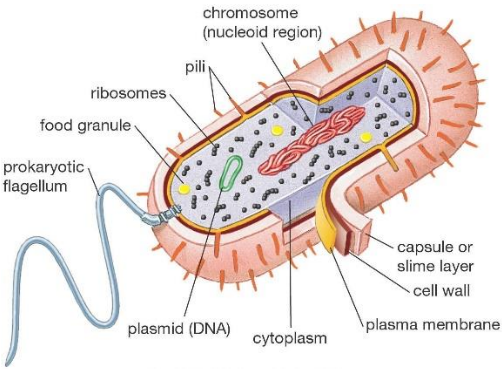
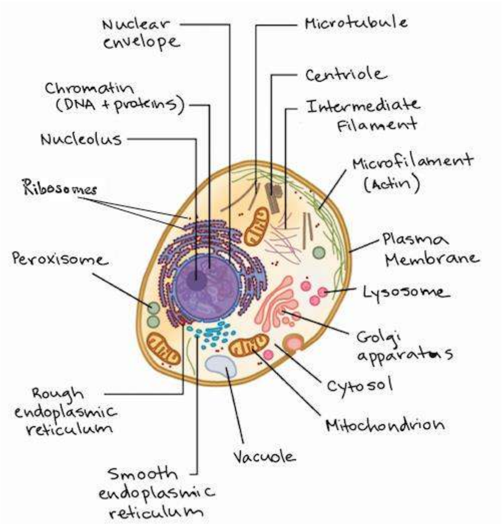
# BIOLOGY SUMMARY

## MODULE 1 – CELLS AS THE BASIS OF LIFE

- There are two types of cells: Prokaryotic and Eukaryotic.
- Prokaryotic (0.1 – 5μm) - single cells that have no membrane bound nucleus or organelles. Bacteria and Archaea are prokaryotic cells.



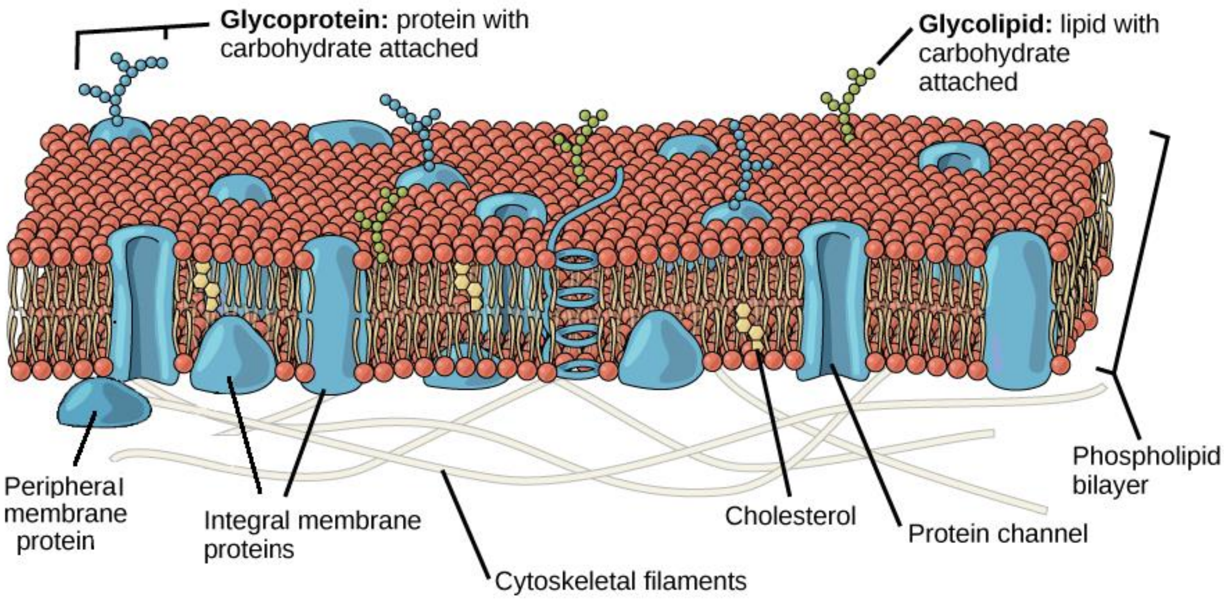

- Eukaryotic (10 – 100μm) - can be multi/uni cellular and have membrane bound organelles and nucleus. Protista, Animals, Fungi and Plants have eukaryotic cells. Plant cells are usually polygon shaped while animal cells are round, and some cells are specialised to perform different functions.



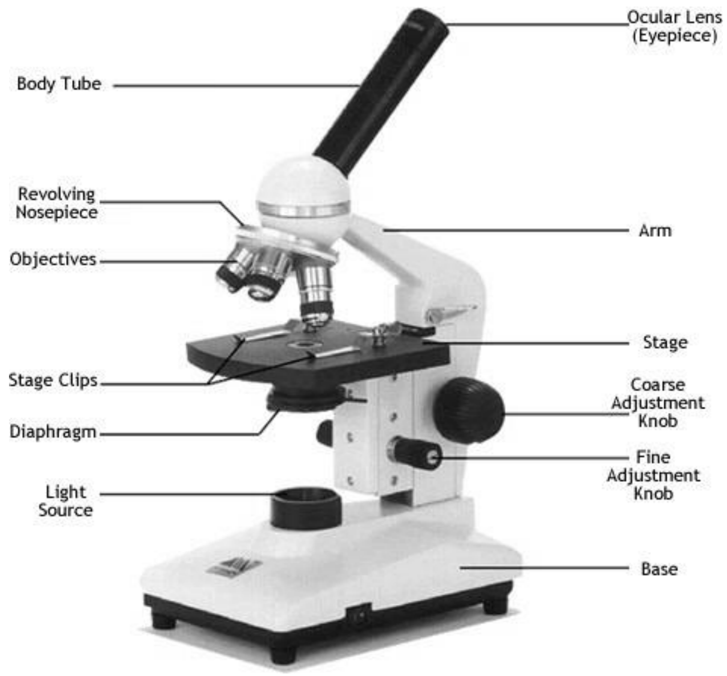

- The magnification of a microscope can be calculated by multiplying the magnification of the ocular lens (x10) and the objective lens.
- Field of view is measured by a microscopic grid where one square is 0.1mm = 100μm. Therefore, 1mm = 1000μm.
- Organelles have a specific structure and function. A higher SA:V ratio means that there can be quicker transport of nutrients and wastes in and out of a cell, where smaller, flatter cells have a larger SA:V ratios than larger, spherical cells.
- Protoplasm is all the living contents inside a cell.
- Centrioles produce spindles for cell division. (Animal Cells)
- Cytoskeletons evenly distribute organelles and aid cell division and cell shape

| Organelle | Structure | Function |
| --- | --- | --- |
| Membrane | Made of phospholipids. (Fluid Mosaic Model) | Selectively permeable; controls movement of substance in and out of cell |
| Nucleus | Spherical. | Coordinates, controls and processes cell functions and stores genetic material (DNA) |
| Endoplasmic Reticulum | Series of flattened, interconnected membranes. | Transports and processes proteins and lipids. Smooth (lipids; outside nucleus). Rough (proteins; attached to nucleus with ribosomes). Intracellular transport. |
| Golgi Body | Stacks of membranes. | Packages and sorts products for transport. |
| Ribosome | Rounded Granules. | Synthesises proteins. |
| Lysosome | Surrounded by a phospholipid membrane, produced by Golgi Body. | Digestion and cell destruction (removes damaged parts of the cell).<br>(Animal Cells) |
| Mitochondria | Oval shaped (football), with two membranes. | Cellular respiration (stores and produces energy - ATP, adenosine triphosphate) |
| Vacuole | Fluid filled sacs. | Storage and provides support.<br>(Plant Cells) |
| Chloroplast | Green, disc shaped. | Site of photosynthesis (contains chlorophyll).<br>(Plant Cells) |
| Cell Wall | Multi - layered, rigid wall. | Shape and support.<br>(Plant Cells) |

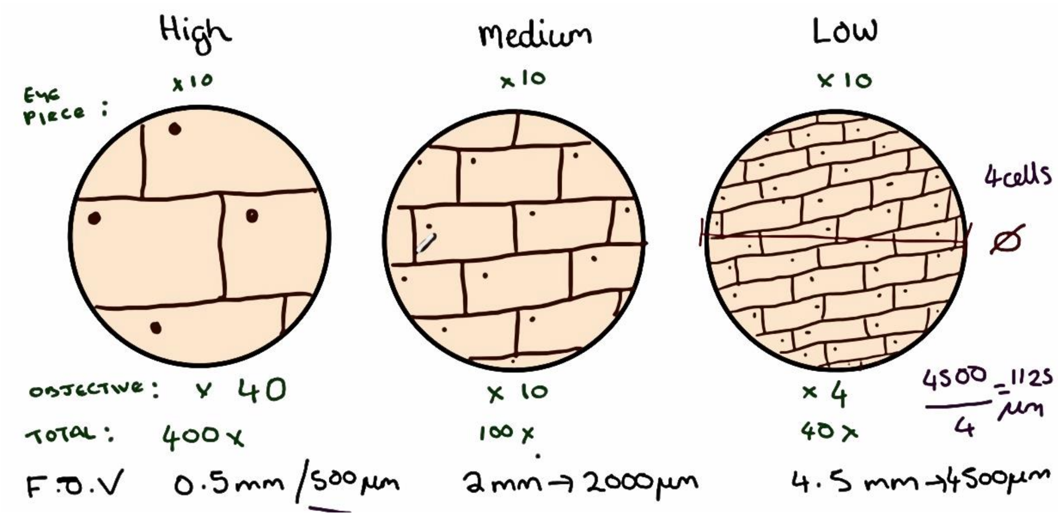
- Fluid Mosaic Model - Model of the cell membrane which displays the semi-permeability of the membrane.
- It consists of a phospholipid bilayer and has the ability to change shape, and hence is fluid.
- The phospholipids are in a certain arrangement and have embedded proteins making them 'mosaic'.
- Some proteins form pores (integral-stuck) which aid in the transport of larger molecules or proteins exist outside the membrane (peripheral) which maintain the intra/extra cellular environments of the cell.
- Some become protein channels for transport where ATP allows for transport against a concentration gradient.
- Other proteins have different functions such as: receptors, recognition and adhesion.
- Glycoproteins (antigens; marker molecules) have proteins attached to carbohydrates, for cell recognition where a foreign particle is identified for the immune system to destroy.
- Cholesterol inside, allows the membrane to be flexible and prevents the membrane from breaking in different conditions.
- The phosphate head is hydrophilic and allows molecules to enter or exit the cell.
- The fatty acid tail is hydrophobic and prevents molecules or ions from passing the cell membrane.



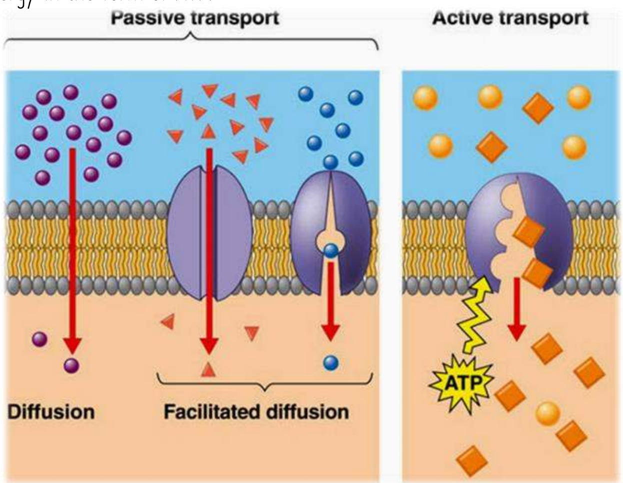
- Light Microscope




- Staining helps better visualise cells or certain parts of a cell.
- Light Microscope - light passes through the specimen and into the convex objective lens which magnifies the image seen through the ocular lens.
- Electron Microscope - uses rays of electrons and electromagnets which provide more resolution and magnification.
- Biological Drawing

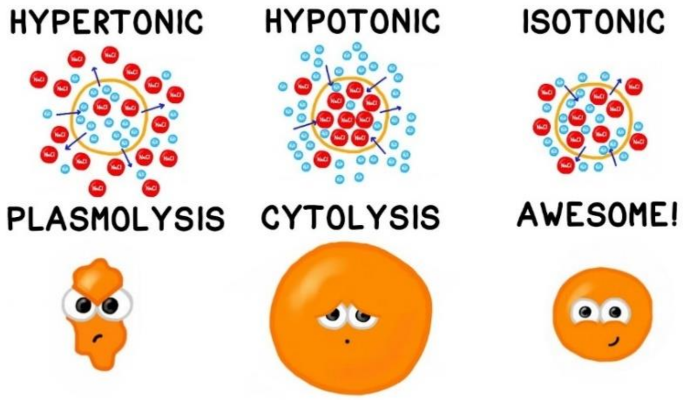


- Substances move from the internal (intracellular) environment to the external (extracellular) environment of a cell and vice versa across the selectively permeable cell membrane.
- Gases, nutrients, water and ions are required by the cell while wastes and cellular products are removed from the cell.
- The permeability of the membrane relative to a particular molecule depends on its size, electrical charge and lipid solubility.
- If a molecule is lipid-soluble it travels faster, as well as molecules that are smaller or molecules that are neutral (non-ions), and therefore these molecules have a high permeability.
- Hydrophilic molecules (water-soluble) have difficulty passing through the cell membrane, as well as well as ions which both have a low permeability.
- To travel across the cell membrane these molecules rely on carrier proteins or a transport proteins (protein channel).
- Water is not lipid-soluble however, due to aquaporins (hydrophilic pores) it travels across the membrane through osmosis.
- Diffusion is the movement of any molecules from a region of high concentration to low concentration, until equilibrium is reached. This is the travel of molecules along a concentration gradient and hence requires no energy input.
- Heat or a steeper concentration gradient increases the rate of diffusion.
- Large molecules or ions don't readily pass through the cell membrane so they undergo facilitated diffusion where carrier proteins and protein channels assist their diffusion into the cell.
- Active transport is the movement of molecules from a low concentration to high concentration (against concentration gradient), which requires input energy in the form of ATP.

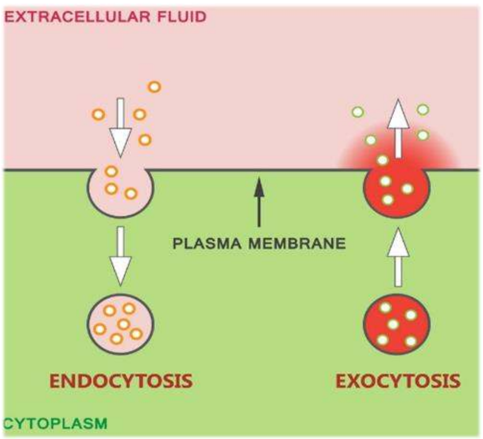



- Osmosis is the diffusion of solvent molecules (water) through a semipermeable membrane.
- The amount of solute (e.g. salt) in a solvent (water) determines the concentration of a solution.
- If the water concentration outside the cell is higher than inside the cell then the water will move into the cell causing swelling or expansion or the vice versa will cause shrinking.
- The pressure created by this movement of water is known as osmotic pressure, the more water that moves the more pressure.
- Dilute - low concentration of solute in solvent.
- Isotonic - same/equal solute concentration.
- Hypotonic - lower solute concentration.
- Hypertonic - higher solute concentration.

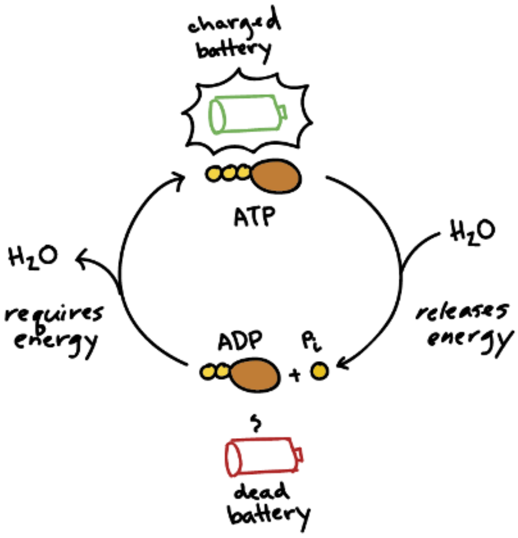
- Plasmolysis is caused by a hypertonic solute external environment, causing the water inside to move out to balance the solute concentration making the cell shrink.
- Cytolysis is caused by a hypotonic solute external environment, causing water to enter the cell to make the outside concentration higher making the cell expand.
- In animal cells there is no cell wall, so cytolysis may cause the cell to burst which is why most animal cells are not exposed to an external environment and are bathed in an isotonic extracellular fluid, for efficient functioning.



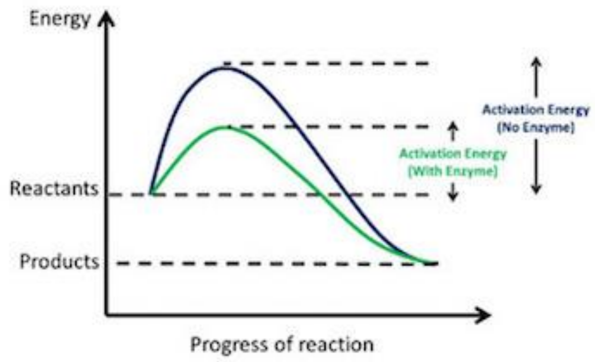

- Cytosis is the movement of a substance/material across a membrane.
- Endocytosis - where the cell membrane changes shape and engulfs the particle.
- Phagocytosis - endocytosis with solid particles.
- Pinocytosis - endocytosis with a fluid/liquid.
- Exocytosis - where a vesicle containing material fuses with the cell membrane, pushing out its contents from the cell.



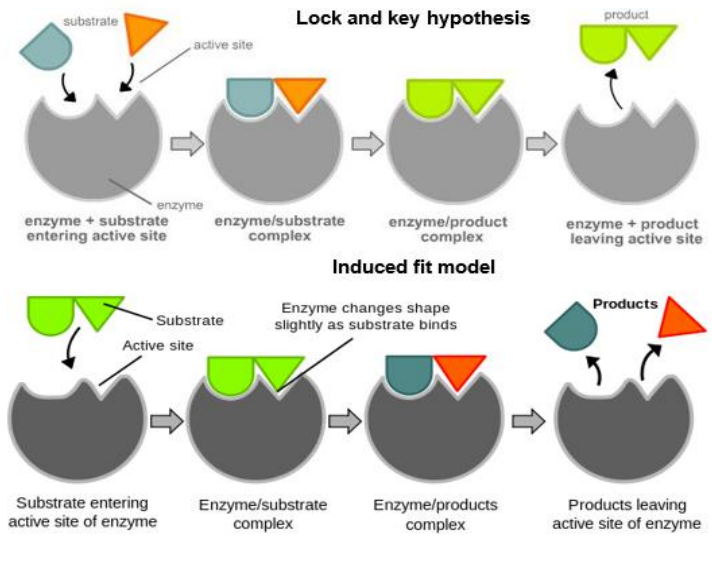

- When the cell needs energy ATP splits off one phosphate and becomes ADP (adenosine diphosphate), and when the cell has extra energy it gives one phosphate to ADP making it ATP.



- Enzymes (biological catalysts) are protein molecules that catalyse biochemical reactions that act upon a substrate.
- They are renewable, meaning they can be reused and aren't used up by a reaction.
- They reduce the amount of activation energy required for a chemical reaction to start, therefore increasing the rate of a reaction.

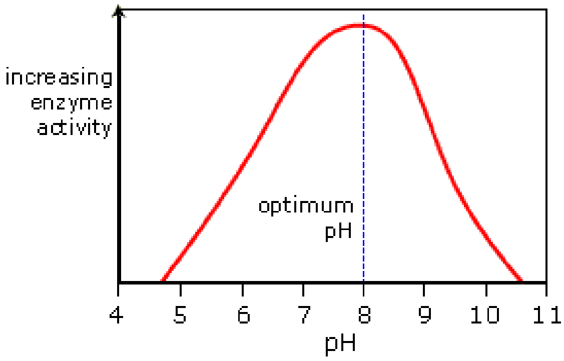



- Enzymes have the prefix -ase, while sugars have the prefix -ose. e.g. lactase and lactose.
- When an enzyme's active site and a substrate bind together it is known as an enzyme-substrate complex.
- Enzymes are ubstrate specific and will only bind with specific substrates that match their active sites.
- There are two models for the process of enzymes. The 'lock-and-key' and 'induced fit' model.
- In the lock and key model, the enzyme and substrate are a perfect fit however, through research the induced fit model was introduced where, the active site isn't rigid can slightly alter shape to accommodate a substrate.

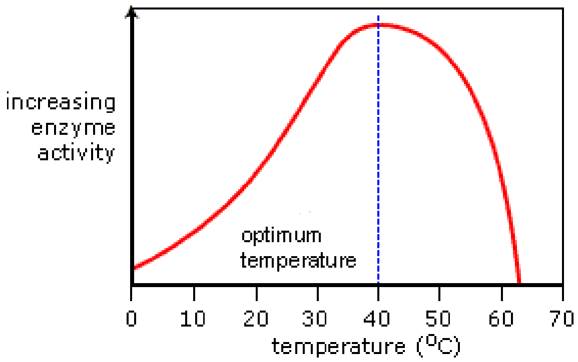



- Anabolic reaction - separate substrates are bonded together.
- Catabolic reaction - the bond is broken in a substrate to break it down into separate products.
- An enzyme is denatured when its active site's shape has been deformed and can no longer bind to substrates, meaning it can no longer function or return to its original state.

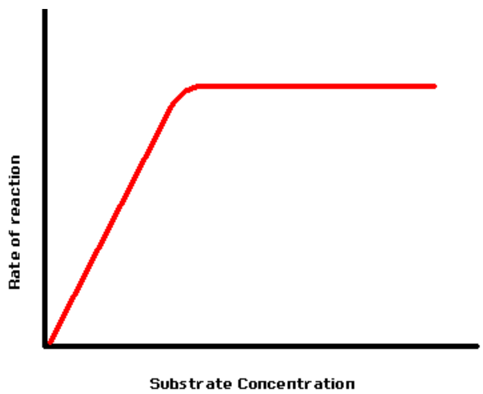
- Each enzyme has an optimum pH at which it functions most efficiently, usually a pH of 7-8. Depending on the location this can change, e.g. pepsin has an optimum pH of 2-3 as it is found in the stomach. Extremes of pH cause the enzyme to become denatured.




- The activity of an enzyme increases as temperature increases until it reaches its optimal temperature (usually 37°C). After this point, just like pH the enzyme activity decreases and eventually denatures.



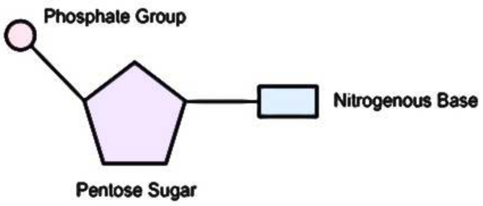

- Just like temperature, the activity of an enzyme increases as substrate concentration increases until it reaches a saturation point, where all the enzymes are being used at their maximum turnover rate and all the active sites are occupied. Therefore, the enzymes have to be reused to act on the remaining substrate and the rate of the reaction after this point stays constant unless more enzymes are produced or added.



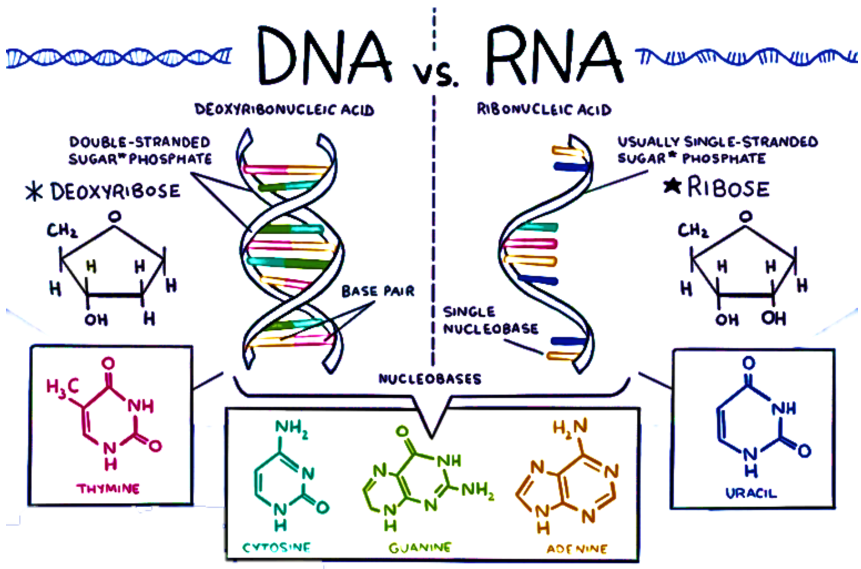

- The equation of a reaction with an enzyme is written as: Hydrogen Peroxide (toxic substance) → Water +Oxygen (harmless)

$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2\,(g)$

- Organic substances are substances produced/synthesised in living things and contain carbon and hydrogen atoms (glucose $C_6H_{12}O_6$, amino acids, fatty acids, glycerol) and are mainly stored as energy but can also have structural purposes.
- Inorganic substances are substances readily found in the abiotic/non-living environment and do not contain long chains of hydrogen or carbon atoms (Water, oxygen, carbon dioxide, gases, phosphates, sodium/chlorine ions, minerals) and form the structural parts of cells and tissues as well as hormones.
- These substances are used in cells as: essential building blocks for cells and tissues or a source of energy for the cell.
- There are four main types of organic, biomacromolecules (large organic molecules): Carbohydrates (e.g. starch), Lipids (e.g. triglyceride), Proteins (e.g. enzymes) and Nucleic Acids (e.g. DNA).
- Carbohydrates are made up of carbon C, hydrogen H and oxygen O. Their ratio is 1:2:1 (e.g. $CH_2O$).
- They are classified as: monosaccharides (simple sugars), disaccharides and polysaccharides (complex sugars), dependent on how many monomers are linked.
- Lipids contain many carbon C and hydrogen H atoms with fewer oxygen O atoms and are relatively insoluble in water.
- Autotrophs can build their own organic compounds whereas consumers must make their organic compounds from food or external nutrients.
- Proteins are made from carbon C, hydrogen H, oxygen O, nitrogen N and sometime sulphur S. These atoms form amino acids which are the building blocks of proteins.
- Proteins are made from one or more (poly)peptides which are chains of amino acids.
- Proteins form structural components in cells and tissues and some proteins such as enzymes have functional roles.
- Nucleic Acids contain carbon C, hydrogen H, nitrogen N, oxygen O and phosphorous P. The two types are DNA and RNA.
- DNA is a double helix structure that stores genetic information, mainly found in the nucleus - coordinates cell activities and production of proteins.
- Both are made up from nucleotides (sugar + base + phosphate)



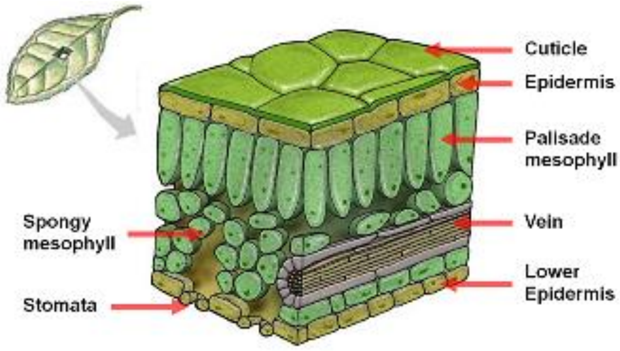

- The bases for DNA are adenine, guanine, cytosine and thymine, whereas in RNA instead of thymine there is uracil. DNA has the sugar deoxyribose and RNA has ribose sugar.
- RNA is found in the nucleus and more in the cytoplasm and is used to make proteins and ribosomes - assists in the manufacture of proteins.

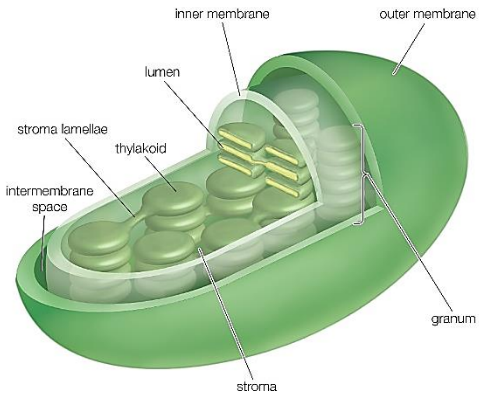


- The two main biochemical processes in cells are: photosynthesis and respiration.
- Photosynthesis: Word equation: carbon dioxide + water $\xrightarrow{\text{light energy/chlorophyll}}$ glucose + oxygen

  Chemical equation: $2CO_2 + 12H_2O \xrightarrow{\text{light energy/chlorophyll}} C_6H_{12}O_6 + 6O_2$
- There are two stages in photosynthesis which are the light dependent (photolysis - occurs in thylakoid membranes) and independent (carbon fixation - occurs in stroma) stages, where both occur in the chloroplast.
- Light dependent: $2H_2O \longrightarrow O_2 + 2H_2$

  Light Independent: $CO_2 + H_2 \longrightarrow C_6H_{12}O_6$



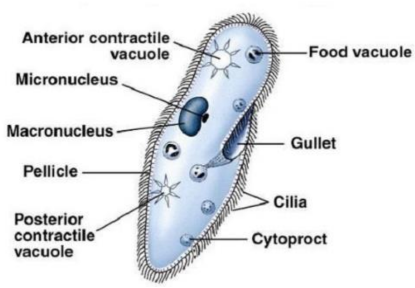

- Anaerobic Respiration - respiration when there is a lack of oxygen. Two common examples of this are alcohol fermentation (products are alcohol/ethanol and carbon dioxide) and lactic acid fermentation (products are lactic acid). Both produce 2 ATP molecules per molecule of glucose.
- Glucose $\longrightarrow$ Ethanol + Carbon Dioxide + Adenosine Triphosphate = $C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2CO_2 + 2ATP$
- Glucose $\longrightarrow$ Lactic Acid + Adenosine Triphosphate = $C_6H_{12}O_6 \longrightarrow 2CH_3CH(OH)COOH + 2ATP$
- Aerobic respiration occurs in the presence of oxygen. The general equation is:

  Glucose + Oxygen $\xrightarrow{\text{many chemical reactions}}$ Carbon Dioxide + Water + Energy (ATP)

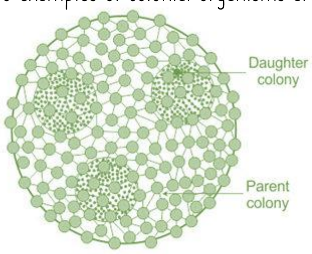
  $C_6H_{12}O_6 + 6O_2 + ADP + P \xrightarrow{\text{many chemical reactions}} 6CO_2 + 6H_2O + 36ATP$
- This type of respiration produces 38/36 ATP molecules where 2ATP molecules are used for glycolysis, for each molecule of glucose.
- Glycolysis - 1st step is the breakdown of glucose into 2 pyruvate and 2 ATP molecules.
- 2nd step, pyruvate in presence of oxygen is broken down to release carbon dioxide, water and 34 ATP molecules.
- The products from photosynthesis are used in aerobic cellular respiration and vice versa.
- Wastes are unnecessary products of cellular reactions that aren't required and can be removed through simple diffusion, exocytosis or destroyed by the enzymes in lysosomes.

# MODULE 2 - ORGANISATION OF LIVING THINGS

- Organisms can exist as single cell (unicellular), single cells working together (colonial) or as an organism made up of many cells (multicellular)
- Unicellular organisms can be either prokaryotic or eukaryotic and have to carry out all metabolic processes themselves e.g. *Paramecium*




- Prokaryotic cells have no membrane bound organelles which decreases the efficiency of their metabolic processes e.g. *Bacteria*
- Eukaryotic cells have membrane bound organelles which increases the efficiency of their metabolic processes e.g. *Paramecium*
- Unicellular organisms have a high SA:V ratio to allow for a more efficient transportation of substances into/out of the cell
- Colonial organisms are individual cells living together in a colony and are thought to be the evolutionary link between uni and multi cellular organisms
- All cells in a colony are capable of carrying out metabolic processes however, more simple specialised cells may be present to improve the efficiency of the functioning of the organism
- Two examples of colonial organisms are *Volvox & Choanoflagellates*

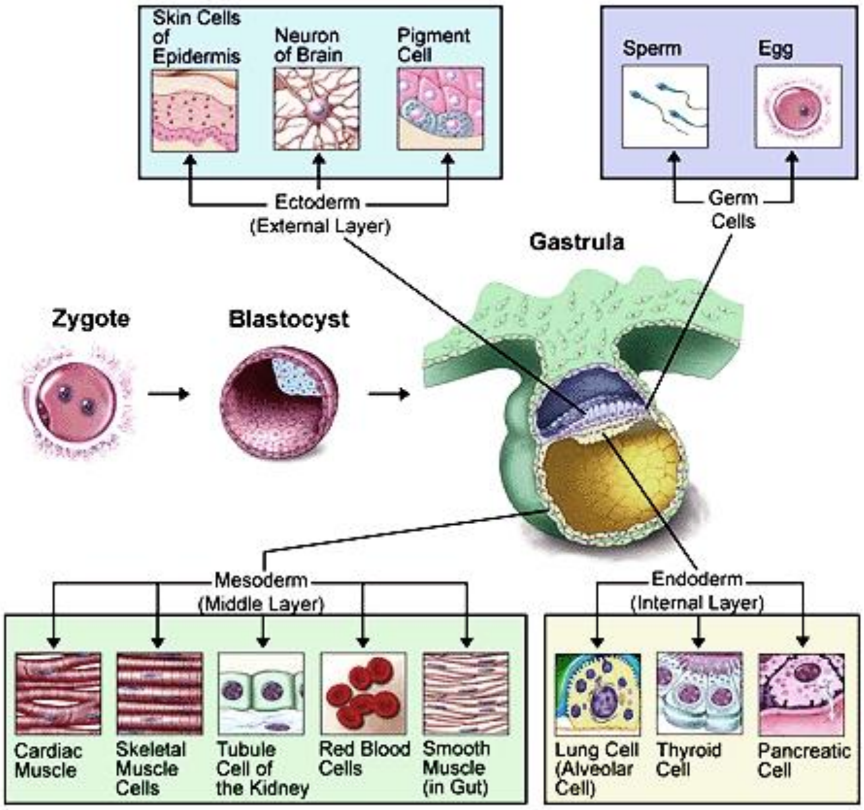



*Volvox*

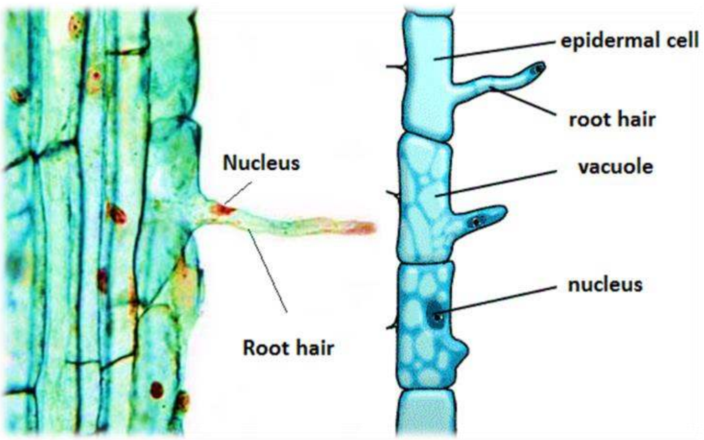
*Choanoflagellates*

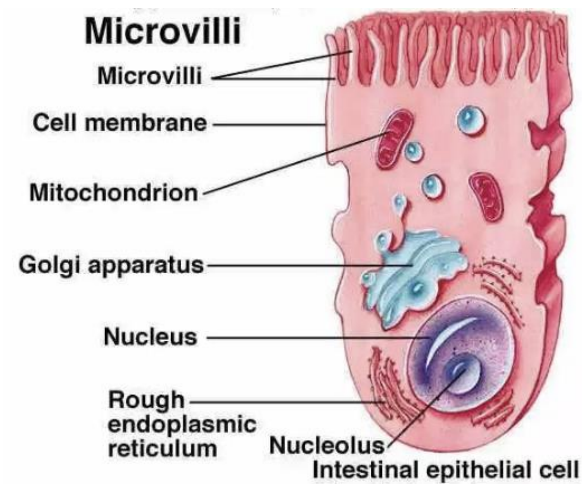
- Multicellular organisms are composed of many different specialised cells where similar cells are grouped together to perform specific functions that increase the efficiency of the functioning of the organism
- Individual cells in multicellular organisms cannot live independently
- When cells specialise, they develop suitable structural features to allow them to carry out their specific functions
- Stem cells are undifferentiated cells with no specialised structures or functions
- Specialised cells are formed when differentiation (maturing of cells to become specialised) of the stem cells occurs and they develop suitable structural features that allow them to carry out their specific functions
- The type of cell that is formed is determined by the location of the undifferentiated cells in the organism and the particular genes that are 'switched on'

- Stem cells can either be embryonic or adult stem cells




- In plants, specialised cells are formed by the differentiation of meristematic tissue found at the tips of roots and shoots
- Cell structure is related to the particular function of the specialised cell
- In animals, chemical secretions and nerve cells relay messages around the body to help coordinate specialised cells and allow them to communicate
- Cells whose functions involve exchanging substances with the external environment will probably be flat and long to increase SA:V, or have many folds to increase SA. Examples are root hair cells, the cells lining the small intestine and the elongated palisade cells in a leaf

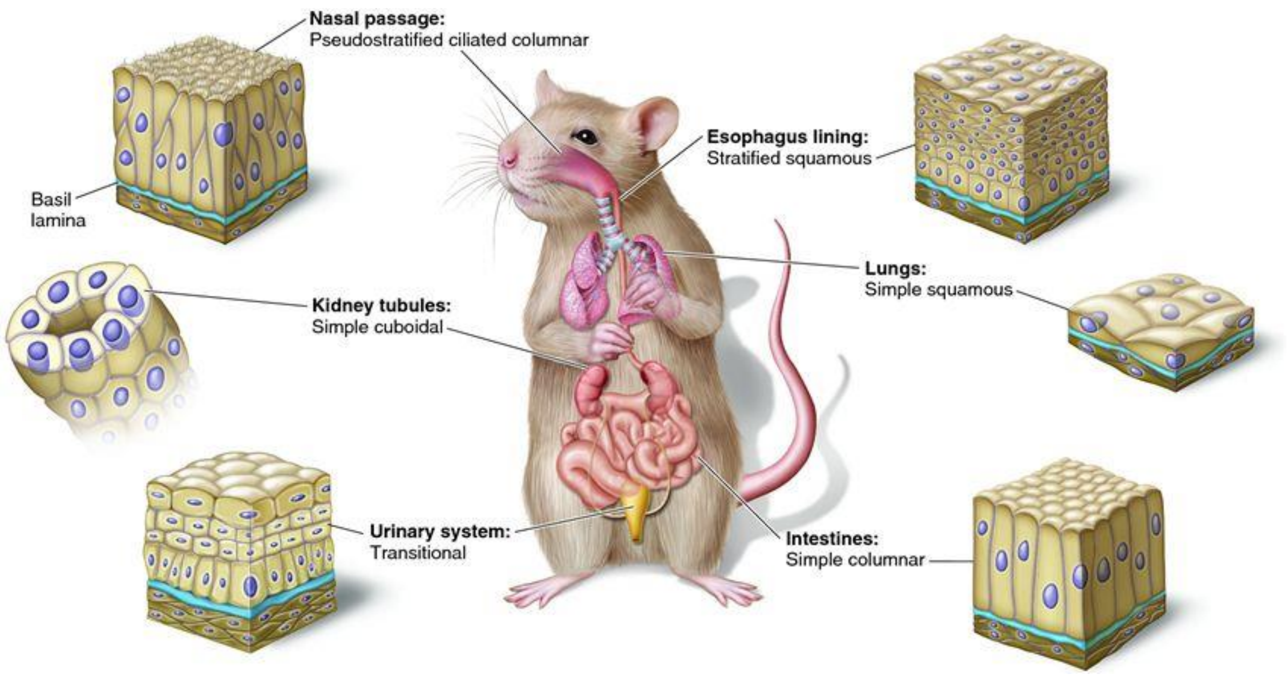


- Another example is that red blood cells are very small and have a biconcave shape to increase SA:V for the exchange of oxygen. Furthermore, they lack a nucleus and organelles, enabling more haemoglobin to be carried in the cell

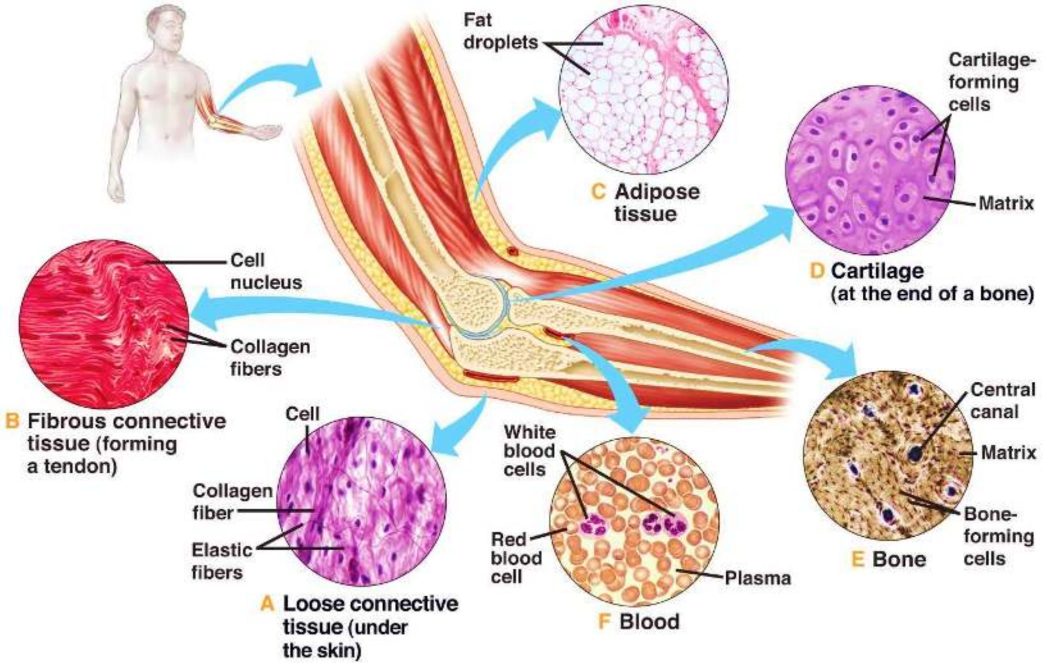
- Organelle *(membrane-bound structures with specific roles in the cell)*
  ↓
  Cell *(basic structural and functional unit of living organisms)*
  ↓
  Tissue *(cells that perform similar functions)*
  ↓
  Organ *(different tissues grouped together to perform a specific function)*
  ↓
  Organ System *(organs grouped together to carry out particular functions)*
  ↓
  Organism *(living thig made up of interrelated components that work together)*

- There are four main types of animal tissue: epithelial (covers body surfaces for protection an forms glands), connective (support, binding, protection), nervous (communication of body parts) and muscle tissues (contract for movement)

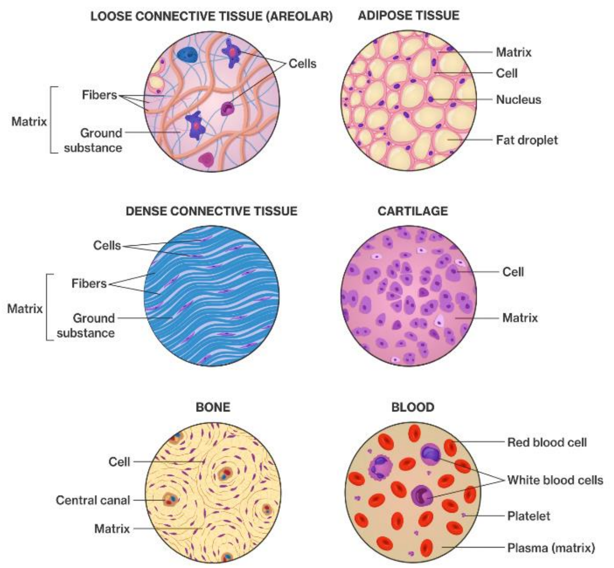



*Epithelial Tissues*

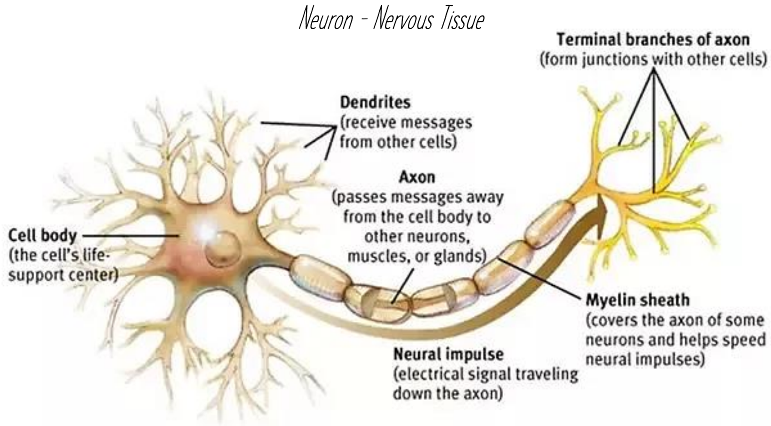
- There are many different forms of each type of these tissues (connective tissues, muscle tissues, nervous tissues and epithelial tissues)

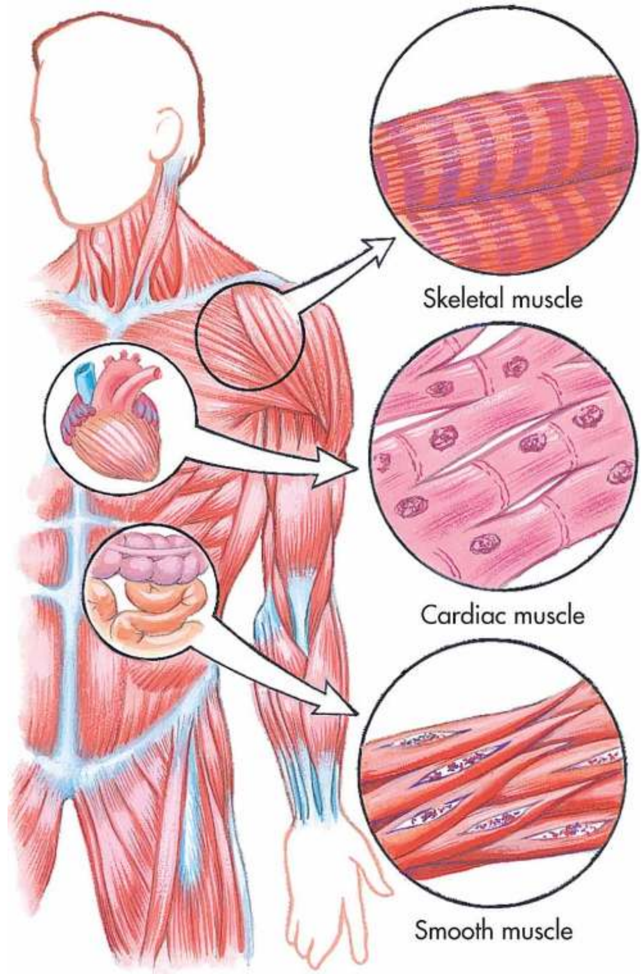



*Connective Tissues*



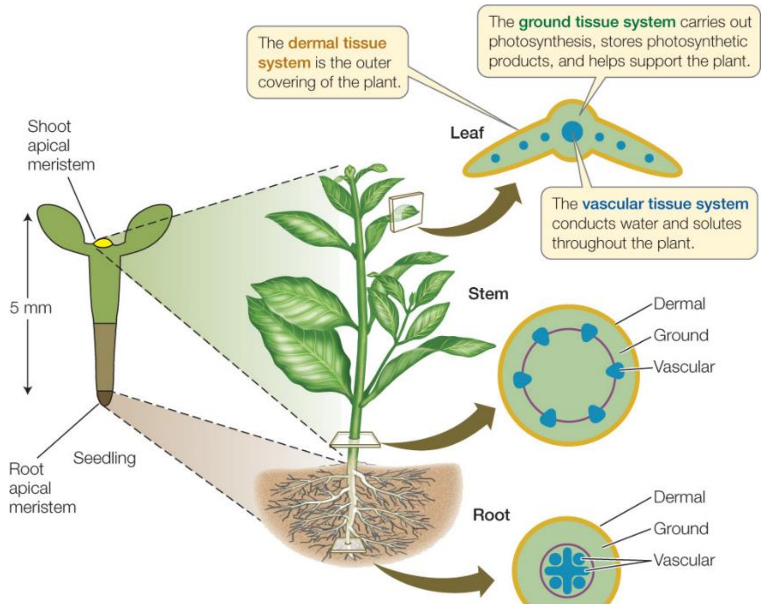

*Neuron - Nervous Tissue*



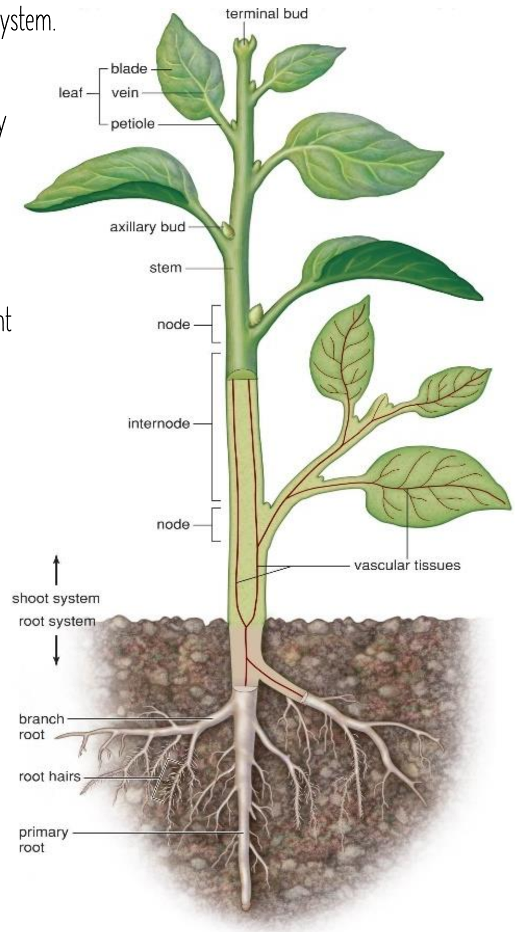




*Muscle Tissues*

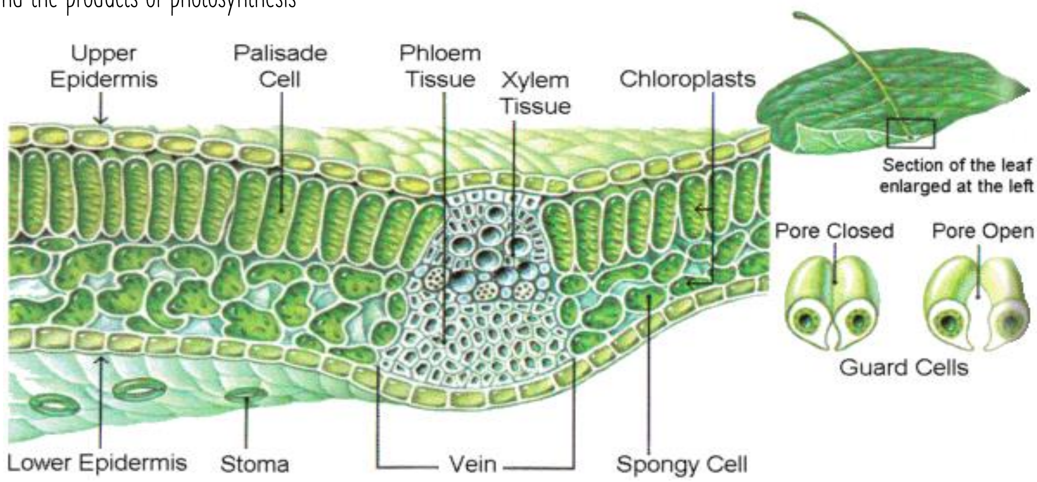
- The four main type of plant tissue: meristematic (like stem cells, in plants), vascular (transport of material), dermal (outer covering for protection) and ground tissues (photosynthesis, storage, support)




- The arrangement of cells into tissues, organs and systems allows for the efficient functioning of multicellular organisms
- The interaction and cooperation between cells, tissues, organ and systems provides multicellular organisms with abilities beyond the limitations of a single cell
- Autotrophs - organisms that generate their own food
- Heterotrophs, - organisms that rely on the environment for energy/nutritional requirements
- Non-Vascular plants (such as mosses) don't possess specialised structures for support and transport
- Most plants are vascular and possess transport systems to move substances around the plant and provide support
- Vascular plants contain a number of 'body' systems - the root, shoot and vascular system.
- Each system has specialised organs to carry out specific functions
- These organs allow the plant to obtain the required nutrients and gases and to carry out all functions effectively and efficiently
- The two types of vascular tissue are xylem and phloem
- Xylem tissue transports water and mineral ions
- Phloem tissue transports dissolved sucrose and other plant products around the plant
- The main functions of the root system are to anchor the plant into the soil and absorb water and mineral ions
- A large surface area is required for efficient absorption of water and mineral ions
- This large surface area is achieved with flattened epidermal cells that possess fine extensions called root hairs
- Branching root systems increase the surface area for absorption
- Water moves from the soil into the root by osmosis

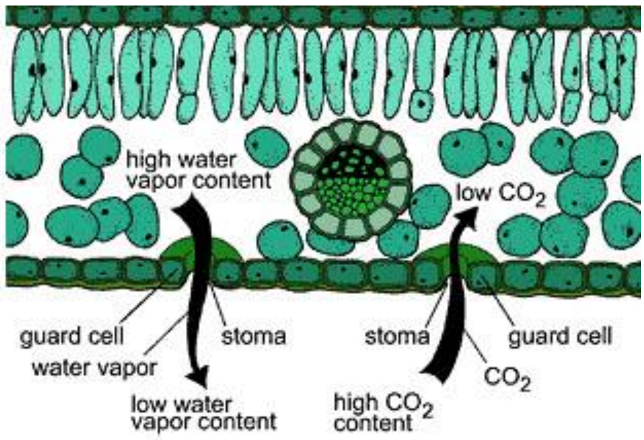


- Mineral ions usually move into the root by diffusion, but if the concentration gradient is too low they are moved in by facilitated diffusion or active transport
- Root cells do not contain chloroplasts and do not photosynthesise but, as with all living cells, they carry out aerobic cellular respiration
- Oxygen gas diffuses into the root cells and carbon dioxide gas diffuses out
- The stem provides structural support and a transport pathway between the roots and the leaves
- There are three main types of tissue in the stem:
  - Dermal tissue is the outer layer of the stem
  - Vascular tissue consists of the xylem and phloem tissue organised in vascular bundles
  - Ground tissue is all the parts of the stem that are not dermal tissue or vascular tissue
- The main function of a leaf is to absorb sunlight and carry out photosynthesis to produce the organic compound glucose
- The thin, flat structure and orientation of the leaf maximises surface area for absorption of sunlight
- A waxy cuticle minimises water loss from the leaf
- Palisade cells containing many chloroplasts are lined up vertically near the upper surface of the leaf to absorb sunlight
- Spongy mesophyll cells are loosely and irregularly organised to allow easy movement of gases through the leaf
- Transport tissue in the leaf is organised into veins. This provides the support as well as a pathway for the movement of water and the products of photosynthesis



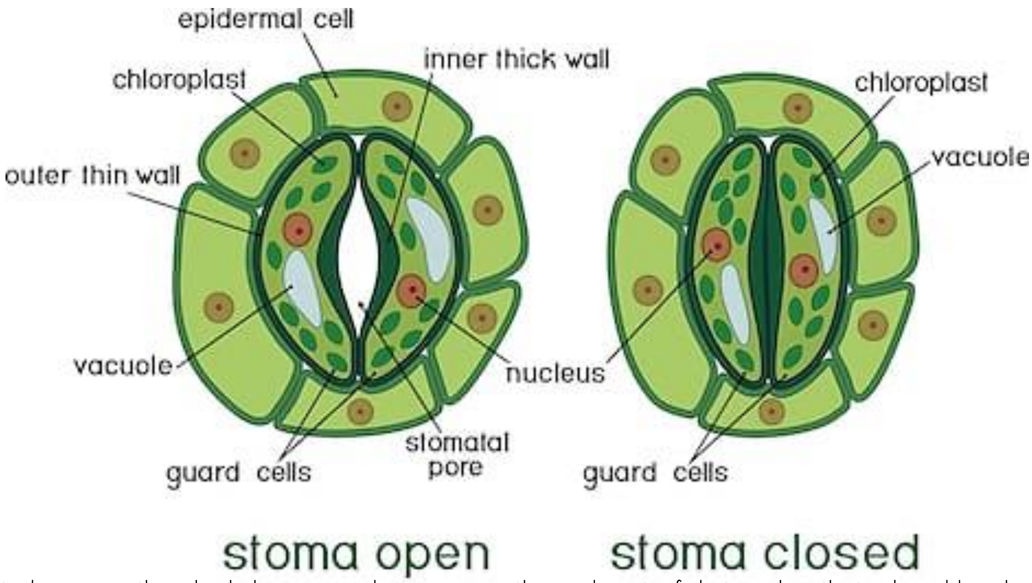

- Guard cells, which are often more numerous on the underside of the leaf, change shape to open and close pores known as stomata
- The gases oxygen and carbon dioxide are exchanged between the inside and outside of the leaf through stomata
- All plant cells carry out cellular respiration both at night and during the day
- Oxygen produced in photosynthesis is used in this process
- Radioisotopes are forms of an element that emit radiation, which can be detected by a number of means. They act as tracers and are used to follow the pathways of molecules involved in photosynthesis
- Radioisotopes were used to determine that oxygen produced in photosynthesis came from the water molecule and not the molecule of carbon dioxide
- Carbon - 14 added to the carbon dioxide supply traced the movement of the glucose produced through the plant

- New technologies can be used to produce 3D images of the structures and pathways involved in the movement of photosynthetic products
- Gas exchange in plants occurs through the stomata and lenticels

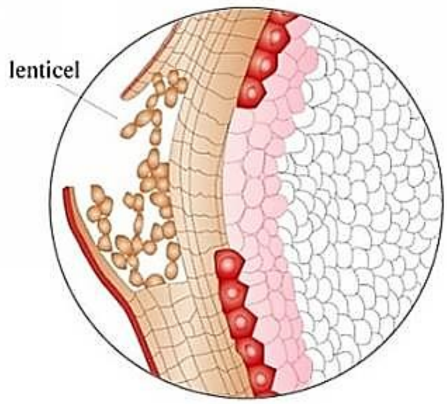



*Lenticels*

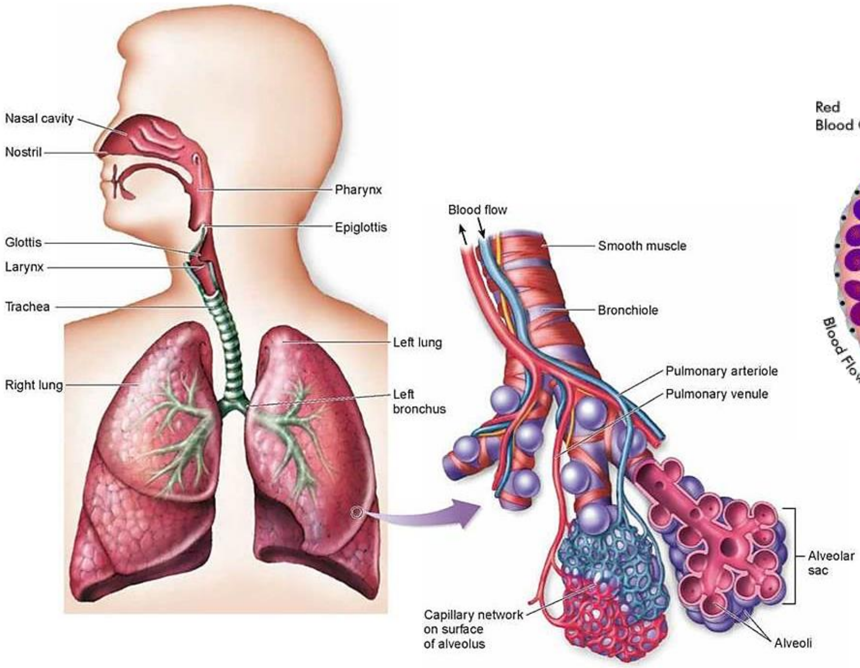
- When guard cells fill with water, they bend outwards and open the stoma, allowing for gas exchange
- When water is lost from the guard cells they straighten and close, preventing both gas exchange and water loss
- Plants have to balance their requirement for gas exchange and the necessity for water conservation
- Stomata open in light and close in the dark

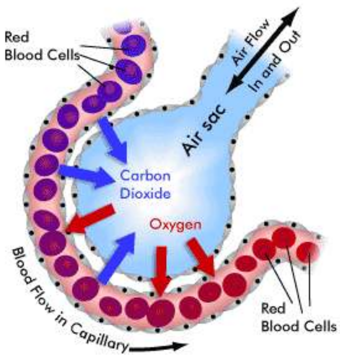



- Lenticels are pores through which gaseous exchange occurs in the woody parts of plants, such as the trunks and branches of trees and woody shrubs and the diffusion of gases through the lenticels is relatively slow

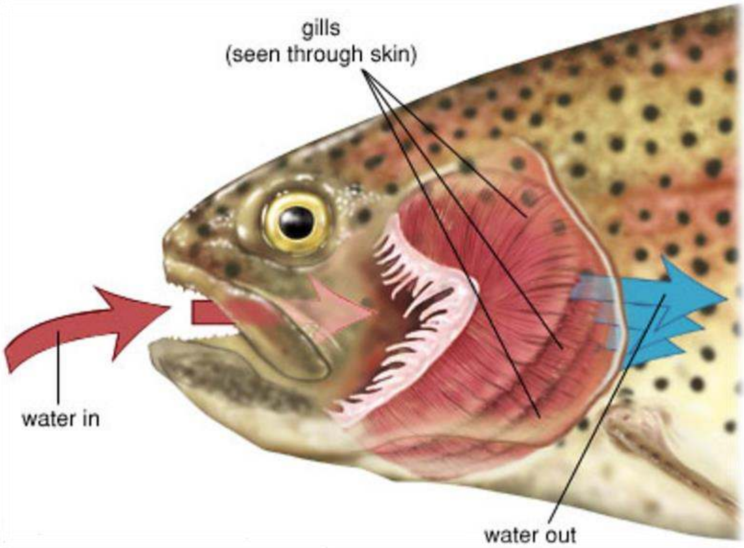


- The movement of gases between the external environment (alveolar air) and internal environment (bloodstream) is known as gaseous exchange
- Different animals possess different specialised structures to exchange gases with their environment
- Common characteristics of all respiratory surfaces are that they have:
  - a large surface area
  - thin, moist surfaces
  - a close proximity to transport systems
  - the concentration gradient maintained for continued diffusion
- Terrestrial animals have internal respiratory systems to reduce water loss
- Alveoli, located in the lungs, are the gaseous exchange surfaces in mammals
- Millions of alveoli in the lungs create a very large surface area for the exchange of gases
- The surface of the alveoli is very thin and moist. Many capillaries surround each alveolus
- Oxygen diffuses from where it is more concentrated in the alveoli into the capillaries where it is less concentrated
- Carbon dioxide is more concentrated in the capillary and diffuses out into the alveolar space

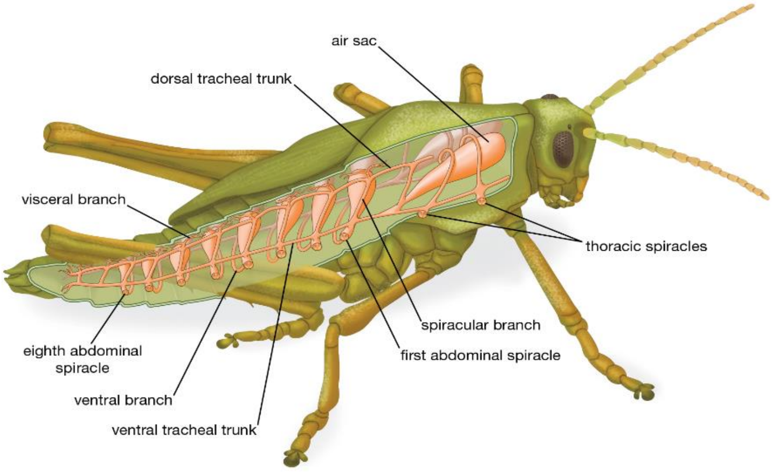


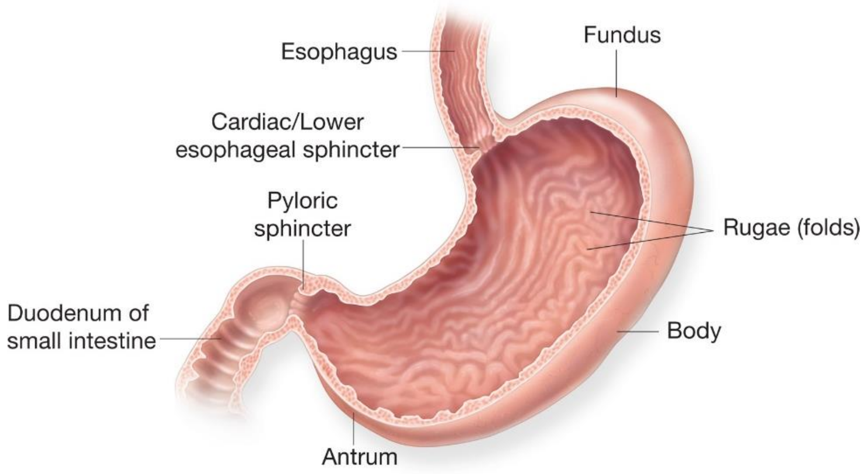

- Fish have specialised structures called gills to absorb the small amount of oxygen that is dissolved in water. Gills are well supplied with blood capillaries



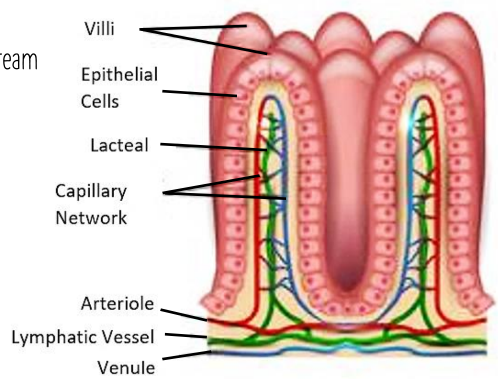
- Insects exchange gases via pores called spiracles, which lead to tracheal tubes, which then branch into smaller tubes called tracheoles
- The tracheoles bring air directly to and from the cells of the insect. Blood is not involved in the transport of gases in an insect

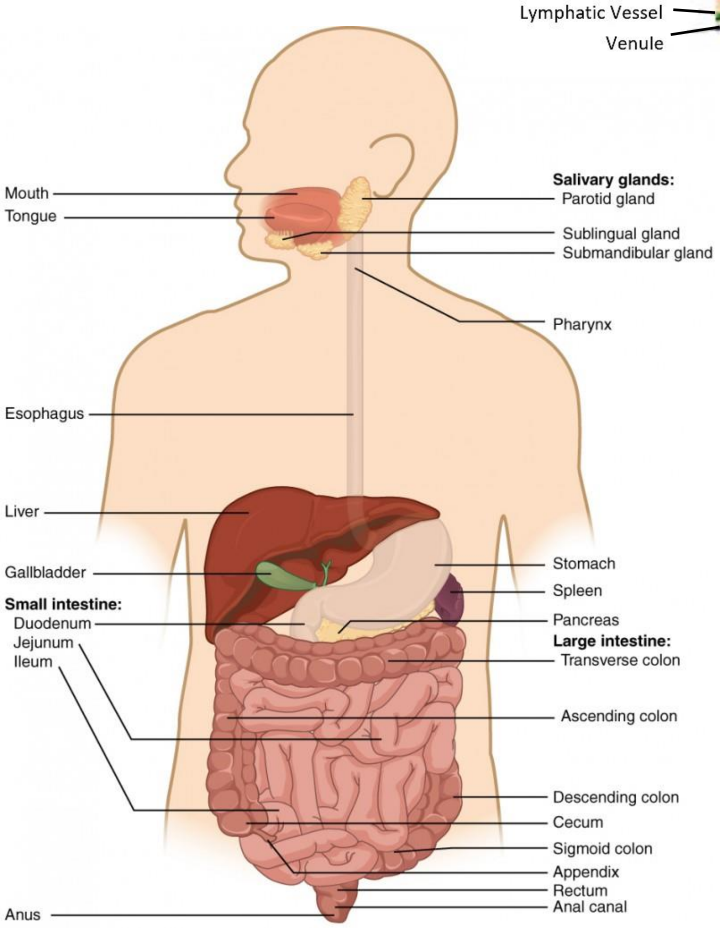



- Digestion is the breakdown of food into particles small enough to be absorbed into the bloodstream
- Mechanical digestion is the physical breakdown of the food into smaller pieces to increase the surface area for the action of enzymes
- The teeth and the churning motion of the stomach are the main ways in which mechanical digestion occurs
- Digestive enzymes enable the chemical breakdown of large, complex molecules into the small molecules that can then be absorbed into the transport systems of the body
- Complex molecules and their simple products formed after digestion are listed below:
  - Proteins are broken down into amino acids
  - Carbohydrates are broken down into simple sugars, such as glucose
  - Lipids are broken down into glycerol and fatty acids
- Mechanical digestion occurs in the mouth by the use of the teeth and the tongue
- Chemical digestion begins in the mouth with the enzyme salivary amylase breaking the complex carbohydrate starch down into simpler sugars
- The food forms into a bolus and travels down the oesophagus (which contracts to push the food down - peristalsis) into the stomach, where the epiglottis (flap of skin, near trachea) opens to allow the food to travel into the stomach where mechanical digestion is continued

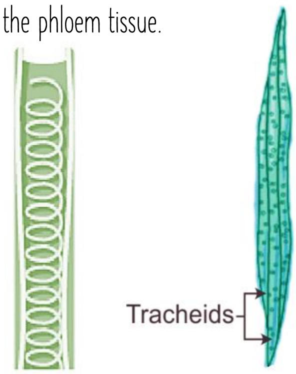


- Pepsin begins the chemical digestion of proteins in the chyme to form shorter peptide chains and the digestion of nucleic acids to nucleotides
- The small intestine is very long and folded and has three regions: the duodenum, the jejunum and the ileum
- Most digestion is completed in the duodenum
- The pancreas releases many different digestive enzymes and bicarbonate ions
- Bicarbonate ions neutralise the acidic chyme as it enters the small intestine
- Bile produced by the liver and stored in the gall bladder emulsifies fat molecules to increase surface area for breakdown by lipases
- Other enzymes complete the chemical breakdown of larger molecules
- Most absorption of products of digestion occurs in the jejunum
- Villi are microscopic projections on the wall of the jejunum that are one cell thick. There are blood capillaries and lymph vessels in close contact with these cells, which absorb glucose/amino acids, while lacteals (connected to lymph system) absorb fatty acids & glycerol as well as water
- Small molecules diffuse or are actively transported through the walls of the villi into the capillary or lymph vessels to be distributed throughout the body
- Water and mineral salts are absorbed from the large intestine into the bloodstream
- The remaining undigested material is called faeces and is stored in the rectum before being eliminated from the body or being excreted
- Digestive products absorbed into the body are used in many different ways, including for structural purposes and for energy storage

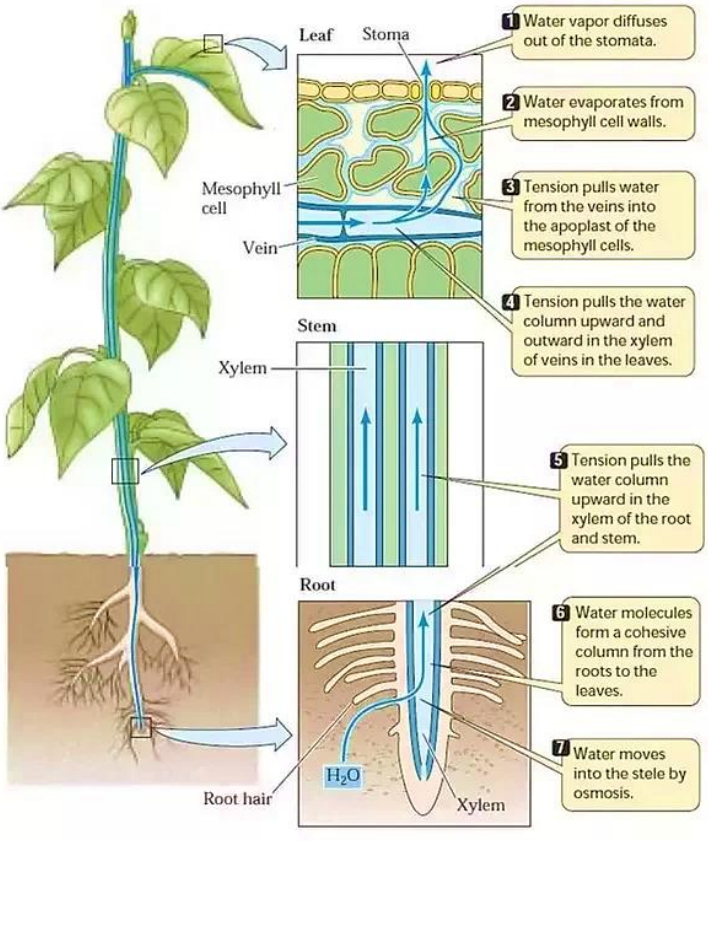


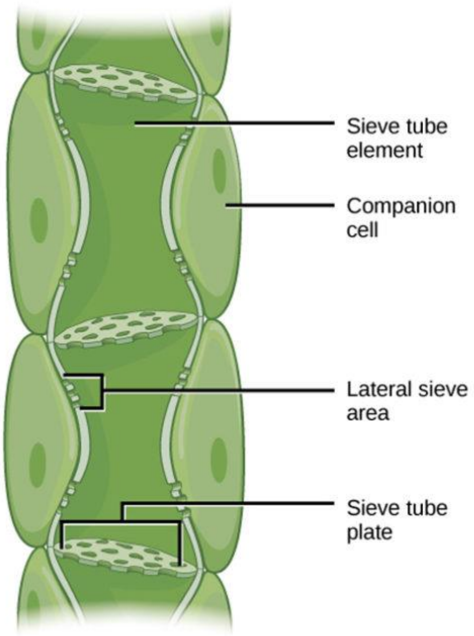
- Autotrophs and heterotrophs require gases and nutrients to maintain efficient and effective metabolic function
- Both heterotrophs and autotrophs require inorganic and organic substances, water and oxygen gas. Autotrophs also require carbon dioxide gas
- Heterotrophs need to take in all their nutrients. Autotrophs produce their own organic nutrients using the energy from the sun, but need to obtain water, mineral ions and the gases carbon dioxide and oxygen
- Autotrophs manufacture their own glucose and other organic substances from inorganic nutrients
- Heterotrophs must obtain all their organic nutrients by consuming autotrophs or other heterotrophs
- Transport systems in plants carry water and mineral ions in one direction only, from the roots to the leaves, in the xylem tissue. The products of photosynthesis are delivered wherever required around the plant in the phloem tissue.
- Xylem tissue is composed of xylem vessels and xylem tracheids (long structures with end walls that taper to a point, where they come into contact with another and overlap; water molecules and dissolved ions pass from tracheids through small holes called pits)
- Xylem vessels are long, thin, continuous tubes composed of dead tissue (cell contents break down to become hollow) with lignin-strengthened walls and fibres (for support)
- The transpiration-cohesion-tension theory explains the movement of substances up the xylem vessels

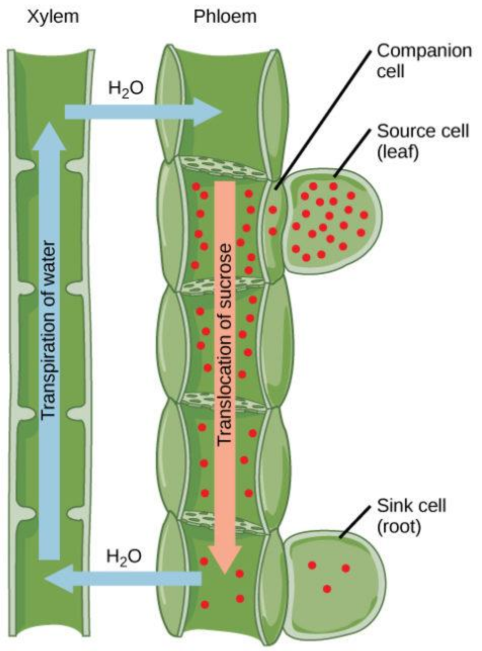



- In the transpiration-cohesion-tension theory water evaporates from the leaves and creates tension, which pulls more water from the veins and then up the xylem vessel
- Cohesion between the water molecules and adhesion between the water molecules and the walls of the xylem maintain the column of water. When water molecules are pulled up, other molecules follow.
- A small amount of root pressure forces the water already present in the xylem vessel upwards.



- Phloem tissue is composed of two types of living tissue: sieve tube cells and companion cells
- Sieve tube cells are lined up one under the other and have sieve plates (perforated cell walls) at each end. The products of photosynthesis move through these tubes in a process called translocation (distribution of photosynthetic products)
- Companion cells assist the sieve tube cells
- The movement of the products of photosynthesis in any direction is explained by the source-sink theory
- Sugars are actively loaded at the source of production; water diffuses in from the xylem by osmosis, creating a high-pressure region Sugars are actively unloaded where required at the sink; water diffuses out by osmosis, creating a low-pressure region
- Materials in the phloem move from a high-pressure region to a low-pressure region




- Our scientific understanding of the structure and functioning of plants has been developed by scientists over many years
- Hypothesis, theories and models are modified when required if new information and results indicate they are no longer correct
- Many scientists have contributed to our understanding of photosynthesis and the transpiration-cohesion-tension as shown below:

**1643:**

Jan Baptista Van Helmont conducted experiments which led him to conclude that trees consumed water, not soil.

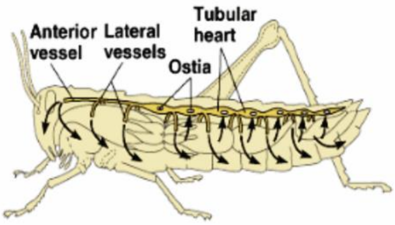
**1744:**

Joseph Priestly discovered a gas, dubbed "dephlogisticated air" by focusing solar rays on mercuric oxide. This gas was later named "oxygen."

**1778:**

Jan Ingen-Housz discovered that plants emitted oxygen gas in light, thereby initializing the concept of photosynthesis.

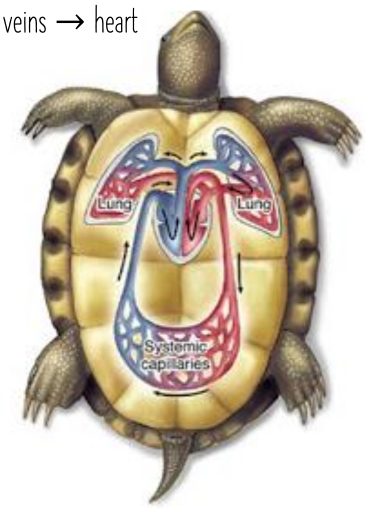
- Open circulatory systems contain a heart that contracts and pushes haemolymph (blood & tissue fluid) through the vessels to bathe the organs
- When the heart muscle relaxes, the heart expands and the fluid is drawn back into the heart
- Haemolymph only transports nutrients and wastes; gases are exchanged in a different system



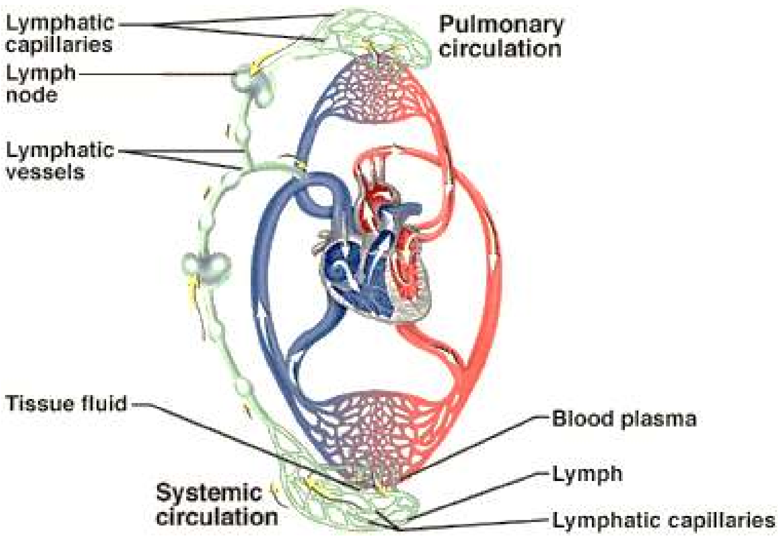

*Open Circulatory System of a Locust*

- Closed circulatory systems contain blood that is totally enclosed in vessels, with a heart providing the driving force to push the blood around the body
- The pathway of blood in blood vessels from the heart, around the body and back to the heart is shown in the flow chart: arteries → arterioles → capillaries → venules → veins → heart

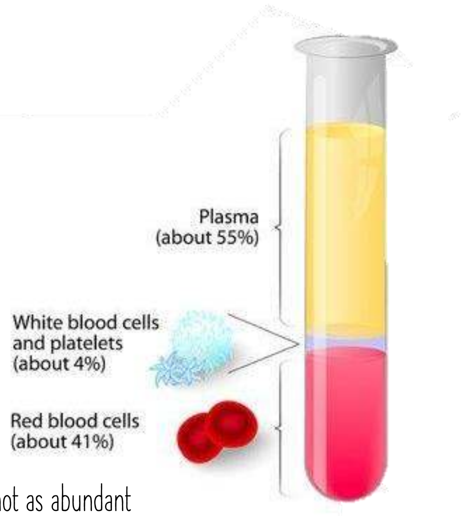
*Closed Circulatory System of a Turtle (Double Circulation - Lungs + Body)*



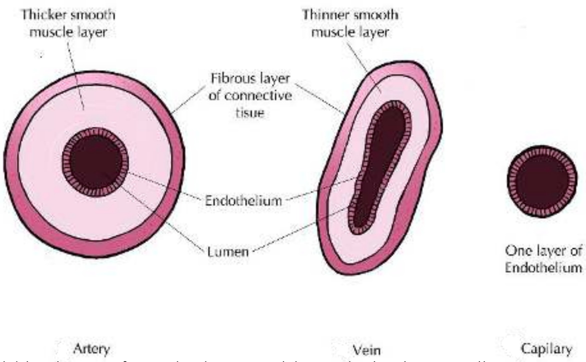

- There are two transport systems in mammals: the cardiovascular system and the lymphatic system
- The lymphatic system transports excess tissue fluid back to the cardiovascular system and is made up of lymph vessels and a fluid called lymph. It prevents the build-up of excess fluid, helps maintain the volume of blood/blood pressure and also plays a role in the defence of the body
- The cardiovascular system is made up of blood, the heart and blood vessels



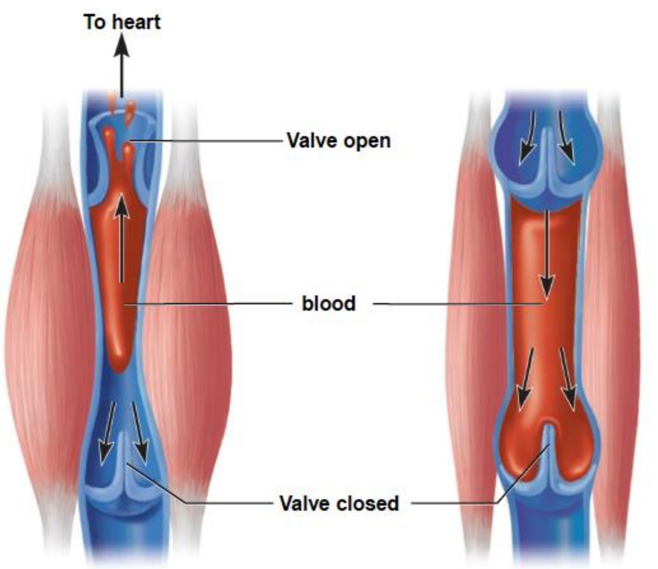
- Blood is composed of 55% plasma and 45% blood cells (white, red & platelets)
- Blood distributes heat, nutrients, gases, wastes, hormones, antibodies & other substances required by the body
- Red blood cells are produced in the bone marrow with a life of 4 months (erythrocytes - approx. 7μm in diameter) have no nucleus, with a biconcave shape and haemoglobin which carries oxygen
- White blood cells (leucocytes) contain a nucleus and are also produced in the bone marrow. They play a role in the immune system by destroying foreign bodies/pathogens and are about 50% bigger than red blood cells but not as abundant



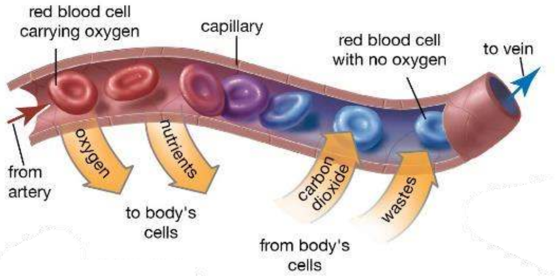

- Platelets (thrombocytes) have a tiny, crescent shape and are also produced in the bone marrow. They play a key role in blood clotting and are about 50% of the size of red blood cells.
- They create clots near a wound when blood is exposed to air by sticking to fibres near the wound. They then release the enzyme thromboplastin which helps the blood clot
- Plasma (made of mainly water & proteins) is a pale-yellow colour liquid that carries the blood cells and many other dissolved substances that are required by the cells
- The three types of blood vessels are arteries, capillaries and veins



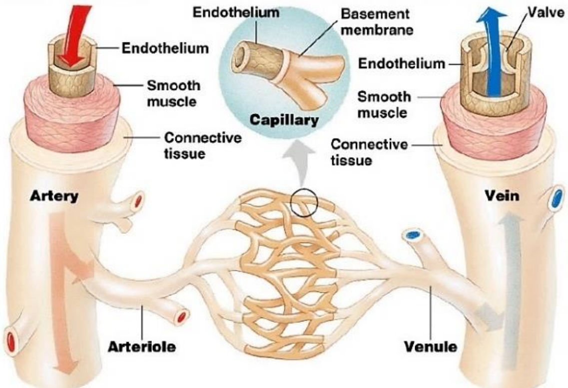

- Arteries carry oxygenated blood away from the heart and have thick, elastic walls to cope with the pressure of pulsing blood. These walls expand and return to their original diameter, helping to propel the blood.
- Veins carry deoxygenated blood back to the heart and have thinner walls because they don't have to cope with blood under pressure
- Veins contain valves to ensure that the blood moves in one direction



- Capillaries form networks so that all cells can be supplied with nutrients and gases, and wastes can be removed
- Capillary walls are one cell thick to allow easy exchange between blood and cells
- Only one cell at a time can move through capillaries; this increases their exposed surface area for exchange of gases, nutrients and wastes




- A diagram of the movement of blood between all three vessels is below:




- Mammals have a four chambered heart with two chambers on each side. The top chamber on each side is called the atrium and the bottom chamber on each side is the ventricle.
- The septum in the middle separates the two sides of the heart
- The left ventricle has a thicker muscular wall because it has to pump blood all around the body while the right ventricle only has to pump blood to the lungs
- Deoxygenated blood (from the body) enters the right atrium (via the inferior and superior vena cava veins) and then moves to the right ventricle from which it is pumped to the lungs (by the pulmonary artery) to gain oxygen
- Oxygenated blood flows back (from the lungs) to the left atrium (via the pulmonary veins) and then to the left ventricle from which it is pumped to the rest of the body (by the aorta) before it once again returns to the right atrium

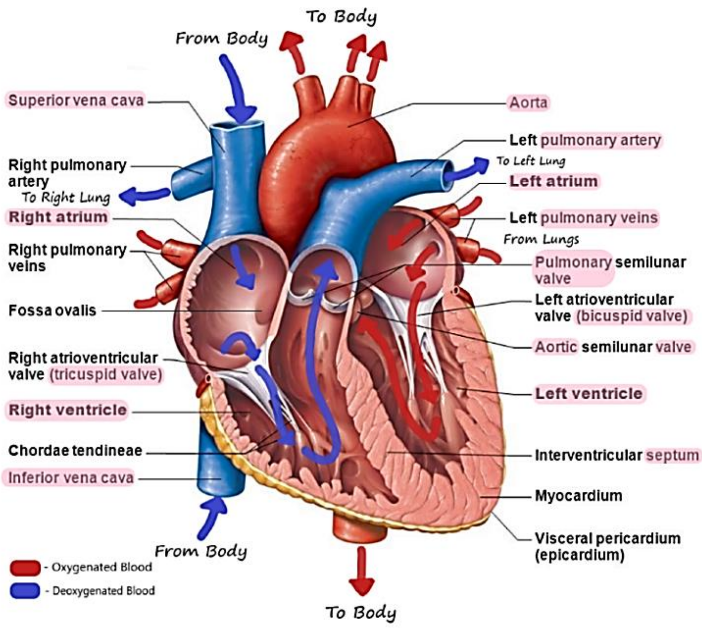
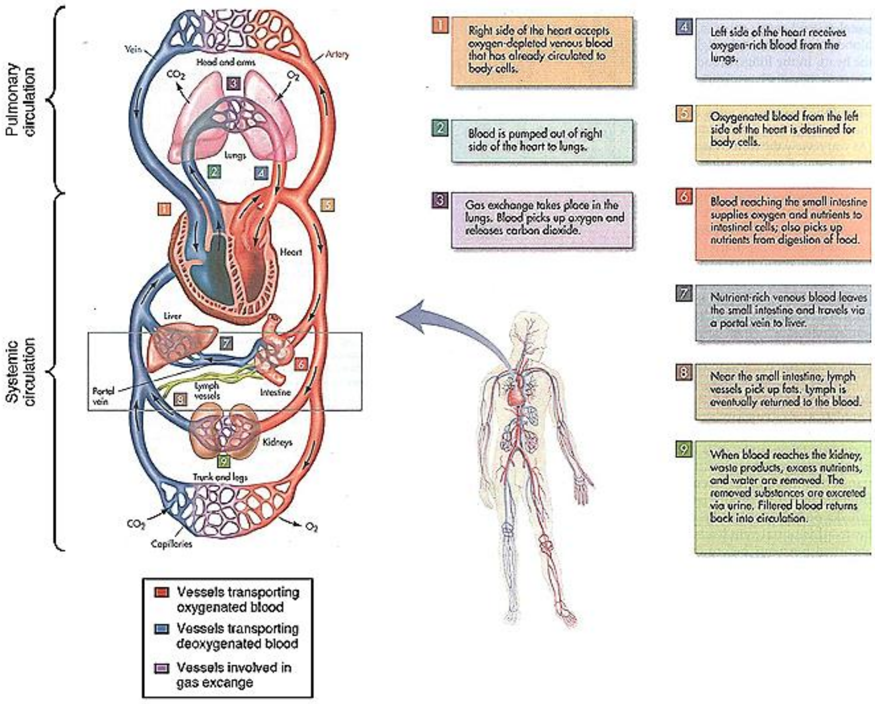



*Diagram of Heart with blood flow*
*(Important parts are highlighted)*

- Systematic Circulation - pumping of oxygenated blood to all parts of the body and the return of deoxygenated blood back to the heart
- Pulmonary Circulation - pathway of blood from the heart to the lungs and back




- The composition of blood changes as it moves around the body and depends on the organ it is moving through
- In all organs and tissues except the lungs, blood loses oxygen and gains carbon dioxide. In the lungs, it gains oxygen and loses carbon dioxide
- In all organs except the small intestine, blood loses nutrients, such as the products of digestion, and gains wastes. Blood gains products of digestion in the small intestine
- In the kidneys, blood has less urea when it leaves, and the concentration of water and salts will have changed according to the requirements of the body

# MODULE 3 - BIOLOGICAL DIVERSITY

- An ecosystem is made up of organisms (biotic) living in an area that interact with each other and with the non-living (abiotic) environment in which they live
- Biotic features of ecosystems vary widely in response to the abiotic features of the environment
- Abiotic and biotic factors act on the characteristics of organism and effect the ability of an organism to survive and reproduce in a particular environment
- Biotic and abiotic factors exert selection pressures that influence the survival and reproduction of an individual, population or species
- Biotic and abiotic selection pressures affect the distribution and abundance of organisms in an ecosystem
- Rainfall, temperature and landform patterns significantly effect the abundance and distribution of organisms in ecosystems in Australia
- Ecologists study the distribution and abundance of organisms and how these properties are affected by interactions between the organisms and their environment
- Sampling techniques are used to calculate the abundance of organisms. These techniques include the use of quadrats to estimate the percentage cover for plant species OR using formula (estimated abundance of species in an area = total no. of individual counted x total area/area of each quadrat x no. of quadrats) and the mark-release-recapture technique with the formula: N = M x n/m

  OR (Total population (N) = no. marked in first sample (M) x total no. of animals recaptured (n)/no. or recaptured animals that are marked)
- Examining population trends can lead to inferences about the species and what abiotic and biotic factors they are most suited to
- If selection pressures in a habitat change, some individuals with characteristics best suited to the changed selection pressures will survive and produce more offspring than those individuals with less suited characteristics
- Cane toads have caused rapid population changes in the diversity of native animal species in the course of their Australian invasion
- Introduction of a biological predator acted as a selection pressure to reduce the abundance and spread of prickly pear in Australia