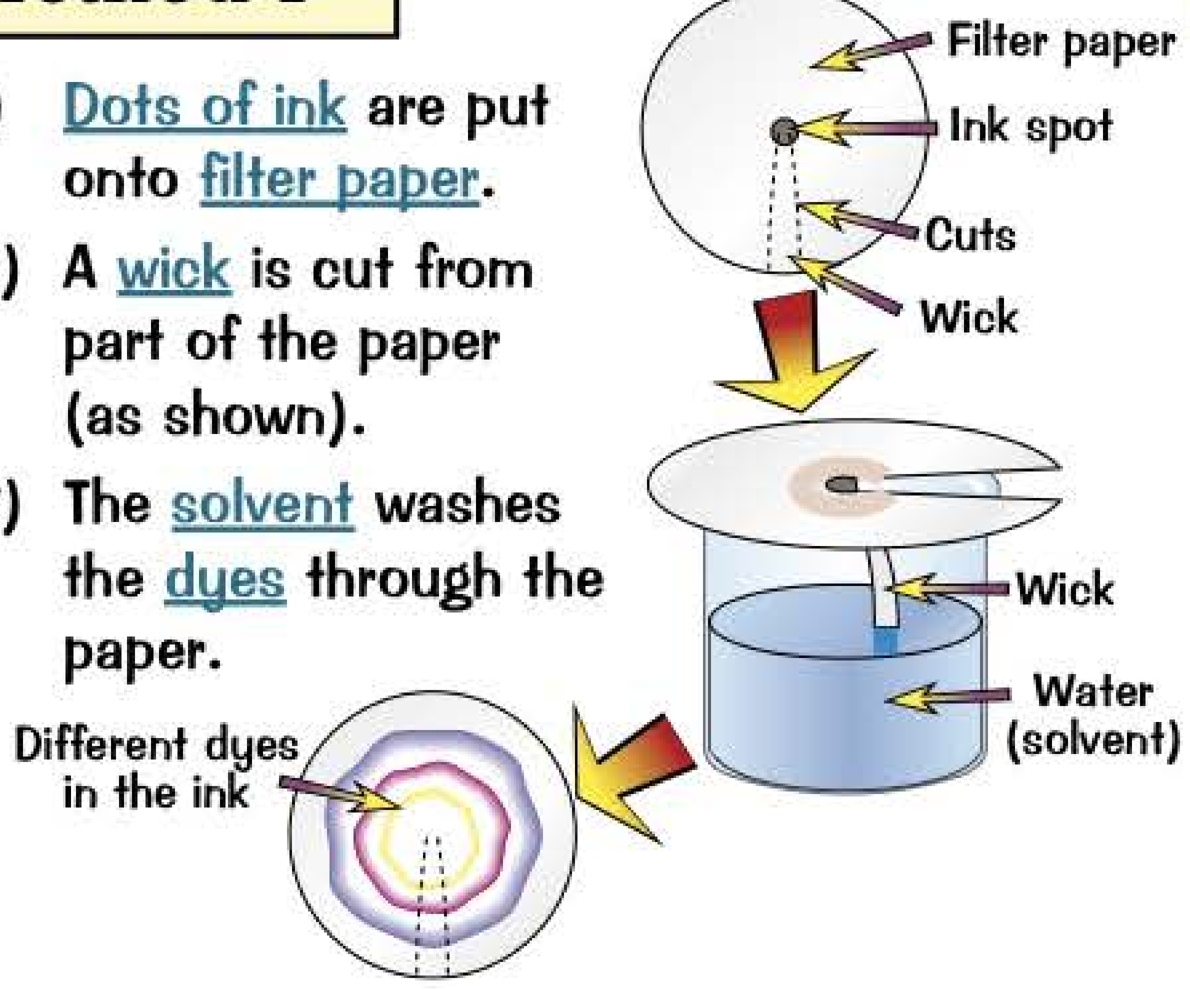
Chromatography is Ideal for Separating Dyes in Inks

1) Different dyes in ink will wash through paper at different rates.
2) Some will stick to the paper and others will dissolve in the solvent (see below) and travel through it quickly.

Chromatography can also be used to identify blood samples and investigate chlorophyll.

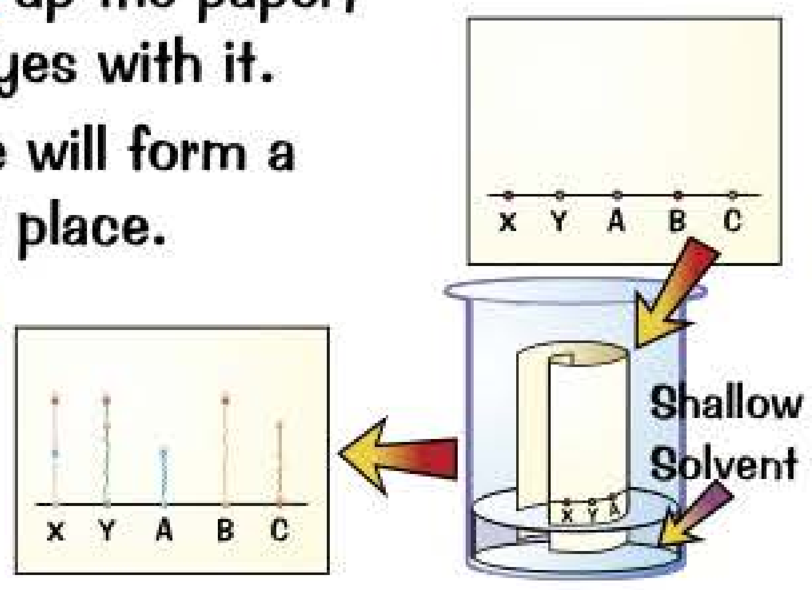
Method 1

1) Dots of ink are put onto filter paper.
2) A wick is cut from part of the paper (as shown).
3) The solvent washes the dyes through the paper.



Method 2

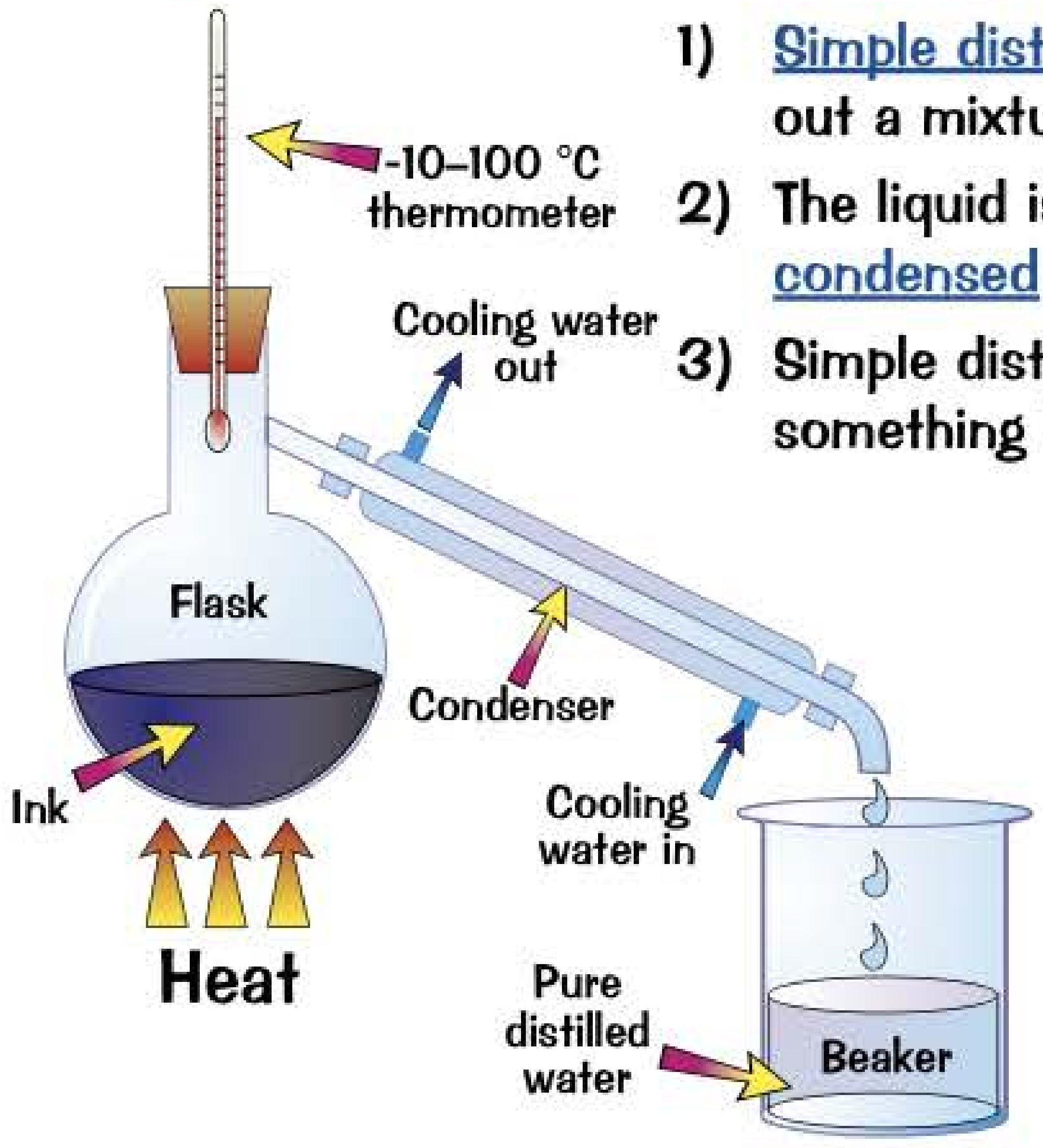
1) Put spots of inks onto a pencil baseline on chromatography paper.
2) Roll the sheet up and put it in a beaker.
3) The solvent seeps up the paper, carrying the ink dyes with it.
4) Each different dye will form a spot in a different place.
5) You can compare a forged ink to a known ink to see which it is.

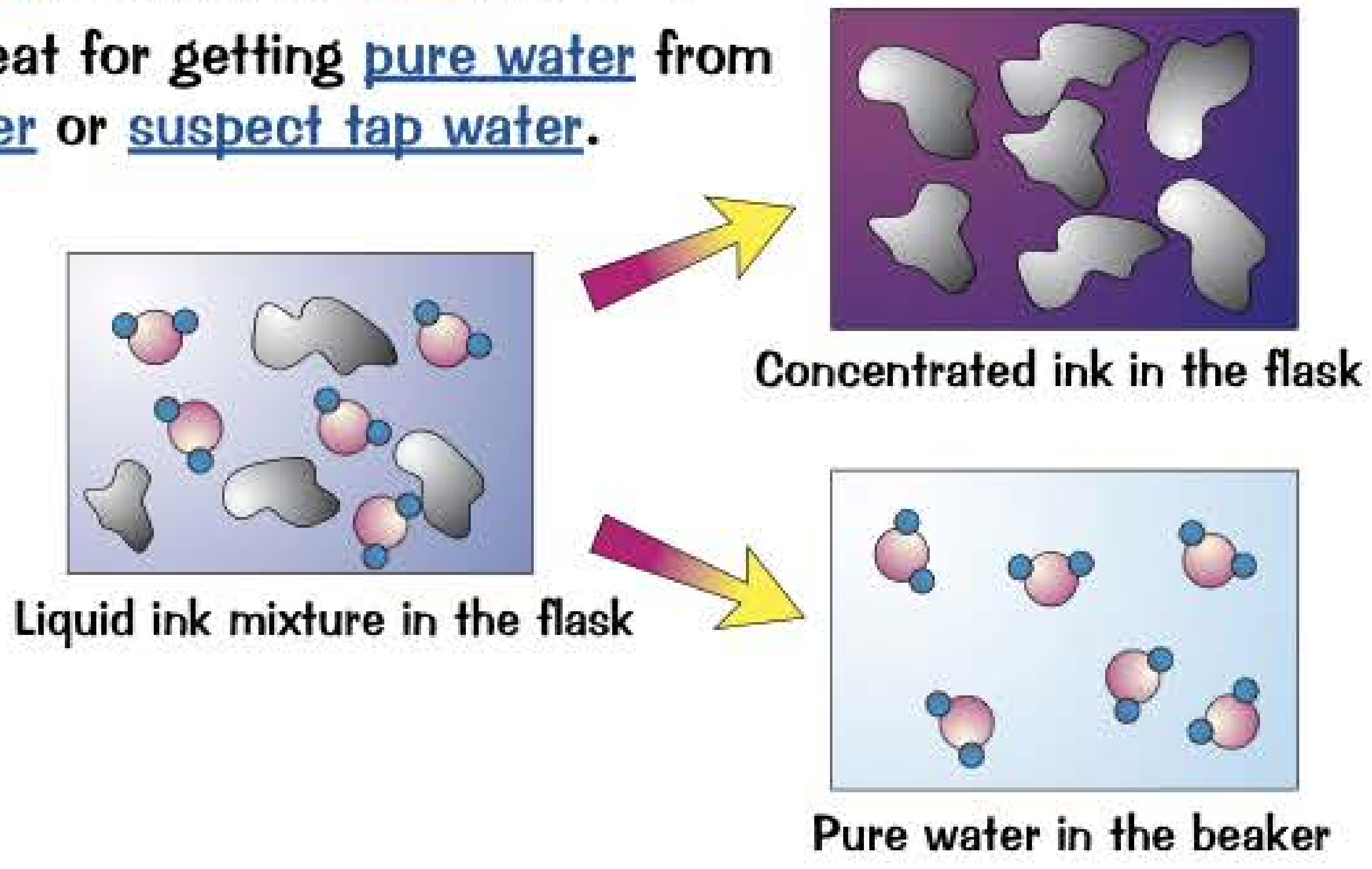


Separating Mixtures

Simple Distillation Separates Pure Water from Ink

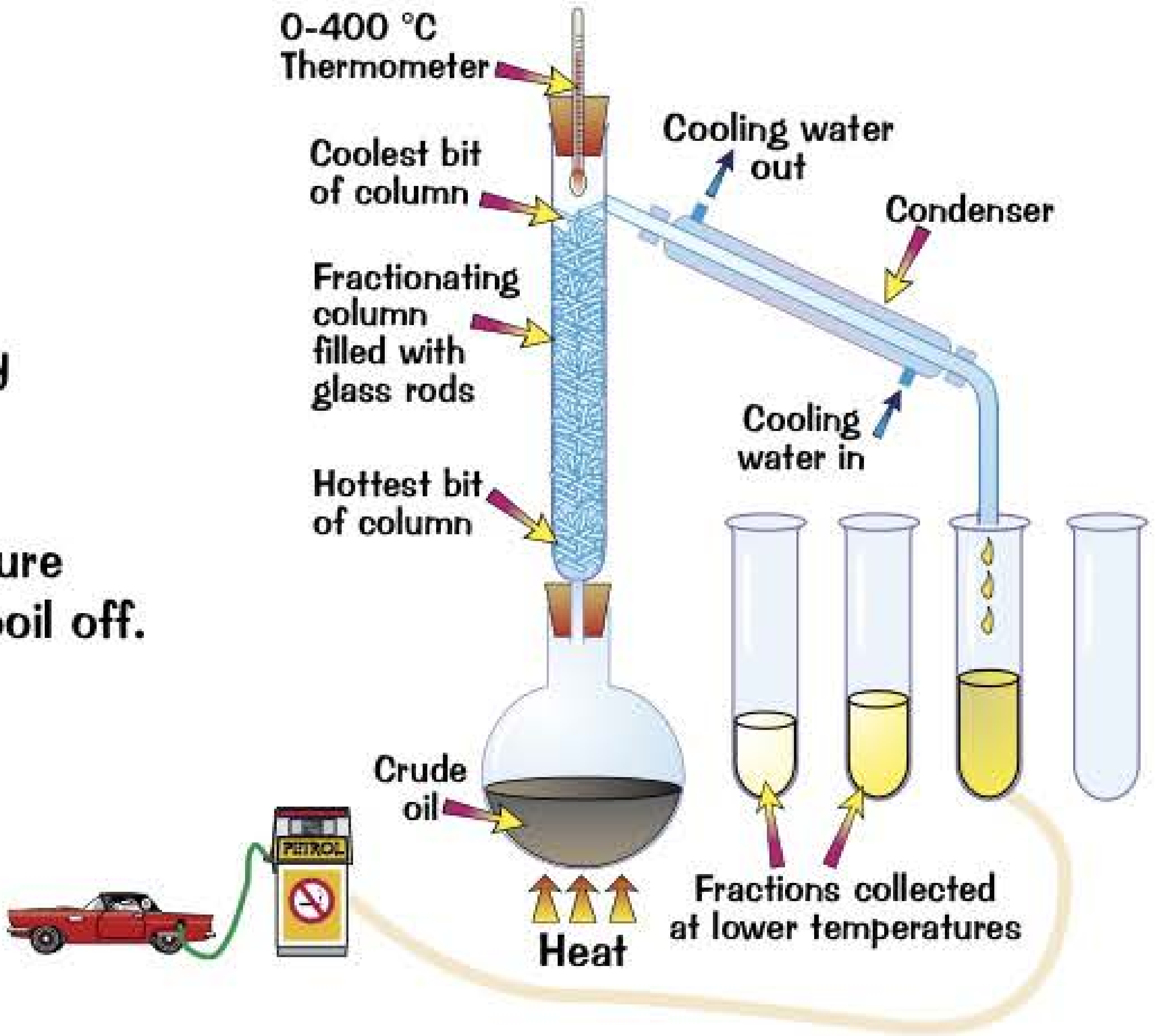
1) Simple distillation can be used for separating out a mixture of a liquid and a solid.
2) The liquid is heated and boils off. It's then cooled, condensed and collected, leaving the solid behind.
3) Simple distillation is great for getting pure water from something like sea water or suspect tap water.





Fractional Distillation Separates Mixed Liquids

1) Fractional distillation is used for separating a mixture of liquids like crude oil.
2) Different liquids will boil off at different temperatures, around their own boiling point.
3) The fractionating column ensures that the "wrong" liquids condense back down, and only the liquid properly boiling at the temperature on the thermometer will make it to the top.
4) When each liquid has boiled off, the temperature reading rises until the next fraction starts to boil off.
5) Real life examples include:
    - distilling whisky,
    - separating crude oil into petrol, diesel and other fuels.



Check Purity with Melting and Boiling Points

1) A pure chemical substance has fixed melting and boiling points. E.g. pure water boils at 100 °C and pure ice melts at 0 °C. These figures are known for a huge range of substances.
2) This helps us to identify unknown substances, e.g. if a liquid boils at exactly 100 °C it's likely to be pure water.
3) Impurities change melting and boiling points, e.g. impurities in water cause it to boil above 100 °C.
4) This means you can test the purity of a substance you've separated from a mixture.

Pure Substance	Melting Point °C	Boiling Point °C
Water	0	100
Ethanol	-114	78
Aluminium	660	2520

Revise mixtures — just filter out the important bits...

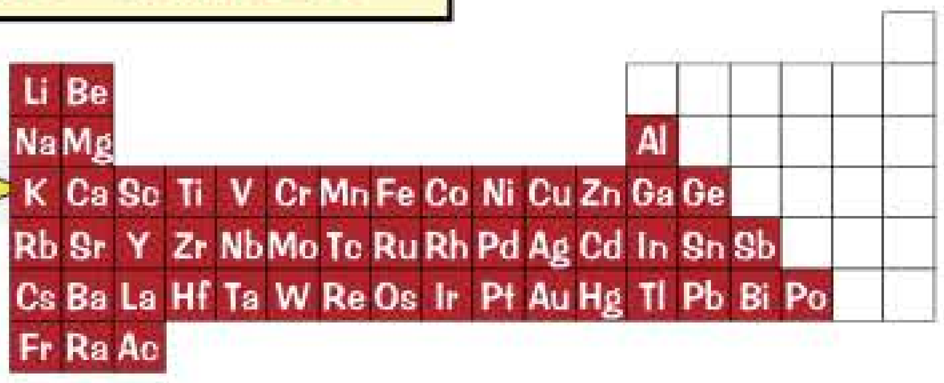
Teachers love asking you about separation techniques (strange, I know), so make sure you've got all the facts AND the diagrams absolutely 100% learnt. Make sure you know how to check purity too.

Properties of Metals

Metals are jolly useful. We use them all the time in bendy wires, bridges, musical instruments and more. So it's only fair that you learn these two pages of glorious facts about them in return...

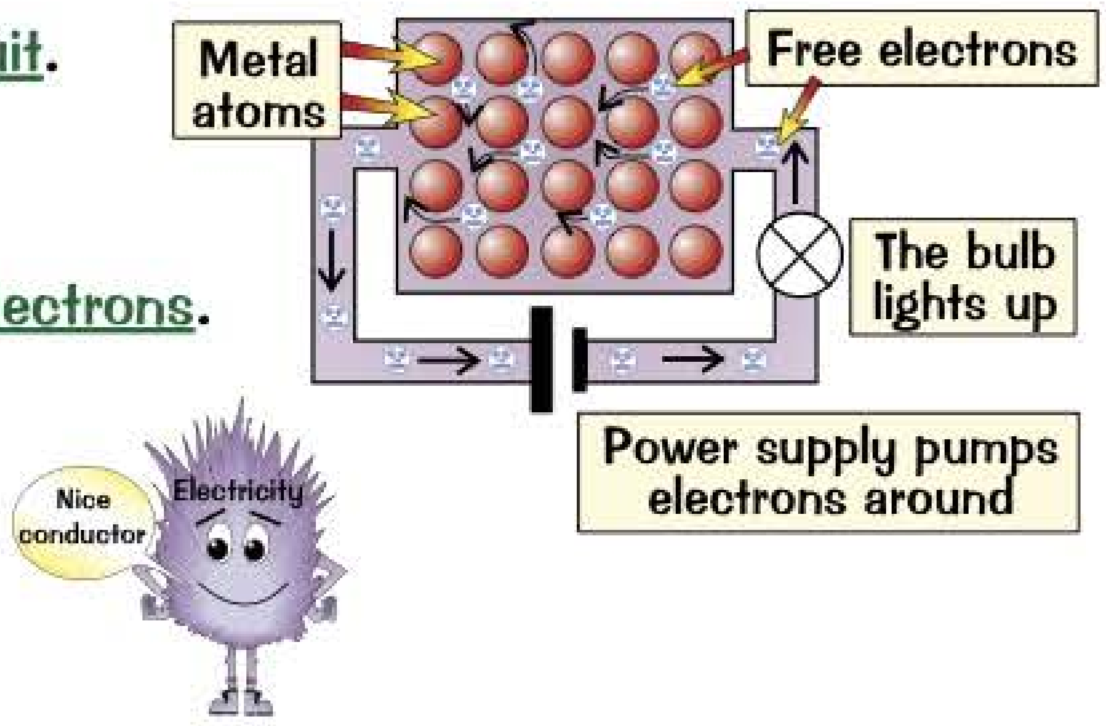
1) Metals Can be Found in the Periodic Table

1) Most of the elements in the periodic table are metals.
2) Some are shown here in red, to the left of the zig zag.



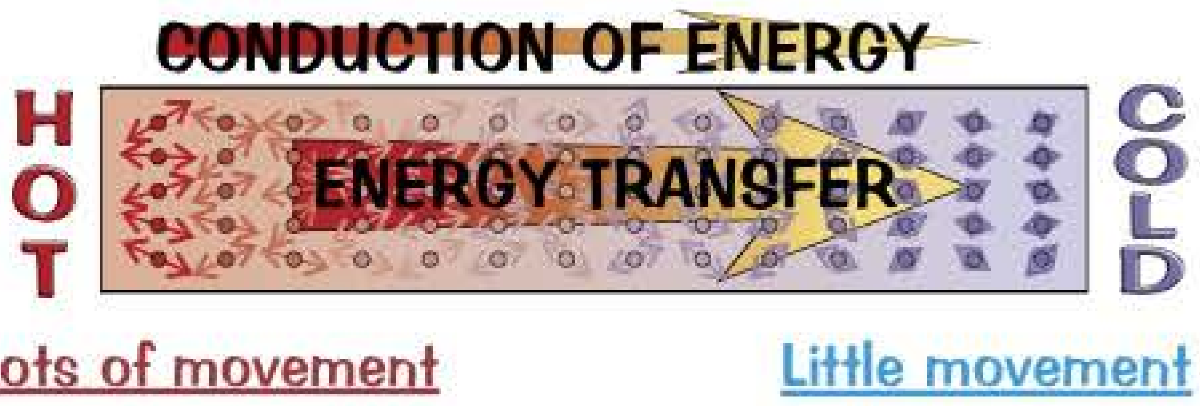
2) Metals Conduct Electricity

1) Electric current is the flow of electrical charge around a circuit.
2) Metals conduct electricity, which means they allow electrical charge to pass through them easily.
3) The moving charges are negatively-charged particles called electrons.
4) Metals contain some electrons that are free to move between the metal atoms. These free electrons can carry an electric charge from one end of the metal to the other.
5) Because they conduct electricity well, metals are often used to make wires and parts of electrical circuits.



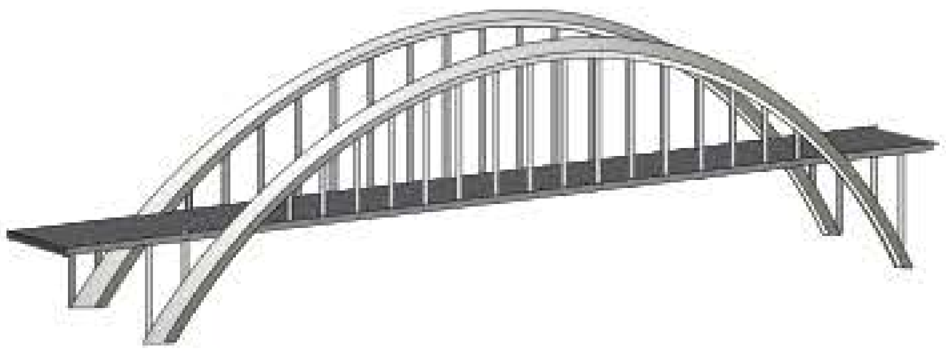
3) Metals Conduct Energy

1) Metals transfer energy from a hot place to a cold place quickly and easily.
2) The "hot" particles vibrate strongly.
3) Because the particles are very close together, the vibrations are easily passed on through the metal.
4) Free electrons in the metal also help to transfer energy from the hot parts of the metal to the cooler parts as they move around.



4) Metals are Strong and Tough

1) Metals have high tensile strength (they can be pulled hard without breaking).
2) This is because there are strong forces between metal atoms that hold them together. Their strength makes them good building materials.

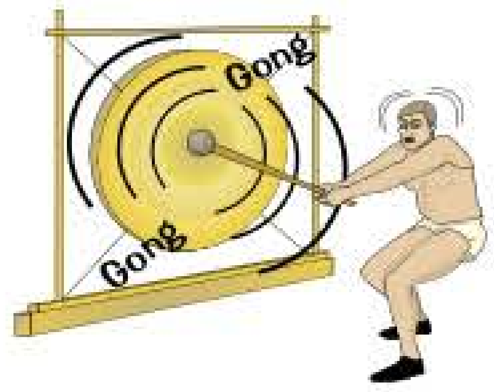


5) Metals are Shiny When Polished

Polished or freshly cut metals give strong reflection of light from their smooth surface. This makes them look shiny.

6) Metals are Sonorous

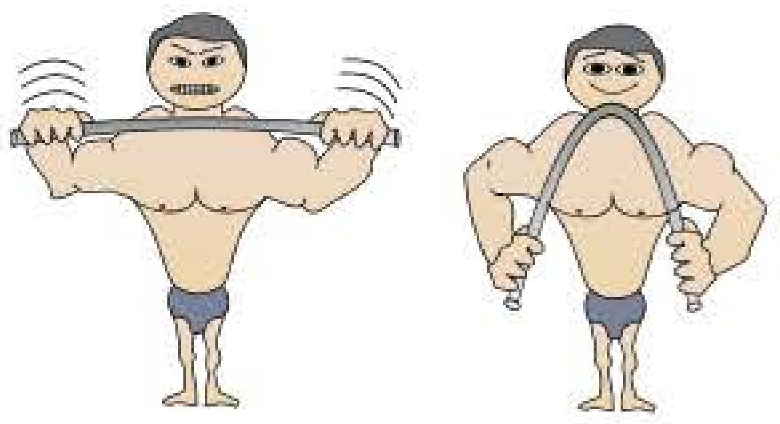
This means they make a nice "donnnnggg" sound when they're hit. If you think about it, it's only metals that do that — you could make a gong out of plastic, but it wouldn't be much good.



Properties of Metals

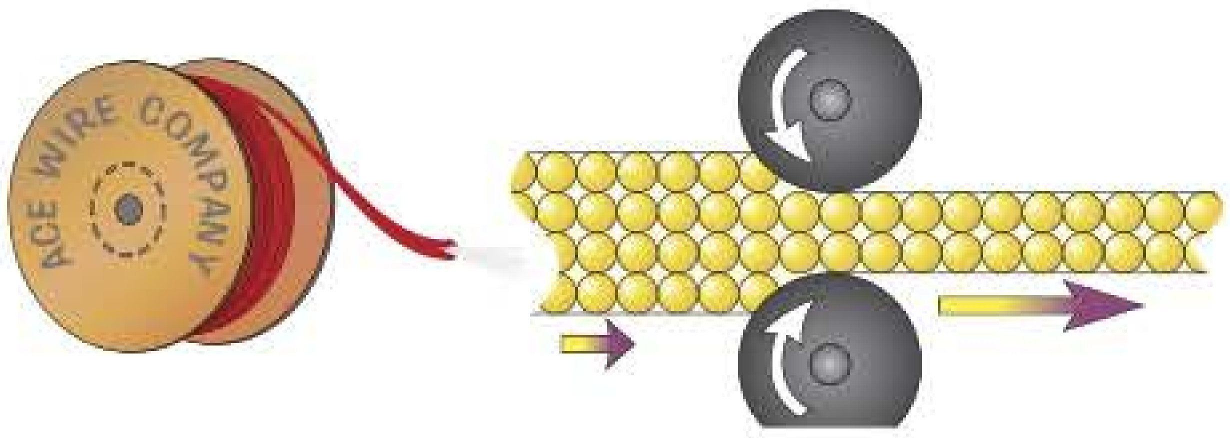
7) Metals are Malleable

1) Metals are easily shaped (malleable) because the atoms in metals can slide over each other.
2) This means metals can be hammered into thin sheets or bent — all without shattering.



8) Metals are Ductile

1) This means they can be drawn into wires.
2) Metals aren't brittle like non-metals (see page 45) are. They just bend and stretch.



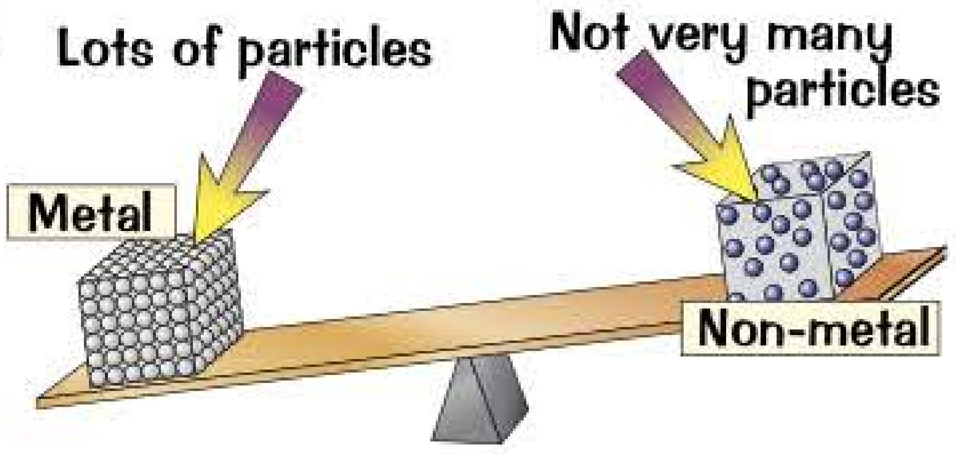
9) Metals have High Melting and Boiling Points

1) A lot of energy is needed to melt metals.
2) This is because their atoms are joined by strong forces.
3) The table shows how hot they have to get to melt.

Metal	Melting Point (°C)	Boiling Point (°C)
Aluminium	660	2520
Copper	1085	2562
Magnesium	650	1090
Iron	1538	2861
Zinc	420	907
Silver	962	2162

10) Metals have High Densities

1) Density is all to do with how much stuff there is squeezed into a certain space.
2) Metals feel heavy for their size (i.e. they're very dense) because they have a lot of atoms tightly packed into a small volume.



11) Metals Make Alloys When Mixed with Other Metals

1) A combination of different metals is called an alloy. The properties of the metals get jumbled up in the new alloy.
2) So lighter, weaker metals can be mixed with heavier, stronger metals and the result is, hopefully, an alloy which is light and strong.

12) Some Metals are Magnetic

1) Only certain metals are magnetic.
2) Most metals aren't magnetic. Iron, nickel and cobalt are. Alloys made with these three metals will also be magnetic — e.g. steel is made mostly from iron, so is also magnetic.

Good Alloys — you can rely on friends from Birmingham...

There they are then. A whole load of facts about metals just waiting to be soaked up into that giant sponge lurking between your ears. You need to keep practising till you can scribble down all the headings with both pages covered. Then try filling in the details. Then turn your doodles into an awesome paper aeroplane.

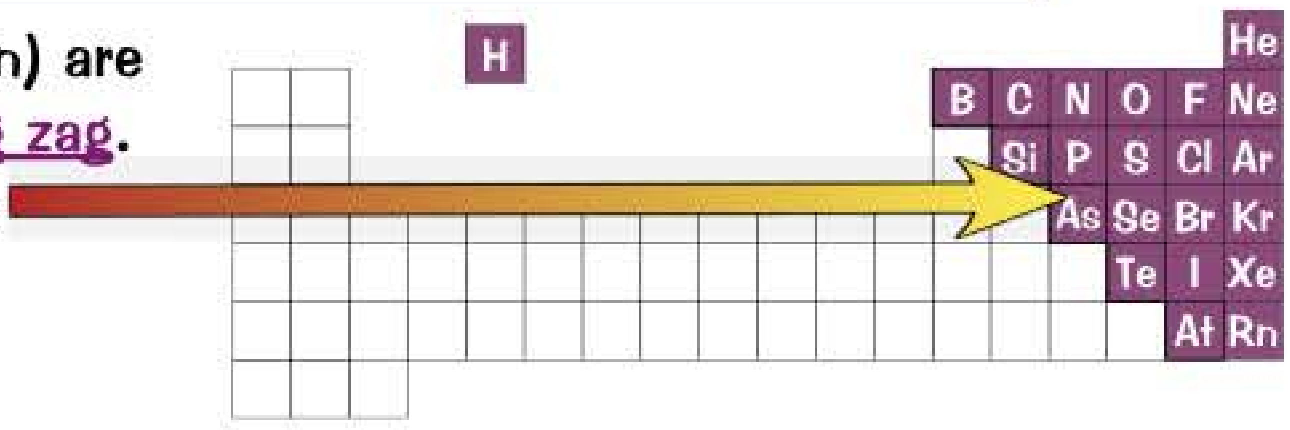
Properties of Non-Metals

The properties of non-metal elements vary quite a lot. Good — life would stink if everything was like sulfur...

1) Non-metals Can be Found in the Periodic Table

1) All the non-metals (with the exception of hydrogen) are clustered in the corner over on the right of the zig zag.

Look, right over there.

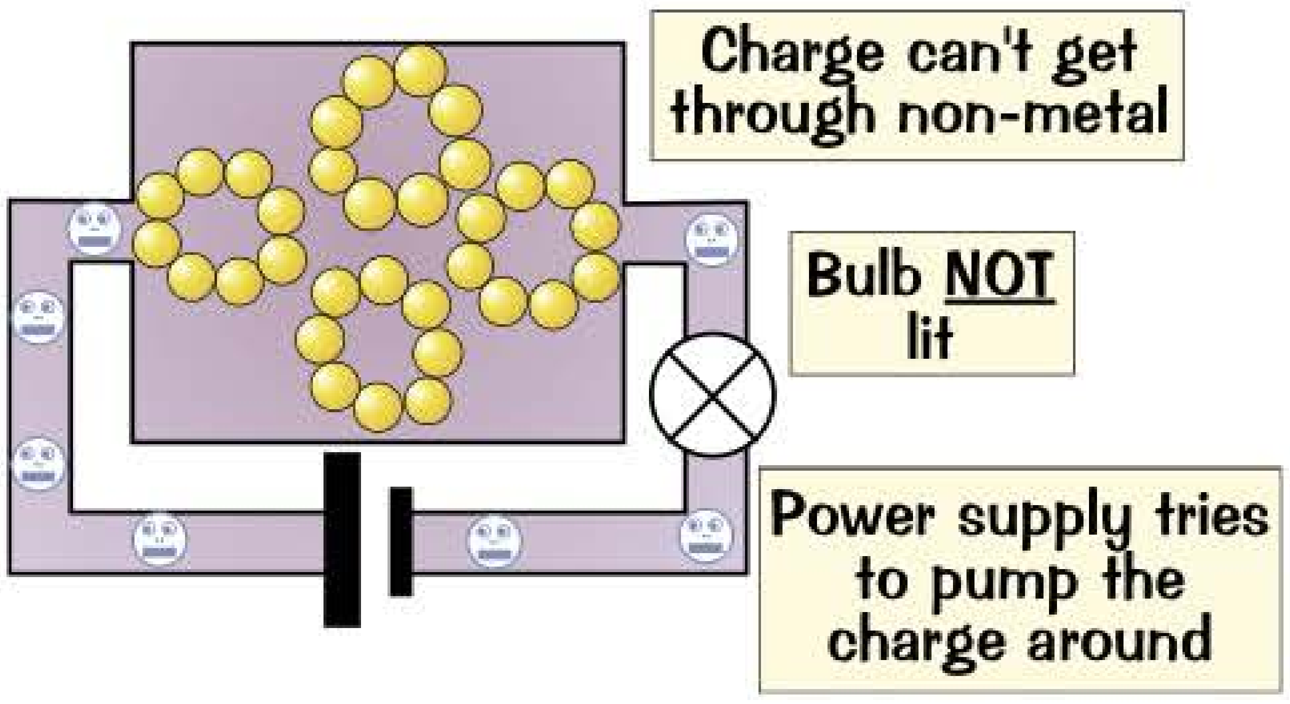


2) There are fewer non-metals than metals.

2) Non-metals are Poor Conductors of Electricity

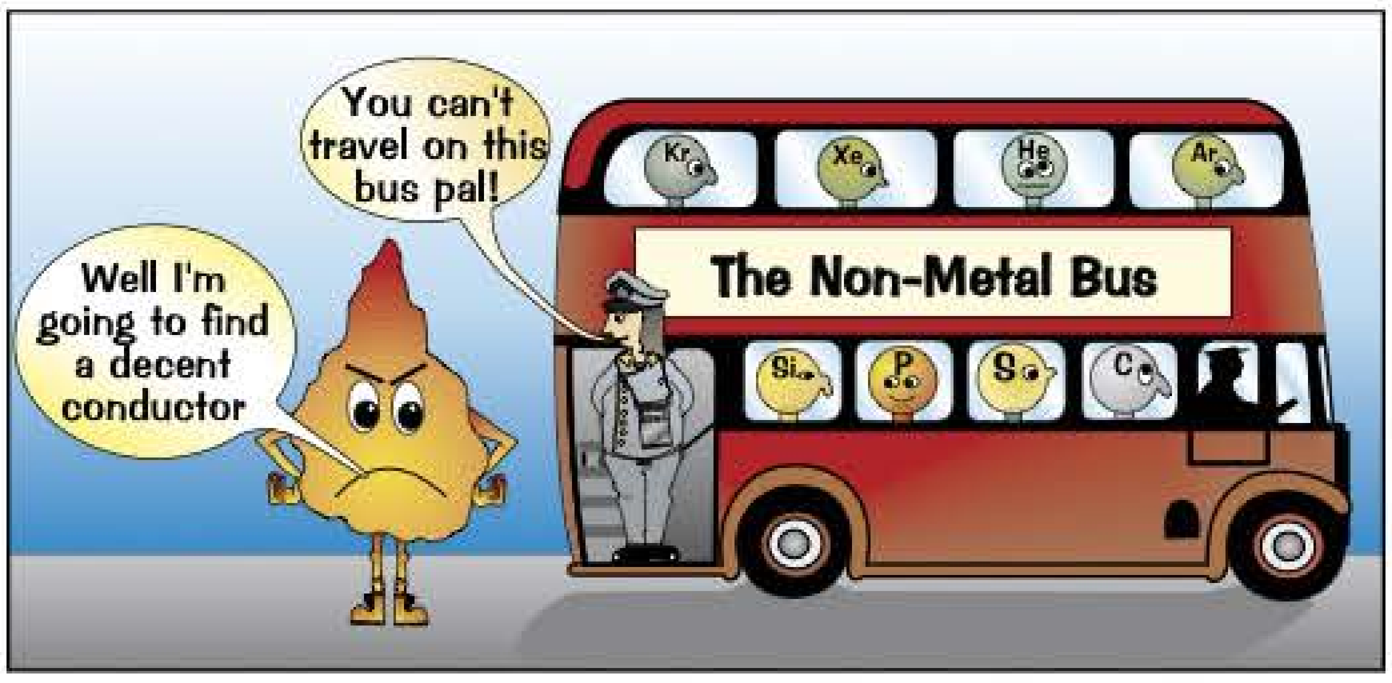
1) Most non-metals are insulators, which means that charges can't flow through them.
2) If charges can't move then no electric current flows. This is very useful — non-metals combine to make things like plugs and electric cable coverings.

One exception to this rule is graphite — a non-metal made purely from carbon atoms. Its atoms are arranged in layers, which allow electrons to move along them, so graphite can conduct electricity.



3) Non-metals are Poor Conductors of Energy by Heating

1) Non-metals don't transfer energy from a hot place to a cold place very quickly or easily.
2) This makes non-metals really good insulators.
3) "Hot" particles don't pass on their vibrations so well.



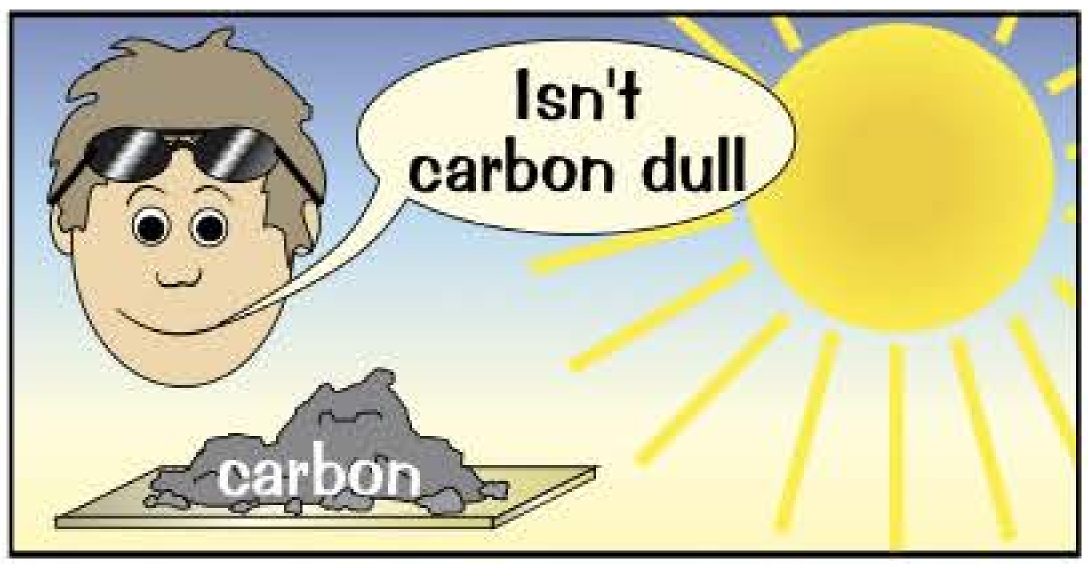
4) Non-metals are NOT Strong or Hard-Wearing

1) The forces between the particles in non-metals are weak — this means they break easily.
2) It's also easy to scrub atoms or molecules off them — so they wear away quickly.

Properties of Non-Metals

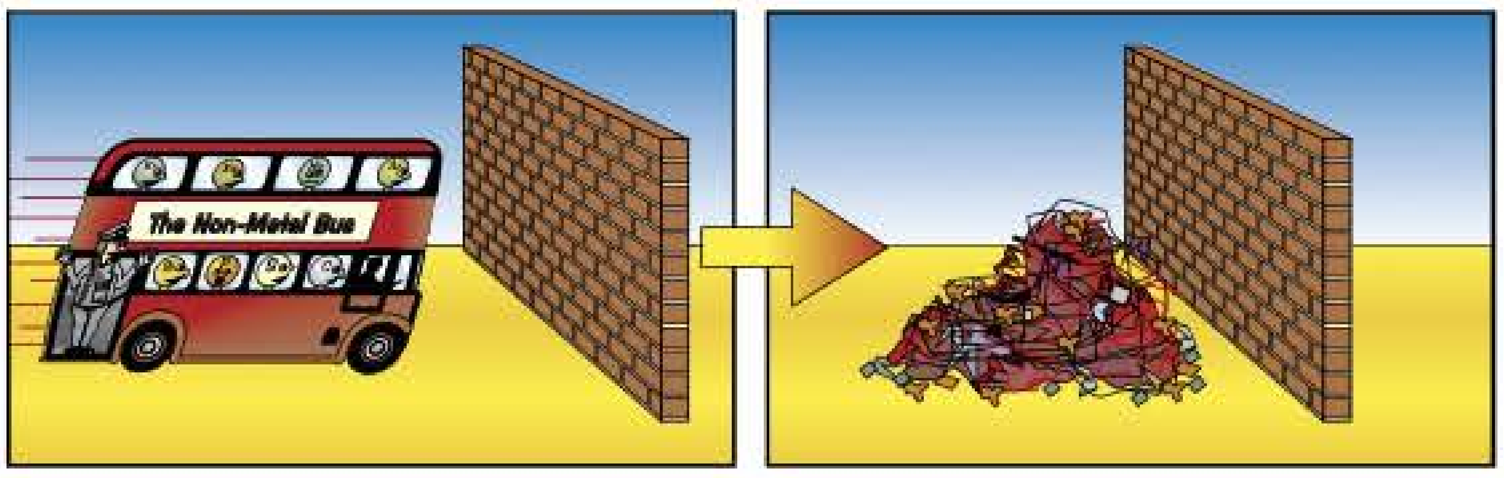
5) Non-metals are Dull

1) Most non-metals don't reflect light very well at all. Their surfaces are not usually as smooth as metals.
2) This makes them look dull.



6) Non-metals are Brittle

1) Non-metal structures are held together by weak forces.
2) This means they can shatter all too easily.



7) Non-metals Have Low Melting Points and Boiling Points

1) The forces which hold the particles in non-metals together are very weak. This means they melt and boil very easily.
2) At room temperature, most non-metals are gases or solids. Only one is a liquid.

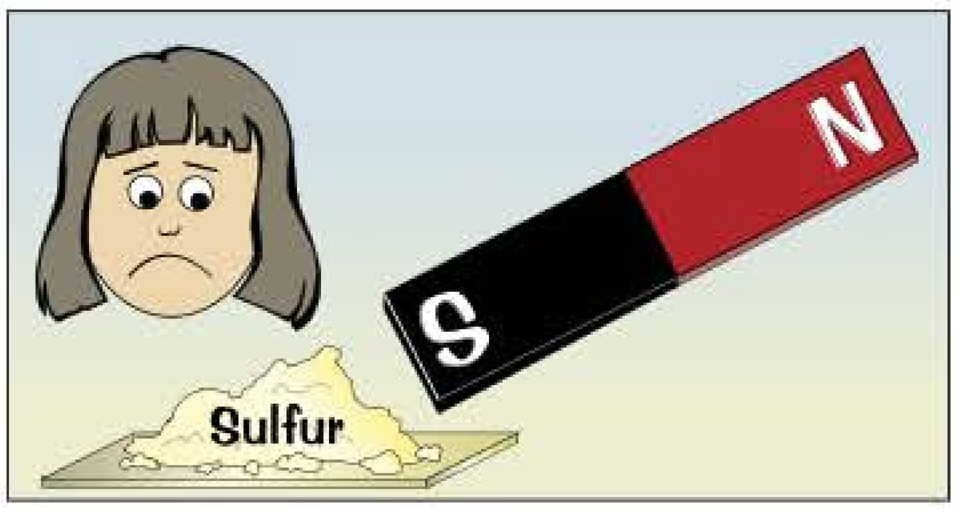
Non-Metal	Melting Point (°C)	Boiling Point (°C)
Sulfur	113	445
Oxygen	-218	-183
Chlorine	-101	-35
Helium	-272	-269
Neon	-249	-246
Bromine	-7	59

8) Non-metals Have Low Densities

1) Obviously the non-metals which are gases will have very low density. Some of these gases will even float in air — ideal for party balloons.
2) This means they don't have very many particles packed into a certain space.
3) Even the liquid and solid non-metals have low densities.

9) Non-metals are Not Magnetic

1) Only a few metals like iron, nickel and cobalt are magnetic.
2) All non-metals are most definitely non-magnetic.



Non-Metals — they REALLY ARE dull aren't they...

You still have to learn all about them though. Do it like this: Cover the page with a bit of paper and try and write down each of the 9 points, one at a time. Lower the paper each time to see if you scribbled it all down right. Keep trying till you can get them all. Then put on some nice relaxing music by Non-Metallica.

Properties of Other Materials

As well as metals and non-metals, you need to learn all about some ace compounds and mixtures of compounds — polymers (plastics), ceramics (like bone china) and composites (like fibreglass).

Polymers Have Many Useful Properties

Polymers (that's plastics to you and me) include nylon, polythene and PVC.

1) Polymers are usually insulators — it's difficult for energy to be transferred through them electrically or by heating.
2) They're often flexible — they can be bent without breaking.
3) They have a low density — they can be very light for their size and strength. This makes them ideal for making things that need to be strong but not heavy.
4) They're easily moulded — they can be used to manufacture equipment with almost any shape.

Polymers are used to make everything from crash helmets and kayaks to carrier bags and drinks bottles.

Polymers are just compounds, made by joining loads of little molecules together in long chains. They usually contain carbon.

Ceramics are Stiff but Brittle

Ceramics include glass, porcelain and bone china (for posh tea cups). They are:

1) Insulators — it's difficult for energy to be transferred through them electrically or by heating.
2) Brittle — they aren't very flexible and will break instead of bending.
3) Stiff — they can withstand strong forces before they break.

As well as tea cups, ceramics are used for brakes and parts of spark plugs in cars.

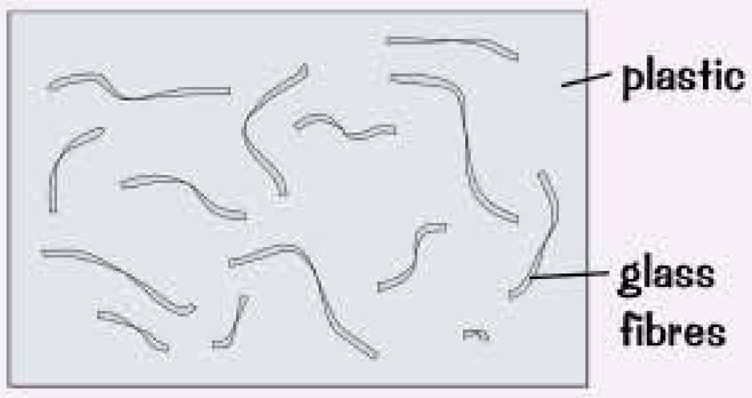
Ceramics are made by 'baking' substances like clay.

Composites are Made of Different Materials

1) Composite materials are made from two or more materials stuck together.
2) This can make a material with more useful properties than either material alone. For example:

Fibreglass

1) Fibreglass (or Glass Reinforced Plastic — GRP) consists of glass fibres embedded in plastic.
2) It has a low density (like plastic) but is very strong (like glass).
3) These properties mean fibreglass is used for things like skis, boats and surfboards.



Concrete

1) Concrete is made from a mixture of sand and gravel embedded in cement.
2) It can withstand high compression stresses (i.e. being squashed) so it's great at supporting heavy things. This makes it ideal for use as a building material, e.g. in skate parks, shopping centres, airports, etc.

Boredom is a common property of revision...

Polymers, ceramics and composites. They're pretty handy — especially when the alternative is a wooden surfboard. Now you need to master everything on this page until you can describe all three AND their uses without any sneaky peeking. Once that's done, stare smugly out the window for 30 seconds.

Section Summary

We've moved on to Chemistry now. Makes a refreshing change from all that slimy Biology anyway. Section 5 is all about Classifying Materials so here's a whole page of delicious Section Summary questions to help you classify how much you've remembered.

You know the drill: work through these questions and try to answer them. For any you can't do, look back through Section 5 and find the answer — and then learn it. Then try all the questions again and see how many more you can do that time. Keep going and before you know it you'll be answering them all perfectly.

1) What are the three states of matter? Describe five properties for each of them.
2) Draw what the particles look like in a solid, a liquid and a gas.
3) Explain how gases exert a pressure on the insides of a container.
4) What happens to the pressure of a gas if the temperature of the gas is increased?
5) What happens to the pressure of a gas if the volume of the gas is decreased?
6) Explain what diffusion is.
7) Give the names of five changes of state, and say which state they go from and to.
8) For any given substance, in which state do the particles have the most energy?
9) Does a change of state involve a change in mass?
10) Explain why a heating curve has a flat bit when a substance is boiling.
11) What is an atom?
12) What is an element? Roughly how many elements are there in the periodic table?
13) In the periodic table: a) What is a group? b) What is a period?
14) Using the periodic table, give the chemical symbol for these:
    a) sodium b) magnesium c) oxygen d) iron e) sulfur
    f) aluminium g) carbon h) chlorine i) calcium j) zinc.
15) Which will show a more violent reaction with water — lithium or rubidium? Why?
16) Use the periodic table to predict whether fluorine or iodine is more reactive.
17) What is a compound? How is a compound different from a mixture?
18) Sketch some molecules that could be in a compound.
19) In what way is iron sulfide different from a mixture of iron and sulfur?
20) Is it easy to split a compound back up into its original elements?
21) Write down the two rules for naming compounds.
22) If two atoms of the same elements combine, what happens to their name?
23)*Give the name of the following:
    a) MgO b) CaO c) $NaCl$ d) $CaCO_3$ e) $CuSO_4$
24)*Give the name of the compound you get from chemically joining up these:
    a) sodium with chlorine b) magnesium with chlorine c) magnesium with carbon and oxygen.
25) What is a pure substance? What is a mixture?
26) Describe what happens when a substance dissolves.
27) What happens to solubility when the temperature increases?
28) List four mixture separation techniques with an example for each one.
29) Which of them would you use to try to identify different colours in a paint?
30) List the 12 facts you need to know about metals.
    Then list the 9 facts you need to know about non-metals.
31) Out of metals and non-metals, which are the:
    a) best conductors b) most brittle c) strongest d) best insulators?
32) Name 4 useful properties of polymers.
33) What are ceramics useful for?
34) What are composites? Name one and describe what it's made of.

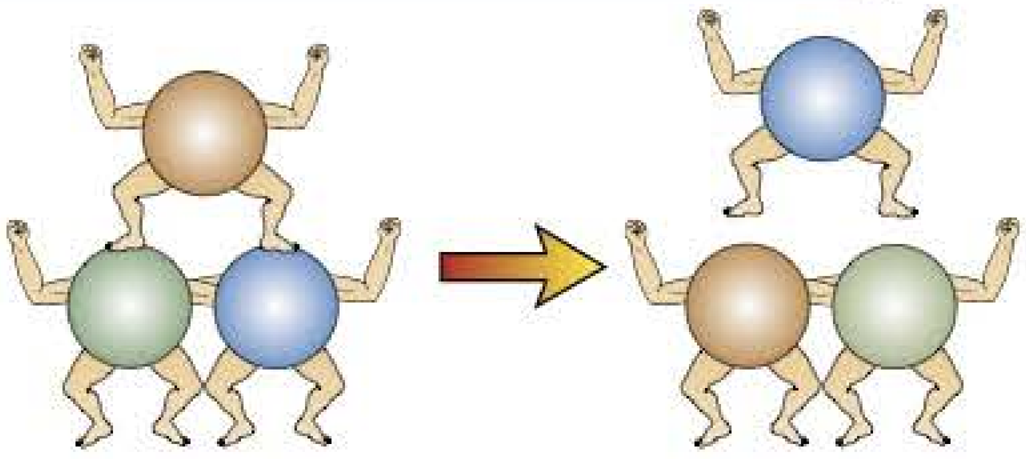
*Answers on page 108

Chemical Reactions

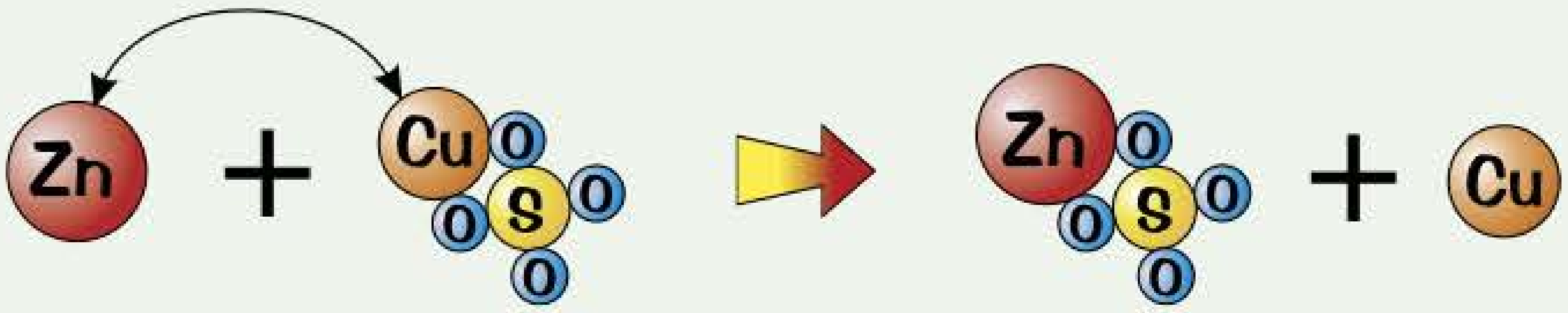
In a chemical reaction, all that's really happening is the atoms moving around into new formations. The reactants might give off energy, make a loud bang, or do a little dance, but the mass won't change.

Atoms Rearrange Themselves in a Chemical Reaction

1) In a chemical reaction atoms are not created or destroyed.
2) The atoms at the start of a reaction are still there at the end.
3) Bonds get broken and made in the reaction, as atoms rearrange themselves in going from the reactants to the products (p. 37). But the atoms themselves are not altered.



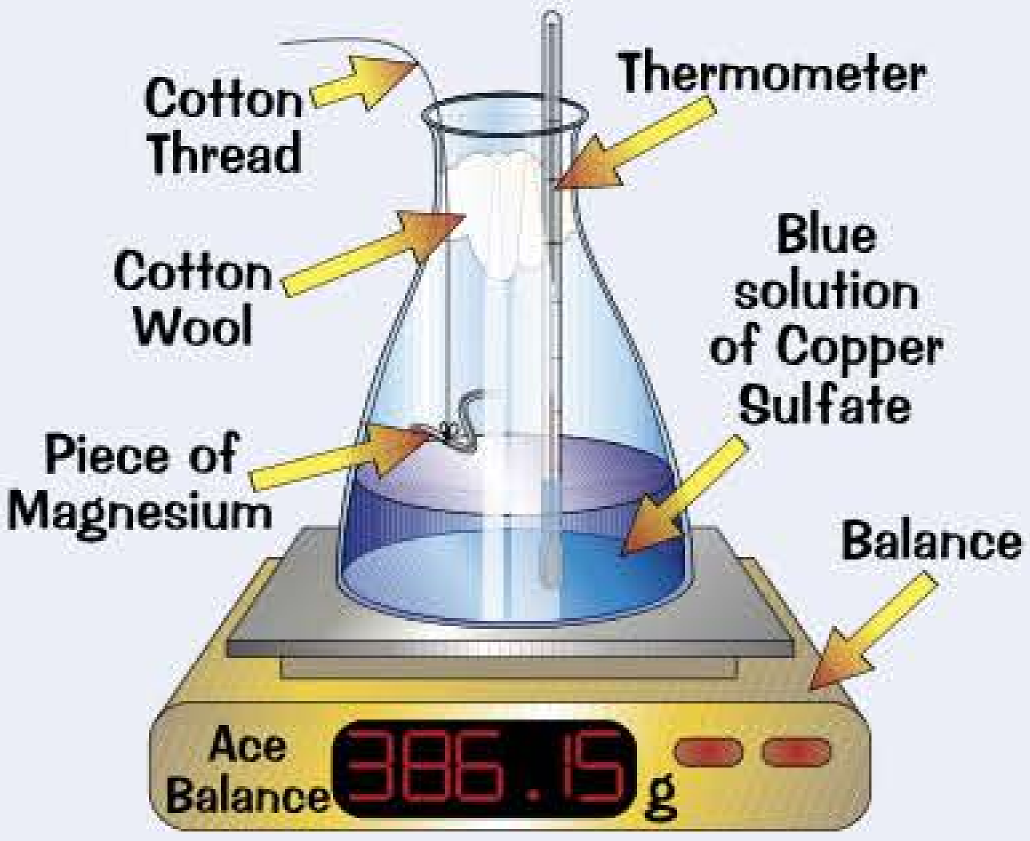
EXAMPLE: zinc + copper sulfate ⟶ zinc sulfate + copper



The Mass Doesn't Change in a Chemical Reaction

1) In a chemical reaction no mass is lost or gained when the reactants turn into the products.
2) This is because the total number of atoms is the same before and after the reaction.
3) Chemical reactions involve a change in energy, i.e. reactions always give out or take in energy (p. 50). This energy is usually transferred by heating, which causes the temperature in a reaction to go up or down.
4) Visible changes can occur in the reaction mixture. These show that a reaction has taken place. For example — a gas comes off, a solid is made, or the colour changes.

EXAMPLE: When magnesium reacts with blue copper sulfate solution, the solution goes colourless, copper coats the magnesium strip and the temperature rises. But the mass stays the same.



Chemical reactions — just a case of atomic acrobatics...

Some chemical reactions involve colour changes, heating up, stinky emissions and even explosions, but there's one thing that always stays the same — the total mass, before and after the reaction. Get your head round that and you've practically solved all of KS3 chemistry. Okay, maybe that's a slight exaggeration.

Examples of Chemical Reactions

Three common examples of chemical reactions coming right up... just what the doctor ordered.

Combustion is Burning in Oxygen

1) Combustion is burning — a fuel reacts with oxygen to release energy.
2) Three things are needed for combustion: →
   1) Fuel
   2) Heating
   3) Oxygen

3) Hydrocarbons are fuels containing only hydrogen and carbon. When it's hot enough there's enough oxygen, hydrocarbons combust (burn) to give water and carbon dioxide:

$$\text{hydrocarbon} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water} \ (+ \text{energy})$$

4) Combustion is useful because energy is transferred away by heating and light. It's the process behind candles, wood fires, car engines, coal power plants, etc.

Oxidation is the Gain of Oxygen

1) When a substance reacts and combines with oxygen, it's called an oxidation reaction.
2) Combustion is an oxidation reaction.
3) Another example of oxidation is rusting. Iron reacts with oxygen in the air to form iron oxide, i.e. rust.

$$\text{iron} + \text{oxygen} \longrightarrow \text{iron oxide (rust)}$$

Thermal Decomposition is Breaking Down When Heated

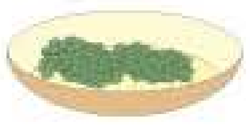
1) Thermal decomposition is when a substance breaks down into at least two other substances when heated.
2) The substance isn't actually reacting with anything, but it is a chemical change.
3) Some metal carbonates break down on heating. Carbonates are substances with CO_3 in them, like copper(II) carbonate ($CuCO_3$) and zinc carbonate ($ZnCO_3$).
4) They break down into a metal oxide (e.g. copper oxide, CuO) and carbon dioxide. This usually results in a colour change.

EXAMPLE: The thermal decomposition of copper(II) carbonate.

$$\text{copper(II) carbonate} \longrightarrow \text{copper(II) oxide} + \text{carbon dioxide}$$

$$CuCO_3 \qquad\qquad CuO + CO_2$$

This is green...



...and this is black.

This page is easy — let me break it down for you...

Here are three common types of chemical reaction to read up and learn. They're here because they're important, so make sure you commit them to memory ASAP. That way you'll have plenty of time to enjoy what's coming up on the next page — that's right, yet more fun and interesting chemical reactions.

More on Chemical Reactions

Chemical reactions always involve a transfer of energy to or from the surroundings.

In an Exothermic Reaction, Energy is Transferred Out

An exothermic reaction is one which transfers energy to the surroundings.

1) Energy is usually given out by heating, so exothermic reactions involve a rise in temperature.
2) The best example of an exothermic reaction is combustion (see previous page). This gives out a lot of energy — it's very exothermic.
3) Many neutralisation reactions (page 53) and oxidation reactions (previous page) are exothermic.
4) Everyday uses of exothermic reactions include hand warmers.

In an Endothermic Reaction, Energy is Taken in

An endothermic reaction is one where energy is taken in from the surroundings.

1) Energy is usually taken in by heating, so endothermic reactions involve a fall in temperature.
2) Endothermic reactions are much less common. Thermal decompositions (previous page) are a good example, since they involve a substance taking in energy and breaking down.
3) Everyday uses of endothermic reactions include sports injury packs. They take in energy and get very cold.

Catalysts Increase the Speed of a Reaction

A catalyst is a substance which speeds up a chemical reaction, without being changed or used up in the reaction itself.

1) Catalysts come out of a reaction the same as when they went in — usually they just give the reacting particles somewhere to meet up and do the business. That means catalysts can be reused.
2) Chemical reactions need energy to get them started — usually through heating. Catalysts lower the minimum amount of energy needed for a reaction to happen.
3) This means a lower temperature can be used to carry out the reaction.

Catalysts Help Reduce Costs in Industry

1) Catalysts are very important for business — most industrial reactions use them.
2) By increasing the speed of the reaction and lowering the temperature needed, they make industrial reactions cheaper and increase the amount of product made in a given time.
3) There are some disadvantages to catalysts. They can be expensive to buy, and different reactions use different catalysts, so businesses can't get away with just buying one to use for everything. They also need to be cleaned and they can be 'poisoned' by impurities.

Catalysts are like my jokes — they can be used over and over

And they're not only used in industry... the enzymes in your body are a type of catalyst — without them, your chemical reactions would be too slow to keep you alive. There's more on enzymes on p. 8.

Balancing Equations

It's important to live a balanced life — that includes work, play, nutrition and chemical equations.

Chemical Equations Show What Happens in a Reaction

You can show what happens in a chemical reaction using:

1) A WORD EQUATION — where the names of the products and reactants are written out in full.
2) A SYMBOL EQUATION — which uses chemical symbols and formulae (see pages 35-37).
A balanced symbol equation shows how many of each chemical react or are made in a reaction.

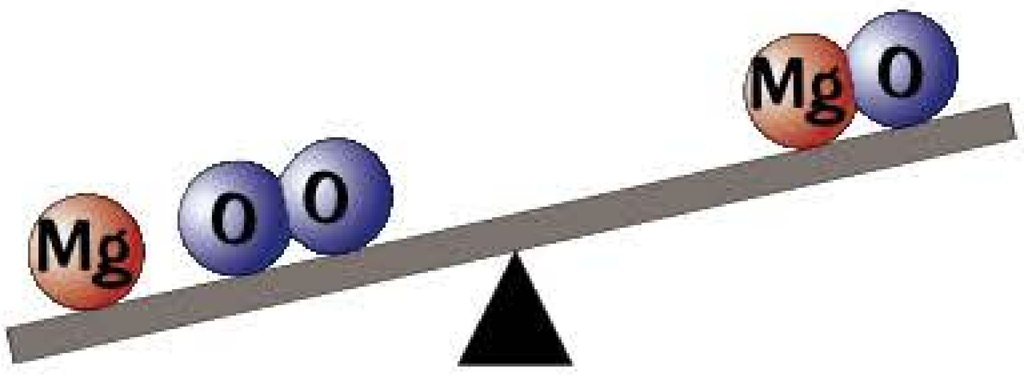
Chemical Equations are Equal on Both Sides

Oxygen gas is made up of pairs of atoms, called molecules — that's why it's O_2.

Here's an example of writing a balanced equation for burning magnesium in oxygen.

1) Write the word equation: magnesium + oxygen → magnesium oxide
2) Write in the chemical formulae of all the reactants and products: $Mg + O_2 \longrightarrow MgO$
3) Check that the equation is balanced by counting the number of each atom on both sides of the equation. Then do steps A, B, C and D below to balance the atoms up one by one. Keep track of the number of atoms on each side as you go:

Left side of equation	Right side of equation
One Magnesium	One Magnesium
Two Oxygen	One Oxygen



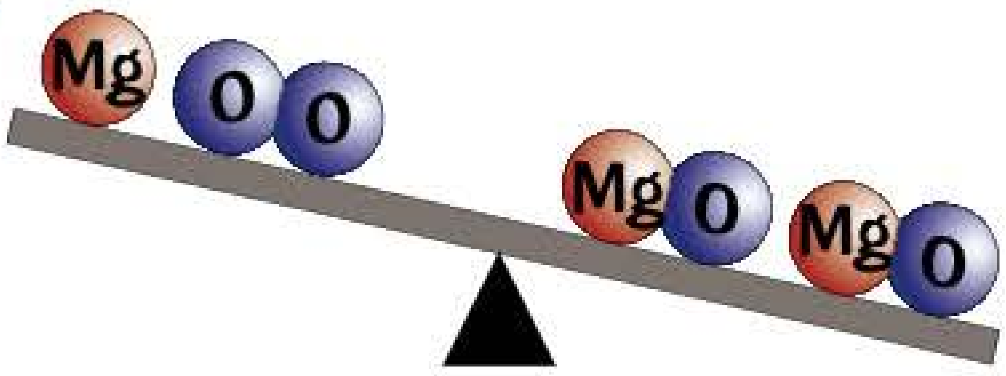
A Find an element that doesn't balance and pencil in a number to try and sort it out.

There isn't enough oxygen on the right side of the equation — add "2" before MgO.

$$Mg + O_2 \longrightarrow 2MgO$$

B See where that gets you by counting up the atoms again.

Left side of equation	Right side of equation
One Magnesium	Two Magnesium
Two Oxygen	Two Oxygen



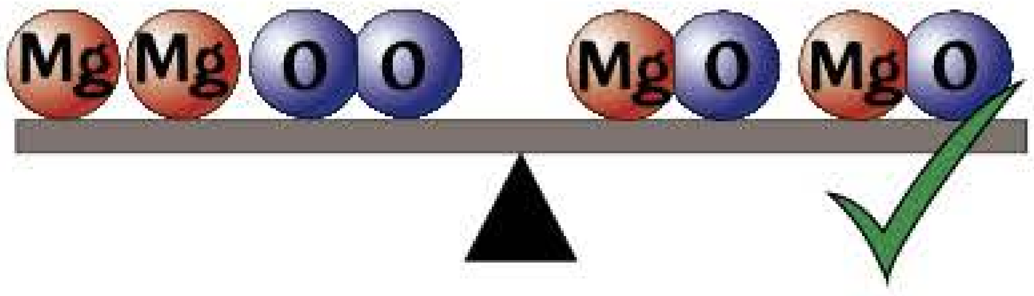
C Continue to chase the unbalanced atoms by going back to A) — pencil in a number before a formula, then see where it gets you when you count up the atoms.

There isn't enough magnesium on the left side of the equation — add a "2" before Mg.

$$2Mg + O_2 \longrightarrow 2MgO$$

D See where that gets you by counting up the atoms again.

Left side of equation	Right side of equation
Two Magnesium	Two Magnesium
Two Oxygen	Two Oxygen



Done and dusted.

All things being equal — you'll be able to sort this out...

This is the hardest thing you'll ever be asked to do in this subject, so don't worry if you find it tricky. Learn the method and then try this one out for size: $Na + Cl_2 \longrightarrow NaCl$. *

---

*Answer on page 108.

Acids and Alkalis

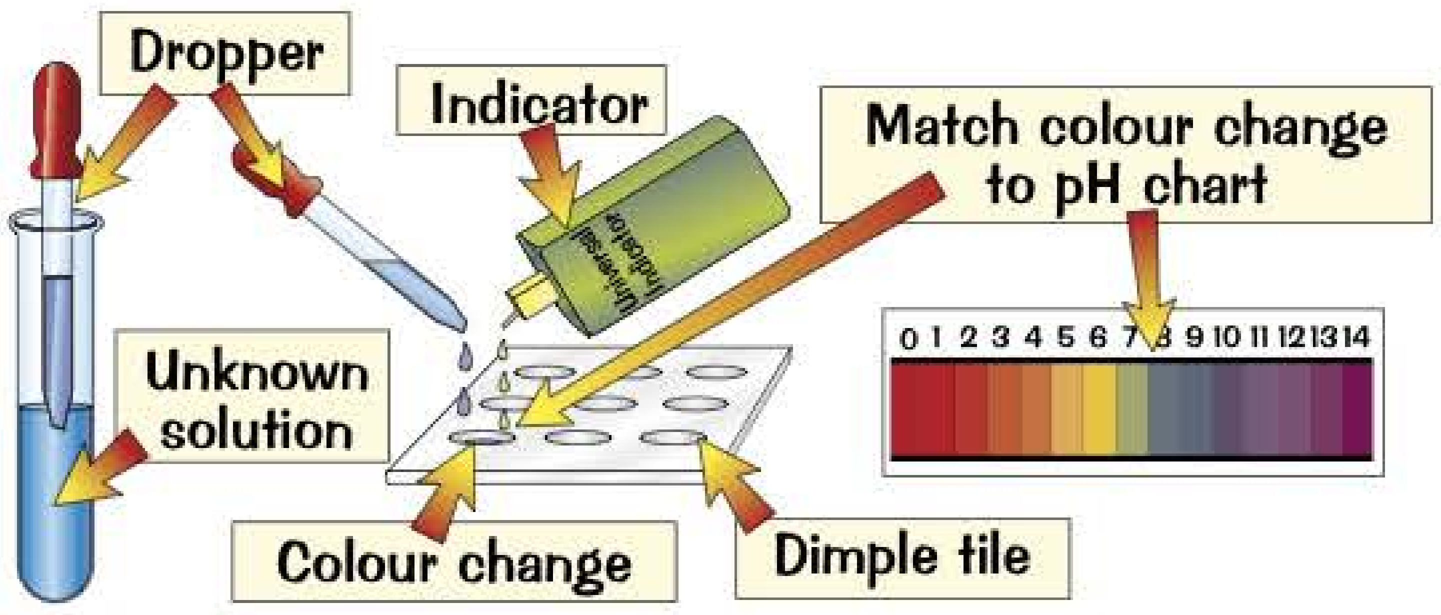
The pH scale is what scientists use to describe how acidic or alkaline a substance is. Universal indicator takes on a colour based on the pH of the substance it's mixed with.

The pH Scale Shows the Strength of Acids and Alkalis

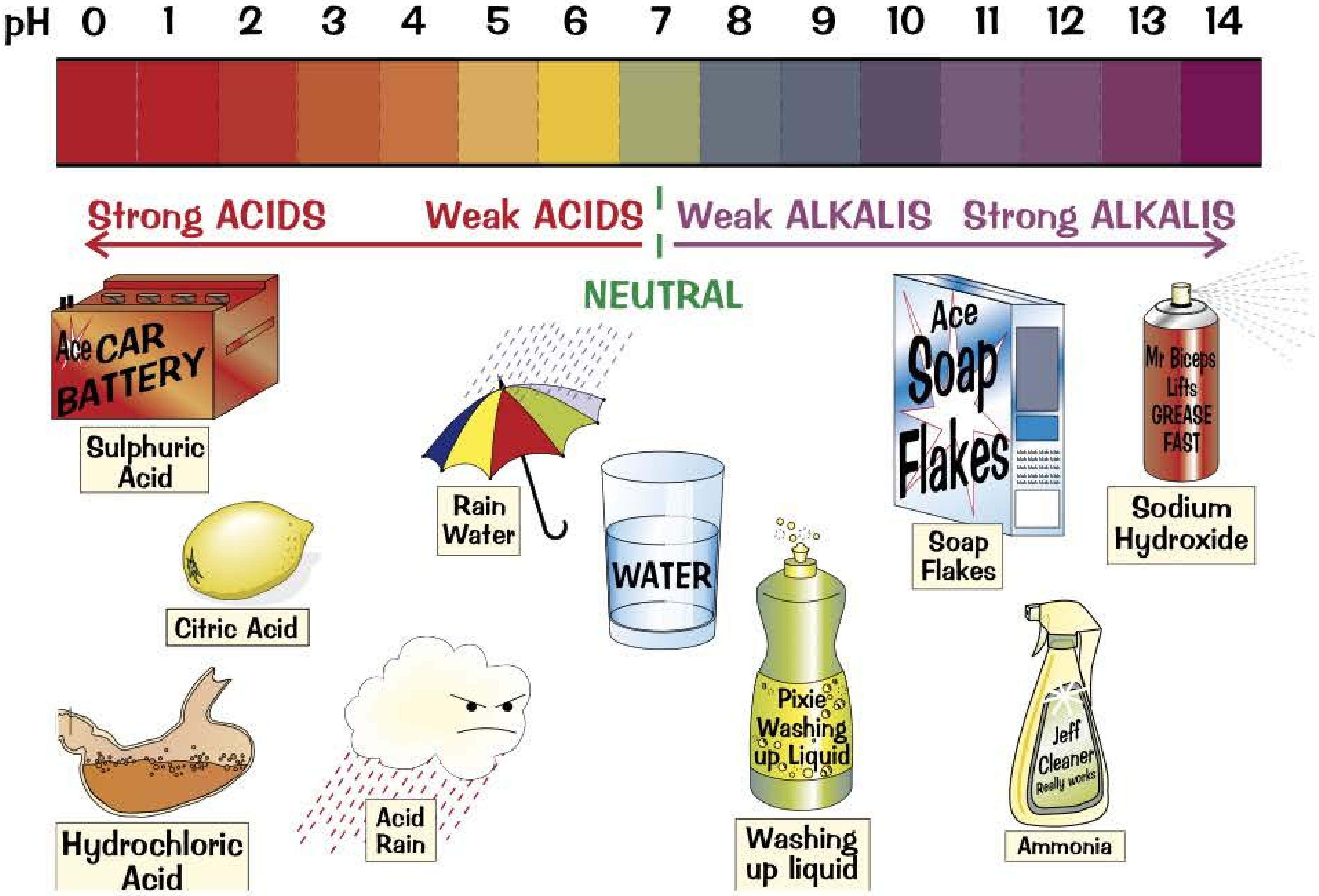
1) The pH scale goes from 0 to 14.
2) Anything with a pH below 7 is an acid. The strongest acid has pH 0.
3) Anything with a pH above 7 is an alkali. The strongest alkali has pH 14.
4) A neutral substance has pH 7 (e.g. water).

Indicators Are Special Dyes Which Change Colour

1) An indicator is just something that changes colour depending on whether it's in an acid or in an alkali.
2) Litmus paper is quite a popular indicator, but it only tells us whether a liquid is an acid or an alkali — it does not say how strong it is. Acids turn litmus paper red and alkalis turn it blue.
3) Universal indicator solution is a very useful mixture of dyes which gives the colours shown in a pH chart.



A pH Chart Shows How Strong an Acid or Alkali is



pHew — the end of another page...

All the pictures above are positioned directly below their actual pH on the pH scale. Make sure you know where each one of them goes, so you don't get your acid rain and your soap flakes mixed up.

Neutralisation Reactions

You might have done something like this in the lab and, if not, I bet you will pretty soon. Make sure you know all this stuff — it's pretty easy and a super-useful thing to know about.

Acids and Alkalis Neutralise Each Other

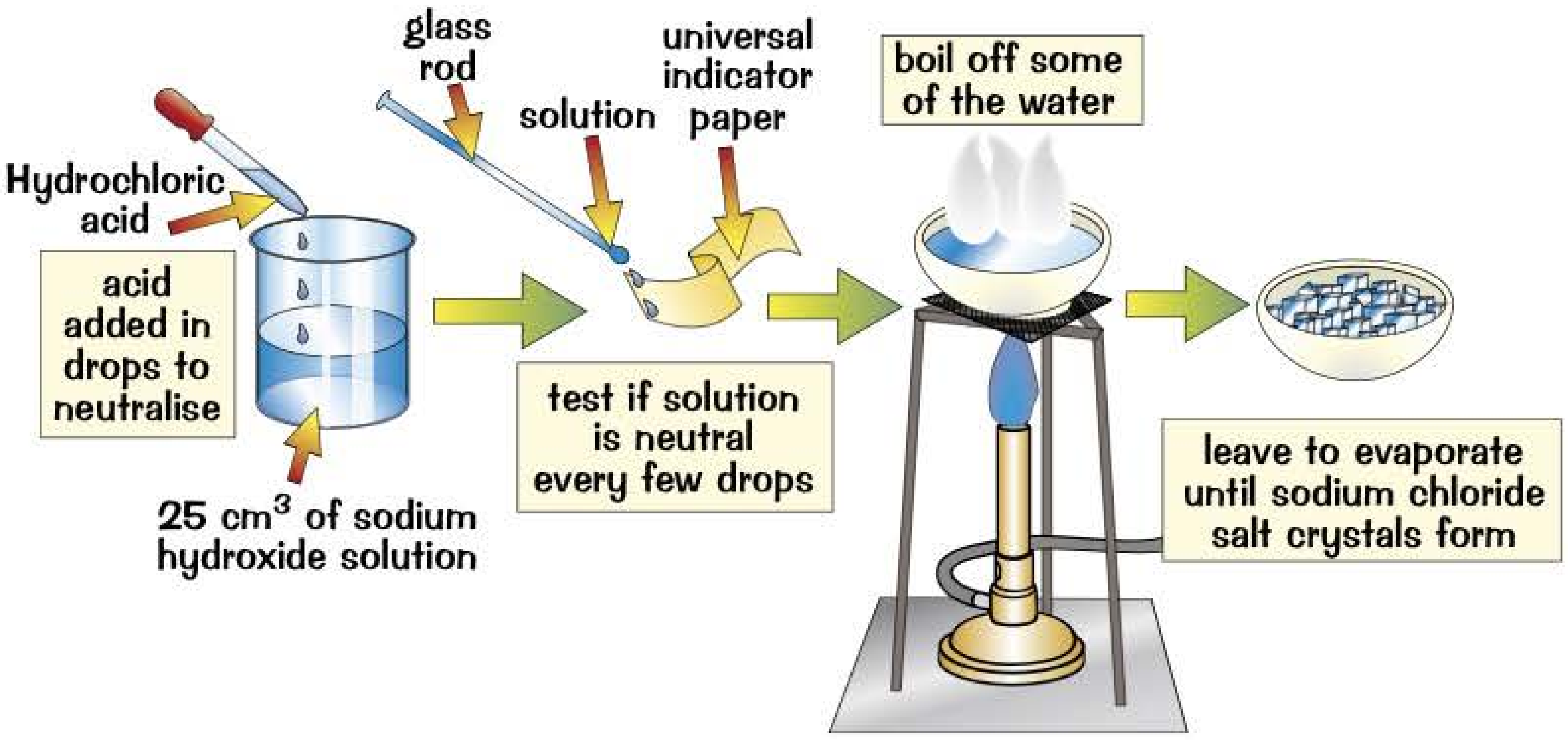
1) Acids react with alkalis to form a neutral solution of a salt and water:

acid + alkali ⟶ salt + water

2) This is known as a neutralisation reaction because the products have a neutral pH, i.e. a pH of 7.

Making Salts by Neutralisation

Making salts is pretty easy — you just need a steady hand and a lot of time. A bit like whisking eggs.



1) Wearing eye protection, add an acid to an alkali dropwise with a pipette.
2) After every few drops, remove a small sample to check if the pH is neutral (pH 7).
3) Keep adding acid until the solution is neutral.
4) When it's neutral the solution is put in an evaporating dish and about two thirds of it can be boiled off to make a saturated solution of the salt.
5) Leave this solution overnight for the rest of the water to evaporate and nice big salt crystals will form. The slower the crystallisation, the bigger the crystals.

A saturated salt solution can't have any more salt dissolved in it. See p.39.

To Change the Salt, You Must Change the Acid

1) The salt you get out of the neutralisation reaction above depends on the acid you use.
2) The clue is normally in the name:

Hydrochloric acid reacts to make chloride salts... like sodium chloride.

Sulfuric acid reacts to make sulfate salts... like copper sulfate.

Nitric acid reacts to make nitrate salts... like sodium nitrate.

It's fun making salts — but I wouldn't put them on yer chips...

Make sure you know which kinds of salts you get from which kind of acid. I could sit here and tell you that if you don't learn this stuff it'll come up at the worst possible opportunity, and that without knowing the really simple stuff on this page you'll get absolutely nowhere... but that would just be rubbing salt into the wounds.

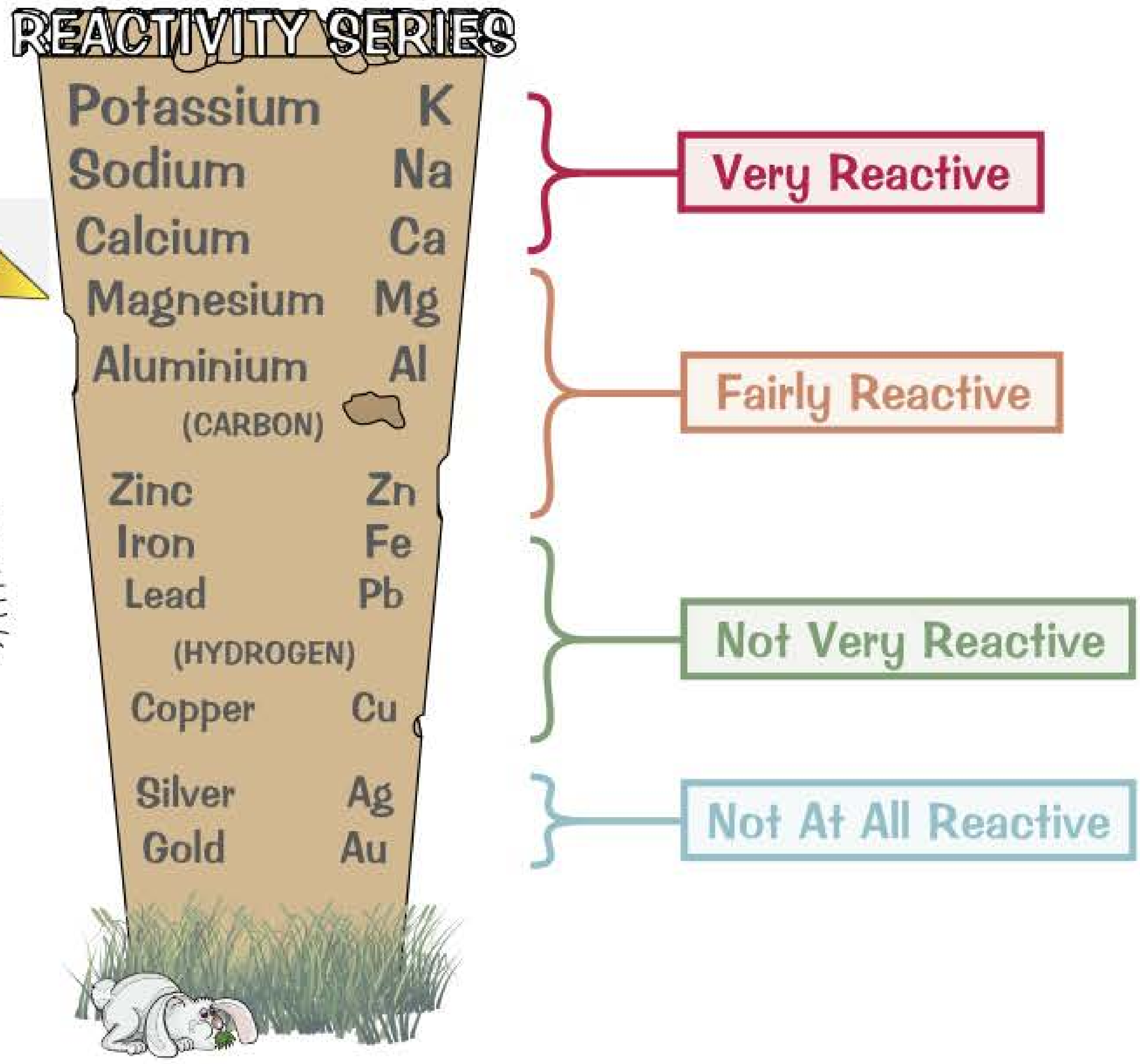
Reactivity Series and Metal Extraction

You need to know which metals are most reactive — and which are least reactive.

The Reactivity Series — How Well a Metal Reacts

The Reactivity Series lists metals in order of their reactivity towards other substances.

Make sure you learn this list:



Carbon and hydrogen are non-metals, but it's useful to know where they are in the reactivity series (see below and p.55).

Some Metals Can Be Extracted With Carbon

1) Metals are usually mined as ores — rocks containing different metals and metal compounds (usually metal oxides — see page 56).
2) A metal can be extracted from its ore by reduction using carbon. When an ore is reduced, oxygen is removed from it. E.g. the oxygen is removed from iron oxide to extract the iron:

iron oxide + carbon ⟶ iron + carbon dioxide

3) Only metals that are less reactive than carbon (i.e. metals below carbon in the reactivity series) can be extracted from their ore using carbon.
4) Metals that are more reactive than carbon need to be extracted using electrolysis (where electrical energy splits up the ore into the elements that make it up).
5) Some metals, like silver and gold, are pretty unreactive, so they're often found in their pure form.

Potassium
Sodium
Calcium
Magnesium
Aluminium

—CARBON—

Zinc
Iron
Lead
Copper
Silver
Gold

Metal extraction — sounds painful...

Let's face it, this is pretty basic stuff on metals. One of the first things you should know about metals is the difference in how reactive they are. In Chemistry, the reactivity of a metal is far and away the most important feature of it, because that's what decides how it will behave in every reaction it's faced with.

Reaction of Metals with Acids

One more page on metals to test your mettle — it's not so bad though, I promise. You don't need to know about each individual reaction, just how the reactivity of each metal affects it. Simple, no?

Reacting Metals With Dilute Acid

metal + acid ⟶ salt + hydrogen

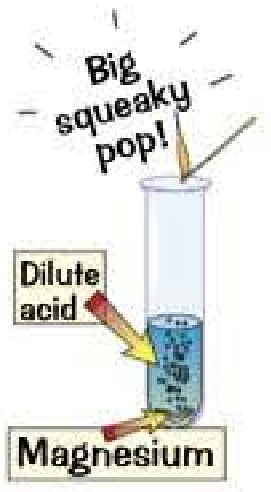
All acids contain hydrogen — so the hydrogen here comes from the acid.

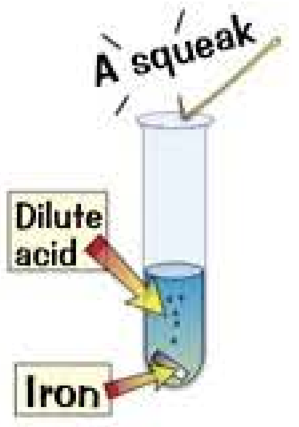
1) Metals above hydrogen in the reactivity series (see page 54) will react with acids to make a salt and hydrogen.
2) The metals below hydrogen in the reactivity series don't react with acids.
3) The reaction becomes less and less exciting as you go down the series.

More Reactive Metals React More Violently

Reaction with Dilute Acids — Results

Potassium Sodium Calcium	React violently with dilute acids. (Likely to explode.)
Magnesium Aluminium Zinc Iron Lead	React fairly well with dilute acids.
Copper Silver Gold	Don't react with dilute acids.





If a lit splint is held to the test tube and a 'squeaky pop' sound is heard, it shows that hydrogen has been made.

The lower the reactivity, the less likely it is for the reaction to happen.

EXAMPLES:

a) zinc + sulfuric acid ⟶ zinc sulfate + hydrogen

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$$

The zinc takes the place of the hydrogen in the acid because it's more reactive than the hydrogen.

b) sodium + hydrochloric acid ⟶ sodium chloride + hydrogen

$$2Na + 2HCl \longrightarrow 2NaCl + H_2$$

The sodium takes the place of the hydrogen in the acid — again because it's more reactive than the hydrogen.

You're probably bored of metals now — time to reactivate...

It might seem like there's loads going on here, but really it's just the same principle repeated over and over. All the metals have roughly the same reaction with acids, some are just more violent than others (and some don't happen at all). All you need to know is the order of violentness. Is that a word? Let's go with yes.

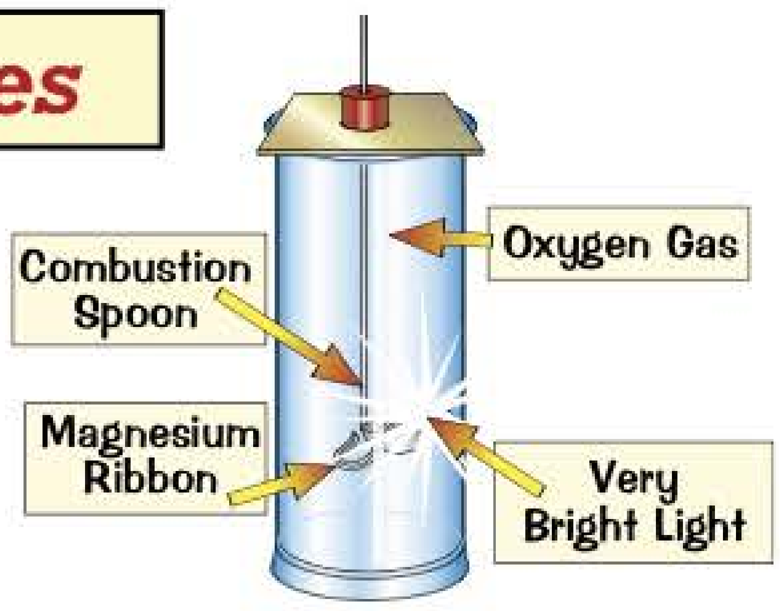
Reactions of Oxides with Acids

Oxides are pretty self-explanatory — they've got oxygen in them somewhere...

Metals React With Oxygen to Make Oxides

Metals react with oxygen to make metal oxides.

E.g. magnesium + oxygen → magnesium oxide.

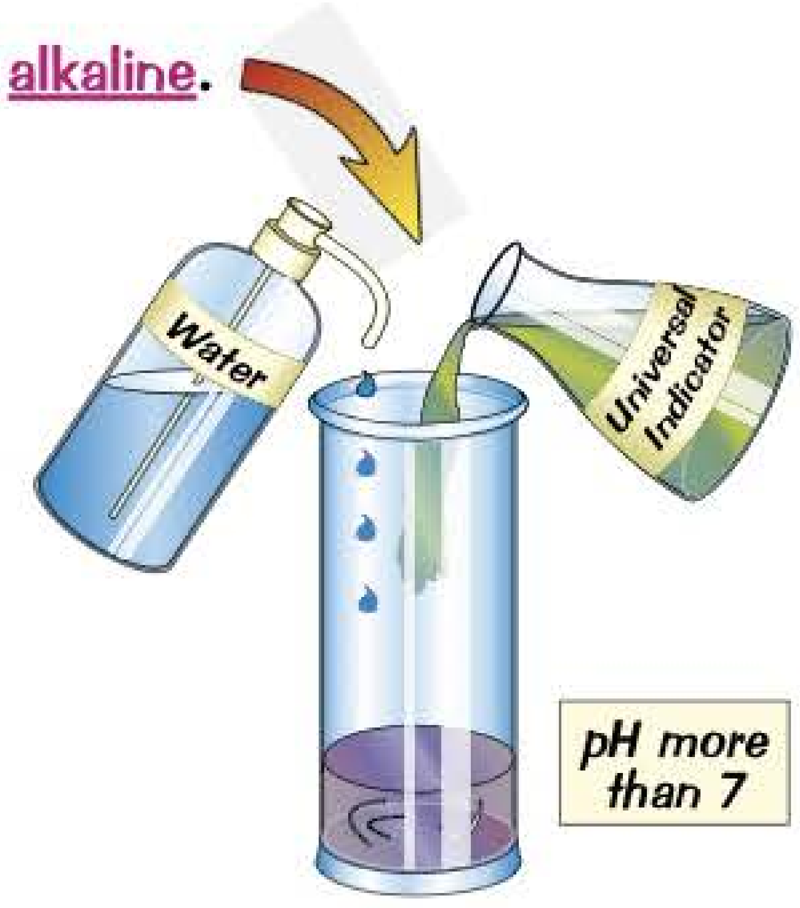


Metal Oxides are Alkaline

1) Metal oxides in solution have a pH which is higher than 7 — i.e. they're alkaline.
2) So metal oxides react with acids to make a salt and water.

acid + metal oxide ⟶ salt + water

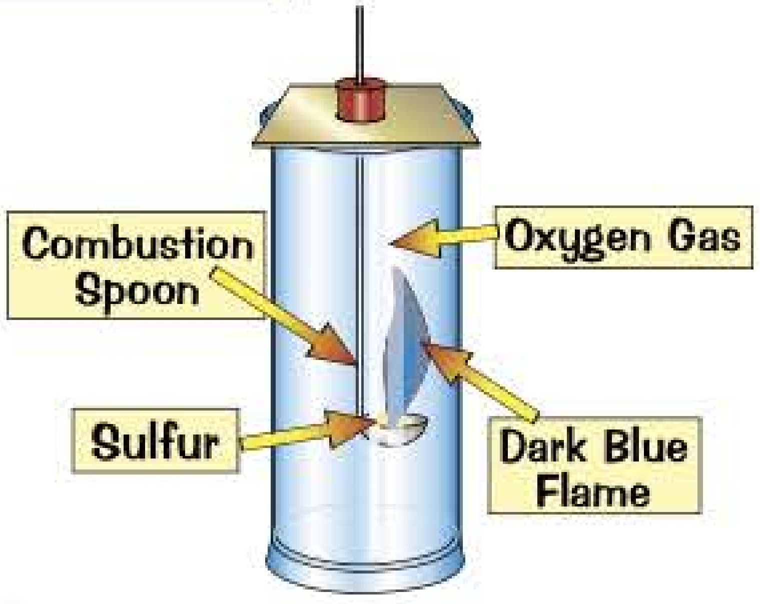
EXAMPLES:
hydrochloric acid + copper oxide → copper chloride + water
sulfuric acid + zinc oxide → zinc sulfate + water
nitric acid + magnesium oxide → magnesium nitrate + water



Non-metals React With Oxygen to Make Oxides

Non-metals also react with oxygen to make oxides.

E.g. sulfur + oxygen → sulfur dioxide.



Non-metal Oxides are Acidic

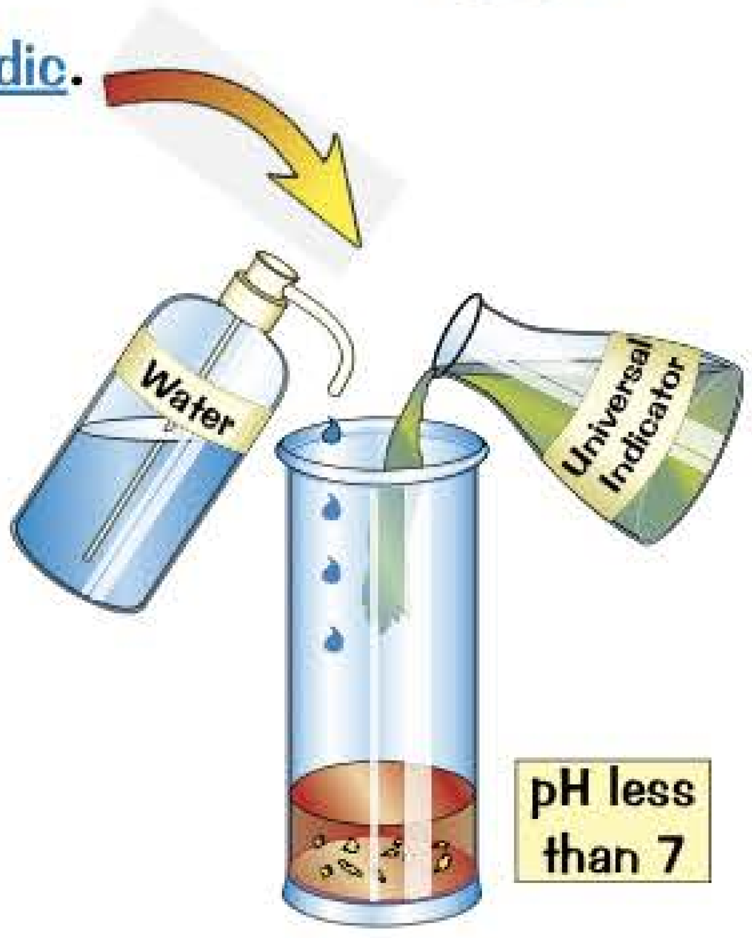
1) The oxides of non-metals have a pH below 7. This means they're acidic.
2) So non-metal oxides will react with alkalis to make a salt and water.

alkali + non-metal oxide ⟶ salt + water

EXAMPLE:
sodium hydroxide + silicon dioxide → sodium silicate + water

an alkali

a non-metal oxide



Everyone has a good side, a bad side and an oxide...

There's not a lot on this page, which means you have no excuses whatsoever not to learn it. You might also notice some similarities between the reactions of metals and non-metals — replace "acid" with "alkali" and they're pretty much identical. With that said, you should probably try not to get the two confused.

Displacement Reactions

This page is pretty crammed, but the stuff on it is actually dead easy, I promise...

'Displacement' Means 'Taking the Place of'

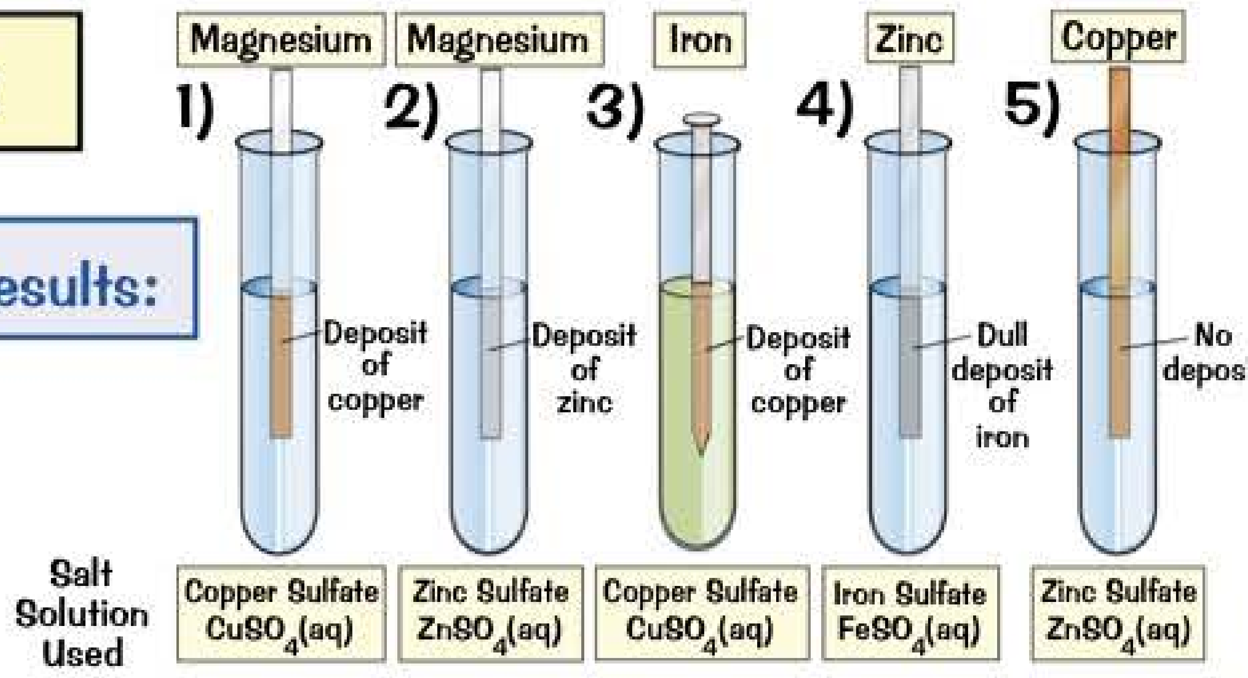
A more reactive metal will displace a less reactive metal from its compound.

1) The reactivity series (see page 54) tells you which are the most reactive metals — i.e. the ones which react most strongly with other things.
2) If you put a more reactive metal like magnesium into a solution of a less reactive metal compound, like copper sulfate, then magnesium will take the place of the copper — and make magnesium sulfate.
3) The "kicked out" metal then coats itself on the reactive metal, so we'd see copper.
4) This only happens if the metal added is more reactive — higher displaces lower. Got it?

A Reactivity Series Investigation

Method: Slap a bit of metal into some salt solutions and see what happens.

Results:



Tube 1: The blue copper sulfate solution goes colourless and the copper coats the magnesium strip.
Magnesium must be more reactive than copper as it takes its place.

magnesium + copper sulfate ⟶ magnesium sulfate + copper

Tube 2: Zinc is seen coating the magnesium strip.
Magnesium must be more reactive than zinc as it takes its place.

magnesium + zinc sulfate ⟶ magnesium sulfate + zinc

Tube 3: The blue copper sulfate solution goes green and the copper coats the nail.
Iron must be more reactive than copper as it takes its place.

iron + copper sulfate ⟶ iron sulfate + copper

Tube 4: Iron is seen coating the zinc strip. Zinc must be more reactive than iron as it takes its place.

zinc + iron sulfate ⟶ zinc sulfate + iron

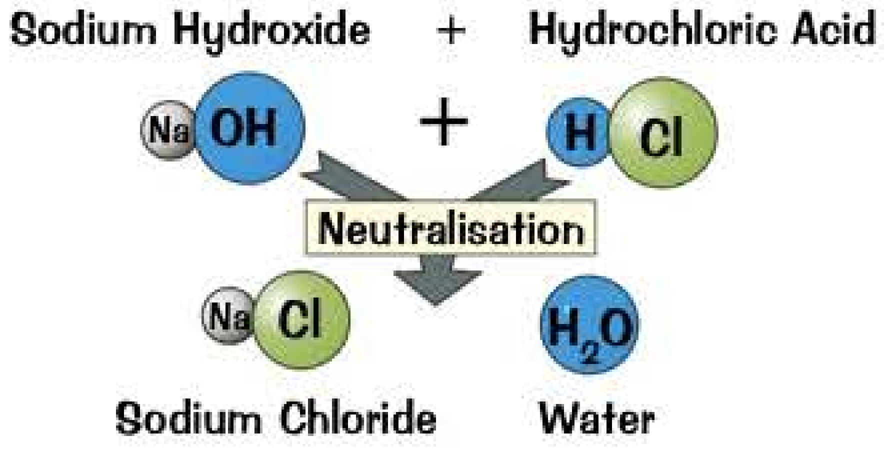
Tube 5: There's no reaction. Copper can't displace zinc — it's not reactive enough.

copper + zinc sulfate ⟶ no way

Most Reactive **Magnesium Zinc Iron Copper** Least Reactive

Neutralisation is a Displacement Reaction

1) The hydrogen in hydrochloric acid is displaced (or replaced) by sodium from the sodium hydroxide (the alkali).
2) This makes NaCl and H_2O.
3) NaCl is sodium chloride — common salt.
And of course H_2O is water. Of course you knew.



Displace or datplace — wherever you do it, learn this stuff...

You've made it to the promised land — the end of another section. What every aspiring student dreams of. Learn all the displacement stuff, then try not to misplace your knowledge when it comes to crunch time.

Section Summary

There's no use getting through a whole section of Chemistry if you can't summarise it with a handy set of questions that test everything you need to know. Luckily for you, that's exactly what this page is for. You must have heard it all before by now, and it's the usual shtick — work through the questions one by one, make sure you know everything, then maybe treat yourself to something sweet.

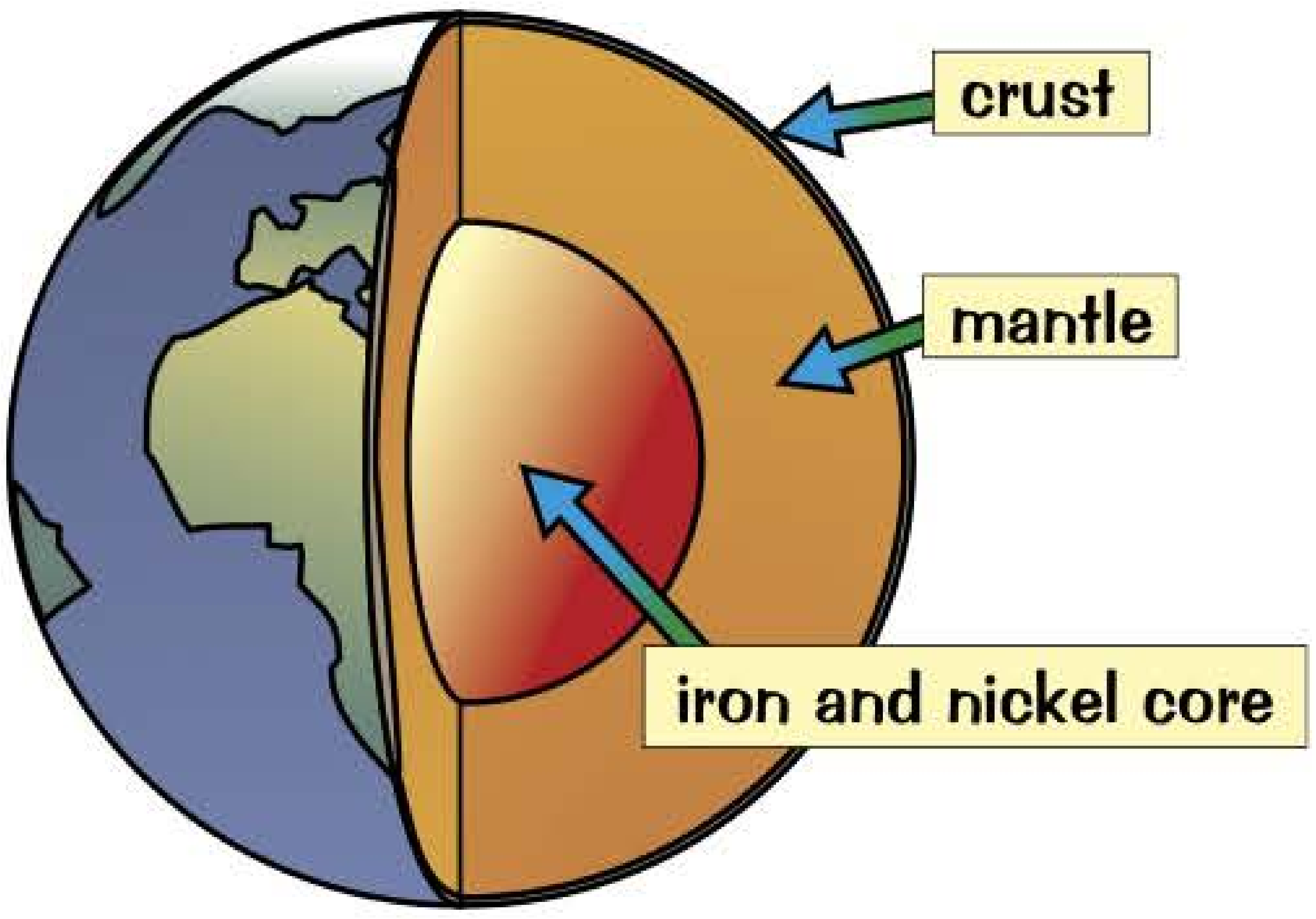
1) What happens to the atoms in a chemical reaction?
2) Does the mass change during a chemical reaction? Why or why not?
3) What's combustion?
4) What's the name of the process in which a chemical gains oxygen?
5) What's thermal decomposition?
6) What's formed when a metal carbonate breaks down by thermal decomposition?
7) What's the main difference between exothermic and endothermic reactions?
8)* If you put sodium in water, it catches fire and burns up. Is this reaction exothermic or endothermic?
9)* When ammonia breaks down to nitrogen and hydrogen, the temperature drops.
Is this reaction exothermic or endothermic?
10) How does a catalyst affect the speed of a reaction?
11) Give two reasons why a chemical production plant might want to use catalysts.
12) Give two reasons why a chemical production plant might <u>not</u> want to use catalysts.
13)* Write a balanced symbol equation for: sulfur + oxygen ⟶ sulfur dioxide (clue: $S + O_2 \longrightarrow$?)
14)* Write a balanced symbol equation for: calcium + oxygen ⟶ calcium oxide
15) What pH does the strongest acid on a pH chart have? And the strongest alkali?
16) What pH does a neutral solution have?
17) What colour would universal indicator go if it was mixed with:
a) a strong acid b) a neutral solution c) a strong alkali
18) What is neutralisation?
19) Outline the method to make common salt — sodium chloride.
20) Hydrochloric acid makes chloride salts — what salts does sulfuric acid make?
21) What kind of salts do you get from nitric acid?
22) List the reactivity series in the correct order. Take the first letter of each element and make up a rhyme to help you remember it — there, that'll cheer you up.
23) If you haven't already, add carbon and hydrogen to your reactivity series from the previous question. If you've already done this, give yourself a pat on the back.
24) Which metals in the reactivity series can be extracted from their ores using carbon?
Which can't? Explain why they can't.
25) What do metals produce when they react with an acid?
26) Which metal will react the most violently with acid?
27) Are metal oxides in solution acidic, neutral or alkaline?
28) Give an example of a neutralisation reaction involving a metal oxide.
29) Are non-metal oxides in solution acidic, neutral or alkaline?
30) What does displacement mean?
31) What is the rule for displacement reactions?
32) Explain why magnesium can displace copper from copper sulfate.
33) In the neutralisation of sulfuric acid by potassium hydroxide, what displaces the hydrogen in the acid?

*Answers on page 108.

The Earth's Structure

Ever wondered what the planet's like on the inside? Well you're in for a treat with this page then.

The Earth Has a Crust, a Mantle and a Core



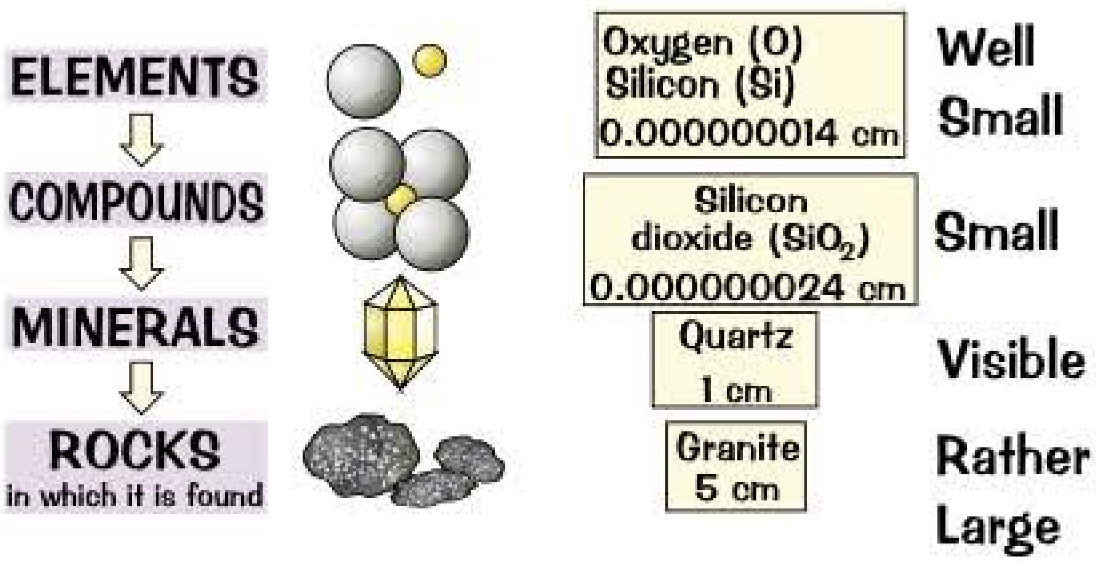
The Earth is almost a sphere and it has a layered structure. A bit like a scotch egg. Or a peach.

1) We live on the crust — a thin, outer layer of solid rock.
2) Below that is the mantle.
3) The mantle is mostly solid, but deep down it can flow very slowly (like a liquid). This is because the temperature increases as you go deeper into the mantle.
4) At the centre of the Earth is the core. We think it's made of iron and nickel.

The Crust Contains Minerals

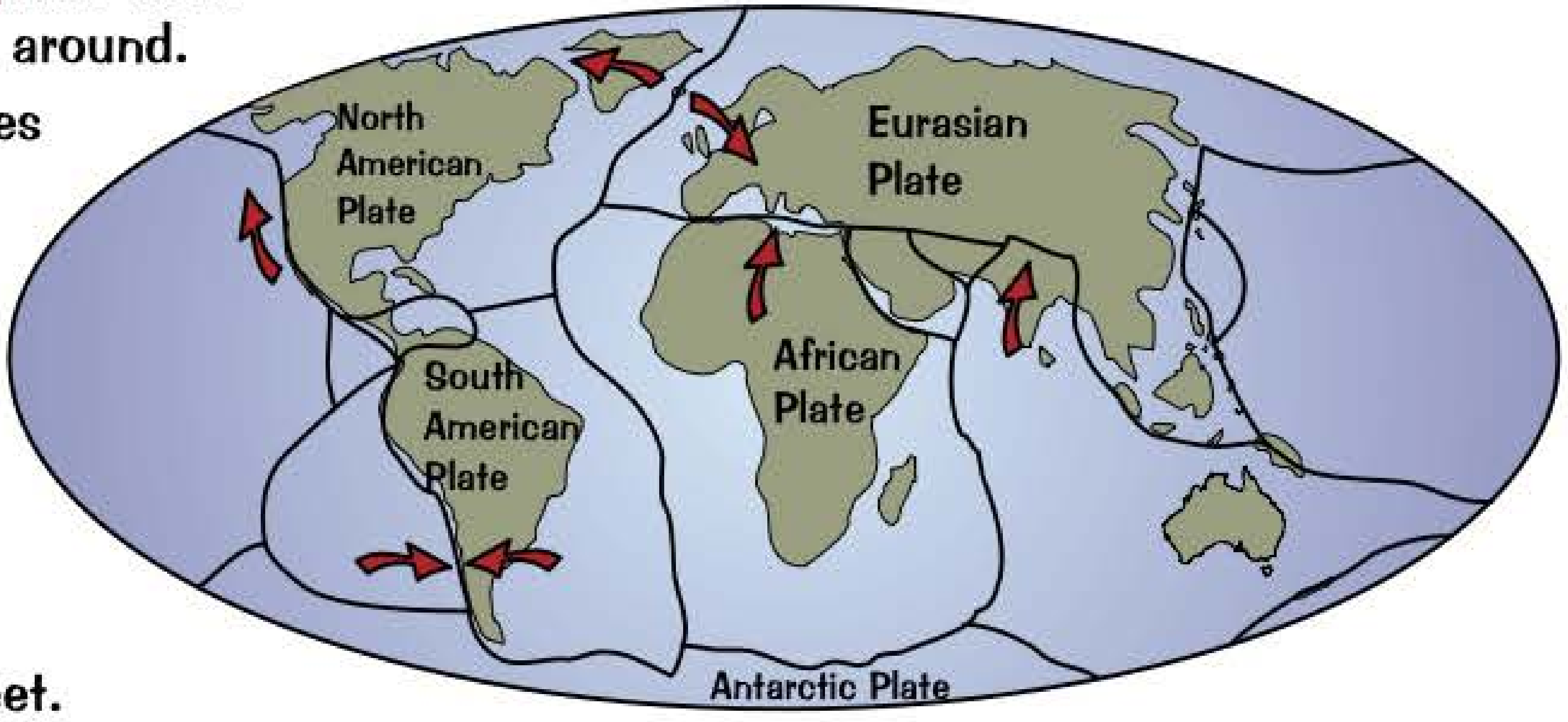
Elements and compounds make up minerals — and these make up rocks in the crust. E.g.

Elements	Compound	Mineral	Rock
Silicon & Oxygen	Silicon dioxide	Quartz	Granite



The Earth's Surface is Made Up of Tectonic Plates

1) The crust and the upper part of the mantle are cracked into a number of large pieces. These pieces are called tectonic plates.
2) Tectonic plates are a bit like big rafts that 'float' on the mantle. They're able to move around.
3) The map shows the edges of the plates as they are now, and the directions they're moving in (red arrows).
4) Most of the plates are moving very slowly (a few centimetres a year).
5) Sometimes, the plates move very suddenly, causing an earthquake.
6) Volcanoes and earthquakes often happen where two tectonic plates meet.



Personally, I always cut off the crust...

You need to know the structure of Earth, i.e. what it would look like if you cut it open (which I wouldn't recommend) and what it's made of. That top diagram is your friend — learn it and learn it well. And, while we're on the subject, you'll need to learn all the words too. On the whole page. Phew.

Rock Types

Yep, there's more than one sort of rock. Who'd have thought it.

There are Three Different Types of Rock

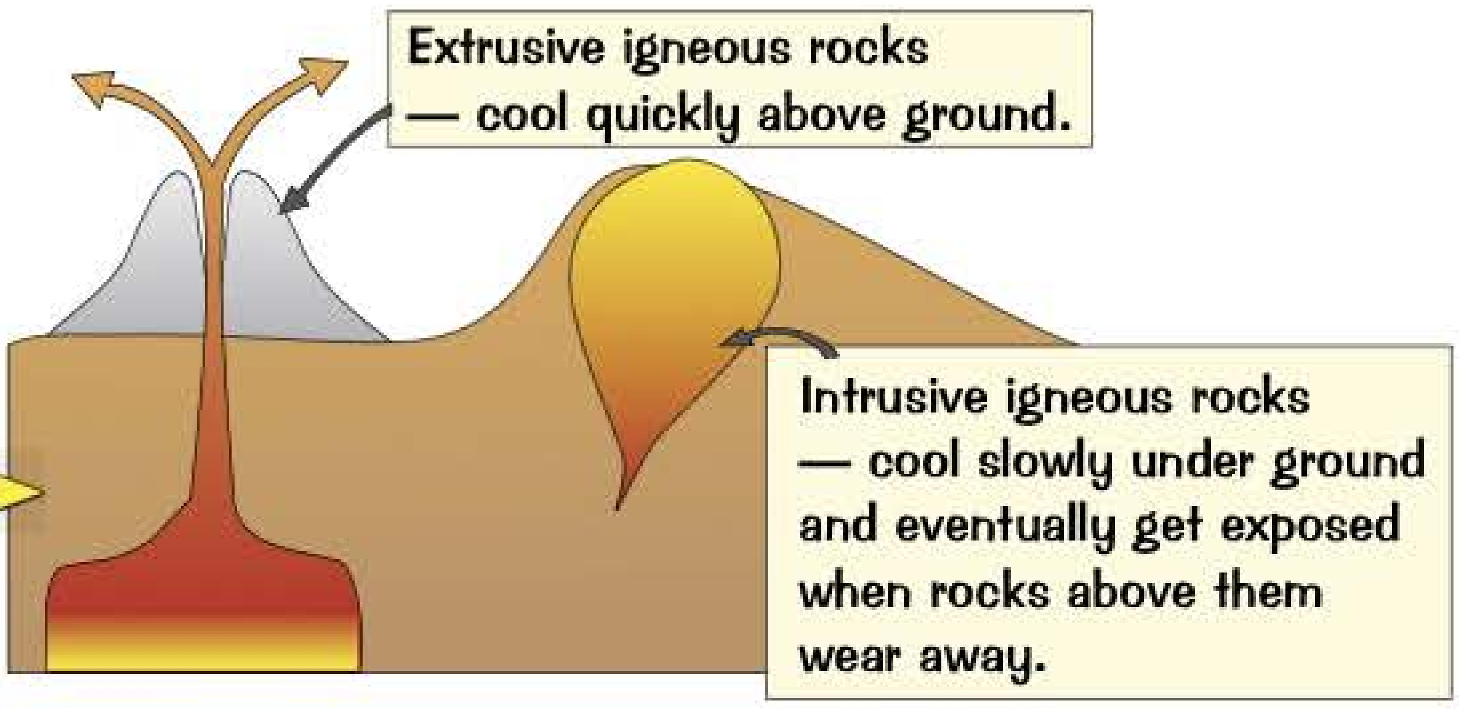
1) Igneous Rocks

1) These are formed from magma (melted underground rock) which is pushed up to the surface of the crust — and often out through volcanoes.

2) They contain various minerals in randomly arranged interlocking crystals. The size of the crystals (or texture) depends on the speed of cooling. Large crystals mean that the rock has cooled slowly.

3) There are two types of igneous rocks: extrusive and intrusive.

EXAMPLES: basalt (extrusive),
granite (intrusive).



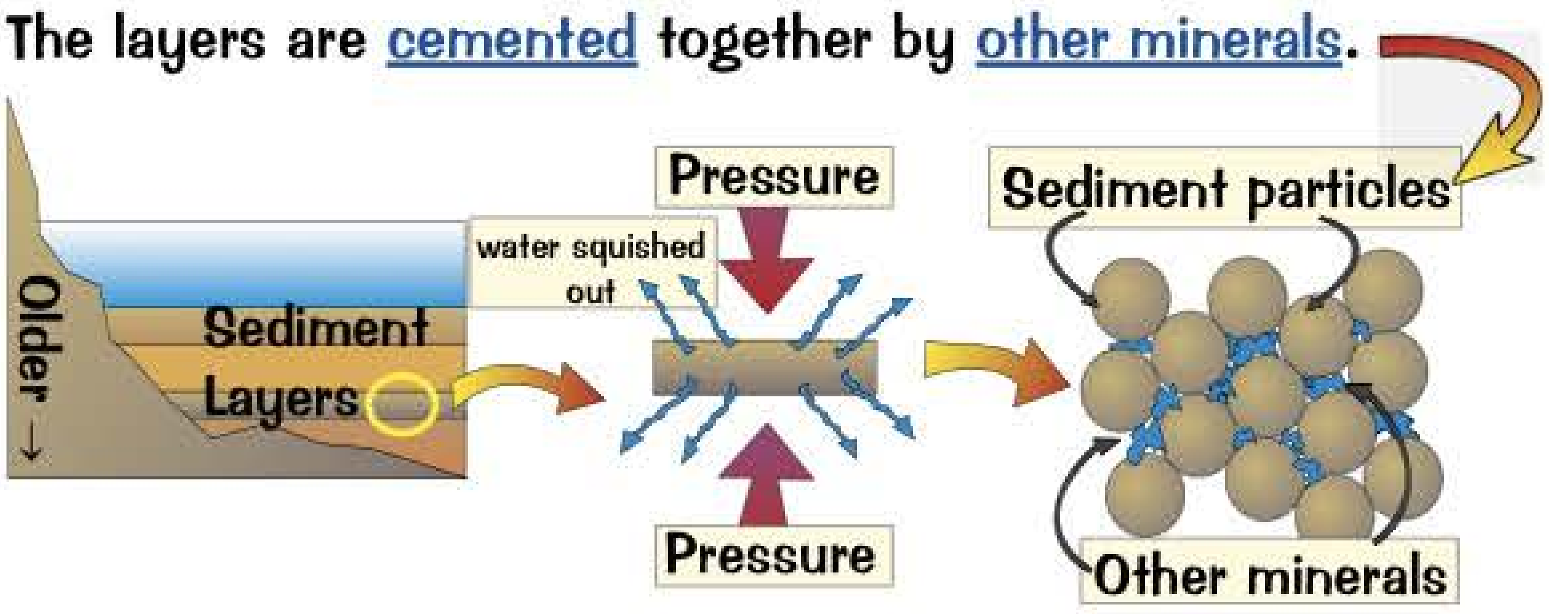
Extrusive igneous rocks — cool quickly above ground.

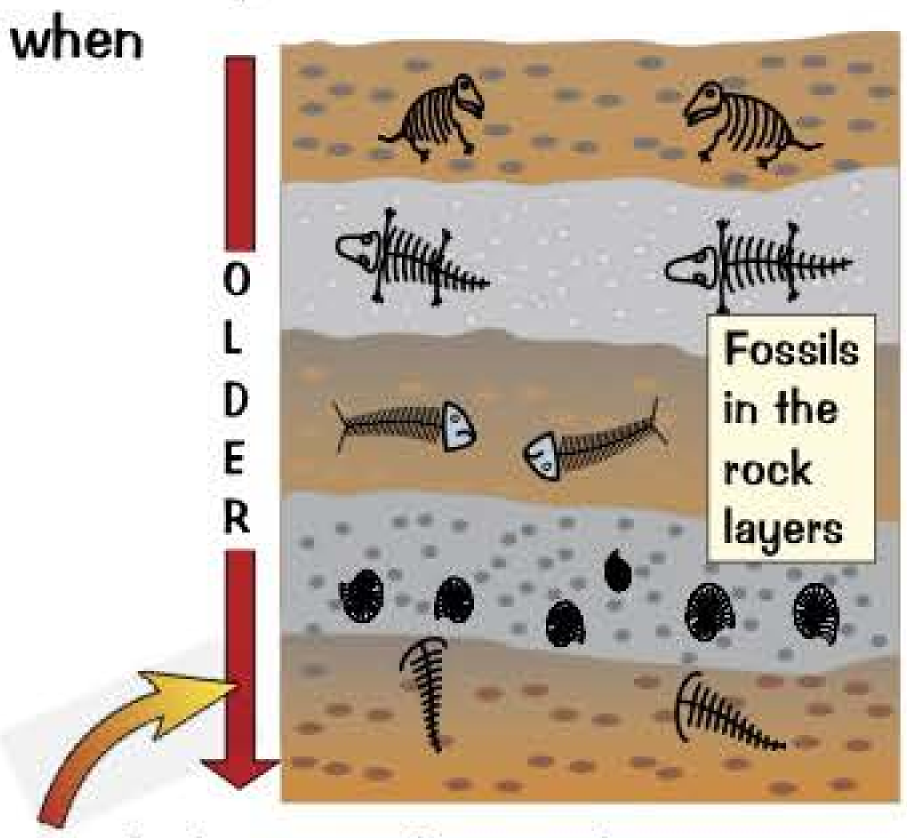
Intrusive igneous rocks — cool slowly under ground and eventually get exposed when rocks above them wear away.

2) Sedimentary Rocks

1) These are formed from layers of sediment (rock fragments or dead matter) laid down in lakes or seas over millions of years. Sedimentary rocks can also form when water evaporates and leaves a dissolved solid (like salt) behind.

2) The layers are cemented together by other minerals.





3) Fossils can form in the sediments. These are the long dead remains of plants and animals. The type of fossil is used to work out the relative age of the rock.

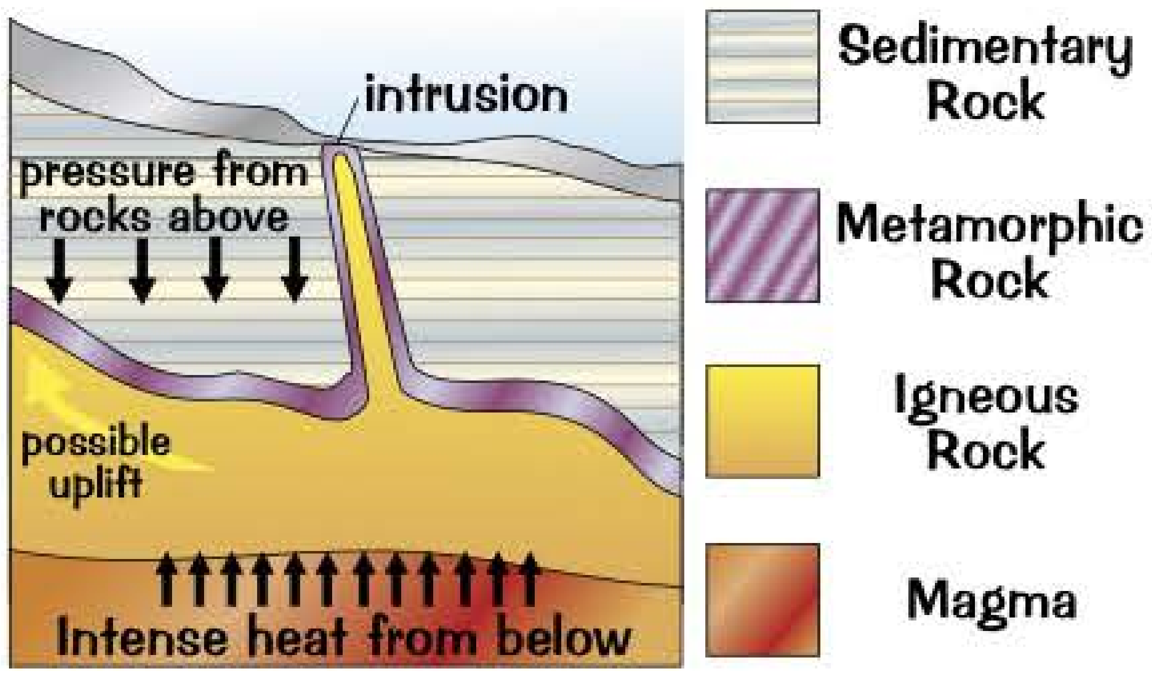
EXAMPLES: limestone, chalk, sandstone.

3) Metamorphic Rocks

1) These are the result of heat and increased pressure acting on existing rocks over long periods of time.

2) They may have really tiny crystals and some have layers.

EXAMPLES: marble, slate, schist.



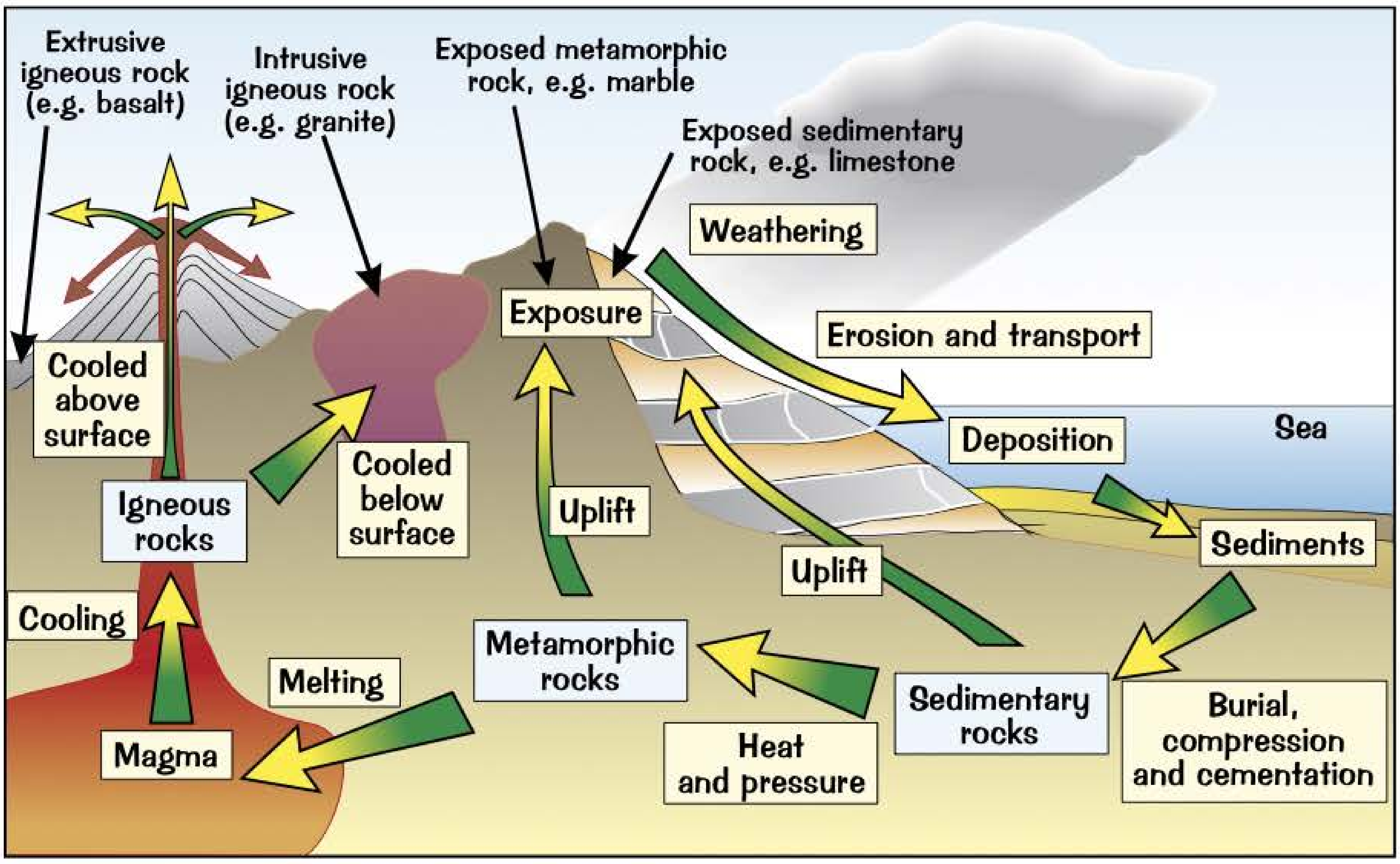
OK, sure — but doesn't Glam-Rock deserve a mention...

Three types of rock for you to know about — make sure you do. I agree they've got pretty scary-looking names but once you get over that little hurdle and just learn them, the rest all follows a lot easier. Learn the headings, then do a mini-essay for each one from memory. Draw out the diagrams too.

The Rock Cycle

The rock cycle involves changes to rocks both inside and outside the Earth.

The Rock Cycle Takes Millions of Years to Complete



The rock cycle involves changing the three types of rock (igneous, sedimentary and metamorphic, see previous page) from one to another. This happens by:

1) WEATHERING: breaking down rocks into smaller bits.
   There are a few different ways this can happen, e.g.
2) EROSION: wearing down rocks, e.g. by rain.
3) TRANSPORTATION: moving the eroded bits of rock round the world by wind and water (mostly).
4) DEPOSITION: laying down of sediment.
5) BURIAL/COMPRESSION/CEMENTATION: squeezing and compressing the layers — eventually they form sedimentary rocks.
6) HEAT/PRESSURE: further squashing and heating — turns the rocks into metamorphic rocks.
7) MELTING: intense heating makes the rock partially melt — that changes it to magma.
8) COOLING: solidification of the molten (melted) rock to form igneous rocks.
9) EXPOSURE: back to weathering and erosion again. Simple huh.
   (The amount of rock on the surface is always about the same, even though it's weathered away.)

Onion skin weathering — this happens when the Sun warms the surface of a rock by day and by night it cools down. This causes the surface to expand and contract, and eventually it breaks away, like peeling an onion.

Freeze-thaw weathering — when water freezes, it expands. If this happens in a crack in a rock it can make the crack bigger. After freezing and thawing many times, bits break off.

The Rock Cycle's a bit like homework — it takes forever...

Nine stages of the rock cycle to learn there — make sure you know what happens at each stage, but also how each of the stages are linked. You'll really impress teach' if you can explain how a sedimentary rock changes into a metamorphic rock and so on. Learn it well and you'll be a rock (cycle) star before long.

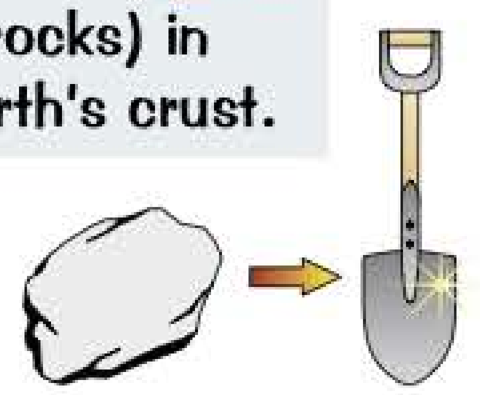
Recycling

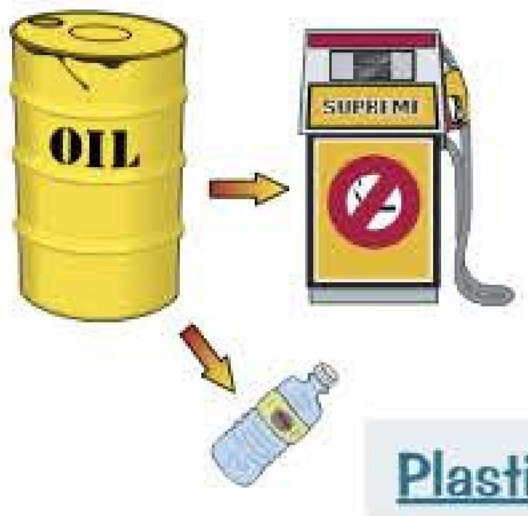
My mum is pretty big on recycling. You can't throw anything in the bin in our house. Turns out we're doing our bit to save limited resources though, so that's OK.

The Earth is the Source of All Our Resources

1) For example, we get:

Metals from metal ores (rocks) in the Earth's crust.





Energy from fossil fuels (coal, crude oil and natural gas).

Fossil fuels are made from the remains of dead plants and animals buried in the Earth's crust for millions of years.

Plastics from crude oil.

2) But these resources are limited. Once we've burnt all the Earth's fossil fuels or mined all the metal ores, that's it — we won't be getting any more any time soon. And that's where recycling comes in.

There are Lots of Good Reasons for Recycling

Recycling means taking old, unwanted products and using the materials to make new stuff. Recycling is generally better than making things from scratch all the time because:

1) It uses less of the Earth's limited resources — things like crude oil and metal ores.
2) It uses less energy — which usually comes from burning fossil fuels.
3) Energy is expensive — so recycling tends to save money too.
4) It makes less rubbish — which would usually end up in landfill sites (rubbish dumps).

Example — recycling aluminium cans:

1) If aluminium wasn't recycled, more aluminium ore would have to be mined.
2) Mining costs money and uses loads of energy. It also makes a mess of the landscape.
3) The ore then needs to be transported and the aluminium extracted — which uses more energy.
4) It then costs to send the used aluminium to landfill.

It's a complex calculation, but for every 1 kg of aluminium cans that are recycled, you save:

- 95% of the energy needed to mine and extract 'fresh' aluminium,
- 4 kg of aluminium ore,
- a lot of waste.

It's really efficient to recycle aluminium.

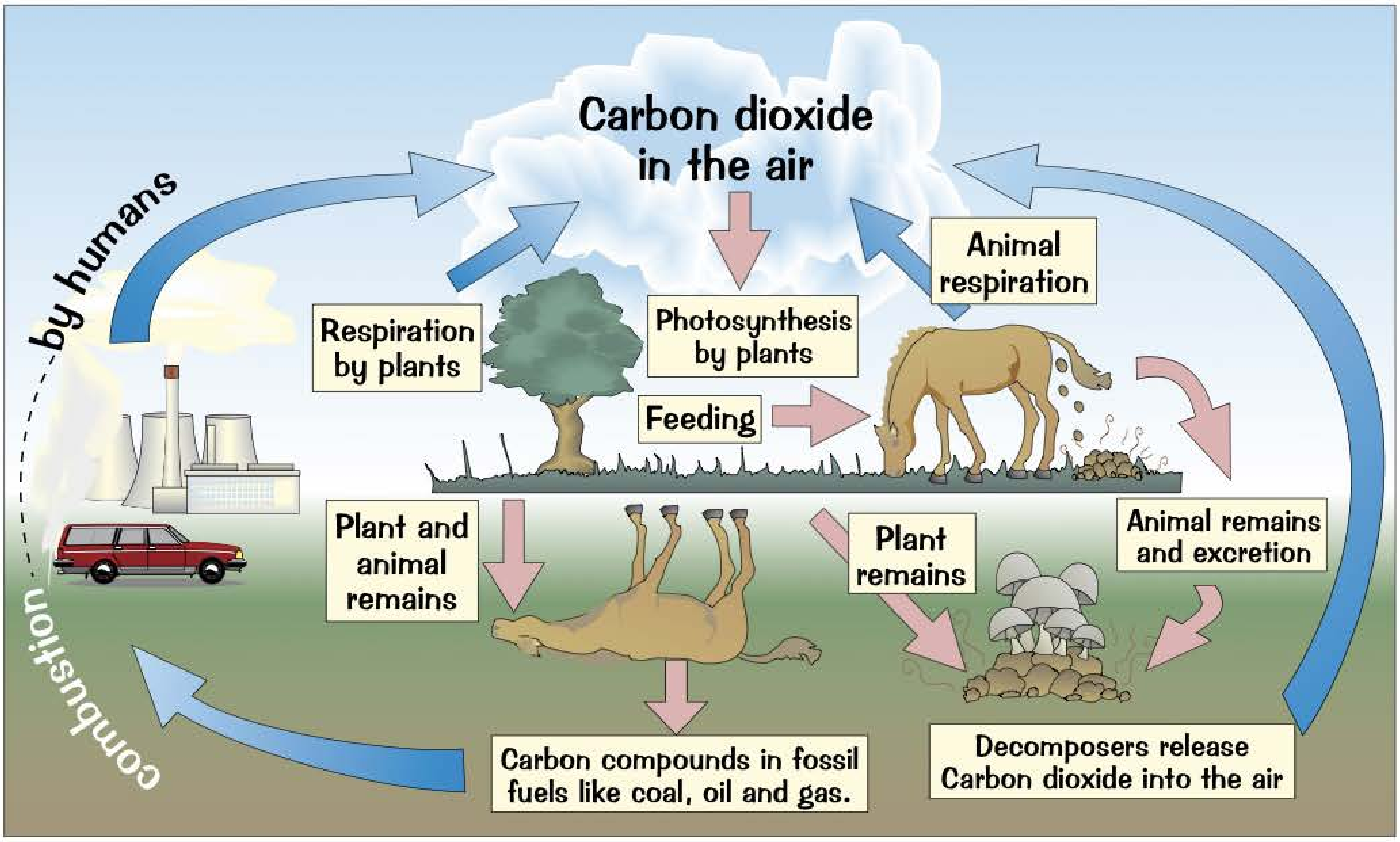
It's usually more efficient (in terms of energy and cost) to recycle materials rather than throw them away and produce new ones. But the efficiency varies depending on what it is you're recycling. E.g. you get an energy saving of 95% by recycling aluminium, but less with plastics (70%) and steel (60%).

Recycle this book — but wait till you've finished KS3 science

Not all materials are as efficient to recycle as aluminium. But even if the energy and cost savings are relatively small, you could still be saving precious limited resources and creating less waste — which can only be a good thing. There's nothing too tricky on this page, so get it all learnt. Pronto.

The Carbon Cycle

Carbon is a very important element because it's part of all living things.
As shown below, it's constantly recycled through the environment.



Learn these points:

1) Photosynthesis Removes Carbon Dioxide from the Air

1) Green plants and algae take in carbon dioxide from the air during photosynthesis (see p.19).
2) The plants and algae use the carbon to make carbohydrates, fats and proteins.

2) Carbon is Passed Along the Food Chain When Animals Feed

1) Some of the carbon in plants is passed on to animals when they eat the plants.
2) The animals then use the carbon to make fats and proteins of their own. The carbon moves along the food chain when the animals are eaten by other animals.

3) Respiration and Combustion Return Carbon Dioxide to the Air

1) Some carbon is returned to the air as carbon dioxide when plants and animals respire (see p.4).
2) When plants and animals die, decomposers (like bacteria and fungi) feed on them. Decomposers also feed on animal waste. When the decomposers respire, carbon dioxide is returned to the air.
3) Some dead plant and animal remains get buried and eventually form fossil fuels. When fossil fuels are burnt (combustion) this releases carbon dioxide back into the air.

Carbon Cycle — you know, like Bradley Wiggins'...

Another cycle for you to learn here. Start by learning the headings — they're the key to how the whole cycle works. Then focus on the details. And remember, photosynthesis removes carbon (in the form of carbon dioxide) from the air. Respiration and combustion put it back again. Well I'm glad we cleared that up.

The Atmosphere and Climate

It's important to know exactly what you're breathing in and out. So read this page and find out.

The Earth's Atmosphere is Made Up of Different Gases

1) The gases that surround a planet make up that planet's atmosphere.
2) The Earth's atmosphere is around:

78% nitrogen (N_2)

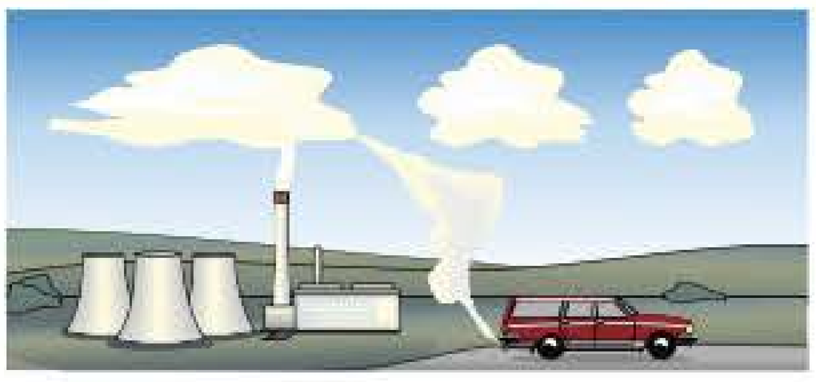
21% oxygen (O_2)

0.04% carbon dioxide (CO_2)

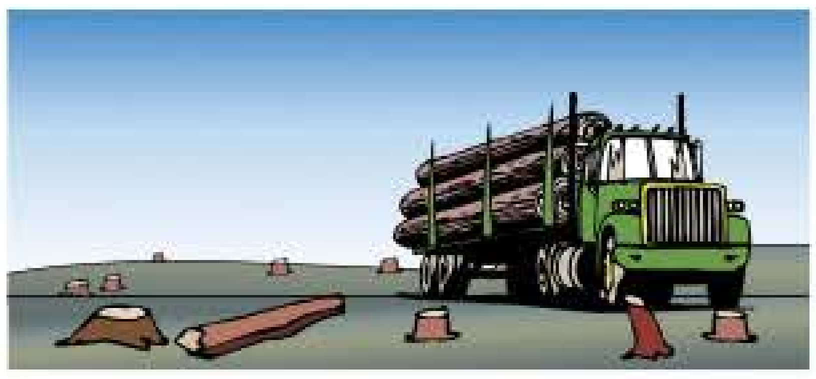
It also contains small amounts of other gases, like water vapour and a few noble gases (see page 36). (There's more water vapour than carbon dioxide in the atmosphere.)

The Carbon Dioxide Level is Increasing...

The level of carbon dioxide in the Earth's atmosphere is rising — and it's down to human activities and natural causes. Here are some examples of human activities that affect carbon dioxide levels:

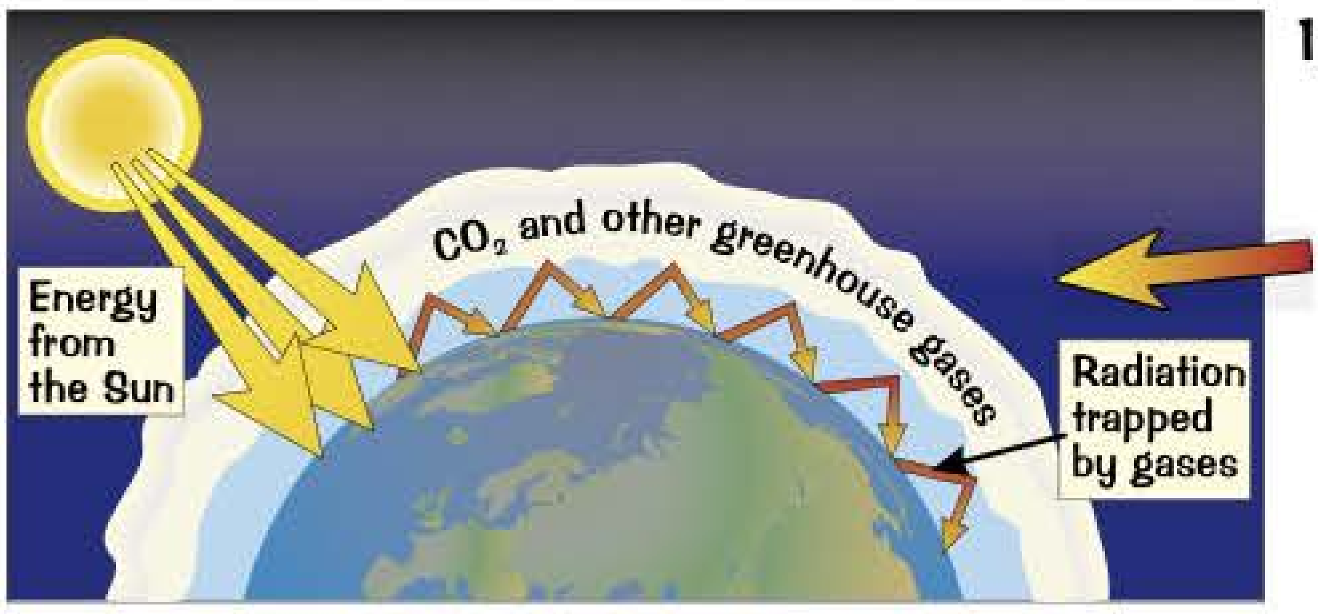


1) Burning fossil fuels to power cars, and to make electricity in power stations, releases lots of carbon dioxide into the atmosphere.



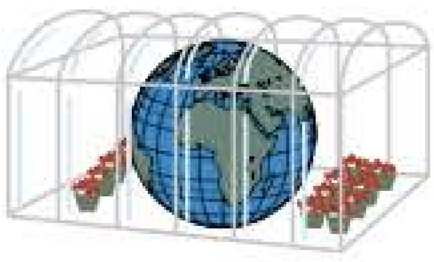
2) Deforestation (chopping down trees) means less carbon dioxide is removed from the atmosphere by photosynthesis.

...Which is Affecting the Earth's Climate



1) Carbon dioxide is what's known as a greenhouse gas. This means it traps energy from the Sun in the Earth's atmosphere. This stops a lot of energy from being lost into space and helps to keep the Earth warm.

This is a bit like what happens in a greenhouse. The Sun shines in, and the glass helps keep some of the energy in.



2) But the level of carbon dioxide (and a few other greenhouse gases) is increasing. The long term trend also shows that the temperature of Earth is increasing. Based on the evidence, most scientists believe this is due to the rise in carbon dioxide levels.
3) This increase in the Earth's temperature is called global warming.
4) Global warming is a type of climate change. It seems to be having serious effects, e.g.
   - Glaciers and ice sheets covering Greenland and Antarctica are melting. They may melt faster, which could cause sea levels to rise and coastal areas to flood.
   - Rainfall patterns are changing, which might make it harder for some farmers to grow crops.

This page is so atmospheric...

You need to know the composition of the Earth's atmosphere — so get learning those percentages at the top of the page. You also need to understand how human activities are affecting the Earth's climate — it's important for both KS3 Science and the future of the planet. So there's no excuse not to know the details.

Section Summary

Well there we are. The end of Section 7. All you have to do now is learn it all. And yes you've guessed it, here below are some lovely questions I prepared earlier. It's no good just idly going through them and managing half-baked answers to one or two that take your fancy. Make sure you can answer all of them.

1) The Earth is covered with a thin outer layer of rock. What is this layer called?
2) What is the name of the structure between the outer layer of rock and the Earth's core? Explain how this structure is both a solid and a liquid.
3) Which two metals do we think the Earth's core is made of?
4) Name a mineral present in the Earth's crust. Say what elements it contains.
5) What are tectonic plates?
6) How are igneous rocks formed?
7) What determines the size of the crystals in igneous rock?
8) How do sedimentary rocks form?
9) The dead remains of plants and animals can become trapped in sedimentary rocks. What are these remains called?
10) How do metamorphic rocks form?
11) Give two examples of: a) igneous rocks, b) sedimentary rocks, c) metamorphic rocks.
12) Draw out the full diagram of the rock cycle with all the labels.
13) What must happen to sedimentary rocks to turn them into metamorphic rocks?
14) What must happen to metamorphic rocks to turn them into igneous rocks?
15) Name two limited resources we get from the Earth.
16) Give four reasons why it's important to recycle materials.
17) How is carbon dioxide removed from the air by plants?
18) How does carbon get from the air into your body?
19) How do plants, animals and decomposers all return carbon dioxide to the air?
20) How else is carbon dioxide returned to the air?
21) What percentage of the Earth's atmosphere is: a) nitrogen, b) oxygen, c) carbon dioxide?
22) Name one other gas present in the Earth's atmosphere.
23) Give two human activities that are increasing the level of carbon dioxide in the atmosphere. Say why each one has an effect on the level of CO_2.
24) How does carbon dioxide help to keep the Earth warm?
25) What is global warming? What's causing it?
26) Describe two possible effects of global warming.

Energy Transfer

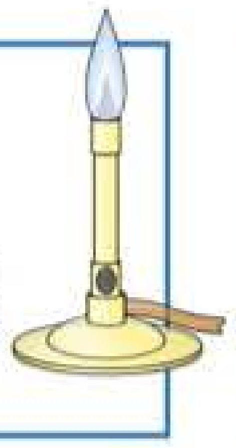
Ah, energy transfer. Everything you do involves energy transfer, which makes this a pretty important page.

Energy Can Be Stored

There are seven stores of energy. Here are some examples of each type:

Thermal Energy Store

Everything has some energy in its thermal energy store — the hotter it is, the higher its temperature and the more energy is in its thermal energy store.

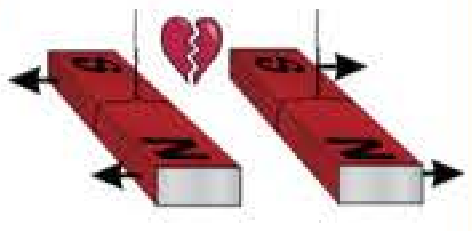


Gravitational Potential Energy Store

Anything in a gravitational field (i.e. anything that can fall) has energy in its potential energy store — the higher it goes, the more it has.

Magnetic Energy Store

Two magnets that attract or repel each other have energy in their magnetic energy stores.



There's more on magnets on page 99.

Kinetic (Movement) Energy Store

Anything that moves has energy in its kinetic energy store.

Chemical Energy Store

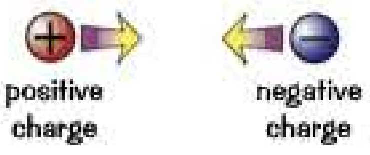
Anything with energy which can be released by a chemical reaction — things like food, fuels and batteries.

Elastic Potential Energy Store

Anything stretched has energy in its elastic energy store — things like rubber bands, springs, knickers, etc.

Electrostatic Energy Store

Two electric charges that attract or repel each other have energy in their electrostatic energy stores.



See page 98 for more.

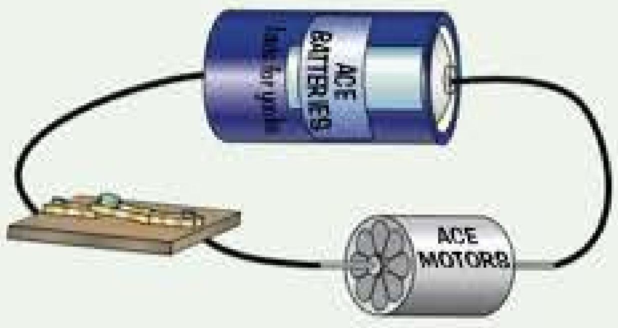
Energy Can Be Transferred Between Stores

Whenever (pretty much) anything happens to an object, energy is transferred from one store to another — the store of energy you transfer to increases and the store of energy you transfer from decreases.

When you drop an object, it moves through a gravitational field. This causes energy to transfer from its gravitational energy store to its kinetic energy store.

When you burn fuel, energy is transferred from the fuel's store of chemical energy to the thermal energy store of the surroundings.

When you switch on this electrical circuit, energy is transferred from the chemical energy store in the battery to the kinetic energy store of the motor. As the motor turns, parts of it rub together — this causes some energy to be transferred from the kinetic energy store to the thermal energy store.



A stretched object, like a spring, has an elastic energy store. When it's released, the energy in the elastic energy store decreases quickly as it is transferred to the kinetic energy store.

Food has energy stored in chemical energy stores. When you eat food, it is metabolised (changed during chemical processes inside your body), which releases (transfers) the energy in the food. You can then use the energy for useful things like walking, keeping warm and studying science.

Energy Transfer

There are Four Ways of Transferring Energy

The four main ways you can transfer energy between stores are:

Mechanically

When a force makes something move (see page 67).
E.g. if an object is pushed, pulled, stretched or squashed.

By Heating

When energy is transferred from hotter objects to colder objects (see page 68).

Electrically

When electric charges move around an electric circuit due to a potential difference (see page 95).

By Light and Sound

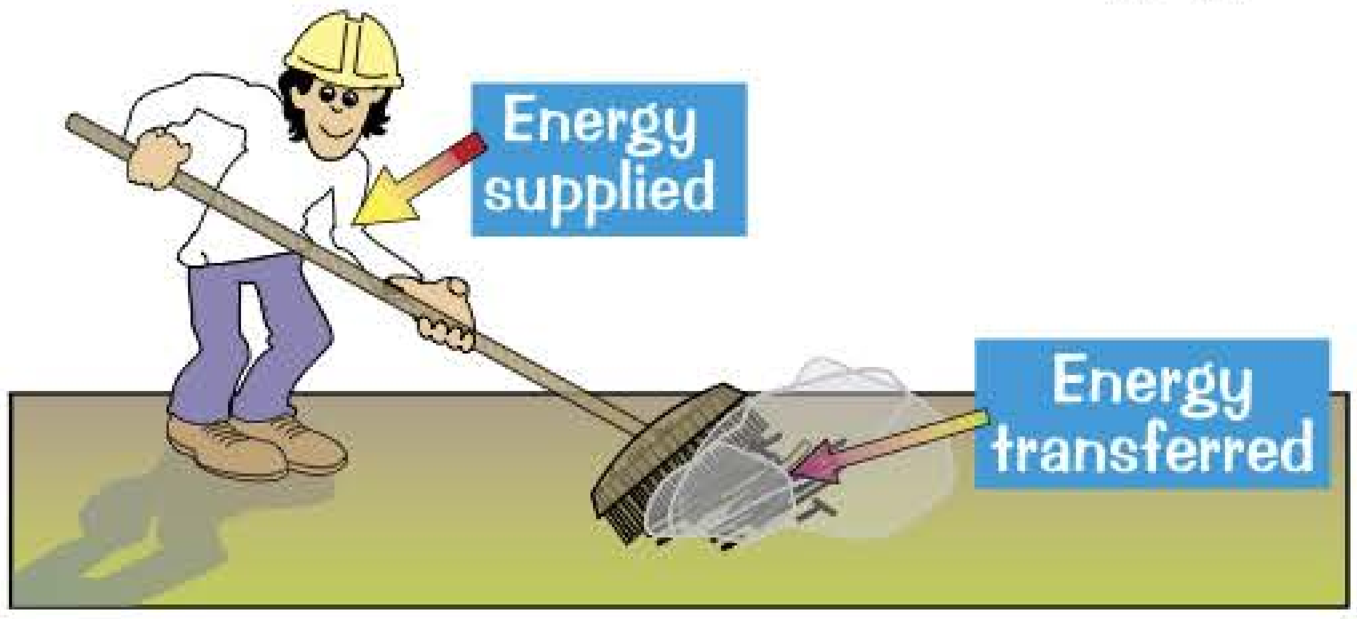
When light or sound waves (see Section 10) carry energy from one place to another.

Energy is Transferred When a Force Moves an Object

When a force moves an object through a distance, energy is transferred.

Energy transferred is the same as work done — see page 83.

1) Whenever something moves, something else is supplying some sort of 'effort' to move it.
2) The thing putting in the effort needs a supply of energy (from fuel or food, etc.).
3) It then transfers energy by moving the object — the supply of energy is transferred to kinetic energy stores.



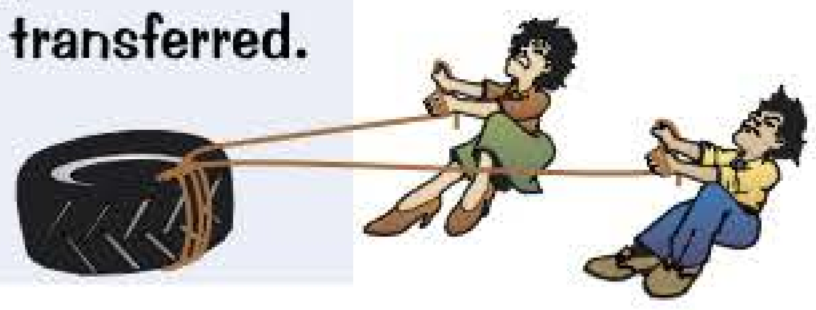
Energy Transferred, Force and Distance are Linked

1) To find how much energy has been transferred (in joules), you just multiply the force in N by the distance moved in m.

Energy Transferred (in joules, J) = Force (in newtons, N) × Distance (in metres, m)

EXAMPLE: Some farmers drag an old tractor tyre 5 m over rough ground. They pull with a total force of 340 N. Find the energy transferred.

ANSWER: Energy transferred = force × distance
= 340 × 5 = 1700 J



2) So, if a machine transfers a certain amount of energy, the amount of force it can apply and the distance over which it can apply it are linked — if one goes up, the other must come down.
3) So the machine can apply a large force over a small distance, or a small force over a large distance.

Start of a new section — I'm feeling energised...

There's plenty to learn here. Make sure you know how energy can be stored and transferred (learn all the examples on the previous page). You also need to know that equation to work out how much energy's transferred when a force moves an object. Cover up the pages and scribble down everything you remember.

Energy Transfer by Heating

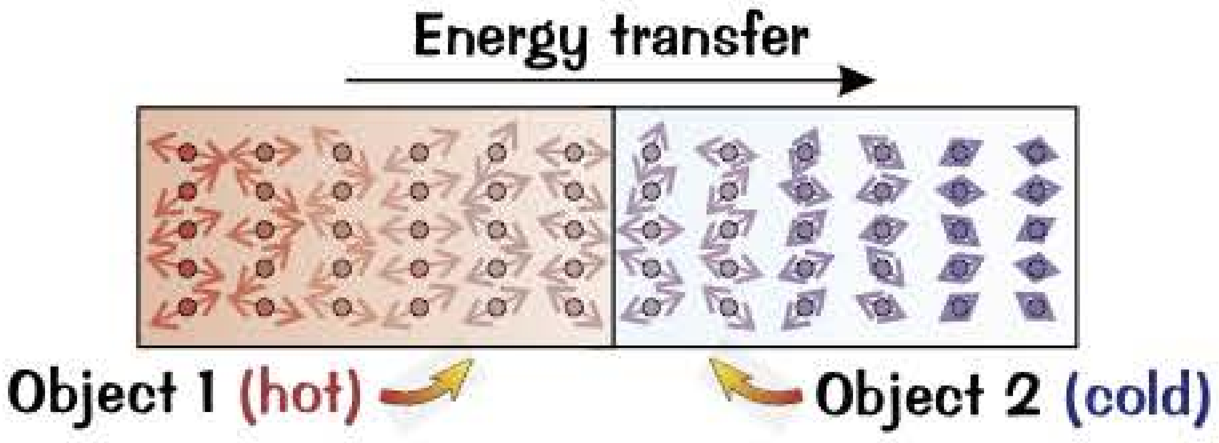
Energy can be transferred between objects by heating.

Energy is Transferred From Hot Objects to Cooler Ones

1) When there's a temperature difference between two objects, energy will be transferred from the hotter one to the cooler one (so the hotter object will cool down and the cooler object will heat up).
2) This carries on until the objects reach thermal equilibrium — the point at which they're both the same temperature.

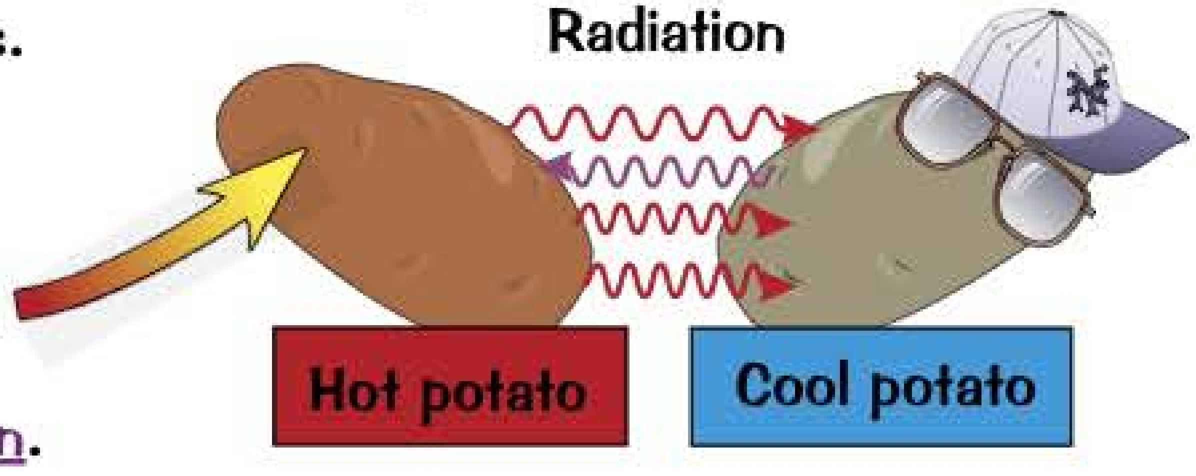
You need to know about two ways in which energy can be transferred between objects by heating:

1) Conduction



1) When an object is heated, the particles in the object start vibrating more — they gain energy in their kinetic energy stores.
2) Conduction occurs when vibrating particles pass on their extra energy to neighbouring particles.
3) It only happens when particles can bump into each other, so the objects must be touching.
4) Particles in the hotter object vibrate faster than particles in the cooler object. When the particles in the hot object bump into the particles in the cold object, energy is transferred. This means the hot object loses energy and cools down and the cold object gains energy and heats up.

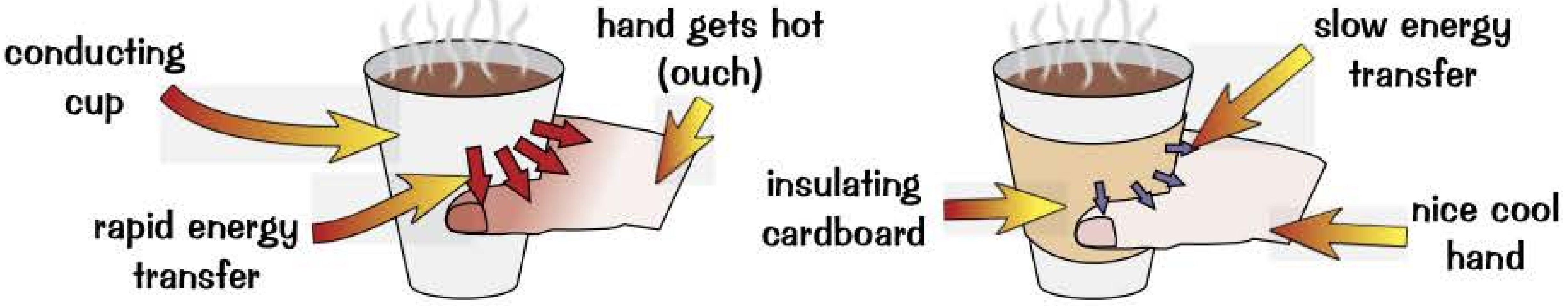
2) Radiation



1) All objects radiate invisible waves that carry energy to the surroundings — the hotter an object is, the more energy it radiates.
2) Radiation isn't transferred by particles, so the objects don't need to be touching.
3) The hotter object (like this hot potato) radiates more energy than the cooler object. The hotter object radiates more energy than it absorbs, so it cools down.
4) The cooler object absorbs some of the radiation from the hot object. It absorbs more energy than it radiates, so it heats up.

Insulators Can Slow Down the Rate of Energy Transfer

1) Some materials transfer energy more quickly than others. Objects made from conductors (e.g. metals) will transfer energy more quickly than objects made from insulators (e.g. plastics).
2) Wrapping an object in an insulator will slow down the rate at which it transfers energy to and from surrounding objects. So insulators help keep hot objects hot, and cold objects cold.



I love energy transfer — it's totally radiation...

Ever wondered why metals at room temperature feel cold when you touch them? Metals are really good conductors, which means they draw energy away from your hand really quickly. Insulators like plastics and wood feel warmer even though they're the same temperature because they don't conduct energy as well.

Conservation of Energy

It's not that energy can be transferred, but more that it has to be. Not necessarily in a useful way, mind.

The Principles of Conservation of Energy

Scientists have only been studying energy for about two or three hundred years so far, and in that short space of time they've already come up with two "Pretty Important Principles" relating to energy. Learn them really well:

THE PRINCIPLE OF CONSERVATION OF ENERGY

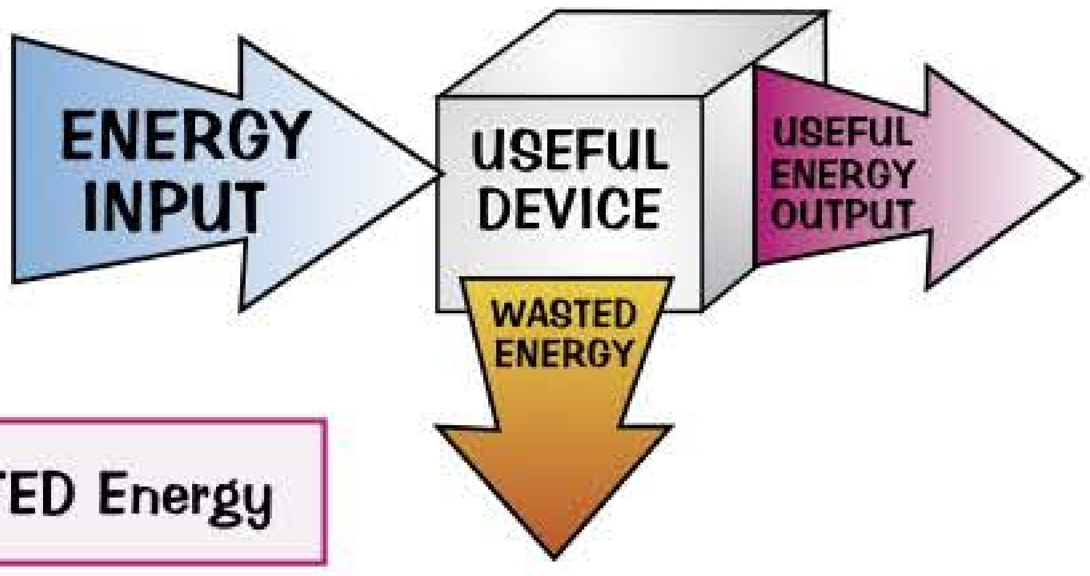
Energy can never be **CREATED** nor **DESTROYED** — it's only ever **TRANSFERRED** from one store to another.

That means energy never simply disappears — it always transfers to another store.
This is another very useful principle:

Energy is **ONLY USEFUL** when it's **TRANSFERRED** from one store to another.

Most Energy Transfers are Not Perfect

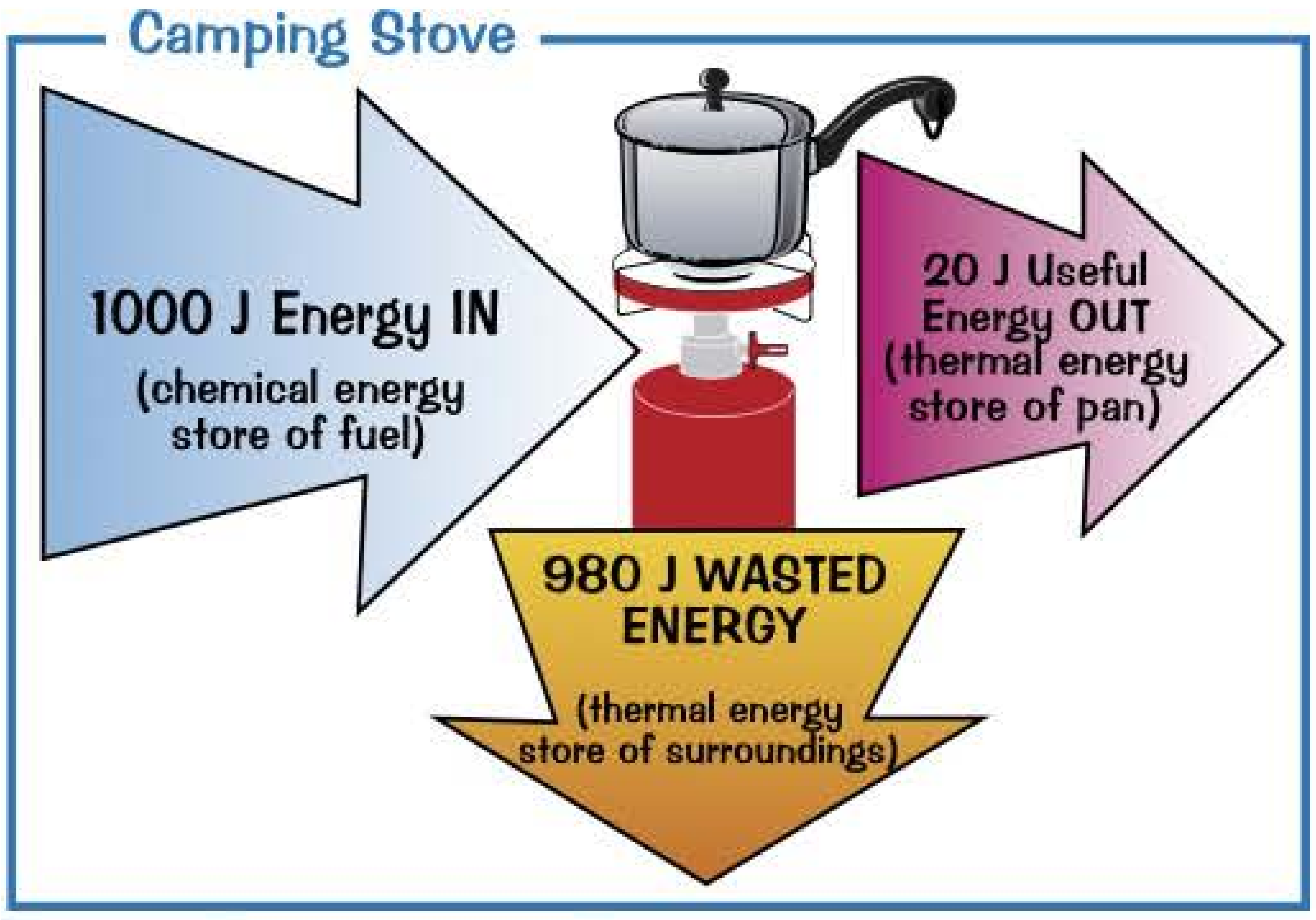
1) Useful devices are useful because they transfer energy from one store to another.
2) Some energy is always lost in some way, nearly always by heating.
3) As the diagram shows, the energy input will always end up coming out partly as useful energy and partly as wasted energy — but no energy is destroyed:



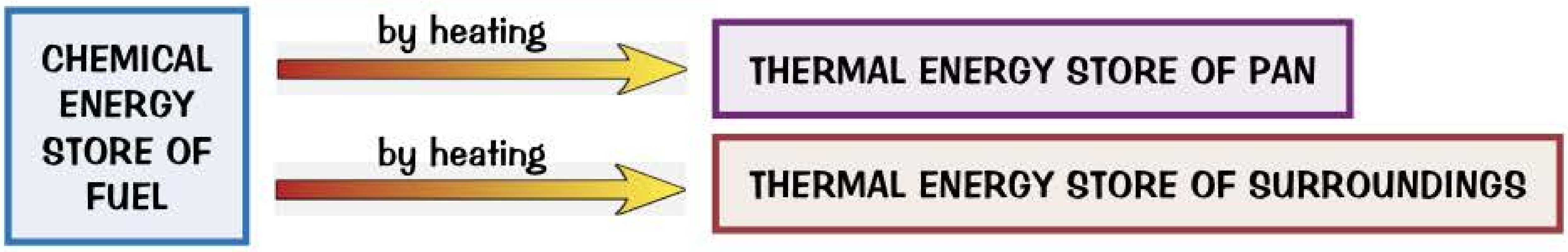
Total Energy INPUT = The USEFUL Energy + The WASTED Energy

You Can Also Draw Energy Transfer Diagrams

Camping Stove



1) You can show how energy moves between stores by drawing an energy transfer diagram (see below).
2) Rectangles are used to represent the different stores.
3) Draw an arrow to show energy being transferred and label it with the method of transfer.
4) If there's more than one transfer, draw an arrow for each one, each going to a different store.



No mum I'm not slacking — I'm just conserving energy...

This stuff's super important, so make sure you can wrap your head around it before ploughing on. Remember, energy's only ever transferred to other stores. No matter how hard you try, you can't ever create or destroy energy. It's just impossible. Futile. Unattainable. 100% completely out of the question.

Energy Resources

The Sun's a useful little critter. It provides us with oodles of energy and asks for nothing in return.

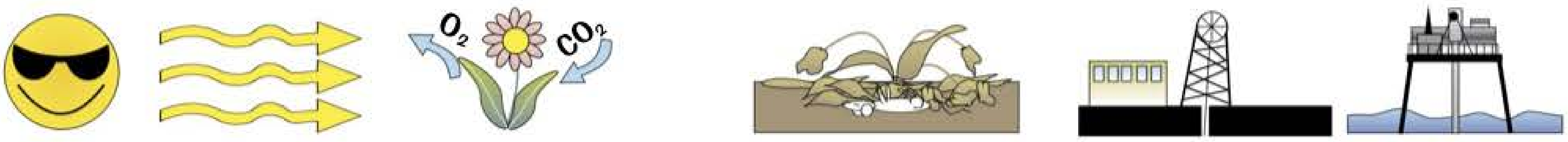
The Sun is the Source of Our Energy Resources

Most of the energy around us originates from the Sun. The Sun's energy is really useful for supplying our energy demands. Often the Sun's energy is transferred to different stores before we use it.

Learn These Six Energy Transfer Chains

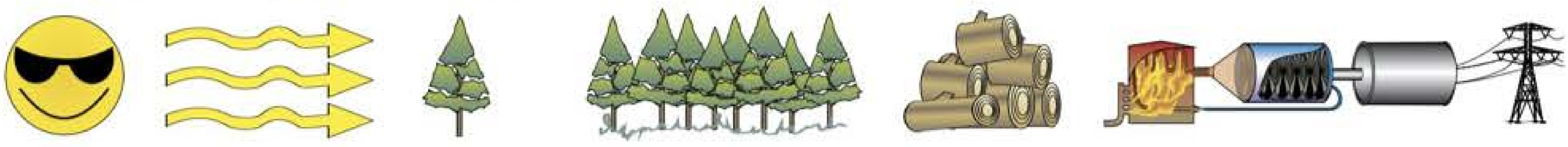
① Sun's Energy → Coal, Oil, and Gas (Fossil Fuels)

Sun → light → photosynthesis → dead plants/animals → FOSSIL FUELS



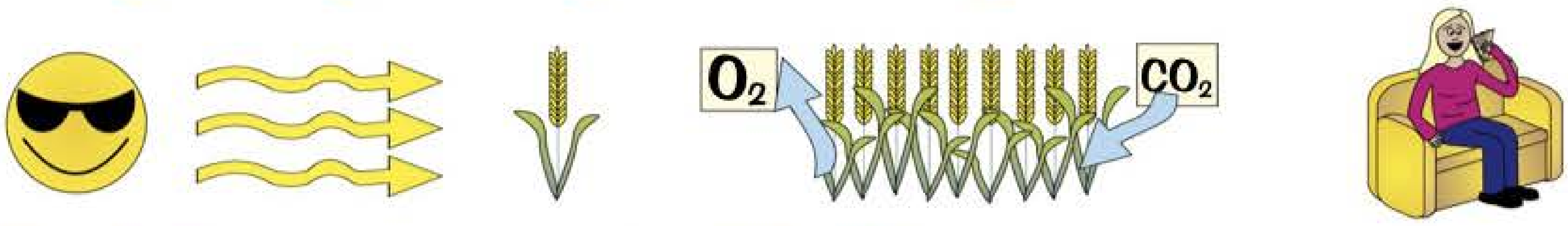
② Sun's Energy → Biomass (e.g. Wood)

Sun → light → plants → photosynthesis → BIOMASS (wood)



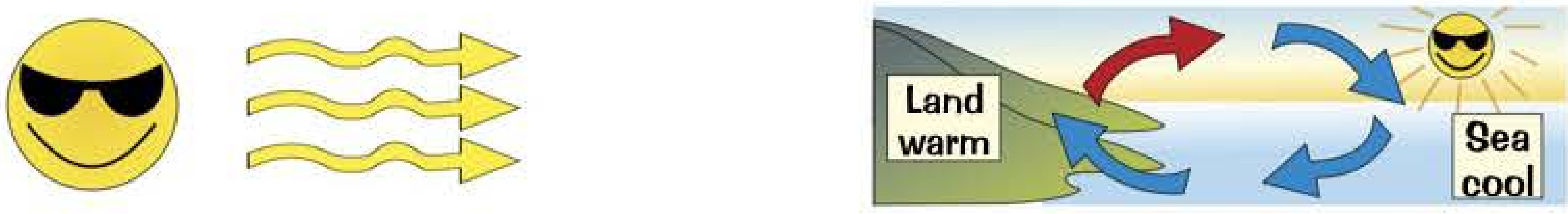
③ Sun's Energy → Food

Sun → light → plants → photosynthesis → BIOMASS (food)



④ Sun's Energy → Wind Power

Sun → heats atmosphere → air circulates → causes WINDS



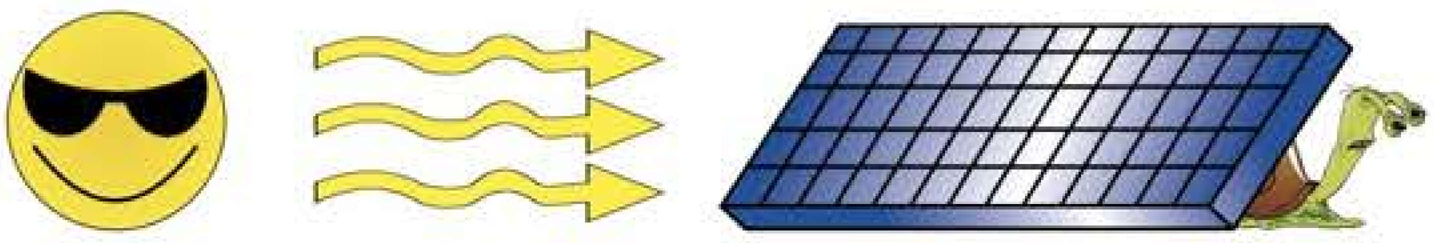
We can use the energy in the kinetic energy stores of the wind and waves to turn turbines and generators, giving us electricity.

⑤ Sun's Energy → Wave Power

Sun → heats atmosphere → causes WINDS → causes WAVES

⑥ Sun's Energy → Solar Cells

Sun → light hits solar cells → generates ELECTRICITY



Baby you light up my world like nobody else...

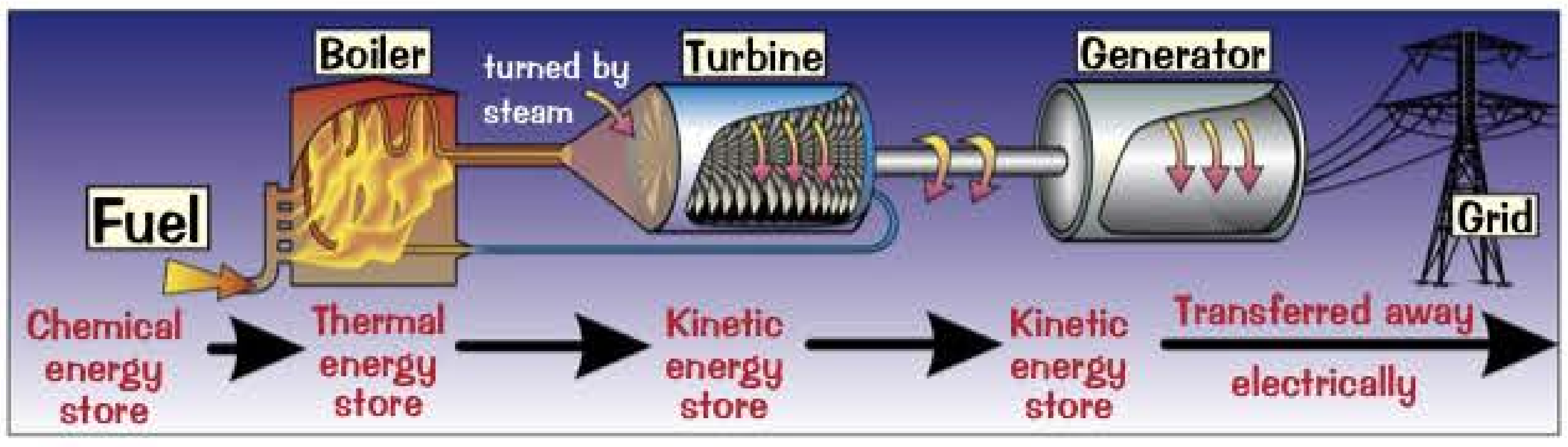
...the way you give energy gets me overwhelmed. The Sun's pretty amazing — without it we'd be totally scuppered. Don't take it for granted, because it supplies pretty much all the energy we have here on Earth.

Generating Electricity

We can use the energy we get from the Sun to generate electricity, in lots of different ways...

There Are Different Ways of Generating Electricity

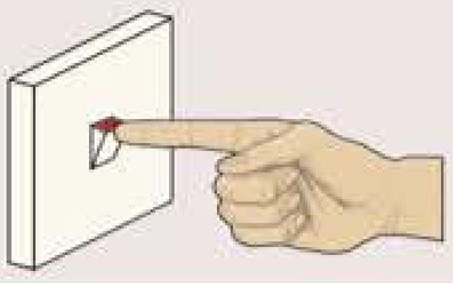
1) There are a variety of different fuels that people use in their homes, e.g. coal is used for fires, gas is used for cookers, etc. But most homes these days rely on electricity for most of their energy needs.
2) We can use energy resources (see previous page) to generate electricity.
3) At the moment we generate most of our electricity by burning fossil fuels.
4) Most ways of generating electricity turn a turbine and a generator — the generator transfers the energy in kinetic energy stores electrically.
5) Energy resources that we use to generate electricity can be split into two groups — non-renewable and renewable.



Non-renewable Energy Resources Will Run Out

1) Fossil fuels took millions of years to come about — and only take minutes to burn.
2) Once they've been taken from the Earth — that's it, they're gone, (unless you're gonna wait around a few more million years for more to be made).
3) There'll come a time when we can't find any more and then we could have a problem.
4) We need to reduce the amount of fossil fuels we use, so they won't run out as quickly. The answer is:

i) Save energy (e.g. turn lights off, drive cars with more fuel-efficient engines).
ii) Recycle more (see page 62).
iii) Use more renewable energy resources (see below).



Renewable Energy Resources Won't Run Out

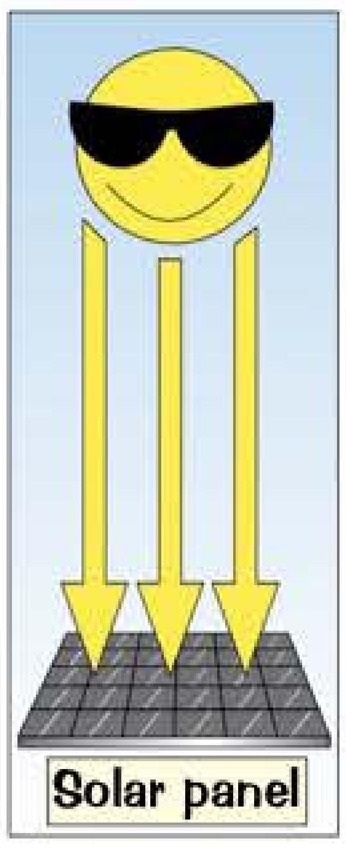
As long as the Sun still shines...

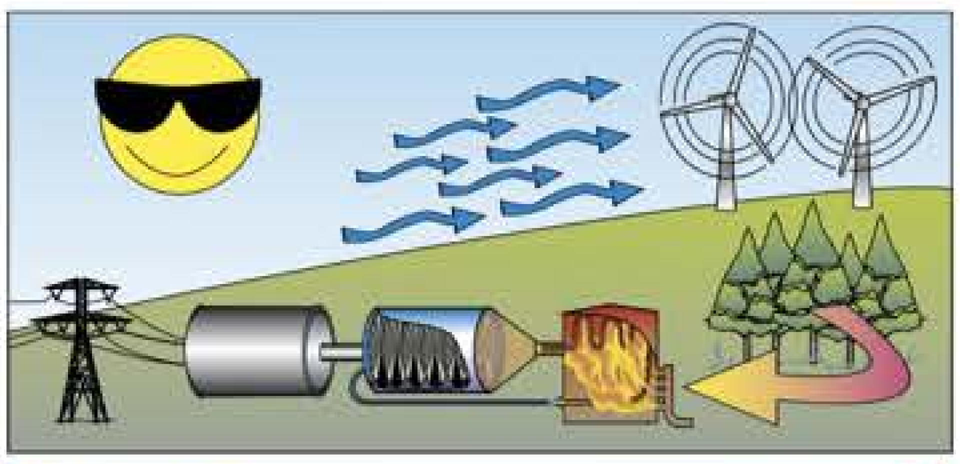
① The WIND will always blow — and turn turbines to generate electricity.

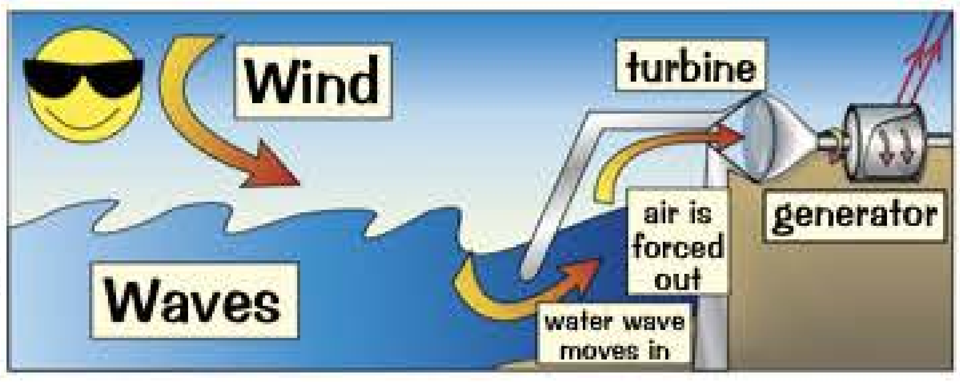
② PLANTS will always grow — which can be burnt to generate electricity.

③ WAVES will always be made — and drive generators to make electricity.

④ SOLAR cells will always work — and use light to make electricity.







One of the drawbacks of renewable energy is that it's not always available like non-renewable resources. For example, there will always be wind, but it isn't always blowing with the same strength, solar cells are only useful during the day etc.

Think on pal — this'll affect all your generation...

Don't call renewable energy resources "re-usable" — no no no no. They'll renew themselves, like trees will grow again if replanted, etc. But once a tree is burnt you can't re-use that particular tree. Don't let the name put you off though — renewable resources are, on the whole, pretty darn great.

The Cost of Electricity

Electricity ain't free you know — ask your mum and dad. At least the cost is pretty easy to calculate.

You Can Calculate the Energy an Appliance Transfers

1) Anything that needs electricity to work is an electrical appliance — electricity is its "fuel".
2) All electrical appliances transfer energy electrically to stores of energy. Energy can be measured in joules (J), kilojoules (kJ) or kilowatt-hours (kWh).
3) Power tells you how fast something transfers energy. It's usually measured in watts (W) or kilowatts (kW). 1 kW = 1000 W.
4) The total amount of energy transferred depends on the amount of time something's switched on for, and its power. If you know the power in watts and the time in seconds, you can calculate energy transferred using this equation:
5) If you know the power in kilowatts and the time in hours, you can use this equation:

ENERGY TRANSFERRED (J) = POWER (W) × TIME (s)

ENERGY TRANSFERRED (kWh) = POWER (kW) × TIME (h)

Electricity Meters Record How Much Electricity is Used

Electricity meters record the amount of energy transferred in kWh. You can use them to work out the energy transferred over different periods of time, e.g. at day and at night:

EXAMPLE: Ganesh wants to find out how much electricity he uses during the day compared to during the night. He writes down his meter reading at three different times during a 24 hour period:
6pm = 44281.25 kWh 6am = 44284.76 kWh 6pm = 44296.12 kWh
Does he use more electricity during the day or during the night?

ANSWER: Energy from 6pm to 6am (i.e. during the night) = 44284.76 – 44281.25 = 3.51 kWh
Energy from 6am to 6pm (i.e. during the day) = 44296.12 – 44284.76 = 11.36 kWh
So he uses more electricity during the day.

Calculating the Cost of Electricity

Domestic fuel bills charge by the kilowatt-hour.
You can calculate what your electricity bill should be with this handy little formula:

COST = Energy transferred (kWh) × PRICE per kWh

Cost = kWh × Price

EXAMPLE: Electricity costs 16p per kWh. At the start of last month, Jo's electricity meter reading was 42729.66 kWh. At the end of the month it was 43044.91 kWh. Calculate the cost of her electricity bill last month.

ANSWER: Energy transferred = 43044.91 – 42729.66 = 315.25 kWh
Cost = Energy transferred × price = 315.25 × 16 = 5044p = £50.44

Many homes use gas as a fuel, e.g. for gas central heating, gas cookers etc.
Your gas bill is calculated using the energy used in kWh, just like your electricity bill.

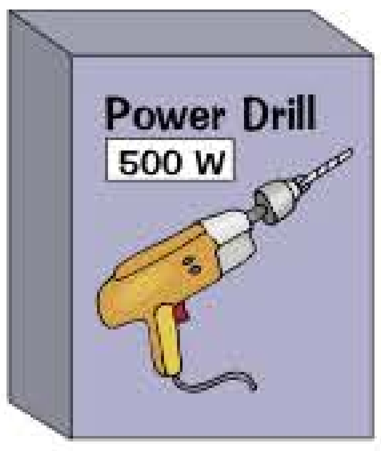
Feeling left in the dark? Maybe you didn't pay your bills...

Ever wondered what those little numbers on your electricity meter read? No? Oh, I guess it's just me then. It's good to check the power company's charged you the right amount every now and then — and now you can do just that with a nice little formula. Lucky you. Make sure you know how to use it — it's dead useful.

Comparing Power Ratings and Energy Values

If you want to know how much energy an appliance uses you can work it out using its power rating. And if you want to know how much energy is in your food, just look on the label. This energy stuff's everywhere.

Power Ratings of Appliances



1) The power rating of an appliance is the energy that it transfers per second when it's operating at its recommended maximum power (i.e. when it's plugged into the mains).
2) You can work out the energy transferred by an appliance in a certain time if you know its power rating. To do this you need to use the equations on the previous page.

The Energy Transferred Depends on the Power Rating

The higher the power rating of an appliance, the more energy it transfers in a given amount of time.
You can compare how much energy is transferred by appliances with different power ratings.

EXAMPLE: How much energy is transferred by a 1.5 kW electric heater compared to a 4 kW electric heater, when they're both left on for 1.5 hours?

ANSWER: Energy transferred (kWh) = power rating (kW) × time (h).
Energy transferred by the 1.5 kW heater = 1.5 × 1.5 = 2.25 kWh.
Energy transferred by the 4 kW heater = 4 × 1.5 = 6 kWh.

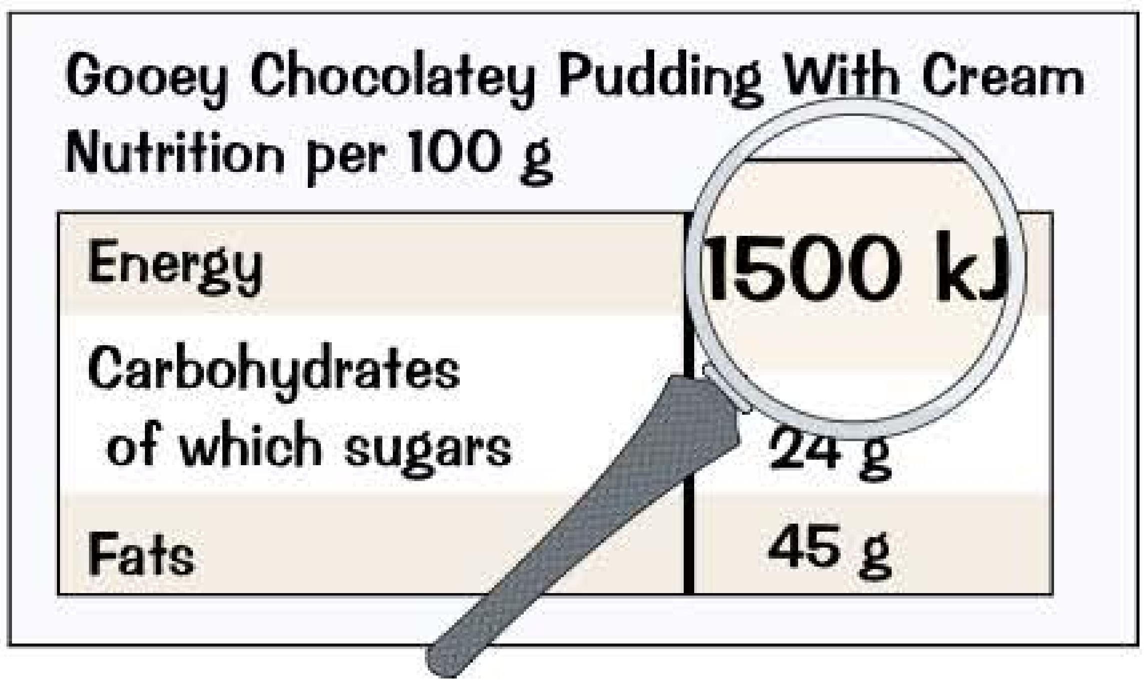
So the 4 kW heater transfers (6 – 2.25) 3.75 kWh more energy than the 1.5 kW heater in 1.5 hours.

Remember, transferring energy costs money. So an appliance with a higher power rating will cost more to run over a set period of time than an appliance with a lower power rating.

Food Labels Tell You How Much Energy is in Food

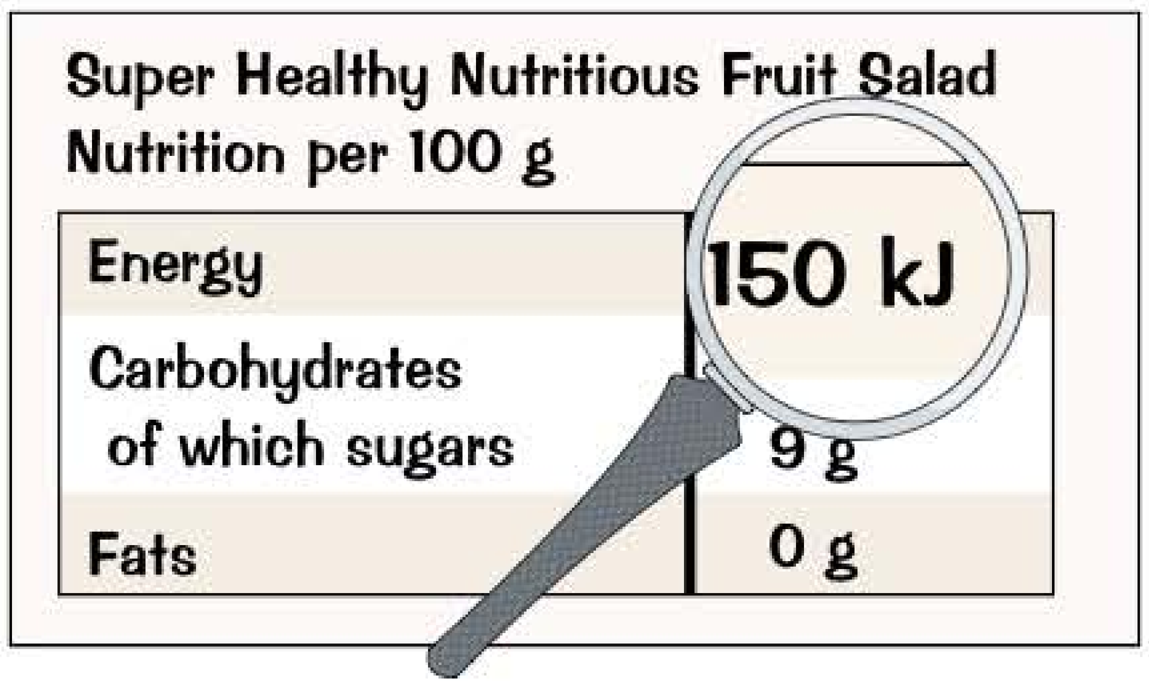
You may also see a value for kcals on a food label — this is just another unit that energy can be measured in.

1) All the food we eat contains energy — it's important to make sure you're taking in the right amount of energy each day (page 7).
2) The energy in food is measured in kilojoules (kJ).
3) You can compare the amount of energy in different foods by looking at their label.



Gooey Chocolatey Pudding With Cream
Nutrition per 100 g

Energy	1500 kJ
Carbohydrates	
of which sugars	24 g
Fats	45 g



Super Healthy Nutritious Fruit Salad
Nutrition per 100 g

Energy	150 kJ
Carbohydrates	
of which sugars	9 g
Fats	0 g

What's my power rating you ask? About 8 out of 10...

Reading labels is not just good fun, but also useful — a label can tell you the power rating of an appliance, or how much energy is in your food. And, you know what they say — energy is what makes the world go round. Ok, I might have made that up, but this stuff's important — make sure you learn it good 'n' proper.

Physical Changes

Even just a change of temperature can change a substance physically. Sounds easier than the gym...

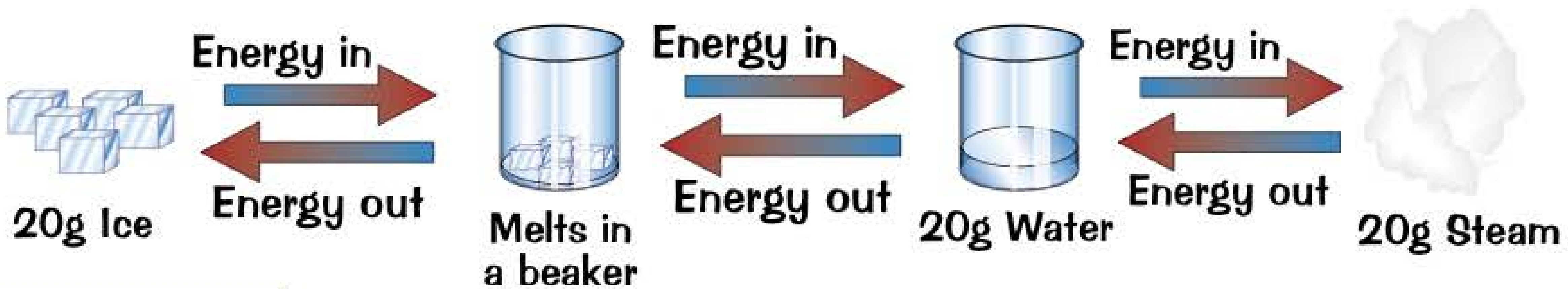
Physical Changes Don't Involve a Change in Mass

1) A substance can either be a solid, a liquid or a gas. These are called states of matter. When a substance changes between these physical states, its mass doesn't change.
2) Physical changes are different to chemical changes because there's no actual reaction taking place and no new substances are made. The particles stay the same, they just have a different arrangement and amount of energy.

There are several different processes that can change the physical state of a substance:

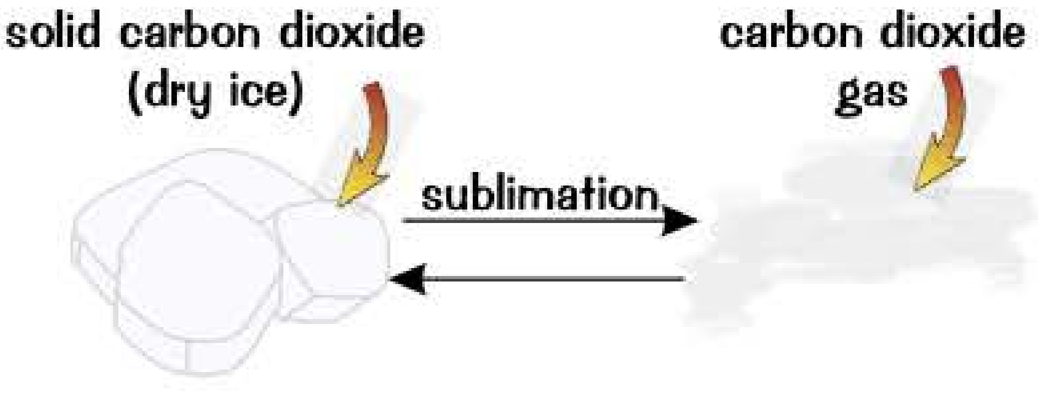
Melting, Evaporating, Condensing, Freezing

1) If you melt a certain amount of ice, you get the same amount of water — and then if you boil that so it evaporates, you get the same amount of steam.
2) It's the same in the other direction — if the steam condenses, you get the same amount of water, and if the water freezes, you get the same amount of ice.



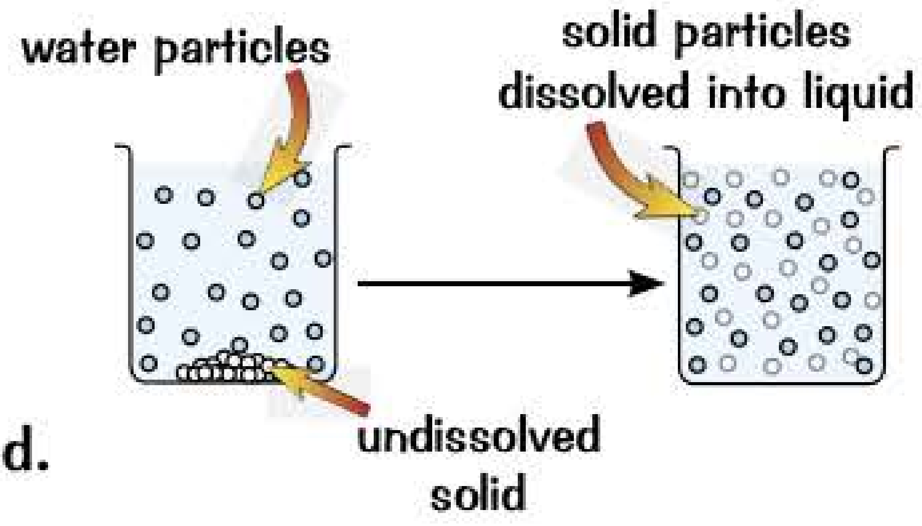
Sublimation

Some substances, such as carbon dioxide, can go straight from being a solid to being a gas — this is called sublimation. When this happens, the mass of gas is (you guessed it) the same as the mass of the solid.



Dissolving

1) When a solid substance dissolves to form a solution (page 39), there's no change in mass. The amount of substance after dissolving is the same as before, it's just in a different form.
2) Dissolving is reversible — if you evaporate all the solvent, you'll be left with the same amount of solid as before it dissolved.



Changes of State Affect a Substance's Physical Properties

1) The particles in solids are packed together tightly compared to gases and liquids — so they're usually more dense. They're also difficult to compress and can't flow.
2) The particles in liquids and gases are free to move around each other, so they can flow.
3) When you heat a substance, the particles move around more and move further apart, causing it to change from a solid, to a liquid, to a gas. The substance expands and becomes less dense.
4) Ice is a funny one though — when it melts (to become water), the particles actually come closer together and its density increases.

See p.32 for more on the physical properties of solids, liquids and gases.

All this studying's getting me in a right change of state...

Remember, physical changes have no effect on the chemical structure of the substance — they just cause it to change state between solid, liquid and gas. Ice is really just water, but with the particles in a more structured formation. If it melts, it goes back to being tasty refreshing water without losing any mass at all.

Movement of Particles

Brownian motion has nothing to do with colours — Brown was just the name of the guy who first noticed it.

Brownian Motion is the Random Movement of Particles

1) In 1827, a scientist called Robert Brown noticed that tiny pollen particles moved with a zigzag, random motion in water.
2) This type of movement of any particle suspended ('floating') within a liquid or gas is known as Brownian motion.
3) Large, heavy particles (e.g. smoke) can be moved with Brownian motion by smaller, lighter particles (e.g. air) travelling at high speeds — which is why smoke particles in air appear to move around randomly when you observe them in the lab.

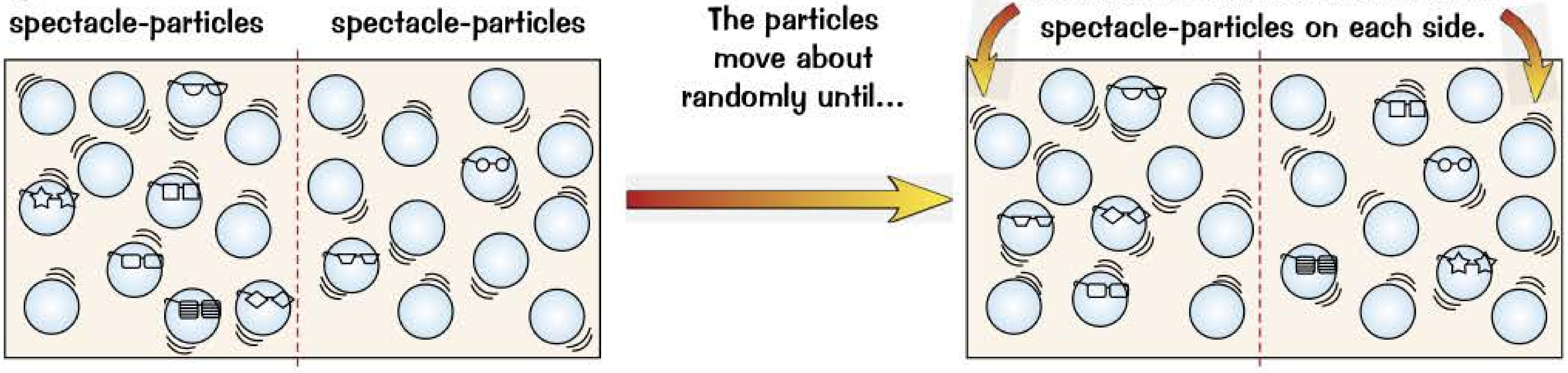
Atoms and molecules are both types of particle.

Diffusion is Caused by the Random Motion of Particles

1) The particles in a liquid or gas move around at random.
2) Particles eventually bump and jiggle their way from an area of high concentration to an area of low concentration. They constantly bump into each other, until they're evenly spread out across the substance.

High concentration of spectacle-particles

Low concentration of spectacle-particles



The particles move about randomly until...

...there's an even concentration of spectacle-particles on each side.

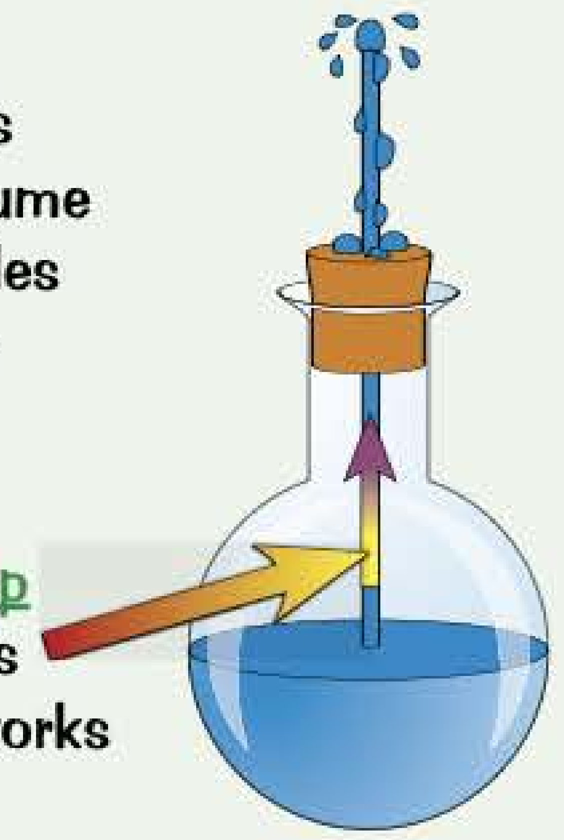
Movement of Particles Increases With Temperature

1) An increase in temperature causes particles to move around more — their speed increases. This means the spaces between the particles get bigger so they take up more space, which causes the material to expand.
2) If you heat a gas or liquid inside a container, the pressure inside the container increases as the particles bump into the sides more often and more quickly.
3) The particles don't get bigger — they just need more space to move around in.

EXAMPLE:

When the liquid in this flask is heated its volume expands as the particles move apart with their extra energy.

So the liquid moves up the thin tube — this is how a thermometer works — dead useful...



I'm a golf comedian — I specialise in par-tickle movement...

...with a PhD in Greenian motion. Ok, I'll admit that was a fairway off being funny, but it's worth taking a long shot every now and then in case you hit the hole in one. You just have to putt in the time if you want to remember all this stuff, so get in your study bunker and buckle down... it'll be over soon, I promise.

Section Summary

Ah, the section summary — on the home stretch at last. In this section, you got to go on a voyage of discovery into the weird and wonderful world of all things energy and matter. All that's left for you now is to work through the exciting questions below and claim your free ice cream at the start of the next section. Ok, the ice cream is a lie, but you won't regret taking the time to work through these questions if you want to be super-amazing at science, trust me. Take your time with them if you like, and maybe have the odd cheeky peek back at the appropriate page if you're stuck — I won't tell anyone, honest.

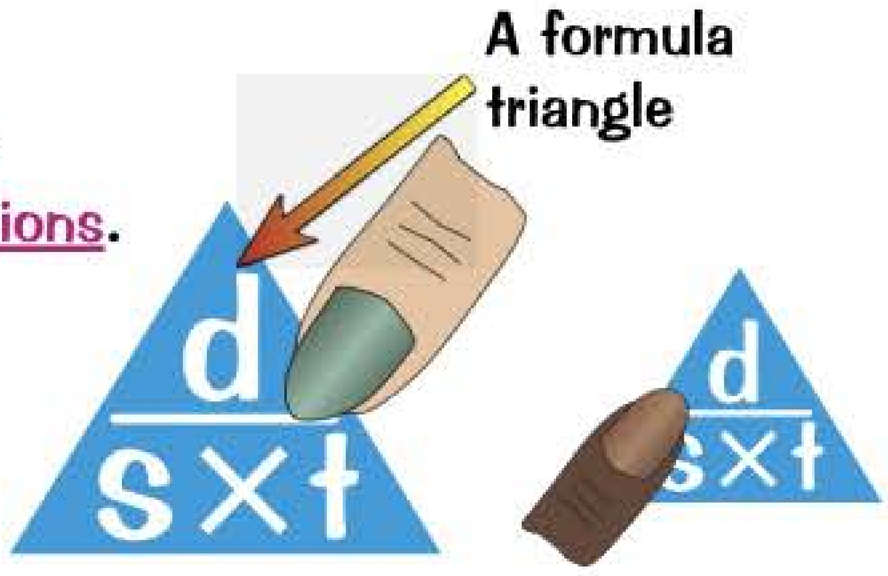
1) Name the seven types of energy stores and the four ways of transferring energy between them.
2) Give one example of energy being transferred electrically to one or more energy stores.
3) Describe the energy transfers for an object that is falling.
4) When does an object have energy stored in its chemical energy store?
5) Replace each row of bumble bees in the sentence below with the correct words.
   When a 🐝-🐝-🐝-🐝 moves an object through a distance, 🐝-🐝-🐝-🐝 is transferred.
6)* A crane applies a force of 2000 N to lift a small elephant 10 m. How much energy does it transfer?
7) What does thermal equilibrium mean?
8) Name two ways in which energy can be transferred between two objects by heating.
9) Describe how energy is transferred when two objects at different temperatures are touching.
10) How does adding an insulator to an object affect the rate of energy transfer?
11) What is the Principle of Conservation of Energy?
12) Why is it important that devices transfer energy from one store to another?
13) Why are most energy transfers <u>NOT</u> perfect?
14) How is wasted energy usually transferred?
15) How does the Sun's energy get stored in fossil fuels?
16) Other than fossils fuels, give two energy resources created using the Sun's energy.
17) What are non-renewable energy resources? How can we use less of them?
18) What are renewable energy resources? Why will they never run out?
19)* Calculate the energy transferred by a 1.5 kW remote-control gibbon used for half an hour.
20) What unit is household electricity measured in?
21)*Electricity costs 15p per kWh. Calculate the cost of an electricity bill for 298.2 kWh.
22) What does the power rating of an appliance tell you?
23)*Which will transfer more energy — a 200 W device left on for 1 hour, or a 300 W device left on for 1 hour?
24) What unit is the energy in food usually measured in?
25) How could you find out the energy contained in a packet of chocolate-flavoured baba ganoush?
26) Give an example of a physical change of state.
27)*50 g of iron is melted. How much liquid iron would be produced?
28) What is sublimation?
29) True or false? Dissolving is not a reversible process.
30) Give two differences between the physical properties of a gas and a solid of the same substance.
31) What's meant by Brownian motion?
32) Particles in gases move from areas of high concentration to low concentration.
    What is the name of this process?
33) Explain why gases expand when they're heated.

*Answers on page 108.

Speed

Neeeeoww... Yes, it's a page on speed. Make sure you can do these calculations — don't zoom through.

Speed is How Fast You're Going



A formula triangle

1) Speed is a measure of how far you travel in a set amount of time.
2) The formula triangle is definitely the best way to do speed calculations.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

This line means divided by or shared by (÷).

3) Use the word SIDOT to help you remember the formula:

SIDOT — **S**peed **I**s **D**istance **O**ver **T**ime.

Always use UNITS.

4) There are three common units for speed. You should realise that they're all kind of the same, i.e. distance unit per time unit.

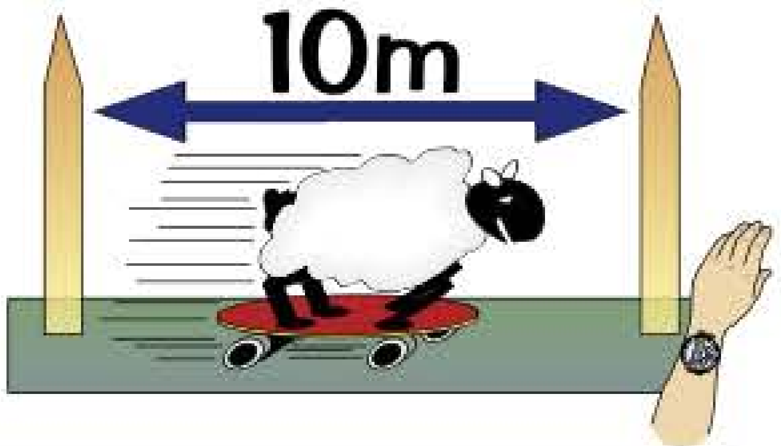
metres per second — m/s
miles per hour — mph or miles/h
kilometres per hour — km/h

Work Out Speed Using Distance and Time

To work out SPEED you need to know the distance travelled and the time taken.

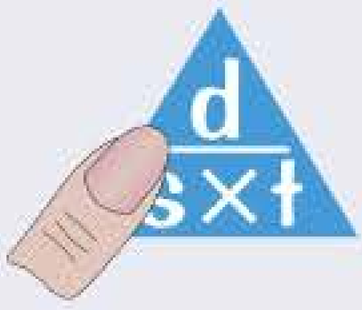
Example 1:

A hooligan sheep is skateboarding down a farmer's track. You notice it takes exactly 5 seconds to move between two fence posts, 10 metres apart. What's the sheep's SPEED?



Answer:

STEP 1) Write down what you know:
distance, d = 10 m time, t = 5 s
STEP 2) We want to find speed, s
from the formula triangle: s=d/t
Speed = Distance ÷ Time = 10 ÷ 5 = 2 m/s

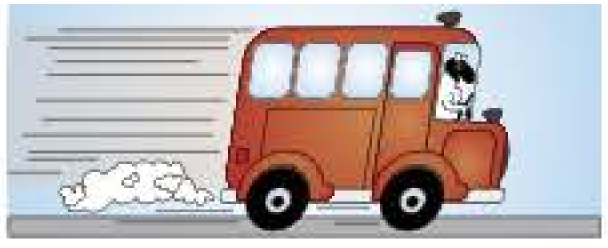


Put your finger over "S" in the formula triangle — which leaves d/t (i.e. d÷t).

Speed questions are a doddle if you just learn the formula triangle.

Example 2:

A campervan sprints down the motorway and travels 15 miles in 30 minutes. What's its speed?



Answer:

STEP 1) Write down what you know:
distance, d = 15 miles time, t = 30 minutes = 0.5 of an hour.
STEP 2) We want to find speed, s, from the formula triangle: s=d/t
Speed = Distance ÷ Time = 15 ÷ 0.5 = 30 miles/hour (mph)

For the answer to be in miles per hour you need the distance in miles and the time in hours so the 30 mins had to become 0.5 hrs.

Speed is ace — well it takes some beating...

Speed is a pretty simple idea really. This page has all the really basic and important facts about speed. There's the formula for a start, and the units, and then a couple of worked examples. Learn it all. Now.

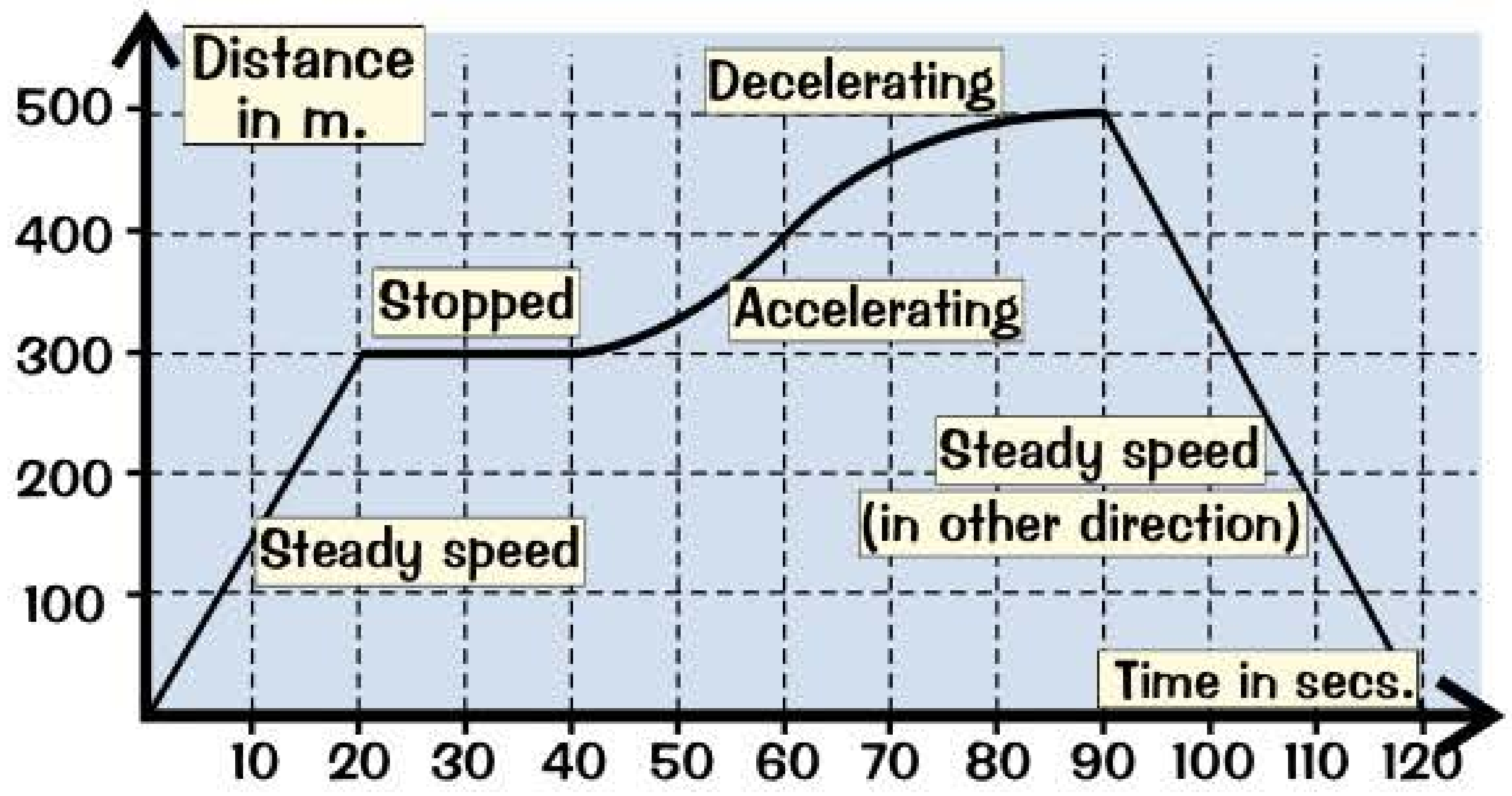
More on Speed

You know what they say — more haste, less speed. Here's some more speed. Make sure you're not hasty.

Distance-Time Graphs

A distance-time graph shows the distance travelled by an object over time.

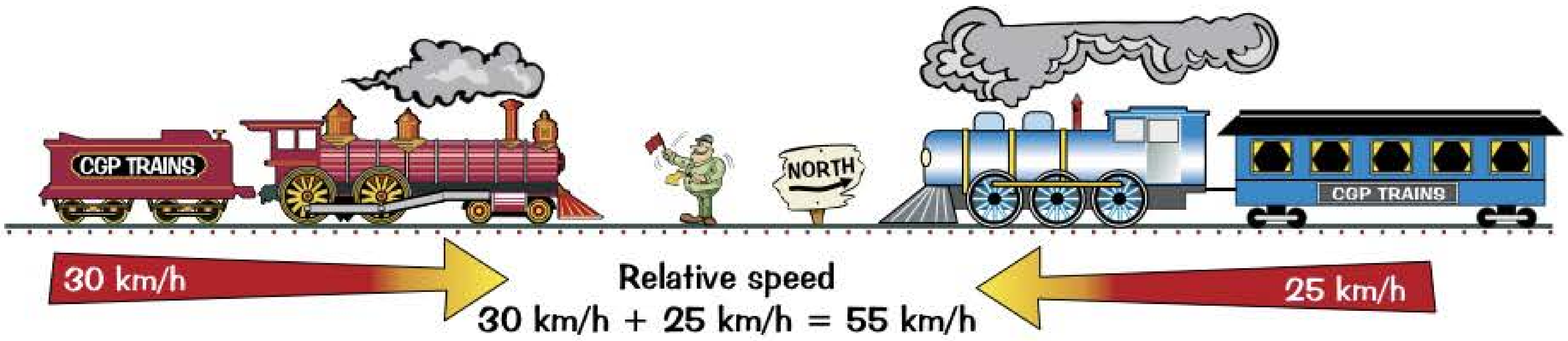
1) The slope of the line (gradient) shows the speed at which the object is moving.
2) The steeper the graph, the faster the object is going.
3) Flat sections are where it's stopped.
4) Downhill sections mean it's moving back toward its starting point.
5) Curves represent a changing speed.
6) A steepening curve means the object is speeding up (accelerating).
7) A curve levelling off means the object is slowing down (decelerating).



Relative Motion — Two Objects Passing Each Other

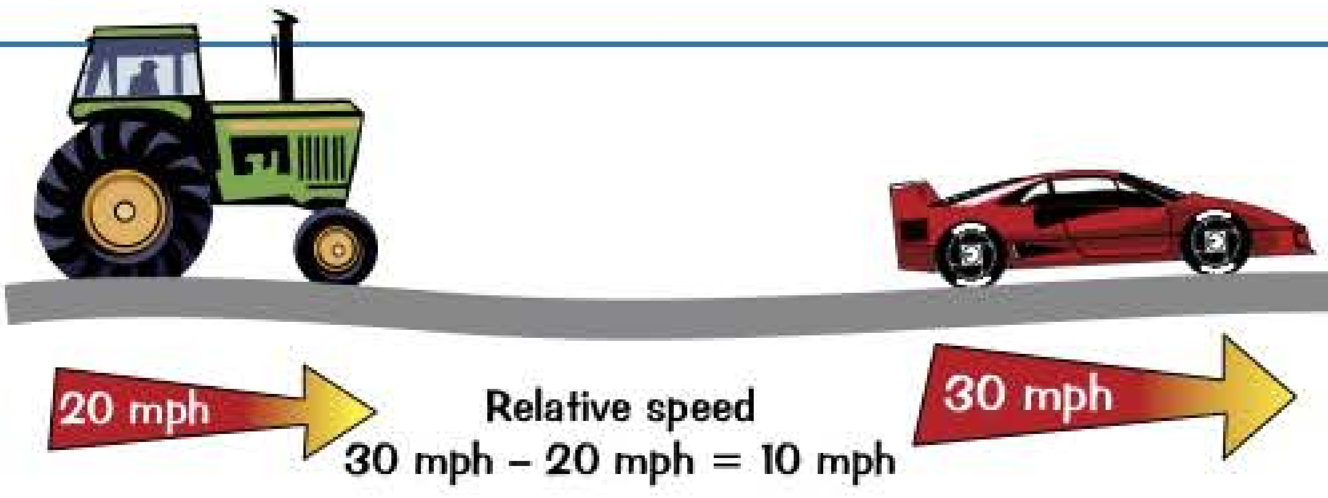
Relative motion is useful if you want to know the speed of something when you are moving too.

1) If two objects are moving in opposite directions on the same straight line you can add their speeds together to calculate their relative motion. Look:



- Both trains are moving towards each other from opposite directions. So if you're sat on the red train, the blue train is getting closer much faster than if you were sat still at the side of the track. This is because it is moving towards you while you're moving towards it.
- To work out the speed of the blue train relative to the red train, just add the speeds together. 30 + 25 = 55 km/h, so the speed of the blue train relative to the red train is 55 km/h.

2) If the objects are moving in the same direction on the same straight line you can subtract their speeds to calculate their relative motion.



- The car is moving in the same direction as the tractor but at a faster speed. If you're in the car, you're getting further away from the tractor more slowly than if it wasn't moving (since it's moving towards you while you're moving away from it).
- To work out the speed of the car relative to the tractor, subtract the speeds. 30 – 20 = 10 mph — the car gets 10 miles further away from the tractor every hour.

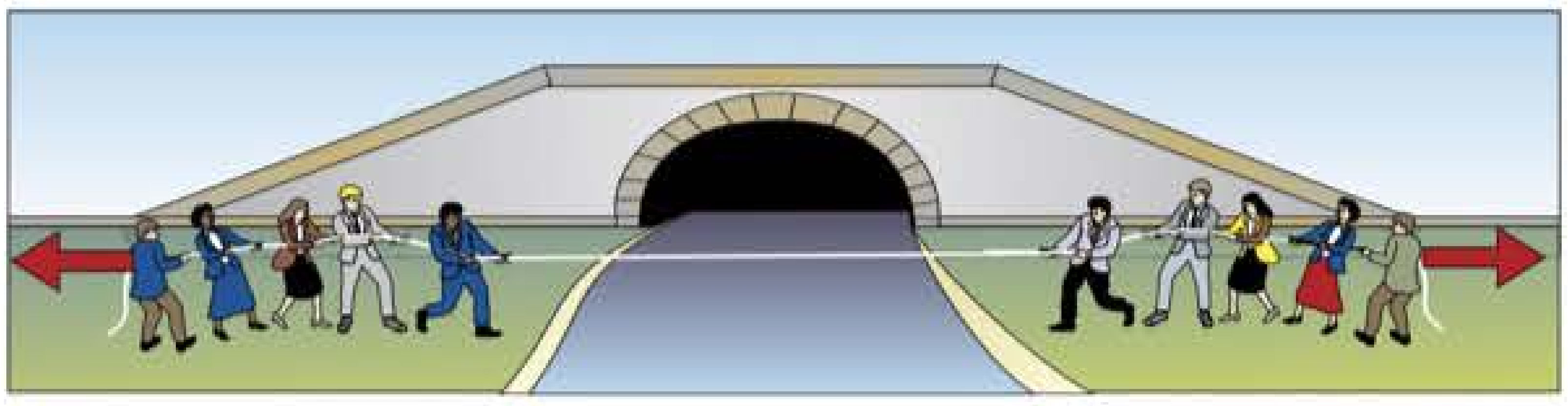
I hate Christmas — all my relatives get too motional...

There are two really important things on this page — distance-time graphs and relative motion. Make sure you can read all the info hidden in a distance-time graph, then check you've got relative motion nailed.

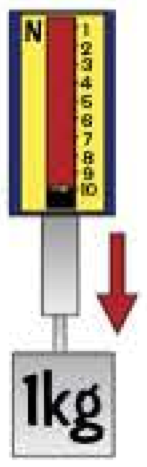
Forces and Movement

Well, I can't force you to read this page — but if I were you, I'd push on with it...

Forces are Nearly Always Pushes and Pulls

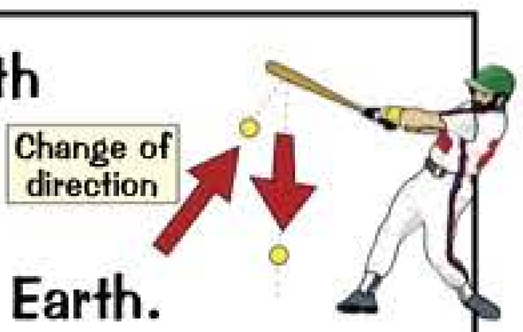
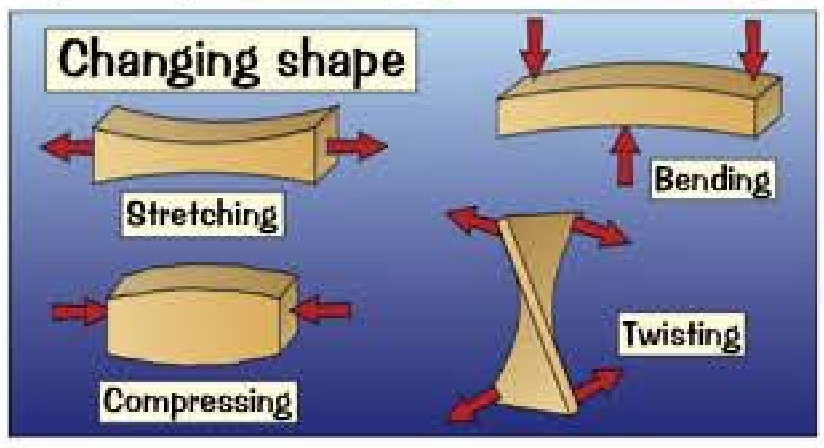


1) Forces are pushes or pulls that occur when two objects interact.
2) Forces can't be seen, but the effects of a force can be seen.
3) Forces are measured in newtons — N.
4) They usually act in pairs.
5) They always act in a certain direction.
6) A newton meter is used to measure forces.



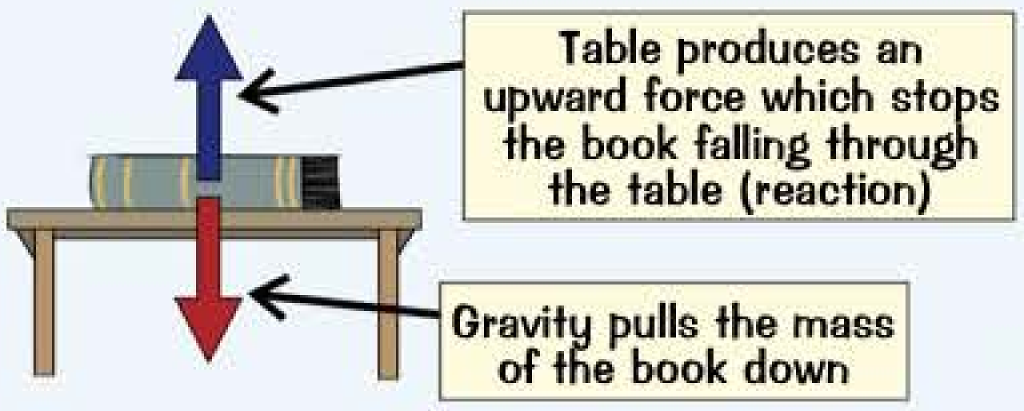
Objects don't need to touch to interact. The gravitational pull between planets (p.102), forces between magnets (p.99) and forces due to static electricity (p.98) are all non-contact forces.

Forces Can Make Objects Do Five Things

1. Speed Up or Start Moving	Like kicking a football. To start something moving, a push force must be larger than resisting forces like friction (see next page). 
2. Slow Down or Stop Moving	Like drag or air resistance (see next page). 
3. Change Direction	Like hitting a ball with a bat or gravity causing footballs to come back down to Earth. 
4. Turn	Like turning a spanner. 
5. Change Shape	Like stretching and compressing (see p.83), bending and twisting. 

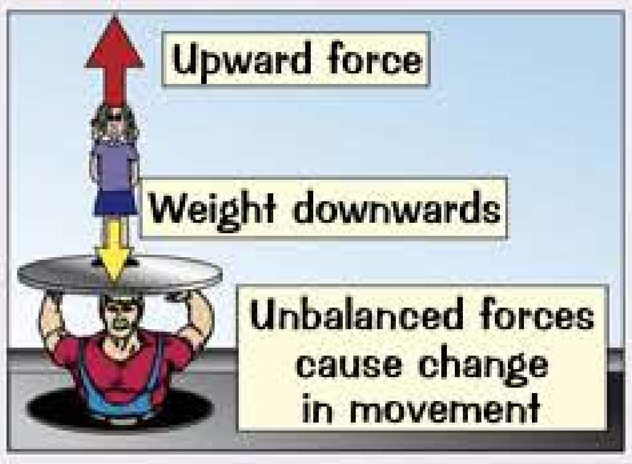
Learn These Two Important Statements:

Balanced Forces produce No Change in Movement



These are force diagrams. See page 81 for more.

Unbalanced Forces Change the Speed and/or Direction of Moving Objects



Force is ace — well it beats speed...

Forces are a simple enough idea, but you still need to know all of the details on this page. Luckily there really isn't much to learn here — just make sure you do. Learn, cover, scribble, check...

Friction and Resistance

Friction Tries to Stop Objects Sliding Past Each Other

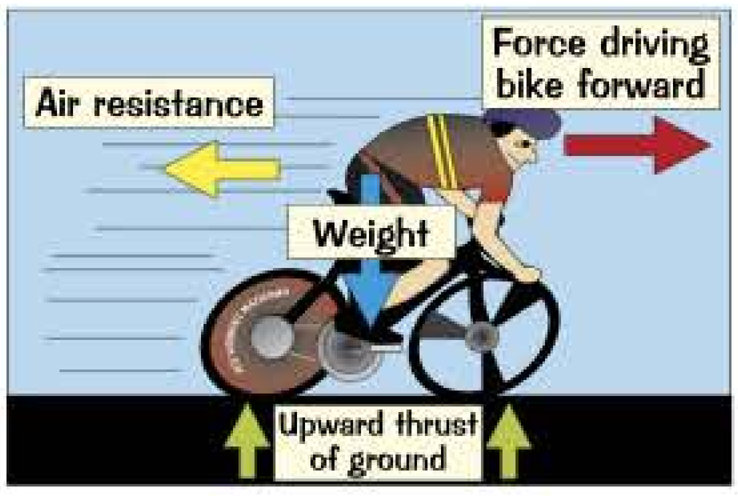
Friction is a force that always acts in the opposite direction to movement.
It's the force you need to overcome when pushing an object out of the way.

The Good Points of Friction — It Allows Things to Start and Stop

1) Friction allows the tyres on a bike to grip the road surface — without this grip you couldn't make the bike move forward and you wouldn't be able to stop it either — it'd be like riding on ice.
2) Friction also acts at the brakes where they rub on the rim of the wheel or on the brake disc. Friction also lets you grip the bike — important if you want to ride it without slipping off.

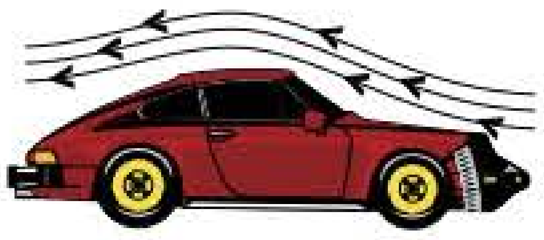
The Bad Points of Friction — It Slows You Down

1) Friction always wastes energy — friction between the moving parts of a bike warms up the gears and bearings — a waste of energy.
2) Friction limits top speed. The air resistance (a kind of friction, see below) takes most of your energy and limits your maximum speed.



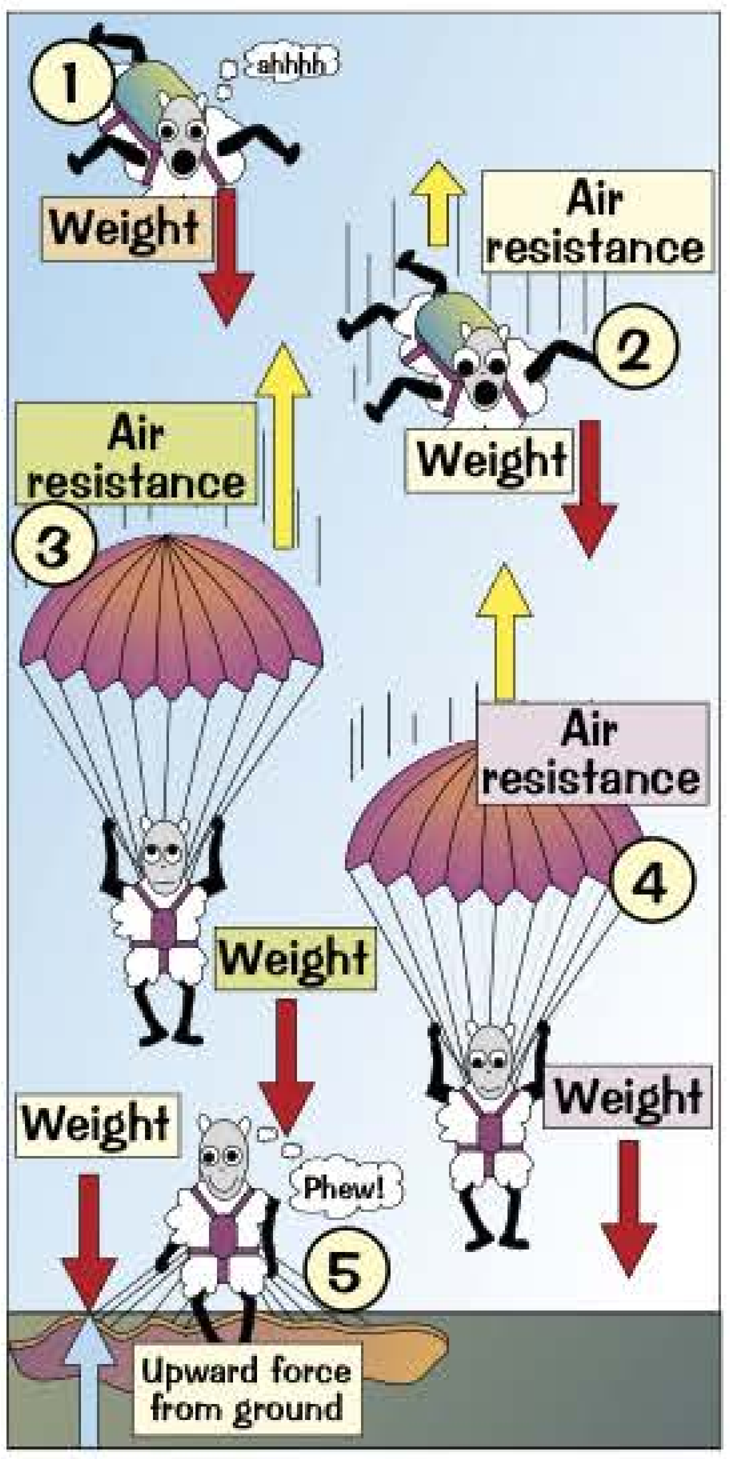
Air and Water Resistance Slow Down Moving Objects

1) Air and water resistance (or "drag") push against objects which are moving through the air or water.
2) These are kinds of frictional force because they try to slow objects down.
3) If things need to go fast, then they have to be made very streamlined — which just means they can slip through the air or water without too much resistance. A good example is a sports car.



How Air Resistance Affects Sheep Jumping Out of Planes

(It happens all the time round here.)



1) Gains Speed

At the start, the sheep only has the force of its weight (i.e. gravity) pulling it down — so it starts to move faster.

2) Still Gaining Speed

As it moves faster, the opposing force of air resistance gets more and more.

3) Losing Speed

When the parachute opens air resistance increases enormously — because there's a much larger area trying to cut through the air. The sheep loses speed and slows down gratefully.

4) Steady Speed

Very quickly the air resistance becomes equal to the weight — the two forces are balanced. The overall force is zero, so the sheep now moves at a steady speed.

5) No Speed

Once safely on the ground, the sheep's weight acting downwards is balanced by an equal upward force from the ground.

Resistance is useless — you've just got to learn about friction...

Air resistance — what a drag, huh. Anyway, here's a page of key facts that you need to learn. Go go go.

Force Diagrams

Force diagrams. They're diagrams that show forces. Bet you weren't expecting that...

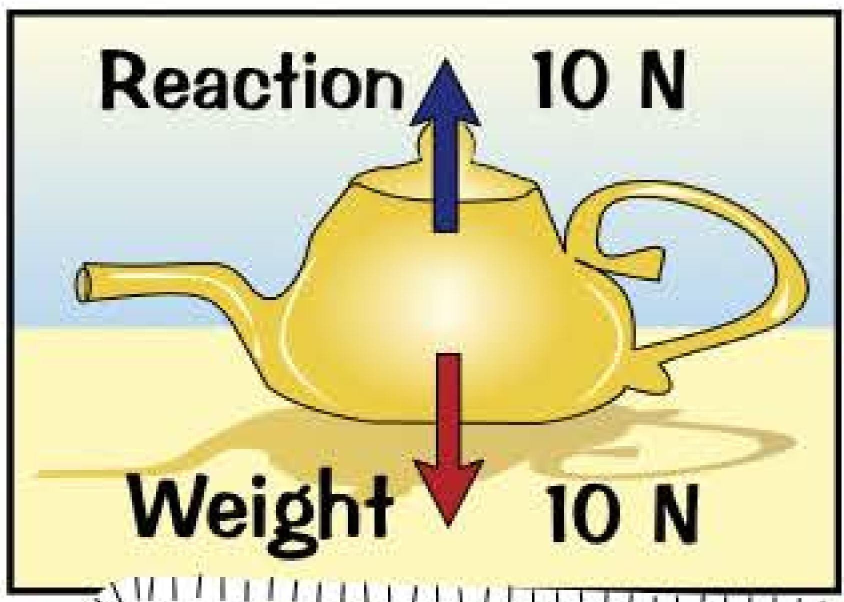
Show the Forces Acting on an Object Using a Force Diagram

Force diagrams show the forces acting on an object and whether they are balanced or unbalanced.

Example: Stationary Teapot Force Diagram

Here's a teapot on a table...

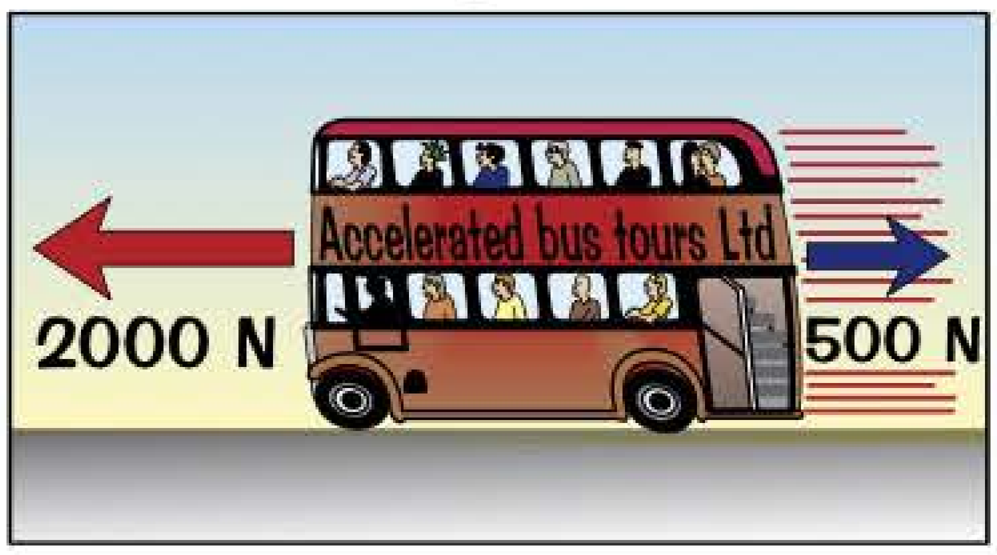
1) The force of gravity (or weight) is acting downwards on the teapot (see page 102) — it's the red arrow.
2) This causes a reaction force from the table's surface pushing up on the teapot — the blue arrow.
3) The reaction force and weight are equal and opposite — you can tell because the arrows are the same size and pointing in opposite directions.
4) This means the forces on the teapot are BALANCED. So it remains stationary (not moving).



If the forces acting on a moving object are balanced, it carries on moving at a steady speed in the same direction.

Example: Accelerating Bus Force Diagram

Here's a force diagram of a bus...



1) The red arrow shows that the engine is creating a force of 2000 N to make the bus move forwards.
2) The blue arrow shows that there is a frictional force of 500 N acting in the opposite direction.
3) The forces are unbalanced (the arrows in the diagram are unequal sizes) so the bus is accelerating in the direction of the bigger force (forwards).

You Can Add or Subtract Forces Along the Same Line

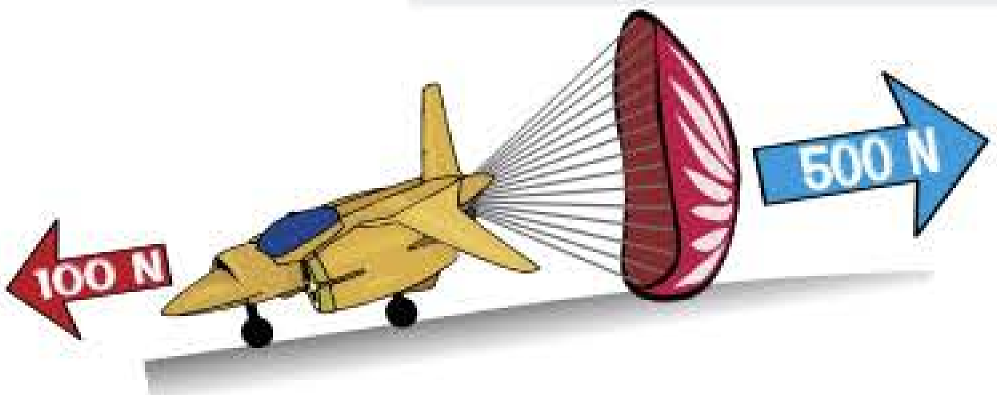
1) If you've got a force diagram where all the forces are acting along the same line (e.g. forwards and backwards OR up and down), you can calculate the overall force by adding or subtracting the forces.
2) This is handy for working out if an object is accelerating (getting faster), decelerating (slowing down) or staying at a steady speed:

Forces acting along the same line are said to be acting in one dimension.

Golden Rules of Force Diagrams

1) If the forces are acting in opposite directions, you subtract the forces to get the overall force.
2) If they're acting in the same direction, you add the forces together to get the overall force.

Overall force
100 – 100 = 0 N
No acceleration, moves at a steady speed



Overall force
100 – 500 = –400 N
Strong deceleration

Overall force
200 + 50 – 20 = 230 N
Strong acceleration

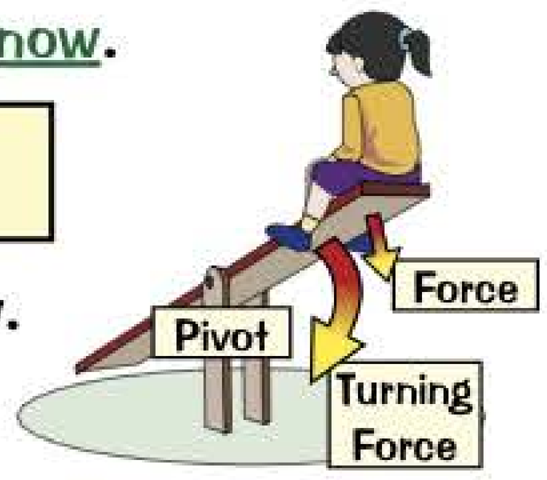
Use the force — look at a diagram, find out if it's accelerating...

Just remember: if the arrows on a force diagram are equal and opposite, the object isn't moving or is moving at a steady speed. If they're different sizes, the forces are unbalanced and the speed will change.

Moments

Don't wait a lifetime to learn moments like this — memorise what's on this page now.

Forces Cause Objects to Turn Around Pivots



A pivot is the point around which rotation happens — like the middle of a seesaw.

A Moment is the Turning Effect of a Force

1) When a force acts on something which has a pivot, it creates a moment.
2) Learn this important equation:

Moment = force x perpendicular distance

Moment in newton metres, Nm

force in newtons, N

perpendicular distance in metres, m

$$M = F \times d$$

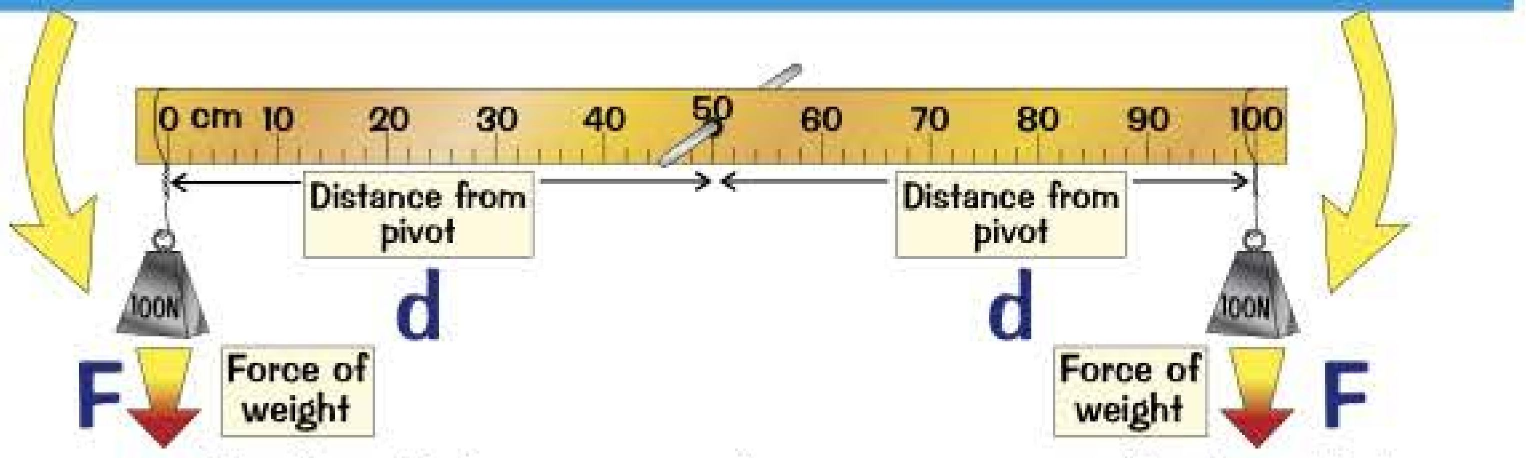
You might remember moments from 'How Muscles Work' (p. 11). Sadly, you need to revisit them again here.

Balancing Moments

Balanced moments mean that...

anticlockwise moments = clockwise moments

If the moments are not balanced, the ruler will turn in the direction of the bigger moment.



ANTICLOCKWISE force x perpendicular distance = force x perpendicular distance CLOCKWISE

100 N x 0.5 m = 100 N x 0.5 m

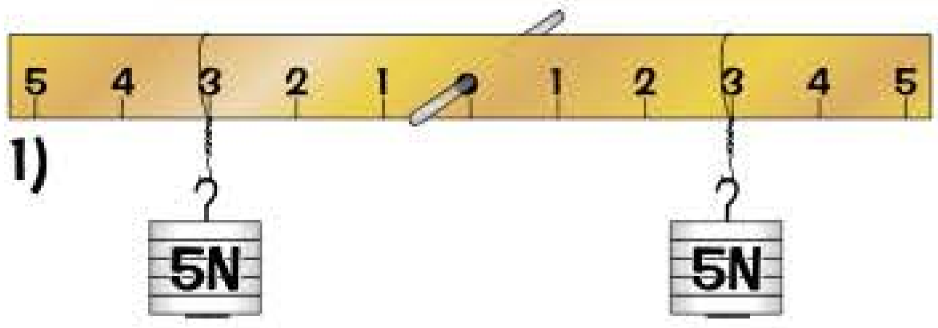
50 Nm = 50 Nm

✓ — BALANCED

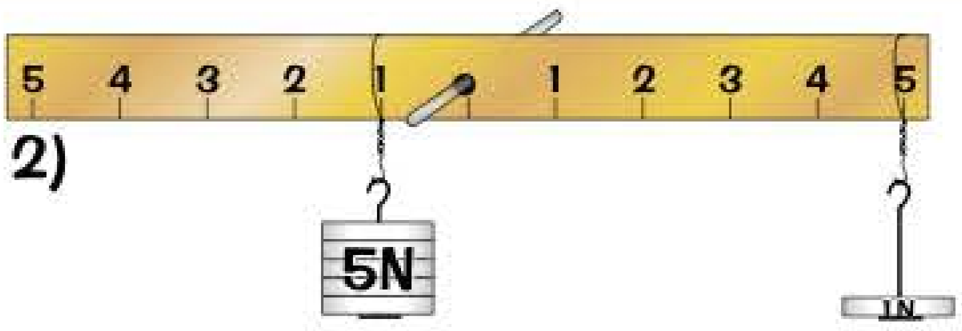
Is it Balanced?

Which rulers are balanced? If you think the ruler is balanced write it on a bit of paper. If you reckon it's unbalanced, then write unbalanced, but say which side of the ruler will dip down. Words to use: balanced, unbalanced, left side down or right side down. Answers on page 108.

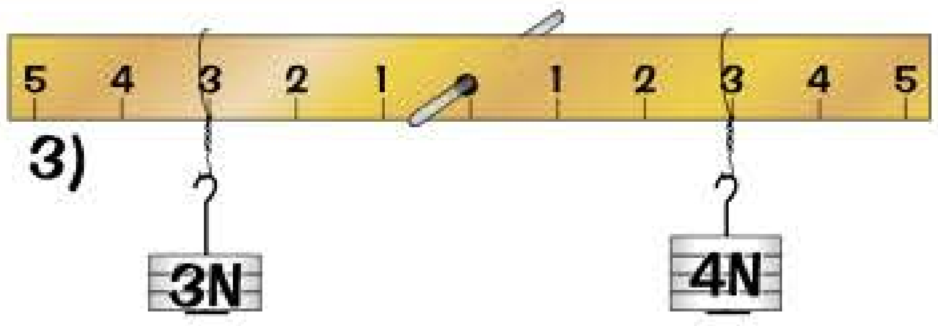
1)



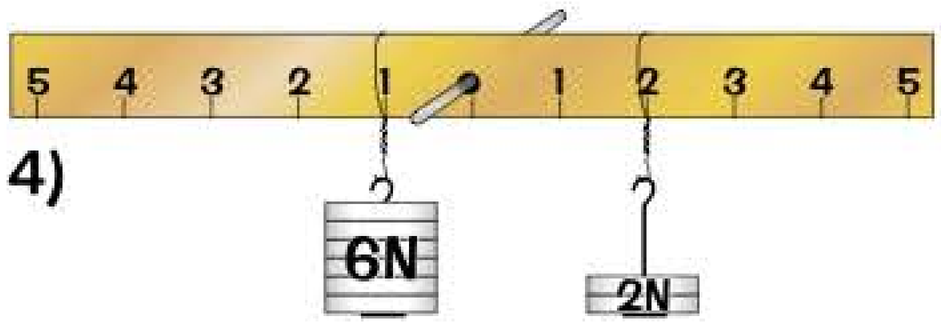
2)



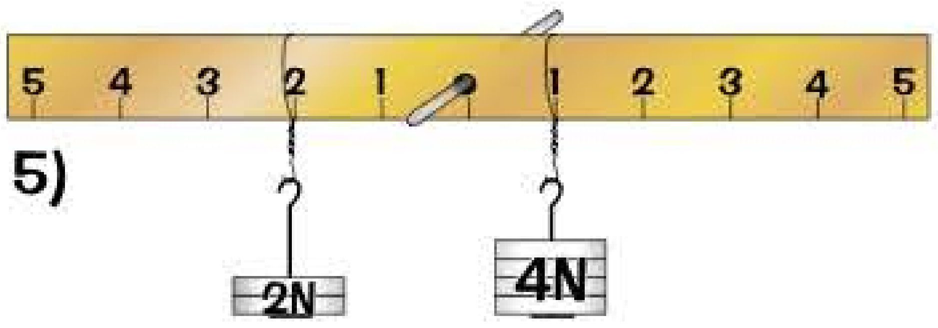
3)



4)



5)



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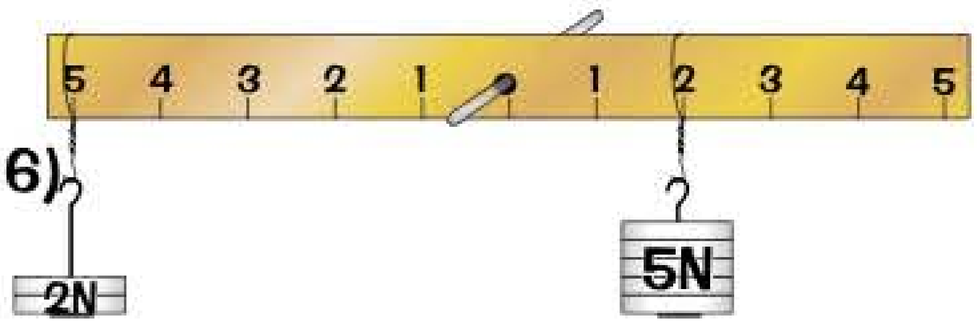


Learn all this page — it'll only take a few moments...

Nope — I don't know why they call them "moments" either. It's a good word for a short period of time, but that's about it. After that it just seems to cause confusion. But there you go — it wouldn't be proper science if it all made perfect sense first time round. And it's a better name than rotating forcey thingy.

Forces and Elasticity

It's not just about turning, pushing and pulling — forces are also able to stretch or squash things.

You Can Deform Objects by Stretching or Squashing

1) You can use forces to stretch or compress (squash) objects, e.g. when you stomp on an empty fizzy pop can.
2) The force you apply causes the object to deform (change its shape).
3) Springs are special because they usually spring back into their original shape after the force has been removed — they are elastic.

Work is Done When a Force Deforms an Object

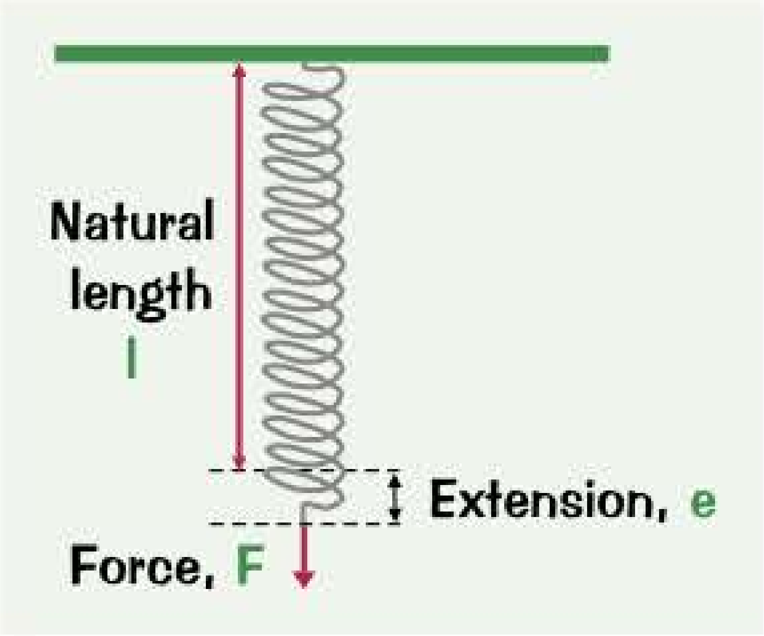
1) You might remember energy transfer from page 67 (if not, take a look). Work done is the same thing.
2) Energy is transferred and work is done when an object is deformed. For example:

- When you stretch a spring, you're doing work by transferring energy.
- The energy is transferred from the kinetic energy store of the spring to its elastic potential energy store.
- When the spring 'springs' back into its original shape, the energy is transferred back to the kinetic energy store.

There's more on different stores of energy on page 66.

Hooke's Law Says Extension of a Spring Depends on the Force

If a spring is supported at the top and then a weight is attached to the bottom, it stretches.



1) Hooke's Law says the amount it stretches (the extension, e), is directly proportional to the force applied, F. I.e. the relationship between force and extension is linear.
2) Some objects obey Hooke's Law, e.g. springs. But it only applies up to a certain force.
3) For springs, the force at which Hooke's Law stops working is much higher than for most materials. Springs are unusual.

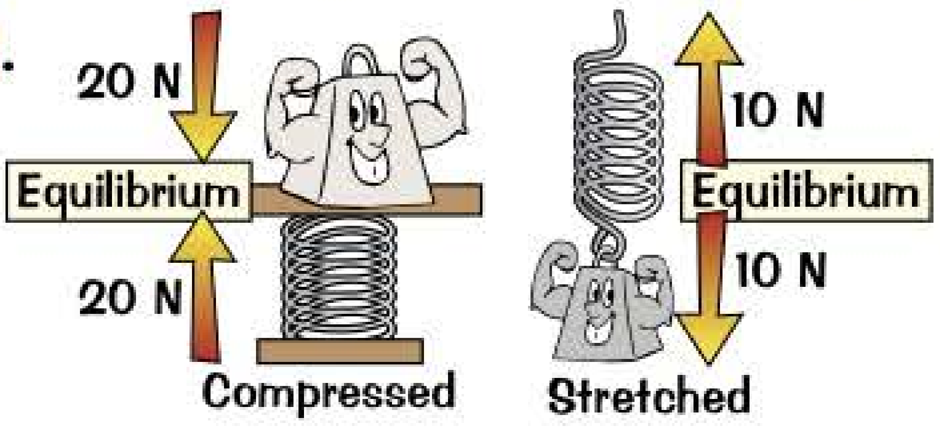
Hooke's Law

$$F = k \times e$$

k is the spring constant. Its value depends on the material that you're stretching and it's measured in newtons per metre (N/m).

When a Stretched Spring Holds a Weight, it's in Equilibrium

1) Equilibrium is just a fancy way of saying all the forces are balanced.
2) When a stretched or compressed spring holds a weight still, the force of the weight is the same as the force of the spring as it tries to return to its original shape. So the forces are balanced and in equilibrium.



This page will stretch you — better do some extra work on it...

It's true — there's an awful lot of stuff to learn here. So read it through again, cover up the page and see if you can scribble down the headings. Then the diagrams and equation. Then the rest. Better get to it...

Pressure

Don't let pressure get you down — here's a lovely page that explains it all. Now that's a load off your mind.

Pressure is How Much Force is Put on a Certain Area

Pressure, force and area are all kind of tied up with each other — as the formula shows. The formula can also be put in a triangle, which is nice.

A given force acting over a big area means a small pressure (and vice versa).

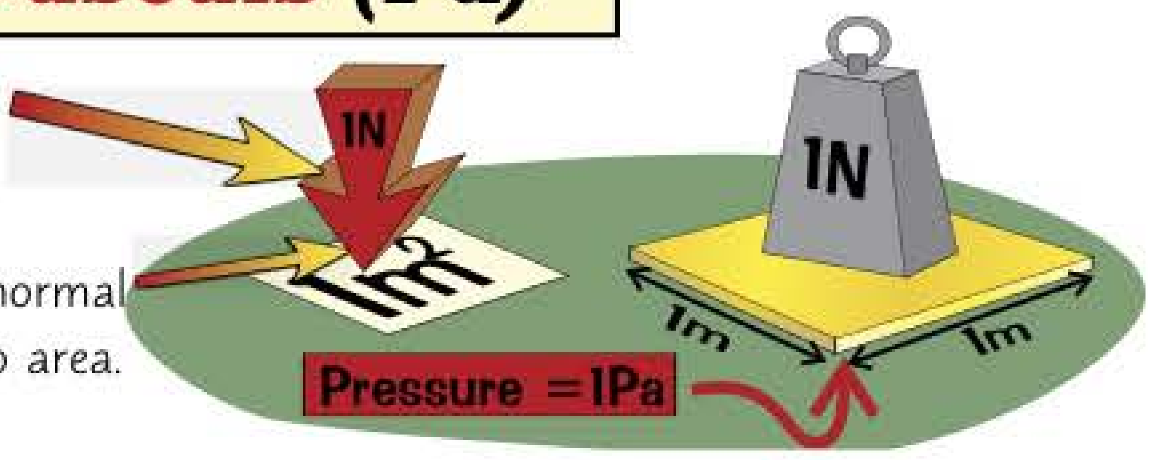
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Pressure is Measured in N/m² or Pascals (Pa)

If a force of 1 newton is spread over an area of 1 m² (like this) then it exerts a pressure of 1 pascal. Simple as that.

$$1 \text{ newton/metre}^2 = 1 \text{ pascal}$$
$$1 \text{ N/m}^2 = 1 \text{ Pa}$$

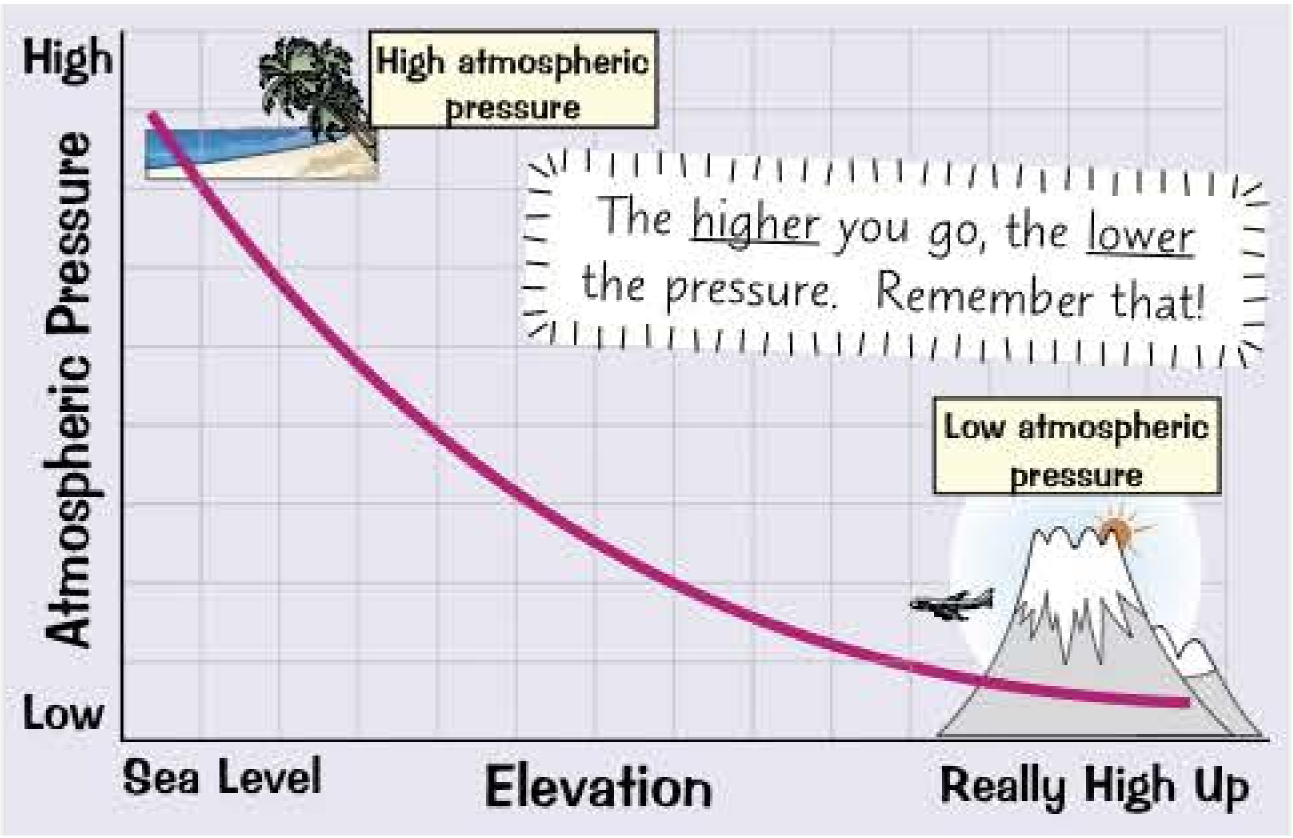
Force acts normal (at 90°) to area.



Atmospheric Pressure is All Around Us All the Time

The weight of the atmosphere is constantly pushing against us — but we're so used to it we can't feel it.

1) The lower you are, the more atmosphere there is above you — so the pressure due to the weight of the atmosphere increases.
2) If you gain height, there's less atmosphere above you, so the atmospheric pressure decreases.
3) Atmospheric pressure is over 100 000 Pa at sea level. But at the top of Mt Everest (8800 m above sea level) the atmospheric pressure is only around 33 000 Pa.



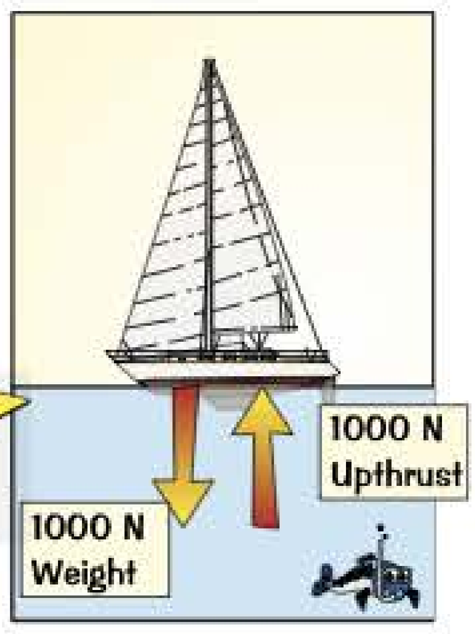
The higher you go, the lower the pressure. Remember that!

The Pressure in Liquids Increases with Depth

For liquids like water, the pressure increases with depth due to the weight of water above.

Water Pressure Causes Upthrust and Makes Things Float

1) If you place an object in water, it experiences water pressure from all directions.
2) Because water pressure increases with depth, the force pushing upwards at the bottom of the object is greater than the force pushing down at the top of the object.
3) This causes an overall upwards force, called upthrust.
4) If the upthrust is equal to the object's weight, then the object will float — like this boat:
5) If the upthrust is less than the object's weight, it will sink.



Pressure — pushing down on you, pressing down on me...

First things first, get that formula learnt. Remember: air and water have a mass. If you increase the amount of this mass above your head, you're increasing the force acting over a given area and you'll get an increase in pressure. That's why pressure in liquids increases with depth and why air pressure decreases with height.

Section Summary

Section 9 is all about forces and motion. It's all pretty straightforward stuff really and the questions below will test whether you've learnt the basic facts.

If you're having trouble learning the stuff, try taking just one page on its own. Start by learning part of it, then covering it up and scribbling it down again. Then learn a bit more and scribble that down. Soon enough you'll have learnt the whole section and be ready to face whatever questions your teachers throw at you.

1) What exactly is speed? Write down the formula triangle for speed.
2) How does SIDOT help you remember what speed is?
3)* A bogie is flicked across the lab by some hoodlum. It travels 5 m in 2 seconds.
Calculate the speed of the bogie.
4)* On sports day you run 100 m in 20 seconds. Can you run faster than the flicked bogie?
5)* When a car is going at 40 mph, how far will it travel in 15 minutes?
6) What does the gradient show on a distance-time graph?
7) What does a straight, flat line mean on a distance-time graph?
8) How would you calculate the relative speed of two trains travelling in the same direction?
9) Can forces be seen? How do we know they're there?
10) What are the units of force? What would you use to measure force?
11) What are the five different things that forces can make objects do?
12) What do balanced forces produce? What do unbalanced forces do?
13) What is friction? When does it occur?
14) Give three good points of friction. Give two bad points of friction.
15) What is air resistance? And water resistance?
16) When a sheep first jumps out of a plane what happens to its speed?
17) As the sheep moves faster, what happens to the air resistance?
18) What happens to air resistance when the sheep's parachute opens?
19) Does the speed then change? When does the sheep's speed become steady?
20) What might happen if the ground didn't provide an upward force to equal the sheep's weight?
21) Draw a force diagram of a kettle resting on a table. The force due to gravity acting on the kettle is 10 N.
22) If the forces acting on a moving bus are balanced, what will happen to its speed?
23) Draw a force diagram showing a bus accelerating. Make sure the arrows are different sizes.
24) What is a pivot?
25) What is a moment? Give the formula for a moment.
26) What does "balanced moments" mean?
27) *A force of 100 N is put 1 m away from the middle of a seesaw.
What distance from the middle should a force of 50 N be applied to balance the seesaw?
28) Give two ways you can deform objects.
29) What does Hooke's Law say? Write down the formula.
30) What is pressure? Give the formula for calculating pressure.
31)* A force of 200 N acts on an area of 2 m^2. Calculate the pressure.
32) Is atmospheric pressure higher at the seaside or up a mountain? Why?
33) When does an object placed in water float?

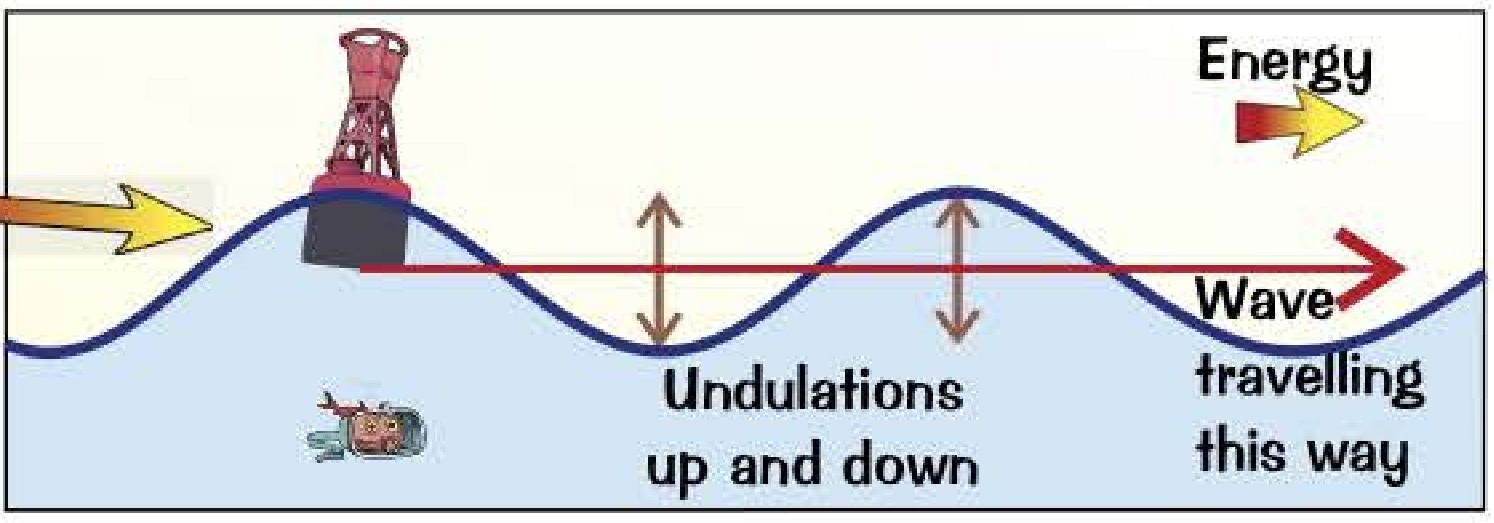
*Answers on page 108

Water Waves

Take a deep breath and dive into the wonderful world of water waves...

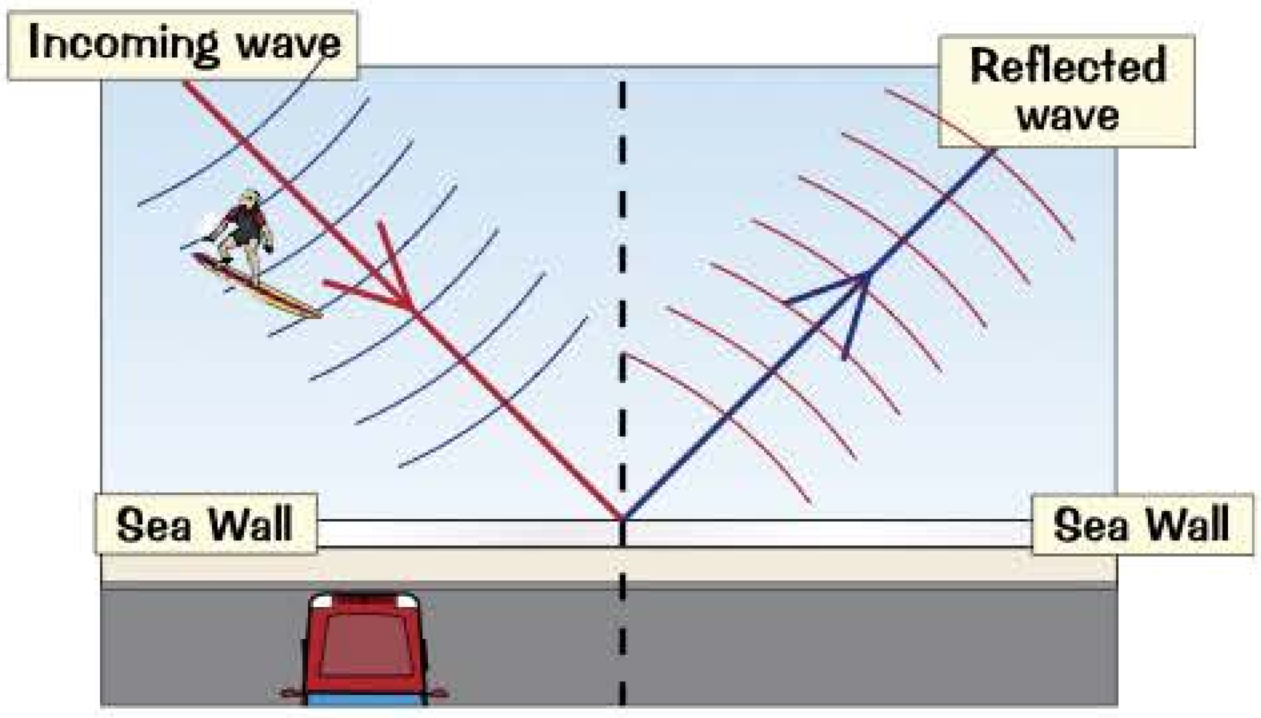
Water Waves are Transverse

1) Waves travelling across the ocean are good examples of transverse waves.
2) A transverse wave has undulations (up and down movements) that are at right angles to the direction the wave is travelling in.
3) Waves transfer energy from one place to another. So the undulations are also at right angles to the direction of energy transfer.
4) Lots of other important waves are transverse too, like light (see next page).

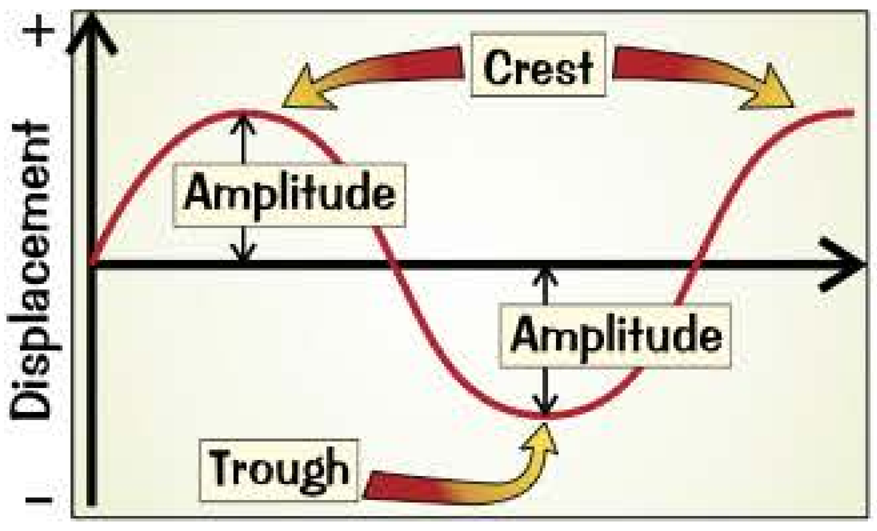


Waves Can be Reflected

1) If a water wave hits a surface, it will be reflected.
2) This causes the direction of the wave to change.
3) All waves can be reflected.
There's more on reflection on page 88.



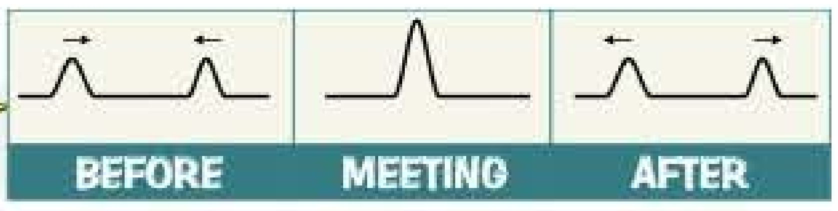
Transverse Waves Have Crests, Troughs and Displacement

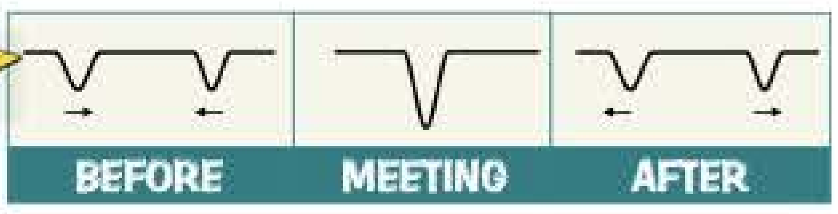


1) The crest is the highest part of the wave.
2) The trough is the lowest part of the wave.
3) The displacement is how far a point on the wave is from the middle line. The amplitude is the maximum displacement — the distance from the middle of the wave to a crest or trough.

Superposition Happens When Two Waves Meet

1) If two water waves meet, their displacements combine briefly. This is superposition. The waves then carry on as they were.
2) If two identical CRESTS meet, the height of each wave is added together. So the crest height doubles.
3) If two identical TROUGHS meet, the depth of each wave is added together. So the trough depth doubles.
4) If one wave is at a crest and the other is at a trough, you subtract the trough depth from the crest height. So the crest or trough will be smaller and may even cancel out, leaving a flat water surface.





Don't let your progress waver — reflect on what you've learnt...

Eeek, that was a bit complicated. So grab a piece of paper and write down all the technical terms on this page and what they mean. Then draw and explain the diagrams. Finally, do all that again with the book closed.

Light Waves

You wouldn't know from looking, but light is actually a wave. Here's a page all about it...

Light is a Wave that Transfers Energy

1) Light is produced by luminous objects such as the Sun, candles, light bulbs, flames and glow worms.
2) Light is a wave, which always travels in a straight line.

Light Waves and Water Waves Are Similar...

1) Like waves in water, light waves are transverse waves — they have undulations at right angles to the direction the wave is travelling in (see previous page).
2) And like waves in water, light waves transfer energy from one place to another.
3) Light waves can be reflected too — this is how mirrors work (see next page for more).

...But Light Waves Don't Need Particles to Travel

1) Water waves travel (and transfer energy) by moving particles.
2) Light waves don't need particles to travel. This is a good thing — light from the Sun has to travel through space (where there aren't many particles, see below) to reach Earth.
3) Light waves are slowed down by particles.

Light Waves Always Travel at the Same Speed in a Vacuum

1) Light travels faster when there are fewer particles to get in the way.
2) Light always travels fastest in a vacuum. A vacuum is where there is nothing at all — no air, no particles, nothing. Space is mostly a vacuum.
3) The speed of light in a vacuum is always 3×10^8 m/s (that's three hundred million metres per second). It's a constant.
4) This means light from the Sun gets to Earth in only 8.3 minutes — even though it's 150,000,000 km away.
5) Nothing travels faster than light in a vacuum.
6) Make sure you learn this:

Speed of light waves in a vacuum = 3×10^8 m/s

7) Although light is slower when it has to travel through matter (like air or water), it's still so fast that its movement appears instant to the human eye.

Confused? Let me shed some light on the problem...

So there you have it. Light is just like all those waves you see at the beach. Except that it doesn't need a load of water to get from A to B — anything like water puts a load of particles in the way and slows the light waves down. Nope, light only hits top gear when it's in a vacuum with absolutely nothing in the way at all.

Reflection and Refraction

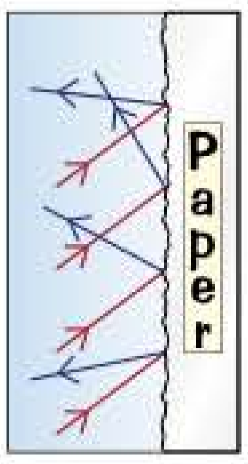
Take a moment and reflect on what you're about to learn...

Mirrors Have Shiny Surfaces Which Reflect Light

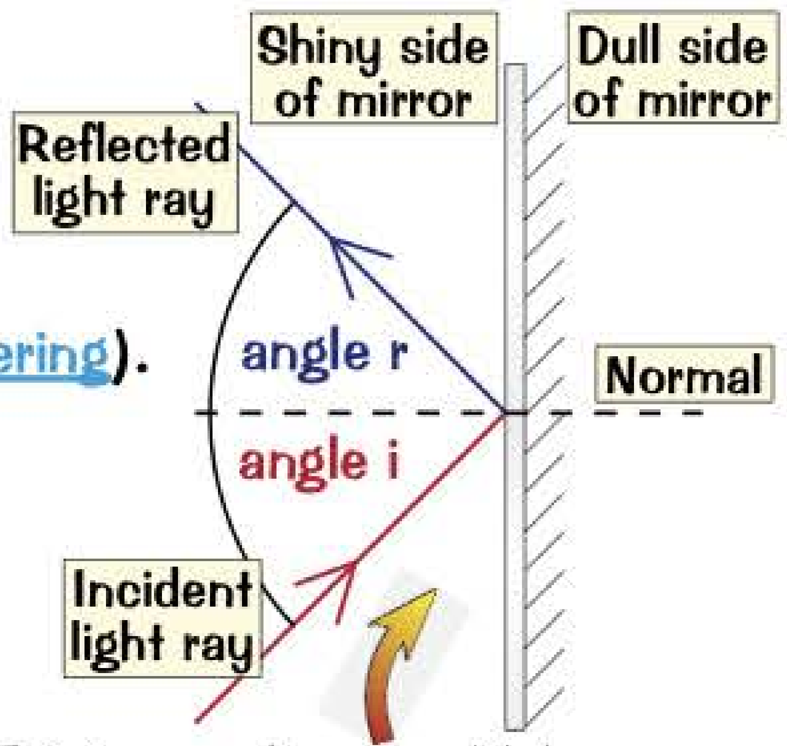
1) A light wave is also known as a light ray. Light rays reflect off mirrors and most other things.
2) Mirrors have a very smooth shiny surface. The shiny surface allows each light ray to reflect off it at the same angle, giving a clear reflection. This is specular reflection.
3) Rough surfaces look dull, because the light is reflected back in lots of different directions (scattered). This is diffuse reflection (or diffuse scattering).
4) Learn the LAW OF REFLECTION:

> ANGLE OF INCIDENCE = ANGLE OF REFLECTION
> ANGLE i = ANGLE r

5) The angle of incidence and the angle of reflection are always measured between the light ray and the normal.
6) The normal is a line at a right angle (90°) to the surface.



Not shiny



This is a ray diagram. Make sure you draw straight lines and get the angles the same when drawing ray diagrams (use a ruler and a protractor).

Refraction is When Light Bends as it Crosses a Boundary

1) Light will travel through transparent (see-through) material, but it won't go through anything opaque (not see-through).
2) Any substance that light (or another wave, e.g. sound) travels through is called a medium.
3) When light travels from one transparent medium to another, it bends or refracts.

LEARN THESE REAL GOOD:

> When light goes from a LESS dense medium to a MORE dense medium: light bends TOWARDS THE NORMAL.

Example: air to glass.

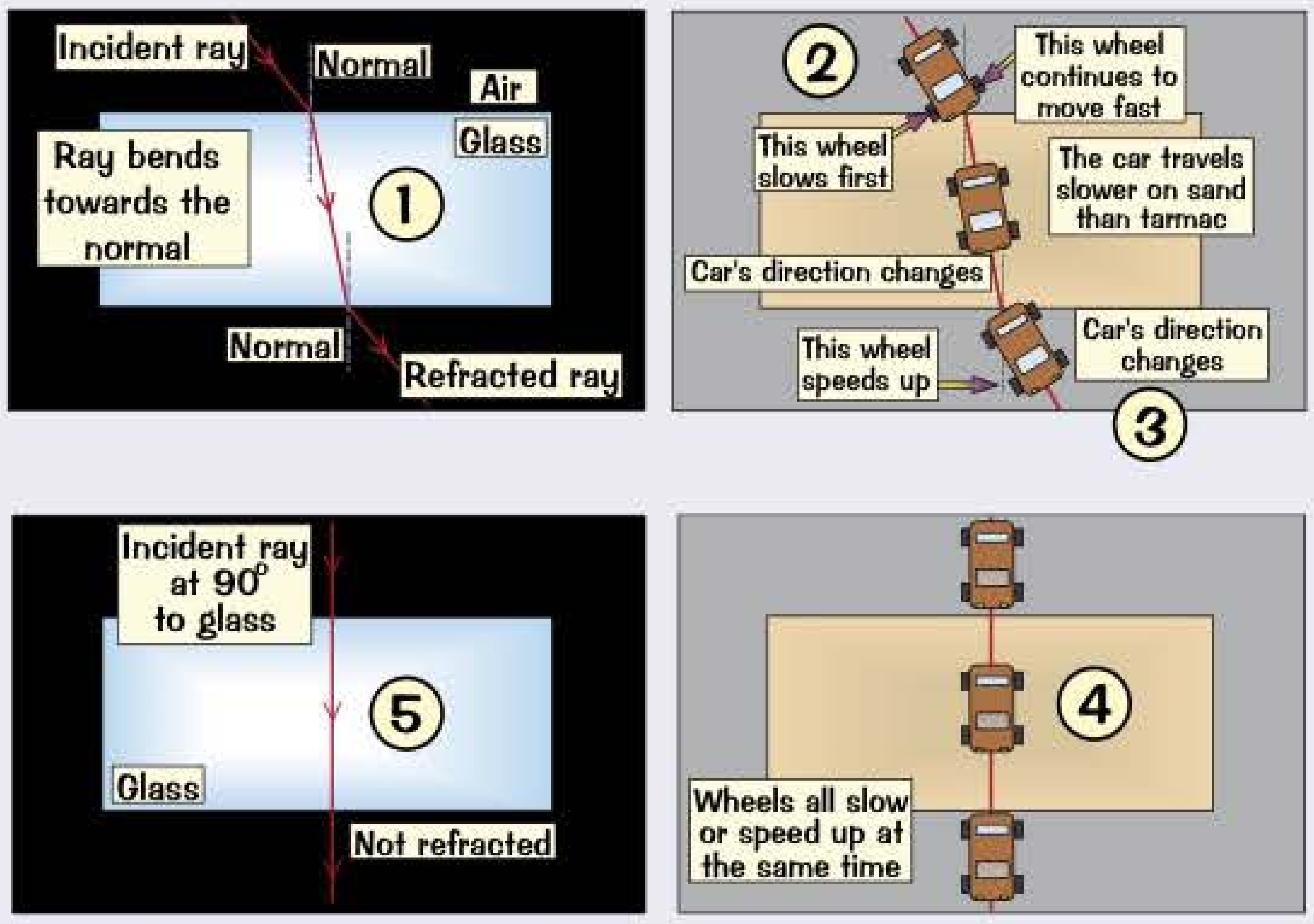
> When light goes from a MORE dense medium to a LESS dense medium: light bends AWAY FROM THE NORMAL.

Example: glass to air.

The plural of medium is 'media'.

Light hitting a glass block is like a car hitting sand

1) Light hits the glass at an angle, slows down and bends.
2) It's a bit like a car hitting sand at an angle. The right wheels get slowed down first and this turns the car to the right — TOWARDS the normal.
3) Leaving the sand, the right wheel speeds up first and this turns the car to the left — AWAY from the normal.
4) If both wheels hit the sand together they slow down together, so the car goes straight through, WITHOUT TURNING.
5) Light does exactly the same when it hits the glass block straight on.



My friend thought she was a medium — but I saw through her...

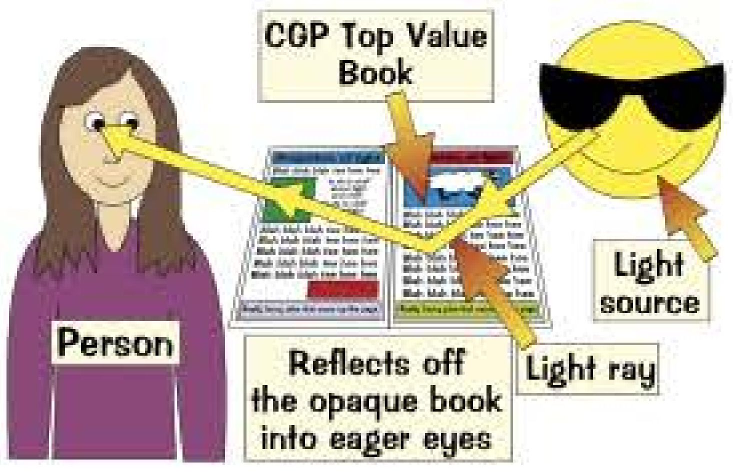
Reflection and refraction — the first thing you've gotta do is spot that they're actually two different words. Watch, I'll do it again: ref-l-e-c-tion and ref-r-a-c-tion. Now all you need to do is learn what they both are.

How We See

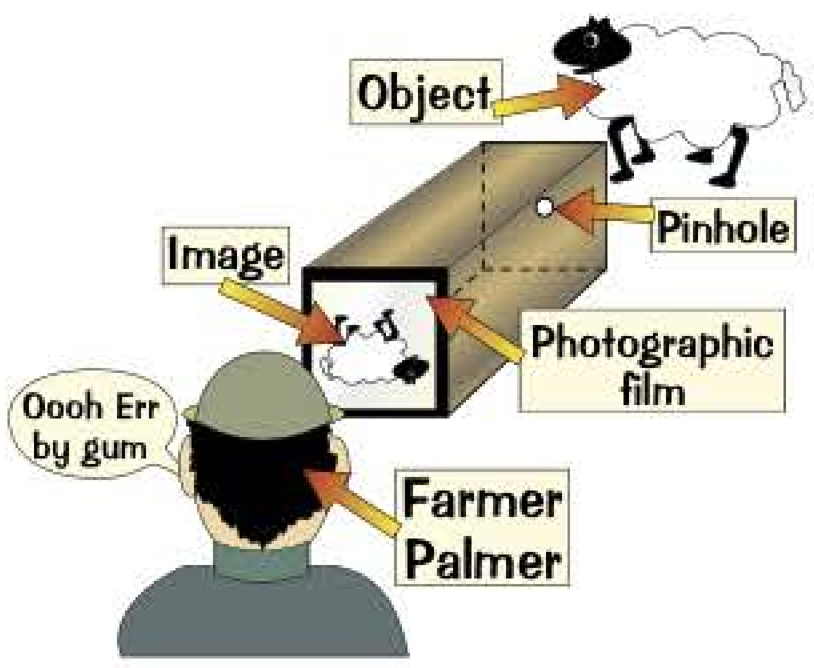
An important page this one — it's all about how we see stuff.

We See Things Because Light Reflects into our Eyes

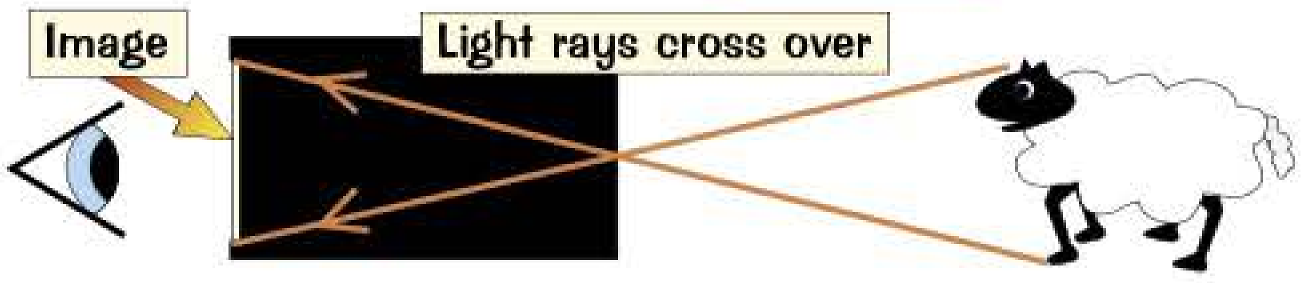
1) When luminous objects produce light (see page 87), it reflects off non-luminous objects, e.g. you, me, books, sheep, etc.
2) Some of the reflected light then goes into our eyes and that, my friend, is how we see.



The Pinhole Camera is a Simple Camera

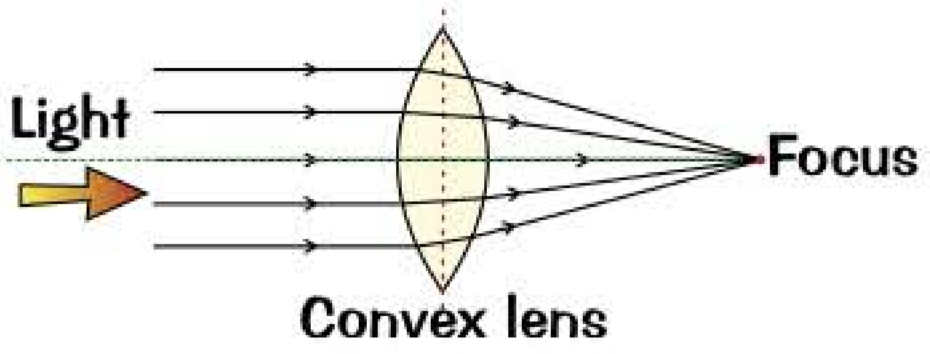


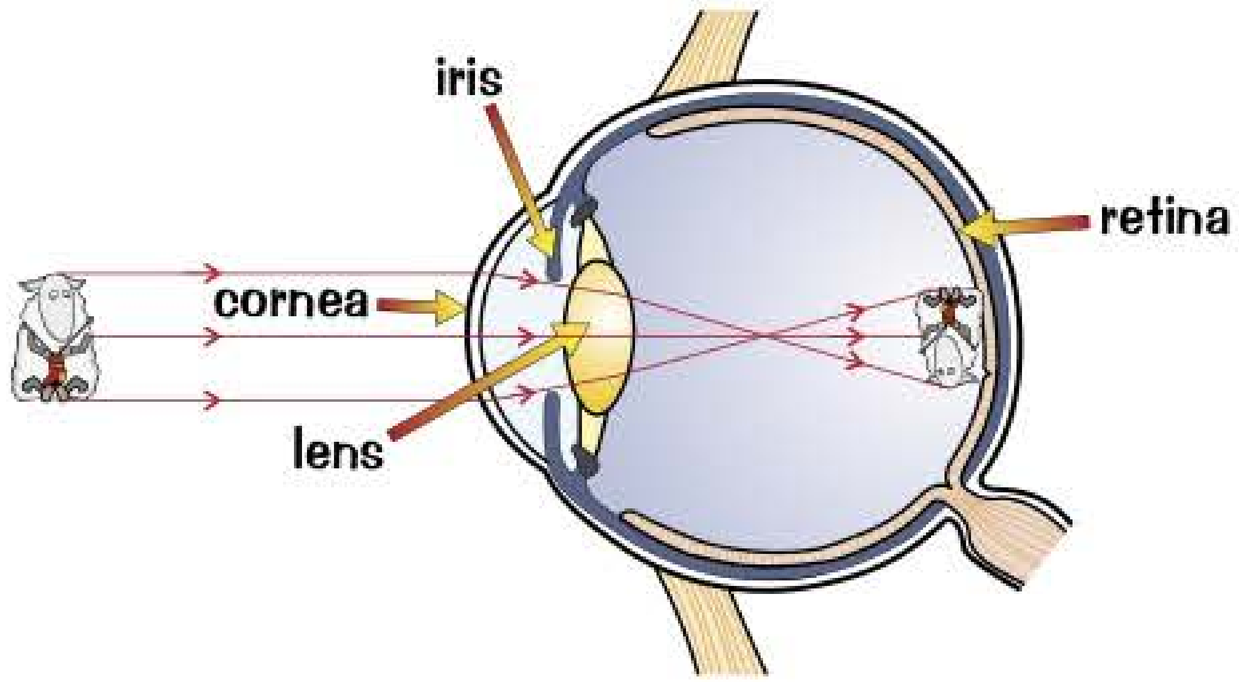
1) The light travels in a straight line from the sheep to the photographic film through the pinhole. Because the hole is small, only one ray gets in from each point on the sheep.
2) The image of the sheep seen by the farmer is upside down and crossed over. This is because the rays of light cross over inside the camera:



Lenses Can be Used to Focus Light

1) A lens refracts (bends) light.
2) A convex lens bulges outwards. It causes rays of light to converge (move together) to a focus.

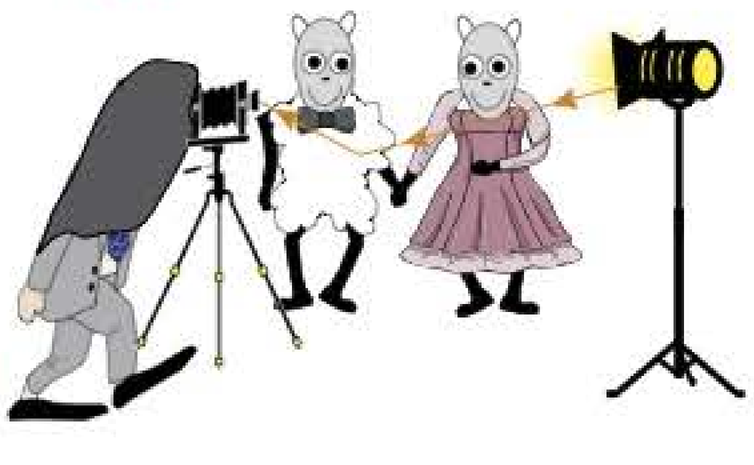




3) In the human eye, the cornea is a transparent 'window' with a convex shape. The cornea does most of the eye's focusing.
4) The convex lens behind the cornea changes shape to focus light from objects at varying distances.
5) The iris is the coloured part of the eye. It controls the amount of light entering the eye.
6) Images are formed on the retina. Cells in the retina are photo-sensitive (sensitive to light).

Energy is Transferred From a Light Source to an Absorber

1) Energy is carried by light waves.
2) Anything that absorbs this energy is called an absorber, e.g. a retina cell in the eye, the film in a film camera or the digital image sensor in a digital camera.
3) The energy is transferred to the absorber when it hits the absorber.
4) When light waves hit a retina cell it causes chemical and electrical changes in special cells that send signals to the brain.
5) In a digital camera, light causes the sensor to generate an electrical charge. The changes in charge are read by a computer and turned into an image.



Next up — How We Dee, Eee and Eff...

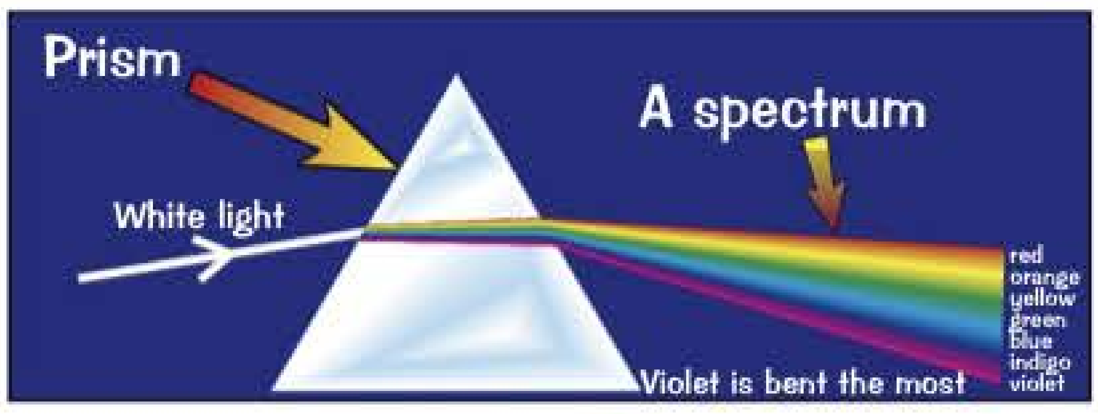
So that's how we see stuff. Now it needs learning — so cast your gaze back up to the top of the page and read it all over again. Then cover up the book and note down the most important bits.

Colour

Ok, prepare yourself — there's a big plot twist coming up on this page. Hold on to your hats.

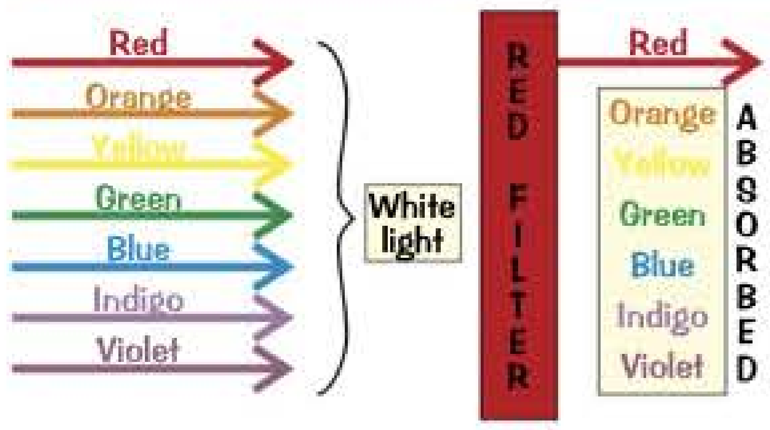
White Light is Not just a Single Colour

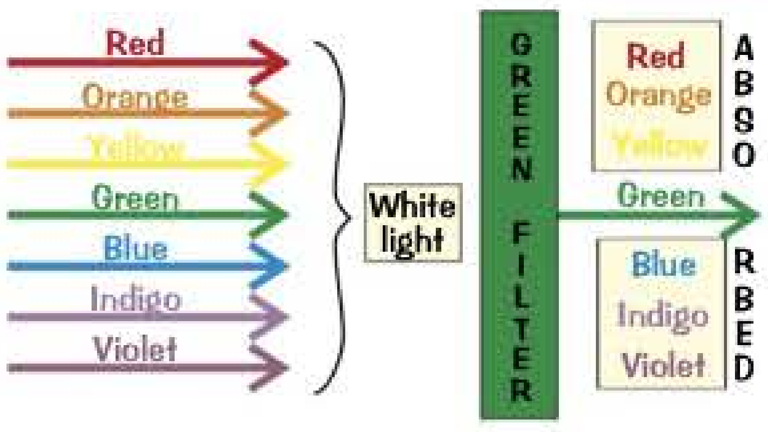
1) Bit of a shocker, I know — but white light is actually a mixture of colours.
2) This shows up bigstyle when white light hits a prism or a rain drop. It gets dispersed (i.e. split up) into a full rainbow of colours.
3) The proper name for this rainbow effect is a spectrum.
4) Learn the order that the colours come out in:
   Red Orange Yellow Green Blue Indigo Violet
   Remember it with this historical jollyism:
   Richard Of York Gave Battle In Velvet
5) The frequency of light is the number of complete waves that pass a point per second.
6) Light waves increase in frequency from red (low frequency) to violet (high frequency).

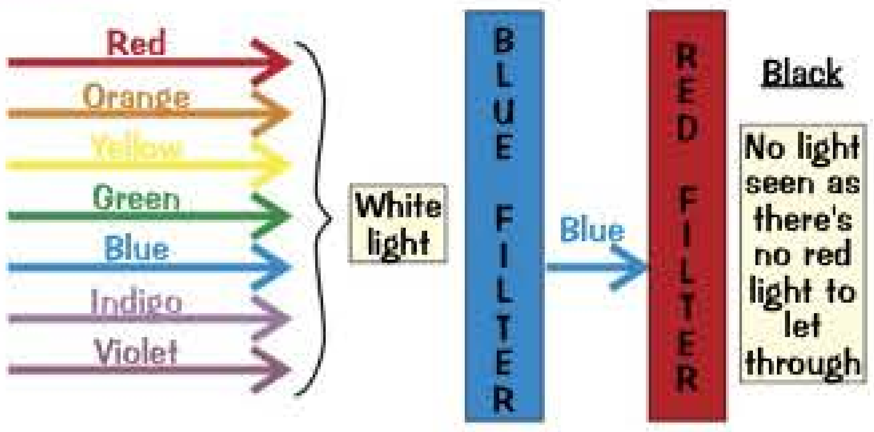


Coloured Filters Only let Their Colour Through

1) A filter only allows one particular colour of light to go through it.
2) All other colours are ABSORBED by the filter — so they don't get through.

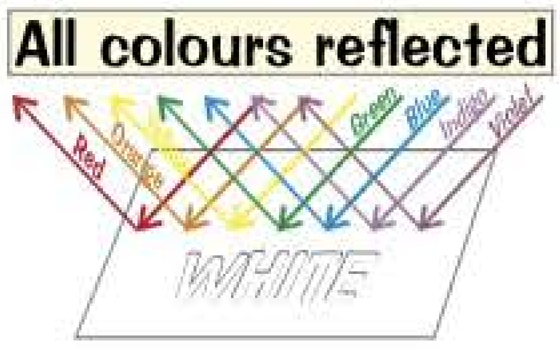


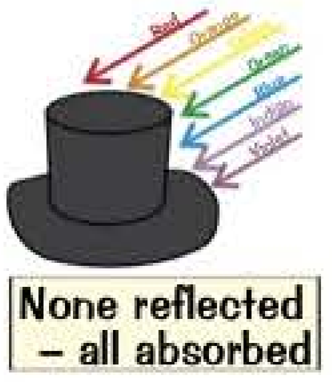




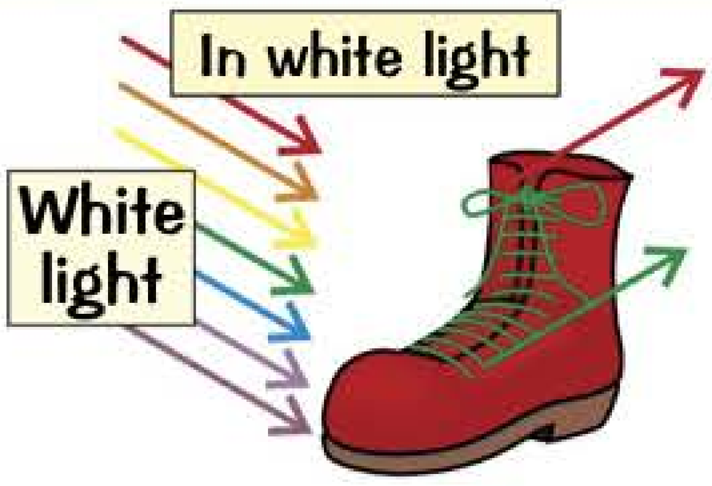
Coloured Objects Reflect Only That Colour

1) Blue jeans are blue because they diffusely reflect blue light and absorb all the other colours.
2) White objects REFLECT all colours.
3) Black objects ABSORB all colours.

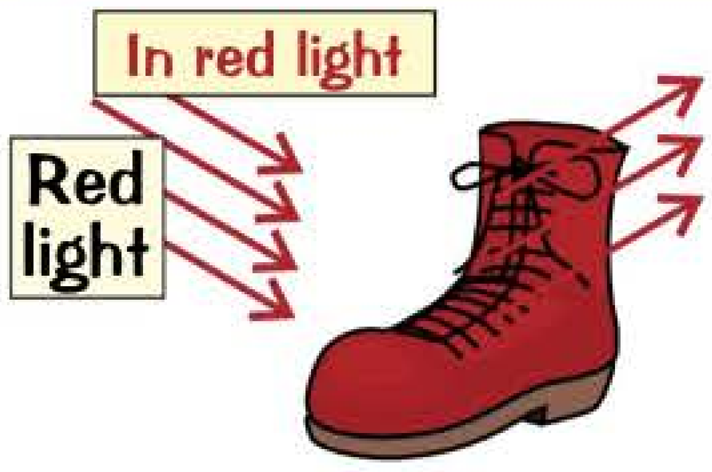




Objects Seem to Change Colour in Coloured Light



1) The boot looks red — it reflects red light and absorbs all other colours.
2) The lace looks green — it reflects green light and absorbs all other colours.



1) The boot looks red — it reflects the red light.
2) The lace looks black — it has no green light to reflect and it absorbs all the red light.

1) The boot looks black — it has no red light to reflect and it absorbs the green light.
2) The lace looks green — it reflects the green light.

Red boots and green laces? Colour me impressed...

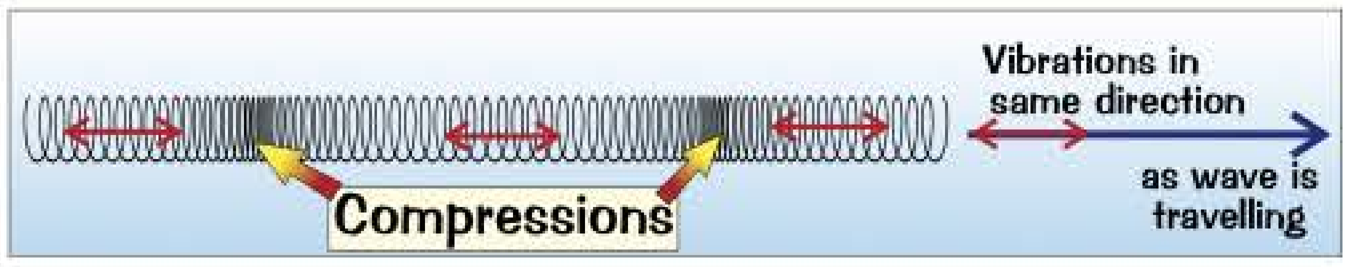
Light — it's full of different colours, but they're all mixed up together so it looks white. Better get learning it.

Sound

Like light, sound is a wave. It's a different type of wave to light though.

Longitudinal Waves Have Vibrations Along the Same Line

1) Longitudinal waves have vibrations that are parallel to the direction of the wave.
2) This means the vibrations are also parallel to the direction of energy transfer.
3) Examples of longitudinal waves include:
   - Sound waves.
   - A slinky spring when you push the end.

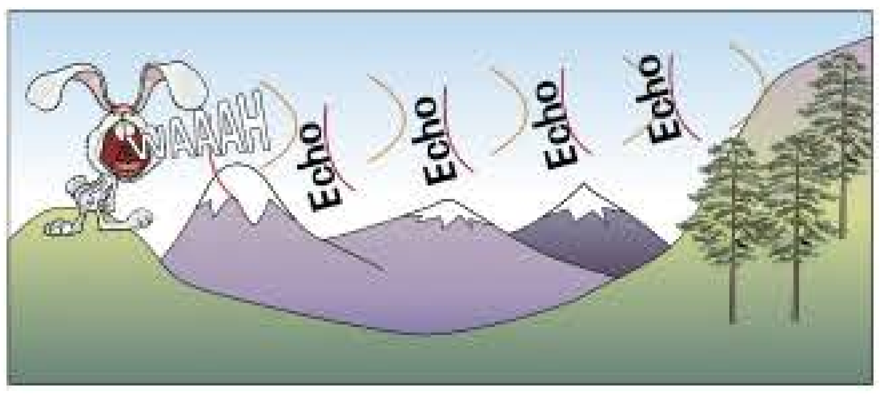


Sound Travels as a Longitudinal Pressure Wave

1) Sound waves are caused by vibrating objects.
2) Sound needs a medium (e.g. air or water) to travel through because something has to pass on the sound vibrations.
3) The vibrations are passed through the medium as a series of compressions (regions of squashed up particles).
4) Sound can't travel in space, because it's mostly a vacuum (there are no particles).

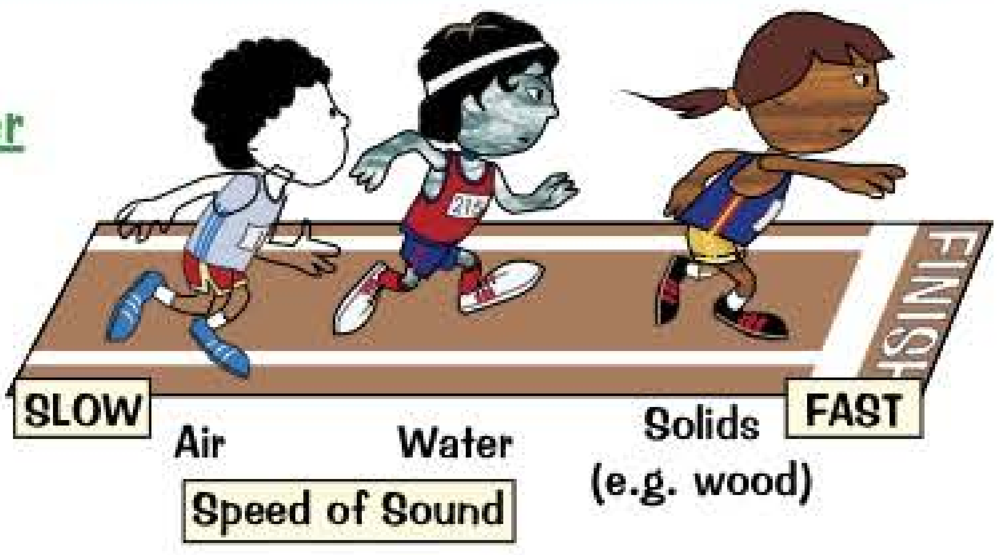
Sound Can be Reflected and Absorbed

1) Sound can be reflected and refracted just like light (see page 88). An echo is sound being reflected from a surface.
2) Sound can also be absorbed. Soft things like carpets, curtains, sheep, etc. absorb sound easily.



The Speed of Sound Depends On What it's Passing Through

1) The more particles there are, the faster a sound wave travels.
2) Dense media have lots of particles in a small space. So the denser the medium, the faster sound travels through it (usually).
3) Sound generally travels faster in solids (like wood) than in liquids (like water) — and faster in liquids than in gases (like air).
4) Sound travels much slower than light.



Frequency is the Pitch of Sound

1) The frequency of sound is the number of complete waves that pass a point per second. A high frequency means more vibrations per second.
2) Frequency is a measure of how high-pitched (squeaky) the sound is. A high frequency means a high-pitched sound.
3) Frequency is measured in hertz (Hz) — the number of vibrations per second.

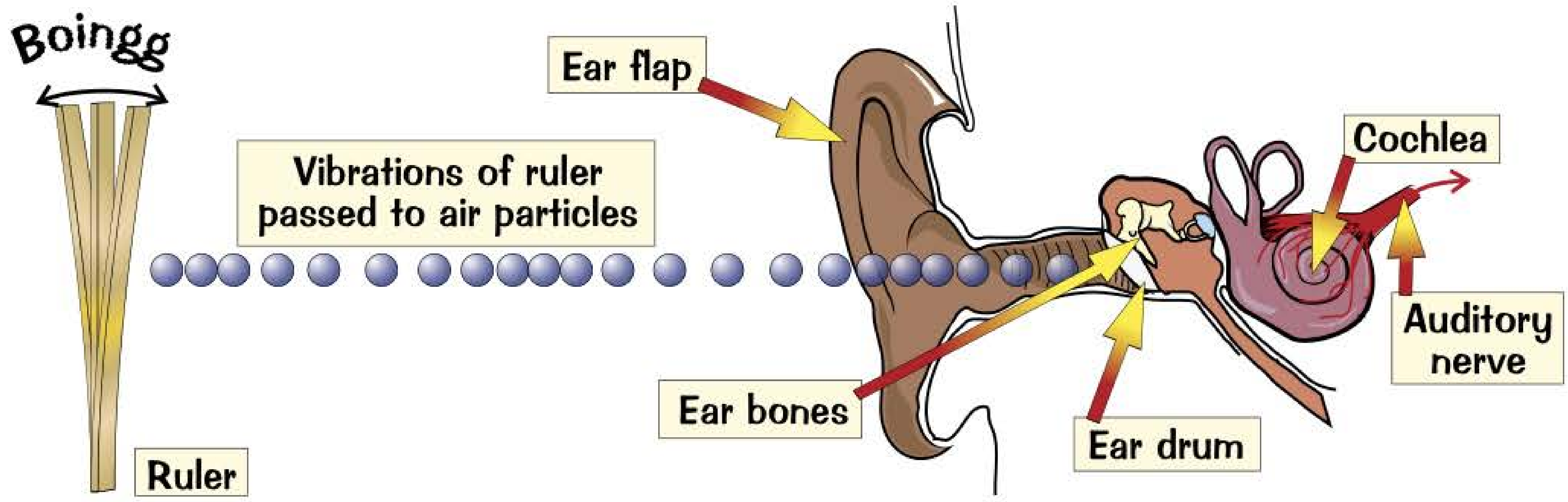
Dear Coldplay, birds can't fly at the speed of sound. Love, CGP.

Yep. That's another sort of wave for you to get your head around. Sound waves are caused by vibrations — if you've ever put a hand on a bass speaker (or turned up the volume and felt the floor vibrate) you'll have 'felt' a sound wave being made. Higher-pitched sounds are just the same, but the vibrations are more frequent.

Hearing

They say gags about mishearing don't work in books. I think that's silly — I'm not fearing anything. Anyway, let's crack on with this here page...

Sound Waves Make Your Ear Drum Vibrate



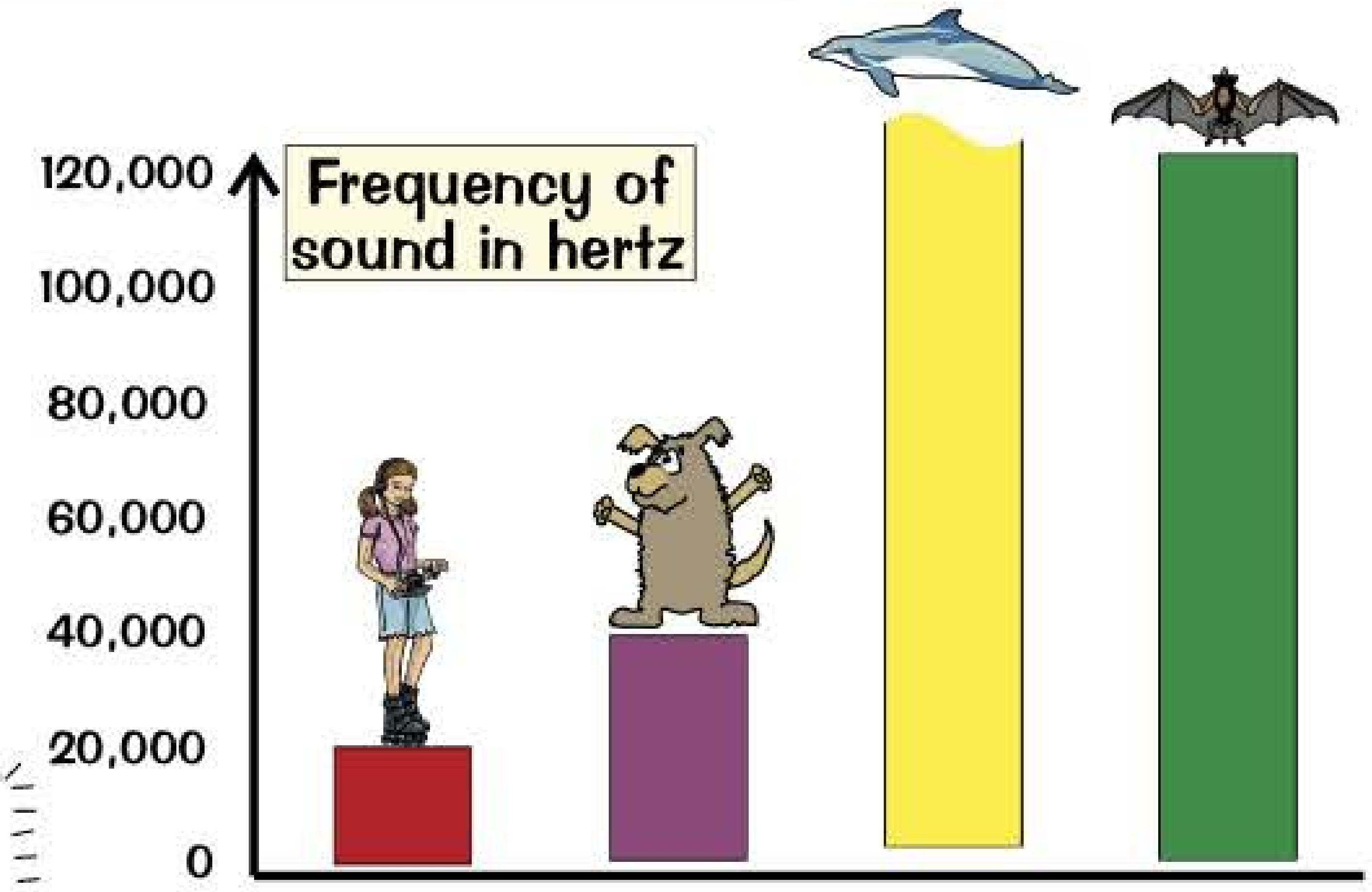
Object vibrates → Air vibrates → Ear drum vibrates → Ear bones vibrate → Hairs vibrate in the cochlea, sending a message to the brain (along the auditory nerve).

People and Animals Have Different Auditory Ranges

Your AUDITORY RANGE is the range of frequencies (vibrations per second) that you can hear.

1) The auditory range of humans varies a lot — but it's typically 20-20 000 Hz.
2) This means we can't hear low-pitched sounds with frequencies of less than 20 Hz or high-pitched sounds above 20 000 Hz.
3) Some animals like dogs, bats and dolphins can hear much higher frequencies than humans, as the chart shows.

Look back at the previous page for more on frequency and pitch.



Save 50% on your auditory range — chop an ear off...

Hey I tell you what, it's a bit of a blockbuster of a diagram that one at the top isn't it? I reckon you really should learn what all the labels are. Remember that we hear things because the air carries the vibrations right into our ear. Also learn all the stuff about auditory ranges — you never know when it might come in useful.

Energy and Waves

You might remember how waves transfer energy (page 86). Well here's a whole page on how useful that is.

Information Can be Transferred by Pressure Waves

1) All waves transfer energy from one place to another. In doing so, they can also transfer information.
2) Sound waves do this through vibrations between particles — in other words, the pressure changes.
3) This is very useful for recording and replaying sounds.

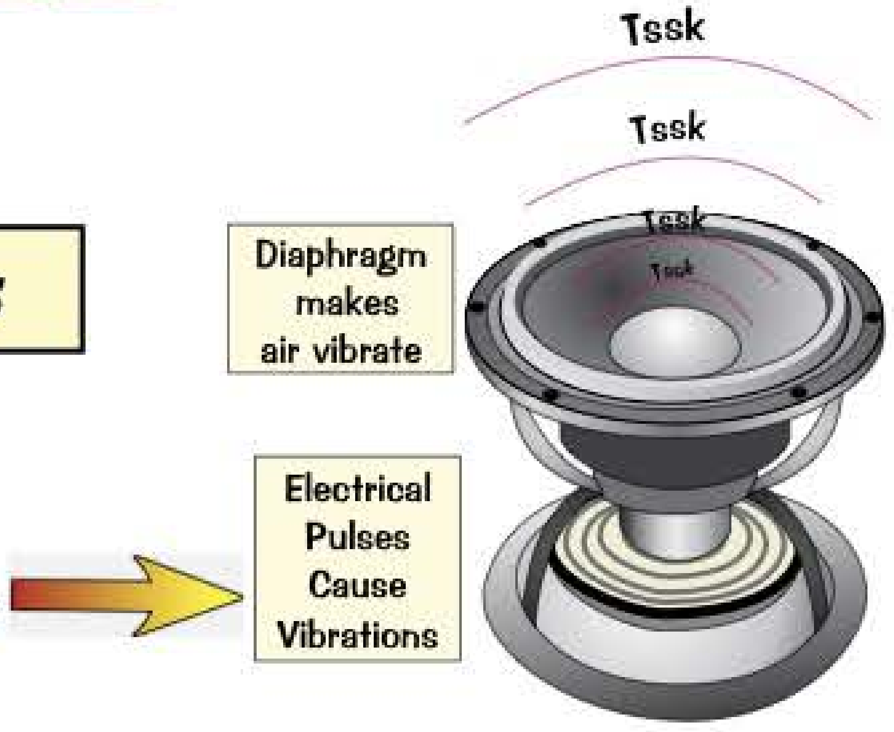
Sound Waves are Detected by Diaphragms in Microphones

1) The vibrations in a sound wave make a sensitive diaphragm (e.g. a thin paper or plastic sheet) vibrate inside the microphone.
2) The microphone converts the vibrations to electric signals.
3) Another device can record the electrical signals so that the sound can be reproduced later.

Loudspeakers Recreate Sound Waves

1) An electrical signal is fed into a loudspeaker.
2) This signal causes the diaphragm to vibrate.
3) This makes the air vibrate, producing sound waves.

It's a bit like a microphone in reverse.



Ultrasound is High Frequency Sound That We Can't Hear

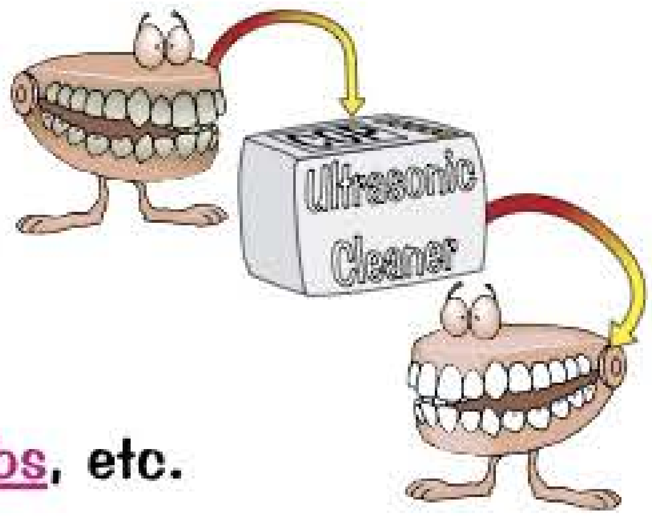
1) Ultrasound includes all sounds that have a higher pitch than the normal auditory range of humans.
2) So that'll be any sound over 20 000 Hz.

Ultrasonic Cleaning Uses Ultrasound

High-frequency sound waves are used to clean things — the vibrations of the pressure waves dislodge dirt in tiny cracks that wouldn't normally be cleaned.

1) An item is placed in a special bath filled with water (or another liquid).
2) High-pressure ultrasound waves cause bubbles to form in cavities (holes).
3) The bubbles knock any bits of dirt (contaminants) off the object, leaving it clean enough to eat your dinner off.

You can use ultrasonic cleaning to clean jewellery, false teeth, fountain pen nibs, etc.



Ultrasound Physiotherapy May be Helpful

1) Ultrasound pressure waves transfer energy through matter — so they can reach inside your body.
2) Some physiotherapists think that this means ultrasound can be used to treat aches and pains in parts of the body that are hard to access — like muscles and tendons deep inside your shoulders.
3) But scientists have found little evidence that ultrasound physiotherapy is an effective treatment.

Ultrasound? What's next, SuperDuperSound?

This page is full of uses for the energy that is transferred by sound waves. And just in case you were wondering, you do have to learn them. Listening to your music player on the way to school doesn't count...

Section Summary

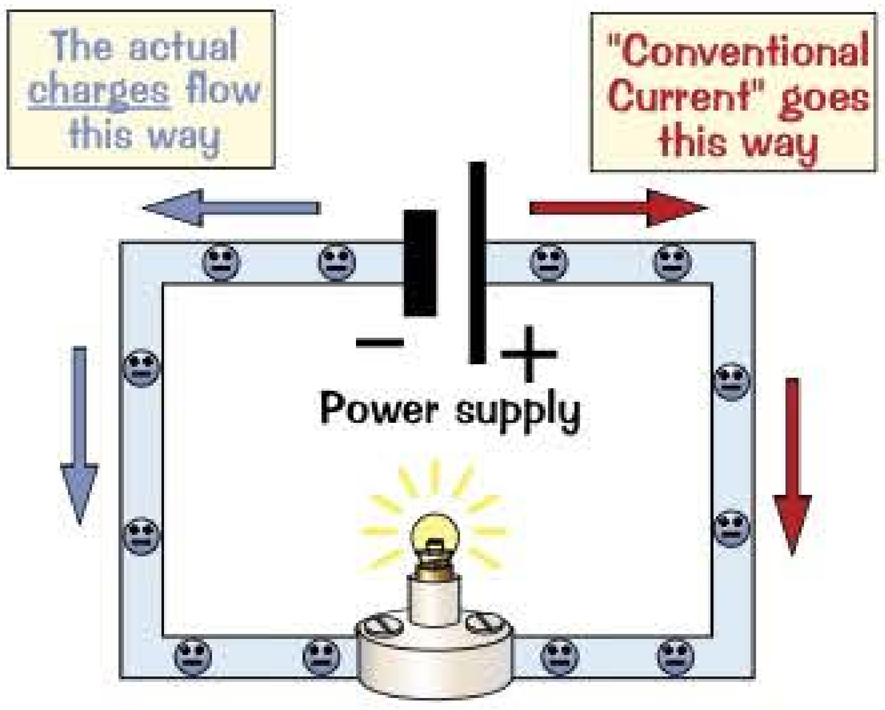
Section 10 tells you everything you need to know about waves. There are quite a few words in there — and some pretty important diagrams too. Science isn't always a complete doddle, so you're bound to find some of the facts a bit tricky to learn. Never fear! As somebody famous once said, "Nothing can take the place of persistence" — in other words, if you want to achieve anything worthwhile or difficult, all you have to do is keep on slogging away at it. Better get cracking with this lot then...

1) What do water waves look like? Sketch out a diagram and label it.
2) Describe what happens to the displacement when two waves meet. What is this called?
3) Give three similarities between water waves and light waves.
4) Give one big difference between water waves and light waves.
5) What speed does light travel at in a vacuum?
6) What is meant by a diffuse reflection?
7) What is the law of reflection?
8) What does that bizarre word "medium" mean?
9) What is refraction?
10) What happens when light goes from a less dense medium to a more dense medium?
11) What happens when light goes from a more dense medium to a less dense medium?
12) Explain in your own words why light "bends" as it enters a glass block.
13) Sketch a diagram of a pinhole camera.
14) Use a diagram to explain why the image is upside down and crossed over.
15) Draw a diagram to show how a convex lens refracts parallel rays of light.
16) Which two parts of the eye help you focus on an object?
17) How do digital cameras form images?
18) How could you show that white light is not just one colour?
19) What is the jollyism for remembering the order of colours in a spectrum?
20) What colour of light has the highest frequency?
21) What colour of light will a red filter let through?
22) Why does something blue look blue in white light?
23) What happens to all the colours in white light when they hit a black object?
24) What colour would green laces look in red light and why?
25) What type of wave are sound (pressure) waves? In which direction are the vibrations?
26) What does sound need to travel from one place to another?
27) Why couldn't you hear a ringing bell in a vacuum?
28) What is an echo?
29) Does sound usually travel faster in solids, liquids or gases? Explain your answer.
30) What does the frequency of a sound mean?
31) Draw a labelled diagram of an ear. Explain how a flicked ruler can be heard.
32) What does auditory range mean?
33) What is the auditory range of humans?
34) How do microphones work?
35) What is ultrasound? What can it be used for?

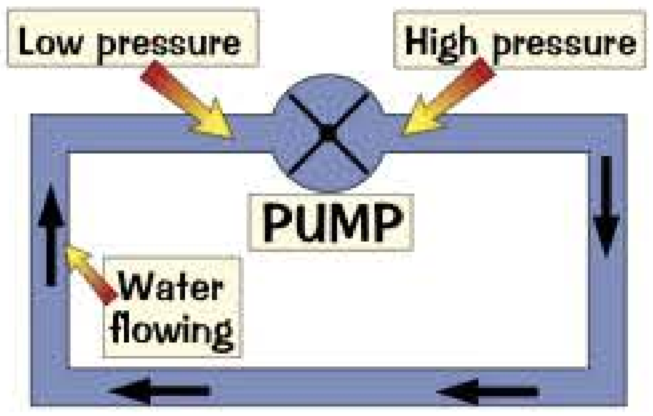
Electrical Circuits

First up in this section, some electricity basics...

Electric Current is the Flow of Charge



1) Electric current is the flow of charge around a circuit.
2) It can only flow if a circuit is complete.
3) The moving charges are actually negative electrons (page 98).
4) Irritatingly, they flow the opposite way to the direction of conventional current, which is shown on circuits as arrows pointing always from positive to negative.
5) It's vital that you realise that CURRENT IS NOT USED UP as it flows through a circuit. The total current in the circuit is always the same.



Current is a bit like water flowing...

The pump drives the water along like a power supply. The water is there at the pump and is still there when it returns to it — and just like the water, electric current in a circuit doesn't get used up either.

Potential Difference Pushes the Current Around

1) In a circuit the battery acts like a pump — it provides the driving force to push the charge round the circuit. This driving force is called the potential difference.
2) If you increase the potential difference more current will flow.
3) Different batteries have different potential differences. You can put several batteries together to make a bigger potential difference too.

Potential difference is sometimes called voltage.

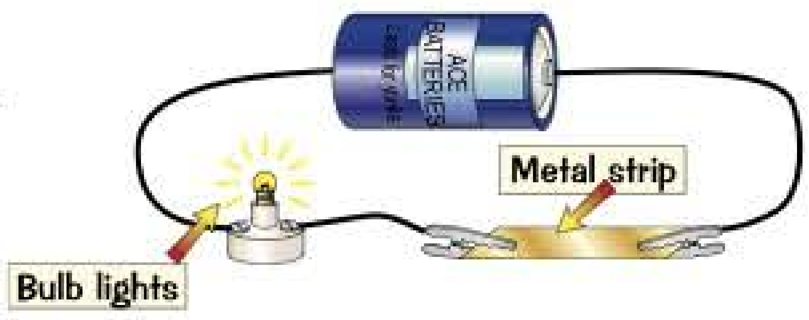
Resistance is How Easily Electricity Can Flow

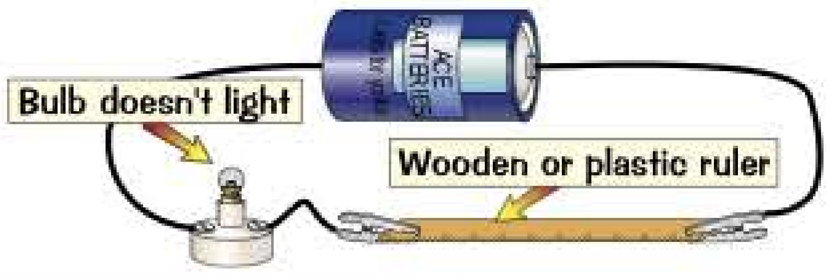
1) Resistance is anything in a circuit that slows down the flow of current. It is measured in ohms (Ω).
2) You can calculate the resistance of a component by finding the ratio of the potential difference and current. This is just a fancy way of saying:

RESISTANCE = POTENTIAL DIFFERENCE ÷ CURRENT

A component is anything you put in a circuit.

3) This means that as long as the potential difference stays the same, the higher the resistance of a component, the smaller the current through it.
4) Components and materials that electricity can easily travel through are called conductors. Metals are good conductors of electricity (p.42).
5) Insulators (e.g. wood) are components and materials that don't easily allow electric charges to pass through them.
6) The lower the resistance of a component, the better it is at conducting electricity.





E.g. bulb A has a resistance of 3 Ω and bulb B has a resistance of 1.5 Ω. Bulb B has a lower resistance, so bulb B is a better conductor than bulb A.

I power all my cakes with electric currents...

Here we have a page that covers all the really basic stuff about electricity. Comparing electric current with water really does help make things clear, so make sure you get that example clear in your head.

Measuring Current and Potential Difference

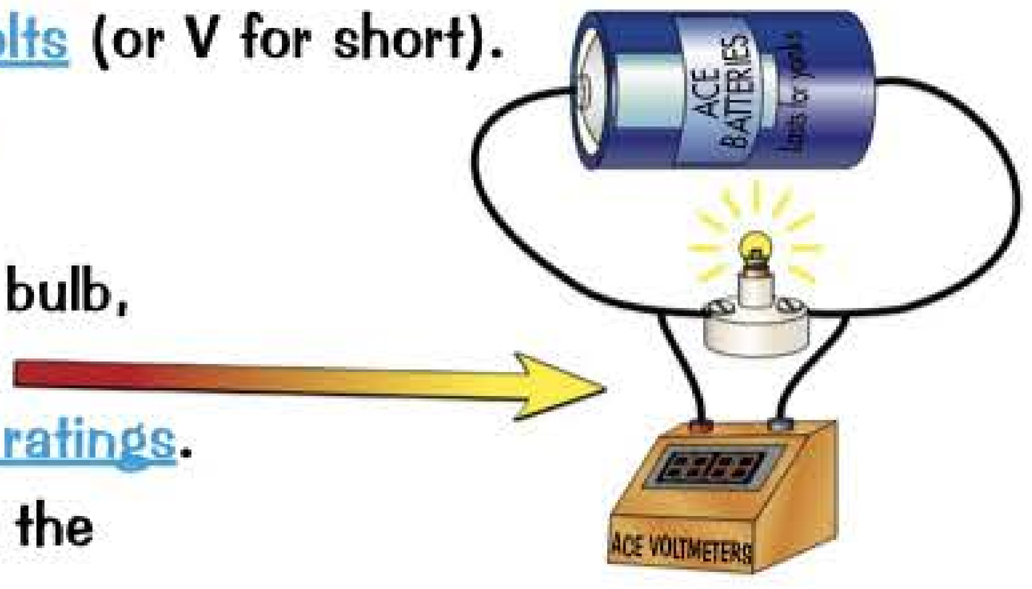
Sadly you don't just need to know what current and potential difference are — you need to be able to measure them too. Handily, some clever chaps have made machines to do just that...

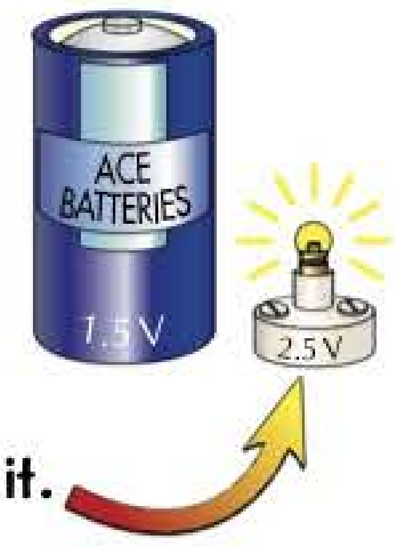
Ammeters Measure Current

1) Ammeters measure electric current. It's measured in amperes (or amps, A, for short).
2) You measure the current through a circuit by inserting the ammeter into the circuit like this:
3) Remember — current doesn't get used up, so the current through the ammeter is the same as through the bulb.

Voltmeters Measure Potential Difference

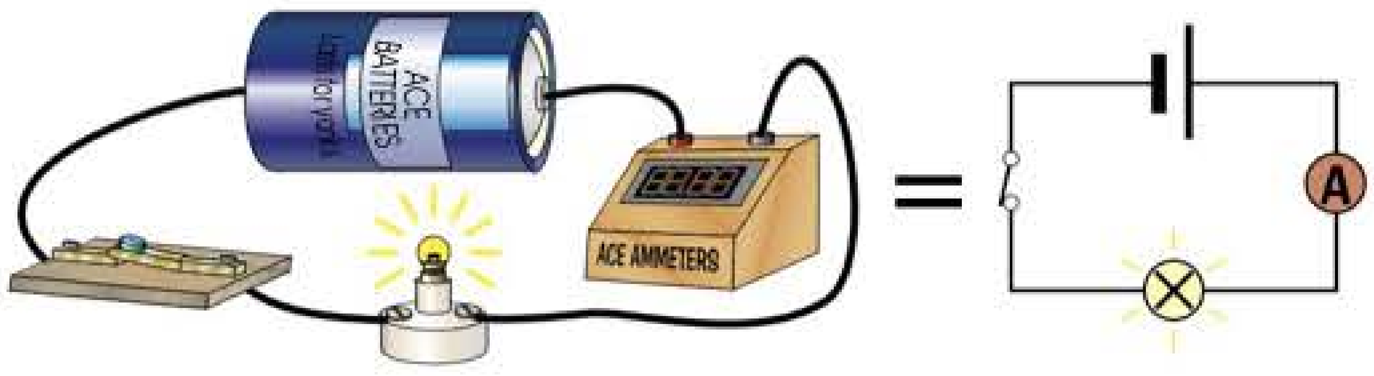
1) Voltmeters measure potential difference in volts (or V for short).
2) You measure the potential difference across something in the circuit, such as a bulb.
3) To measure the potential difference across a bulb, you'd connect a voltmeter across it like this:
   Batteries and bulbs have potential difference ratings.
4) A battery potential difference rating tells you the potential difference it will supply.
5) A bulb rating tells you the maximum potential difference that you can safely put across it.



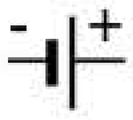


Circuit Diagrams Represent Real Circuits

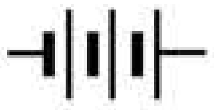
Circuit diagrams are simplified drawings of real circuits. You start at the cell or battery and go round the circuit, putting in the symbol for each component.



Here are the circuit symbols you need to know:

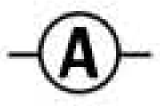
A cell = 

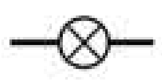
(a single energy source) 

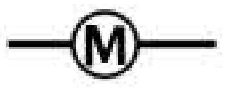
A battery = 

(a battery is two or more cells put together)

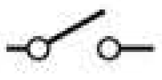
A voltmeter = 

An ammeter = 

A bulb = 

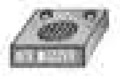
A motor = 

A switch:

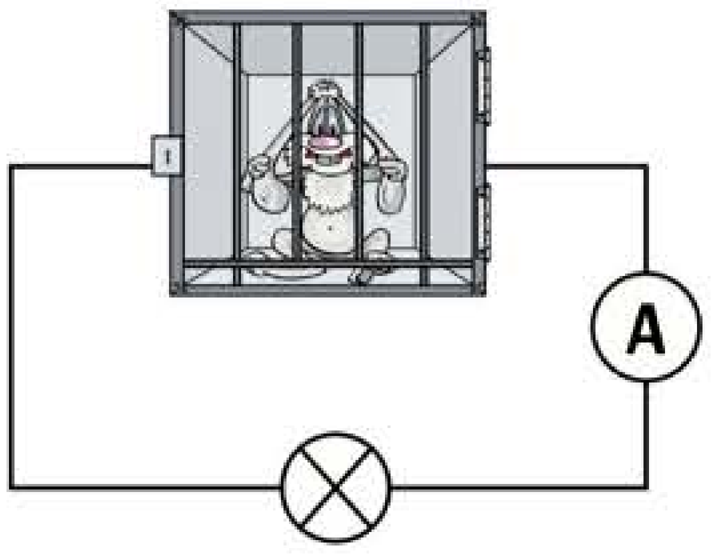
 – open = 

 – closed = 

A buzzer = 



In everyday life we call a cell a battery.



A kilogram of bacon? — Weigh it on the 'ammeter...

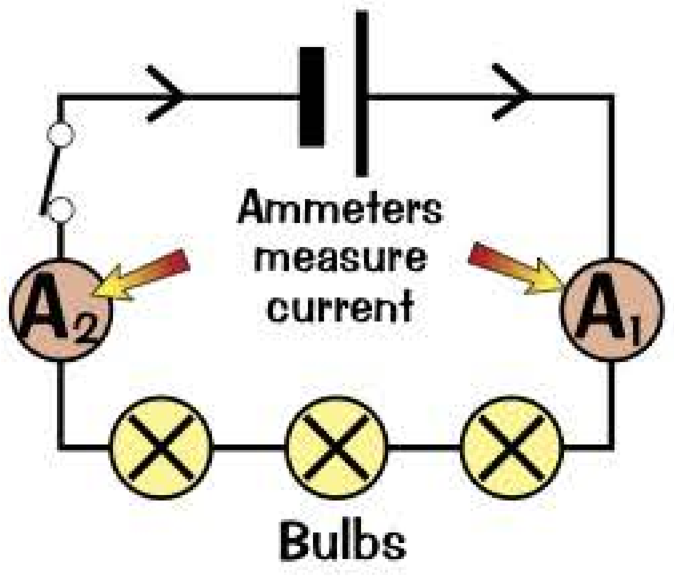
You'll need to get your ruler out to draw a nice, neat circuit diagram. They don't look much like the real circuits they show — but they do make it easier to see how everything is connected up. It's a bit like the London Tube map that way. Symbols are also much quicker and easier to draw than the actual components.

Series and Parallel Circuits

The big difference between series and parallel circuits is that in parallel circuits, current can take different routes around the circuit. And the charges don't even need a map or a GPS to do it...

Series Circuits — Current has No Choice of Route

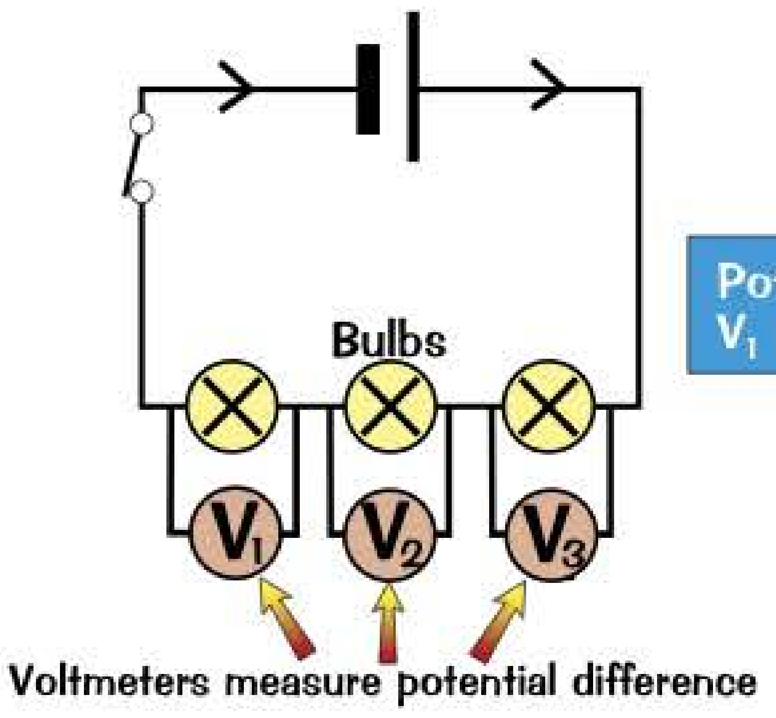
1) In the circuit on the right current flows out of the cell, through the ammeter, the bulbs, then through the other ammeter and the switch and back to the cell. As it passes through, the current gives up some of its energy to the bulbs.
2) The current is the same anywhere in this circuit as the current has no choice of route. Did I tell you current isn't used up — well don't forget.



Ammeter readings: $A_1 = A_2$

> In series circuits the current is either on or off — the switch being open or any other break in the circuit will stop the current flowing everywhere.

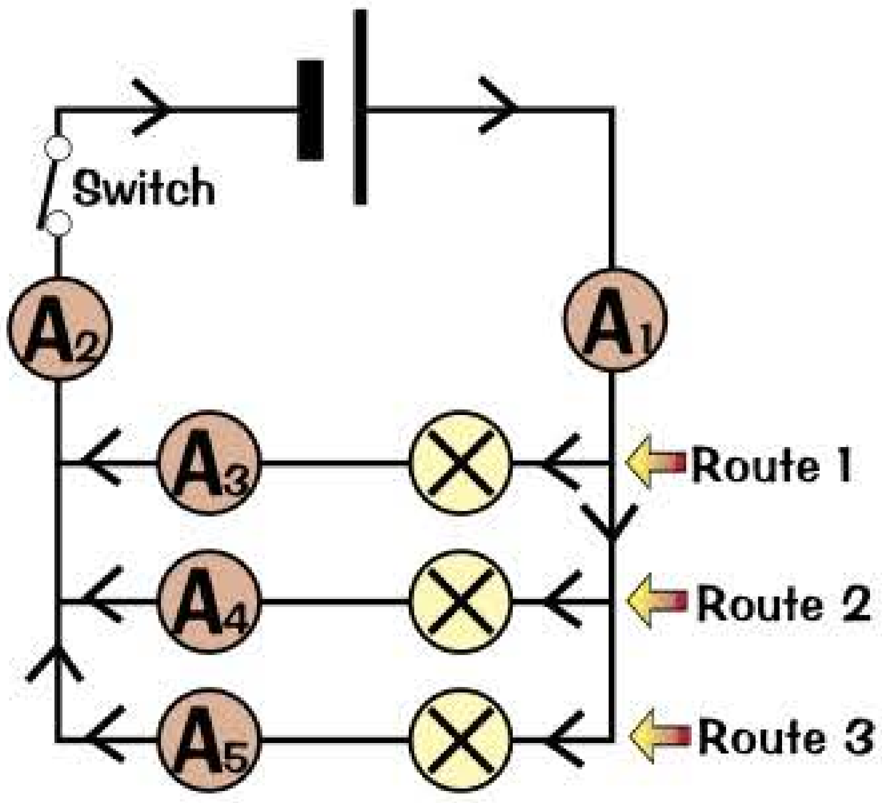
3) In series circuits, the potential differences across the components add up to the potential difference of the cell (or battery).

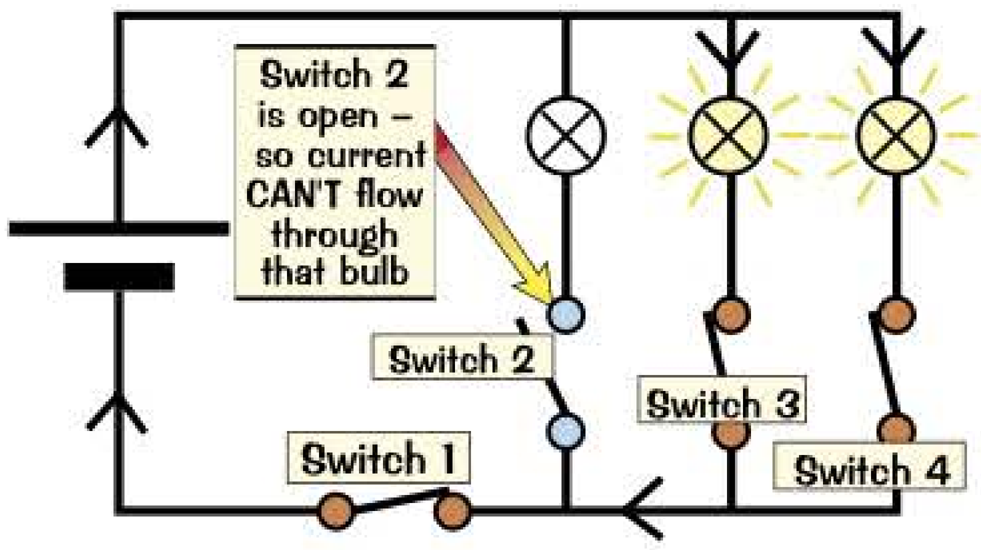


Potential difference readings:
$V_1 + V_2 + V_3$ = total cell potential difference

Parallel Circuits — Current has a Choice

1) In the circuit shown, current flows out of the cell and it all flows through the first ammeter A_1. It then has a "choice" of three routes and the current splits down routes 1, 2 and 3.
2) The readings of ammeters A_3, A_4 and A_5 will usually be different, depending on the resistance of the components — i.e. the bulbs.
3) The three currents join up again on their way back to the cell. So the readings of $A_3+A_4+A_5$ added together will be equal to the reading for current on ammeter A_2 (which will also equal A_1).
4) It's difficult to believe I know, but the current through A_1 is the same as the current through A_2 — the current is NOT USED UP. (I may have told you that once or twice already.)





5) Parallel circuits are sensible because part of them can be ON while other bits are OFF. In the circuit here, two bulbs are on and the other one is off.
6) Don't get confused — the potential difference across each bulb in this circuit is equal to the potential difference of the cell.

A series of circuits — well, there are four on this page...

Circuits cause people a lot of gyp, that's for sure. The worst thing about them is that you can't actually see the current flowing, so it's very difficult to appreciate what's going on. Toughsky.

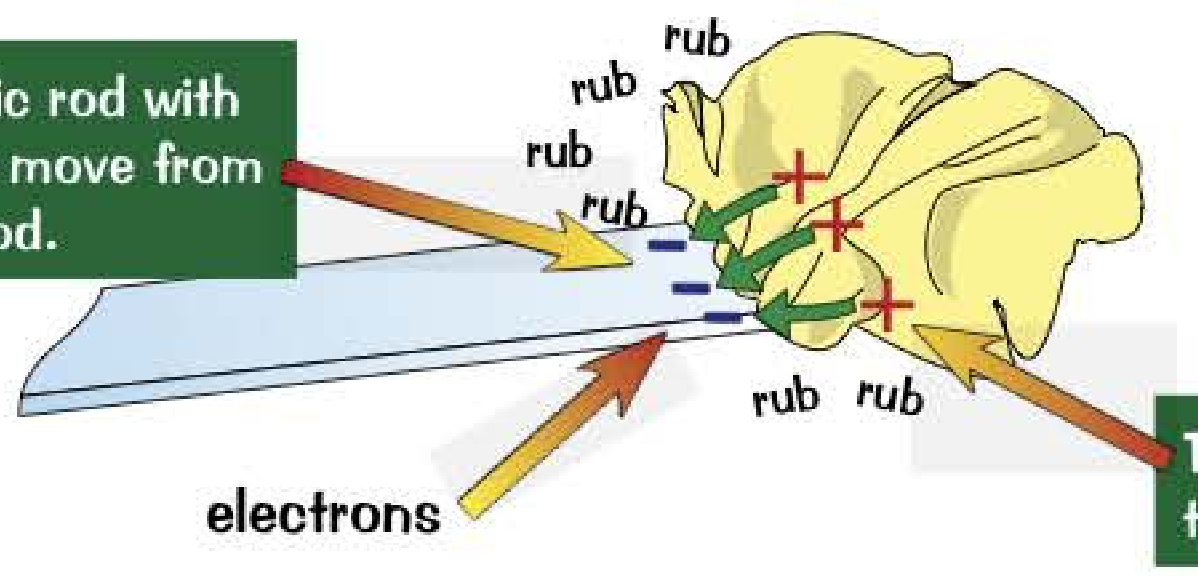
Static Electricity

Right, that's enough on charges flowing about the place. Now let's look at static charges...

Charges Can Build Up When Objects are Rubbed Together

1) Atoms (see page 35) contain positive and negative charges.
2) The negative charges are called electrons. Electrons can move, but positive charges can't.
3) When two insulating objects (see page 95) are rubbed together, the electrons are scraped off one object and left on the other.

The object that gains electrons becomes negatively charged.
The object that loses electrons is left with an equal but positive charge.



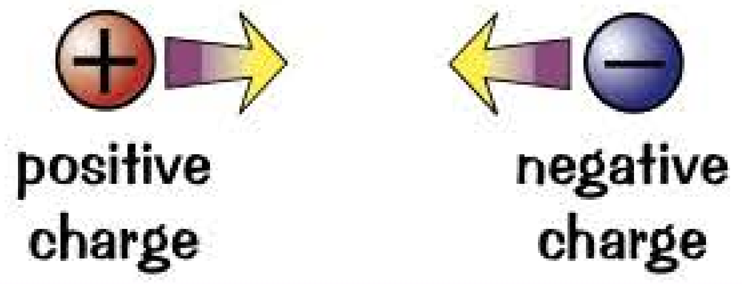
If you rub a plastic rod with a cloth, electrons move from the cloth to the rod.

The places where the electrons left the cloth now have a positive charge.

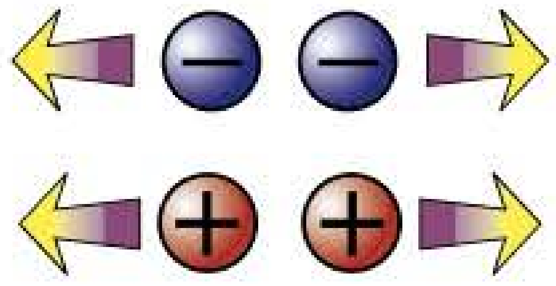
All Charged Objects Have an Electric Field Around Them

1) Charged objects don't have to touch each other for them to feel a force from each other.
2) An electric field is the space around a charged object where other charged objects will feel a force. That's right, electric forces can act across a gap. Clever stuff.
3) The force charged objects feel when they come near each other depends on what type of charge they have.

Two things with OPPOSITE electric charges are ATTRACTED to each other. Positive and negative charges attract.



Two things with the SAME electric charge will REPEL each other.



Electrons put me in a bad mood — they're so negative...

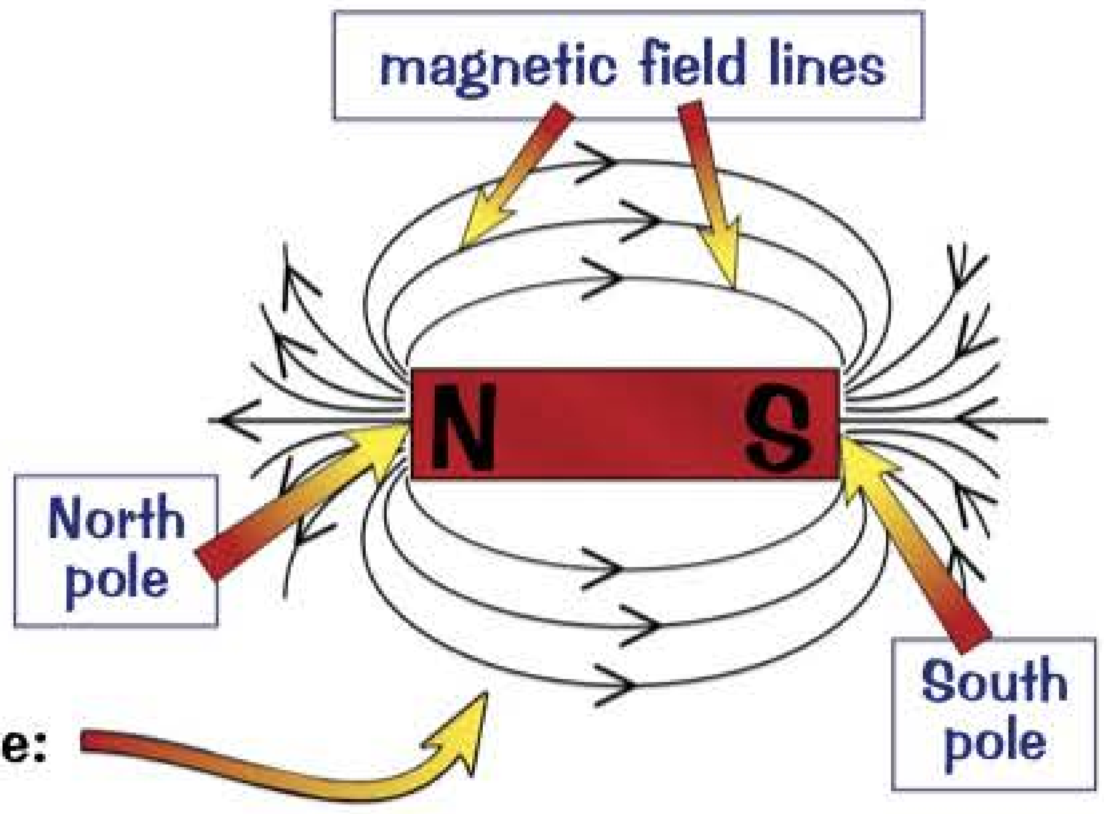
When materials are rubbed together it's only ever the electrons that move — the positive charges never ever get to go anywhere (poor lambs). Static electricity's great fun. You must have tried it — rubbing a balloon against your head and getting your hair to stick up like a crazy scientist's. Your hair sticks up like that because each of your hairs has the same type of charge, so they repel each other. Neat.

Magnets

Electric charges aren't the only things to push and pull each other without touching, magnets can do it too.

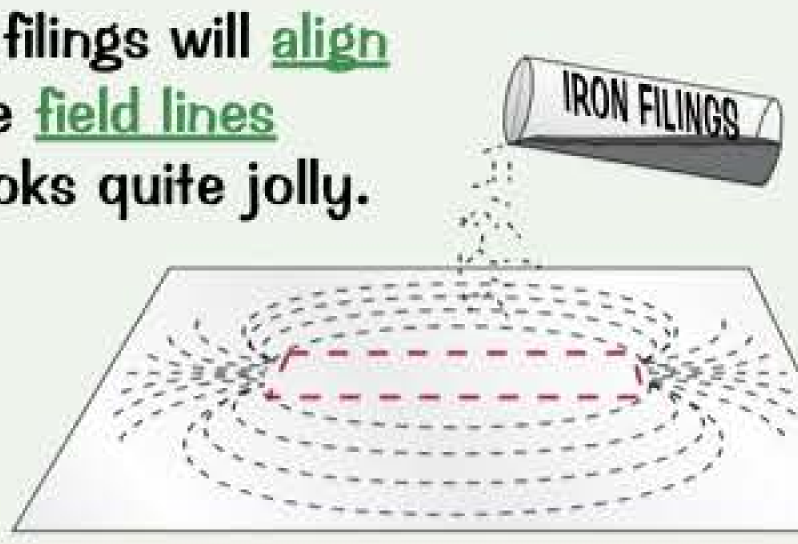
Magnets are Surrounded by Fields

1) Bar magnets are (surprisingly enough) magnets that are in the shape of a bar. One end of the bar magnet is called the North pole and the other end is called the South pole.
2) All bar magnets have invisible magnetic fields round them.
3) A magnetic field is a region where magnetic materials (e.g. iron) experience a force.
4) You can draw a magnetic field using lines called magnetic field lines. The magnetic field lines always point from the N-pole to the S-pole.
5) This is what the magnetic field around a bar magnet looks like:



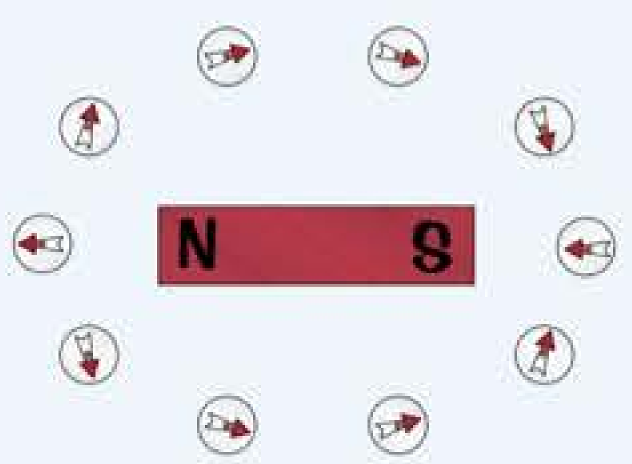
6) You can investigate magnetic fields using either iron filings or a plotting compass...

The iron filings will align along the field lines which looks quite jolly.



The compass will always point from N to S along the field lines wherever it's placed in the field.

The field lines (or "lines of force") always point from NORTH to SOUTH.

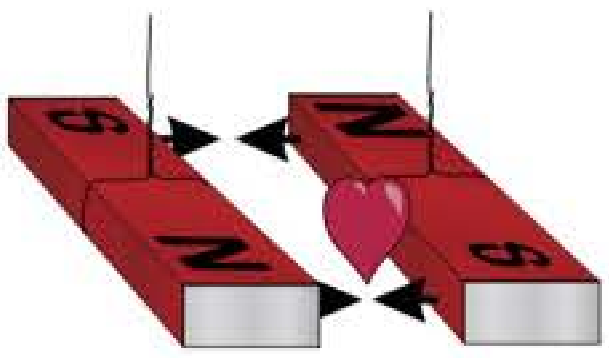


Opposite Poles Attract — Like Poles Repel

Just like electric charges (see page 98), magnets don't need to touch for there to be a force between them.

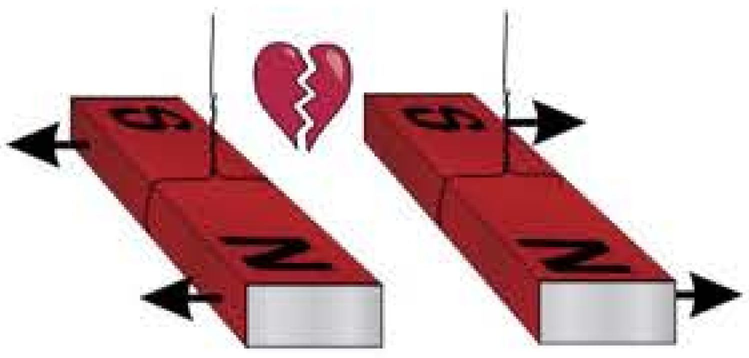
Attraction

North poles and South poles are attracted to each other.

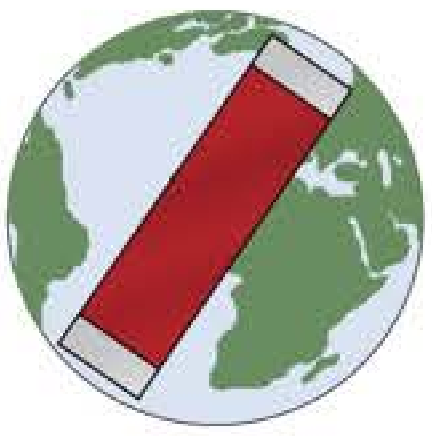


Repulsion

If you try and bring two of the same type of magnetic pole together, they repel each other.



The Earth has a Magnetic Field



1) The Earth has a magnetic field. It has a North pole and a South pole, just like a bar magnet.
2) Compasses line up with magnetic fields — so unless you're stood right next to a magnet, they will point to the Earth's magnetic North pole (which handily is very close to the actual North pole).
3) Maps always have an arrow on them showing you which direction is North. This means you can use a map and a compass to find your way.

Magnets are like farmers — surrounded by fields...

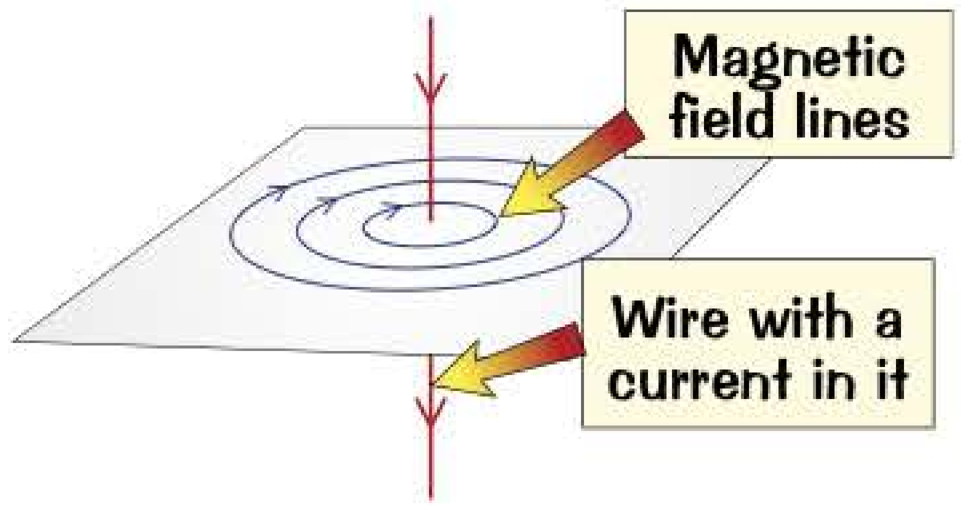
Who knew that magnets weren't only fun to play with, but could also stop you getting lost? Make sure you know all the fun magnetic facts on this page. You know the drill by now — learn, cover and scribble.

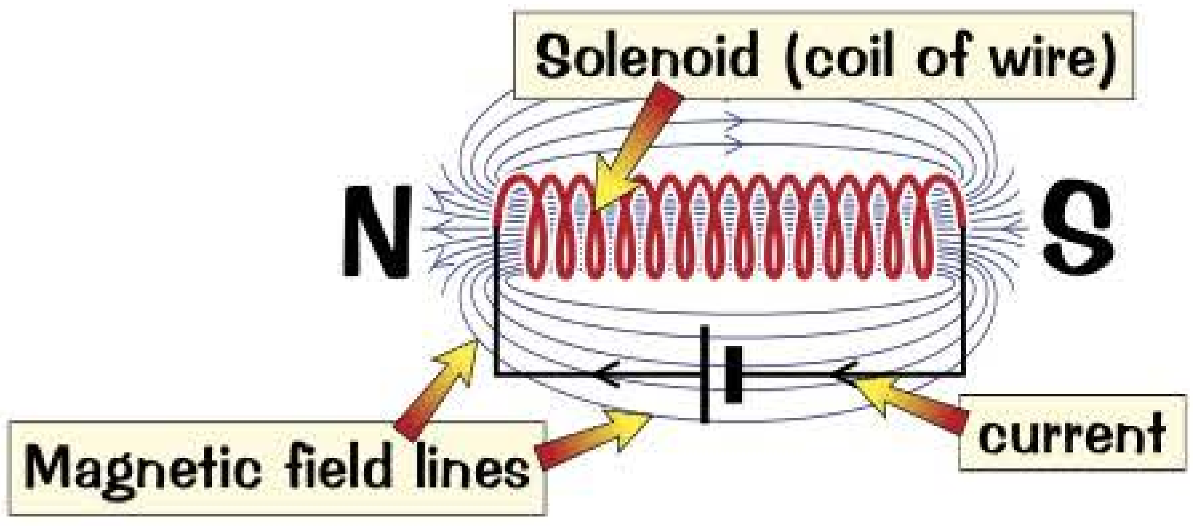
Electromagnets

Bar magnets stay magnetic all the time. Electromagnets are fancy magnets which you can turn on and off.

A Wire With a Current in it Has a Magnetic Field Round it

1) A current going through a wire causes a magnetic field around the wire.
2) A solenoid is just a long coil of wire. Its magnetic field is the same as that of a bar magnet when a current flows through it.

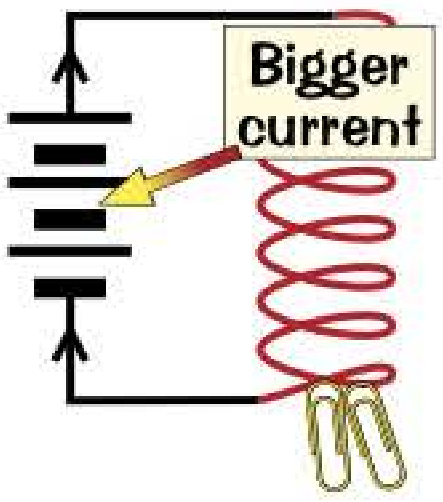




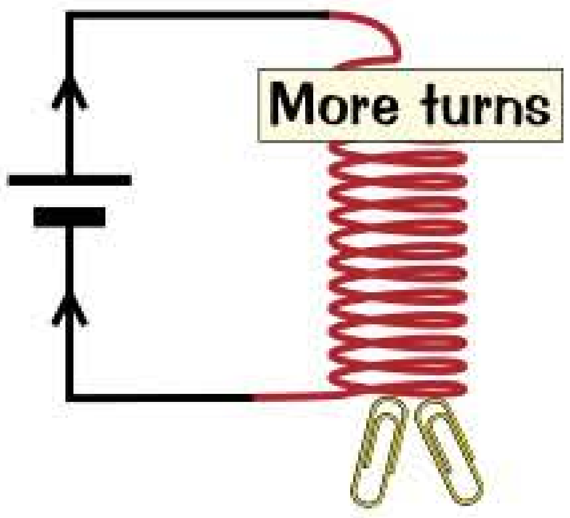
3) Magnets made from a current-carrying wire are called ELECTROMAGNETS.
4) Because you can turn the current on and off, the magnetic field can be turned on and off.

You Can Increase the Strength of an Electromagnet

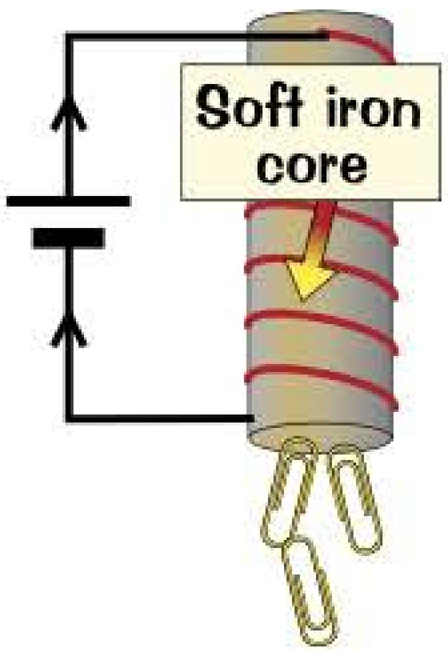
1) More current in the wire.



2) More turns on the solenoid per unit length.



3) A core of soft iron inside the solenoid.

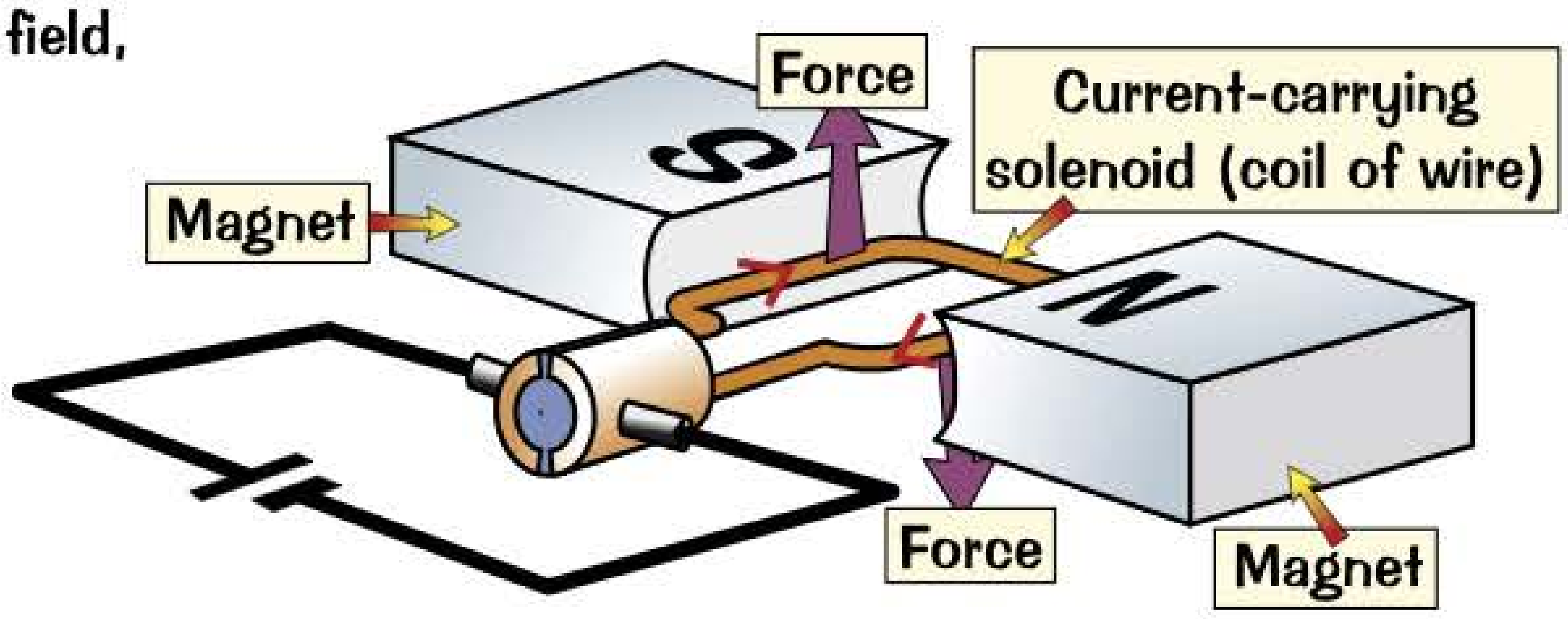


You can't just use any metal to make an electromagnet core. Soft iron has to be used for the core to make it perform as an electromagnet should — i.e. turning on and off when the current is turned on and off.

If a steel core was used, it would stay magnetised after the current was switched off — which would be no good at all.

Electric Motors are Made Using an Electromagnet

1) A simple electric motor is made from a loop of coiled wire in a magnetic field.
2) When current flows through the wire, a magnetic field forms around the wire.
3) Because the wire is already in a magnetic field, there are forces on the loop of the wire. These forces act in opposite directions and cause the loop of wire to turn.
4) Bob's your uncle, you've got a motor.



Electromagnets — they're so awesome...

... not only can we use them to make motors, but they're also used in medicine, in scrap yards, in loudspeakers... is there anything they can't do? Well yes, sadly they can't learn this page for you. Make sure you know what an electromagnet is, how to strengthen one and how a simple motor works.

Section Summary

Phew. Electricity and Magnetism — it's no holiday, that's for sure. There are certainly quite a few grisly bits and bobs in this section. There again, life isn't all bad — just look at all these lovely questions I've cooked up for your delight and enjoyment. These are very simple questions which just test how much stuff you've taken on board. They're in the same order as the stuff appears throughout Section 11 — so for any you can't do, just look back, find the answer, and then learn it good and proper for next time.
Yeah that's right, next time — the whole idea of these questions is that you just keep practising them time after time after time — until you can do them all effortlessly.

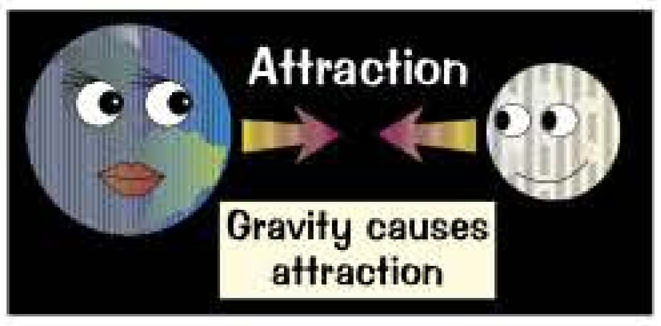
1) Current is the flow of what?
2) Can current flow in an incomplete circuit?
3) What job does a battery do in a circuit?
4) What is potential difference?
5) What is resistance?
6) What is the difference between a conductor and an insulator?
7)* Component A has a resistance of 1 Ω, Component B has a resistance of 0.5 Ω and Component C has a resistance of 0.01 Ω. Which component is the best electrical conductor?
8) What instrument do we use to measure current? How would you connect it in a circuit?
9) What are the units of current?
10) What instrument do we use to measure potential difference? How would you connect it in a circuit?
11) What are the units of potential difference?
12) What is a circuit diagram? Why don't we draw out the real thing all the time?
13) Sketch the circuit symbol for all of these:
    a) a buzzer b) a bulb c) a battery d) a switch (open) e) a cell
    f) an ammeter g) a voltmeter.
14)* A series circuit contains 3 bulbs. A current of 3 A flows through the first bulb. What current flows through the third bulb?
15) What happens if there is a break in a series circuit?
16) Which type of circuit allows part of the circuit to be switched off?
17) In parallel circuits current has a choice of what?
18) True or false? Adding the current through each branch of a parallel circuit gives you the total current.
19) Explain how a cloth and a plastic rod both become charged when they're rubbed together.
20) Do charged objects need to touch to repel each other?
21) State whether each of these pairs of charged objects will be attracted or repelled by each other.
    a) positive and positive b) negative and positive c) negative and negative
22) What is a magnetic field? In which direction do field lines always go?
23) Sketch a diagram showing how a plotting compass points around a bar magnet.
24) Name two magnetic poles that will: a) attract each other b) repel each other.
25) Explain why you can use a compass to navigate.
26) What's a solenoid? What do the field lines around a solenoid look like?
27) What's an electromagnet? List three ways to increase the strength of one.
28) Explain how a simple electric motor works.

* Answers on page 108.

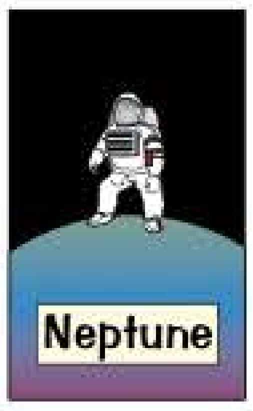
Gravity

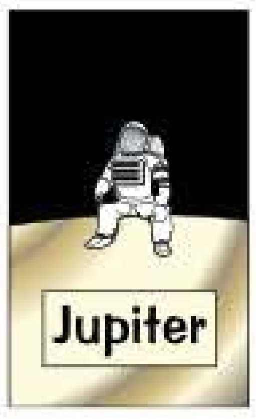
It's not magic that keeps your feet on the ground, it's gravity. As Sandra Bullock will tell you.

Gravity is a Force that Attracts All Masses



1) Anything with mass will attract anything else with mass. In other words, everything in the Universe is attracted by the force of gravity to everything else. (But you only notice it when one of the things is really big like a planet.)
2) The Earth and Moon are attracted by gravity — that's what keeps the Moon in its orbit. The Earth and the Sun are attracted by an even bigger force of gravity.
3) The more massive the object (or body) — the stronger the force of gravity is (so planets with a large mass have high gravity).
4) The further the distance between objects — the weaker the gravitational attraction becomes.



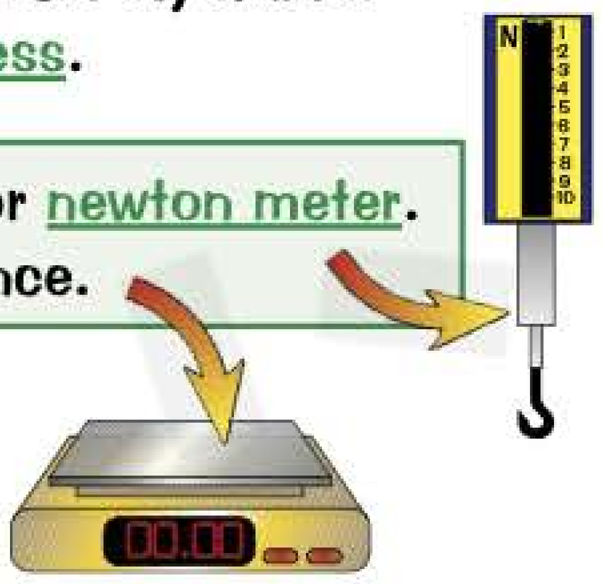


Gravity Gives You Weight — But Not Mass

To understand this you must learn all these facts about mass and weight:

1) Mass is just the amount of 'stuff' in an object. The mass of an object never changes, no matter where it is in the Universe.
2) Weight is caused by the pull of gravity.
3) An object has the same mass whether it's on Earth or on another planet (or on a star) — but its weight will be different. For example, a 1 kg mass will weigh less on Mars (about 3.7 N) than it does on Earth (about 10 N), simply because the force of gravity pulling on it is less.

Weight is a force measured in newtons (N). It's measured using a spring balance or newton meter. Mass is not a force. It's measured in kilograms (kg) with a mass balance.



Learn this Important Formula...

weight = mass × gravitational field strength

in N — in kg — in N/kg

$$W = m \times g$$

1) The letter "g" represents the strength of the gravity and its value is different for different planets. On Earth g ≈ 10 N/kg. On Mars, where the gravity is weaker, g is only about 3.7 N/kg.
2) This formula is hideously easy to use:

Example: What is the weight, in newtons, of a 5 kg mass, both on Earth and on Mars?

Answer: $W = m \times g$. On Earth: $W = 5 \times 10 = 50$ N (The weight of the 5 kg mass is 50 N.)
On Mars: $W = 5 \times 3.7 = 18.5$ N (The weight of the 5 kg mass is 18.5 N.)

See what I mean? Hideously easy — as long as you've learnt what all the letters mean.

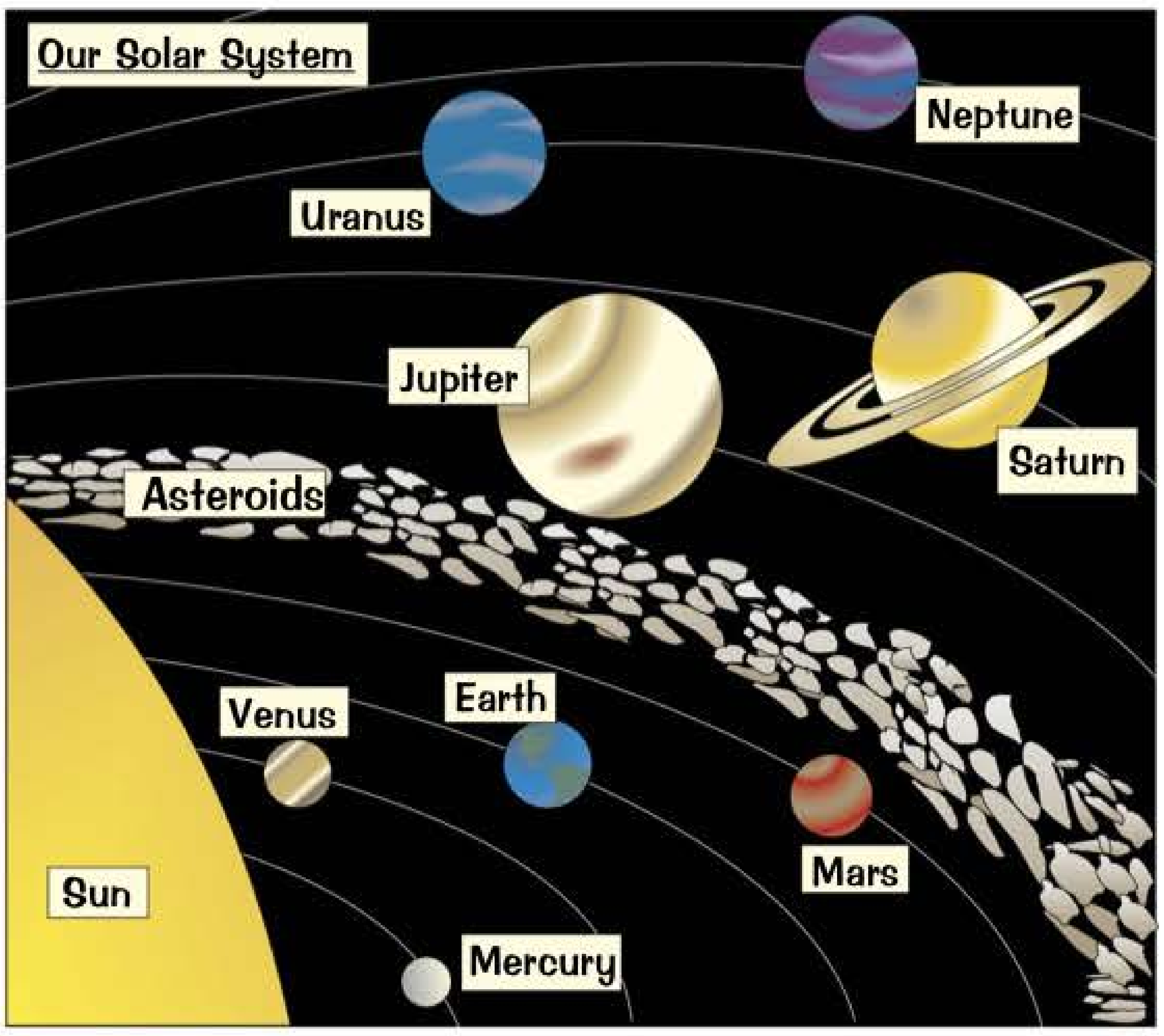
Just make sure you appreciate the gravity of all this...

Remember: weight and mass are NOT the same — they're linked by the formula above. Learn it. You don't need to know what g is on other planets, but you do need to know that on Earth it's around 10 N/kg.

The Sun and Stars

Ahh. This is going to be a nice page, I can tell. Look at all those lovely big pictures for a start.

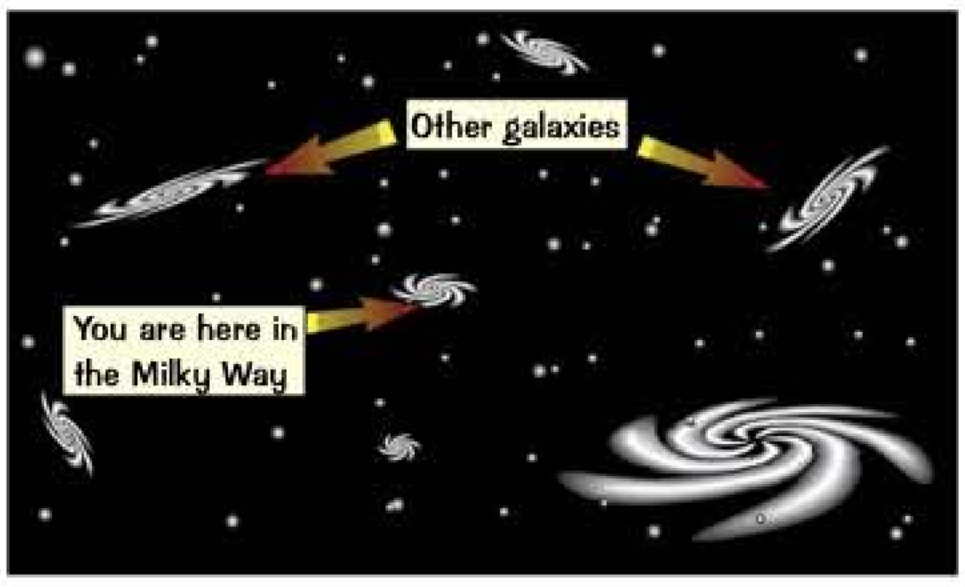
The Sun is at the Centre of Our Solar System



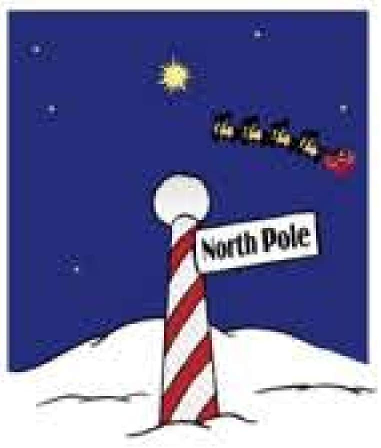
1) A planet is something which orbits around a star.
2) The Sun (at the centre of our Solar System) is a star. The Earth is one of eight planets which orbit the Sun.
3) The Sun is really huge and has a big mass — so its gravity is really strong. The pull from the Sun's gravity is what keeps all the planets in their orbits.
4) The planets all move in elliptical orbits (elongated circles).
5) Planets don't give out light but the Sun and other stars do.
6) The Sun gives out a massive amount of energy which is transferred by light.

Beyond the Solar System

1) A galaxy is a large collection of stars. The Universe is made up of billions of galaxies.
2) Most of the stars you see at night are in our own galaxy — the Milky Way. The other galaxies are all so far away they just look like small fuzzy stars.

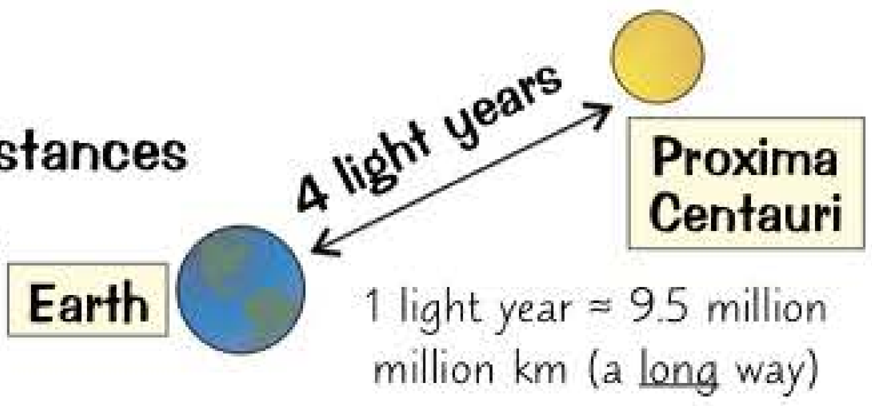


3) There are billions of stars in our galaxy, including the Sun.
4) Other stars in our galaxy include the North star or Pole star (which appears in the sky above the North Pole) and Proxima Centauri (our nearest star after the Sun).



A Light Year is a Unit of Distance

1) A light year is how far light travels in one year.
2) It's used for measuring huge distances between objects — like the distances you find in space. E.g. Proxima Centauri is about 4 light years away, which means it takes light from the star 4 years to reach Earth.



1 light year ≈ 9.5 million million km (a long way)

Galaxies, the Milky Way — physicists must like chocolate...

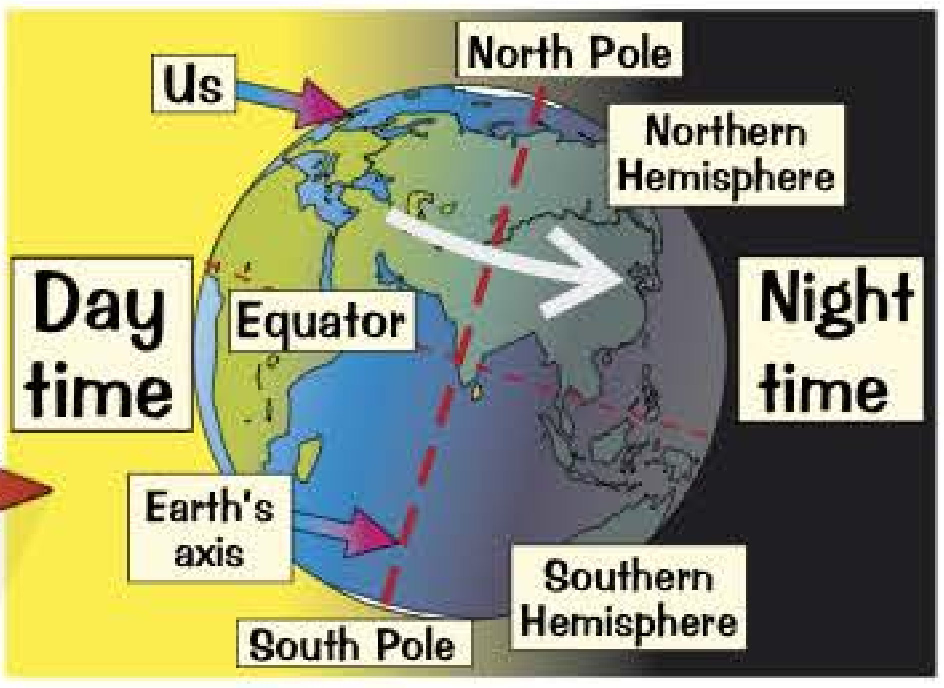
See, I told you this would be a nice page. And an easy one at that. So there's absolutely no excuse for not learning everything on it. You know the score by now. Cover up the page and scribble down everything you can remember. Then check back over the page to see what you missed. Then try again, till you get it all.

Day and Night and the Four Seasons

In years to come, this stuff will come up in a quiz and you'll be able to wow your teammates with the answer. You also need to know it for KS3 Science. So get cracking...

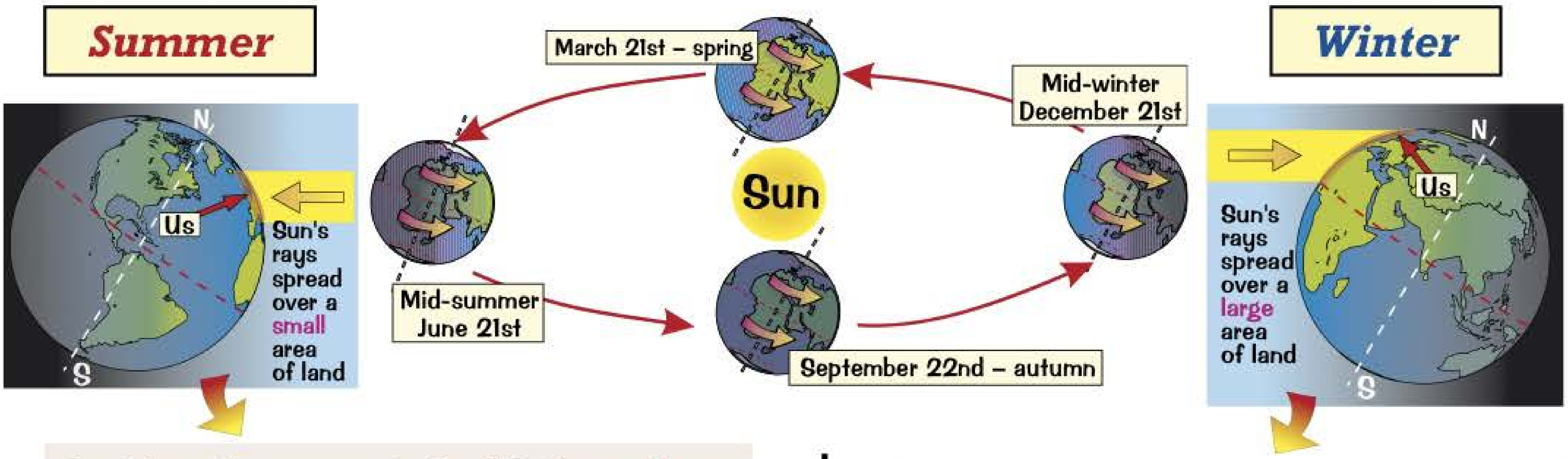
Day and Night are Due to the Steady Rotation of The Earth

1) The Earth does one complete rotation in 24 hours. That's what a day actually is — one complete rotation of the Earth about its axis.
2) The Sun doesn't really move, so as the Earth rotates, any place on its surface (like England, say) will sometimes face the Sun (day time) and other times face away into dark space (night time).



The Seasons are Caused by the Earth's Tilt

1) The Earth takes 365 ¼ days to orbit once around the Sun. That's one year of course. (The extra ¼ day is sorted out every leap year.) Each year has four seasons.
2) The seasons are caused by the tilt of the Earth's axis.



1) When it's summer in the UK, the northern hemisphere (everything above the equator) is tilted towards the Sun.
2) The northern half of the Earth spends more time in sunlight than it does in darkness, i.e. days are longer than nights. Longer days mean more hours of sunshine — so the land heats up.
3) Not only that, but the Sun's rays cover a small area of land. This means that the radiation is focused on a small area. So it gets warm (see p.67) and we have summer — hoorah.

1) When it's winter in the UK, the northern hemisphere is tilted away from the Sun.
2) The north now spends less time in sunlight so days are shorter than nights.
3) Also, the Sun's rays cover a larger area of land so the radiation is more spread out. So it gets colder and we have winter.

When it's summer in the northern hemisphere, it's winter in the southern hemisphere — and vice versa.

Phew — I feel quite giddy now...

Well this is all very jolly. Not like usual boring old science at all. This is really interesting. OK. Fairly interesting. Anyway, learn the headings, the diagrams, the details — and scribble. Make sure you know how the tilt of the Earth's axis gives us warm summers (yeah, right) and cold winters.

Section Summary

Section 12 only has three pages of information — not much really, considering it deals with the whole Universe. It's amazing just how many people go their whole lives and never really know the answers to all those burning questions, like what is gravity? Or why are the days longer in summer than in winter? Make sure you learn all the burning answers now...

1) What is gravity?
2) Which is stronger, the gravitational attraction between the Moon and the Earth or the Sun and the Earth?
3) How does the mass of a planet affect its gravitational field strength?
4) What is the difference between weight and mass?
5) What is weight measured in? What is mass measured in?
6) In the formula $W = m \times g$, what does 'g' stand for?
7) On Earth, what does 'g' equal?
8)*On Jupiter, $g = 25$ N/kg. What would a 5 kg mass weigh on Jupiter? Remember to include the correct unit in your answer.
9) What is at the centre of our Solar System?
10) How are all the planets kept in orbit around the Sun?
11) What is a galaxy?
12) What is the name of our galaxy?
13) Apart from the Sun, name one other star in our galaxy.
14) What is a light year?
15) How long does it take for the Earth to complete one full rotation on its own axis?
16) Explain what "day time" and "night time" actually are.
17) Do all places on the Earth have "day time" at the same time?
18) How long does it take for the Earth to complete one full orbit around the Sun?
19) How many seasons are there?
20) Why are days longer than nights in summer?
21) Give two reasons why it's (supposedly) hotter in Britain in summer than winter.
22) When it's summer in the northern hemisphere, what season is it in the southern hemisphere? Explain why.

* Answers on page 108.

Index

Index

Index and Answers

Answers to Top Tip Questions

p.24 a) Fewer otters means more pike, which will eat more water beetles.
b) More pike would mean fewer perch, which could mean fewer water beetles get eaten.

p.38 a) sodium fluoride b) iodine c) calcium sulfate

p.51 $2Na + Cl_2 \longrightarrow 2NaCl$

p.82 1) Balanced. 2) Balanced. 3) Unbalanced — right side down.
4) Unbalanced — left side down. 5) Balanced. 6) Balanced.

Answers to Selected Section Summary Questions

Section Summary 2 — Page 18

6) Daily basic energy requirement = 5.4 × 24 hours × body mass (kg) = 5.4 × 24 × 54 = 6998.4 kJ

19) Size of moment = force × perpendicular distance = 8 × 0.2 = 1.6 Nm.
Force applied by the muscle = moment ÷ perpendicular distance = 1.6 ÷ 0.04 = 40 N.

Section Summary 5 — Page 47

23) a) magnesium oxide b) calcium oxide c) sodium chloride d) calcium carbonate e) copper sulfate

24) a) sodium chloride b) magnesium chloride c) magnesium carbonate

Section Summary 6 — Page 58

8) exothermic **9)** endothermic **13)** $S + O_2 \longrightarrow SO_2$ **14)** $2Ca + O_2 \longrightarrow 2CaO$

Section Summary 8 — Page 76

6) Energy transferred (J) = force (N) × distance moved (m) = 2000 × 10 = 20 000 J = 20 kJ

19) Energy transferred = power (kW) × time (h) = 1.5 kW × 0.5 h = 0.75 kWh

21) Cost = energy transferred in kWh × price per kWh = 298.2 × 15 = 4473p = £44.73

23) The 300 W device (it has a higher power rating).

27) 50 g (the amount of substance is the same before and after).

Section Summary 9 — Page 85

3) s = d/t = 5 ÷ 2 = 2.5 m/s. **4)** s = d/t = 100 ÷ 20 = 5 m/s. Yes.

5) s = d/t so d = s × t = 40 × 0.25 = 10 miles. (15 minutes = 0.25 hours).

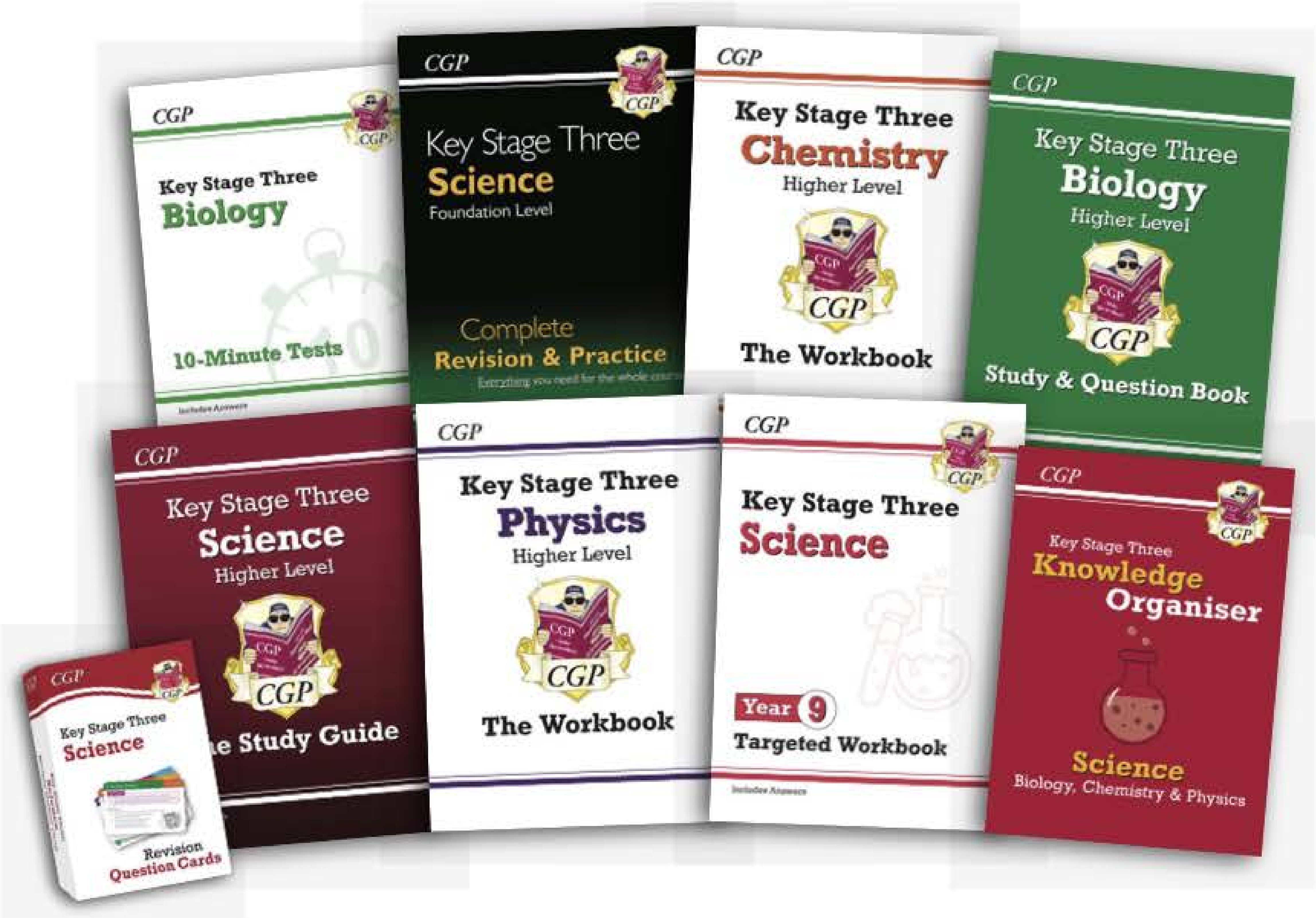
27) 50 × d = 100 so d = 2 m. **31)** 200/2 = 100 N/m^2 (or 100 Pa).

Section Summary 11 — Page 101

7) Component C (it has the smallest resistance). **14)** 3 A

Section Summary 12 — Page 105

8) W = m × g = 5 × 25 = 125 N



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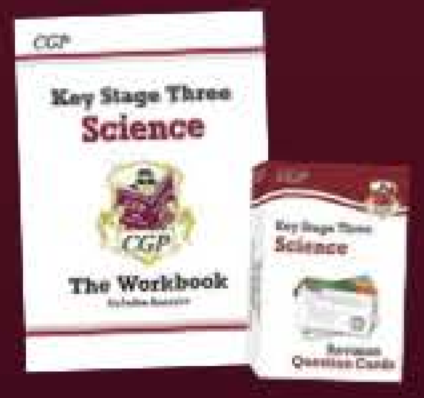

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