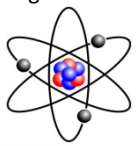
1.1.1 – Atoms

All substances are made from **atoms.** Each element has a unique chemical symbol. An **element** is a substance made up of only one atom, a **compound** is a substance made from two or more types of atoms joined together.



Atoms have a central **nucleus** containing **protons** and **neutrons.** Outside the nucleus are **electrons**.

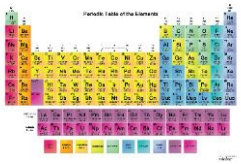
Particle	Mass	Charge
Protons	1	+1
Neutrons	1	0
Electrons	0	-1

1.1.2 – Electrons

Electrons can be **lost, gained or shared** in chemical reactions, creating **ions** (charged atoms), being positive when losing and negative when gaining. **Covalent bonds** form to make molecules. Number of atoms and mass does not change in a chemical reaction.

1.1.3 – Electrons & Periodic Table

Electrons are arranged in **energy levels (electrons shells)** around the first 20 elements in the pattern 2,8,8,2.



In the periodic table, **metals** are on the left, **non-metals** on the right; elements are listed in order of atomic numbers.

1.1.4 – Group 1 & 0

Group 1 contains very reactive metals because they have one electron in their outer shell, reacts with oxygen and water. Group 0 contains unreactive gases because they have a full outer shell.

1.2.1 – The Earth Provides

Rocks provide most of raw materials. Digging rocks in the Earth requires **quarries**. Advantages: **building materials,** providing **employment** and **money**. Disadvantages: **noise** and **dirt** produced, destruction of **habitats** and **wildlife**.

1.2.2 – Limestone

Limestone is Calcium Carbonate (CaCO3) which reacts with acid to form a salt, water and CO2. Acid rain can dissolve limestone, but limestone can also be used to neutralize acidic lakes.

1.2.3 – New Materials from Limestone

Limestone can be broken down by **thermal decomposition** to form Calcium Oxide and CO2, which can be turned into Calcium Hydroxide by reacting with water, which can be used to neutralize acid and improve soils. CO2 is tested by bubbling it through **limewater**, which turns **cloudy**.

1.2.4 – New Rocks From Old

Cement is made by heating **limestone** with **clay** in a **rotary kiln**. **Concrete** is made by mixing cement, sand, aggregate, and water; which can be used for **building material**, and when reinforced with steel, becomes stronger.

1.3.1 – Digging Up the Ore

Most metals are found in **ores** (rocks containing useful compounds) underground. **Mining** ores produce jobs and raw materials but also pollution and habitat destruction. **Recycling** is the process of converting waste into useful material. It saves money, energy and raw materials but also produces pollution.

1.3.2 – Metal from the Ore

Less-reactive metals can be extracted through **reduction** with carbon. More-reactive metals cannot be reduced by Carbon and require **electrolysis.**

1.3.3 – New Methods of Extraction

Iron is extracted from its ore in a **blast furnace**, where it is heated and reacted with carbon to be reduced. Other extraction methods include **bioleaching** (using special bacteria to consume copper ions) and **phytomining** (using special plants that absorb metals from the soil).

1.3.4 – Finite Resources

Recycling can help to conserve raw materials and reduce pollution and energy consumption but also costs money.

1.3.5 – Heavy/Light Metals

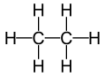
Metals are strong, shapeable, have high melting points, and conduct heat and electricity. Iron and copper are used for appliances. Aluminium and titanium are used for aircrafts.

1.3.6 – Improving Metals

Alloys are mixture of two or more metals. In pure metal, atoms are arranged in rows, which are weak. However, in alloys, they rows are distorted, meaning it is more difficult to bend.

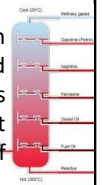
1.4.1 – Alkanes

Crude oil is a **fossil fuel** formed over millions of years from plant and animal fossils. It is a mixture of compounds, mostly **hydrocarbons**, (hydrogen and carbon compounds).



Alkanes are **saturated hydrocarbons** with only **C-C single bonds** and having the general formula C_nC_{2n+2}

1.42 – Separating Crude Oil

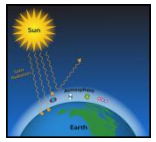


Fractional distillation is used to obtain **fractions** from crude oil. Oil is vaporized then cooled, with different fractions condensing at different parts. Short chain alkenes are good fuels because of low melting point and flammability.

1.4.3 – Burning Fuels

Complete combustion occurs when fuel burns in **plenty of air,** forming CO2. **Incomplete combustion** happens if there is **not much air**, forming CO. Burning **natural gas** forms CO2, water and SO2. At high temp., Nitrogen and Oxygen react to from **Nitrogen Oxides**. Harmful gases can cause **global warming** and **acid rain**.

1.4.4 – Problem Fuels



Carbon dioxide contributes to **global warming** because it is a **greenhouse gas**, trapping sunrays in the atmosphere.

Global **dimming** is caused by **solid particles** reflecting sunlight back into space. **Acid rain** is caused by sulfur dioxide from combustion which forms sulfuric acid when reacting with water.

1.4.5 – Better Fuels

Crude oil, coal and natural gases are **non-renewa**ble resources, meaning they cannot be replaced. **Ethanol** is a **renewable** fuel made from **fermentation**. **Hydrogen gas** is also a renewable fuel by electrolysis.

1.5.1 – Cracking

Cracking is the production of smaller molecules by decomposing large molecules. The hydrocarbon is vaporized, then passed over a catalyst. Shorter alkanes are more demanded but low supply. Alkenes are **unsaturated** hydrocarbons that contain **C=C double bonds** with the general formula C_nC_{2n}

1.5.2 – Polymers

A **polymer** is a large molecule made from many small molecules (**monomers**). Many common polymers are made from alkenes and can be used to make everyday products.

1.5.3 - New Uses for Polymers

New polymers are being developed with new uses and properties. **Smart materials** are materials that have properties that change with conditions. **Shape-memory polymers** can change shape as the temperature changes but return to the original shape.

1.5.4 – Disposing of Polymers

Methods to dispose of polymers are burial in **landfill**, easy and cheap but needs land and will not decompose; **incineration**, creating heat energy but also pollution; and **recycling**, which can convert waste into useful products, but requires money and manual labour.

1.5.5 – Ethanol

Ethanol can be made by **fermentation** of crops, which is cheap and renewable but slow and uses batch process; or **hydration of ethane**, which is fast and continuous but is expensive and non-renewable.

1.6.1 – Vegetable Oils and Biodiesel

Some plant materials are rich in vegetable oils, which can be extracted by **pressing**; which involves crushing the plant and separating and filtering the oil. **Biodiesel** is a biofuel made from vegetable oils, which produces less pollution and is renewable.

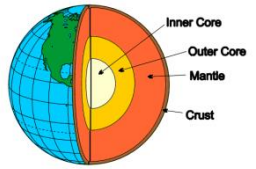
1.6.2 – Emulsions

Emulsions are mixtures of two substances which **are** immiscible used in foods, cosmetics, etc. Emulsifiers contain a **hydrophilic head** which dissolves in water, and a **hydrophobic tail** which dissolves in oil, mixing the two substances.

1.6.3 – Hardening Vegetable Oils

Unsaturated vegetable oils contain C=C double bonds. Unsaturation can be tested with **Bromine water** which **decolorizes** when mixed with unsaturated oils. **Hydrogenation** hardens the oil, by reacting it with **Hydrogen at 60°C with Nickel catalyst**.

1.7.1 – Structure of the Earth



At the center of the Earth is the **core**, made mostly of **molten iron**. Next is the **mantle** made of rock. The thin outer layer is called the **crust**. Above the crust is the **atmosphere**, a layer of **gases.**

Tectonic plates move due to **convection currents** and cause **continental drift**. **Earthquakes** and **volcanoes** occur at **plate boundaries** but are hard to predict.

1.7.2 – Continental Drift

Alfred Wegener developed a theory called **continental drift** which involved the **movement of continents**. Soon it was accepted due to new evidence of convection currents.

1.7.3 – Atmosphere Today & 1.7.4 Changing Atmosphere

The atmosphere is a mixture of gases consisting mostly of **Nitrogen, Oxygen, etc.** Volcanic activity released **CO2, ammonia, methane and water**, forming oceans which began life to **photosynthesizing organisms**, which used up the CO2 to form **Oxygen**, and **Nitrogen** was formed by bacteria. The beginning of life is uncertain but the **Miller-Urey experiment** showed that **amino acids**, the basic foundation of life, could be formed by elements in the early atmosphere.

1.7.5 – Carbon Dioxide and Global Warming

Most of the CO2 in the early atmosphere has been used up for **photosynthesis** or as **limestone**. However, it has started to rise due to **human activity**, leading to **global warming**. As the CO2 composition increases, the **pH of oceans fall**, affecting oceanic wildlife.

1.1.1 – Infrared Radiation

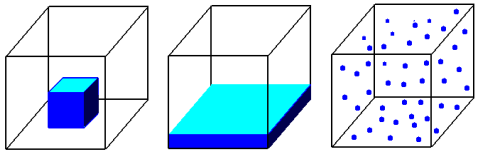
Infrared radiation is an invisible **electromagnetic** wave. **Light-colored shiny surfaces** are good at reflecting radiation, so are poor absorbers and emitters. **Dark, matt surfaces** are good absorbers and emitters. It can be used for **heating** and **thermal imaging**.

1.1.2 – Kinetic Theory

In **solids**, particles are held closely together by bonds. Can vibrate but not move.

In **liquids**, particles can move past each other. Can flow and take shape of container.

In **gases**, particles are far apart, moving quickly. Can compress and take shape of container.



Evaporation absorbs energy away from liquid.

Condensation releases energy by creating bonds.

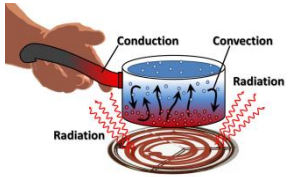
Occurs faster if temperature is higher, more surface area, and higher movement of air.

1.1.3 – Conduction

Heat travels through solids by **conduction.** Upon heating, particles gain energy, vibrating more, passing on the energy. **Metals** are good conductors due to **free electrons**.

1.1.4 – Convection

Convection takes place in fluids. Heating a fluid makes it less dense, thus causing it to rise past the cooler particles. Used for hot water systems and radiators.



1.1.6 – Heating Buildings

Solar panels can be used to heat buildings or water. **Payback time** is the time taken to save the amount of money that an improvement cost. **U-values** measure energy transfer. Houses can have **insulation**, **glazing** and **thick layers** to be energy-efficient.

1.1.7 – Specific Heat Capacities

Specific heat capacity is the energy needed to raise the temperature of 1 kg of a material by 1°C.

E = m x c x Θ

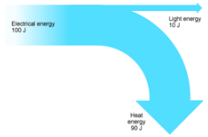
Energy = **mass** x **heat capacity** x **temp. change**

1.2.1 – Energy Transfers

Energy is needed for processes, and comes in different forms: **kinetic, chemical, electrical, nuclear, gravitational**, etc. Energy cannot be **created** or **destroyed**, only **transferred**, **stored** or **wasted**.

1.2.2 – Efficiency and Sankey Diagrams

All energy transfers produce some forms of wasted energy. **Efficiency** is a measure of the amount of energy that is usefully transferred.



Sankey diagrams represent energy transfers.

Efficiency = useful energy out / total energy in

1.3.1 – Electrical Energy

Electricity is energy caused by charged particles. The amount of electrical energy a device uses depends on its power and usage time.

E = P x t

Energy = Power x **Time**

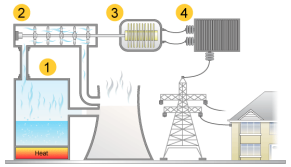
1.3.2 – Paying for Electricity

Electricity bills are worked out from the energy used.

Cost = number of kWh x **cost per kWh**

1.4.1 – Power Stations

Power stations generate electricity from other forms of energy.



- **Fuel is burnt to produce steam**
- **Steam used to spin turbine**
- **Turbine turns generator, converting kinetic energy to electrical energy**
- **Water is cooled in cooling tower for reuse**

Most power stations use **fossil fuels;** some use **nuclear fuels** (uranium, plutonium) by **nuclear fission**. **Biomass** is biological material obtained from living things. **Biofuels** are renewable fuels made from biomass (e.g. ethanol, biodiesel, methane).

1.4.2 – Comparing Power Stations

Fossil fuel power stations release **harmful gases** into the atmosphere. **Nuclear** power stations produce **hazardous waste**, is **expensive**, and needs to be **decommissioned**.

1.4.3 – Renewable Resources

Wind and water can be used to generate electricity by turning turbines. (**hydroelectricity, tidal and wave power**). **Solar** cells contain chemicals that convert light energy into electrical energy. **Geothermal** energy uses heat from the earth to produce electricity.

1.4.4 – Renewables and the Environment

Wind turbines cause visual and noise pollution. Hydroelectric power stations destroy habitats and change river flow, affecting wildlife. Power stations emit waste gases and uses land which could be used for food or habitats.

1.4.5 – Electricity Distribution and Voltage

All power stations and electricity users are connected by a system of wires and cables called the **National Grid.** Voltage is changed using transformers.

P = V x I

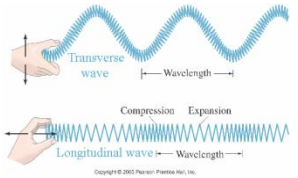
Power = Voltage x **Current**

Over-ground cables can be damaged my lightning, winds or weather but are easy to find and repair. Underground cables are less likely to be damaged by weather and do not cause visual pollution but are more difficult to repair.

1.5.1 – Waves

Waves are oscillations that travels between two places. **Transverse** waves are where oscillations are **perpendicular** to the direction of energy transfer. (e.g. electromagnetic) **Longitudinal** waves are where oscillations are **parallel** to the direction of energy transfer (e.g. sound).

Waves transfer energy but the medium does not move.



1.5.2 – Measuring Waves

A **wavelength** is the length of one complete wave. The **amplitude** is the maximum displacement that a point moves away from zero. **Frequency** is the number of cycles passing a point in one second. **Wave speed** depends on the medium.

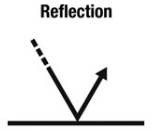
V = f x λ

Speed = frequency x **wavelength**

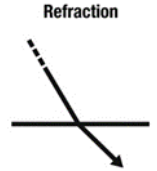
1.5.3 – Wave Behavior

When waves are transmitted, they are travelling through a medium. All waves can be **reflected**, **refracted** and **diffracted**.

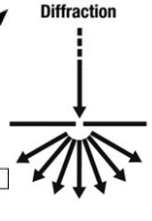
Reflection is the bouncing back of waves. When waves are reflected, the angle of incidence = angle of reflection.

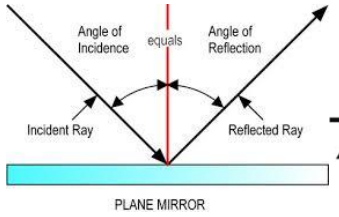


Refraction is the change in direction of a wave due to change in medium and speed.



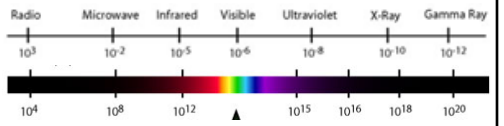
Diffraction is the spreading out of waves when passing through a gap. It is greatest when the gap is the same size as the wavelength.





1.5.4 – Electromagnetic Waves

The **electromagnetic spectrum** is the complete range of electromagnetic wavelengths, all travelling at the speed of light (3x10^8 m/s) in a vacuum.

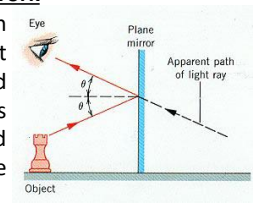


1.5.5 – Radio Waves and Microwaves

Radio waves are used to broadcast radio and television signals from transmitters and diffract through large objects. **Microwaves** are used to communicate with satellites because they pass through the atmosphere. Exposure to powerful waves can cause dangers of radiation.

1.5.7 – Making Light Work

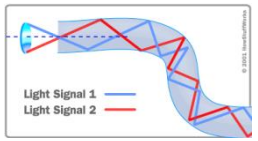
A mirror creates an **image** of the object which is upright and same sized but is laterally inverted and also seems to be behind the mirror.



Light rays do not pass through the **virtual image**, only appear to come from it. A camera produces a **real image,** which light rays do pass through; but is smaller and upside down.

1.5.8 – Light and Infrared

Infrared radiation is used in remote controls and communication.



Optical fibers are used to transmit light and infrared radiation. More info. can be carried and is more secure.

1.5.9 – Sound

Sound is a **longitudinal** wave which travels at **330 m/s** in air and is caused by **vibrations** in a **medium**. The **pitch** of a sound increases with **frequency**.

1.6.1 – Doppler Effect

The wavelength of waves decreases whereas the frequency increases when the source moves relatively closer to the observer**. Red-shift** is the increase in wavelength of EM radiation from distant celestial objects due to Doppler effect.

1.6.2 – The Expanding Universe

Red shift is evidence that the universe is expanding and galaxies are moving apart.

1.6.3 – The Big Bang Theory

If the Universe is expanding, it must have started from a small point with an explosion 13.7 billion years ago called the **Big Bang**. **CMBR** is background radiation spread around the universe caused by the Big Bang, and provides evidence for it.

1.1.1 – Diet and Exercise

A **balanced diet** is needed to keep the body healthy. **Metabolic rate** is the speed at which chemical reactions in our body occur, and is affected by diet, exercise and inheritance. **Carbohydrates** and **fats** provide energy; **proteins**, **vitamins** and **minerals** is used for growth and health. **Malnutrition** occurs when an unbalanced diet is eaten.

1.1.3 – Pathogens

Microorganisms are microscopic organisms. **Pathogens** cause infectious diseases. **Antiseptics** are chemicals to clean **wounds**, **disinfectants** are chemicals to clean work surfaces.

1.1.4 – Defense against Disease

Bacteria reproduce rapidly and produce toxins. **Viruses** hijack body cells and multiply. White blood cells defend against pathogens by ingesting them or producing **antibodies**/ antitoxins.

1.1.5 – Treating and Preventing Disease

Medicines help to relieve symptoms, **antibiotics** are medicines to kill bacteria. **Vaccination** allows immunity of a disease.

- Weak or dead microbes are injected into the body
- Antibodies are produced which destroy the microbes and toxins.
- **White blood cells** can quickly produce antibodies if this pathogen enters the body again.

1.1.6 – Controlling Infection

Mutations of pathogens produce new strains – bacteria can develop resistance to antibiotics, meaning they cannot be killed by antibiotics. **Epidemic** is when a disease outbreak affects a country, a **pandemic** is when it spreads around the world.

1.1.8 – Keeping Things Sterile

Uncontaminated cultures of microorganisms are required for investigation, done by **sterilizing** petri dishes and cultures, heating **inoculating** loops, are securing dish lids.

1.2.1 – The Nervous System

Nervous system enable us to react to surroundings and coordinate behaviour.

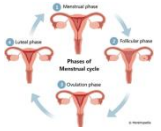
Receptors, including light, sound, taste, smell, touch; detect **stimuli** changes, then sends an electrical impulse to the **sensory neuron**, through the **relay neuron** and the spinal cord, then to the **motor neuron** to an **effector**.

1.2.2 – Controlling our Internal Environment

Water and **ions** are lost from sweating and urinating. Body temperature is kept at 37°C to maintain optimum enzyme activity. **Blood sugar levels** are regulated by kidneys to provide cells a constant supply of energy. Heat exhaustion and heatstroke occurs due to overheating of the body, causing fatal symptoms.

1.2.3 – Controlling Pregnancy

Hormones are chemical substances that control body processes.



- Day 1-5 – uterus lining
- breaks down, bleeding
- Day 5-14 – uterus lining
- builds up for fertilized egg
- Day 14 – egg released from ovary
- Day 14-30 – if no egg is fertilized, uterus lining breaks down

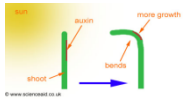
FSH is secreted by the pituitary gland and causes eggs to mature, **LH** stimulates egg release, and **Oestrogen** is secreted by the ovaries and causes formation of LH and inhibits LSH production. **Oral contraceptive pills** inhibits FSH and egg release to prevent pregnancy.

1.2.4 – Fertility Treatment

IVF treatment involves giving FSH injections to stimulate egg maturation. Then, eggs are removed, inseminating and incubating it, then transferring it into the womb as an embryo. Multiple births can occur due to IVF.

1.2.5 – Plant Responses

Plants are sensitive and respond to light moisture and gravity, and produce hormones to coordinate and control growth. **Auxins** controls **phototropism** and **gravitropism**, shoots grow towards light, and away from gravity; whereas roots grow to gravity and water.



1.2.6 – Using Plant Hormones

Plant growth hormones are used in agriculture and horticulture as weed killers, which selectively kill weeds but does not affect grass, and as rooting hormones to encourage growth of roots and shoots using auxins.

1.3.1 – Developing New Drugs

Drugs are chemicals that affect our body chemistry. **Placebos** are fake drugs used in clinical double-blind trials.

- Lab – animals and tissues used to test toxicity and function
- Stage 1 – low doses tested to small group to test safety and side effects
- Stage 2 – larger group to see effectiveness and optimum dose
- Stage 3 – large group to confirm effectiveness and side effects

Thalidomide was used for morning sickness but caused deformed births. **Statins** are used to lower blood cholesterol levels.

1.3.2 – Recreational Drugs & Establishing Links

Drugs can be used for **recreational** uses, because it alters their mood, and can be addictive. e.g. legal: caffeine and tobacco; illegal: cocaine, cannabis, heroin. Drugs mimic chemicals released across the synapses.

Tolerance builds up due to overuse of drugs, requiring larger doses. Smoking cannabis lead to addiction to hard drugs, being a **gateway drug**.

1.3.4 – Steroids and Athletics

Athletes use **steroids** to enhance performance, banned by law and sporting regulations. e.g. stimulants to boost heart rate, anabolic steroids to stimulate muscle growth. However, they cause harmful health effects.

1.4.1 – Plant Adaptations

Plants have **adaptations** which help them grow well in different conditions. In the cold, plants have rounded shape. In rainforests, plants have shiny surfaces and pointed tips for rain. In the dry, they have wide root systems to collect water, or water-storage tissues.

1.4.2 – Animal Adaptations

Animals are affected by physical factors e.g. temperature, water to grow and survive. In the cold, they have thick fur and extra fat for insulation. In deserts, extremities are longer to radiate more heat and have thin fur and fat.

1.4.3 – Presence of Others

Plants have spines and poisons to deter herbivores, animals have camouflage and poison to avoid predators. Plants compete for water, light and nutrients; animals compete for food, territory and mate.

1.4.4 – Extreme Microbes

Extremophiles are organisms that can survive extreme conditions. Some can withstand high temperatures, light or oxygen deprivation, using chemosynthesis and anaerobic respiration.

1.4.5 – Changing Environments

Environment changes affects the **distribution** of living organisms, e.g. change in competitor, diseases, temperature or rainfall.

1.4.6 – Pollution Indicators

Living organisms can be used as **indicators** of environmental changes such as pollution. Some species of plants/animals can live in pollution, but others need clean air/water. Lichens are used as air pollution indicators, invertebrate animals can be used as water pollution indicators.

1.5.1 – Energy in Biomass

Mass of living material (**biomass**) at each stage in a food chain is less than the previous stage. Material and energy is reduced at each successive stage due to excretion, respiration, etc. Plants gain energy from the sun, transferring light to chemical energy during **photosynthesis**. Animals gain energy from food and loses it from egestion and movement.

1.5.2 – Natural Recycling

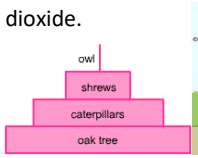
Microorganisms decay complex organic substances to simple ones, important for recycling nutrients. Best conditions are aerobic, water and warmth.

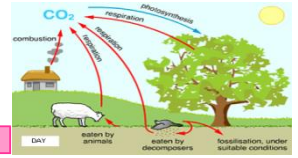
1.5.3 – Recycling Issues

Food and animal wastes can be recycled by **compost heaps** (piling and decomposing waste), **in-vessel composting**, and **anaerobic digestion** (decay by methanogens).

1.5.4 – Carbon Cycle

Plants/algae remove carbon from the atmosphere by photosynthesis to make chemicals; and are eaten by animals, who respire to release carbon dioxide. Upon death, microorganisms feed on the bodies. Combustion of fossil fuels releases carbon dioxide.





1.6.1 – Gene Basics

Genes are sections of chromosomes in nucleus, passing information to inherit characteristics. Variation is differences between members of the same species, can be environmental or genetic.

1.6.2 – Reproduction

Asexual reproduction produces genetically-identical offspring by mitosis and requires one parent. **Sexual reproduction** occurs during fusion of gametes, and leads to variation.

1.6.3 – Cloning Plants and Animals

Plants can be cloned by using **cuttings** or tissue culture (growing cells from part of a plant). Animals can be cloned by **embryo transplants** (fertilizing egg cells from male and transplanting them into host mother) and **adult cell cloning** (replacing nucleus of egg cell with adult cell by electric shock and placing into womb)

1.6.4 – Modifying Genetic Code

Genes from human **chromosomes** can be cut out using enzymes and transferred to cells of other organisms to change characteristics; and can be transferred at an early stage to develop with desired characteristics.

1.6.5 – GM Crops

Genetically modified crops, grown using tissue culture, affects populations of wild flowers and insects and may be harmful to human health, but can be an economic way to feed the poor since it increases yield and nutrition.

1.7.1 – Evolution

Studying similarities and differences between organisms helps to classify living organisms into animals, plants and microorganisms, and this helps us to understand **evolutionary and ecological relationships**.

1.7.2 – Natural Selection

Darwin's theory of evolution by **natural selection** states that all species of living things have evolved from simple life forms developed three billion years ago; but was refused by religious beliefs and insufficient evidence.

1.7.3 – Other Theories

Lamarck's theory states that an organism (plant/animal) can pass on characteristics that the organism has acquired in its lifetime and can pass on these acquired characteristics to its offspring.