Science

1. Chemistry

Ionic compound is where a cation (metal) donates electrons to anions (non-metal) to form a bond.

Naming convention: metal first then non-mental takes (-ide)

Covalent compounds are two or more non-metals that share their electrons so they each have 8 electrons (in their outer shell).

Naming convention: non-metal furthest to the left (takes numeral prefix if >2) *[without -ide]*, then the other non-metal (takes numeral prefix and -ide suffix)

Name of Polyatomic ion	**Formula of polyatomic ion and its valence**
Ammonium ion	NH_4^{+}
Carbonate ion	CO_3^{2-}
Hydroxide ion	OH^{-}
Nitrate ion	NO_3^{-}
Sulfate ion	SO_4^{2-}
Phosphate	PO_4^{3-}

The **Law of the Conservation of Mass** states that matter can neither be created or destroyed in a chemical reaction.

$$\text{Reactants} \rightarrow / \overset{\Delta}{\rightarrow} \text{Products}$$

Exothermic – energy is **released**, in the form of heat, from the products. *(Energy: reactants > products)*, this increases the temperature.

Endothermic – energy is **absorbed** from the surrounds, in the form of heat, into the products. *(Energy: reactants < products)*, this decreases the temperature.

Reactions with Oxygen

Corrosion

General equation	Metal + oxygen → metal oxide
Description	Metals combines with oxygen to create a metal oxide
Examples	Iron rusting ($Fe_{(s)} + O_{2\,(g)} \rightarrow Fe_2O_{3\,(s)}$), copper corroding

Combustion

General equation	Fuel + oxygen → carbon dioxide + water
Description	Fuel burns in oxygen to produce carbon dioxide and water.
Examples	Ethanol ($C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$)

Respiration

General equation	Glucose + oxygen → carbon dioxide + water
Description	Glucose burns slowly in oxygen to produce carbon dioxide and water.
Examples	Humans breathing

Acid Equations

Acid + metal

General equation	$acid + metal \rightarrow salt + \text{hydrogen}\ gas$
Description	An acid reacts with a metal to form a salt and hydrogen gas.
Examples	$2\,HCl_{(aq)} + Cu_{(s)} \rightarrow CuCl_{2(aq)} + H_{2(g)}$

Acid + carbonate

General equation	$acid + carbonate \rightarrow salt + carbon\ dioxide\ gas + water$
Description	An acid reacts with a carbonate to form a salt, carbon dioxide gas and water.
Examples	$H_2SO_{4(aq)} + CuCO_{3(s)} \rightarrow CuSO_{4(aq)} + CO_{2(g)} + H_2O_{(g)}$

Acid + base (Neutralisation)

General equation	$acid + base \rightarrow salt + water$
Description	An acid and a base react forming salt and water, bringing the pH closer to 7.
Examples	$HNO_{3(aq)} + KOH_{(aq)} \rightarrow KNO_{3(aq)} + H_2O_{(g)}$

Precipitation reactions

General equation	$ab + cd \rightarrow ad + cb$
Description	Two compounds react and swap the last ionic compound (e.g., b & d). Usually, one of the products is insoluble AKA a solid.
Examples	$Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

Decomposition reactions

General equation	$ab \rightarrow a + b$
Description	A compound decomposes into two products, usually as a result of heat.
Examples	$CuCO_3 \xrightarrow{\Delta} CO_2 + CuO_2$

For two particles to **react** they must have enough **energy** and be in the correct **orientation**.
Salts is an ionic compound e.g.; copper sulfate are always aqueous (aq).
Acids are always aqueous (aq), most metals are solids (s) expect mercury.
Rates of reactions are affected by concentration, temperature, surface area, catalyst, and volume of container.

Acids are compounds that have a pH under 7, they contain a hydrogen element. e.g., sulfuric acid $H_2SO_{4\,(aq)}$
Bases are compounds that a pH over 7, they contain a hydroxide element, e.g., sodium hydroxide $NaOH_{(s)}$

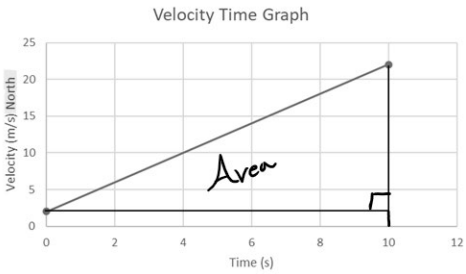
2. Physics

Distance is how far an object has travelled in total.	s		$25km$
Displacement is the change in both distance and direction from a starting point	$\underset{s}{\rightarrow}$		$2.5km\ NE$
Speed is how fast an object travels.	v	$v = \frac{s}{t}$	$8m/s$
Velocity is how fast and in what direction an object is going. *Velocity is the rate of change in displacement.*	v_{av}	$v_{av} = \frac{\underset{s}{\rightarrow}}{t}$	$7km/h\ S$
Acceleration is the rate of change in velocity	a	$a = \frac{v-u}{t}$	$5m/s^2$

$$m/s \xrightarrow[\times 3.6]{} km/h \qquad km/h \xrightarrow[\div 3.6]{} m/s$$

For **displacement-time** graphs: the x-axis graphs time while the y-axis graphs position in a specific direction. A line is then used to show an object's position at a given time from its starting point. *Gradient gives velocity.*

For **speed/velocity-time** graphs: the x-axis graphs time while the y-axis graphs velocity. Both velocity and time can be read off the graph. The gradient of the graph gives acceleration. The area under the graph (line) to the *origin* gives the change in distance travelled (displacement). *Gradient gives acceleration, area gives displacement.*



Area of graph is displacement

triangle $= \frac{1}{2}bh$
$= \frac{1}{2} \times 10 \times 20$
$= 100$

rectangle $= bh$
$= 2 \times 10$
$= 20$

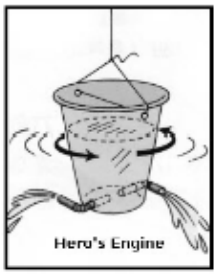
$A = \triangle + \square$
$= 100 + 20$
$= 120\,m$

Displacement $= 120\,m\,N$

Net force: sum of forces on an object.
Unbalanced force: net force isn't zero.
Newton's **first law** states, *"An object at rest will stay that way unless a force acts on it. An object in motion will continue to move in the same direction, at the same speed, until a force acts on it."*

Inertia is the tendency of an object to resist a change in its motion.
e.g., if a pen is placed on a desk, it requires a force to get it to move.

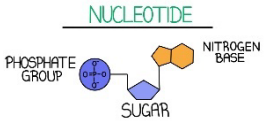
Newton's **second law** states, *"An object is acted upon by a force, the time rate of change of its momentum equals the force."*
So, $F = ma$
F is **net** force (N, Newtons); m is mass (kg); a is acceleration (m/s^2)



Newton's **third law** states, *"Every action has an equal and opposite reaction"*.
e.g., in a *Hero's engine* the water leaving the cup induces spin in the opposite direction.

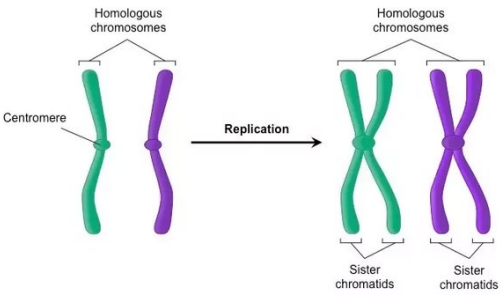
3. Biology

Genetics is the study of the passing of characteristics through inheritance.

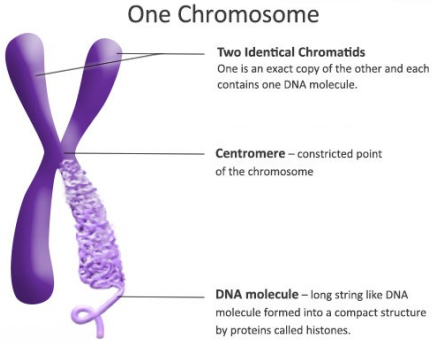


DNA (deoxyribonucleic acid) is a double helix structure made up of **nucleotides** (base, sugar & phosphoric acid):
Adenine (A) ↔ Thymine (T)

Cytosine (C) ↔ Guanine (G)
Base pairs (A/T & C/G) make DNA accurate as it prevents undesirable pairing of *bases* during replication which sustains accuracy and avoids mutations.



Cells need to divide to:
Grow; repair damaged tissue; a cell cannot be too big as it would starve.
DNA is replicated in *Interphase*. From 1 chromatid, it replicates so now there are two.



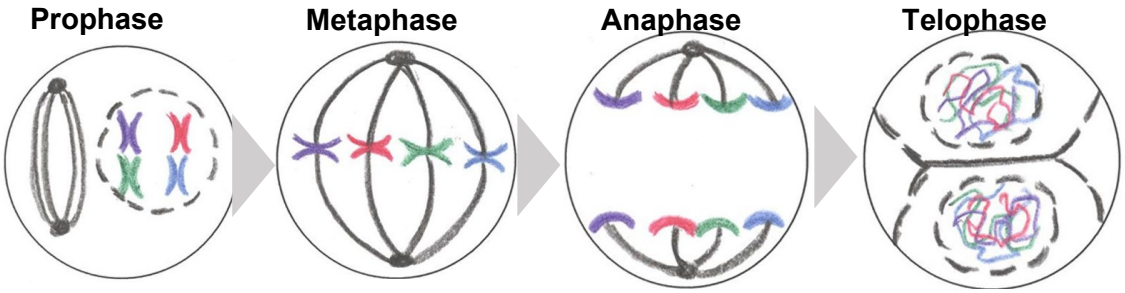
DNA is in a doubled, coiled, and condensed form *(in replication after prophase)* called a **chromosome**. Which consists of a **chromatid** and a **centromere**.

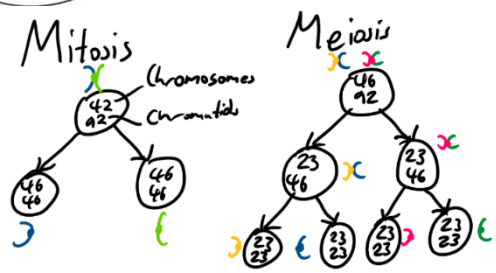
DNA replicates by:
1. Split into to two strands of bases.
2. These strands are used as templates to repopulate with bases.
3. DNA is wound back up into regular form.

*DNA is counted by **centromeres**, so during replication the number of chromosomes doesn't change while the number of **chromatids** do.*

Mitosis is the (asexual) replication of body (somatic) cells and results in the production of two identical diploid (full) daughter cells.
1. *Interphase*: cell growth and development:
   a. DNA replicates
   b. The cell continues to grow and carries out normal cell function.
   c. A cell spends most of its life cycle in *interphase (90%)*
2. *Prophase:* chromosomes coil up, nuclear envelope disappears, spindle fibres form
3. *Metaphase:* chromosomes line up in middle of cell, spindle fibres connect to single chromatids

4. *Anaphase*: chromosome copies divide into chromatids, spindle fibres pull chromosomes to opposite poles
5. *Telophase*: chromosomes uncoil, nuclear envelope forms, 2 new nuclei form, spindle fibres disappear
6. *Cytokinesis:* division of the rest of the cell, cell returns to interphase.

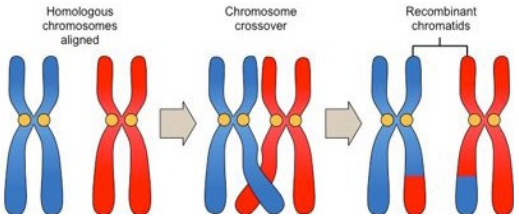




Meiosis is the replication of sexual (gametes) cells. They contain ½ of the normal (23 chromosomes, compared to the normal 46 total chromosomes/23 pairs of chromosomes)

Humans have 23 pairs of **homologous** chromosomes (one maternal and one paternal):

22 pairs of autosomes
1 pair of sex chromosomes



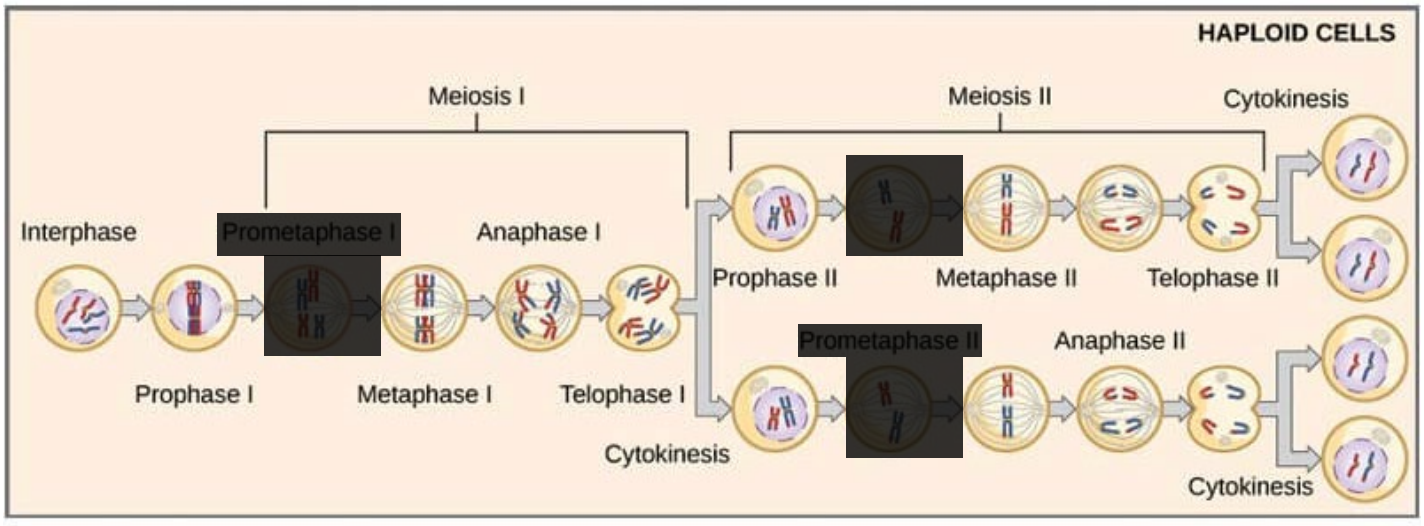
Meiosis *I*

1. *Interphase*: DNA replication
2. *Prophase I:* nuclear envelope disappears, **crossing over** occurs.
    a. Homologous chromosomes come together to form a **tetrad.**
3. *Metaphase I:* tetrads align in middle.
4. *Anaphase I*: homologous chromosomes separate and move to the poles.
5. *Telophase I*: nuclear envelope forms, 2 new nuclei form, spindle fibres disappear.
6. *Cytokinesis I:* division of the rest of the cell, two haploid daughter cells are formed.

Meiosis *II (like mitosis with ½ chromosomes)*

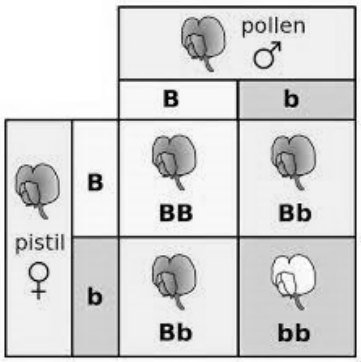
1. *Prophase II:* centrioles appear, spindle fibres form.
2. *Metaphase II:* chromosomes align in middle.
3. *Anaphase II*: chromatids separate and move to the poles.
4. *Telophase II*: nuclear envelope forms, 2 new nuclei form, spindle fibres disappear.
5. *Cytokinesis II:* division of the rest of the cell, two more haploid daughter cells are formed.

Meiosis starts with one cell and ends with **4** haploid (half) cells.



The father determines the sex of an offspring, as a sperm can either contain an *X* or *Y* chromosome.

During interphase cells duplicate their chromosomes. This produces 2 **chromatids** for every chromosome. In humans this would be 92 chromatids.
Chromosomes usually only have **one** chromosome.



There are two types of traits:

Dominant were having at least one allele means you display a characteristic. *(Upper case letter)*
Recessive means you need two identical alleles to display a characteristic. *(Lower case letter)*
A **punnet square** is a way to identify the phenotypes and genotypes of potential offspring.

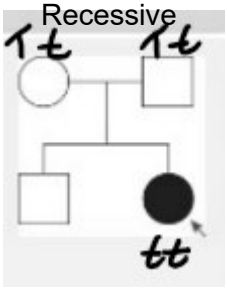
A **genotype** is a set of genes.
A **phenotype** is a set of observable traits.
A **gene** is an area of DNA which contain information about a trait.
An **allele** is the two different versions of a gene.
A genotype where the alleles are the same is called **homozygous** e.g., BB or bb
A genotype where the alleles are the different is called **heterozygous** e.g., Bb

Alleles are **variations** of a **gene** (the actual DNA that is coding for the trait)**.** They code for **different variations** of the **same characteristic.**
Alleles can be **recessive** or **dominant.**
The recessive allele is referred to with a **small letter** and the dominant allele is given a **capital letter.**

A **pedigree** or a family tree is a diagram to show inheritance patterns in people who are related.

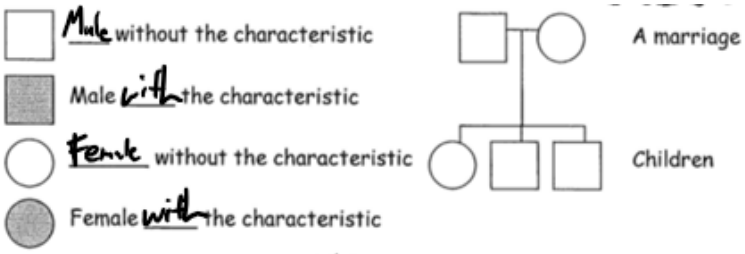
Pedigrees can be used to show whether a trait is dominant or recessive.

Recessive

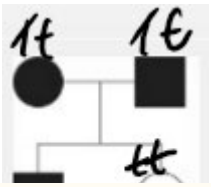


If two unaffected parents have an affected child, the trait cannot be dominant.

If two affected parents have an unaffected child, the trait must be dominant.
With a dominant trait, a person only needs one allele to show the trait.



Dominant

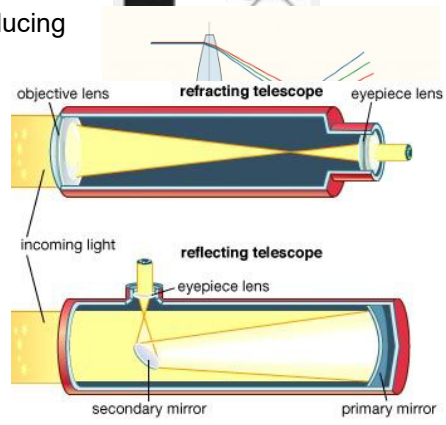


Genetic engineering – the deliberate modification of the characteristics of an organism by manipulating its genetic material.

Biotechnology – using biological processes for industrial or other purposes, e.g., producing antibiotics.

Scientific models are representations of simplified explanations, they do not seek to explain every situation or every detail. This means that scientific models often are not identical with the 'real world' from which they are derived.

James Watson and *Francis Crick* envisaged the double helix structure of DNA.
Mendel discovered and explained the inheritance of genes.
Rosalind Franklin used x-rays to demonstrate the double-helix structure of DNA.

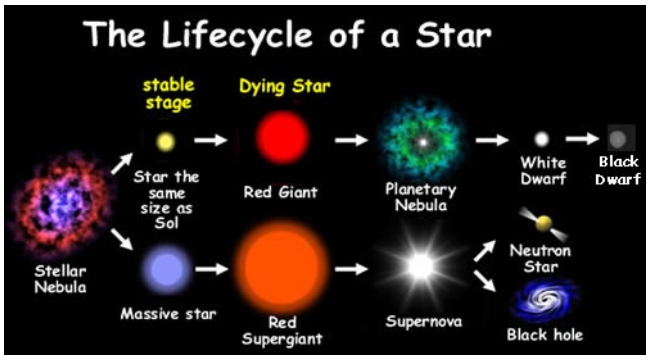


4. Astronomy

There are two types of telescopes:

1. **Refracting** telescopes, uses a lens to focus/collect light, ***has*** *chromatic aberration* – long and thin

2. **Reflecting** telescopes, uses a *mirror* to focus/collect light, *prevents* chromatic aberration – short and stubby



Gravity can have a huge effect on the orbit of planets, governed by Newton's 2nd Law ($F = ma$)

It can sometimes be difficult to tell how close or bright a star is from earth.
So, scientists use Absolute Magnitude – the traits of the star if it was only 10 parsecs from Earth.

Temperature can be determined by looking at the **wavelength** of light emitted by the star.

Plants from a collapsed disk of rock.

A **HR** diagram demonstrates the relationship between temperature, brightness, and wavelength of light (colour).
For stars: blue = hot, yellow = warm, red = cool (2000 K)

The Big Bang is a theory that the universe formed from one point and just expanded from that tiny point.
Evidence:

Cosmological red shift	By using the doppler effect coupled with red shift – *is the tendency of objects moving away to 'shift' down in the light spectrum.* With the abundance of red shift, it can be observed that all galaxies are moving away from us.
Microwave background	There is ever present heat radiation left over from the Big Bang, we are seeing the remnants of the very hot environment from plasma of the Big Bang.
Abundance of Helium	There is a large amount of Helium in the universe, with only one explainable event, a big event that caused all the Hydrogen to fuse – the Big Bang.

Over time our understanding of universe has changed radically.

Greeks	Every orbited in perfect circles around the earth.
Copernicus/Kepler	The sun is at the centre of our solar system, with everything orbiting in elliptical orbits.

Steady state model – the universe has always been like this and has never evolved, never *coming* from anything

5. Geology

There earth is composed of three main layers:

Crust	*Continental* *Less dense*	*Oceanic* *Dense*	*Lithosphere – solid, rocky layer*	O, Si, Al, Fe
Mantle			*Asthenosphere – ductile (easily malleable) solid rock*	Fe, Al, Ca, Na & K
Core			*Outer core – liquid*	Fe & Ni
			Inner core – solid	

Four spheres: *Atmosphere, Biosphere, Hydrosphere and Lithosphere*

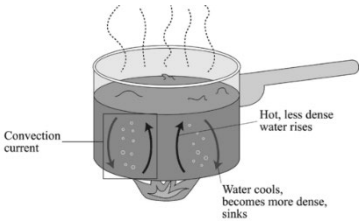
Continents move around with:
- Theory of plate tectonics: the gradual movement/drift of the continents

Evidence:
- *Sea floor spreading*: the plates under some seas have been moving apart creating new sea floor
- *Uneven sea floor*: historical changes in the sea floor from spreading and magmatic movements
- *Underwater volcanos*: caused by magma coming to the surface
- *Fossils*: are like each other even across continents

Plate boundaries:

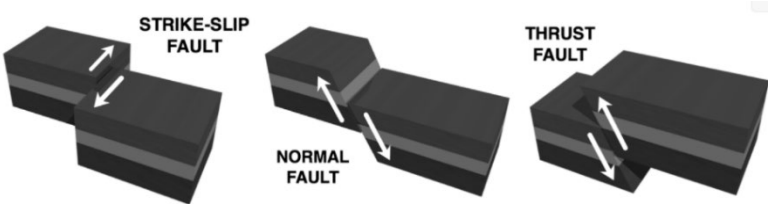
Convergent	Two plates push into each other.	Subduction: denser plate under another	Mountains, earthquakes, and volcanos.
		Abduction: plates create a ridge/mountain	
Transform	Two plates slide past each other.		Valleys/fissures and earthquakes.
Divergent	Two plates separate from each other.	Continental	Large valleys
		Oceanic	New sea floor

Convection is the process of heat movement in a fluid system. Warm air rises after being heated, cools as it reaches the top and descends – completing the cycle.



Plates are moved by:

- Slab pull: heavy plates pulled into the earth by gravity
- Ridge push: ridges push the plates forming them away
- Convection traction: convection currents move plates around



Folding caused most mountain ranges:

- Anticline – top
- Syncline – bottom

A volcano is an opening on the earth's surface where lava, ash and hot gases are expelled from.

Tallest to Shortest	Formation
Shield	Slow solidification of lava over many years
Composite	Successive eruptions and lava flows causing a tall, thin volcano
Dome	Caused by more viscous lava creating a narrower volcano
Cone	Solidified rock from eruptions

Volcanos usually fall on plate boundaries.
Volcanos emit a variety of gases (water, CO_2, sulphur), liquids (lava which is classified by viscosity *(less viscous = move faster)* and variety of solids (ash and rocks).

Earthquakes are caused by plate movements.
An **epicentre** is the point directly above the focus on land.
The **focus** is the exact point at which the earthquake occurred – on a fault.

Seismograph employs a seismometer to measure earth movement – earthquakes.

Earthquakes

- **P** – compression wave that travels in the body of the earth
- **S** – transverse wave that travels slower through the body of the earth (not the core)
- **L** – transverse wave the travels slowest on the surface of the earth

6. General Science

Line graphs are used to show continuous data e.g., temperature
Independent variable, thing that is changed (x-axis, left of table) e.g., time, weight.
Dependent, thing that is measured (y-axis, right of table) e.g., force, length.