Module 1- Cells As a Basis Of Life

Cell Structure

Inquiry Question: What Distinguishes one cell from another?

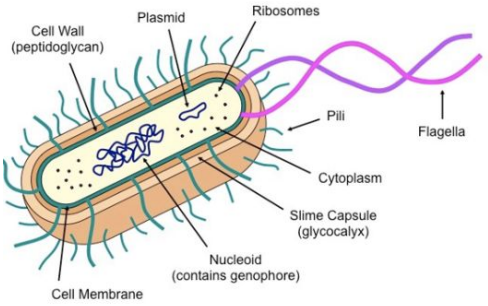
Cell Theory-

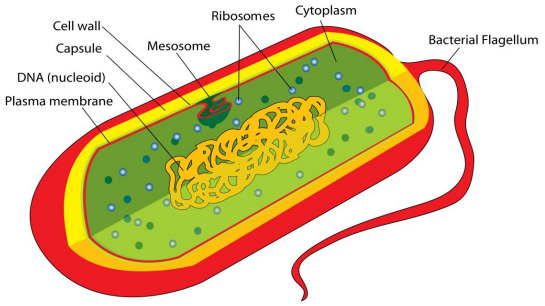
- All living things are made of cells
- Cells are the basic structural and functional units of organisms
- All cells come from pre-existing cells

Cell Structure-

Classification of cells

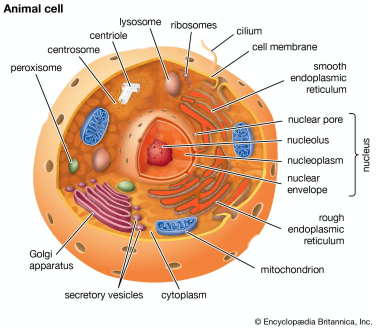
- Prokaryotes (Unicellular Organisms)
    - Primitive cells
    - Much smaller and simpler than eukaryotic cells
    - More abundance compared to eukaryotic cells
    - No membrane bound organelles
    - Divided into two groups → Archaea and Bacteria
    - Small and efficient→ High SA:V ratio
    - Four Main Structures
        - Cell membrane
        - Cytoplasm
        - Ribosomes
        - Genetic Material → Found in a large loop called the nucleoid.

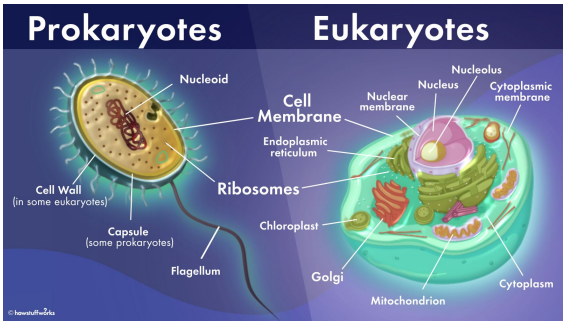




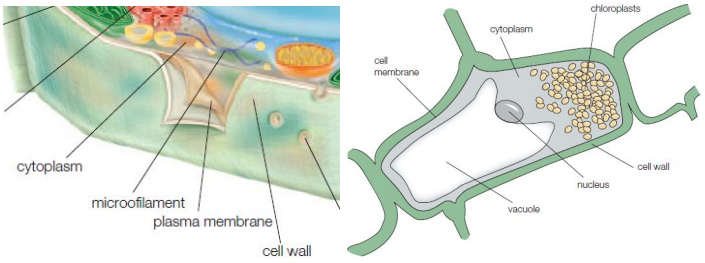
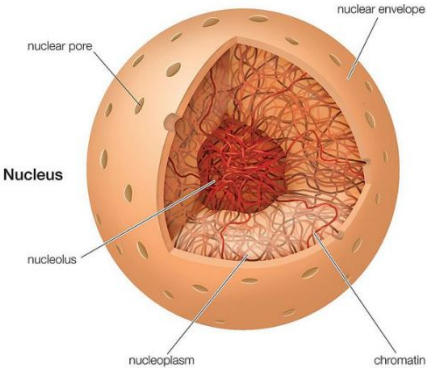
- Eukaryotes (Unicellular and Multicellular)
    - More complex and large than prokaryotes
    - Approx. 10-100um.
    - Multicellular plants and animals are composed of a variety of different types of eukaryotic cells.
    - Divided into kingdoms → Amoeba, fungi, Plantae and animalia
    - Contain membrane bound organelles
        - Each organelle has a specific function within the cell
        - Together the organelles carry out all the biochemical processes and reactions like transpiration and photosynthesis.
    - Endosymbiosis

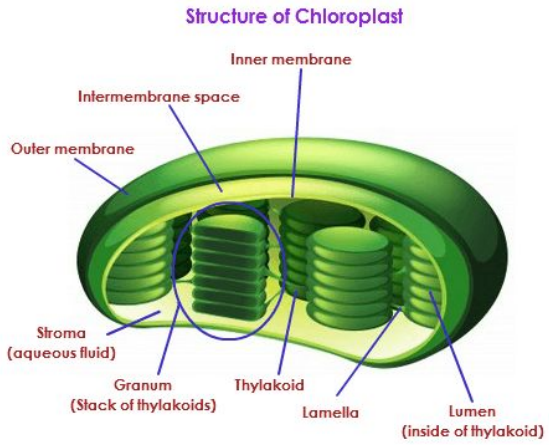
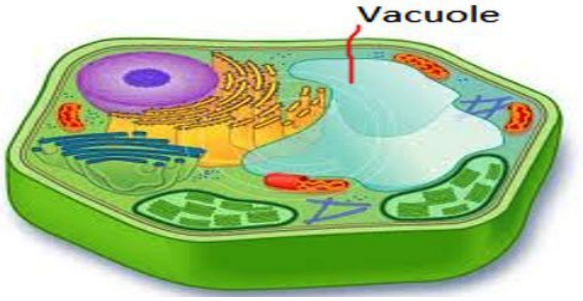
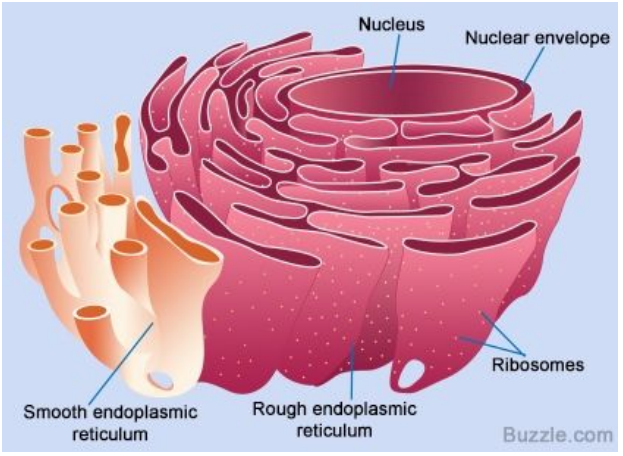
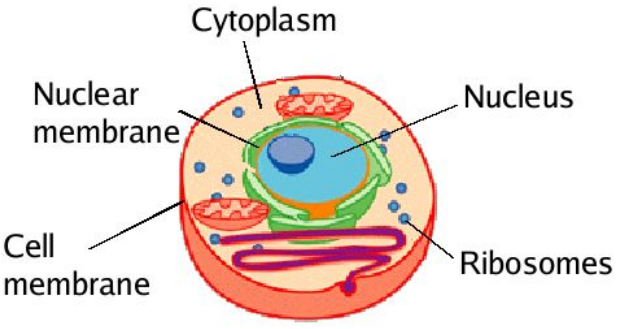
- Large prokaryotic cells engulfed smaller prokaryotic cells → Photosynthesising made chloroplasts + cells that used oxygen to produce their own energy made a mitochondria.
- Size of mitochondria and chloroplasts tend to be the same size as bacteria
- The way mitochondria and chloroplasts divide tend to be the same process as prokaryotes

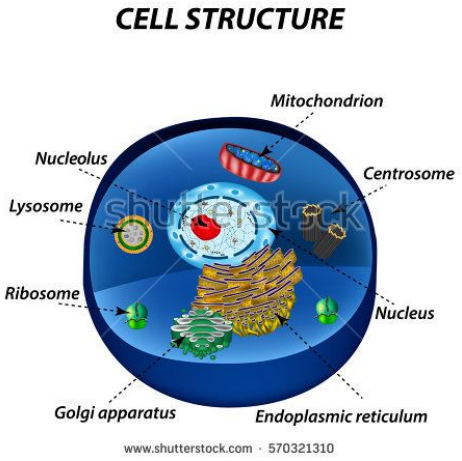
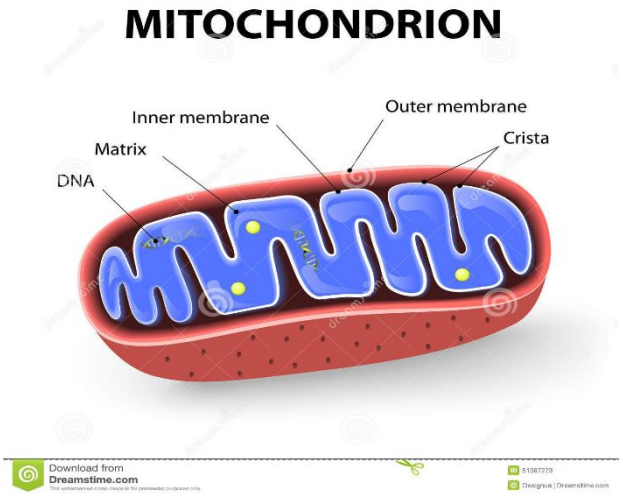


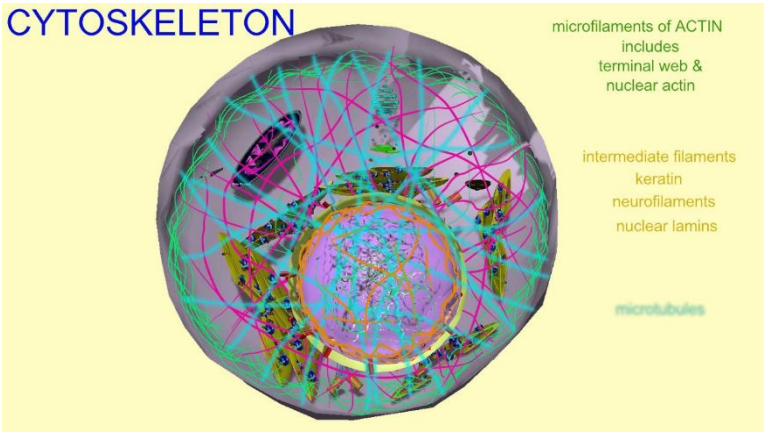
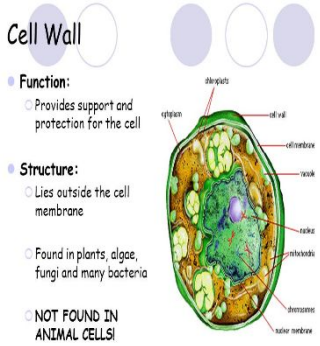


- **Organelles**

Name	Structure	Function
Cytoplasm		• consists of a liquid based background, in which there are *dissolved* chemical substances (e.g. ions such as chloride ions) • Approximately 90 per cent of the cytoplasm is water
Nucleus		The nucleus is a large spherical oval structure in the cytoplasm. The nucleus is transparent and colourless. There are two main functions for a nucleus including; storing the cell's DNA and being responsible for the cells growth, reproduction etc. The nucleus produces ribosomes.

Chloroplasts		Chloroplasts are only found in plant cells. Photosynthesis occurs in this section of the cell. The chloroplast uses the sunlight to convert the energy into sugars to power the plant cells. Inside of the chloroplasts there are little green chlorophylls (molecules).
Vacuoles		Is a sac-like structure that stores materials such as water, ions, wastes and proteins. The size of the vacuoles depends on the shape and size of the cell. They are found in both plant and animal cells, but are larger in plants. Has a membrane
Endoplasmic Reticulum		The endoplasmic reticulum also known as ER is an organelle found in the cells of eukaryotic organisms. ER occurs in nearly every type of eukaryotic cell except red blood cells and sperm cells. There are two types of endoplasmic reticulum rough endoplasmic reticulum (RER) (have ribosomes attached) and smooth endoplasmic reticulum (SER). It is a form of transportation for materials
Ribosomes		Ribosomes are a cell structure that assists with making protein. Ribosomes are found floating around in the cytoplasm and/or attached to the rough endoplasmic reticulum.

Golgi Bodies		The golgi body is an organelle found in most eukaryotic cells. There are numerous functions of the golgi such as **sorting and processing** proteins. They are also responsible for determining which proteins are allowed outside of the cell. They take in the ribosomes, a bit like a post office.
Lysosomes		The main function of lysosomes is to digest and remove waste from the cell. They contain digestive enzymes. They are the stomach of the cell. Lysosomes are surrounded by a layer of lipids acting as a membrane.
Mitochondria		The mitochondria is the powerhouse of the cell. They produce the energy for the cell known as ATP through cellular respiration. Responsible for creating more than 90% of the energy needed to sustain life. Animals have more than plants. Plants only use their mitochondria at night.

Cytoskeleton		Cytoskeleton are present in all cells. They are a complex network of interlinking filaments and tubules throughout the cytoplasm. They supports, shape and helps facilitate movement.
Cell Wall		The cell wall provides support and protection for the cell. They are only found in plant cells. Cell walls lie on the outside of the cell membrane

- **Technology**
  - Light Microscope
    - A light source passes through a condenser lens then through the specimen
    - The beam of light passes through the convex objective lens, the image is magnified and viewed through the ocular lens.
    - Magnification of up to 1500x and maximum resolution of 200nm

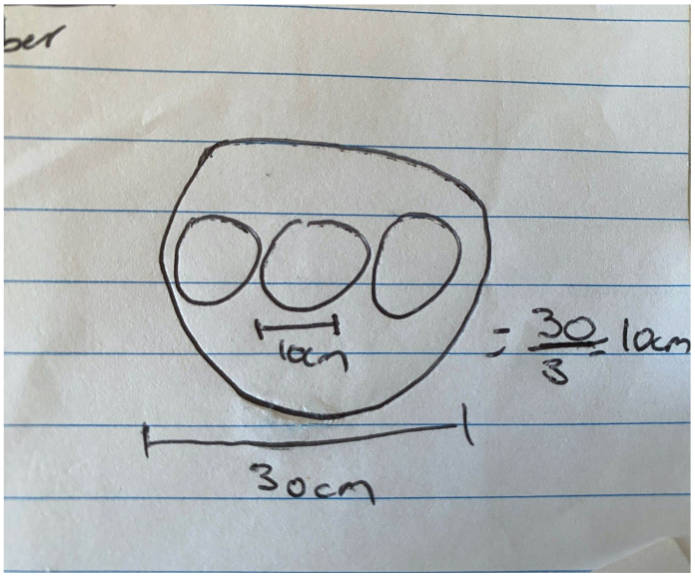
  - Fluorescence Microscope
    - Better resolution than light microscope
    - Sample is labeled with a fluorescent dye that attaches to particular structures
    - Sample is illuminated with a high intensity source of light that causes the fluorescent substance to emit light.

  - Electron Microscope
    - Uses an electronic beam instead of light and electromagnetism instead of glass lenses
    - Greater resolution due to shorter wavelengths
    - Many cells were seen for the first time with this invention

  - Computer Enhanced Technology

- Microscopic images can be digitally processed to allow cells to be viewed in different ways
- Cells scan software can provide #D images of cell structures.

- **Biological Drawings**
  - Cell Size (1mm = 1000micrometres)
    - Size of Object/cells = Field of view / Fit Number
    - Eg FOV is 30mm, 3 cells fill it up → Each cell is 10cm wide



  - Field Of View
    - Field Number / Eyepiece x Objective

- **Fluid Mosaic Model**
  - Controls the exchange of material between internal and external environments of the cell
  - Selectively permeable → Allows certain molecules and ions into and out of the cell
  - The structure of it allows the concentration to be constant inside and outside of the cell
  - The membrane is not stationary and continuously moving.

  - Phospholipid Bilayer (Phoshpate-Lipid)
    - Phosphate heads are hydrophilic (able to absorb water)
    - Lipid tails are hydrophobic (water avoidant and not able to dissolve in water)

  - Factors affecting the membrane
    - Cholesterol-
      - Gives stability to the cell membrane without affecting the fluidity.

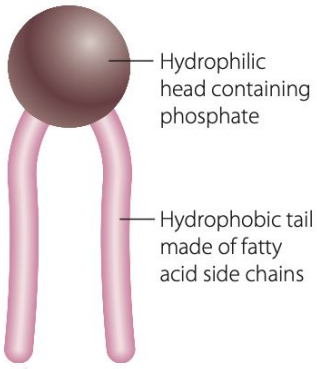
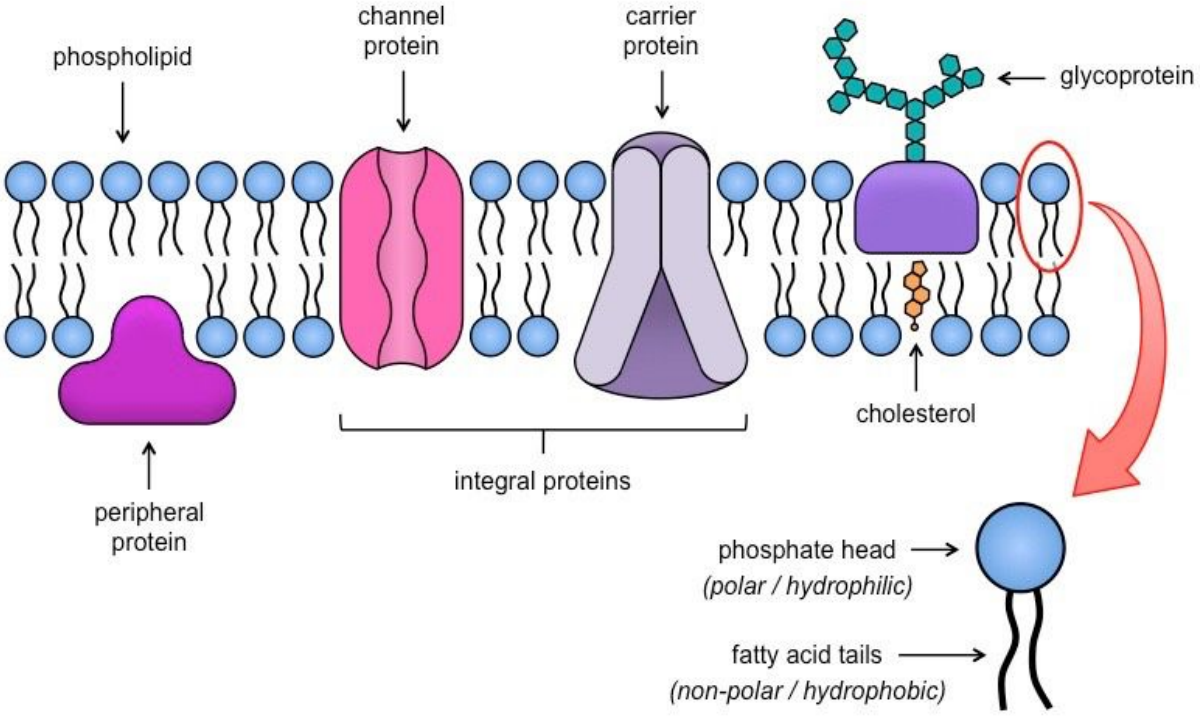


FIGURE 2.31 A phospholipid molecule. The hydrophilic head is attracted to water whereas the hydrophobic tails repel water.

- Reduces the permeability of the cell membrane to small, water soluble molecules.

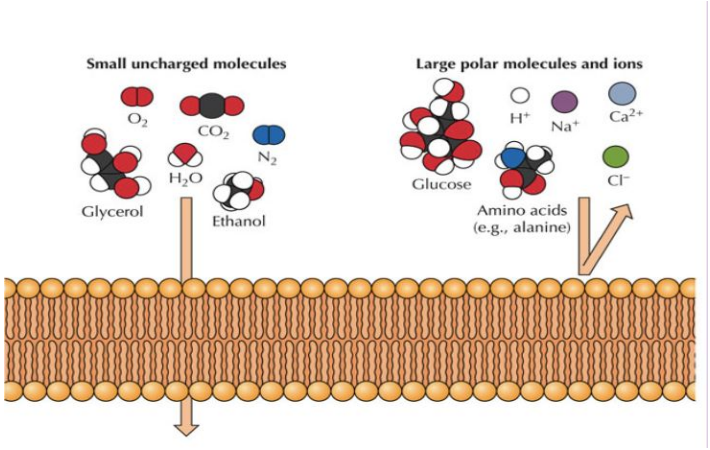
- Temperature
  - As temperature increases, fluidity increases.
  - Phospholipids chrome less tightly packed and move more freely
  - As temperature decreases, cell membranes with a high percentage of saturated fatty acid may solidify
- Proteins
  - Some penetrate the whole way through the membrane, forming channels that allow some materials to pass through the membrane.
  - Receptor proteins cause the cells to respond only to signals from substances.
  - Carrier proteins can assist in facilitated diffusion or active transport (May require energy to go against the concentration gradient)



Cell Function

Inquiry Question: How do cells coordinate activities within their internal and external environments?

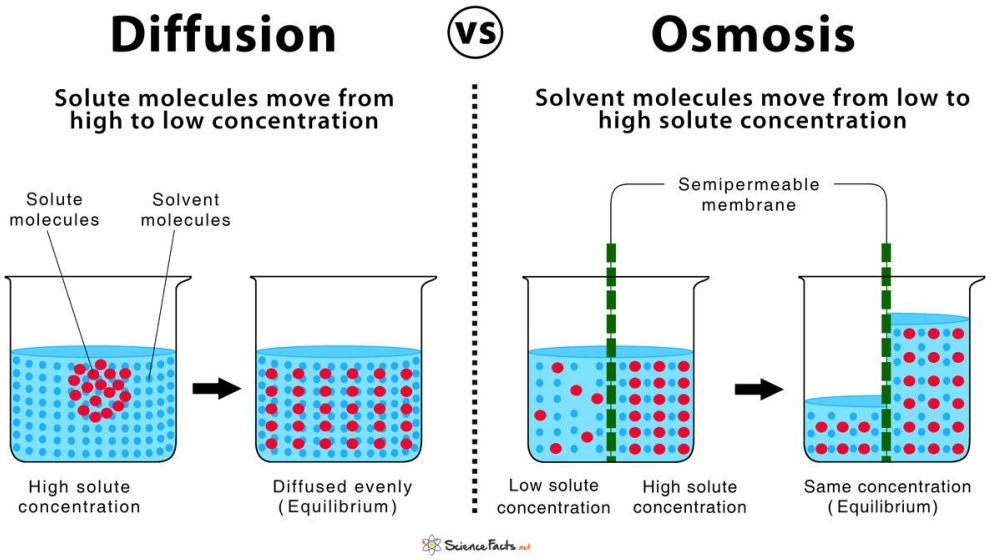
- **Movement across cell membrane**
  - Chemical properties of the material being moved
  - Physical properties like shape and size
  - Permeability of the cell membrane to the material
  - Concentration gradient → Higher the gradient, faster the movement
  - Surface Area to volume ratio



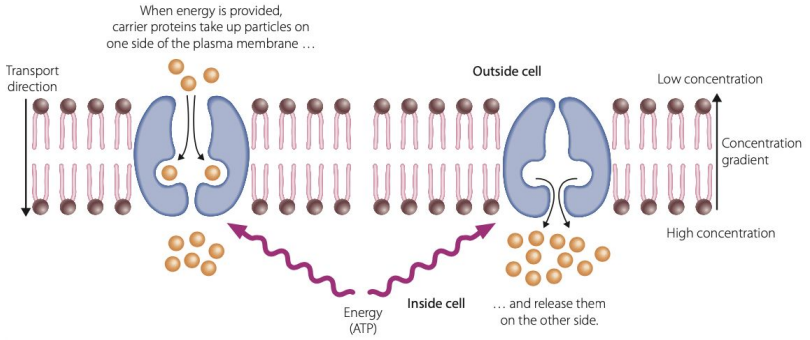
- **Diffusion**
  - Particles move from a high concentration to a low concentration
  - Movement is slow as particles collide
  - Passive movement → Does not require Energy
  - Factors Influencing diffusion → Particle size, Concentration, Temperature
  - Simple Diffusion
    - Solute membranes diffuse across a membrane if the membrane is permeable to them
    - Movement is constant
    - If the concentration is equal on both sides, there is no net movement
  - Facilitated Diffusion
    - Membrane transport proteins are specific for particular particles, so transport is selective.
    - Transport is more rapid than simple diffusion.
    - Transport proteins can become saturated as the concentration of the transported substance increases.
    - No energy is required, movement is with a concentration gradient.
    - Require a channel or carrier protein to assist in transport

- **Osmosis**
  - The net movement of water molecules across a semipermeable membrane.
  - If a dilute and concentrated solution are separated by a semipermeable membrane which allows the movement of free water molecules, the water molecules will move from the dilute solution to the concentrated solution.
  - The pressure causing water to move is called osmotic pressure.

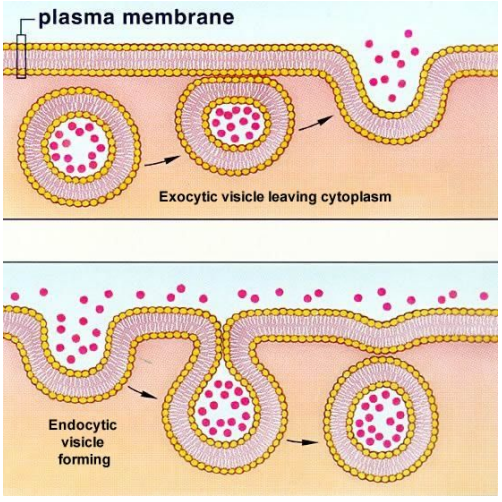
- Hypotonic - Concentration of solute is higher in the cell, water will be diffused into the cell.
- Hypertonic - Concentration of solute is higher outside the cell, water will be diffused out of the cell.



- **Active Transport**
  - Movement of molecules from a low concentration to a high concentration→ Against the concentration gradient
  - Requires energy input.
  - Active transport requires a carrier protein that spans the membrane to actively move chemicals from a low to a high concentration, utilising cellular energy



- **Endocytosis**
  - A particle is too large to pass through the membrane, the membrane can change shape to surround and engulf the particle.
  - Form vesicles in the membrane
  - Phagocytosis- Eating
  - Pinocytosis- Drinking
- **Exocytosis**
  - A process in which substances are transported to the external environment of the cell.
  - Used for secreting proteins, removing waste and breakdown products from the lysosomes.



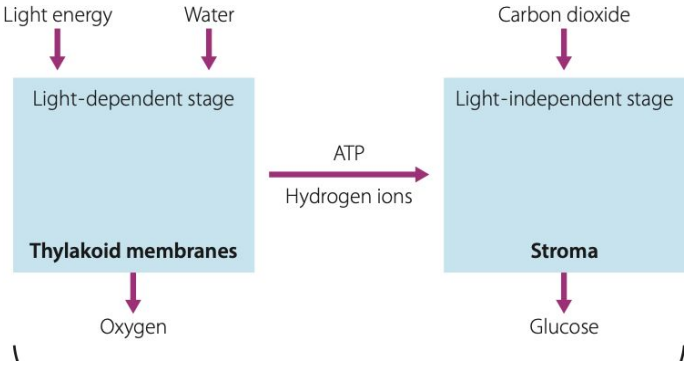
- **Surface Area to Volume**
    - Smaller cells = More efficient
    - The larger the cell becomes, the smaller the SA:V ratio, therefore becomes less efficient to absorb nutrients
    - Smaller cells allow a faster movement of substances between the center and surface of the cell → Less energy required
    - Cells may have elongated extensions to increase SA:V ratio to be more efficient.
    - As the cell size continues to grow it reaches a point where diffusion is not fast enough to sustain the cell, so the cell divides if it's possible.
    - Increasing SA:V ratio
        - Cell Compartmentalisation
            - Organelles live and work in separate areas.
            - Allows for more efficient movement because of more space
            - Reduces the amount of exchange between the membrane
        - Flattened Shape
            - Volume constant but increases surface area
            - Red blood cells
        - Membrane extensions
            - Works well for absorbing cells and secreting cells
            - Microvilli

Concept/Term	Meaning
Simple Diffusion	Does not require energy. Allows smaller molecules to easily move through the membrane
Facilitated Diffusion	Requires energy and is assisted by carrier proteins and channel proteins. Allows large molecules to pass through
Solute	what will be dissolved
Solvent	the liquid in which a solute is dissolved in. They will form a solution
Solution	is a mixture of two or more substances mixed together
Concentrated Solution	Is a solution that contains a large amount of solute compared to the amount that could dissolve
Dilute Solution	Dilution is decreasing the concentration of a solute in the solution. Occurs when mixing with more solvent.
Concentration Gradient	an area where particles move from high concentration to low concentration
Semi Permeable	allows certain substances to enter into the cell through the 'semipermeable membrane'
Impermeable	Does not allow substances through the membrane
Selectively Permeable	the membrane only lets some materials through, by passive or active transport
Channel Proteins	used in passive transport
Carrier Proteins	used in active transport
Osmosis	Is the process in which water moves in and out of the cell, it does not need energy. Goes from high concentration to low concentration. Diffusion of water
Osmotic gradient	the difference in concentration between two solutions on either side of a semipermeable membrane.

Osmotic pressure	the pressure that is applied to a solvent to stop it from passing into a given solution by osmosis.
Isotonic solution	Two solutions that have the same osmotic pressure across the membrane
Hypertonic solution	When the concentration is greater outside the cell than inside
Hypotonic Solution	When the concentration isgreater inside the cell than outside
Active Transport	Moves from low concentration to high concentration against the gradient ; requires energy
Passive Transport	The movement of substances in and out of the cells without exerting energy
Endocytosis	Large particles that have to be moved into the cell, the membrane changes shape to let the particle in. type of active transport. turns into vesicle once inside the cell.
Exocytosis	moves materials out of the cell eg: waste. removes vesicle membrane
Vesicles	small structure in a cell which consists of fluid enclosed by a lipid bilayer. (membrane bubble)
Phagocytosis	'cell eating' when solid particles are engulfed
Pinocytosis	'cell drinking' when fluid is engulfed
Receptor-mediated	detectives specific molecules

- **Cell Requirements**
- Organic Compounds
    - Contain Carbon and Hydrogen → Protein, Vitamins, Carbohydrate
- Inorganic Compounds
    - Water (H2O)
        - Important solvent and transport medium.
    - Oxygen (O2)
        - Needed for efficient energy supply from cellular respiration.
        - Taken in as gas or in solution.
    - Carbon Dioxide (CO2)
        - Ultimate source of carbon atoms for organic molecules.
    - Nitrogen (N2)
        - Key atom in the acids that make up proteins.
    - Minerals
        - Important for building enzymes and vitamins.

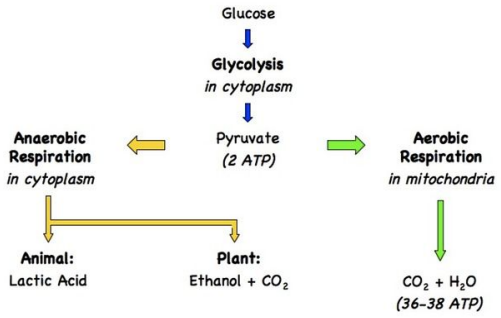
- **Biochemical Processes**
- Photosynthesis
    - Stage 1 → Light Stage
        - Photon from the sun enter the chlorophyll
        - The light is used to break down water into oxygen and hydrogen.
        - Oxygen is released into the atmosphere
        - Hydrogen is absorbed.
    - Stage 2 → Light independent Stage
        - Occurs in the stroma
        - ATP energy is used to combine hydrogen and CO2
        - Glucose is produced → Hydrogen + CO2
            - $C_6H_{12}O_6$



- Factors Affecting Photosynthesis
  - Light intensity
    - More light, faster the rate → Until it reaches optimal rate
  - CO2
    - Carbon Dioxide is required to make glucose
    - The more abundant the quicker the rate
  - Temperature
    - Temperature affects the rate that the enzymes catalyse at

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{light energy}} \text{glucose} + \text{oxygen}$$

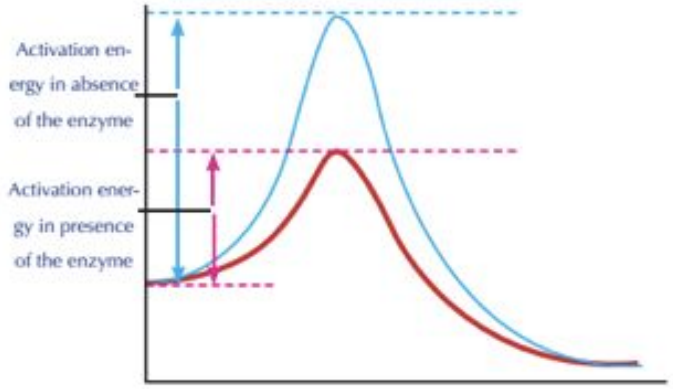
- Cellular Respiration
  - Anaerobic
    - Not a good supply of oxygen
    - Breakdown of Glucose to form ethanol and carbon dioxide
    - This supplies the cell with ATP → adenosine triphosphate
    - Less efficient and lactic acid is created
  - Aerobic
    - In the presence of oxygen
    - Glucose and oxygen are broken down to create energy
    - ATP is released in the process



- **Removal Of Waste**
  - Waste are the products that are not used for cellular activity

    - Many of these wastes can be removed by simple diffusion through the cell membrane → CO2 in muscle activity is diffused into the capillaries
    - Other wastes are removed by exocytosis or by the enzymes present in lysosomes

- **Enzymes**
    - Protein molecules that control all metabolic reactions within a cell
    - Biological catalysts that speed up the rate of reactions → Get rid of the activation energy required for a reaction.
    - Specific for unique reactions → Enzymes in stomach differ from enzymes in mouth
    - Factors that Impact enzyme activity
        - Temperature
        - Concentration
        - pH



Module 2- Organisation Of Living things

Organisation Of Cells

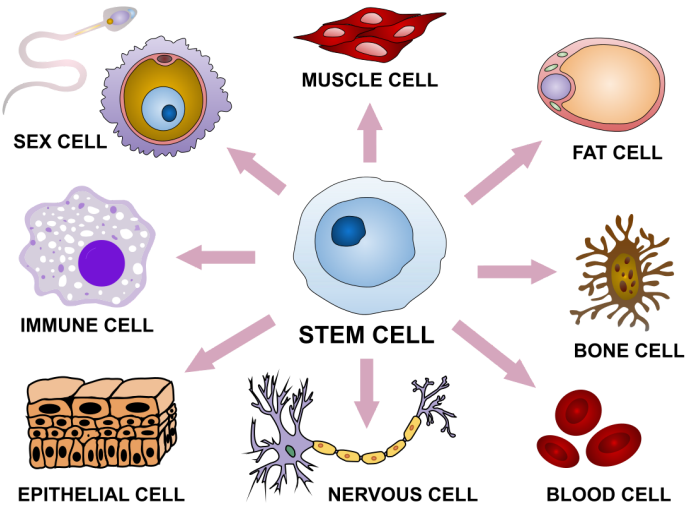
Inquiry Question- How are cells arranged in a multicellular organism?

- **Unicellular Organisms (Bacteria)**
    - Contain one cell, either prokaryotic or eukaryotic
    - First forms of life
    - A single cell carries out all life processes → obtaining nutrients, exchanging gas, removing waste and reproduction
    - High SA:V ratio which allows for more efficient movement of substances
    - Requires a moist environments for diffusion and osmosis to occur

- **Colonial Organisms (Volvox)**
    - A group of cells working or organism working collectively is called a colony
    - May be unicellular or multicellular
    - Can exist independently, however in a multicellular organism colonial organisms cannot exist alone.

- **Multicellular Organisms**
  - A community of cells working together to enable the organism to carry out life processes, including reproduction.
  - Composed of many different specialised cells, Similar cells are grouped together and perform specific functions that combine for the efficient functioning for the organism
  - Consists of eukaryotic cells.
  - Large organisms made up of smaller cells increases SA:V ratio.
  - Each specialised cell type is structurally suited to a particular function.
  - Embryonic cells develop suitable structural changes to best suit their function → Red blood cell

- **FORMATION OF SPECIALISED CELLS**
  - When cells become specialised they differentiate – they develop structures enabling them to carry out their function, making them different to other cells.
  - Specialised cells originate from stem cells, which are undifferentiated cells with the ability to divide repeatedly.
  - Cell specialisation refers to the function of the cell, while differentiation is the process of a stem cell goes through to become specialised.
  - Enables organisms to grow larger while still efficiently carrying out processes.
  - Specialised cells cannot survive independently – they rely on other cells in the organisms to carry out functions they cannot.
  - Communication between cells is vital.
    - In animals this is via the bloodstream and nervous system whereas in the plants it is brought about by chemical and physical contact between cells.

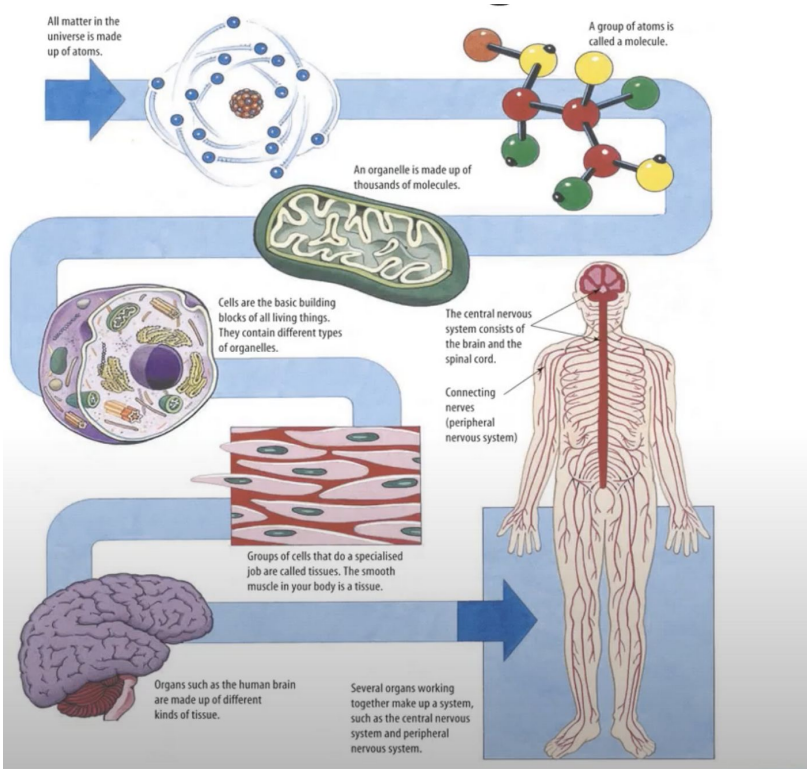


- **Cell Hierarchy**
  - Organelle Cell Tissue Organ Organ System Organism
    - Mitochondria Cardiac Muscle Cell Cardiac Muscle Tissue Heart Cardiovascular System Human

- **Animal Tissues**
    - Epithelial Tissue
        - Covers body surfaces, protects organs and forms glands.
        - Densely packed cells in single sheets or layers.
        - Doesn't contain blood vessels.
        - 2 distinct surfaces – exposed to the exterior body cavity or exposed to adjacent tissue.
        - Some are specialised for absorption or secretion.
    - Connective Tissue
        - Provides support, ensures that all body parts are bound together and protects against damage
        - Fibrous connective tissue, loose connective tissue, adipose tissue, cartilage and bone → Differences are from the arrangement of cells and specialised structure.
        - Collagen (strength) + Elastin (Flexibility)
    - Nervous Tissue
        - Comprises brain, spinal cord and peripheral nerves.
        - Highly specialised for communication between all parts of the body
        - Highly specialised of passing messages between themselves and other cells
    - Muscle Tissue
        - Muscle cells are highly specialized for contraction
        - Skeletal, Smooth, Cardiac
        - Responsible for the movement of the body and particular contractions in various processes (oesophagus peristalsis)

- **Plant Tissues**
    - Meristematic Tissue
        - Tips of roots and shoots
        - Cells divide to produce new growth
        - Site of cell differentiation
        -
    - Dermal Tissue
        - Protects plant tissue and is found in outer layers of stems, roots and leaves.
        - Epidermal layer is the outmost, secreting a waxy layer called cuticle, vital to reduce water loss
        - Lack Chloroplasts
    - Vascular Tissue
        - Responsible for the transport of substances around the plant
        - Xylem transports water and minerals from the roots to the leaves
        - Phloem transports products of photosynthesis around the plant
    - Ground Tissue
        - Internal cells of a plant other than the vascular

- Specialised for storage, support and photosynthesis



Nutrient and Gas Requirements

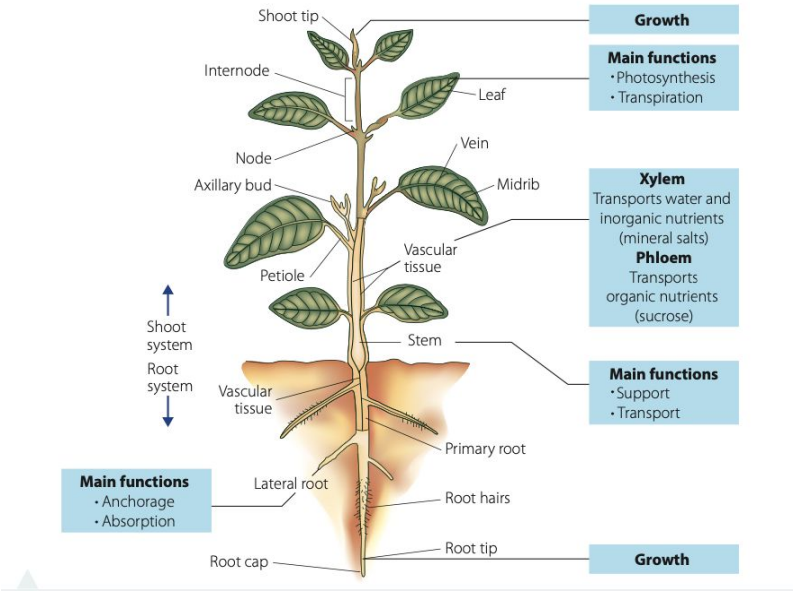
Inquiry Question: What is the difference in nutrient and gas requirements between autotrophs and heterotrophs?

- **Autotrophs**
  - Produce their own organic compounds and energy from inorganic compounds from their environment, such as carbon dioxide and water.
  - Can be divided into two groups:
    - Photoautotrophs – use light energy (e.g. green plants).
    - Chemoautotrophs – use chemical energy (e.g. nitrifying bacteria in the soil)

- **Heterotrophs**
  - Obtain organic compounds from obtaining other organism
  - Include all animals and fungi

- **Vascular and Nonvascular Plants**
  - Majority of autotrophic organisms are plants.
  - Vascular plants possess a transport system to move substances from one part of the plant to another.
  - Plants have specialised cells grouped into tissues
  - These tissues work collaboratively to carry out life processes like photosynthesis and gas exchange.
  - A small number of plants are called non-vascular because they do not possess this transport system (e.g. mosses and liverworts).
    - Have a very simple structure.

- All nutrients are absorbed, and wastes are removed by diffusion and osmosis through the surfaces of the plant.



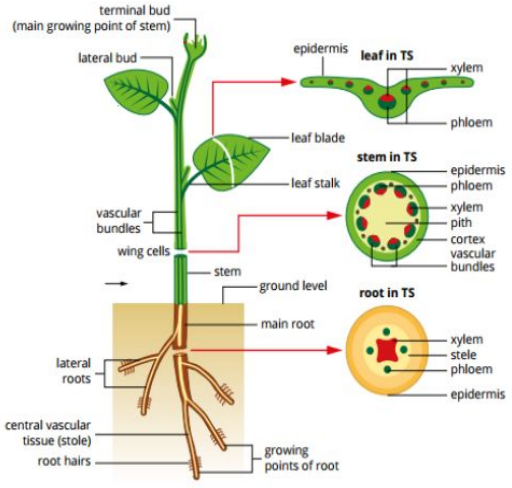
- **Root System**
  - Usually underground.
  - The main function of anchoring the plant and absorbing water and inorganic nutrients from the soil.
  - Very large surface area.
  - Absorption occurs through specialised epidermal cells in the outermost layer of the root.
  - Increased surface area achieved in the following ways:
    - Extensive branching (also provides good anchorage)
    - Root hair zone located in the younger part of each root – epidermal cells protrude outwards into the surrounding soil, as microscopic extensions called root hairs.
    - Flattened epidermal cells increase the exposed surface.
  - Water moves via osmosis.
  - Mineral ions usually move via diffusion – if diffusion is too slow, facilitated diffusion and active transport may be involved.
  - Root cells have no chloroplasts and thus cannot photosynthesise, but they can carry out respiration

- **Shoot System (Stem)**
  - Provides structural support and a transport pathway
  - Located above ground
  - Consists of 3 main functions
    - Dermal→ Waterproofing, protection, gas exchange
    - Vascular → Composed of the xylem and the phloem within vascular bundles
    - Ground Tissue → Fills in around vascular tissue

- **Shoot System (Leaves)**

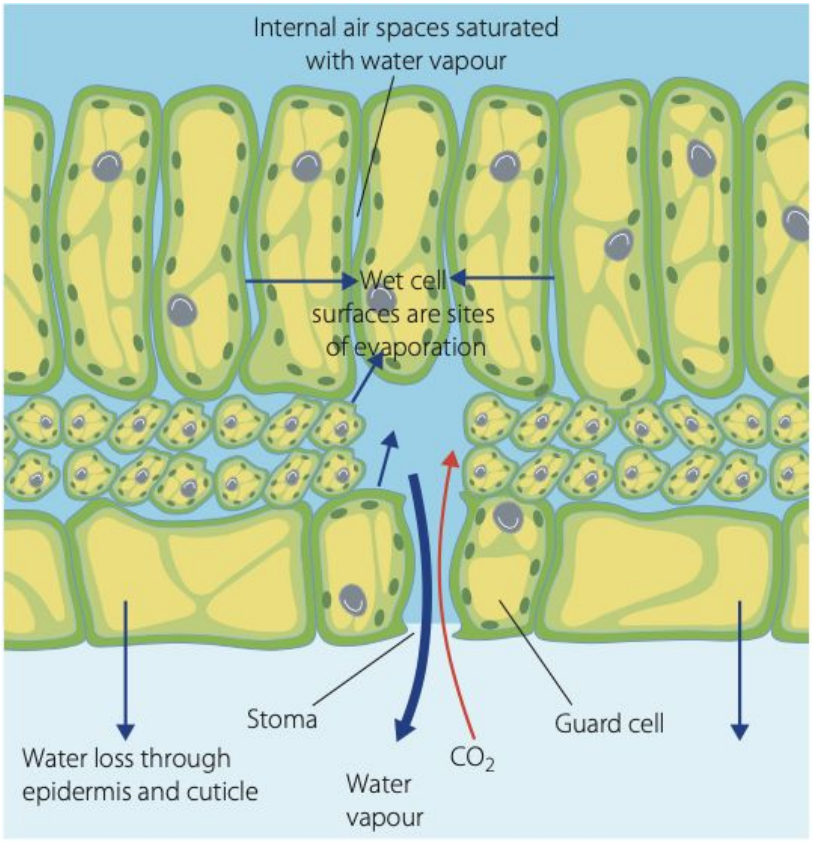
- Located above ground
- Main function is to absorb sunlight and carbon dioxide and produce glucose through the process of *photosynthesis.*
    - Leaves are adapted to absorb the maximum amount of sunlight possible to provide the energy needed to break bonds in water during the first stage of photosynthesis.
    - Thin, flat structure of leaves is well suited to this function – no internal cell is too far from the light.
    - Large SA allows maximum absorption.
    - Transparent epidermis allows sunlight to penetrate the photosynthetic cells beneath.
    - *Mesophyll* is responsible for most of the plant's photosynthesis.
        - **Palisade Cells:** Dense with chloroplasts and are main photosynthetic cells, situated vertically, large numbers ensure maximum rate of photosynthesis.
        - **Spongy Mesophyll Cells:** Irregular in shape and distribution, situated between palisade cells and lower epidermis, fewer chloroplasts.
- Leaves are also the site of *transpiration,* which is a process by which water evaporates from the leaf and aids the movement of water from the roots to the leaves and cools the plant.
- The structure of a leaf allows it to carry out these functions in an efficient and effective manner.
- Sizes and shapes of leaves vary immensely.
- Plants in hot, dry habitats have:
    - Waxy Cuticles – reduce the amount of water lost through evaporation.
    - Small Leaves – minimal surface area to reduce water loss.
- Rainforest Plants have:
    - Large, Thin, Flat Leaves – absorb as much sunlight as possible.
    - Less concern about water loss due to high humidity.
- Gaseous Exchange:
    - Epidermis covers the surface of leaves.
    - Epidermal cells protect the inner tissues and are able to secrete a waterproof cuticle to prevent evaporation of water.
    - Epidermal cells are transparent to allow light to pass to the cell layers beneath.
    - Guard Cells – control exchange of gases and the loss of water through leaves, occur in pairs surrounding the *stoma*.

- **Transport**



- Main transport tissues are the xylem and phloem in the centre of the root
- The main vein in the leaf, the midrib, and many smaller veins branch out from it
- Distribution of vascular tissue around the plant ensures that all cells are getting the energy required to function.

- **Cellular Respiration in Plants**
  - Plants carry out cellular respiration as well as photosynthesis
  - Occur during night and day
  - Oxygen and CO2 enter and exit the plant via the guard cells



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- **Nutrient Requirements in Plants**
  - Carbon Dioxide
    - The opening and closing of the stomata has the greatest effect on carbon dioxide concentration in the leaf.
    - If the stomata is closed, available carbon dioxide is used up and the rate of photosynthesis is reduced.
  - Water
    - Amount of water needed for photosynthesis is small compared to that needed for survival.
    - When water availability level is low, stomata close and reduce the amount of carbon dioxide entering the leaf, reducing the rate of photosynthesis.
  - Light Energy

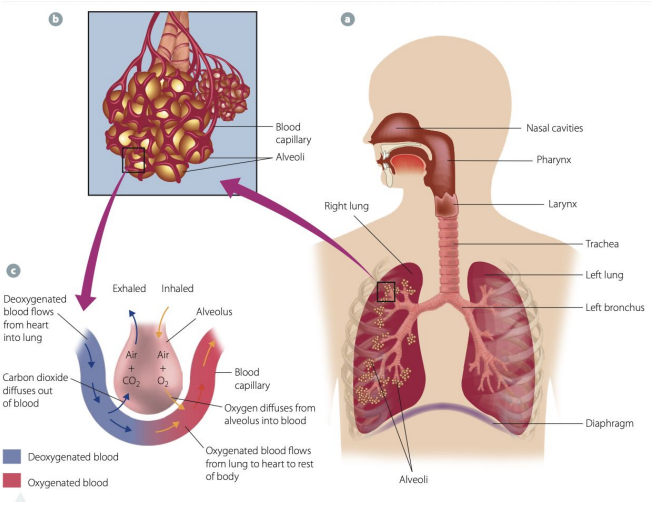
        - The greater the light intensity the faster the rate of photosynthesis until a plateau is reached.
        - The plateau is where all photosynthesis systems and enzymes are working at optimum rate.

- **Imaging Technologies + Tracing Products Of Photosynthesis**
    - MRI→ uses radio waves and magnetic field to take a series of images of the plant structures that are used to produce a 3D image of the structure
    - X-Ray→ Reveals deeper knowledge of the internal structure of the plant
    - Radioisotopes are used to determine whether the oxygen released during photosynthesis originated from the oxygen atom in water or carbon dioxide
    - Carbon-14 is added to the carbon dioxide supply of a plant → The carbon-14 then takes part in the reactions of photosynthesis and is incorporated into the glucose molecules
    - The radioisotopes can be traced by the radiation they emit

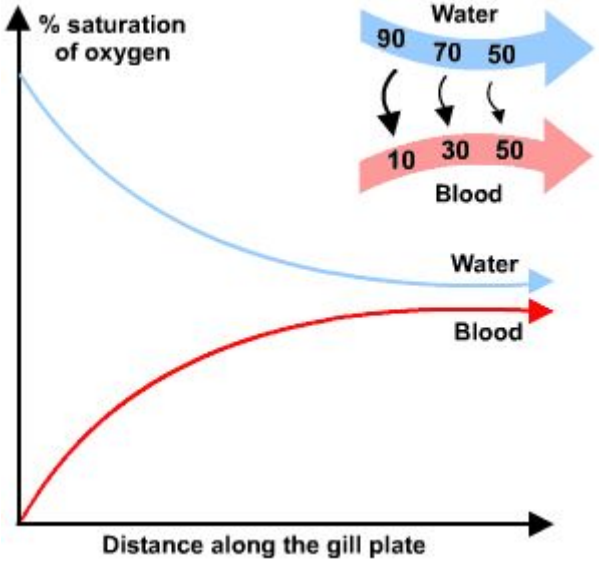
- **Gas Exchange in Plants**
    - Leaves are adapted for gas exchange.
    - Large and flat – large SAV ratio.
    - Spongy mesophyll layer increases surface area and allow gases to move freely within the leaf.
    - Surface of cell is moist
    - Occurs through stomata and the lenticels.
    - Stomata:
        - Found on the underside of the leaf.
        - Occasionally found on the upper epidermis.
        - Both sides of the stomata are the guard cells.
        - These bean-shaped cells contain chloroplasts (unlike other epidermal cells)
        - The inner wall of each guard cell is thicker than the outer wall.
        - Stomata open and close when the guard cells gain or lose water.
    - Lenticels:
        - Pores through which gaseous exchange happens in woody plants
        - Found on trunks and branches of trees and woody shrubs
        - Appear as small dots, but under the microscope they are seen as clusters of loose cells in the cork layer
        - Diffusion through lenticels is relatively slow

- **Gas Exchange in Animals**
    - Oxygen is essential for cellular respiration
    - Carbon Dioxide must be removed as it is highly toxic in large concentrations
    - Mammals have lungs, fish have gills and insects have tracheal system
    - Large surface area enhanced by folding, branching or flattening.
    - Moist, thin surfaces so that gasses can dissolve and diffuse.
    - Close proximity to the transport system so gases can move easily.
    - Maintenance of a concentration gradient.

- Lungs
  - Gas exchange structures → alveoli
    - Increased surface area – folded
    - Thin lining – flattened single layer of cells
    - Moist surfaces – saturated with water vapour and mucus
    - Shares a membrane with the capillaries, hence this facilitates diffusion of gasses

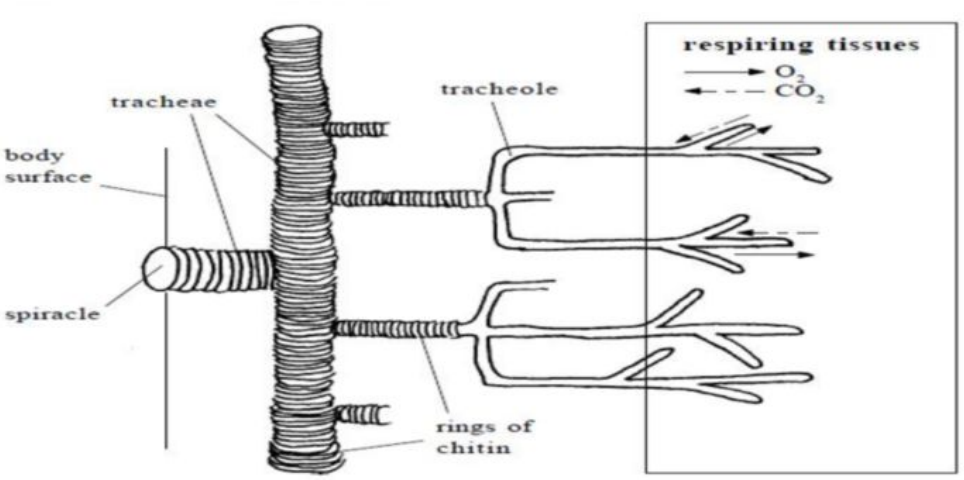


- Gills
  - Gills extract the most oxygen possible out of water
  - As the water passes through the gills oxygen diffuses into the fish
  - This is undertaken by a countercurrent process, this ensures the most oxygen is being diffused from the water (furthest away from equilibrium).

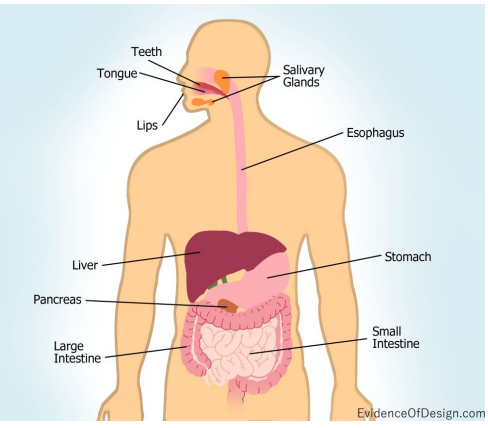


- Tracheal System
  - Insects obtain and release air through spiracles
  - Do not have lungs or capillaries
  - Branching air tubes are called tracheal tubes

- Oxygen dissolves in fluid, this can be diffused into the cells and carbon dioxide diffuses out.



- **Human Digestive System**
  - Mouth
    - Teeth break down food for more efficient action of enzymes
    - Salivary amylase is release and mixed by the tongue
    - Tongue forms a bolus
  - Oesophagus
    - Peristalsis is the muscular contraction that forces food down
    - Food is moved toward the stomach
  - Stomach
    - Gastric juices contain water, HCL and pepsin
    - Contractions of muscles is a form of mechanical digestion
    - pH → 2.0-3.0
    - Breaks down larger and complex proteins to a obtainable level
  - Small Intestine
    - Emulsifies fats into smaller droplets
    - Move by diffusion and osmosis
    - Villi increases the surface area for absorption
    - Lacteals are collected by the lymphatic system
    - Glucose and amino acids are absorbed into the capillaries
  - Liver
    - Duodenum
      - Neutralise the acidic chyme leaving the stomach and break down food
    - Jejunum
      - Breaks down food into smaller pieces
      - Breaks down lipids into fatty acids
    - Ileum
      - Absorption of products are moved by diffusion or active transport through villi



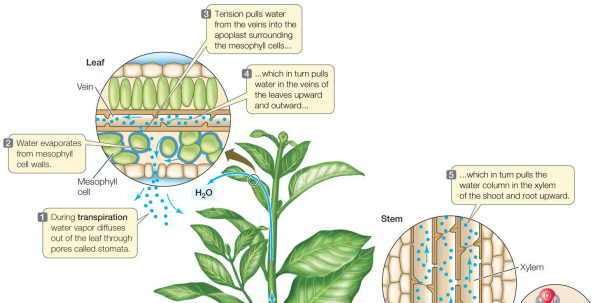
- Large intestine
  - Undigested material moves to the large intestine
  - Site of water and salt absorption
  - Remaining faeces is moved to the rectum and anus via peristalsis

Transport

Inquiry Question: How does the composition of the transport medium change as it moves around an organism?

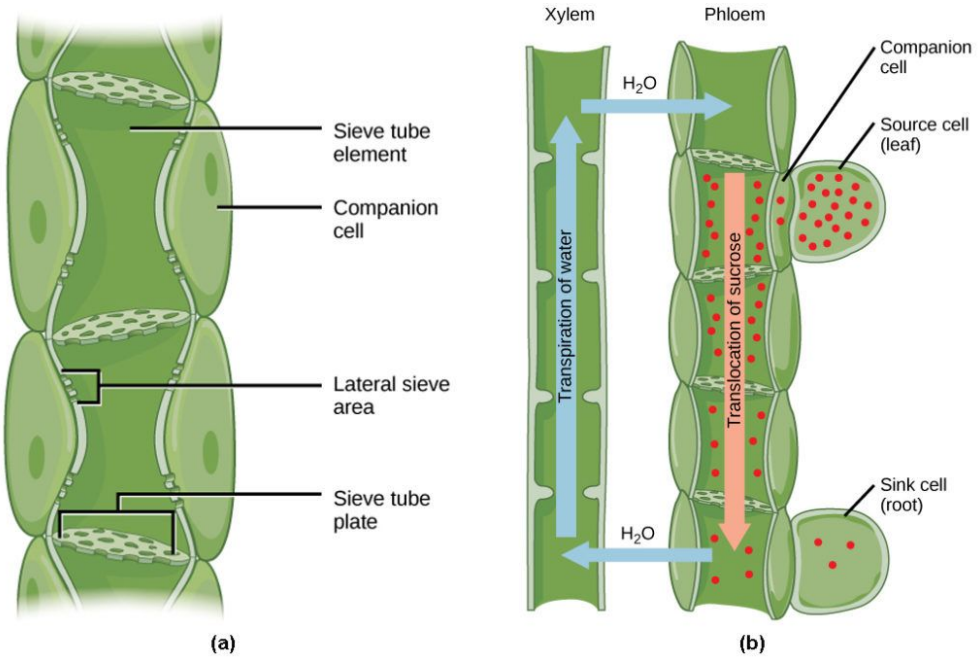
- **Transport System in Plants**
  - Involves vascular tissue arranged in vascular bundles made up of the phloem and xylem
  - Xylem
    - Moves upwards from the root
    - Movement upwards from the root.
    - Consists of xylem tracheids and xylem vessels.
    - *Tracheids:* long structures with tapered end walls in contact with each other.
    - Xylem vessels are continuous tubes for the transport of water.
    - Walls of vessels and tracheids are lined with lignin – helps prevent the collapse of the vessel and easy movement of water.
    - Fibres provide support.
  - Phloem
    - Carries products of photosynthesis
    - Sieve tube cells and companion cells.
    - Sieve tube cells are long thin phloem cells with large pores through their end cell walls.
    - These perforated cell walls are called sieve plates
    - Sieve tube cells possess mitochondria and endoplasmic reticulum, but no nuclei or other organelles
    - They are arranged end to end forming sieve tubes
    - Sieve tube cells share cytoplasm, their sieve tubes form channels through which sugars and other plant products can flow
    - Companion cells are found alongside sieve tubes.
    - They have a nucleus and other organelles that are lacking in sieve tubes.
    - Companion cell function is uncertain, but they are thought to assist effectiveness of sieve tube elements by providing ATP.
    - They also help with loading and unloading of sugars into a sieve tube.

- **Transpiration-Cohesion-Tension Theory**
  - Transportation → Process of water vapour leaving the leaves via the stoma
  - Cohesion → Water is attracted to itself as it is a polar molecule: Hydrogen + Oxygen molecules.



- Adhesion → Water sticks to the walls of the xylem (Narrow xylem is more beneficial)
- Positive root pressure in the roots via osmosis
- Tensions is created by the pull from the leaves

- **Source-Sink Theory**
  - Glucose produced in the leaf during photosynthesis is either stored as starch or converted to sucrose and distributed to all parts of the plant
  - Distribution is called translocation and occurs in the phloem
  - Substances in the phloem move in whichever direction is required.
  - The phloem also carries amino acids and some mineral nutrients
  - Sucrose makes up approx. 90% of phloem sap.
  - Once it reaches cells is it converted to glucose for respiration or stored as starch
  - The movement is driven by the formation of high- and low-pressure regions within the phloem
  - Movement occurs from high to low pressure
  - High-pressure occurs where the sucrose is produced (the source) and low-pressure occurs where the sucrose is required (the sink)
  - <u>The xylem and phloem are adjacent, hence during this process the water from the xylem is diffused into the phloem to dilute the sugar.</u>
  - Actively transported into stem and root cells for growth.



- **Transport System in Animals**
  - Open circulation
    - Found in invertebrates such as insects

        - Contains one or more hearts that contract to push blood fluid
        - Hemolymph bathes organs and tissues
        - Blood and interstitial fluid cannot be distinguished
        - Blood is in direct contact with tissue
        - Less efficient, low pressure, Slow
        - Volume of blood cannot be controlled
    - Closed Circulation
        - Found in all vertebrates like fish, mammals frogs and reptiles
        - Contains blood that is enclosed by blood vessels with a driving force of the heart
        - Pathway is from the heart, around the body and back to the heart
        - Transport nutrients and oxygen to the cells as well as returning waste and Carbon Dioxide
        - BLood is not in direct contact with tissue
        - Heart has 4 chambers to divide oxygenated and deoxygenated blood
        - Pumped blood can be controlled by contractions and valves
    - Lymphatic System
        - Transports excess fluid back into the cardiovascular system and is made up of lymph vessels and lymph.
        - Maintains homeostasis
        - Lymph → Watery fluid
    - The Heart
        - Vene Cana → Right Atrium → Right Ventricle → Pulmonary Artery → Lungs → Pulmonary vein → Left Atrium → Left Ventricle → Aorta
        - Composed of cardiac muscle cells
        - Responsible for pumping blood around the body
        - Pulmonary circulation is blood travelling from heart to lungs
        - Systemic Circulation is the process of pumping the blood around the body and back to the heart

- **Structure of Blood Vessels**
    - Each vessel is best structured to suit the function of the vessel
    - Artery
        - Thicker walls and narrow cross section as blood enters under high pressure, and thicker walls minimise the chance of the artery tearing.
        - Walls also are more elastic, so it can expand and contract.
        - Carries blood from the heart.
        - Contraction squeezes blood forward and propels it along.
    - Vein
        - Thinner walls and wider lumen as the blood is not as high pressure.
        - The walls are not as elastic as the veins do not need to contract and expand as much as the arteries.
        - Returns blood to the heart.
        - Cross section is wider to allow easy flow of blood.
        - Blood is propelled by the contracting of muscles surrounding the veins.
        - Valves situated at regular intervals to stop the reverse flow of blood.
    - Capillaries

        - Walls are one cell layer thick so that substances can be diffused efficiently.
        - Brings blood into close contact with the tissues, enabling exchange of chemical substances between cells and the bloodstream.
        - Red blood cells pass through in a single file, increasing their exposed surface area for the exchange of gases, nutrients and waste.

- **Blood As a Transport Medium**
    - Red Blood cells (Erythrocytes)
        - Transport oxygen.
        - Form in bone marrow.
        - Haemoglobin (oxygen carrier) is developed within the cell.
        - Round, biconcave and slightly flattened towards the centre – more SA:V and elastic in order to squeeze through capillaries.
        - No nucleus so it has more hemoglobin for oxygen → Structure for function
    - White Blood Cells (Leukocytes)
        - Also produced in bone marrow.
        - Part of the immune system.
        - Role is to defend the body against foreign bodies.
        - Found in tissues as well as the blood.
        - Can pass through capillaries by squeezing between the cells that make up the wall of the capillary.
        - Larger than red blood cells.
        - Not as abundant as red blood cells.
        - All white blood cells have a nucleus.
    - Platelets (Themocytes)
        - Function in the clotting of blood.
        - Contact between fibres and platelets causes platelets to break open and release an enzyme, thromboplastin, which sets in progress a sequence of steps to seal the blood vessels and cause blood to clot.
        - Crescent shaped.
        - Half the size of red blood cells.
    - Plasma
        - Yellow, watery fluid.
        - 90% water, 10% protein
        - Makes up the majority of the volume of blood and carries many substances throughout the body:
            - Proteins
            - Nutrients
            - Gases
            - Excretory Waste Products
            - Ions
            - Hormones
            - Vitamins

- **Changes in Compositions Of Blood**
    - Lungs

        - As blood moves through the lungs it gains oxygen and loses carbon dioxide.
    - Digestive System
        - Increase in digestive end products.
    - Lymphatic System
        - Gain fatty acids that have been emptied into the bloodstream.
    - Heart
        - High lipid content.
    - Stomach
        - Water and other substances are diffused into the blood.
    - Liver
        - Decrease in digestive end products.
        - Glucose may be added or removed.
        - Urea is added to the blood.
        - Toxins such as alcohol are removed.
        - Some vitamins and iron are removed.
    - Kidneys
        - Urea is decreased.
        - Excess water and salts are removed.
    - Large Intestines
        - Water, salts and vitamins are absorbed into the blood.
    - Endocrine Glands
        - Hormones are added.

Module 3- Biological Diversity

Effects of the Environment On Organisms

Inquiry Question: How do environmental pressures promote a change in species diversity and abundance?

- **Ecosystems**
    - Combination of all the organisms, biotic and abiotic, living in a community and how they interact
    - Organisms with favorable characteristics/adaptations that are uniquely suited for that ecosystem will ultimately survive better
    - Diversity and abundance is due to variation in biotic and abiotic factors
    - Environment refers to the surroundings or dwelling place of all living things → habitat or setting
    - Abiotic factors directly influence selection pressures on organisms
    - Terrestrial
        - Found on land
        - Dessert, grasslands, forest, Woodland
    - Aquatic
        - Wetlands, Mangrove swamps, estuaries, rivers, lakes
        - Salt concentration, light availability

- **Selection Pressures in an Ecosystem**
  - Selection pressures are all the factors of an ecosystem that influences changes of survival
  - **Natural selection** is a process whereby species which have traits that enable them to adapt in an environment survive and reproduce, and then pass on their genes to the next generation.
  - Drives natural selection
  - Those individuals within the population that have random variations that make them better suited to survive in the changed environment are more likely to survive
  - Genetic based variation are passed from presurvung parents to offspring
  - Biodiversity is essential for a surviving population → If all organisms were the same, no organisms could adapt to new conditions.
  - Abiotic pressures:
    - Temperature
    - Light intensity
    - Pressure
    - Salt concentration
    - Water availability
  - Biotic Factors
    - Competition
    - Prey Availability
    - Predation

- **Abundance and Distribution**
  - Abundance → How many individuals of that species live throughout an ecosystem
  - Distribution → Where it is found
  - Both abiotic and biotic factors affect these

- **Ecology**
  - The study of interrelationships between different types of organisms and between organisms and their environment.
  - Determines the distribution and abundance of flora and fauna
  - Determines measures of populations in areas
  - Studies the patterns that are formed → Increase or decrease in population
  - What factors influence the distribution and abundance of populations in ecosystems?

- **Measuring Plant Abundance**
  - Non mobile organism are easier to collect data about
  - $$\text{Estimated abundance of a species in an area} = \frac{\text{total number of individuals counted}}{\text{area of each quadrat} \times \text{number of quadrats}} \times \text{total area}$$

- 120 daises have been collect in 10 1mx1m quadrats. What is the estimated abundance of daises in that area
  - (120/1x10) x 800

- **Measuring Animal Abundance**
  - Mark, Release, Capture
  - $$\text{Total population } (N) = \frac{\text{no. marked in first sample } (M) \times \text{total number of animals recaptured } (n)}{\text{number of recaptured animals that are marked } (m)}$$
  - First sample, 20 individuals were marked. Second sample 50 were collected, 10 were marked.
    - (20x50/10)

- **Population Trends**
  - Examining population trends can lead to inferences about the species and what abiotic and biotic characteristics they are most suited too.

- **Changes in Populations Over Time**
  - Members in population that survive and reproduce in their habitat carry the traits most suitable for the conditions
  - Cane Toads
    - Introduced to Australia in 1935 to control the greyback cane beetle in sugar plantations
    - Increasing at a fast rate
    - Specific structural adaptations and behaviours to suit Australia
      - Feed at night, no predators, breed all year, absorb water through skin.
    - The Cane Toads are evolving to be faster, but more prone to arthritis
    - Predators have increased resistance to the toxin and those reluctant to eat cane toads are ones that survive and reproduce
    - Red Belly Black snakes have gotten smaller due to the inability to consume the frogs → Snakes big enough to eat them die due to the toxin
    - The Northern Quoll has developed a Toad aversion mechanism to avoid the consumption of the toads
  - Prickly Pear
    - Introduced to Australia to start cochineal dye industry
    - Due to the lack of environmental pressures prickly pears spread at a rapid rate
    - Nonetheless, due to the lack of biodiversity, introducing a moth provided a strong selection pressure that quickly reduced the numbers and distribution of the prickly pears.

Adaptations

Inquiry Question: How do adaptations increase the organism's ability to survive?

- **Adaptations**
  - Organisms are adapted to survive in their natural environment as a result of evolutionary change by natural selection
  - An adaptation is a characteristic that an organism has inherited and makes it suited for its environment
  - It is a result of change that arise via mutation, when a cell divides and replicates during the process of reproduction
  - Structural Adaptation
    - How an organism is built
  - Physiological
    - How an organism functions
  - Behavioural
    - How an organism acts and behaves

- **Structural Adaptation- Plants**
  - Desert plants are able to balance photosynthesis and water for cooling purposes without risking dehydration
  - Xenophytes → Structural adaptations to maximise absorption and storage or water and minimal loss of water
  - Eucalypts → Waxy leaves to minimise transpiration of water and exposure to sunlight
  - Cypress Pines → Tiny cylindrical leaves to have a small SA:V ratio

- **Structural Adaptations- Animals**
  - Thorny Devil
    - Has spikes on its body to make it look more ferocious as well as being harder to swallow by prey
    - Has scales that absorb water straight into its mouth
    - Gold and brown camouflages in dessert
  - Wombat
    - Muscular shoulders and large claws used for extensive digging
    - Pouch to protect joeys from dirt whilst digging

- **Physiological Adaptations- Plant**
  - Salt tolerant plants are able to maintain metabolic functioning through their cells accumulate sodium and chloride ions
  - Minimise salt toxicity by increasing water content in vacuole

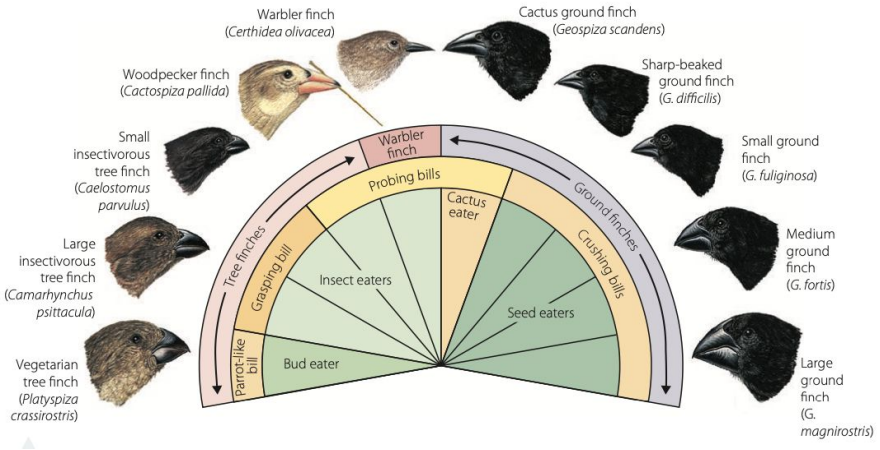
- **Physiological Adaptations- Animal**
  - Penguins, seals and polar bears convert a lot of their diet to a fat layer to insulate them from the cold
  - Some animals slow down their metabolic rates so their overall temperature is cooled
  - Cane toads dig a water tight mucus cocoon for cooling

- **Behavioural Adaptations- Plant**
  - The venus flytrap has adapted to live in nitrogen-poor soils which it obtains via insects

- It can act rapidly when it detects an insect
- Insect becomes trapped and the plant absorbs its nutrients

- **Behavioural Adaptations- Animal**
  - Puffer fish pumping air into their stomachs and blow up twice their size to frighten predators
  - Penguins route in packs to reduce time spent in the cold

- **Darwin in the Galapagos Islands**
  - Dariwn observed small ground finches on the Galapagos Islands
  - The shape of their beak was observed → Size of beaks differed
  - Naturally occurring changes in colour, beak size and leg length
  - Depending on which island they lived on, and the conditions they found themselves in, some birds thrive and reproduced
  - Charles Noted:
    - There is a variation in all populations with many variation heritable
    - There are more organisms born then the environment can sustain
    - Those individuals that have more suitable characteristics survive
    - Survivors pass on traits to offspring
    - Favorable traits will become more numerous if the environment is stable



- **Survival of the Fittest**
  - Variation exists with more population
  - More offspring are produced that can survive
  - The offspring better adapted will survive and reproduce
  - The favourable characteristics are passed on
  - Overtime favourable characteristics will increase in the population

Theory Of Natural Selection

Inquiry Question: What is the relationship between biodiversity and evolution?

- **The Theory Of Evolution By Natural Selection**

- Diversity allows adaptations to change in an environment
- Species have been developing for billions of years
- All theories of evolution share a common basic premises
    - Living organisms arose from common ancestors or a common life form and have changed over time
    - Differences that occur among groups of living organisms imply that living things change over time
    - Similarities occur in living things and suggest a common ancestry; the basic chemistry, inherited from a common life form, has remained relatively unchanged and has been passed down through generations.

- **Biological Diversity**
    - The variety of forms of life on Earth, the diversity of the characteristics of living organisms and the variety of their ecosystems.
    - Diversity allows for adaptations
    - Three levels of biodiversity
        - Genetic → Genetic makeup in a species
        - Species → Measure of the diversity of species
        - Ecosystem → Variation of different ecosystems

- **Genetic Diversity**
    - Important for the population to be able to adapt
    - Environments are constantly changing and pose selection pressures that enable some organisms with favourable characteristics to survive and reproduce
    - No variation in the population will be more detrimental for an invasive organism or pressure
    - More genetic diversity = more chance of survival

- **Concept of Natural Selection**
    - Organisms must possess traits that favor their survival in that environment
    - Variability→ All populations have random differences or variations among members
    - Heritability→ Variation must be inherited
    - Over Reproduction→ Organisms produce more offspring than what the ecosystem can sustain
    - Competition→ The best suited traits will ultimately thrive and reproduce
    - If there is a sudden change in the environments, those individuals that randomly possess a variation that is an advantage are more likely to survive the changed conditions

- **Diversification of Life on Earth**
    - The move form unicellular organisms to multicellular organs began when these cells clustered together

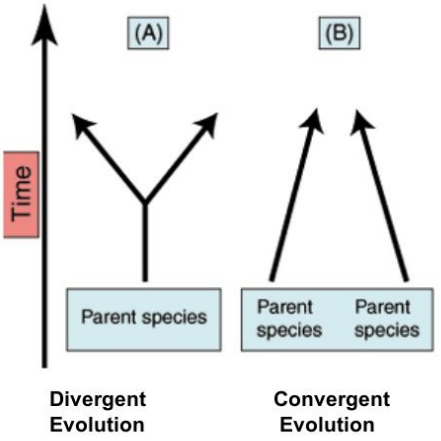
- Life began to diversify further with a rise in invertebrates to fish and amphibians
- Followed by the dominance of reptiles
- Mammals species then began to dominate
- Selection pressures lead to the thrive and extinction of species

- **Microevolution vs Macroevolution**
  - Macroevolution → Takes place over millions of years, usually results in new species
  - Microevolution→ shorter periods and results in changes of a particular species, but does not create a new species
    - Small changes can lead to a dramatic difference
    - New varieties or races (Dog Breeds)

- **Evolution Of The Horse**
  - Has a complete fossil record
  - Mammal belonging to the family Equidae
  - Evolved over 50 million years from a dog-sized, forest-dwelling animal *Hyracotherium*
  - Shares a common ancestor with tapirs and rhinoceroses
  - Horse evolution has a branching nature (rather than a linear evolution)
  - The fossil record showed there were several different migrations, changes in trends from smaller to larger sizes as well as reduction in size. The rate of evolutionary change did not appear to be constant.
  - Fossils have shown changes in body size, number of toes and dentition (teeth - development of grinding surfaces)
  - Genetic variation caused by mutations, natural selection, genetic drift and speciation have all contributed to the evolution of the horse
  - Microevolution can occur when a series of mutations leads to a change in gene frequency in a population. This change in the gene pool is due to chance and is called genetic drift. If a population becomes isolated speciation might occur.
  - A small population with a mutated gene may become separated from the main population, causing the mutated gene to increase in the population as interbreeding occurs. If the change is favourable it is selected for (it increases chance of survival)
  - The isolated population evolves to become significantly different from the original population and eventually if brought back together they would not be able to interbreed, resulting in the formation of a new species.

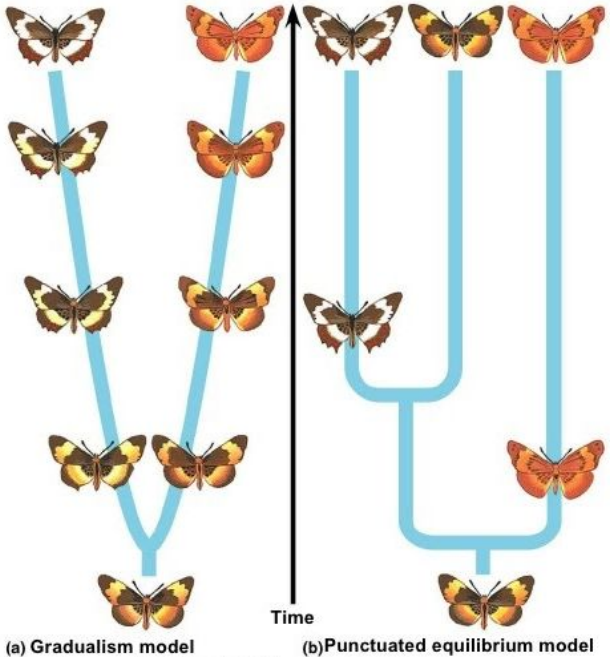
- **Evolution Of The Platypus**
  - Platypus shows similar features to birds, reptiles and mammals
    - Webbed feet, venom gland, hair on body
  - Genetic evidence suggest that monotremes split off first evolved
    - The first split was between marsupials and mammals

- Platypus and echidna share common ancestors
- Very well adapted to the environment it lives in
- Lay an egg with yolk
- Platypus can located prey with their eyes closed, by sensing electric pulses given off by muscles
- A type of macroevolution



- **Convergent Vs Divergent Evolution**
  - Convergent
    - Distantly related species which have moved to similar environments and are exposed to similar selection pressures to evolve similarly
    - Similar habitats, similar variation would be favoured by natural selection to enable them to survive
  - Divergent
    - Ancestral species radiates into a number of descendant species with both similar and different traits
    - Usually influenced by various selection pressures
    - An example is Darwin's finches

- **Gradual Natural selection vs Punctuated Equilibrium**
  - Gradualism
    - Populations slowly diverge by accumulating changes in characteristics due to selection pressures
    - Suggest that transitional forms should exist
    - Common ancestor
    - Small variation
  - Punctuated Equilibrium
    - Occurs in short bursts of rapid change, followed by long period of stability within populations
    - Mutations are passed on

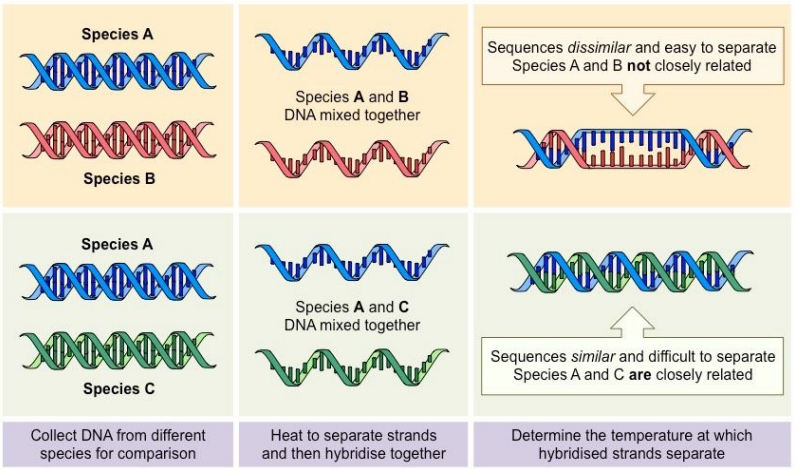


Evolution- The Evidence

Inquiry Question: What is the evidence that supports the Theory of Evolution by Natural Selection?

- **Biochemical Evidence**
  - All living things share the same macromolecules such as proteins and DNA and biochemical process such as cellular respiration
  - Biochemistry is the study of chemicals found in sound
  - More closely related species have more similar DNA and proteins
  - Similarities imply they had a common ancestor
  - Amino Acid Sequencing
    - Proteins are a component of all living organism
    - Made up of amino acids
    - The sequence of amino acids in the protein is analysed and similarities and differences between organisms are identified.
    - Differences imply the organism has evolved.
    - Number of differences is proportional to the length of time since the organism separated
  - DNA Hybridisation
    - Samples of DNA are removed from two different organism
    - The separated strands of the species to be compared are then mixed.
    - The two strands combine (reassociation) and form a ‘hybrid’ DNA molecule
    - The more closely matched the DNA, the tighter the binding.
    - Heat is applied to determine how tightly the DNA strands have combined. More closely related species have more similar sequences of bases and therefore the strands bind tightly.

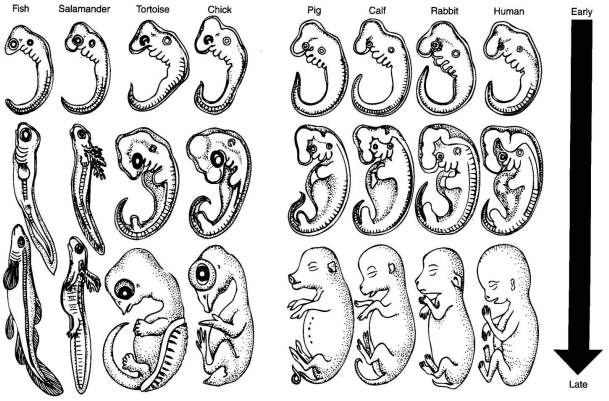
- DNA Sequencing
  - The exact order of bases in DNA of one species is compared with a similar fragment of another species.
  - A piece of DNA is isolated from each organism.
  - Multiple copies are made, and dye is used to label the bases.
  - A DNA sequencer is used to graph and print out the sequence of bases, which are then compared.
  - Organisms that share a common ancestor share fewer differences.
  - Provides more detailed information than other biochemical methods.



- **Comparative Anatomy**
  - Study of similarities and differences in the structure of living things
  - More similarities imply the organism have separated from a common ancestor recently
  - Homologous Structures (Divergent Evolution)
    - Differences in structure represent modification.
    - Organisms that have the same basic plan to their structure but show modifications are called homologous – they have the same evolutionary origins.
  - Analogous Structures (Convergent Evolution)
    - Structures that look similar but are very different (e.g. wings of bird and wings of grasshopper)
    - May have started off differently but over time evolve to look similar.
    - E.g. Australian Echidna and European Hedgehog
    - Do not show evolutionary relatedness – shows the evolution of structures for a common purpose.
  - Vestigial Structures
    - Evolutionary remnants of body parts that no longer serve a useful function.
    - Provides evidence of common ancestry.
    - E.g. presence of coccyx and appendix in humans.

- **Comparative Embryology**

- Comparison of development stages of an organism
- Related species show similarities in development
- Fish, mammals, amphibians, birds

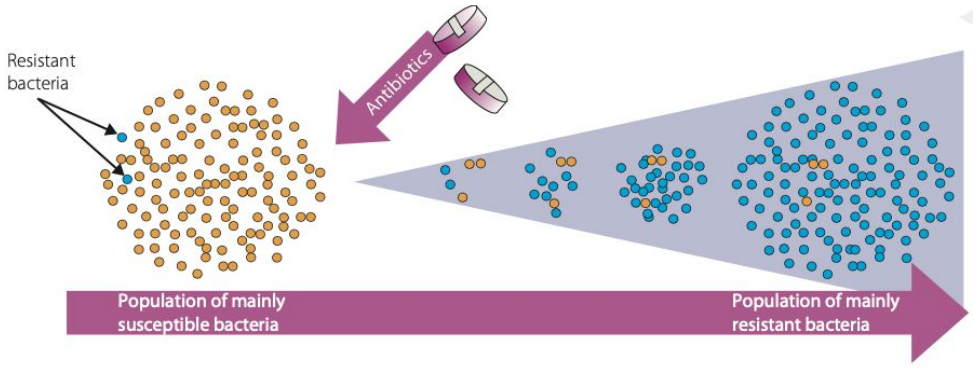


- **Biogeography**
  - Study of the distribution of organisms
  - For a new species to arise, it must be genetically isolated.

- **Fossil Evidence**
  - Fossils provide direct evidence of the existence of an organism in the past
  - The sequence in which fossils are laid down in a rock reflects the order in which they were formed
  - Law of Superposition
    - Further down in a rock represent an older fossil
  - Relative dating relies on the assumption that the fossils higher up in the rock are younger than the lower fossils → Fossils are dated relative to one another
  - Absolute dating enables the actual age of the specimen to be determined by using radioactive elements that are present

- **Modern Day Evolution**
  - Cane Toad
    - Faster and larger cane toads have reproduced more, hence the whole population is slowly getting faster
    - Red-belly black snakes have developed a smaller mouth so they are incapable of consuming the organism
    - There are no selection pressures on the cane toad, hence they will be able to continue to reproduce at exponential rates.
  - Antibiotic resistant Bacteria
    - Antibiotics are chemical that inhibit the growth of bacteria or destroy them → Target cell wall and inhibit cell metabolism
    - When penicillin and other antibiotics were introduced the threat posed by infections was reduced

- However, strains of bacteria has developed that are not affected by antibiotics
- The bacteria that survives passes on genes which leads to a whole new variation of bacteria



Module 4- Ecosystem Dynamics

Population Dynamics

Inquiry Question: What effect can one species have on the other species in a community?

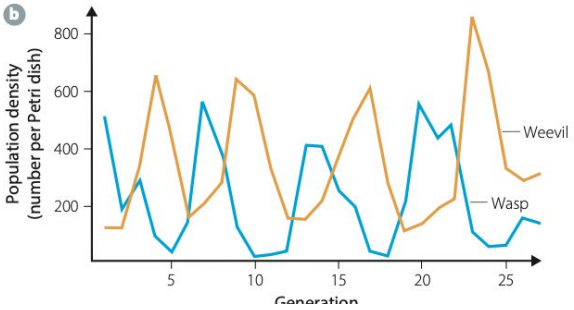
- **Organisation within ecosystems**
  - Biosphere contains all the living thighs on Earth
  - Environments can positively or negatively impact an organism
  - An organism living and non-living surrounds its ecosystem

- **Impact of Abiotic Factors**
  - Abiotic factors are not easily disturbed
  - Own unique way of thriving within the limits of the abiotic environment
  - Water is a very effective filter of sunlight
  - Rapid drop in temperature
  - Oxygen levels

- **Impact Of Biotic Factors**
  - Living organisms can affect each other by predation and symbiosis but also have an equally profound effect on resources
    - Food sources, mates, light, nutrients, water
  - Predation
    - Predator obtains its food by killing and eating another animals
    - Found in aquatic or terrestrial ecosystems
    - Spider capturing bugs in its web and eating it
  - Competition

        - Competition is usually for a resource in the environment that is limited supply but valuable for survival
        - All competition involves risk to the competitors and the rewards must outweigh the inherent risk
        - Intraspecific → Within a species
        - Interspecific → Between species
    - Symbiotic
        - Interactions in which two organisms live together in a close relationship that is beneficial to at least one of them
        - Obligate relationship → species depend on each other to live
    - Mutualism
        - Both organism benefit
        - Clownfish and sea anemone → Clown fish is protected by the sea anemone whilst the fish cleans the plant
    - Commensalism
        - One species is benefited whilst the other is not harmed or helped
        - Birds that live in hollow holes in trees
    - Parasitism
        - One species benefits whilst the other is harmed
        - Parasite obtains shelter from the host organism while feeding upon the tissue and fluids

- **Ecological Niches occupied by Species**
    - The part of an ecosystem that the organism occupies is called a niche
    - Refers to all the resources that a species uses, including biotic and abiotic
    - The process of having unique living strategies
    - Fundamental niche → The perfect conditions and resources for an organism to live and reproduce
    - Realised Niche → All the aspects of the ecosystem including the interactions of other species
- **Consequences in ecosystems**
    - Predation
        - Effect the distribution and abundance of prey
        - If the prey can reproduce fast enough, rates wont drop
        - Prey and predators are in direct proportion
    - Competition
        - Effects reproduction and survival rates
        - More food sources → More abundance of both species
        - Different traits will boost a species survival of getting resources



    - Symbiosis
        - Increased evolutionary diversification
        - Development of new species from the integration of genetic material

        - More resilient ecosystems → Biodiversity
    - Disease
        - Any process that adversely affects the normal functioning of tissue in a living organism
        - Bacteria, virus, Pathogen
        - Alter the balance of food webs → Affected species will decline in numbers

- **Recent Extinction**
- Climate Change
    - Continent dried out
    - Rainforests were contracting – stored moisture and returned moisture to the atmosphere.
        - Eucalypt forests replaced these, and water was not as efficiently retained.
    - Became hotter and drier, fires broke out due to lightning.
    - Plants and animals that survived the drought and fire reproduced, changing the flora and fauna.
- Arrival Of Humans
    - Aboriginal people arrived successful predators.
    - Used 'fire stick' farming techniques.
    - Introduction of dingoes may have reduced the diversity of carnivore predators.
- Level Of Nutrients
    - Low level of nutrients in the soil → dry
    - Led to smaller animals →F can be sustained on less
    - Evidence for this can be seen in the smaller size of mammals in Australia compared to counterparts across the world.

Past Ecosystems

Inquiry Question: How do selection pressures within an ecosystem influence evolutionary change?

- **Past Ecosystems**
    - It is unclear when humans first became interested in fossils.
    - Philosophers hinted that fossils were evidence of previous life.
    - Law of superposition → oldest layer at bottom and newest at top.

- **Aboriginal Rock Paintings**
    - Longest unbroken tradition in the world
    - Humans are driven by nature to record details of their existence
    - West Kimberly's rock paintings
    - Radiometric dating is used to date the paintings
    - Uranium/Thorium can be used to underlying calcite formations to show when they were formed
    - Types and abundance of animals depicted in paintings changed overtime

- **Geological Evidence**

    - Allows reconstruction of timeline of events
    - Represents the course of changes in geological and fossil deposits
    - Banded iron Formations
        - Form of geochemical evidence found in Australia
        - Earth's atmosphere has undergone changes, change from anaerobic to aerobic
        - Form of iron rich and iron poor sediments
        - Prokaryotes lead to an increase in oxygen concentration in the ocean, leading to precipitation of insoluble iron oxide
        - Precipitate accumulated at the bottom of the ocean, forming an iron rich layer of sediments
        - Great oxygenation event transformed Earth's atmosphere
        - Resulted in much larger and multicellular organism→ Organisms had to adapt to more oxygen
    - Palaeontological Evidence
        - Fossils offer clues to the selection pressures of living things like the climate and environment at the time
        - Found in sedimentary rocks → Preserve evidence rather than destroying it
        - Fossilised soils contain large concentrations of carbon that indicate presence of life
        - Chemosynthesis is a process where organisms use inorganic compounds available from their environment.
        - The fossils formed from stromalites provide valuable informationof early orgaims and the environment in which they lived

- **Ice Core Drilling**
    - Accumulation of ice layers in places such as antarctica leaves an annual record of gas and dust in that atmosphere of that time
    - Scientists can drill into the ice, extract gases and reconstruct the climate record
    - Increases understanding of past environments

- **Radiometric Dating**
    - Process where scientists determine the age in years of a fossil, rock or mineral
    - Based off the content of radioactive isotopes
    - Unstable isotopes change to form stable isotopes → Undergoes radioactive decay which scientists can compare to examine the life of the rock
    - More half lives → Older
    - Rate of decay is calculated using the *age equation* that compares the abundance of the naturally occurring isotope with the abundance of the decay product.

- **Gas Analysis**
    - Scientists can use data in ice cores to reconstruct atmospheric concentrations of certain gases, particularly CO_2 and $O_{2.}$

- CO_2 is a normal part of Earth's atmosphere along with nitrogen, oxygen, argon and other trace gases
- But CO_2 is also considered a 'greenhouse gas' that traps solar radiation keeping the Earth warm enough to sustain life
- However, increasing CO_2 in atmosphere is likely to increase Earth's atmospheric temperature, known as the 'enhanced greenhouse effect' or 'global warming'
- Scientists use ancient CO_2 levels to infer past climates - warming or cooling would have a direct effect on the types of plants and animals that are suited to survive in such a climate
- Oxygen has three naturally occurring isotopes: ^{16}O, ^{17}O and ^{18}O which are incorporated into water molecules. The ratio of $^{18}O/^{16}O$ in analysed ice core samples indicates ancient water temperatures which scientists can use to reconstruct water temperatures on Earth.

- **Small Mammals**
  - We Can use fossil of past animals to show similarities and differences to present day animals and therefore propose evolutionary relationships between them.
  - When comparing the modern platypus to fossils, body shape became smaller + more simplified.
  - We can infer a change in diet as dentition is different
  - Habitat reduced in size → May have become vulnerable.

- **Reasons for Change**
  - Australia's change in climate due to the split of Gondwana
  - Climate change
  - Arrival of indigenous
  - Introduction of non native plant + animals → invasive species → Destroys or affects the natural food web

Future Ecosystems

Inquiry Question: How can human activity impact an ecosystem?

- **Human Induced Species**
  - Increasing Population
    - Selective breeding, use of fertilisers, pesticides and herbicides
    - Medical breakthroughs with antibiotics, better hygiene and vaccinations
    - Increasing populations of humans lead to an increase of the demand of resources from ecosystems
    - Selective breeding limits the biodiversity of species, hence making them more susceptible to being majorly effected by disease or change
  - Agriculture

        - Removal of trees leaves the soil vulnerable to erosion → Loss of valuable minerals for an ecosystem
        - Pollutions harms the water and atmosphere
        - Irrigation was developed alongside the domestication of plants
        - Selective breeding of crops and livestock radically altered their features to favour large yields
    - Introduced Species
        - Many invasive species out compete native species for light, water, habitats and nutrients
        - Change the environments to alter the microclimate of the areas to favour their own development
        - Completely alter the food web system which has detrimental effects on the rest of the ecosystem
    - Land Clearing
        - Refers to the removal of native vegetation for urban and agricultural development
        - Removes nesting and habitats of native animals → Cannot reestablish anywhere else.
    - Extinction
        - Habitat loss is the leading cause of extinction
        - Most historic extinctions have occurred on islands because a small habitat loss has devastating effects
        - Extinction opened niches for surviving organism to expand into → Rapid development of species

- **Past To Inform the Future**
    - Can estimate rates of extinction by studying recorded extinction events, examining fossil record and by analysing modern trends in habitat loss
    - Over exploitation of resources → Harvesting an amount that is not sustainable over time
    - Introduced species → New species effect relationships due to competition, predation and disease
    - Disruption of ecological relationships → loss of available niches alter the distribution and abundance of species

- **Biodiversity**
    - Genetic diversity → Intraspecies diversity in traits that makes a population resilient to environmental changes
    - Species Diversity → Variety of species in an ecosystem
    - Ecosystem diversity → Variety of ecosystems available in a broader area such a continents or globally

- **Climate Change**
    - Greenhouse Effect
        - Solar radiation reaches and penetrates earths atmosphere

        - Some energy is trapped and absorbed into the land and ocean
        - Keeps earth warm and sustainable
    - Enhanced Greenhouse
        - Increase of concentration of greenhouse gases
        - More energy being absorbed in oceans and land
        - Warmer climate
        - External factors → Solar input from the sun, Earths variety in orbit
        - Internal factors → Active release of CO_2 from volcanoes, diffusion of CO_2 from ocean, less reflection of light from ice (Melting ice is bad)
        - Human Factors → burning fossil fuels, agriculture, land clearing

- **Models Predicting Biodiversity**
    - Resources increase slow
    - Humans grow quick
    - Humans will outgrow their ability to feed themselves
    - Greater fertility will lead to starvation
    - Keep numbers and population in check

- **Mining Sites**
    - Required to follow laws and strict guidelines, which include submitting information on how they intended to ensure minimal harm to environment
    - All mining companies must complete an environmental impact statement as a part of their license application

- **Land Degradation and Agriculture**
    - Marked improvement in the management of Australiansoils and waterways
    - Farm owners can have their land inspected by scientists
    - Management of salinity and erosion are high priorities
    - Biological controls are being used to maintain pests