Knowledge Organiser – 4.1.1 Cell Biology

4.1.1 Cell Structure

4.1.1.1. Eukaryotes & Prokaryotes:

Eukaryotic (plant, animal & fungal cells).

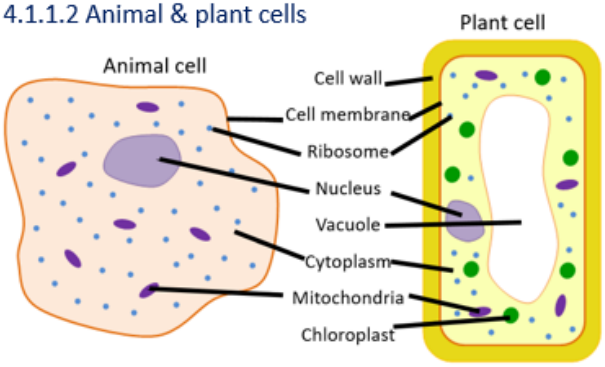
- Cell membrane
- Cytoplasm
- Genetic material enclosed in membrane

Prokaryotic (bacteria and archaea)

- smaller with no true nucleus.
- No mitochondria or chloroplasts.
- DNA loops called plasmids
- Bacteria are prokaryotes.

4.1.1.2	Definitions
eukaryotic	A type of cell that has a nucleus.
prokaryotic cell	A simple cell that does not have a nucleus – the DNA is free in the cytoplasm.
mitochondria	Structures in the cytoplasm of all cells where aerobic respiration takes place
ribosome	The site of protein synthesis.
sub-cellular	Structures smaller than a cell that are found within it.
tissue	A group of similar cells that carry out the same function, eg muscle tissue.
Nucleus	Contains the cell's genetic materials
Cell membrane	Controls the movement of substances in and out of the cell
Cytoplasm	where many chemical reactions take place
Chloroplasts	where photosynthesis occurs
Vacuole	Filled with cell sap to help support the plant
Cell wall	made of cellulose to strengthen the cell.

4.1.1.2 Animal & plant cells



You must be able to label the animal and plant cells

Sub-cellular structures:

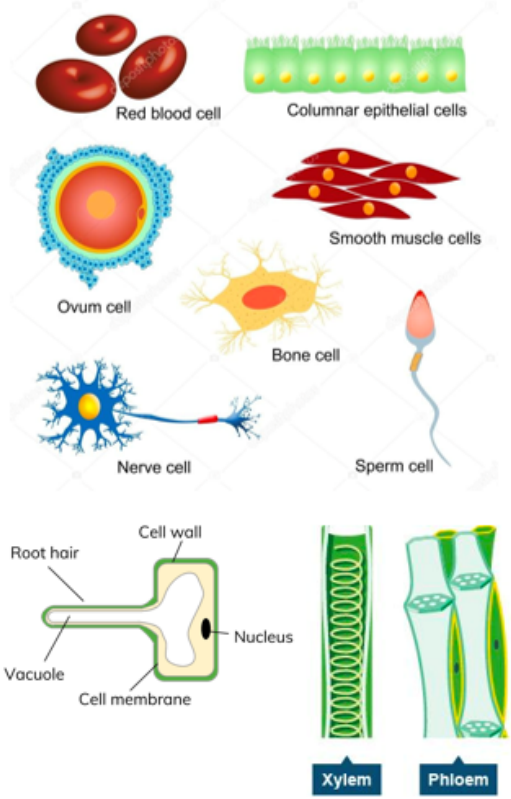
Most animal cells have the following

- **nucleus**
- **cytoplasm**
- **a cell membrane**
- **mitochondria**
- **ribosomes.**

In addition to the parts found in animal cells, plant cells often have:

- **chloroplasts**
- a permanent **vacuole** filled with cell sap.
- Plant and algal cells also have a **cell wall made of cellulose**, which strengthens the cell

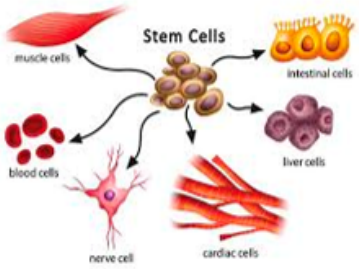
4.1.1.3. Cell specialisation:



4.1.1.4 Cell differentiation

As an organism develops, cells differentiate to form different types of cells.

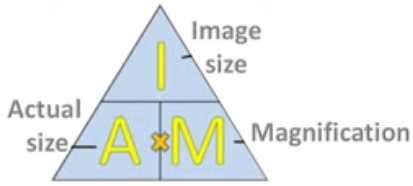
- Most types of animal cell differentiate at an early stage.
- Many types of plant cells retain the ability to differentiate throughout life.



4.1.1.5 Microscopy

Electron microscope

- has much **higher magnification** and **resolving power** than a light microscope.
- Can be used to **study cells in much finer detail.**
- Enabled biologists to see and **understand many more sub-cellular structures.**



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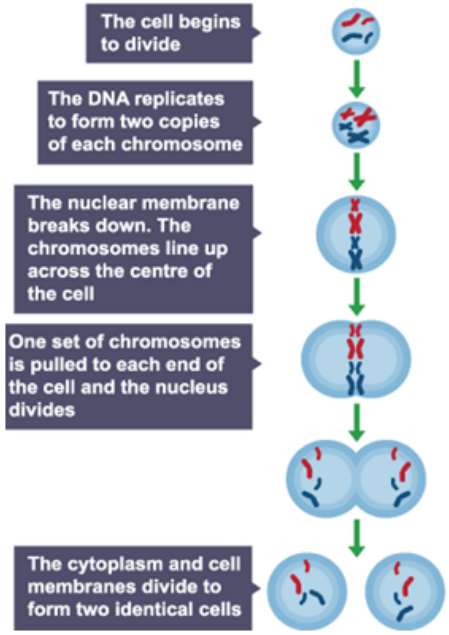
Knowledge Organiser – 4.1.2 Cell Biology

4.1.2 Cell Division : MITOSIS

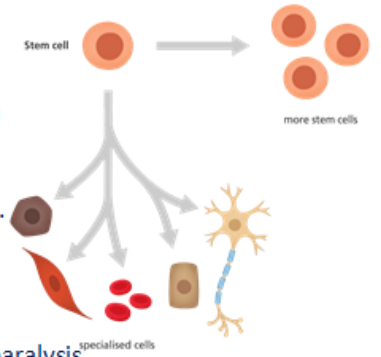
- The nucleus of a cell contains **chromosomes** made of **DNA** molecules.
- Each chromosome carries a large number of **genes**.
- In body cells the chromosomes are **normally found in pairs**.
- **Mitosis** is **cell division for growth & repair**.
- 2 genetically identical daughter cells are formed.



4.1.2.3 Stem cells - Plants

- **Meristem tissue** in plants can **differentiate into any type of plant cell**, throughout the life of the plant.
- can be used to **produce clones** of plants quickly and economically and to prevent extinction.
- **Crop plants** with special features such as disease resistance can be cloned to produce large numbers of identical plants for farmers.

4.1.2.3 Stem cells - animals



- A **stem cell is an undifferentiated cell of an organism** which is capable of giving rise to cells of any type.
- **Stem cells from human embryos can be cloned** and made to **differentiate into most** types of human cells.
- **Stem cells from adult bone marrow** can form many types of cells including **blood cells.**

Treatment with stem cells

- may be able to help conditions such as diabetes and paralysis.
- In **therapeutic cloning** an embryo is produced with the same genes as the patient. Stem cells from the embryo are not rejected by the patient' body so they may be used for medical treatment.
- The use of stem cells has potential risks such as transfer of viral infection and some people have ethical or religious objections.

RPA: Microscopy	Definitions
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field of view	The area seen when looking through a microscope.
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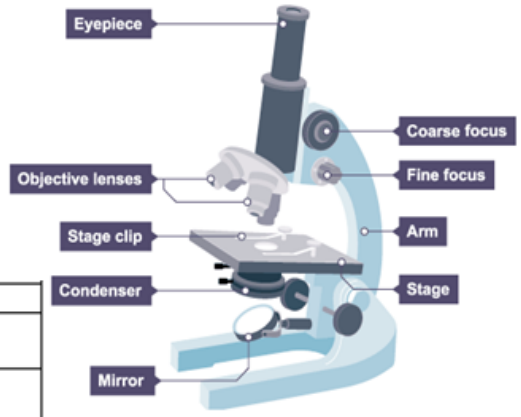
Required practical activity: use a light microscope to observe, draw and label a selection of plant and animal cells.
A magnification scale must be included



Millimetre (mm)	0.001m	10^{-3}m
Micrometre (μm)	0.000001m	10^{-6}m
Nanometre (nm)	0.000000001m	10^{-9}m

Knowledge Organiser – 4.1.3 Transport in Cells

4.1.3.1 Diffusion

Substances may move into and out of cells across the cell membranes via diffusion.

- Diffusion is the spreading out of the particles of any substance in solution, or particles of a gas, resulting in **a net movement from an area of higher concentration to an area of lower concentration**.

Some of the substances transported in and out of cells by diffusion are:

- **oxygen** and **carbon dioxide** in gas exchange,
- waste product **urea** from cells into the blood plasma for excretion in the kidney.

Factors which affect the rate of diffusion are:

- the difference in concentrations **(concentration gradient)**
- the **temperature**
- the **surface area** of the membrane.

The effectiveness of an exchange surface is increased by:

- having a **large surface area**
- a membrane that is **thin** to provide a short diffusion path
- (in animals) having an **efficient blood supply**
- (in animals, for gaseous exchange) being **ventilated**.

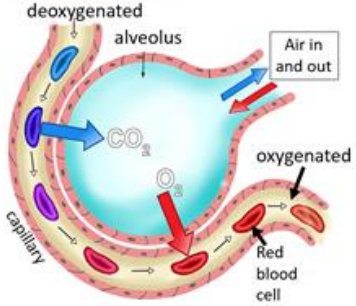
4.1.3.1 Diffusion - examples

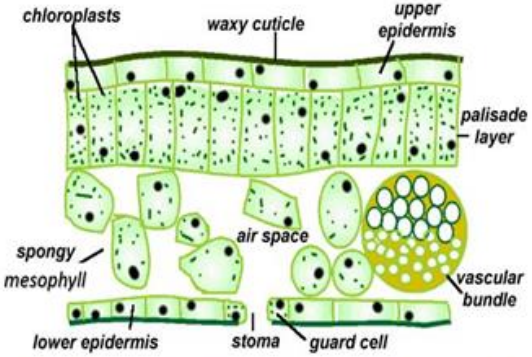
Single-celled organisms have a **large surface area to volume ratio**, allowing sufficient transport of molecules in and out of the cell.

Multicellular organisms have a **relatively small surface area to volume ratio** so they **need specialised exchange surfaces** and a transport system:

- Large surface area
- Thin membranes for a short diffusion path
- Efficient blood supply (animals)
- Being ventilated (animals)

Gas exchange in the alveoli





CO_2 diffuses from high concentration in the air space to a low concentration inside the mesophyll cells

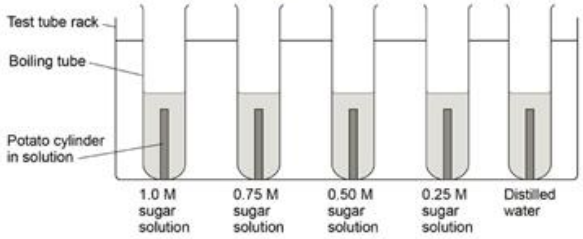
4.1.3.2 Osmosis

Osmosis is the **diffusion of water from a dilute solution** to a **concentrated solution** through a partially permeable membrane.

Effects of Osmosis on Plant Cells

In dilute solution = turgid	In isotonic solution = same	In concentrated solution = flaccid	Plasmolysed cell= cytoplasm pulls away from cell wall

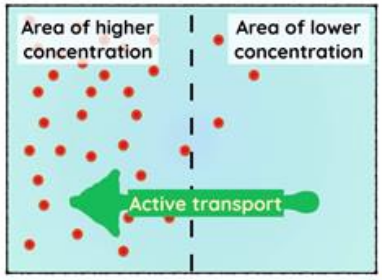
RPA: investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue



4.1.3.3 Active Transport

Is the movement of substances from a more dilute to a more concentrated solution (against the concentration gradient). **It needs ENERGY from respiration.** for respiration.

Eg 1- **Mineral ions** absorbed **into root hair cells** from very dilute solutions in the soil.
Eg 2- **Sugar molecules** absorbed **from the gut** (lower concentration) into the blood for respiration.

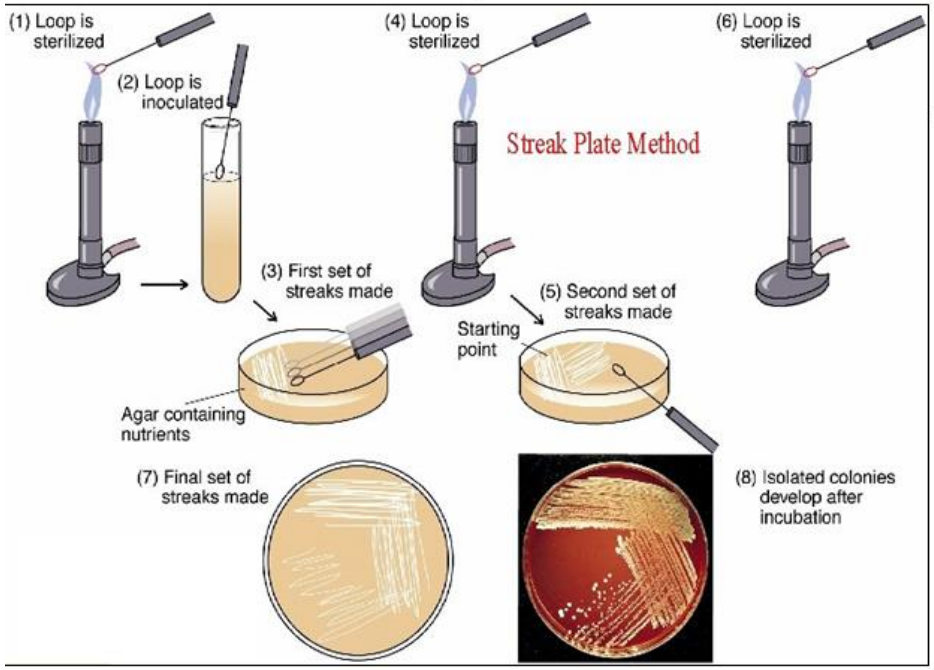


Knowledge Organiser – 4.1.1.6 Culturing Microorganisms (Separate Biology RPA)

4.1.1.6 Culturing microorganisms

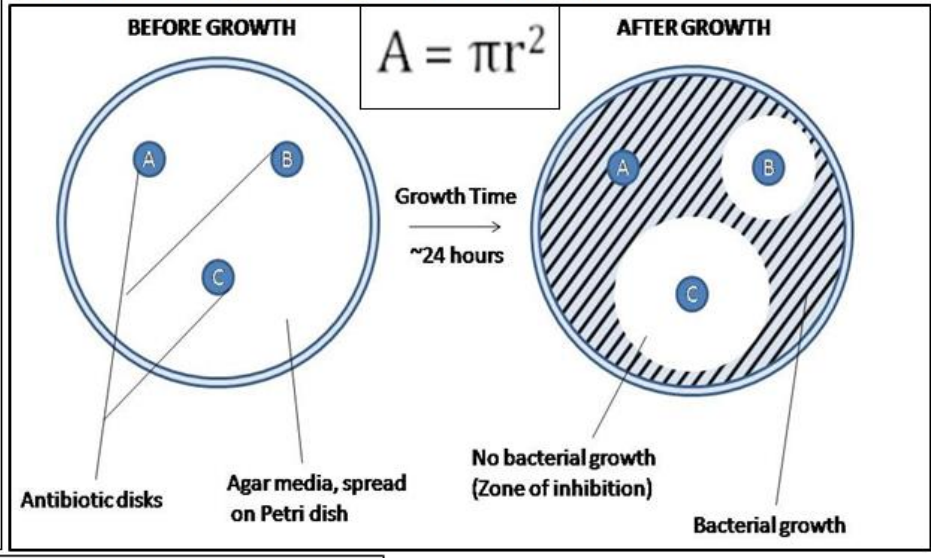
The loop is sterilised by the Bunsen flame as the microbes are killed by the heat

The base of the petri dish should be labelled with date, sample etc just in case the lid comes off.



Bacterial Growth

Bacteria multiply by simple cell division if they have enough nutrients and a suitable temperature
You can investigate the effects of disinfectants and antibiotics on bacterial growth using agar plates and calculating the cross-sectional area of colonies grown or of clear areas of agar



Do not blow on the loop as it cools – this might transfer microbes from you to the loop

Replace the lid quickly after inoculation to avoid contamination.

The lid must be taped on in a cross shape so air flow is not stopped – this will prevent harmful anaerobic bacteria from growing.

The petri dish must be stored upside down to prevent condensation dripping on the surface of the agar.

Knowledge Organiser – 4.1.1 Cell Biology

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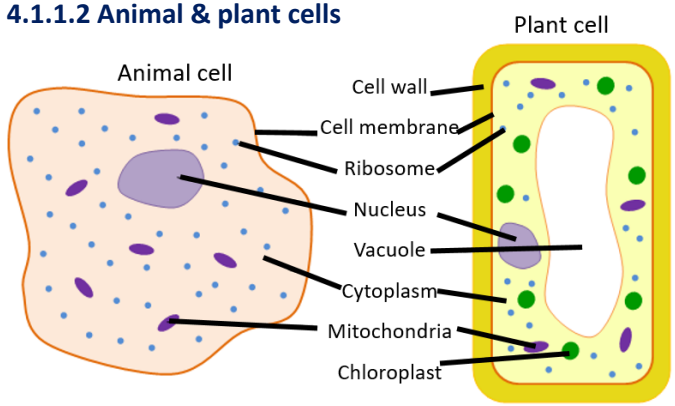

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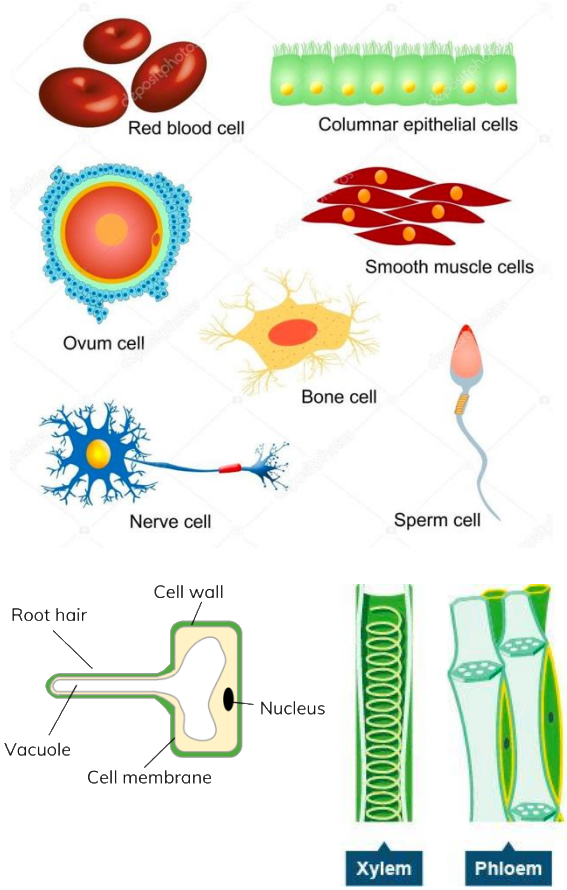

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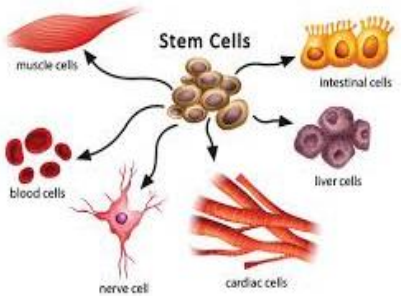

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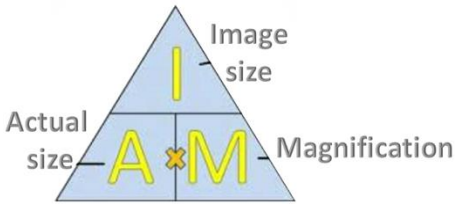

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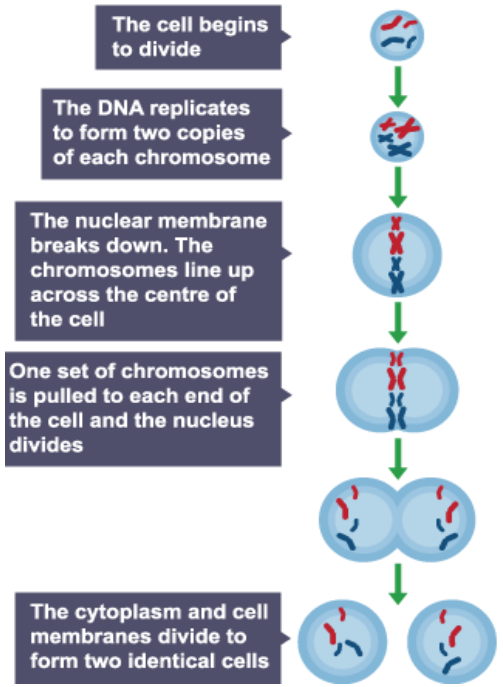

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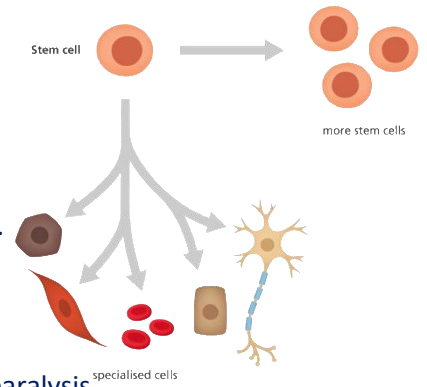

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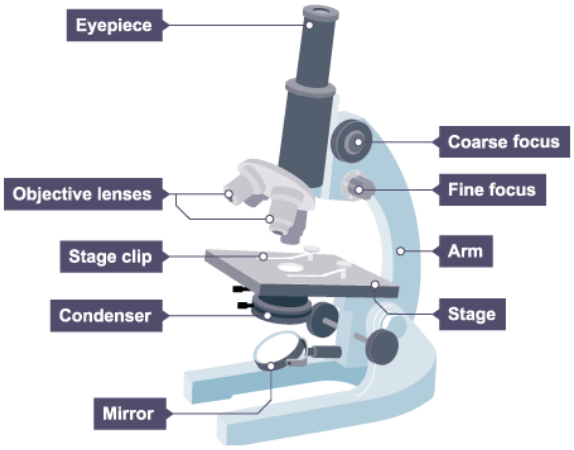

Knowledge Organiser – 4.1.3 Transport in Cells

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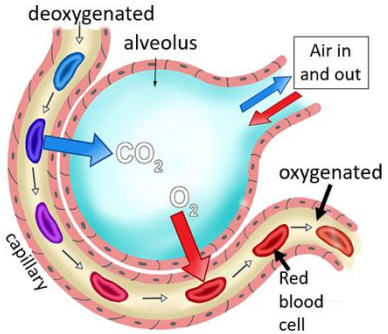

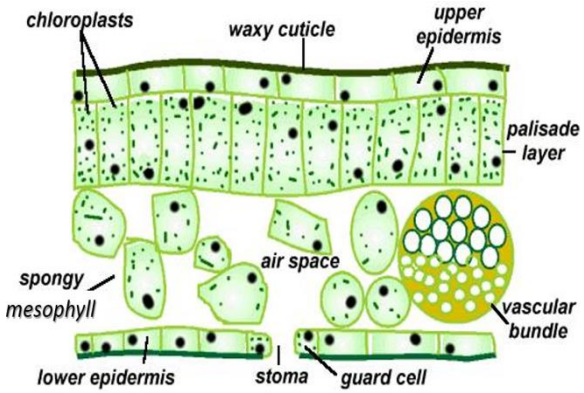

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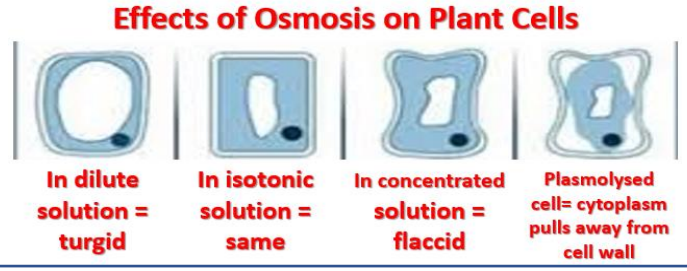

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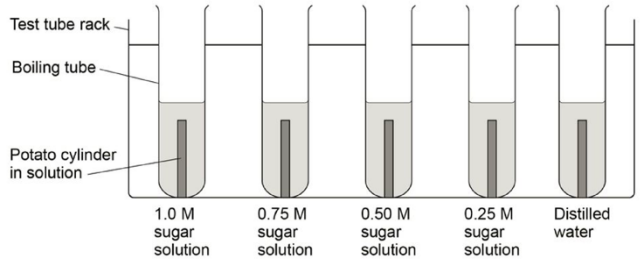

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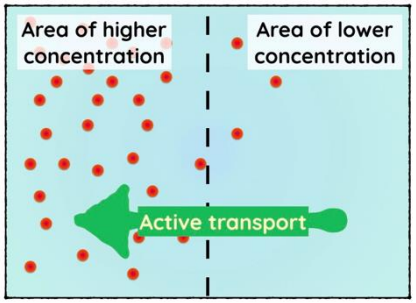


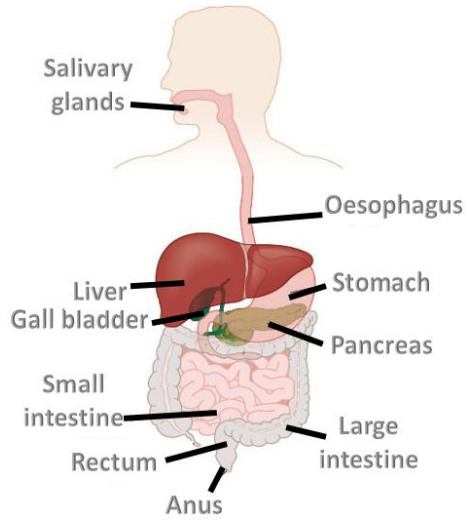
Knowledge Organiser – 4.2 Organisation

4.2.1 Principles of organisation

4.2.1	Definitions
Cells	The basic building blocks of all living organisms. Eg. Muscle, skin, nerve, root hair and palisade leaf cells
Tissue	A group of cells with a similar structure and function (job). Eg. Muscle, heart, xylem and epidermal tissue
Organs	A group of tissues performing a specific function. Eg. Heart, liver, brain, roots, stem, leaf & flower
Organ systems	Groups of organs working together to form an organism. Eg. circulatory, nervous & transpiration systems
Digestive system	Organ system in which several organs work together to digest & absorb food.

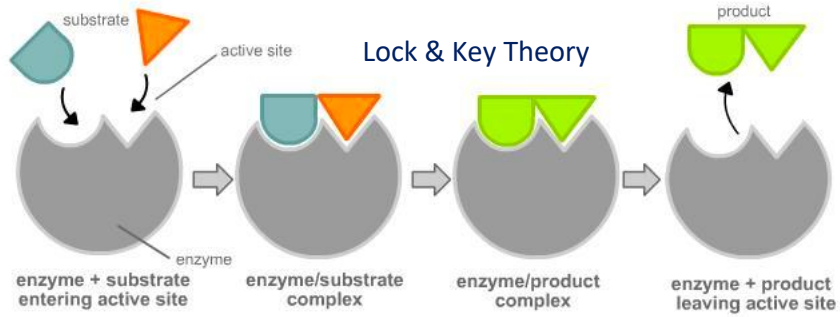
4.2.2 Animal tissues, organs and organ systems

4.2.2.1 The human digestive system



Enzyme	Produced	Nutrients acted upon	Products (smaller molecules)	Optimum pH & temperature
Carbohydrase Eg. Amylase	Salivary glands	Carbohydrate Eg. starch	Simple sugars Eg. glucose	pH7 37°C
Protease	Stomach, pancreas	Protein	Amino acids	pH2 37°C
Lipase	Pancreas, small intestine	Lipid (fats & oils)	Glycerol & fatty acids	pH8 37°C

Enzymes are **biological catalysts** that breakdown food into small, soluble molecules that can be absorbed into the bloodstream from the digestive system.



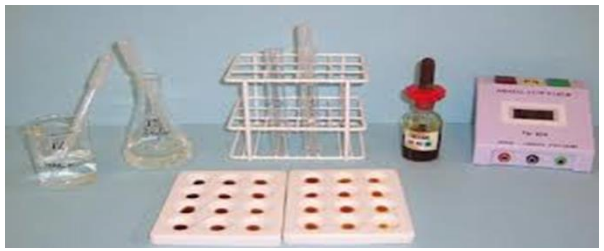
Denature. If the optimum conditions are not correct for an enzyme, it loses it's shape and cannot attach to the substrate (nutrient molecule). It is "denatured".

bile	Made in the liver, stored in gall bladder. Emulsifies fats to for digestion and neutralises stomach acid.
carbohydrate	Food consisting of sugars, starch and cellulose. Carbohydrates are vital for energy in humans and are stored as fat if eaten in excess.
digestion	The breakdown of large insoluble food molecules to smaller soluble ones.
digestive system	Organ system involved in breaking food down so that it can be absorbed into the bloodstream.
egestion	The process of passing out the remains of food that has not been digested, as faeces, through the anus.
emulsify	To mix water with lipids to produce a cloudy mixture called an emulsion.
fats	Naturally occurring compounds of carbon, hydrogen and oxygen. They are esters made from fatty acids and glycerol.
fatty acids	Carboxylic acids with a long chain of carbon atoms. Fatty acids react with glycerol to produce lipids (fats and oils).
gall bladder	Stores bile before releasing it into the duodenum.
glucose	A simple sugar used by cells for respiration.
glycogen	Animals store glucose as glycogen in their liver and muscle tissues.
gut	The digestive system.
lipid	Fat or oils, composed of fatty acids and glycerol.
liver	The large organ, beside the stomach, which has many functions, including processing substances absorbed by the digestive system and a role in the storage of the body's carbohydrate.
metabolism	All the chemical reactions in the cells of an organism, including respiration.
microvilli	Projections from the surface of an epithelial cell of the small intestine wall.
pancreas	Large gland located in the abdomen near the stomach which produces digestive enzymes and the hormone insulin.
protein	Organic compound made up of amino acid molecules. Proteins are needed by the body for cell growth and repair.
starch	A type of carbohydrate. Plants can turn the glucose produced in photosynthesis into starch for storage
sugar	A simple carbohydrate that is sweet to the taste.
villi	Finger-like projections in the small intestine that provide a large surface area for the absorption of food.

Knowledge Organiser – 4.2 Organisation

RPA: investigate the effect of pH on the rate of reaction of amylase on starch

Amylase breaks down starch. Starch turns blue/black when iodine (an orange solution) is added.



- Starch solution (CV)
- Amylase solution (CV)
- Buffer solutions of different pH (**IV**)
- Spotting tiles
- Test tubes
- Water bath (temp CV)
- Iodine solution
- Stop clock

DV is the time at which the starch/ amylase solution no longer turns blue/black.

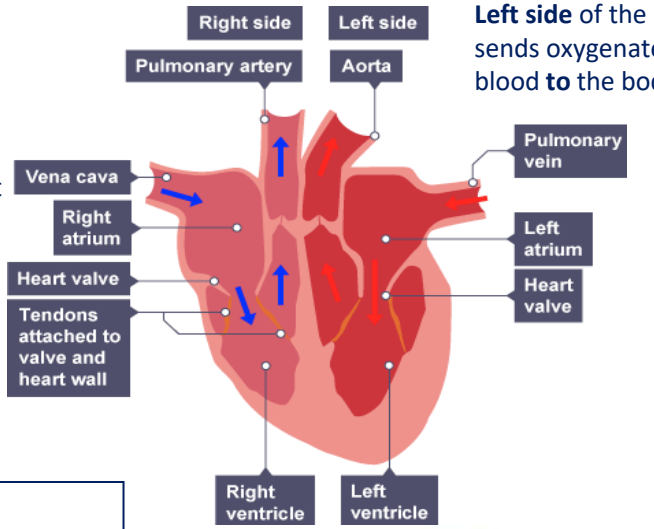
RPA: use qualitative reagents to test for carbohydrates (starch and glucose), proteins and lipids

Food group	Reagent	Positive result
Glucose	Benedict's solution (heated) 	Bright blue to orange/ brick red 
Protein	Biuret's solution 	Bright blue to lilac 
Starch	Iodine solution 	Orange to blue/ black 
Lipid (Fat/oil)	Ethanol & water 	Clear to Milky/ cloudy 

4.2.2.2 The heart and blood vessels

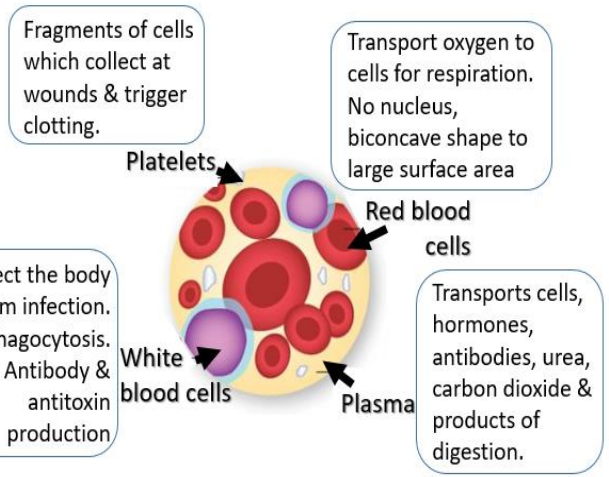
Right side of the heart receives deoxygenated blood **from** the body and pumps it to the lungs.

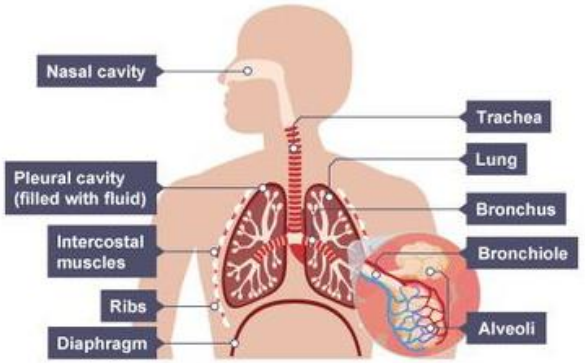
Pacemaker
Group of cells in the right atrium that control resting heart rate.



Left side of the heart sends oxygenated blood **to** the body.

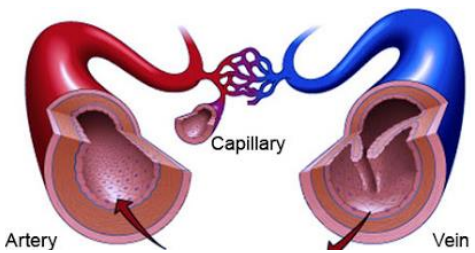
4.2.2.2 The heart and blood vessels





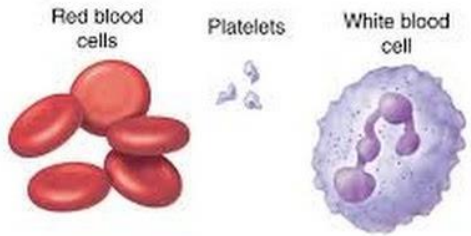
4.2.2.3 Blood

- Blood away from heart
- Thick muscular wall
- Small lumen
- Under high pressure



- Blood towards from heart
- Thinner wall
- Large lumen
- Under low pressure

4.2.2.3 Blood



Blood is a tissue consisting of plasma containing red blood cells, white blood cells and platelets

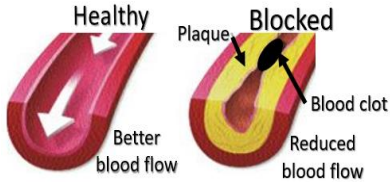
Knowledge Organiser – 4.2 Organisation

4.2.2.4 Coronary heart disease: a non-communicable disease

- **Coronary heart disease** layers of fatty material build up inside the coronary arteries, narrowing them.
- Reduces the flow of blood through the coronary arteries, resulting in a lack of oxygen for the heart muscle.
- Stents are used to keep the coronary arteries open.
- Statins are widely used to reduce blood cholesterol levels which slows down the rate of fatty material deposit.

- **Heart valves may become faulty**, preventing the valve from opening fully, or the heart valve might develop a leak.
- Faulty heart valves can be replaced using biological or mechanical valves.

- **Heart Transplants**: the case of heart failure a donor heart, or heart and lungs can be transplanted.
- Artificial hearts are occasionally used to keep patients alive whilst waiting for a heart transplant, or the heart to rest as an aid to recovery.



4.2.2.5 Health issues & types of disease

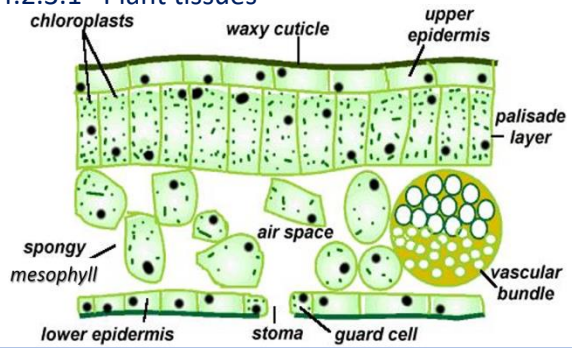
communicable, can be transferred from one organism to another, e.g. measles, food poisoning and malaria
non-communicable, which are not transferred between people or other organisms, e.g.

- **cancer**
- **diabetes**
- **genetic diseases** and conditions
- heart disease
- neurological disorders

Other factors that can effect physical and mental health include:

- **diet**
- **lifestyle factors** such as alcohol and other drugs
- **stress**
- situations that may occur in a person's life

4.2.3.1 Plant tissues



Epidermis	Covers outer leaf surface for protection
Palisade mesophyll	Main site for photosynthesis. Many chloroplasts
Spongy mesophyll	Air spaces between cells allow gases to diffuse

4.2.2.6 lifestyle on non-communicable disease

Risk factors are linked to increased rate of a disease. aspects of a person's lifestyle

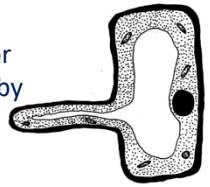
- substances in the body or environment.
- The effects of diet, smoking and exercise on cardiovascular disease.
- Obesity as a risk factor for Type 2 diabetes.
- The effect of alcohol on liver & brain function.
- Effect of smoking on lung disease & lung cancer.
- Effects of smoking & alcohol on unborn babies.
- Carcinogens, including ionising radiation, as risk factors in cancer.

4.2.2.7 Cancer

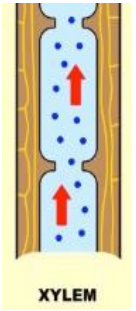
Benign tumours are abnormal cell growths contained in one area, **usually within a membrane**. They do not invade other parts of the body.
Malignant tumour cells are cancers. Invade neighbouring tissues and **spread to different parts of the body** where they form secondary tumours.

4.2.3.2 Plant organ system

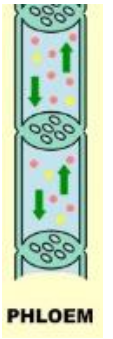
Roots, stem, leaves form plant transport organ system.



- **Root hair cells** are adapted for the efficient uptake of water by osmosis, and mineral ions by active transport.

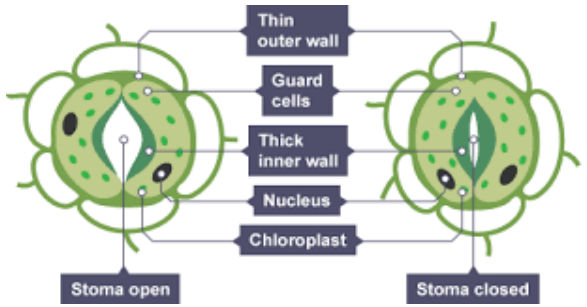


- **Xylem tissue** transports water and mineral ions from the roots to the stems and leaves.
- Made of hollow tubes strengthened by **lignin** adapted for the transport of water in the **transpiration** stream.



- **Phloem tissue** transports dissolved sugars from the leaves to the rest of the plant for immediate use or storage. This transport is called **translocation**.
- **Phloem** is composed of tubes of elongated cells. **Cell sap can move from one phloem cell to the next through pores in the end walls**.

- **Stomata** and **guard cells** control gas exchange and water loss.



Knowledge Organiser – 4.3 Infection and response

4.3.1.1 Communicable (infectious) diseases

Pathogens are microorganisms that cause infectious disease.

Pathogens may be **viruses**, **bacteria**, **protists** or **fungi**.

- They may infect plants or animals and can be spread by direct contact, by water or by air.
- Bacteria and viruses may reproduce rapidly inside the body.
- Bacteria may produce poisons (toxins) that damage tissues and make us feel ill.
- Viruses live and reproduce inside cells, causing cell damage. Viruses are not considered to be living organisms.

Pathogen	Example in animals	Example in plants	Treatment
Viruses	Measles, HIV potentially leading to AIDS	Tobacco mosaic virus	Vaccination
Bacteria	Salmonella Gonorrhoea	Agrobacterium	Antibiotics
Fungi	Athlete's foot	Rose black spot	Anti fungal medication & Fungicides.
Protists	Malaria (Spread by mosquitos)	Downy mildew	Anti malarial drugs, prevention from vector contact eg mosquito nets

Tobacco mosaic virus

Rose Black Spot

Downy mildew

4.3.1.2 Viral diseases

Measles is a **viral disease**

- Symptoms: fever and a red skin rash.
- Measles can be fatal if complications arise.
- Most young children are vaccinated against measles.
- The measles virus is spread by inhalation of droplets from sneezes and coughs.

HIV initially causes a flu-like illness.

- Unless successfully controlled with antiretroviral drugs the virus attacks the body's immune cells.
- Late stage HIV infection, or AIDS, occurs when the body's immune system becomes so badly damaged it can no longer deal with other infections or cancers.
- HIV is spread by sexual contact or exchange of body fluids such as blood which occurs when drug users share needles.

Tobacco mosaic virus (TMV) is a widespread plant pathogen

- Affecting many species of plants including tomatoes.
- Symptoms: Gives a distinctive 'mosaic' pattern of discolouration on the leaves which affects the growth of the plant due to lack of photosynthesis.

4.3.1.3 Bacterial diseases

Salmonella food poisoning

- Spread by bacteria ingested in food, or on food prepared in unhygienic conditions.
- In the UK, poultry are vaccinated against salmonella to control the spread.
- Symptoms: Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete.

Gonorrhoea is a sexually transmitted disease (STD)

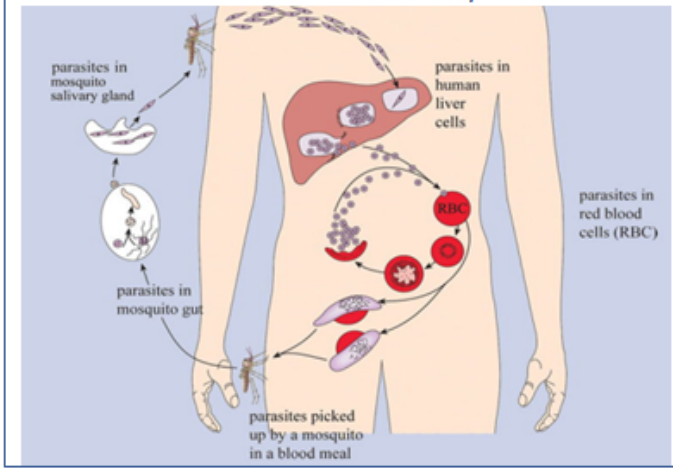
- Symptoms: thick yellow or green discharge from the vagina or penis and pain on urinating.
- Was easily treated with the antibiotic penicillin until many **resistant strains appeared.**
- Spread by sexual contact.
- The spread can be controlled by treatment with antibiotics or the use of a barrier method of contraception such as a condom.

4.3.1.4 Fungal diseases

Rose black spot is a fungal disease

- Symptoms: purple or black spots develop on leaves, which often turn yellow and drop early.
- It affects the growth of the plant as photosynthesis is reduced.
- It is spread in the environment by water or wind. Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves.

4.3.1.5 Protist diseases : Malaria Life Cycle

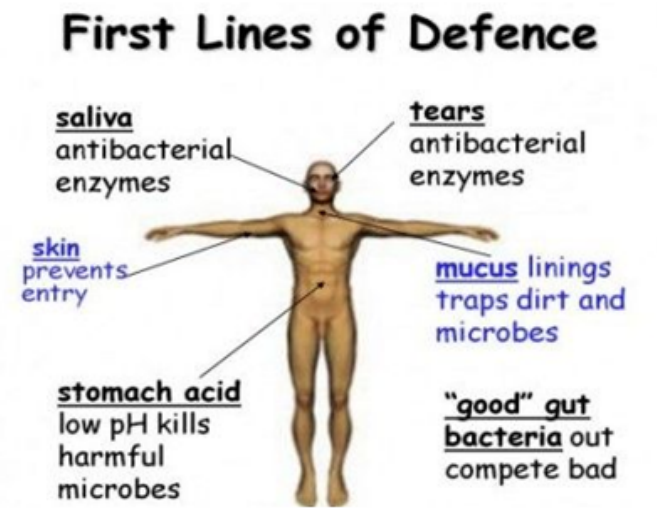


Knowledge Organiser – 4.3.1.6 Human defence systems

4.3.1.6 Human defence systems

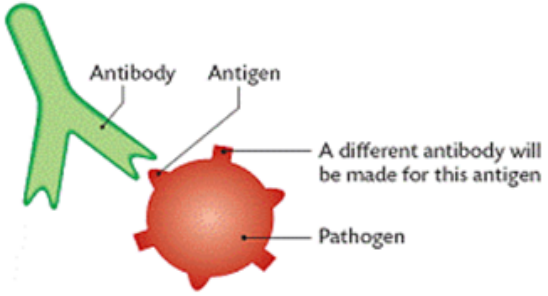
Humans have a variety of **specific** and **non specific** Human defences against invading pathogens.

Non-specific:	**Specific via white blood cells**
Skin (physical barrier)	Phagocytosis
Nose (mucus)	Antibodies
Trachea and bronchi (cilia)	Antitoxins
Stomach (acid)	



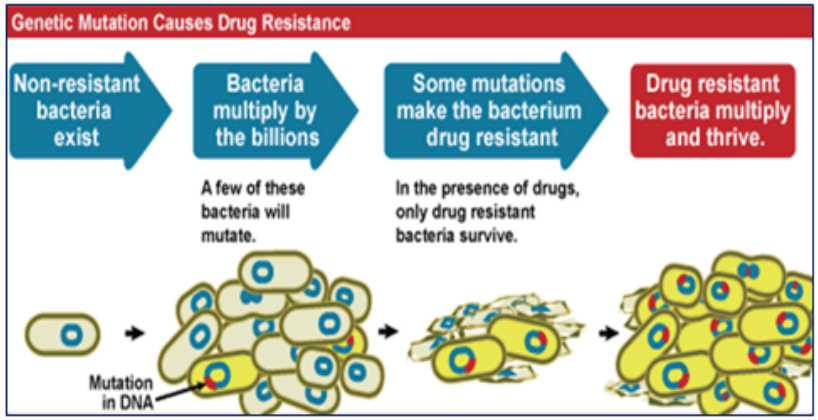
4.3.1.7 Vaccination

- Introducing small **quantities of dead or inactive pathogens** to **stimulate antibody production.**
- This leads to a quicker response in future infections.



4.3.1.8 Antibiotics and pain killers

- **Antibiotics**, such as **penicillin**, are medicines that help to cure bacterial disease by killing infective bacteria inside the body.
- Specific bacteria should be treated by specific antibiotics
- **Emergence of antibiotic resistant bacteria** is of great concern.
- **Antibiotics CANNOT kill viral pathogens**
- Painkillers and other drugs are used to treat the symptoms of disease, but do not kill pathogens.

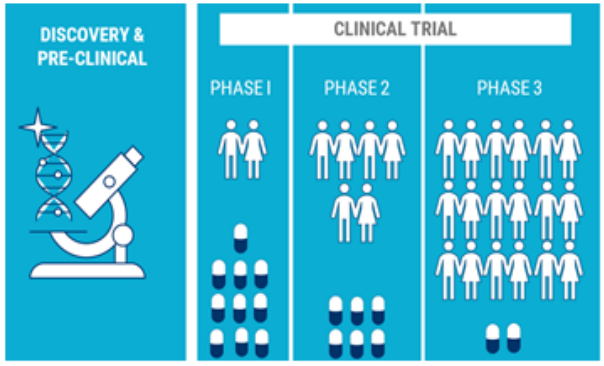


4.3.1.9 Discovery and development of drugs

Have traditionally been extracted from Plants and microorganisms.

Digitalis – Foxgloves
Aspirin – Willow
Penicillin – Penicillium mould

- Most new drugs are **synthesised by chemists** in pharmaceutical industry
- New drugs have to be **tested** and **trialled** before use to check they are **safe and effective.**
- New drugs tested for **toxicity, efficacy and dose**



Clinical trials use healthy volunteers and patients.

- Very low doses of the drug are given at the start of the clinical trial.
- If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug.
- In double blind trials, some patients are given a placebo

Knowledge Organiser – 4.3 Separate Biology

4.3.2.1 Producing monoclonal antibodies (HT) are identical copies of one ***type of antibody*** produced in a laboratory. How to produce monoclonal antibodies:

1. A **mouse** is injected with a **pathogen**
2. White blood cells called lymphocytes produce **antibodies**
3. **Lymphocytes** are removed from the mouse and fused with rapidly dividing mouse **tumour** cells. The new cells are called **hybridomas**.
4. The hybridomas divide **rapidly** & release lots of **antibodies** which are then **collected**

4.3.2.2 Uses of monoclonal antibodies: Used in treatment of diseases and monoclonal antibodies have been developed against the **antigens** on **cancer cells**. Monoclonal antibodies are bound to **radioactive** substances (or **toxic** drugs and chemicals) that **stop** cells growing and dividing. Monoclonal antibodies have **side effects** and are not as widely used in cancer treatment.

4.3.3.1 Detection and identification of plant diseases

Plants can be infected by a range of **viral, bacterial and fungal** pathogens as well as insect **pests**. We can detect a plant is diseased by looking for **unusual growths, spots or discoloured leaves and malformed leaves and stems**. A disease can be identified by:

- Gardening manuals & websites
- Test kits containing monoclonal antibodies
- Taking infected plants to a laboratory to ID the pathogen

Deficiency of Mineral Ions

Nitrate ions --> Needed by plants for protein synthesis and growth. Lack of nitrate ions results in stunted growth of plants.

Magnesium ions --> Needed by plants to produce chlorophyll. Lack of magnesium ions results in chlorosis (yellowing of leaves due to lack of chlorophyll)

4.3.3.2 Plant defence responses

Type of plant defence used (mechanical, physical or chemical)	What is the plant being defended against?	Describe the defence being used
Mechanical	Herbivores eating it	Thorns or hairs
Chemical	Pathogens/bacteria Herbivores/animals	The chemical released is antibacterial or poisonous
Physical	Herbivores and pathogen entry	Dead bark coating which falls off
Physical	Insects such as aphids	Waxy cuticle/cellulose cell walls are hard to penetrate

The presence of pests

Stunted growth

Chlorosis

Thorns

Knowledge Organiser – 4.3 Infection and response

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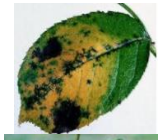

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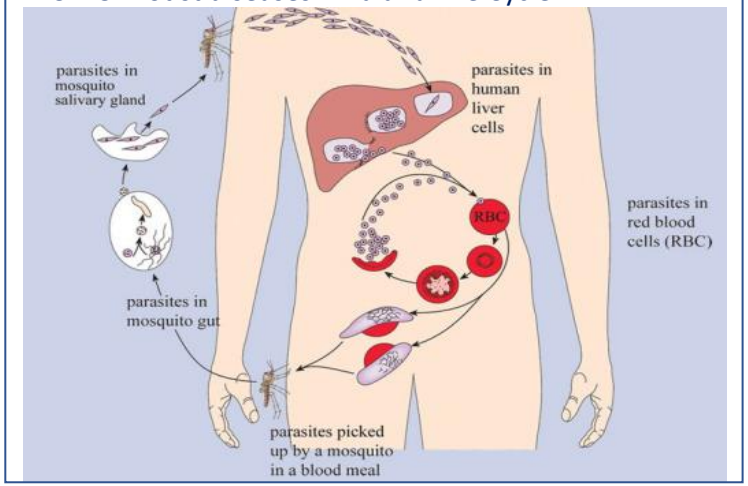

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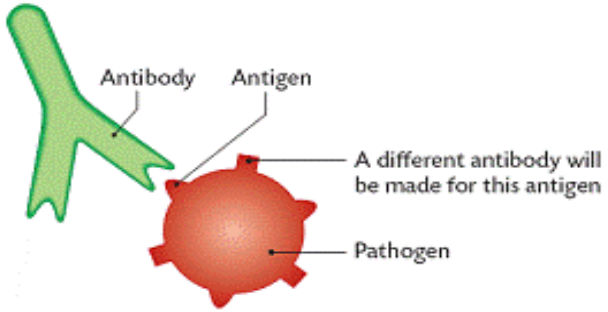

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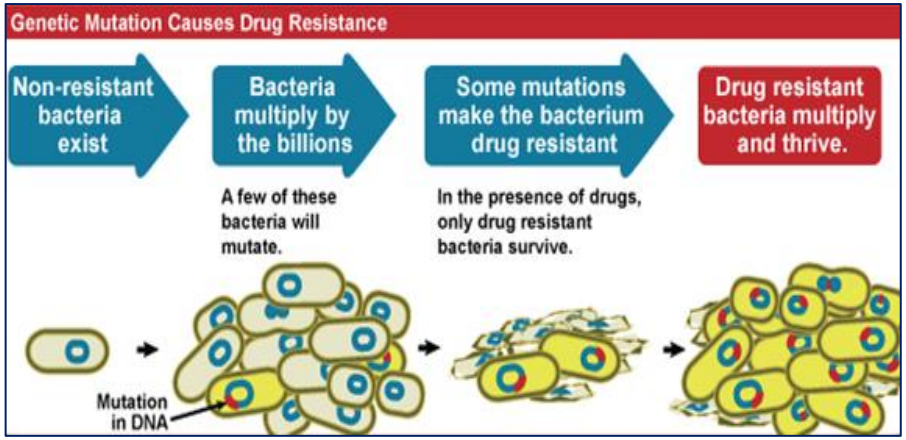

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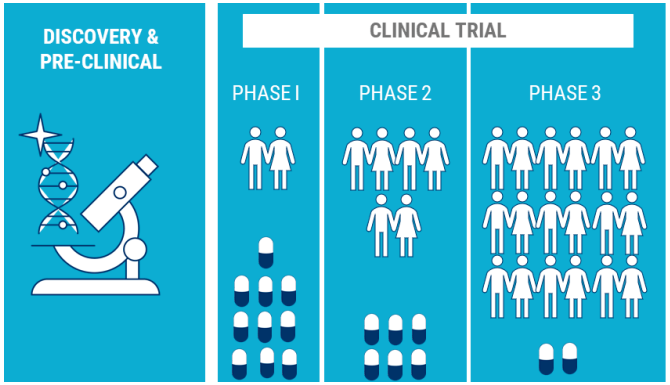

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Knowledge Organiser – 4.4 Bioenergetics

4.4.1 Photosynthetic reaction

- Captures light energy from the sun and uses it to produce chemical potential energy
- transfer of light energy to chemical potential energy in cells
- **endothermic** reaction.
- Trapped by chlorophyll in chloroplasts

The reaction can be shown in these equations:

carbon dioxide + water $\xrightarrow{\text{light}}$ glucose + oxygen

$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

Key Terms	Photosynthesis Definitions
Photosynthesis	The endothermic reaction that transfers light energy to chemical potential energy. In it, simple molecules (CO2 and H2O) are converted into more complex molecules (glucose) that can be used for food.
Nitrates	Ions containing nitrogen and oxygen. These are found in the soil; plants need nitrates to produce amino acids.
Rate	As always, rate means how quickly something happens.
Light intensity	The amount/strength of light. Use this term instead of 'amount of light'.
Chlorophyll	The green pigment in leaves that absorbs light for photosynthesis. Chlorophyll is found in chloroplasts.

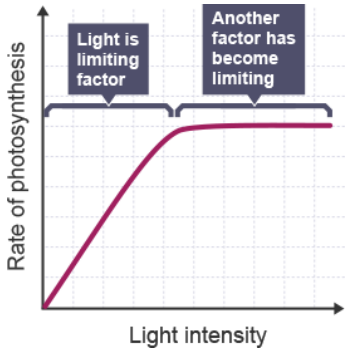
4.4.1.3 Uses of glucose from photosynthesis

- Used in <u>respiration</u> in the cells of the plant/algae
- Converted into insoluble **starch** for <u>storage</u>.
- Produces **fats or oils (lipids)** for <u>storage</u>. Eg Nuts & seeds
- Used to produce **cellulose**, which strengthens the cell wall.
- Used to produce **amino acids**, to <u>synthesise proteins</u>. To produce amino acids, plants also require **nitrates** from the soil.

4.4.1.2 Rate of Photosynthesis

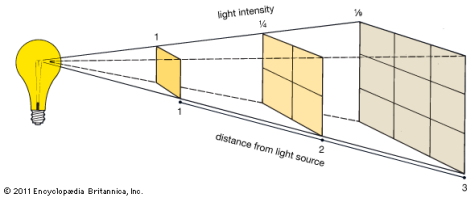
The following factors affect the rate of photosynthesis:

- **Temperature**: because all chemical reactions speed up as the temperature increases. As photosynthesis is controlled by enzymes which are affected by temperature



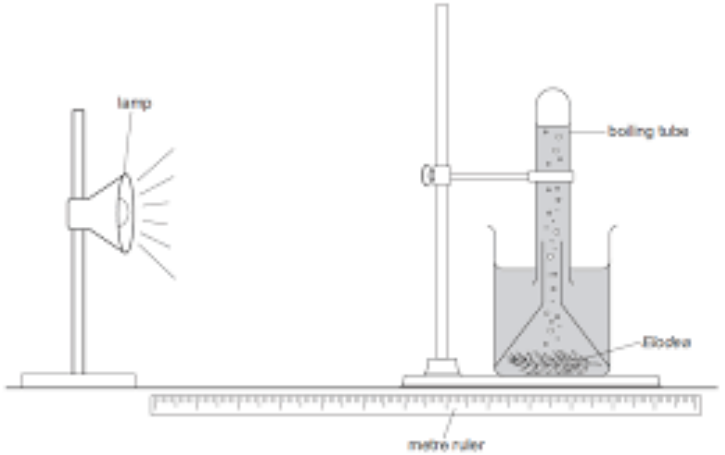
- **Carbon dioxide concentration**: the higher the concentration of CO2 in the air, the more is available for photosynthesis, so the rate increases as concentration increases.
- **Light intensity**: as the equation shows, photosynthesis requires light energy. So, the higher the light intensity, the higher the rate of photosynthesis.

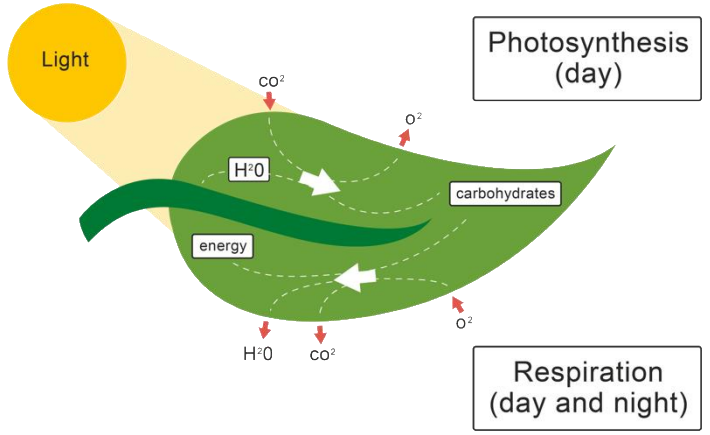
$$\text{light intensity} = \frac{}{distance\ from\ source2}$$



- **Amount of chlorophyll**: more chlorophyll means more light can be absorbed.

RPA: investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.





Knowledge Organiser – 4.4 Bioenergetics

4.4.2 Respiration

- the chemical potential energy stored in food molecules is released through **oxidation** reactions
- The energy released allows living cells to do **work including:**.
  - Chemical reactions to build larger molecules from smaller ones
  - Movement.
  - Keeping warm.
- There are two types of respiration: **aerobic** and **anaerobic**.

4.4.2.1 Aerobic and anaerobic respiration

Aerobic respiration occurs when oxygen is used in the reaction

glucose + oxygen → carbon dioxide + water

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

aerobic respiration releases much more energy than anaerobic respiration.

Anaerobic respiration occurs when there is insufficient oxygen available for complete oxidation of the glucose.

The reaction differs depending on the organism

In *animals:* glucose → lactic acid

In *plants* and *yeast*: glucose → ethanol and carbon dioxide

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$

In yeast, anaerobic respiration is called fermentation. Used for:

- making bread (the CO2 makes it rise)
- making alcoholic drinks (since ethanol is a type of alcohol).

4.4.2.2 Response to exercise

During exercise, more energy is required by the body than when resting, due to increased muscle contractions.

The body reacts to this increased **demand** for energy:

- **heart rate**, **breathing rate**, and **volume of each breath** all **increase**.
- these **increase the amount of oxygenated blood** reaching the muscles.
- oxygenated blood provides the **extra oxygen and glucose** needed for **respiration in muscle cells**, to transfer more energy to meet demand.

If insufficient oxygen reaches muscles but exercise continues, the muscle cells use **anaerobic respiration** to transfer energy.

- incomplete oxidation of glucose takes place
- **lactic acid** is produced which is a poison
- lactic acid builds up and causes an **oxygen debt** causing **fatigue**.
- breathing deeply after exercise repays the oxygen debt.

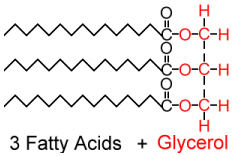
4.4.2.3 Metabolism

Metabolism is the sum of ALL the chemical reactions happening in a cell or in the whole body.

- Metabolism relies on energy transferred by respiration.
- chemical reactions in cells are controlled by enzymes.
- Reactants are used to make products: new molecules are synthesised.

metabolism includes these reactions:

- Conversion of glucose to glycogen (animals), or to starch or cellulose (plants).
- Formation of lipid (fat) molecules from one molecule of glycerol and three molecules of fatty acids
- In plants, the use of glucose and nitrate ions to make amino acids. These amino acids are then used to synthesise proteins.
- Respiration, both aerobic and anaerobic.
- Breaking down excess proteins into urea for excretion



Key Terms	Respiration Definitions
Aerobic	Using oxygen
Anaerobic	Not using oxygen
Oxidation	A reaction with oxygen. In this case, food molecules like glucose reacting with oxygen.
Fatigue	Tiredness. Fatigue in muscles is caused by a build-up of lactic acid, which is produced during anaerobic respiration (when there is insufficient oxygen).
Oxygen debt	After exercise, the lactic acid has built up and caused an extra need for oxygen – called the oxygen debt.
Lactic acid	Chemical produced by the incomplete oxidation of glucose (anaerobic respiration).

4.4.2.2 Response to exercise (HT)

HT: oxygen debt is the amount of extra oxygen needed to react with lactic acid in muscles and remove it from cells.

- The blood flow through muscles removes lactic acid and transports it to the liver to be converted back into glucose.

Knowledge Organiser – 4.5 Homeostasis

4.5.1 Homeostasis

Homeostasis is the regulation of the internal conditions of a cell or organism to **maintain optimum** conditions for function **in response to internal and external changes.**

In humans this includes **autonomic control** of:

- **blood glucose concentration**
- body **temperature**
- **water** levels.

All control systems include:

- cells called **receptors**, which detect stimuli (changes in the environment)
- **coordination centres** (such as the brain, spinal cord and pancreas) that receive and process information from receptors
- **effectors**, muscles or glands, which bring about responses which restore optimum levels.

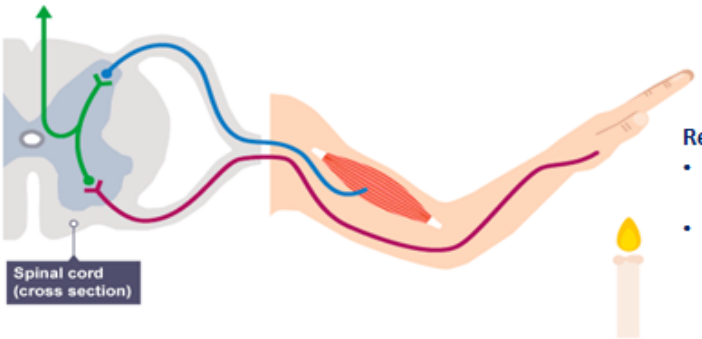
4.5.2 The human nervous system

The nervous system enables humans to **react to their surroundings** and to **coordinate their behaviour.**

Information from receptors passes along cells (neurones) as electrical impulses to the **central nervous system** (CNS).

- CNS is the brain and spinal cord.
- CNS coordinates the response of effectors eg **muscles contracting** or **glands secreting hormones.**

stimulus → receptor → coordinator → effector → response

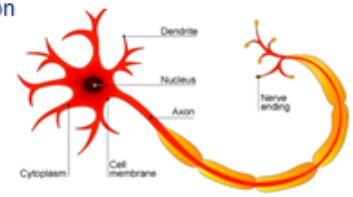


Reflex Arc

- automatic and rapid
- do not involve the conscious part of the brain.

	Definition
Enzyme	Protein which catalyses or speeds up a chemical reaction
evaporation	Process in which a liquid changes state and turns into a gas.
glucose	Simple sugar used by cells for respiration.
glycogen	The storage form of glucose in animal cells.
hormone	Chemical messenger produced in glands and carried in blood to specific organs in the body.
Insulate	To help maintain the temperature.
Insulin	hormone that regulates the level of sugar in the blood
nerve impulses	Electrical signals that travel along the nerve fibre from one end of the nerve cell to the other.
Obesity	Medical term for being very overweight, due to accumulation of body fat.
Vasoconstriction	Narrowing of the skin arterioles to reduce blood flow and reduce heat loss by radiation.
vasodilation	Increase in diameter of the skin arterioles to increase blood flow & increase heat loss by radiation.

Receptor in the skin detects a stimulus
Sensory neurone sends electrical impulses to **relay neurone**, which are located in the spinal cord. They connect sensory neurones to motor neurones.
Motor neurone sends electrical impulses to an effector.
Effector produces a response eg muscle contraction



RPA: Plan and carry out an investigation into the effect of a factor on human reaction times

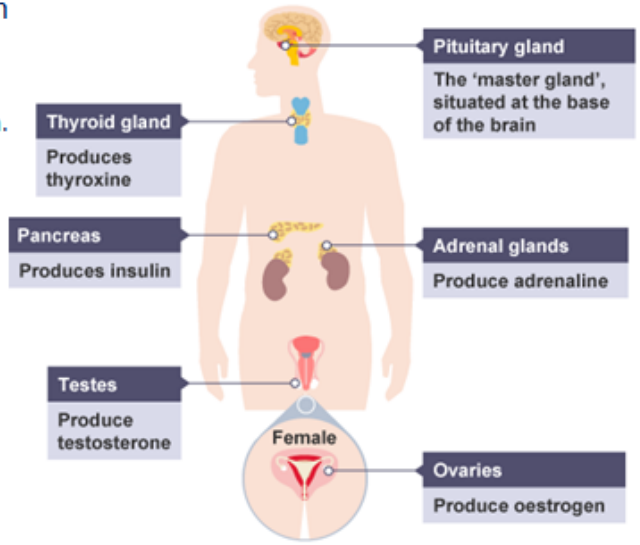
Knowledge Organiser – 4.5.3 Hormonal coordination in humans

4.5.3.1 Human endocrine system

- The **endocrine system** is composed of **glands** which **secrete chemicals** called **hormones** directly into the bloodstream.
- Hormones carried by blood to a **target organ** where it produces an **effect**.
- Compared to the nervous system the **effects are slower but act for longer**.

Pituitary gland in the brain

- **'master gland'** which secretes several hormones into the blood in response to body conditions.
- These hormones act on other glands to **stimulate other hormones** to be released to bring about effects.



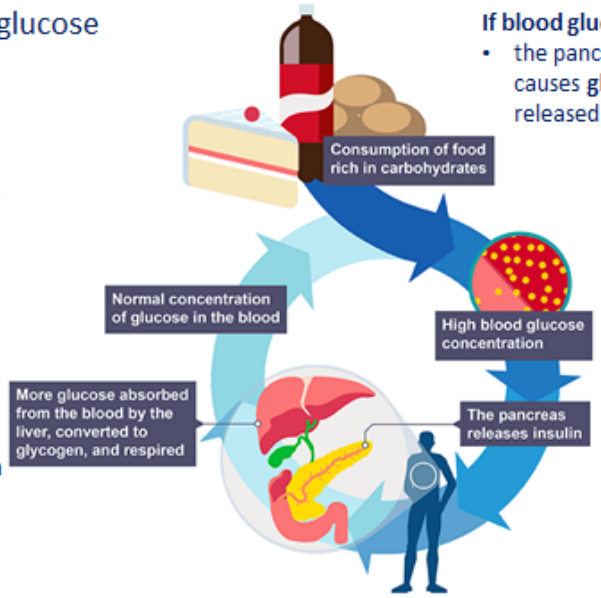
Differences between Hormonal and Nervous coordination	Nervous	Hormonal
Type of signal	Electrical (chemical at synapses)	Chemical
Transmission of signal	By nerve cells (neurones)	By the bloodstream
Effectors	Muscles or glands	Target cells in particular tissues
Type of response	Muscle contraction or secretion	Chemical change
Speed of response	Very rapid	Slower
Duration of response	Short (until nerve impulses stop)	Long (until hormone is broken down)

4.5.3.2 Control of blood glucose concentration

- Monitored and controlled by the **pancreas**.
- High blood glucose damages cells due to a loss of water by osmosis.

If **blood glucose concentration is too high**:

- Pancreas detects the increase
- Pancreas produces the hormone **insulin**.
- Increases **glucose absorption** in liver and muscle cells.
- **Excess glucose** is **converted** to **glycogen** for storage in liver and muscle.

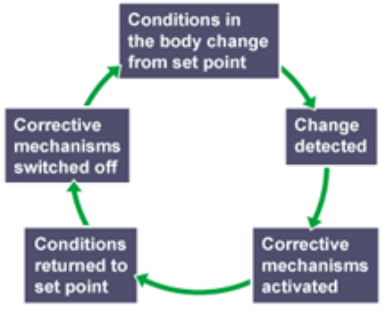


If blood glucose concentration is too low:

- the pancreas produces the hormone **glucagon** that causes **glycogen to be converted into glucose** and released into the blood.

Negative feedback

Glucagon and Insulin interacting to manage glucose levels in the blood is an example of a **negative feedback cycle**.



Diabetes:

Type 1 diabetes is a disorder in which the pancreas fails to produce sufficient insulin. It is characterised by uncontrolled high blood glucose level.

Treatment:

- normally treated with **insulin injections**

Type 2 diabetes the body cells no longer respond to insulin produced by the pancreas. Obesity is a risk factor for Type 2 diabetes.

Treatment:

- A carbohydrate controlled **diet**
- **Exercise** regime

Knowledge Organiser – 4.5.3 Hormonal coordination in human reproduction

4.5.3.3 Hormones in human reproduction

Menstruation & Puberty in Females

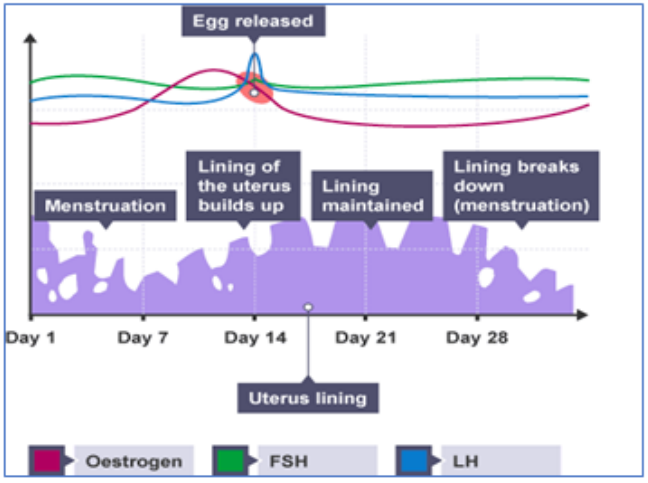
- During puberty reproductive hormones cause secondary sex characteristics to develop.
- Oestrogen is the main female reproductive hormone produced in the ovary.
- At puberty eggs begin to mature and one is released approximately every 28 days. This is called ovulation.

Puberty in Males

- Males start to produce testosterone at puberty.
- Testosterone is the main male reproductive hormone produced by the testes
- Testosterone stimulates sperm production.

Several hormones are involved in the menstrual cycle of a woman.

Hormone	Produced	Role
FSH (follicle stimulating hormone)	Pituitary gland	Causes an egg to mature in an ovary. Stimulates the ovaries to release oestrogen
Oestrogen	Ovaries	Stops FSH being produced (so that only one egg matures in a cycle). Repairs, thickens and maintains the uterus lining. Stimulates the pituitary gland to release LH.
LH (luteinising hormone)	Pituitary gland	Triggers ovulation (the release of a mature egg)
Progesterone	Ovaries	Maintains the lining of the uterus during the middle part of the menstrual cycle and during pregnancy.



4.5.3.4 Contraception

Fertility can be controlled by a variety of hormonal and non-hormonal methods of contraception.

These include:

- Hormonal **oral contraceptives** inhibiting FSH production so that no eggs mature
- **injection, implant or skin patch** of slow release progesterone to inhibit the maturation and release of eggs over a long period
- **barrier methods** such as condoms and diaphragms which prevent the sperm reaching an egg
- **intrauterine devices** which prevent the implantation of an embryo or release a hormone
- **spermicidal agents** which kill or disable sperm
- **abstaining from intercourse** when an egg may be in the oviduct
- **surgical** methods of male and female **sterilisation**.

4.5.3.5 The use of hormones to treat infertility (HT only)

Fertility drugs

- Provide woman with FSH and LH in a 'fertility drug'
- She may then become pregnant in the normal way.

Fertility: The ability to reproduce.

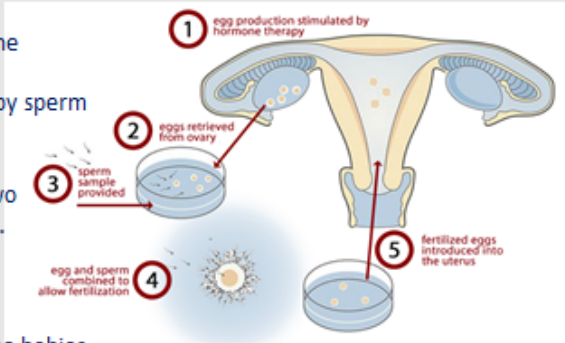
4.5.3.5 The use of hormones to treat infertility (HT only)

In Vitro Fertilisation (IVF) treatment.

- IVF involves giving a mother FSH and LH to stimulate the maturation of several eggs.
- The eggs are collected from the mother and fertilised by sperm from the father in the laboratory.
- The fertilised eggs develop into embryos.
- At the stage when they are tiny balls of cells, one or two embryos are inserted into the mother's uterus (womb).

Negatives of IVF

- it is very emotionally and physically stressful
- the success rates are not high
- it can lead to multiple births which are a risk to both the babies and the mother.

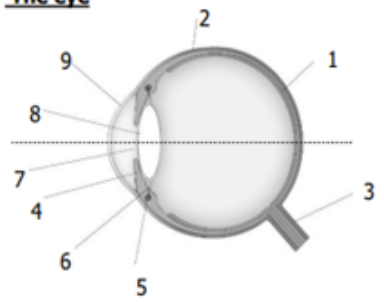


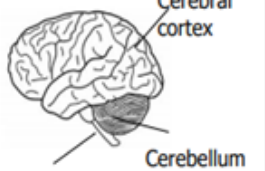
Knowledge Organiser – 4.5.2 Separate Biology

The brain	
Cerebral cortex	Outer wrinkly part, responsible for consciousness, intelligence, memory and language
Medulla oblongata	Controls unconscious activities e.g. breathing and heartbeat
Cerebellum	Responsible for muscle coordination

Studying the brain (HT)	
Study people with **brain damage**	If a part of the brain has been damaged the effect on the patient can tell you what this part does
Electrically stimulate the brain	By observing what stimulating different parts of the brain does its possible to get an idea of what those parts do
MRI scans	MRI scans produce detailed pictures of the brain. Scientists can see which parts are active when people are doing things
The brain is **complex** and **delicate** – investigating and treating it is difficult	

The eye





Focusing on near and distant objects
To look at **near** objects – ciliary muscles **contract**, suspensory ligaments **slacken**, lens becomes **fat**, **increasing** amount of refraction
To look at **distant** objects – ciliary muscles **relax**, suspensory ligaments **tighten**, lens becomes **thin**, **decreasing** amount of refraction

The eye key terms and parts

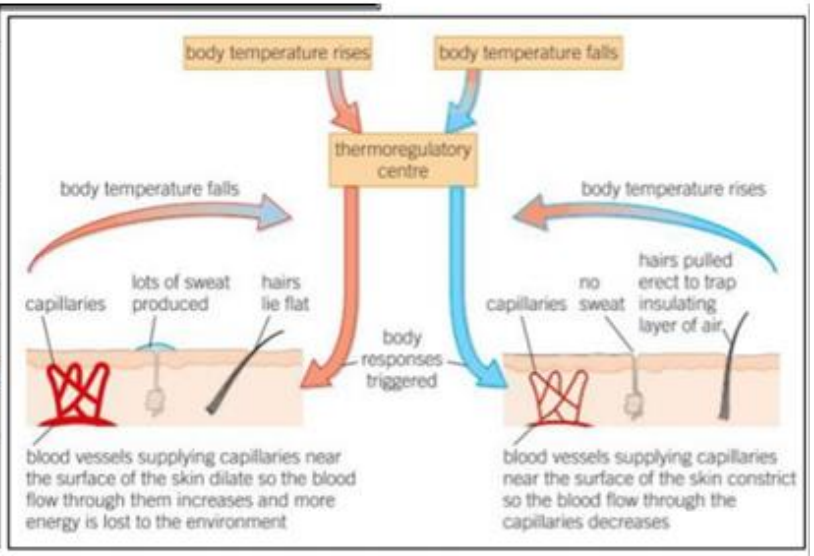
Refraction – the bending of light rays when they pass from one medium to another

Part	Function
1 Retina	Where an image forms at the back of the eye, contains rods and cones
2 Sclera	The white part, protects the eye
3 Optic nerve	Send electrical impulses from the retina to the brain
4 Iris	Coloured muscle controls the size of the pupil
5 Ciliary muscles	Contract and relax to change the shape of the lens
6 Suspensory ligaments	Controls the shape of the lens to focus light rays on the retina
7 Pupil	Hole located in the centre of the iris of the eye that allows light to strike the retina
8 Lens	Refracts light to be focused on the retina
9 Cornea	Refracts light through the pupil
Rods	Light sensitive receptor cells that let you see in low light conditions
Cones	Light sensitive receptor cells that let you see colour

Correcting vision problems			
Long sighted (HYPEROPIA)	**Where the image focuses**	**How to correct it**	**Why it occurs**
	Behind the retina	Convex lens	The lens is too weak or the eyeball is too short
Short sighted (MYOPIA)	**Where the image focuses**	**How to correct it**	**Why it occurs**
	In front of the retina	Concave lens	The lens is too strong, or the eyeball is too long
Contact lenses	Good for sports/activities, almost invisible. Could cause infection if not sterilised properly		
Laser eye surgery	Permanent correction of vision problems, however, surgery carries risks		
Lens replacement	Permanent solution, risk of vision loss		

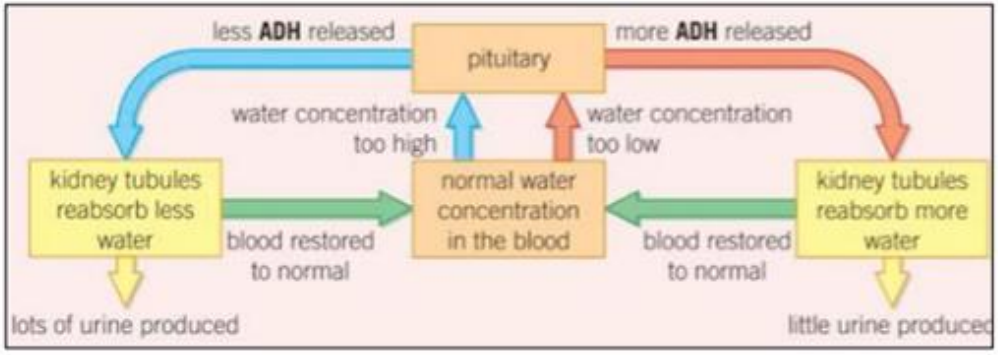
Knowledge Organiser – 4.5.2 & 3 Separate Biology

Temperature control	
Vasodilation	Arterioles (blood vessels) supplying skin capillaries dilate so more blood can flow close to the surface of the skin. Helps transfer heat energy from the skin to the environment to cool you down
Vasoconstriction	Arterioles supplying the skin capillaries constrict so less blood flows under the surface of the skin. Reducing heat loss when you are too cold
Sweating	Sweat glands release sweat when you are too hot. When sweat evaporates it transfers energy to the environment
Shivering	Shivering is when muscles contract rapidly, this need respiration which transfers energy to the body to warm you up
Thermoregulatory centre	Found in the hypothalamus in the brain, detects blood temperature changes and receives information about skin temperature too



Water and nitrogen control **Urine contains.....**	
Urea	Excess proteins are broken down into amino acids in the liver. These amino acids are turned into ammonia which is toxic so it is quickly turned into urea and excreted from the body in urine
Ions	Excess ions are removed in the urine
Water	Water leaves the body via the lungs during exhalation Water, mineral ions and urea are lost through the skin in sweat Excess water and mineral ions is removed via the kidneys in urine If the body cells lose or gain too much water through osmosis, they do not function efficiently.

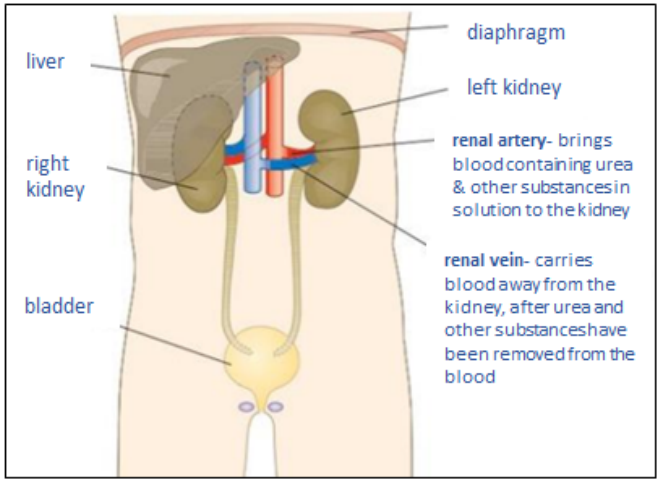
Water and nitrogen control - ADH	
ADH	Anti-diuretic hormone controls the concentration of the urine
Pituitary gland	Releases more or less ADH depending on how much water is in the body
Negative feedback	Controls water levels in the body



Knowledge Organiser – 4.5.3 & 4.5.4 Separate Biology

4.5.3.3 Maintaining water and nitrogen balance in the body

A kidney produces urine firstly by **filtering** the blood.
Selective reabsorption then occurs. This means that **all** of the **glucose** is reabsorbed back into the blood, along with **some** of the **ions** and **some** of the **water** depending on the concentration of these within the body.
The kidney **excretes urea** in the urine along with any **excess water and ions**.
Protein molecules are too **large** to pass through the kidney filters so remain in the blood and are not therefore excreted in the urine of a healthy person.



4.5.4.1 – Plant Hormones – Coordination and Control

Tropism – a plant's response to a stimulus
Phototropism – a plant's response to light
Geotropism – a plant's response to gravity

4.5.4.1 A plant's response to light

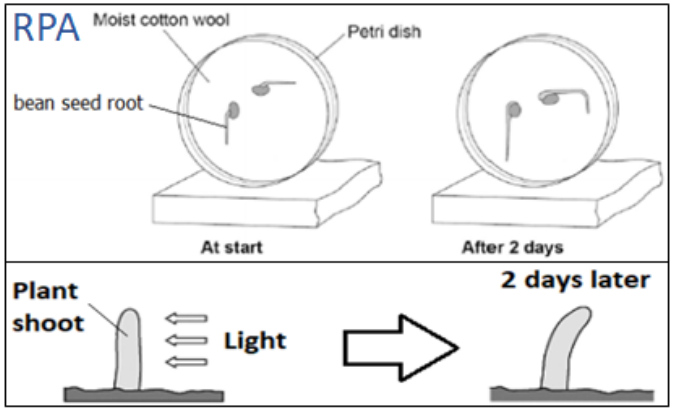
- Auxin (a plant hormone) redistributes unequally in the shoot
- More auxin gathers on the dark side of the shoot
- Auxin promotes cell elongation in the shoot
- If the plant cells on the dark side have more auxin they will grow more/faster & longer
- This causes the plant to bend towards the light

A plant's response to gravity

- Gravity produces unequal distribution of auxin
- Auxin is pulled to the lower side of the roots (by gravity)
- In the root auxin inhibits cell growth
- The cells on top elongate faster
- This causes the root to bend downward

4.5.4.2 – Use of Plant Hormones

Hormones	Needed for	Used for:
Auxin	cell elongation/ plant growth	killing weeds, growing cuttings with rooting powder, growing cells in tissue culture
Ethene	ripening	speed up ripening of fruit (sprayed over fruit in shipping containers)
Gibberellin	seed germination	controlling seed dormancy and germination, inducing flowering, growing larger fruit



	Advantages	Disadvantages
Kidney transplants	• Patients can lead a more normal life without having to watch what they eat and drink • Cheaper for the NHS overall	• Organ rejection by the patient's immune system • Must take immune-suppressant drugs which increase the risk of infection • Shortage of organ donors • Kidney only lasts 8-9 years on average • Any operation carries risks
Kidney dialysis	• Available to all kidney patients (no shortage) • Can buy valuable time until a donor is found • No need for immune-suppressant drugs	• Patient must limit their salt and protein intake between dialysis sessions • Expensive for the NHS • Regular dialysis sessions – impacts on the patient's lifestyle • Can cause blood clots or infections

4.5.3.7 – Negative feedback - Thyroxine (HT)

- Hormone produced by the **thyroid gland**.
- Thyroxine stimulates the **metabolic rate**.
- Important in **growth and development**.
- Controlled by **negative feedback** (HT)
- If levels of thyroxine in blood fall, sensors in the **brain** detect this and **TSH** is released from the pituitary gland.
- TSH stimulates the **production of thyroxine** by the thyroid gland.
- As the level of thyroxine goes up, it is detected by the **sensors** and the **level of TSH released falls**.

Knowledge Organiser – 4.5 Homeostasis

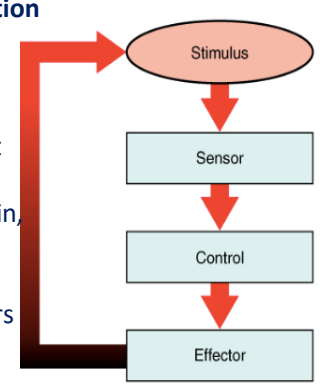
4.5.1 Homeostasis

Homeostasis is the autonomic regulation of the internal conditions of a cell or organism to **maintain optimum** conditions for function **in response to internal and external changes. E.g:**

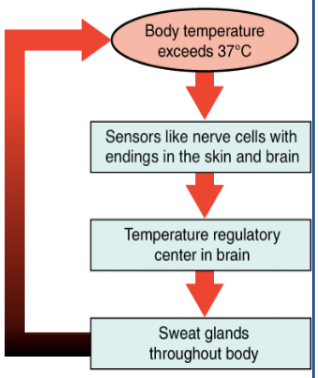
- **blood glucose concentration**
- body **temperature**
- **water** levels.

All control systems include:

- cells called **receptors**, that detect stimuli
- **coordination centres** (brain, spinal cord and pancreas) that receive and process information from receptors
- **effectors**, muscles or glands, which bring about responses which restore optimum levels.



Negative feedback loop



Body temperature regulation

4.5.2 The human nervous system

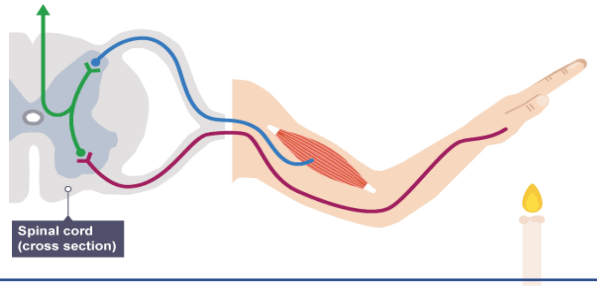
The nervous system enables humans to **react to their surroundings** and to **coordinate their behaviour**.

- This is a **protective reflex to speed up the reaction time** of pulling away from a dangerous stimulus, like putting your hand on a hot stove!
- If you had to think first it would cost valuable time and risk further damage.

Information from receptors passes along cells (neurones) as electrical impulses to the **central nervous system** (CNS).

- CNS is the brain and spinal cord.
- CNS coordinates the response of effectors eg **muscles contracting** or **glands secreting hormones**.

stimulus → receptor → coordinator → effector → response



Reflex Arc

- automatic and rapid
- do not involve the conscious part of the brain.

	Definition
Enzyme	Protein which catalyses or speeds up a chemical reaction
evaporation	Process in which a liquid changes state and turns into a gas.
glucose	Simple sugar used by cells for respiration.
glycogen	The storage form of glucose in animal cells.
hormone	Chemical messenger produced in glands and carried in blood to specific organs in the body.
Insulate	To help maintain the temperature.
Insulin	hormone that regulates the level of sugar in the blood
nerve impulses	Electrical signals that travel along the nerve fibre from one end of the nerve cell to the other.
Obesity	Medical term for being very overweight, due to accumulation of body fat.
Vasoconstriction	Narrowing of the skin arterioles to reduce blood flow and reduce heat loss by radiation.
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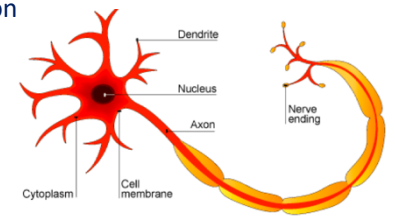
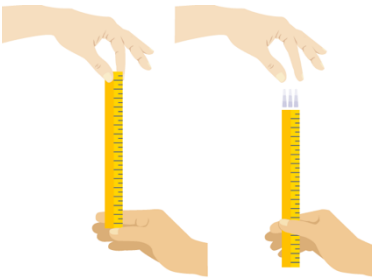
Receptor in the skin detects a stimulus
Sensory neurone sends electrical impulses to **relay neurone**, which are located in the spinal cord. They connect sensory neurones to motor neurones.
Motor neurone sends electrical impulses to an effector.
Effector produces a response eg muscle contraction



RPA: Plan and carry out an investigation into the effect of a factor on human reaction times



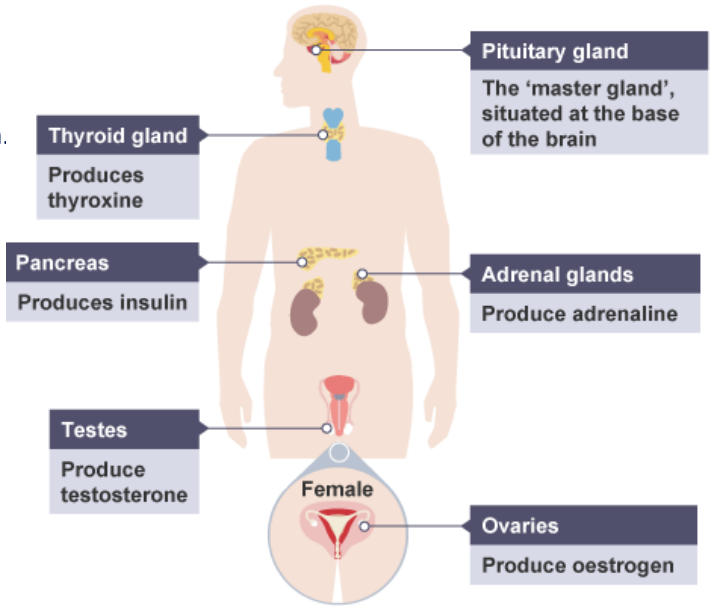
Knowledge Organiser – 4.5.3 Hormonal coordination in humans

4.5.3.1 Human endocrine system

- The **endocrine system** is composed of **glands** which **secrete chemicals** called **hormones** directly into the bloodstream.
- Hormones carried by blood to a **target organ** where it produces an **effect**.
- Compared to the nervous system the **effects are slower but act for longer**.

Pituitary gland in the brain

- '**master gland**' which secretes several hormones into the blood in response to body conditions.
- These hormones act on other glands to **stimulate other hormones** to be released to bring about effects.



Differences between Hormonal and Nervous coordination	Nervous	Hormonal
Type of signal	Electrical (chemical at synapses)	Chemical
Transmission of signal	By nerve cells	By the bloodstream
Effectors	Muscles or glands	Target cells in particular tissues
Type of response	Muscle contraction or secretion	Chemical change
Speed of response	Very rapid	Slower
Duration of response	Short (until nerve impulses stop)	Long - Until hormone broken down

Diabetes:

Type 1 diabetes is a disorder in which the pancreas fails to produce sufficient insulin. It is characterised by uncontrolled high blood glucose level.

Treatment:

- normally treated with **insulin injections**

Type 2 diabetes the body cells no longer respond to insulin produced by the pancreas. Obesity is a risk factor for Type 2 diabetes.

Treatment:

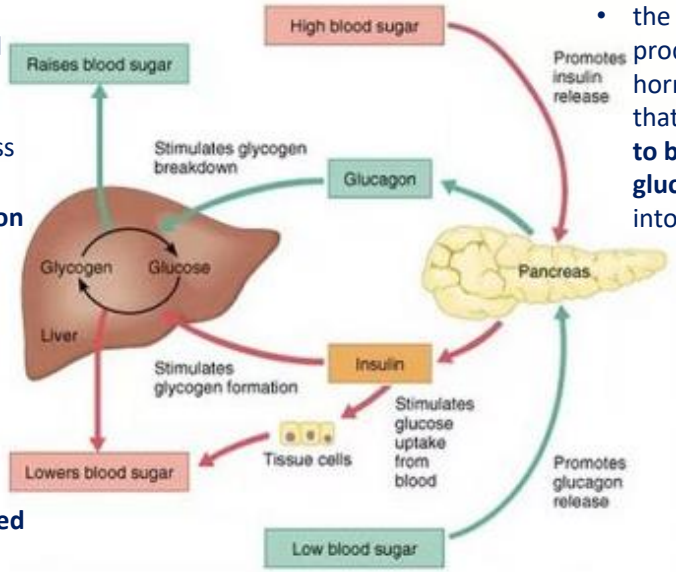
- A carbohydrate controlled **diet** & **Exercise** regime

4.5.3.2 Control of blood glucose concentration

- Monitored and controlled by the **pancreas**.
- High blood glucose damages cells due to a loss of water by osmosis.

If **blood glucose concentration is too high**:

- Pancreas detects the increase
- Pancreas produces the hormone **insulin**.
- Increases **glucose absorption** in liver and muscle cells.
- **Excess glucose** is **converted** to **glycogen** for storage in liver and muscle.

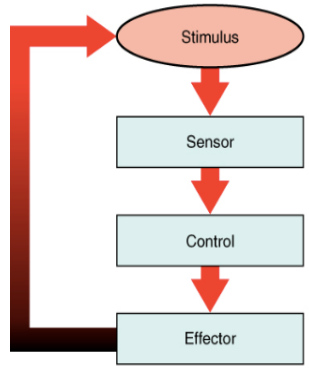


If blood glucose concentration is too low:

- the pancreas produces the hormone **glucagon** that causes **glycogen to be converted into glucose** and released into the blood.

Negative feedback (HT Only)

- when a stimulus produces an output which can dampen the original stimulus and prevent or reduce further output.
- Body controlling outputs once an appropriate response has been effected.
- Maintenance of blood sugar is an example of negative feedback loop.



Negative feedback loop

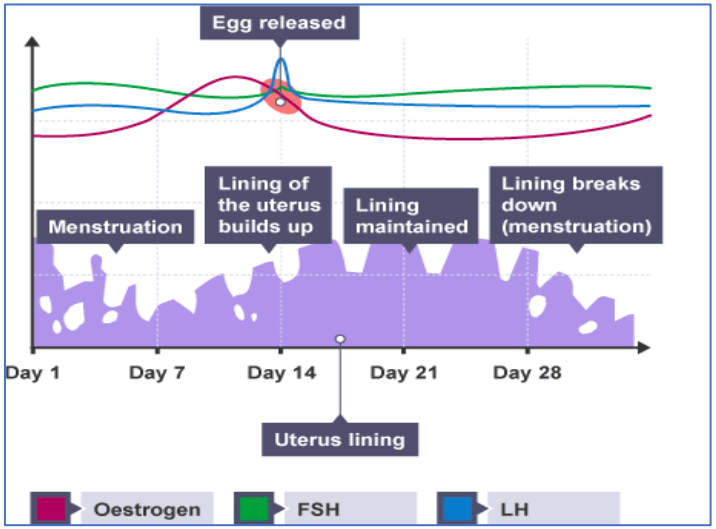
Knowledge Organiser – 4.5.3 Hormonal coordination in human reproduction

4.5.3.3 Hormones in human reproduction

- During puberty, reproductive hormones cause secondary sex characteristics to develop.
- **Oestrogen** is the main female reproductive hormone.
- At puberty, eggs begin to mature and 1 is released approximately **every 28 days**.
- The diagram at the bottom of the page shows hormone fluctuation during the **menstrual cycle**.

Several hormones are involved in the menstrual cycle of a woman.

Hormone	Produced	Role
FSH (follicle stimulating hormone)	Pituitary gland	Causes an egg to mature in an ovary. Stimulates the ovaries to release oestrogen
Oestrogen	Ovaries	Stops FSH being produced (so that only one egg matures in a cycle). Repairs, thickens and maintains the uterus lining. Stimulates the pituitary gland to release LH.
LH (luteinising hormone)	Pituitary gland	Triggers ovulation (the release of a mature egg)
Progesterone	Ovaries	Maintains the lining of the uterus during the middle part of the menstrual cycle and during pregnancy.



Puberty in Males

- Males start to produce testosterone at puberty.
- Testosterone is the main male reproductive hormone produced by the testes
- Testosterone stimulates sperm production.

4.5.3.4 Contraception

Fertility can be controlled by a variety of hormonal and non-hormonal methods of contraception.
These include:

- Hormonal **oral contraceptives** inhibiting FSH production so that no eggs mature
- **injection, implant or skin patch** of slow release progesterone to inhibit the maturation and release of eggs over a long period
- **barrier methods** such as condoms and diaphragms which prevent the sperm reaching an egg
- **intrauterine devices** which prevent the implantation of an embryo or release a hormone
- **spermicidal agents** which kill or disable sperm
- **abstaining from intercourse** when an egg may be in the oviduct
- **surgical** methods of male and female **sterilisation**.

4.5.3.5 The use of hormones to treat infertility (HT only)

Fertility drugs

- Provide woman with FSH and LH in a 'fertility drug'
- She may then become pregnant in the normal way.

Fertility: The ability to reproduce.

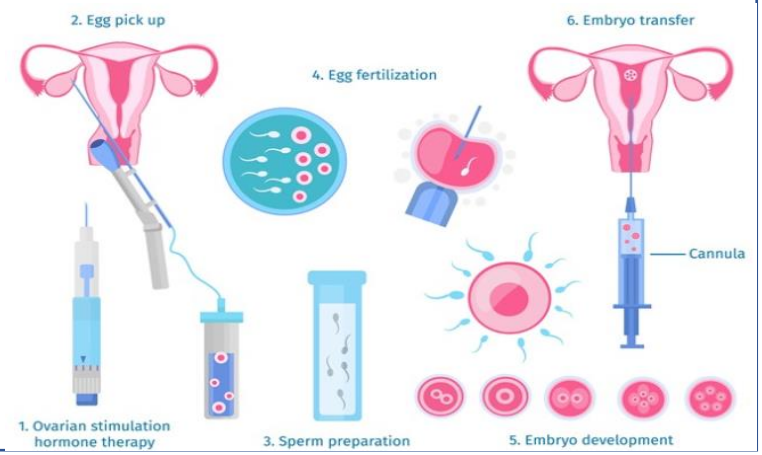
4.5.3.5 The use of hormones to treat infertility (HT only)

In Vitro Fertilisation (IVF) treatment.

- Giving a mother **FSH** and **LH** to stimulate egg maturation
- Eggs are collected and fertilised by father's sperm in the laboratory.
- Fertilised eggs develop into embryos
- Embryos are inserted into the mothers uterus (womb).

Negatives of IVF

- emotionally and physically stressful
- the success rates are not high
- can lead to multiple births, risking both babies and mother.



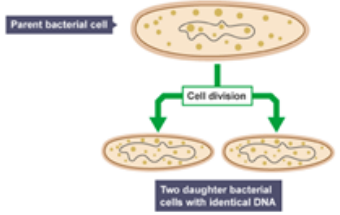
Knowledge Organiser – 4.6 Inheritance, variation and evolution

Sexual reproduction involves the joining (fusion) of male and female gametes:
- sperm and egg cells in animals
- pollen and egg cells in flowering plants.
- mixing of genetic information which leads to variety in the offspring.
- The formation of gametes involves meiosis.

Meiosis: non-identical offspring

Asexual reproduction involves only one parent
- No fusion of gametes.
- No mixing of genetic information.
- leads to genetically identical offspring (clones).
- Only mitosis is involved.

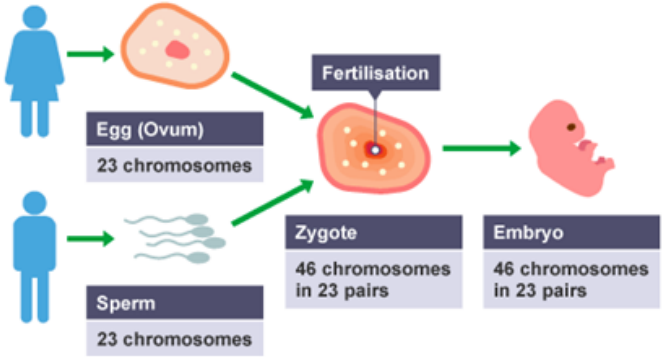
Mitosis: identical offspring



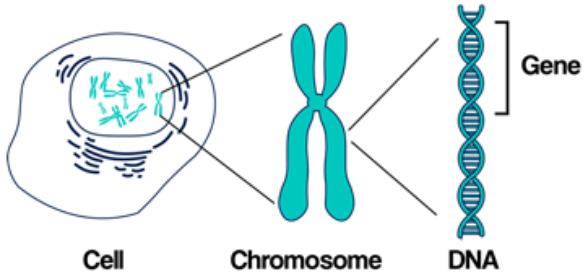
4.6.1.2 Meiosis

Sexual reproduction uses the process of **meiosis**, which creates gametes. The process of meiosis happens in the male and female reproductive organs.
Meiosis halves the number of chromosomes in gametes
Fertilisation restores the full number of chromosomes.
Cells in reproductive organs divide by meiosis to form gametes:

- **copies of the genetic information** are made
- the cell divides **twice** to form **four gametes**, each with a **single set of chromosomes (haploid)**
- all gametes are **genetically different** from each other.
- Gametes **join at fertilisation** to **restore the normal number of chromosomes**.
- The new cell divides by mitosis.
- The number of cells increases.
- As the embryo develops cells differentiate.



4.6.1.3 DNA and the genome



DNA Deoxyribonucleic acid
- The **genetic material in the nucleus of a cell** is composed of a chemical called DNA.
- DNA is a **polymer** made up of two strands forming a **double helix**.

Chromosome
- The DNA is contained in structures called **chromosomes**.
- Codes for all the characteristics of an organism.

Gene
- A gene is a small section of DNA on a chromosome.
- Each gene codes for a particular sequence of amino acids, to make a specific protein.

Genome
- genome of an organism is the entire genetic material of that organism.
- The whole human genome has now been studied and this will have great importance for medicine in the future.

Definitions	
diploid	A cell that contains two sets of chromosomes.
double helix	shape of the DNA molecule with two strands twisted together in a spiral.
gamete	Sex cell (sperm in males and ova/eggs in females).
haploid	A sex cell (gamete) containing one set of chromosomes.
heredity	Genetic information that determines an organism's characteristics, passed on from one generation to another. To do with passing genes to an offspring from its parent or parents.
mitosis	A type of cell division which produces daughter cells identical to the parent.
nucleus	The central part of an atom. It contains protons and neutrons, and has most of the mass of the atom. The plural of nucleus is nuclei.
organism	Living entity, eg animals, plants or bacteria.

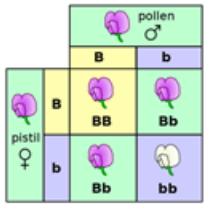
Knowledge Organiser – 4.6.1 Inheritance, variation and evolution

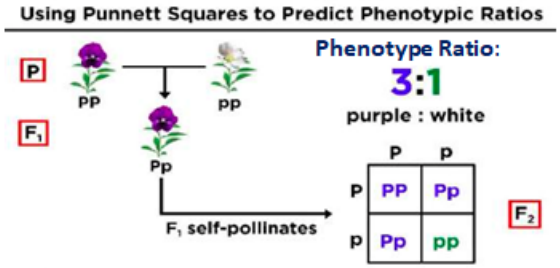
4.6.1.4 Genetic inheritance

Some **characteristics** are controlled by a single gene e.g: fur colour in mice; and red-green colour blindness in humans.

- Each **gene** may have different forms called **alleles**.
- The **alleles** present (**genotype**), operate at a molecular level to develop **characteristics** that can be expressed as a **phenotype**.
- A **dominant allele** is **always expressed**, even if only one copy is present.
- A **recessive allele** is **only expressed if two copies are present**.
- If the **two alleles** are the same the organism is **homozygous** for that trait
- If the **alleles are different** they are **heterozygous**.

Punnett square





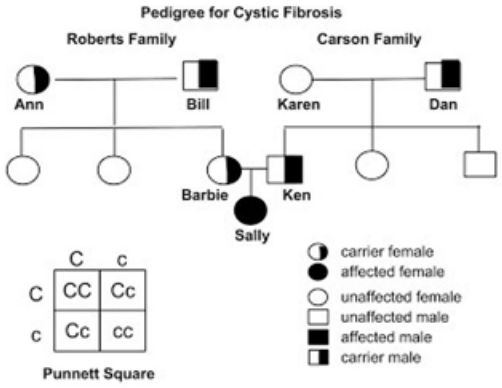
Genotype Ratio:
25% PP
50% Pp
25% pp
1:2:1 ratio

- Most **phenotype characteristics** are a result of multiple genes interacting, rather than a single gene.

4.6.1.5 Inherited disorders

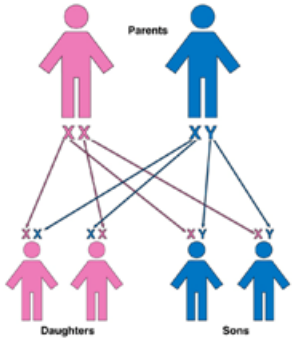
Some disorders are inherited.
These disorders are caused by the inheritance of certain alleles.

- **Polydactyly** (having extra fingers or toes) is caused by a dominant allele.
- **Cystic fibrosis** (a disorder of cell membranes) is caused by a recessive allele.



4.6.1.6 Sex determination

- Human body cells contain 23 pairs of chromosomes
- 22 pairs control characteristics only
- 1 pair carries the genes that determine sex.
- **Females:** sex chromosomes - **XX**
- **Males:** chromosomes are different - **XY**



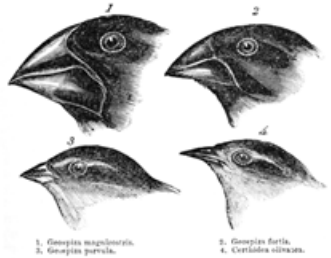
4.6.2 Variation and evolution

Differences in the characteristics of individuals in a population is called variation and may be due to differences in:

- the genes they have inherited (**genetic** causes)
- the conditions in which they have developed (**environmental** causes)
- a **combination of genes and the environment.**
- Usually extensive genetic variation within a population of a species
- All variants arise from mutations and **most have no effect on the phenotype; some influence** phenotype; **very few determine** phenotype.
- **Mutations occur continuously.** Very rarely a mutation will lead to a new phenotype.
- If a new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.

Evolution:

- The theory of evolution by natural selection states that **all species of living things have evolved from simple life forms that first developed more than three billion years ago.**
- Evolution occurs through **natural selection of variants** that give rise to **phenotypes** best suited to their **environment.**
- If two populations of one species become so different in phenotype that they can **no longer interbreed to produce fertile offspring** they have formed two **new species.**



Knowledge Organiser – 4.6.2 Selective breeding & Genetic Engineering

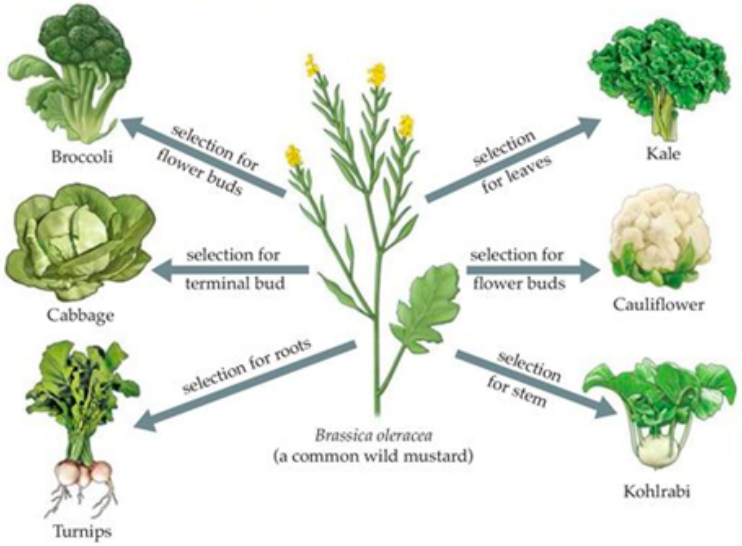
4.6.2.3 Selective breeding or Artificial selection

Selective breeding (artificial selection) is the human breeding of plants and animals for particular genetic characteristics.
Involves:

- **choosing parents with the desired characteristic** from a mixed population.
- They are **bred together**.
- From the **offspring those with the desired characteristic are bred together**.
- **continues over many generations** until **all** the offspring show the **desired characteristic.**

Characteristics might include:

- **Disease resistance** in food crops.
- Animals which produce **more meat or milk**.
- Selective breeding **can lead to 'inbreeding'** where some breeds are particularly prone to disease or inherited defects.



4.6.2.4 Genetic engineering

Genetic engineering involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.

- **Plant crops have been genetically engineered to be resistant to diseases** or to produce bigger better fruits.
- **Bacterial cells have been genetically engineered** to produce human **insulin** to treat diabetes.
- **Genes** from the chromosomes of humans and other organisms **can be 'cut out'** and **transferred to cells of other organisms.**

GM Crops

- Crops that have had their genes modified in this way are called genetically modified (GM) crops.
- GM crops include ones that are resistant to insect attack or to herbicides.
- GM crops generally show increased yields.

Negatives

- Concerns about GM crops include the effect on populations of wild flowers and insects.
- Some people feel the effects of eating GM crops on human health have not been fully explored.

Positives

- Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.
- Much faster than selective breeding
- More productive crops, resistant to climate change and other environmental challenges

Process of genetic engineering (HT only):

- **enzymes** are used to **isolate** the required gene
- this **gene is inserted into a vector**, usually a bacterial plasmid or a virus
- the **vector is used to insert the gene into the required cells**
- genes are **transferred to the cells of animals, plants** or **microorganisms** at an early stage in their development so that they develop with desired characteristics.

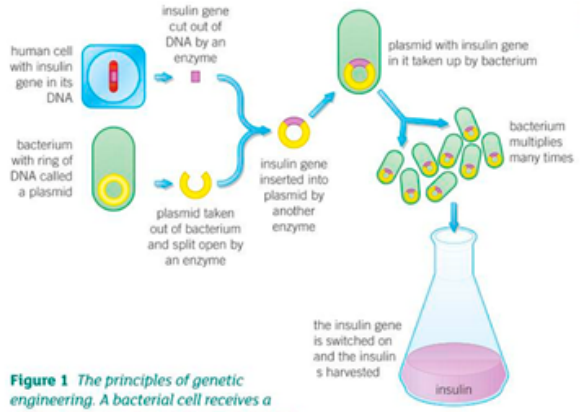


Figure 1 *The principles of genetic engineering. A bacterial cell receives a human gene so it makes a human protein – in this case, the hormone insulin*

Knowledge Organiser – 4.6.3 Development of understanding of genetics & evolution

Evidence for evolution

- The theory of evolution by natural selection is now widely accepted.
- Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in **genes**.
- There is further evidence in the **fossil record**
- And by **knowledge of how resistance to antibiotics evolves in bacteria.**

Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks. Fossils may be formed:

- from **parts of organisms that have not decayed** because one or more of the conditions needed for decay are absent
- when parts of the organism are **replaced by minerals as they decay**
- as **preserved traces of organisms**, such as footprints, burrows and rootlet traces.
- Many **early forms of life were soft-bodied**, which means that they have left few traces behind.
- What traces there were have been mainly **destroyed by geological activity**. This is why scientists cannot be certain about how life began on Earth.
- We can learn from fossils how much or how little different organisms have changed as life developed on Earth.

Extinctions occur when there are no remaining individuals of a species still alive.

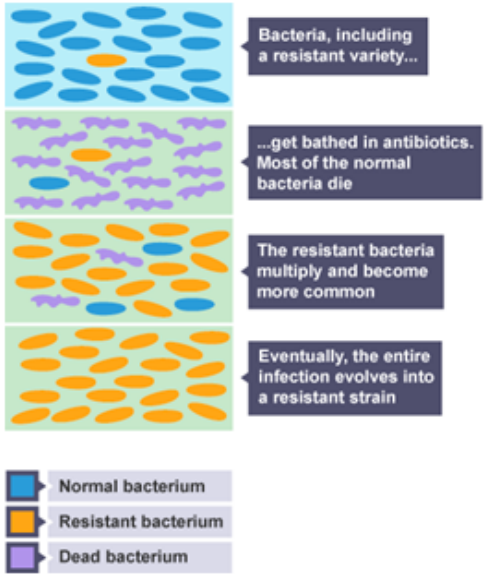
4.6.3.4 Resistant bacteria

- **Bacteria can evolve rapidly because they reproduce at a fast rate.**
  - **Mutations** of bacterial pathogens produce new strains.
  - **Some strains might be resistant to antibiotics**, and so are not killed.
  - They **survive and reproduce**, so the population of the resistant strain rises.
  - The **resistant strain will then spread because people are not immune** to it and there is no effective treatment.

E.g. MRSA is resistant to antibiotics.

To reduce the rate of development of antibiotic resistant strains:

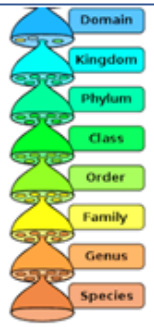
- doctors should not prescribe antibiotics inappropriately, such as treating non-serious or viral infections
- patients should complete their course of antibiotics so no bacteria survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted.
- The development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.

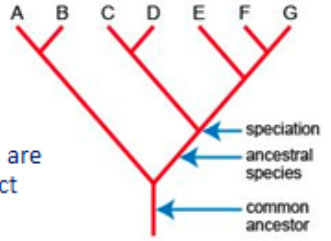


4.6.4 Classification of living organisms

- **Traditionally** living things have been **classified** into groups **depending on their structure and characteristics** in a system developed by Carl **Linnaeus**.
- Linnaeus classified living things into **kingdom, phylum, class, order, family, genus and species.**
- Organisms are named by the **binomial system of genus and species.**

- As evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed.
- Due to evidence available from chemical analysis **there is now a 'three-domain system'** developed by Carl **Woese.**
  - **Archaea** (primitive bacteria usually living in extreme environments)
  - **Bacteria** (true bacteria)
  - **Eukaryota** (which includes protists, fungi, plants and animals).
- **Evolutionary trees** are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms.

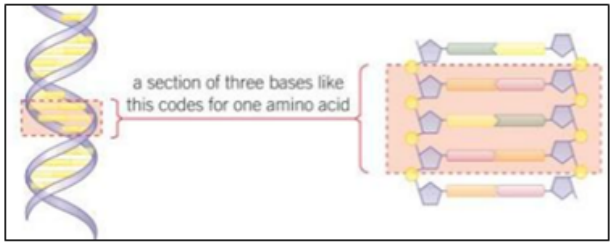


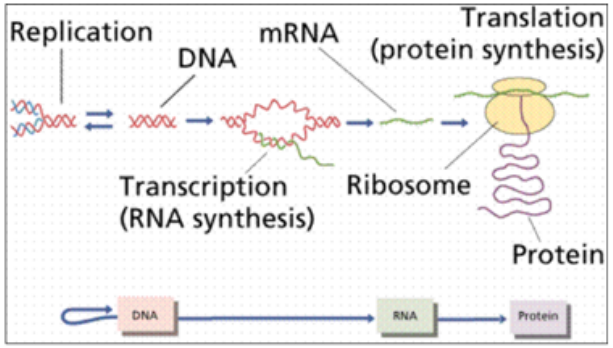


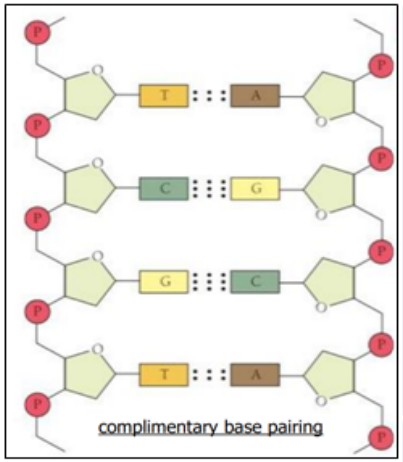
Knowledge Organiser – 4.6.1.5 DNA structure & 4.6.2.5 Cloning (sep biology)

4.6.1.5 DNA structure

- ❑ DNA strands are polymers made up of lots of repeating units called nucleotides
- ❑ Each nucleotide consists of one **sugar** molecule, one **phosphate** molecule and one **base**
- ❑ The sugar and phosphate molecules in the nucleotides form a **backbone** to the DNA strands. The sugar and phosphate molecules **alternate**.
- ❑ One of four different bases — **A, T, C or G** — joins to each sugar. Each base links to a base on the **opposite** strand in the **helix**
- ❑ A always pairs up with T, and C always pairs up with G. This is called **complimentary base pairing.**
- ❑ It's the **order of bases** in a gene that decides the **order of amino acids** in a protein
- ❑ Each amino acid is coded for by a sequence of **three bases in the gene**
- ❑ The amino acids are joined together to make various **proteins**, depending on the **order** of the gene's **bases.**







Mutations (HT)

- **A mutation**: A random change in the DNA
- **Cause**? Exposure to certain substances/some radiation types
- **Types**? Insertions, deletions, substitutions
- Enzyme active site is altered.

4.6.2.5 Cloning

Tissue culture: using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries.

Cuttings: an older, but simple, method used by gardeners to produce many identical new plants from a parent plant.

Embryo transplants: splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers

4.6.1.3 Advantages and disadvantages of sexual and asexual reproduction

Advantages of Sexual Reproduction:

Produces variation in the offspring / If the environment changes variation gives a survival advantage by natural selection /Natural selection can be speeded up by humans in selective breeding to increase food production.

Advantages of Asexual Reproduction:

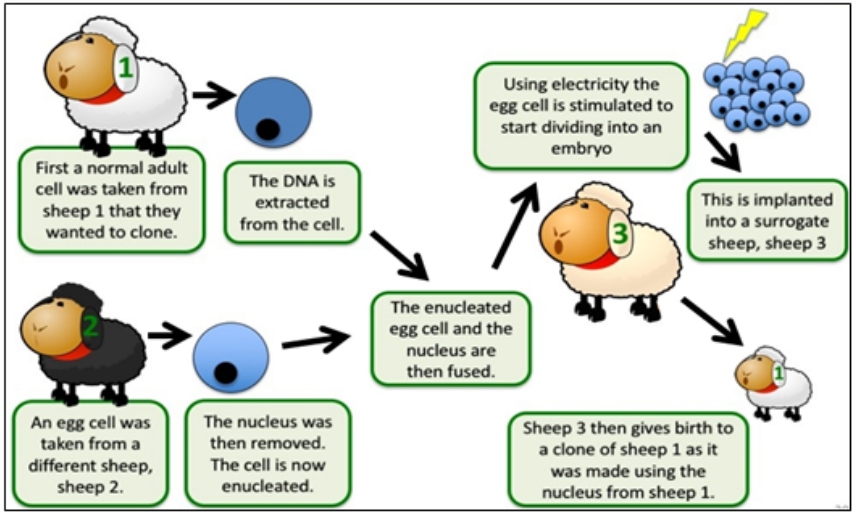
Only one parent needed / More time and energy efficient as do not need to find a mate / Faster than sexual reproduction / Many identical offspring can be produced when conditions are favourable.

Examples of organisms that carry out both types of reproduction:

Malaria parasites reproduce sexually in mosquitoes and asexually in their human hosts / Many fungi reproduce asexually by spores but can also reproduce sexually to give variation / Many plants produce seeds sexually but also reproduce asexually e.g. strawberries by runners or daffodils by bulb division

Protein synthesis (HT) – Key Terms

- **Proteins** → Examples include enzymes, hormones, structural proteins like collagen
- **Transcription**→ The first part of the process of making a protein. It takes place inside the cell nucleus. Transcription involves copying the DNA.
- **Translation** →Takes place in the ribosomes that are found in the cytoplasm. This is where the messenger RNA is 'interpreted' and the new protein formed
- **mRNA** -- Messenger RNA
- **tRNA** →Transfer RNA.



Knowledge Organiser – 4.6 Genetics & Evolution (sep biology)

4.6.3.1 Theory of evolution - Darwin vs Lamarck

Darwin's idea → Evolution by natural selection

Controversy at the time as people did not believe Darwin at the time because: -

- It went against religious beliefs - DNA/genes/the mechanism of inheritance was not understood at the time
- There was not enough evidence to convince other scientists

Lamarck's idea → Evolution by acquired characteristics

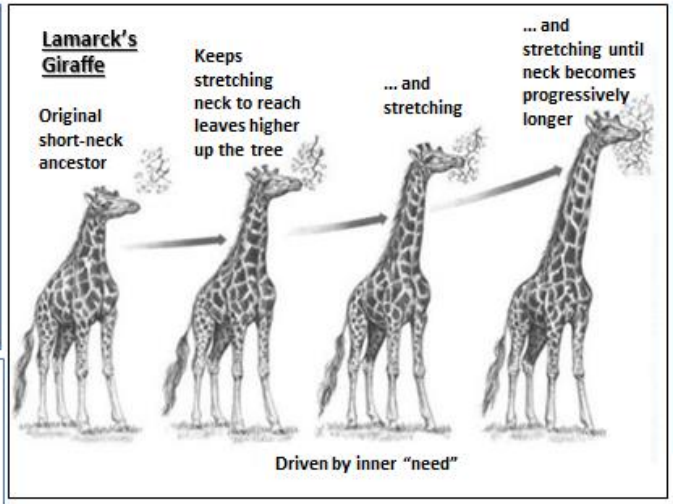
Organisms that use a characteristic a lot during its lifetime would become more developed e.g. a rabbit using its legs a lot to run would become longer. Then the organisms offspring would inherit this characteristic e.g. the rabbits offspring would also have longer legs.

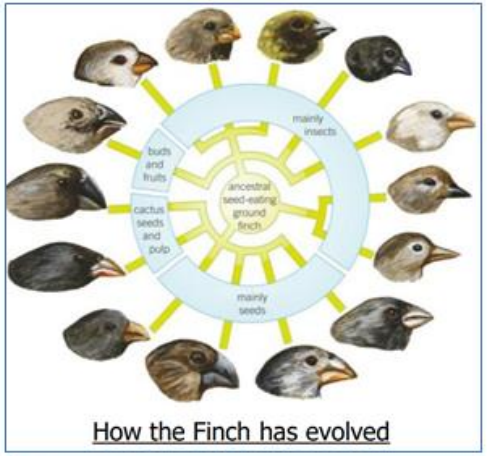
4.6.3.3 The understanding of genetics

- Mendel was a monk who's research led to the foundation of modern genetics
- Experiments In the mid-19th century → Mendel carried out breeding experiments on pea plants.
- He observed that inheritance of each characteristic is determined by 'units' that are passed on from parents to offspring
- Rejection → Mendel's work was rejected at the time as:
  - he was just a monk (not a scientist), chromosomes / DNA / genes not seen / discovered / known at the time, other theories accepted at the time

4.6.3.3

	Flower Colour	Plant Height	Seed Color	Seed Shape	Pod Colour	Pod Shape	Flower Position
Dominant Trait	Purple	Tall	Yellow	Round	Green	Inflated (full)	Axial
Recessive Trait	White	Short	Green	Wrinkled	Yellow	Constricted (flat)	Terminal



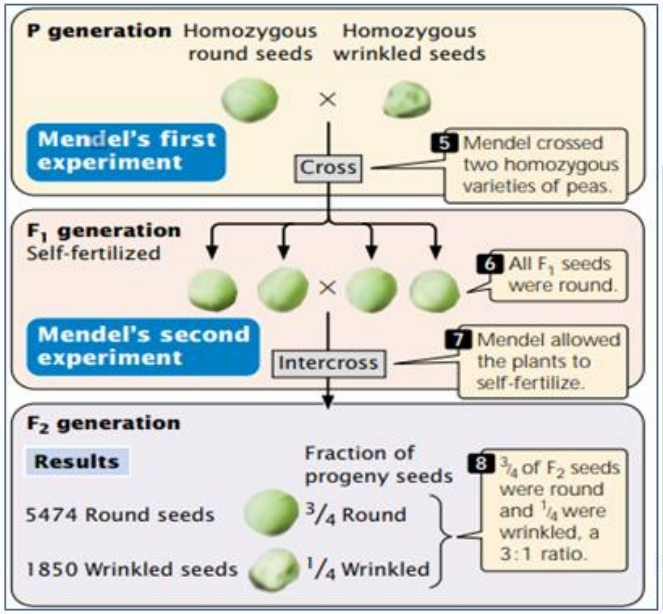


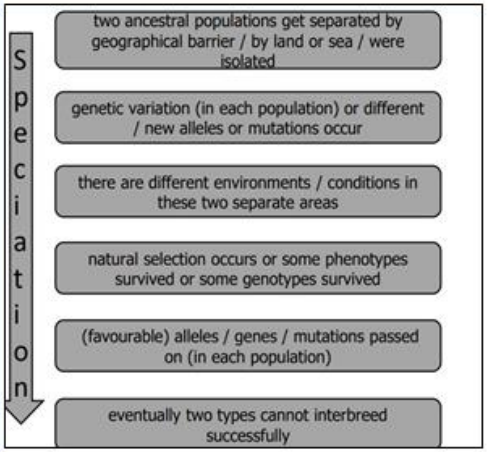
How the Finch has evolved

4.6.3.2 Speciation

Species → A group of similar organisms that can reproduce to give fertile offspring

Speciation → The development of a new species





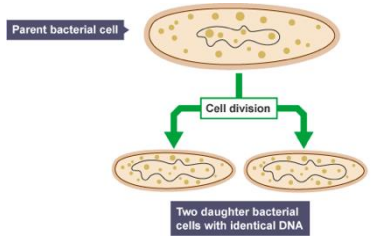
Knowledge Organiser – 4.6 Inheritance, variation and evolution

Sexual reproduction involves the joining (fusion) of male and female gametes:
- sperm and egg cells in animals
- pollen and egg cells in flowering plants.
- mixing of genetic information which leads to variety in the offspring.
- The formation of gametes involves meiosis.

Meiosis: **non-identical** offspring

Asexual reproduction involves only one parent
- No fusion of gametes.
- No mixing of genetic information.
- leads to genetically identical offspring (clones).
- Only mitosis is involved.

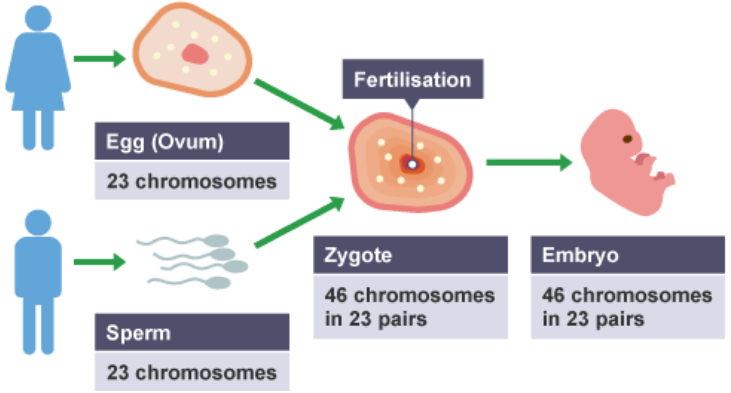
Mitosis: **identical** offspring



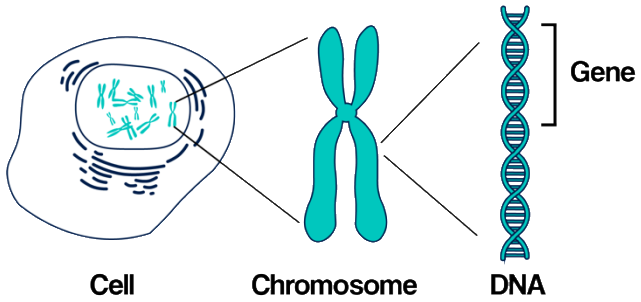
4.6.1.2 Meiosis

Sexual reproduction uses the process of **meiosis**, which creates gametes. The process of meiosis happens in the male and female reproductive organs.
Meiosis halves the number of chromosomes in gametes
Fertilisation restores the full number of chromosomes.
Cells in reproductive organs divide by meiosis to form gametes:

- **copies of the genetic information** are made
- the cell divides **twice** to form **four gametes**, each with a **single set of chromosomes (haploid)**
- all gametes are **genetically different** from each other.
- Gametes **join at fertilisation** to **restore the normal number of chromosomes**.
- The new cell divides by mitosis.
- The number of cells increases.
- As the embryo develops cells differentiate.



4.6.1.3 DNA and the genome



DNA Deoxyribonucleic acid
- The **genetic material in the nucleus of a cell** is composed of a chemical called DNA.
- DNA is a **polymer** made up of two strands forming a **double helix**.

Chromosome
- The DNA is contained in structures called **chromosomes**.
- Codes for all the characteristics of an organism.

Gene
- A gene is a small section of DNA on a chromosome.
- Each gene codes for a particular sequence of amino acids, to make a specific protein.

Genome
- genome of an organism is the entire genetic material of that organism.
- The whole human genome has now been studied and this will have great importance for medicine in the future.

Definitions	
diploid	A cell that contains two sets of chromosomes.
double helix	shape of the DNA molecule with two strands twisted together in a spiral.
gamete	Sex cell (sperm in males and ova/eggs in females).
haploid	A sex cell (gamete) containing one set of chromosomes.
heredity	Genetic information that determines an organism's characteristics, passed on from one generation to another. To do with passing genes to an offspring from its parent or parents.
mitosis	A type of cell division which produces daughter cells identical to the parent.
nucleus	The central part of an atom. It contains protons and neutrons, and has most of the mass of the atom. The plural of nucleus is nuclei.
organism	Living entity, eg animals, plants or bacteria.

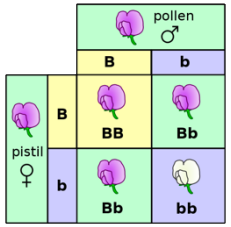
Knowledge Organiser – 4.6.1 Inheritance, variation and evolution

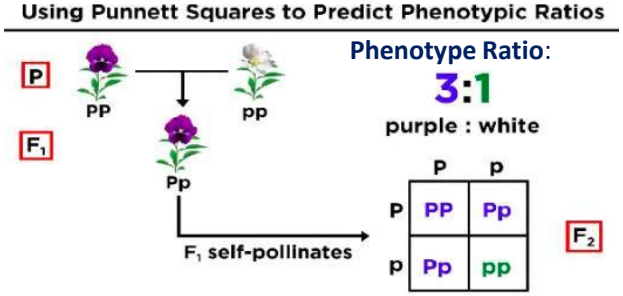
4.6.1.4 Genetic inheritance

Some **characteristics** are controlled by a single gene e.g: fur colour in mice; and red-green colour blindness in humans.

- Each **gene** may have different forms called **alleles**.
- The **alleles** present (**genotype**), operate at a molecular level to develop **characteristics** that can be expressed as a **phenotype**.
- A **dominant allele** is **always expressed**, even if only one copy is present.
- A **recessive allele** is **only expressed if two copies are present**.
- If the **two alleles** are the same the organism is **homozygous** for that trait
- If the **alleles are different** they are **heterozygous**.

Punnett square





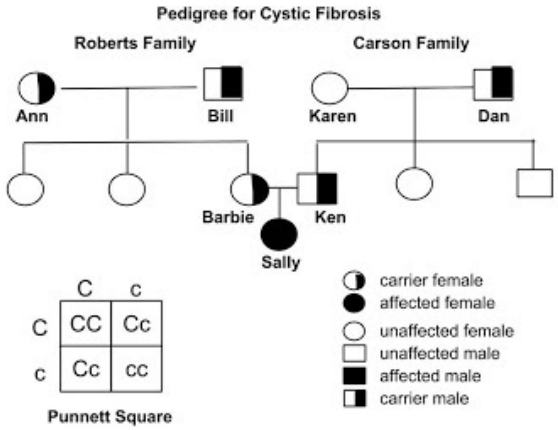
Genotype Ratio:
25% PP
50% Pp
25% pp
1:2:1 ratio

- Most **phenotype characteristics** are a result of multiple genes interacting, rather than a single gene.

4.6.1.5 Inherited disorders

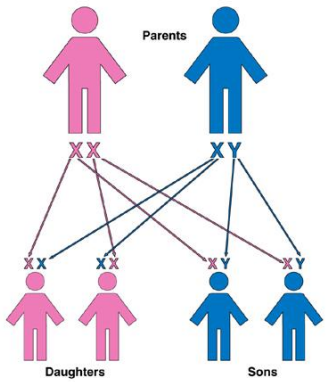
Some disorders are inherited.
These disorders are caused by the inheritance of certain alleles.

- **Polydactyly** (having extra fingers or toes) is caused by a dominant allele.
- **Cystic fibrosis** (a disorder of cell membranes) is caused by a recessive allele.



4.6.1.6 Sex determination

- Human body cells contain 23 pairs of chromosomes
- 22 pairs control characteristics only
- 1 pair carries the genes that determine sex.
- **Females:** sex chromosomes - **XX**
- **Males:** chromosomes are different - **XY**



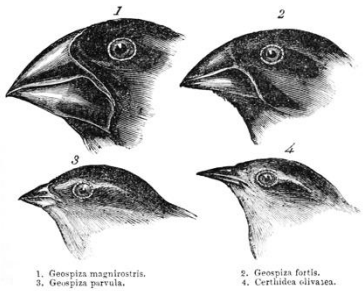
4.6.2 Variation and evolution

Differences in the characteristics of individuals in a population is called variation and may be due to differences in:

- the genes they have inherited (**genetic** causes)
- the conditions in which they have developed (**environmental** causes)
- a **combination of genes and the environment**.
- Usually extensive genetic variation within a population of a species
- All variants arise from mutations and **most have no effect on the phenotype**; **some influence** phenotype; **very few determine** phenotype.
- **Mutations occur continuously**. Very rarely a mutation will lead to a new phenotype.
- If a new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.

Evolution:

- The theory of evolution by natural selection states that **all species of living things have evolved from simple life forms that first developed more than three billion years ago**.
- Evolution occurs through **natural selection of variants** that give rise to **phenotypes** best suited to their **environment**.
- If two populations of one species become so different in phenotype that they can **no longer interbreed to produce fertile offspring** they have formed two **new species**.



Knowledge Organiser – 4.6.2 Selective breeding & Genetic Engineering

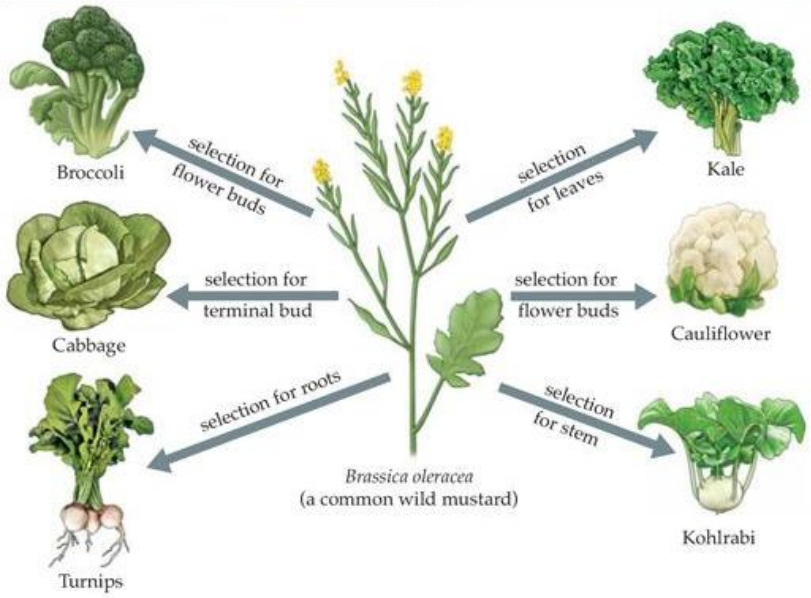
4.6.2.3 Selective breeding or Artificial selection

Selective breeding (artificial selection) is the human breeding of plants and animals for particular genetic characteristics.
Involves:

- **choosing parents with the desired characteristic** from a mixed population.
- They are **bred together**.
- From the **offspring those with the desired characteristic are bred together**.
- **continues over many generations** until **all** the offspring show the **desired characteristic.**

Characteristics might include:

- **Disease resistance** in food crops.
- Animals which produce **more meat or milk**.
- Selective breeding **can lead to 'inbreeding'** where some breeds are particularly prone to disease or inherited defects.



4.6.2.4 Genetic engineering

Genetic engineering involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.

- **Plant crops have been genetically engineered to be resistant to diseases** or to produce bigger better fruits.
- **Bacterial cells have been genetically engineered** to produce human **insulin** to treat diabetes.
- **Genes** from the chromosomes of humans and other organisms **can be 'cut out'** and **transferred to cells of other organisms**.

GM Crops

- Crops that have had their genes modified in this way are called genetically modified (GM) crops.
- GM crops include ones that are resistant to insect attack or to herbicides.
- GM crops generally show increased yields.

Negatives

- Concerns about GM crops include the effect on populations of wild flowers and insects.
- Some people feel the effects of eating GM crops on human health have not been fully explored.

Positives

- Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.
- Much faster than selective breeding
- More productive crops, resistant to climate change and other environmental challenges

Process of genetic engineering (HT only):

- **enzymes** are used to **isolate** the required gene
- this **gene is inserted into a vector**, usually a bacterial plasmid or a virus
- the **vector is used to insert the gene into the required cells**
- genes are **transferred to the cells of animals, plants** or **microorganisms** at an early stage in their development so that they develop with desired characteristics.

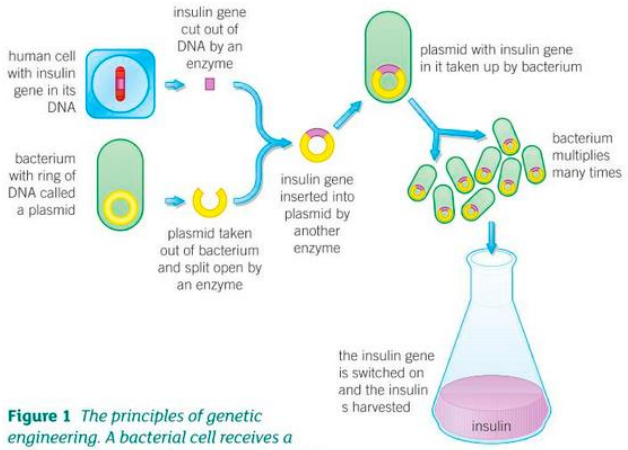


Figure 1 *The principles of genetic engineering. A bacterial cell receives a human gene so it makes a human protein – in this case, the hormone insulin*

Knowledge Organiser – 4.6.3 Development of understanding of genetics and evolution

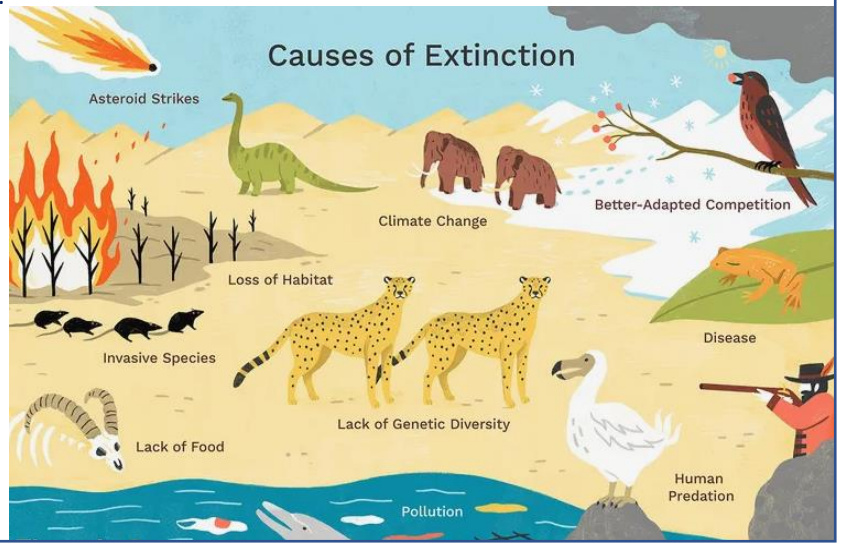
Evidence for evolution

- The theory of evolution by natural selection is now widely accepted.
- Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in **genes**.
- There is further evidence in the **fossil record**
- And by **knowledge of how resistance to antibiotics evolves in bacteria.**

Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks. Fossils may be formed:

- from **parts of organisms that have not decayed** because one or more of the conditions needed for decay are absent
- when parts of the organism are **replaced by minerals as they decay**
- as **preserved traces of organisms**, such as footprints, burrows and rootlet traces.
- Fossils can how much or how little different organisms have changed as life developed .

Extinctions occur when there are no remaining individuals of a species still alive.



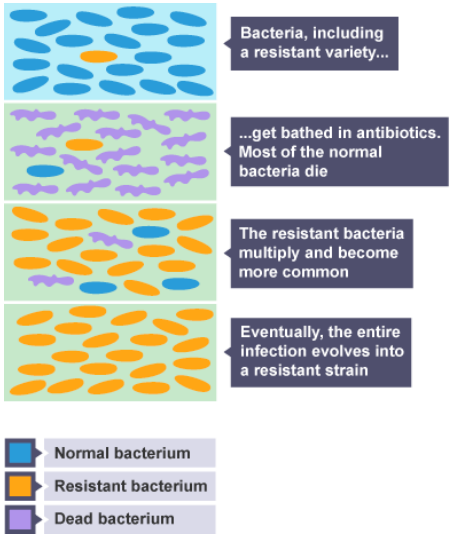
4.6.3.4 Resistant bacteria

- **Bacteria can evolve rapidly because they reproduce at a fast rate**.
  - **Mutations** of bacterial pathogens produce new strains.
  - **Some strains might be resistant to antibiotics**, and so are not killed.
  - They **survive and reproduce**, so the population of the resistant strain rises.
  - The **resistant strain will then spread because people are not immune** to it and there is no effective treatment.

E.g. MRSA is resistant to antibiotics.

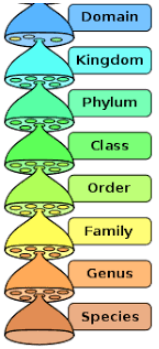
To reduce the rate of development of antibiotic resistant strains:

- doctors should not prescribe antibiotics inappropriately, eg for viral infections
- patients must complete a course of antibiotics so no bacteria survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted.

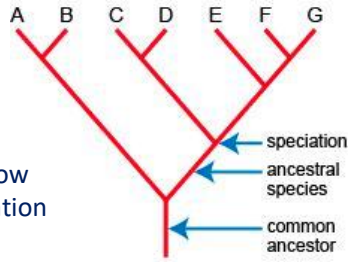


4.6.4 Classification of living organisms

- **Traditionally** living things have been **classified** into groups **depending on their structure and characteristics** in a system developed by Carl **Linnaeus**.
- Linnaeus classified living things into **kingdom, phylum, class, order, family, genus and species.**
- Organisms are named by the **binomial system of genus and species**.

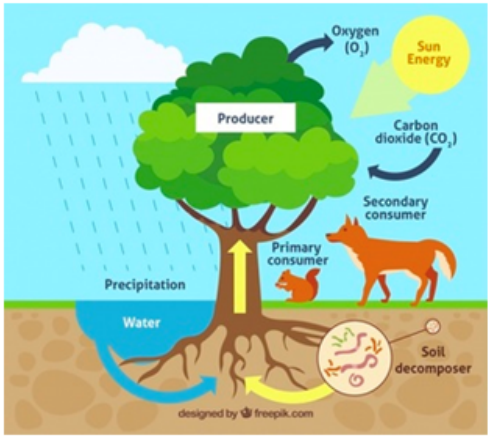


- As evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed.
- Due to evidence available from chemical analysis **there is now a 'three-domain system'** developed by Carl **Woese**.
  - **Archaea** (primitive bacteria usually living in extreme environments)
  - **Bacteria** (true bacteria)
  - **Eukaryota** (which includes protists, fungi, plants and animals).
- **Evolutionary trees** are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms.



Knowledge Organiser – 4.7.1 Ecology Adaptations, interdependence and competition

4.7 Ecology



4.7.1.1 Communities

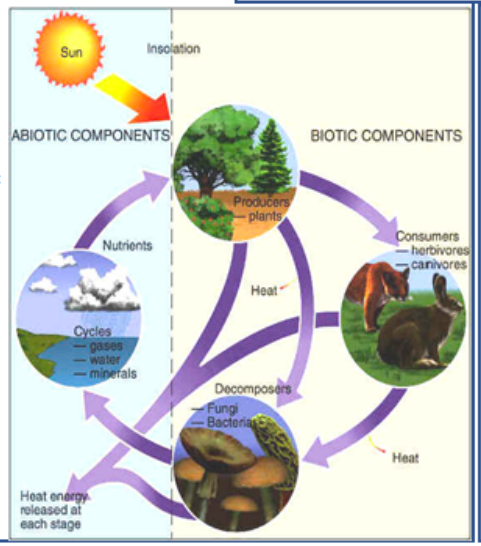
- An **ecosystem** is the **interaction of a community of living organisms** (biotic) **with the non-living** (abiotic) **parts of their environment**.
- **To survive and reproduce**, organisms require a supply of materials from their surroundings and from the other living organisms there.
- **Plants** in a community or habitat often **compete with each other**:
  - for light, space and for water and mineral ions from the soil.
- **Animals** often **compete with each other**:
  - for food, mates, territory
- Within a community **each species depends on other species**
- If one species is removed it can affect the whole community. This is called **interdependence**.
- A **stable community** is one where all the species and environmental factors are in balance so **that population sizes remain fairly constant**.

4.7.1.2 Abiotic factors

- light intensity
- temperature
- moisture levels
- soil pH and mineral content
- wind intensity and direction
- carbon dioxide levels for plants
- oxygen levels for aquatic animals.

4.7.1.3 Biotic factors

- availability of food
- new predators arriving
- new pathogens
- one species outcompeting another so the numbers are no longer sufficient to breed.



4.7.1.4 Adaptations

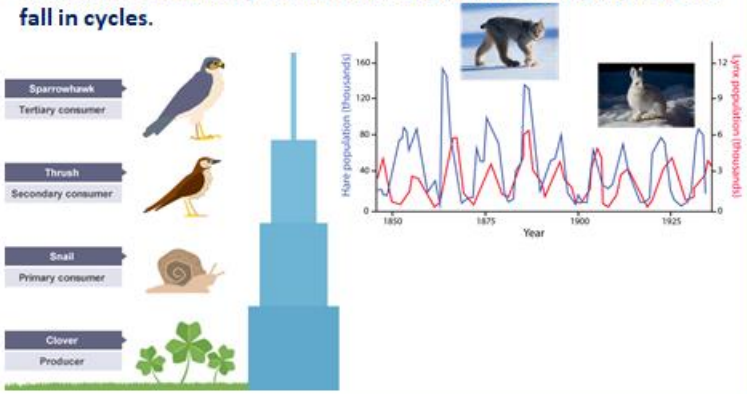
- Organisms are **adapted to live in their natural environment**
- Organisms have **features (adaptations) that enable them to survive** in the conditions in which they normally live.
- These **adaptations** may be **structural**, **behavioural** or **functional**.
- **Extremophiles** are organisms that live in environments that are very extreme, such as at high temperature, pressure, or salt concentration.
  Eg Bacteria living in deep sea vents

Definition	
abiotic	Non-living elements of an ecosystem, such as climate, temperature, water, and soil type.
biotic	Living elements of an ecosystem, eg plants, animals.
community	All the organisms that live in a habitat
ecosystem	The living organisms in a particular area, together with the non-living components of the environment.
food chain	A sequence (usually shown as a diagram) of feeding relationships between organisms, showing which organisms eat what and the movement of energy through trophic levels.
gene	The basic unit of genetic material inherited from our parents. A gene is a section of DNA which controls part of a cell's chemistry - particularly protein production.
indicator species	The presence, abundance or absence of these organisms provides information such as the level of pollution in the environment.
interdependence	Refers to the fact that all organisms that live in an ecosystem depend upon each other, for food, protection, shelter, etc, in order to survive.
interspecific competition	The competition which occurs between organisms of different species for a common resource.
intraspecific competition	The competition between organisms within the same species.
nitrate	The chemical absorbed from the soil by plants to produce their protein.
pathogen	Microorganism that causes disease.
population	All of the members of a single species that live within a geographical area.
predator	An animal that hunts, kills & eats other animals
prey	Organisms that predators kill for food.
producer	Plants that begin food chains by making energy from carbon dioxide and water.
species	A type of organism that is the basic unit of classification. Individuals of different species are not able to interbreed successfully.

Knowledge Organiser – 4.7.2 Organisation of an ecosystem

4.7.2.1 Levels of organisation

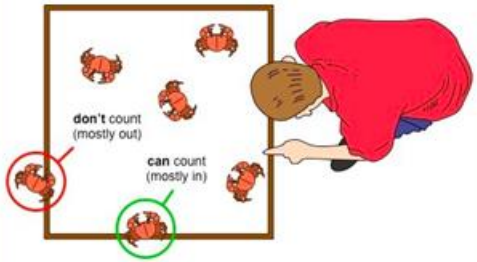
- **Photosynthetic organisms** are the producers of **biomass** for life on Earth.
- **Feeding relationships within a community can be represented by food chains**. All food chains begin with a producer which synthesises molecules. This is usually a green plant or alga which makes glucose by photosynthesis.
- **Producers** are eaten by **primary consumers**, which in turn may be eaten by **secondary consumers** and then **tertiary consumers**.
- Consumers that kill and eat other animals are **predators**, and those eaten are **prey**.
- **In a stable community the numbers of predators and prey rise and fall in cycles**.



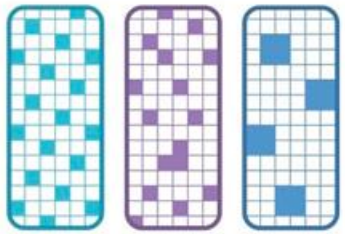
Definitions	
mean	The mean is calculated by adding all of the data and dividing by the number of items
Mode	The value that occurs most often.
median	The 'middle' value in the list of numbers
quadrat	A square frame of known area used for sampling the abundance and distribution of slow or non-moving organisms.
transect	A line created, for instance, with a tape measure, along which sampling occurs.
yield	The mass of product made in a chemical reaction. The percentage yield is a measure of the yield obtained compared to the maximum possible yield.

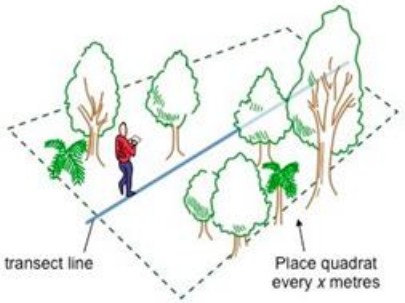
RPA: measure the population size of a common species in a habitat.
Use sampling techniques to investigate the effect of a factor on the distribution of this species.

Quadrat Counting Method

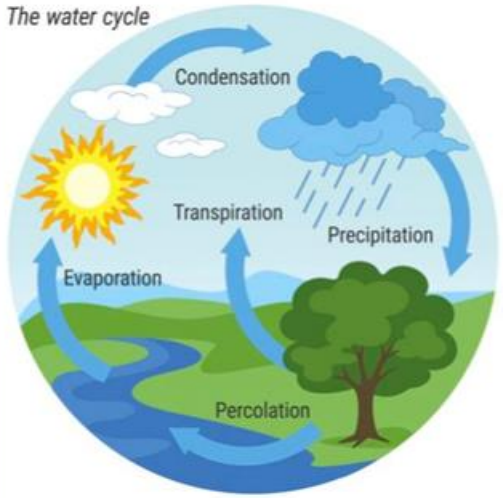


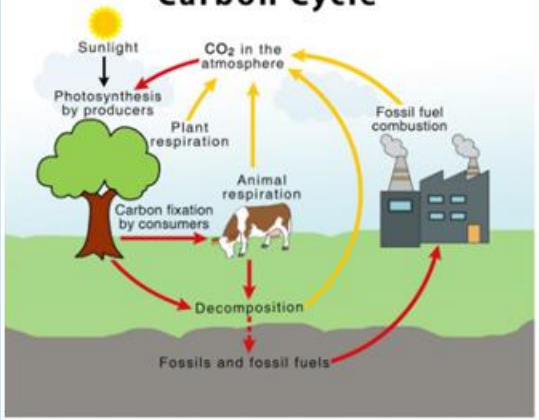
Types of Sampling Distributions





4.7.2.2 How materials are cycled





Knowledge Organiser – 4.7.3 Biodiversity and the effect of human interaction on ecosystems

4.7.3.1 Biodiversity

- **Biodiversity** is the **variety of all the different species of organisms on earth, or within an ecosystem.**
- **Greater biodiversity ensures the stability of ecosystems** by reducing the dependence of one species on another for food, shelte and the maintenance of the physical environment.
- Many human activities are reducing biodiversity

4.7.3.2 Waste management

- **Rapid growth in the human population** and an increase in the standard of living mean that increasingly **more resources are used and more waste is produced.**
- Unless waste and chemical materials are properly handled, more **pollution** will be caused.

Pollution can occur:

- in **water**, from sewage, fertiliser or toxic chemicals
- in **air**, from smoke and acidic gases
- on **land**, from landfill and from toxic chemicals.
- Pollution kills plants and animals which can **reduce biodiversity.**

4.7.3.3 Land use

- Humans **reduce the amount of land available** for other animals and plants by **building, quarrying, farming and dumping waste.**

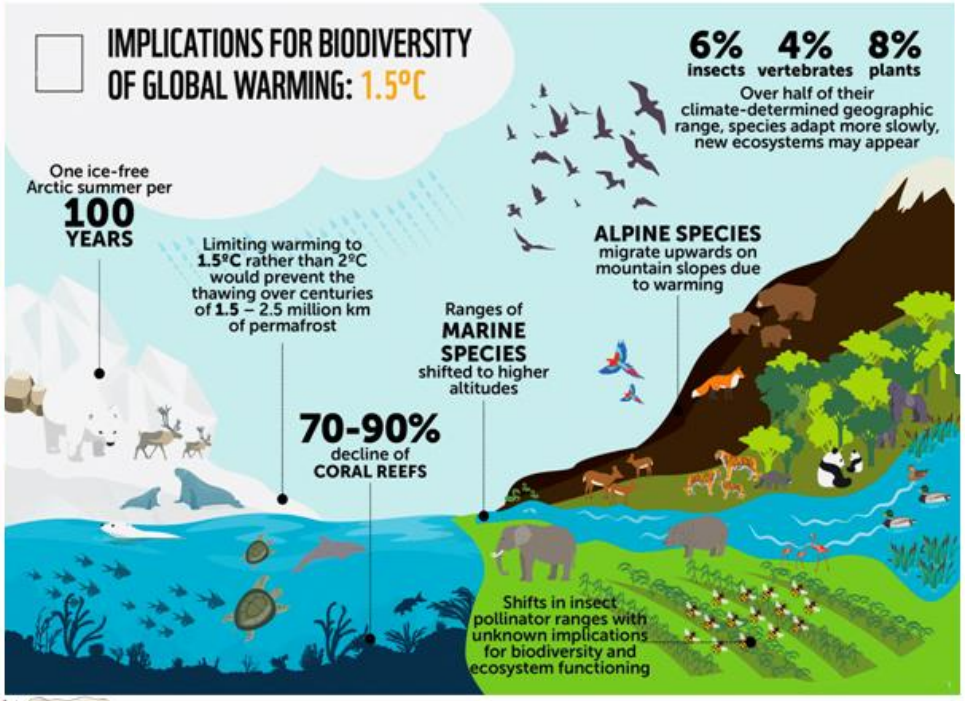
For example:

- The **destruction of peat bogs**, and other areas of peat to produce garden compost, **reduces the area of this habitat** and thus the variety of different plant, animal and microorganism species that live there (**biodiversity**).
- The **decay or burning** of the peat **releases carbon dioxide** into the atmosphere.

4.7.3.4 Deforestation

- Large-scale deforestation in tropical areas has occurred to:
  - provide land for cattle and rice fields
  - grow crops for biofuels

4.7.3.5 Global warming



4.7.3.6 Maintaining biodiversity

Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity.

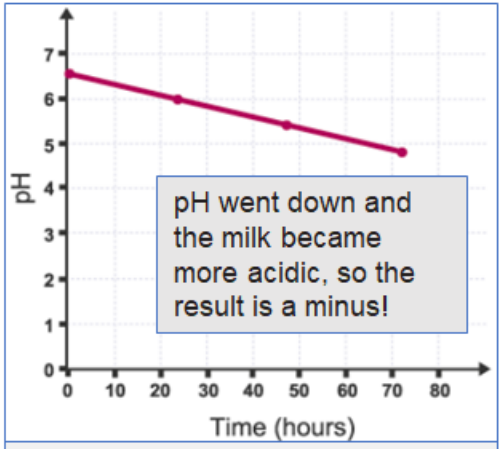
These include:

- breeding programmes for endangered species
- protection and regeneration of rare habitats
- reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop
- reduction of deforestation and carbon dioxide emissions by some governments
- recycling resources rather than dumping waste in landfill.

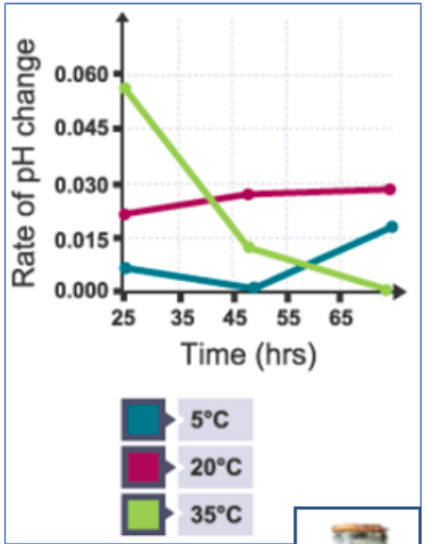
Knowledge Organiser – 4.7.2.3 Decomposition & RPA (Separate Biology)

4.7.2.3 Decomposition / Decay: Key Terms

- **Compost** - **Decomposed** organics matter
- **Decomposition** - The breakdown of organic matter by **microbes** (bacteria/fungi) or detritus feeders (worms)
- **Conditions for decay** - **Warm**, plenty of **oxygen**, **moisture**, plenty of microbes
- **Biogas** - Methane gas produced by **anaerobic** decay of waste material, methane is used as a fuel for cooking, heating
- **Biogas generator** - Need constant temperature, 2 types: **batch** and **continuous**



$$\text{rate of change} = \frac{\text{vertical change}}{\text{horizontal change}}$$



Use the **gradient of a graph** to find a **rate** of change is **easier** than calculating rate if there's a lot of data/ variability in data.

RPA - Investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change

As milk **decays** its pH reduces. This is because bacteria present in milk carry out a chemical process to provide them with energy. This process converts lactose sugar in the milk to lactic acid, and producing this acid reduces the pH of the milk.

Aim

To investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change.

Method

1. Place 20 cm^3 of fresh milk into three beakers
2. Decide the three temperatures you will investigate. Write these onto the sides of the beakers. They could be 5, 20 and 35°C.
3. Use universal indicator paper or solution to determine the pH of the milk in the three beakers
4. Cover each beaker in cling film and incubate at the appropriate temperature
5. Use universal indicator paper or solution to determine the pH of the milk in the three beakers after 24, 48 and 72 hours

RPA – Skill

The rate of change can be calculated from the above graph by finding the gradient of the trend-line, using the equation above.

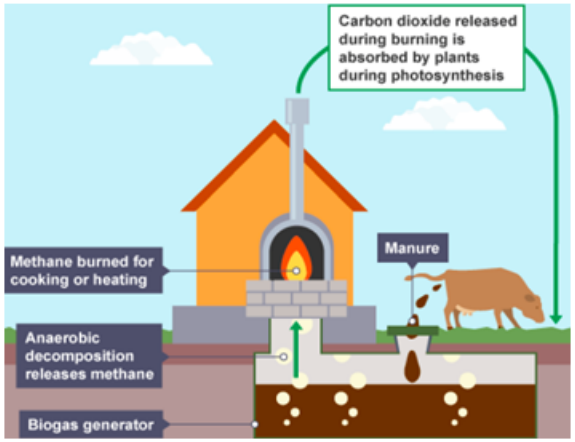
For example, after 0 hours in the above graph, the pH is 6.6; after 50 hours it is 5.4.

calculate

$$= \frac{5.4 - 6.6 \text{ pH units}}{50 - 0 \text{ hours}}$$

$$= \frac{-1.2 \text{ pH units}}{50 \text{ hours}}$$

$$= -0.024 \text{ pH units/hour} \text{ (to 2 significant figures)}$$



Knowledge Organiser – 4.7.3 Biodiversity & 4.7.4 Trophic Levels (Separate Biology)

4.7.2.4 Impact of environmental change (HT)

- **Temperature:** As you climb up a mountain the temperature reduces. This reduction, together with other **abiotic** and **biotic** factors, determines what **species** of plant are found at different elevations.
- **Availability of water:** All life on Earth needs water. Too much and some species will drown or rot. Too little and all species die.
- **Atmospheric gases:** Gases dissolve in liquids, thus oxygen in the air dissolves in water. It is this dissolved oxygen, together with that produced by plants and algae, that support aquatic life. When levels of pollution increase the levels of dissolved oxygen reduce.

These changes may be seasonal, geographic or caused by human interaction.

4.7.4.1 Trophic levels

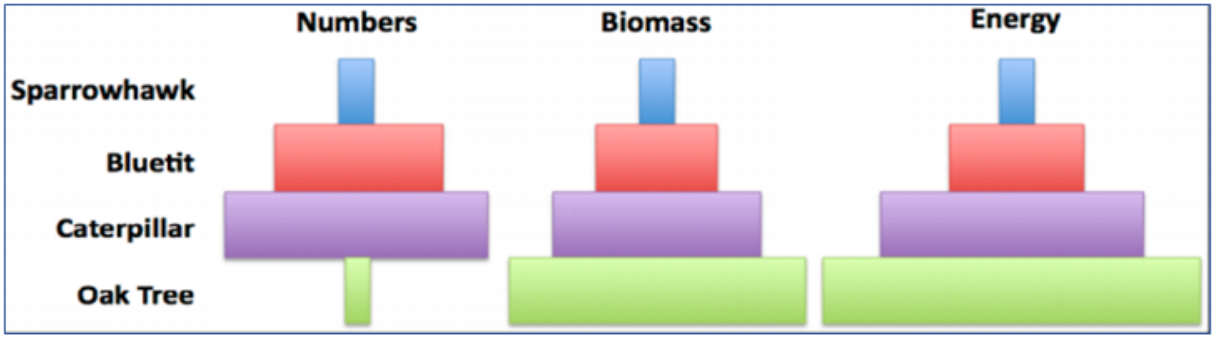
A simple **food chain** is:

algae → mosquito larvae → dragon fly larvae → perch

$$\text{efficiency} = \frac{\text{biomass transferred to the next level}}{\text{biomass available at the previous level}} \times 100$$

4.7.4.2 Pyramids of biomass

Show the relative mass of each trophic level, must be drawn to scale Biomass The total quantity or mass of organisms in a given area or volume



Key Terms	Meaning
Producers	Green plants - they make glucose during photosynthesis.
Primary consumers	Usually eat plant material - they are herbivores. For example rabbits, caterpillars, cows and sheep.
Secondary consumers	Usually eat animal material - they are carnivores. For example cats, dogs and lions.
Predators	Kill for food. They are either secondary or tertiary consumers.
Prey	The animals that predators feed on.
Scavengers	Feed on dead animals. For example, crows, vultures and hyenas are scavengers.
Decomposers	Feed on dead and decaying organisms, and on the undigested parts of plant and animal matter in faeces.

Organism	Biomass, dry mass (g)
Oak tree	100 000
Caterpillar	5000
Blue tit	30
Sparrow hawk	3

calculate

To calculate the % of the energy in the oak tree that is **passed to the sparrow hawk** here's what to do:

3 ÷ 100 000 = 0.00003

0.0003 x 100 = **0.003%**

4.7.4.3 Transfer of biomass

The amount of energy (in the biomass of organisms) is **reduced** at each successive stage in a food chain because:

- All of prey organism is **not consumed** e.g. bones, teeth, hair
- Energy is '**lost**' as the organisms' **waste materials** (faeces and urine)
- Energy is transferred / lost / released during **respiration**
- Energy is transferred / lost as **movement** (kinetic energy)
- Energy is transferred / lost as **heat** (thermal energy)
- Energy is transferred / lost to the **surroundings**

Knowledge Organiser – 4.7.5 Food Production (Separate Biology)

4.7.5.1 Factors affecting food Security

- ❑ World's birth rate increased
- ❑ Diets changing around world
- ❑ Food transported
- ❑ New pests and pathogens affect farming
- ❑ Environmental change e.g. temp rise or rainfall/ famine
- ❑ Cost of agricultural inputs
- ❑ Conflicts in the world

We need a sustainable way of feeding the world's population

4.7.5.2 Farming Techniques: Advantages and disadvantages of intensive farming practices

Advantage	Disadvantage
Higher yields	Costly additives needed
More efficient use of food	Risk of antibiotic resistance
Quality control easier	Considered unethical by some people

4.7.5.3. Sustainable fisheries do not reduce the overall number of fish, because the number of fish that are caught and killed does not ever exceed the birth of new fish.

- At one point we thought that we could remove as many fish as we wanted from the oceans without any consequence. During this period, we drastically **overfished** some of our oceans and seas and reduced some **populations** to critically low numbers.
- Some scientists think that as much as 85% of the world's fish populations have been overfished. Common examples are cod in the North Sea and sole in the Irish Sea and English Channel. Overfishing can cause a critical point in populations that means certain **species** cannot ever recover and will become **extinct**.

To address overfishing many countries eg NZ and Iceland are adopting a more sustainable strategy for fishing:

- Introduced fishing quotas limiting the amount of fish that can be caught and killed from specific species.
- Bigger gaps in nets to ensure juvenile fish can reach reproductive maturity and have offspring before being killed.

Organic farming :- Many people object to intensive farming because it reduces biodiversity and increases pollution. More recently some farms have become **organic** to address this. Organic farmers do not use machines to the same extent as intensive farming. They do not apply **pesticides** to their crops and use natural fertilisers such as **compost** and **manure**. They rotate their crops to avoid monoculture

4.7.5.4 Role of biotechnology

- Producing **protein** from fungus is much more efficient than from meat from livestock.
- Only about 10% of the energy found in grass is transferred to the animals like cows that eat it. 1000 g of plant carbohydrate can produce up to 14 g of beef, 49 g of chicken or 136 g of mycoprotein.
- Additionally, fermenters can be used to produce protein in places where grass and livestock cannot grow.

The fungus is grown in large containers called **fermenters**. The conditions inside are maintained to promote maximum growth:

Quorn 

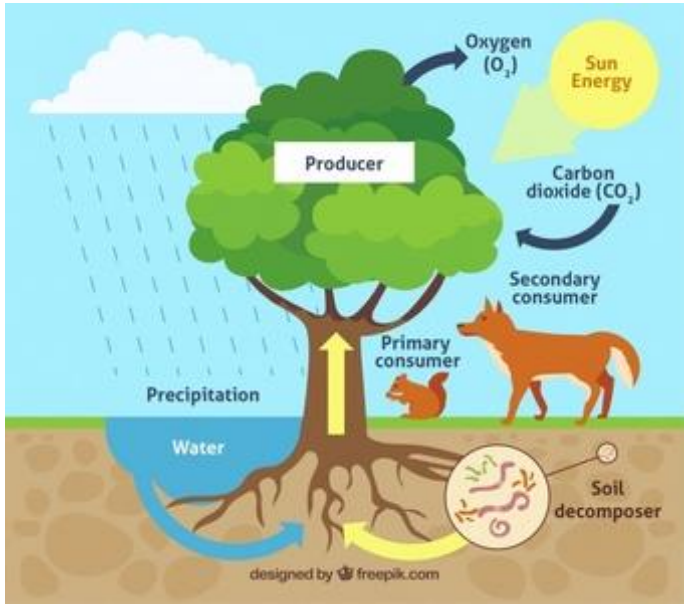
1. The pH and temperature are
2. maintained at the **optimum**
3. The temperature is controlled by a water jacket
4. Sterile oxygen is added to make sure that **aerobic respiration** occurs
5. A food source like glucose syrup is added
6. The mixture inside is stirred to make sure all the oxygen and nutrients are equally distributed

4.7.5.4 Role of biotechnology

Humans have used biotechnology for thousands of years in **agriculture** and used selective breeding to produce better foods and medicines. More recent examples of biotechnology include **cloning** and **genetic modification**. Biotechnology can help us meet the food demands of our ever increasing **population**.

Knowledge Organiser – 4.7.1 Ecology Adaptations, interdependence and competition

4.7 Ecology



4.7.1.1 Communities

- An **ecosystem** is the **interaction of a community of living organisms** (biotic) **with the non-living** (abiotic) **parts of their environment**.
- **To survive and reproduce**, organisms require a supply of materials from their surroundings and from the other living organisms there.
- **Plants** in a community or habitat often **compete with each other**:
  - for light
  - space,
  - for water and mineral ions from the soil.
- **Animals** often **compete with each other**:
  - for food
  - mates
  - Territory

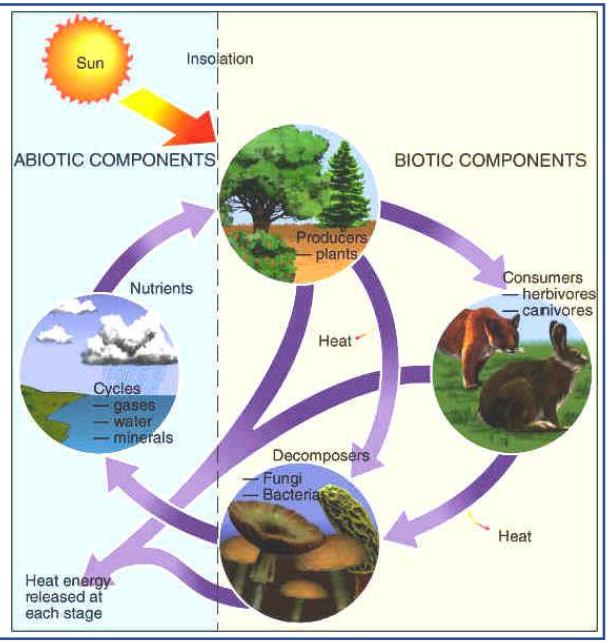
- Within a community **each species depends on other species**
- If one species is removed it can affect the whole community. This is called **interdependence**.
- A **stable community** is one where all the species and environmental factors are in balance so **that population sizes remain fairly constant**.

4.7.1.2 Abiotic factors

- light intensity
- temperature
- moisture levels
- soil pH and mineral content
- wind intensity and direction
- carbon dioxide levels for plants
- oxygen levels for aquatic animals.

4.7.1.3 Biotic factors

- availability of food
- new predators arriving
- new pathogens
- one species outcompeting another so the numbers are no longer sufficient to breed.



4.7.1.4 Adaptations

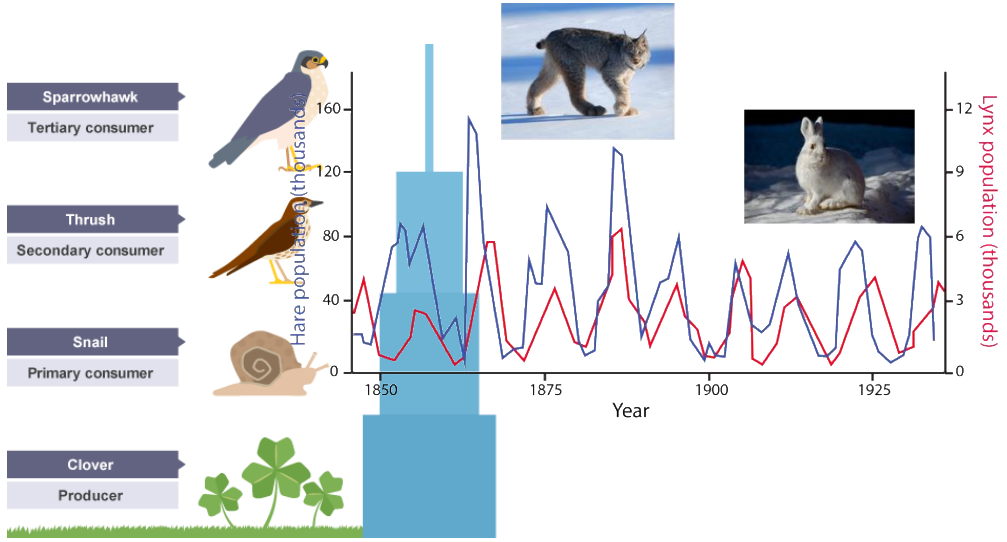
- Organisms are **adapted to live in their natural environment**
- Organisms have **features (adaptations) that enable them to survive** in the conditions in which they normally live.
- These **adaptations** may be **structural**, **behavioural** or **functional**.
- **Extremophiles** are organisms that live in environments that are very extreme, such as at high temperature, pressure, or salt concentration.
  Eg Bacteria living in deep sea vents

Definition	
abiotic	Non-living elements of an ecosystem, such as climate, temperature, water, and soil type.
biotic	Living elements of an ecosystem, such as plants and animals.
community	All the organisms that live in a habitat (plants and animals).
ecosystem	The living organisms in a particular area, together with the non-living components of the environment.
food chain	A sequence (usually shown as a diagram) of feeding relationships between organisms, showing which organisms eat what and the movement of energy through trophic levels.
gene	The basic unit of genetic material inherited from our parents. A gene is a section of DNA which controls part of a cell's chemistry - particularly protein production.
indicator species	The presence, abundance or absence of these organisms provides information such as the level of pollution in the environment.
interdependence	Refers to the fact that all organisms that live in an ecosystem depend upon each other, for food, protection, shelter, etc, in order to survive.
interspecific competition	The competition which occurs between organisms of different species for a common resource.
intraspecific competition	The competition between organisms within the same species.
nitrate	The chemical absorbed from the soil by plants to produce their protein.
pathogen	Microorganism that causes disease.
population	All of the members of a single species that live within a geographical area.
predator	An animal that hunts, kills and eats other animals for food.
prey	Organisms that predators kill for food.
producer	Plants that begin food chains by making energy from carbon dioxide and water.
species	A type of organism that is the basic unit of classification. Individuals of different species are not able to interbreed successfully.

Knowledge Organiser – 4.7.2 Organisation of an ecosystem

4.7.2.1 Levels of organisation

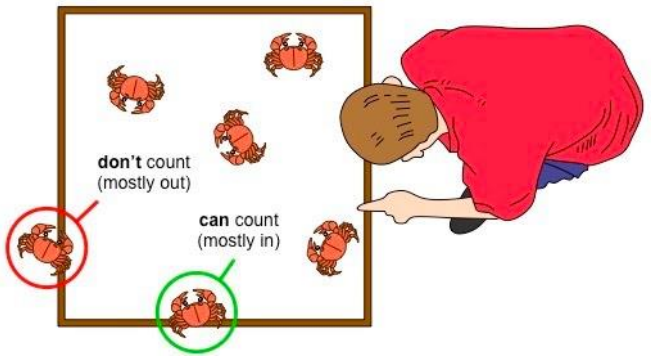
- **Photosynthetic organisms** are the producers of **biomass** for life on Earth.
- **Feeding relationships within a community can be represented by food chains**. All food chains begin with a producer which synthesises molecules. This is usually a green plant or alga which makes glucose by photosynthesis.
- **Producers** are eaten by **primary consumers**, which in turn may be eaten by **secondary consumers** and then **tertiary consumers**.
- Consumers that kill and eat other animals are **predators**, and those eaten are **prey**.
- **In a stable community the numbers of predators and prey rise and fall in cycles**.



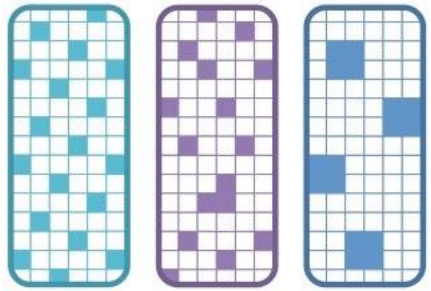
Definitions	
mean	The mean is calculated by adding all of the data and dividing by the number of items
Mode	The value that occurs most often.
median	The 'middle' value in the list of numbers
quadrat	A square frame of known area used for sampling the abundance and distribution of slow or non-moving organisms.
transect	A line created, for instance, with a tape measure, along which sampling occurs.
yield	The mass of product made in a chemical reaction. The percentage yield is a measure of the yield obtained compared to the maximum possible yield.

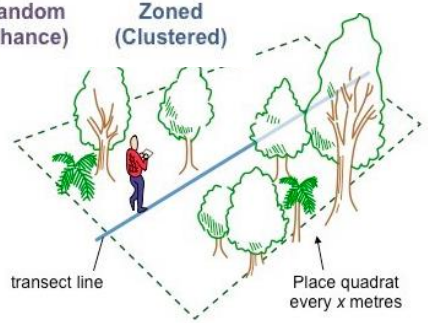
RPA: measure the population size of a common species in a habitat.
Use sampling techniques to investigate the effect of a factor on the distribution of this species.

Quadrat Counting Method

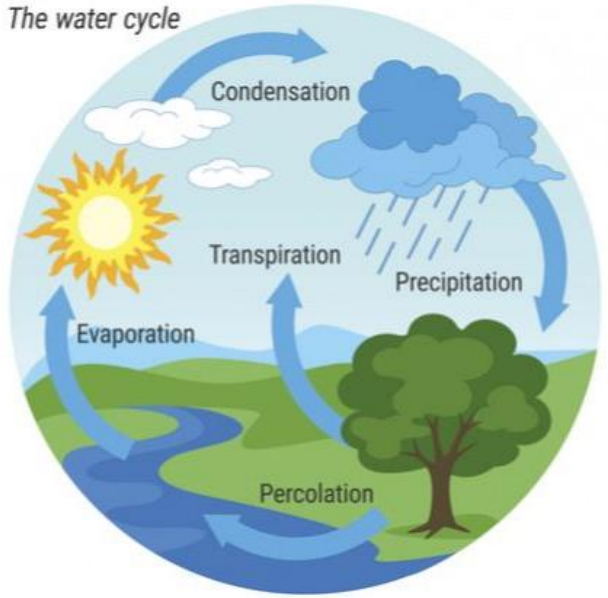


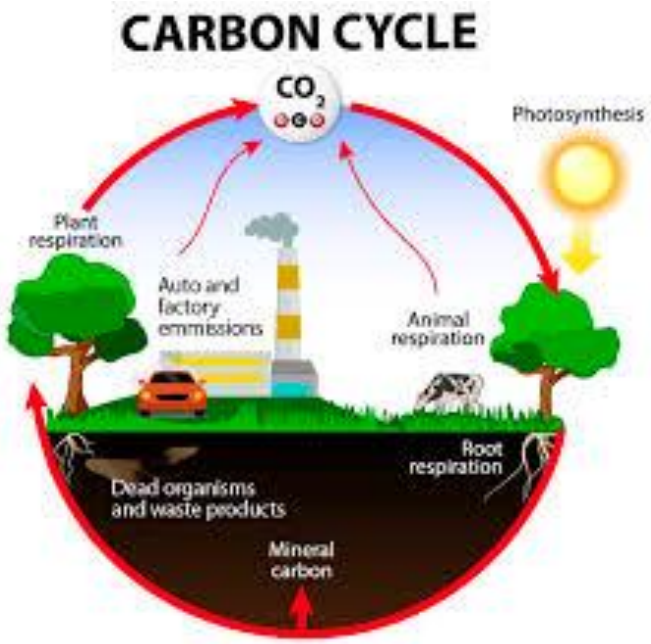
Types of Sampling Distributions





4.7.2.2 How materials are cycled





Knowledge Organiser – 4.7.3 Biodiversity and the effect of human interaction on ecosystems

4.7.3.1 Biodiversity

- **Biodiversity** is the **variety of all the different species of organisms on earth, or within an ecosystem**.
- **Greater biodiversity ensures the stability of ecosystems** by reducing the dependence of one species on another for food, shelter and the maintenance of the physical environment.
- Many human activities are reducing biodiversity

4.7.3.2 Waste management

- **Rapid growth in the human population** and an increase in the standard of living mean that increasingly **more resources are used and more waste is produced.**
- Unless waste and chemical materials are properly handled, more **pollution** will be caused.

Pollution can occur:

- in **water**, from sewage, fertiliser or toxic chemicals
- in **air**, from smoke and acidic gases
- on **land**, from landfill and from toxic chemicals.
- Pollution kills plants and animals which can **reduce biodiversity.**

4.7.3.3 Land use

- Humans **reduce the amount of land available** for other animals and plants by **building, quarrying, farming and dumping waste**.

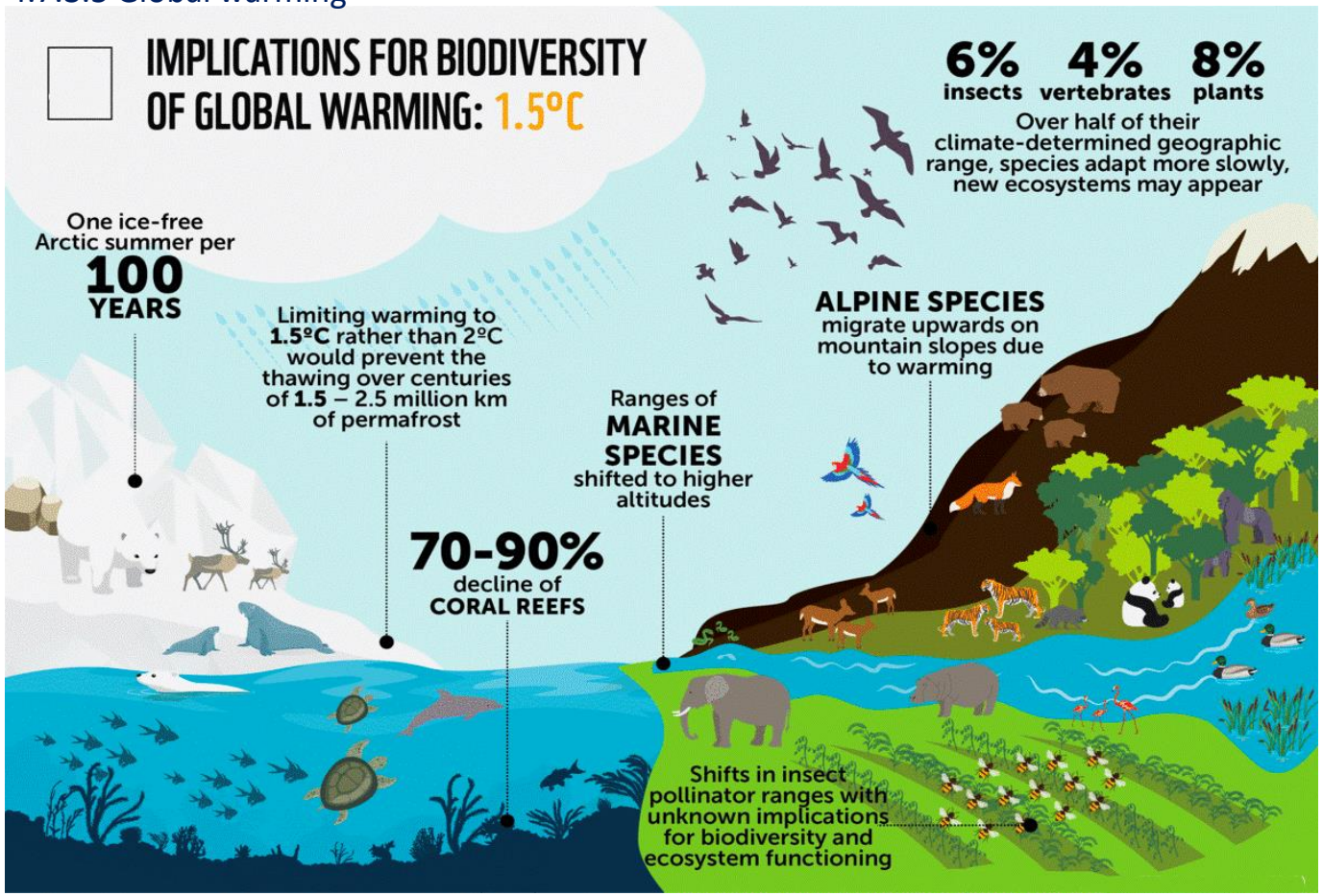
For example:

- The **destruction of peat bogs**, and other areas of peat to produce garden compost, **reduces the area of this habitat** and thus the variety of different plant, animal and microorganism species that live there (**biodiversity**).
- The **decay or burning** of the peat **releases carbon dioxide** into the atmosphere.

4.7.3.4 Deforestation

- Large-scale deforestation in tropical areas has occurred to:
  - provide land for cattle and rice fields
  - grow crops for biofuels

4.7.3.5 Global warming



4.7.3.6 Maintaining biodiversity

Scientists and concerned citizens have put in place programmes to reduce the negative effects of humans on ecosystems and biodiversity.

These include:

- breeding programmes for endangered species
- protection and regeneration of rare habitats
- reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop
- reduction of deforestation and carbon dioxide emissions by some governments
- recycling resources rather than dumping waste in landfill.