# BIO SEM 2

## Human effects

**Biodiversity:** the variety of all living things on earth
**Local damage:** damage of an ecosystem in a small area
**Extinction:** when the entire population of a species dies (the eventual disappearance of a species due to death overtime)
**Local extinction:** when a species disappears over a small part of a range. Too many local extinctions will lead to total extinction.
**Mega-fauna:** large terrestrial animals. E.g. elephants, giraffe
**Switching predator:** predators that hunt several prey species. E.g. hedgehogs, humans
**Biological hotspot:** a place where there are thousands of species living (high density area)

### Pollution

occurs when an amount of any substance or any form of energy is put into the environment at a rate faster than it can be dispersed or safely stored

### Bioaccumulation

the accumulation over time of a substance and especially a contaminant (such as a pesticide or heavy metal) in a living organism.
effects on nature –

A chemical will accumulate if it is taken up and stored faster than it is broken down and excreted. Synthetic chemicals enter the environment in air, water, and soil. Chemicals enter organisms through food intake, skin contact, or respiration. If the accumulation of a substance is too high, it can be harmful. (Some chemicals are temporarily stored in fat tissue but are released from storage when fat is burned for energy). These chemicals can harm the animal if they are not metabolized (chemically changed) or excreted in the feces or urine. Synthetic and organic chemicals can affect animals' nervous, immune, and reproductive systems. Bioaccumulation of these chemicals can cause birth defects in offspring or a complete failure to reproduce. These chemicals affect not only individual organisms but also entire ecosystems when keystone species are affected.

e.g. –

Typically, mercury (or a chemical version called methylmercury) is taken up by bacteria and phytoplankton. Small fish eat the bacteria and phytoplankton and accumulate the mercury. exposure to mercury can lead to reduced liver function and metabolism, altered behaviour, impaired reproduction, deformity, damage to the gills and olfaction organs, and mortality. In Minimata bay in Japan large amounts of fish were exposed to mercury which caused humans that are the fish to also be exposed and get sick or die

### Biomagnification

the process by which a compound (such as a pollutant or pesticide) increases its concentration in the tissues of organisms as it travels up the food chain
effects on nature -

- Chemicals bioaccumulate and become biomagnified when pollutants are stored in plant tissue and in the fat tissue of animals. Chemicals remain trapped in plants and animals until they are eaten and the tissues and fats are broken down for energy. herbivores eat large quantities of plants and carnivores eat many times their body weight of prey during their lifetimes. For this reason, even small concentrations of chemicals in producers and primary and secondary consumers can build up to cause problems at higher trophic levels.

e.g. –

DDT (**d**ichloro **d**iphenyl **t**richloroethane)

- DDT is a chemical pesticide that is sprayed on crops and subsequently washed into waterways at low concentrations.
- It is fat-soluble and is selectively retained within the tissues of an organism instead of being excreted
- When DDT is sprayed on the water to eliminate mosquito larvae, it is taken up by algae and passed on to primary consumers
- At each subsequent trophic level, the concentration of DDT stored in the body increases due to increased food intake
- Very high levels of DDT were discovered in birds that preyed on fish and were found to interfere with eggshell formation.
- Birds exposed to high levels of DDT were found to produce thinner shells, which decreased the survival rates of fledglings.

**Eutrophication**

Eutrophication is a natural process that results from accumulation of nutrients in lakes or other bodies of water. Algae that feed on nutrients grow into unsightly scum on the water surface, decreasing recreational value and clogging water-intake pipes.

Occurs in a body of water and when there are too many nutrients present
Nitrates and phosphates (from fertilisers) are washed in the rivers or lakes. This leads to increased nutrient concentration.
Nutrients are food for algae and they then grow and reproduce quickly
When the algae grows to a large amount it creates a thick layer on the surface of the water and the algae will use the sunlight so it can't reach the bottom. The plants on the bottom need sunlight to photosynthesis but without it they will die.
The algae will then die when all the nutrients are used in the water.
Decomposers such as bacteria will break down the dead plants are return more nutrients to the water.
The bacteria with a large food source will also grow into large numbers consuming oxygen as they grow and respire
There is not much water to begin with so when the bacteria consume it, it may run out quickly. Water without oxygen is called anoxic. If the water become anoxic all non-bacterial life in the water will die - Making the environment unliveable.
Which is why humans should be careful when using fertilizers.

**5 main human effects:**

- Overharvesting:
    - overharvesting, exploiting a natural resource until its supply is so diminished that its exploitation is no longer sustainable. When the resource is being harvested at a faster rate than it can reproduce and recover. This can lead to the extinction of a species.
    - E.g.
- Introduced (alien) species:

    - The introduction of species to places where they are not native. This can cause the decline or extinction of native species, outcompeting them for food, water and space, preying upon them or introducing them to new diseases
    - E.g. wildcats in Australia
    - E.g. Pythons in everglades
        - The everglades is a wetland in southern Florida, once abounded with rabbits, racoons and other small mammals.
        - Roughly 15 years ago these species started becoming scarce by the Burmese python.
        - These pythons are native to southeast Asia and were released to the everglades by people who kept them as exotic pets.
        - They eat a variety of animals and even large alligators. Once they came to the everglades, sightings of racoons and opossums dropped by 99%.
        - There is no solution to this problem discovered. They are very difficult to catch and researchers don't know how to measure their size or population. (2015)
        - Now (2023) they are being killed and sold around the area.

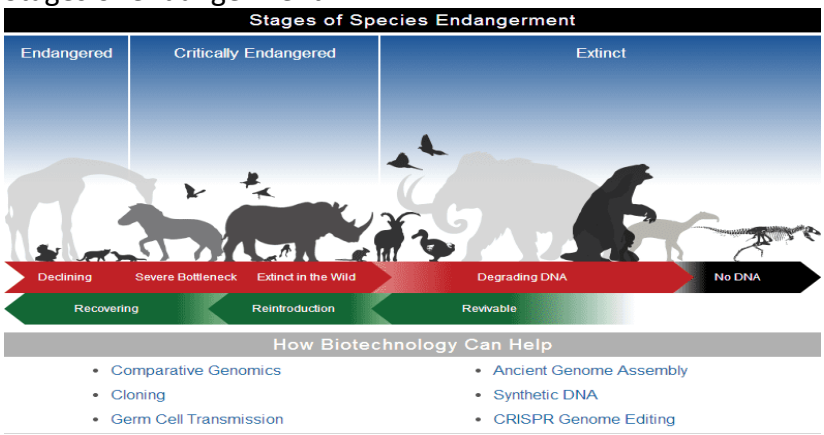
- Habitat destruction:
    - the process by which a natural habitat becomes incapable of supporting its native species from primarily human destruction.
    - E.g. cutting down trees for land to build buildings, farms, and houses.
- Ilandisation/Fragmentation:
    - Closely related to habitat destruction, when habitats are broken down from one large area into smaller fragments of land (habitat)
    - E.g. an area of forest could be split in the middle by a road, large animals can cross the road but small creatures would be to scared to cross and therefore be stuck in one area, this ends up with species living in isolated populations which leads to extinction.
- Pollution:
    - The introduction of harmful materials/chemicals called pollutants into our environment/ atmosphere. This leads to global warming because heat can't escape the atmosphere and heats up our planet. This causes sea levels to rise.
    - Some animals can not live in high temperatures, and it becomes a problem, animals that live on ice/glaciers are losing their habitat due to ice melting.

**Threats to biodiversity:**

- Habitat destruction
- Habitat fragmentation
- Pollution
- Over exploitation

- Introduction of exotic species
- Diseases
- Poaching of wildlife

**Extinction:**
Stages of endangerment –




## Conservation strategies

**Environmental strategies**
Revegetation: Is the process of replanting and rebuilding the soil of disturbed land.

Control of introduced species: strategies for controlling invasive species include using fences to exclude species, traps and poison to try and reduce invasive species populations. Some biological control methods include using natural predators or parasites and disease-carrying bacteria and viruses.

**Genetic strategies**
Gene/ seed banks: Gene banking is a method to preserve a wide variety of species. They work by collecting genetic samples from organisms and store them in frozen vaults. This genetic material can be used for research, breeding or re-introduction. A seedbank is a type of gene bank were seeds are stored to preserve genetic biodiversity.

Captive breeding programs: captive breeding programs are used to prevent extinction of species. These programs work by providing a safe, controlled environment to produce offspring which are given a head start in life by protecting them from predators, weather conditions and providing them with nutrition.

**Management strategies**
Protect areas:

Restricted commercial and recreational access:

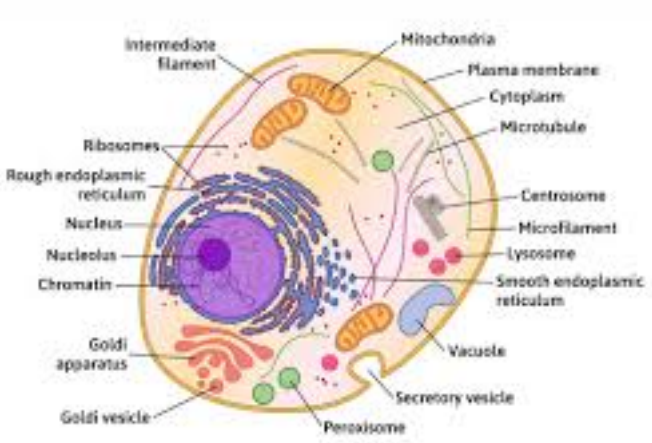
**In situ:** refers to conservation where the animal remains in its original home. E.g. wildlife sanctuaries or national parks. The land is protected and the animals can remain in their original home.

**Ex situ:** conservation where the animal is removed from its home and placed in man-made habitats. E.g. zoo, seed bank and gene bank. This allows for specialists to monitor and learn more about the animal.

## Cells as the basis of life

- *cells require energy inputs, including light energy or chemical energy in complex molecules, and matter, including gases, simple nutrients and ions, and removal of wastes, to survive*
- *prokaryotic and eukaryotic cells have many features in common, which is a reflection of their common evolutionary past, but prokaryotes lack internal membrane-bound organelles, do not have a nucleus, are significantly smaller than eukaryotes, usually have a single circular chromosome, and exist as single cells*
- *metabolism describes the sum total of the physical and chemical processes by which cell components transform matter and energy needed to sustain life*
- *eukaryotic cells carry out specific cellular functions in specialised structures and organelles, including*
    - *cell membrane*
    - *cell wall*
    - *chloroplasts*
    - *endoplasmic reticulum (rough and smooth)*
    - *Golgi apparatus*
    - *lysosomes*
    - *mitochondria*
    - *nucleus*
    - *ribosomes*
    - *vacuoles*
- *the currently accepted model of the cell membrane is the fluid mosaic model*
- *the cell membrane separates the cell from its surroundings and controls the exchange of materials, including gases, nutrients and wastes, between the cell and its environment*
- *movement of materials across membranes occurs via*
    - *passive processes, including diffusion, facilitated diffusion, osmosis*
    - *active processes, including active transport, endocytosis and exocytosis*
- *factors that affect exchange of materials across membranes include*
    - *the surface area to volume ratio of the cell*
    - *concentration gradients*
    - *the physical and chemical nature of the materials being exchanged*
- *biological molecules are synthesised from monomers to produce complex structures, including carbohydrates, proteins and lipids*
- *biochemical processes in the cell are controlled by factors, including the nature and arrangement of internal membranes, and the presence of specific enzymes*
- *enzymes have specific functions which can be affected by factors, including*
    - *temperature*
    - *pH*
    - *presence of inhibitors*
    - *concentrations of reactants and products*

- *two models that are used to explain enzyme action are the lock and key model and the induced fit model*
- *photosynthesis is a biochemical process that uses light energy to synthesise organic compounds; light dependent and light independent reactions occur at different sites in the chloroplast; and make up separate parts of the overall process that can be represented as a balanced chemical equation*
- *the rate of photosynthesis can be affected by the availability of light and carbon dioxide, and temperature*
- *cellular respiration is a biochemical process that occurs in different locations in the cytosol and mitochondria, and metabolises organic compounds, aerobically or anaerobically, to release useable energy in the form of ATP; products of anaerobic respiration vary between organisms (plants, yeast, bacteria, animals); the overall process of aerobic respiration can be represented as a balanced chemical equation*
- *the rate of respiration can be affected by the availability of oxygen and glucose, and temperature*




## Cell structure:

EUCARYOTE:

Organelles ---------

Nucleus:

- contains DNA, contains RNA -used to code to make ribosomes.

Nucleolus:

- produces and assembles the ribosomes

DNA:

- code for the instructions that control all aspects of the cell.
- Ability to pass on hereditary info

Nuclear pore:

- Regulates what goes in and out of the nucleus

Nuclear membrane:

- To contain the nuclear material, so it stays protected

Chromatin:

- contains DNA wrapped in histones

Cytoplasm:

- the cite of all cell activities (cell, jelly)

Ribosome:

- read code of RNA and make protein (poly ribosome, rough er ribosome)

Rough endoplasmic reticulum:

- a transport system for the proteins make by ribosomes

Smooth endoplasmic reticulum:

- a transport system for material

Cell membrane:

- regulates the entry and exit of material in the cell

Microtubule:

- give cells form/ structure (suspend organelles)

Mitochondria:

- turns oxygen and glucose into energy for the cell in the process of cellular respiration

golgi body:

- packages materials in vesicles
- synthesis of materials
- modification of materials

centrioles:

- form spindle network for miotic division

lysosome:

- breakdown of excess waste or material in the cell (digestive enzymes), removes excess material and unwanted waste.

Vesicle:

- Vesicles are involved in metabolism, transport, buoyancy control, and enzyme storage.
- They can also act as chemical reaction chambers.

Other-------

- in the nucleus is DNA which is assembled in chromatin (tangled and wrapped in proteins called histones). When DNA needs to replicate, it will assemble into 46 chromosomes.
- Can be unicellular (e.g. protist) or multicellular (e.g. animal, plant)

PLANT (differences):

Chloroplast:

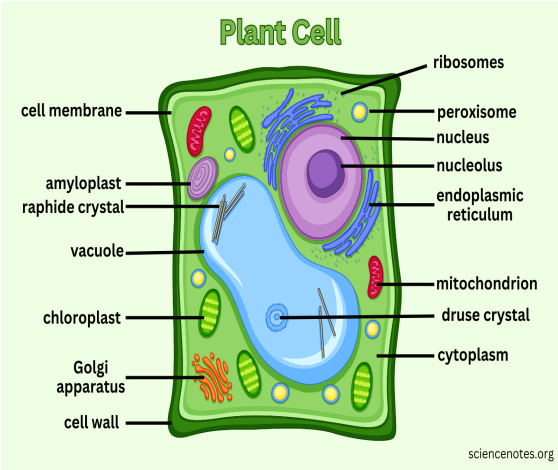
- is the organelle is involved in photosynthesis
- produces energy and glucose for the plant to grow
- releases oxygen as a by-product of photosynthesis

Vacuoles:

- storage, waste disposal, protection, and growth

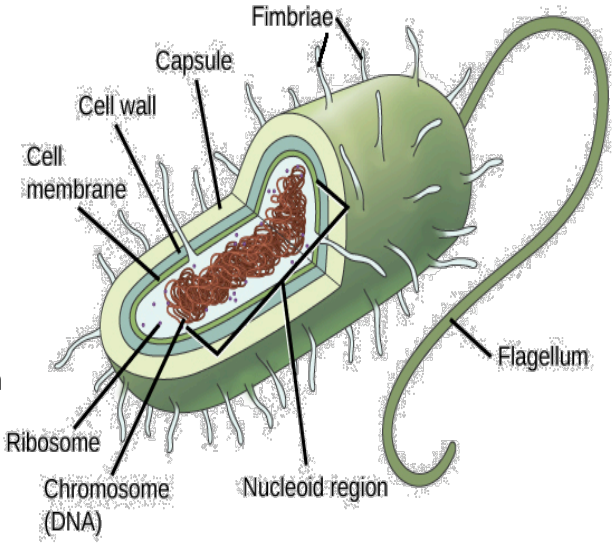
Cell wall:

- plants have both cell walls and membranes. The cell walls provides protection and strength.
- is thick and has a fixed shape (compared to cell membrane)
- is fully permeable to small molecules (unlike selectively permeable cell membranes)



PROKARYOTE (differences):

- unicellular (e.g. bacteria, archaea)
- no membrane-bound nucleus. (genetic material is free to float around in the nucleoid region)
- have 1-4 chromosomes
- no mitochondria, rough or smooth endoplasmic reticulum, Golgi body.
- Have a cell wall.
- Some prokaryotes have additional flagella (role in cell movement) or pili (role in movement and adherence to surfaces)
- Since there are no mitochondria, respiration takes place in cytoplasm.

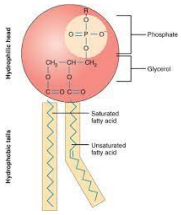



## Cell membrane:

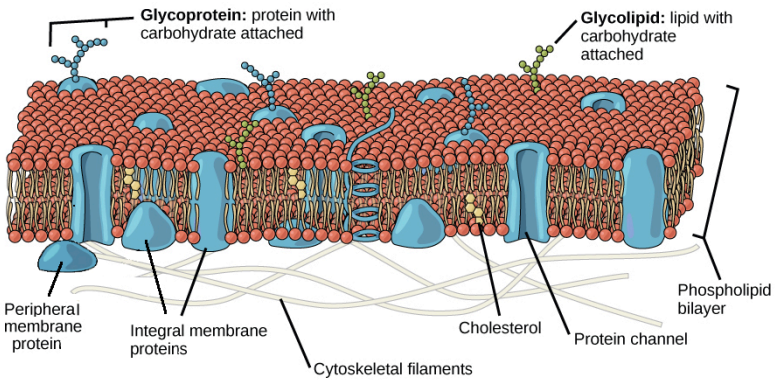
**Membrane functions:**

- Physical barrier
  - Separates intracellular from extra cellular that have different compositions
  - Extracellular fluid includes Tissue fluid (Intercellular / Interstitial fluid) & Blood plasma
- Regulations of what enters/leaves
  - Selective permeability (semi permeable)
  - Regulates homeostasis.
- Sensitivity
  - First part of the cell affected by any changes in the extracellular fluid. 
    Receptors that are sensitive to particular molecules
- Support
  - Attacked to the cytoskeleton

**Structure of membrane:**



- Fluid mosaic model meaning it includes a lot of different molecules and it is constantly moving
- Only lipid-soluble substances can pass through the lipid portion of the membrane. Proteins channels are used to pass through non lipid soluble substances.
- The structure is made of a phospholipid bi-layer
- Phosphate molecules (the head) and attached to lipids (the tail)
- Phosphate head is hydrophilic meaning water loving.
- Lipid tail is hydrophobic meaning water hating.
- Embedded in the bi-layer are cholesterol molecules that stiffen, while also maintaining fluidity




**Proteins embedded in bilayer:**

- Channel proteins (transmembrane protein)
    - Form a channel for smaller molecules to pass through
    - Used for simple diffusions.
- Carrier proteins (transmembrane protein)
    - Bind to larger molecules and help them pass across the membrane
    - Used for facilitated diffusion and active transport
- Receptor proteins
    - Molecules outside bind with the receptors and cause a change within the cell
    - Each receptor will only bind with one cell
    - E.g. The hormone Insulin binds to a specific receptor protein and this leads to an increase in glucose absorption by the cell.
- Recognition proteins
    - Have carbohydrate group projecting from the membrane that act as ID tags allowing the cell to be recognised as self or non self
    - This helps prevent an attack on itself by the immune system
- Glycoprotein
    - Glycoproteins in the cell membrane have many vital roles including cell signalling, cell-cell recognition, and cell adhesion. Cell adhesion provides structural integrity, and cell-cell recognition helps the immune system recognize antigens from pathogens
- Glycolipid
    - lipids that are found on the extracellular face of eukaryotic cellular membranes, and function to maintain stability of the membrane and to facilitate cell–cell interactions. Glycolipids can also act as receptors for viruses and other pathogens to enter cells.
- Peripheral protein
    - is a protein that is found temporarily attached to the cell or mitochondrial membrane. Peripheral membrane proteins attach to the membrane but are not embedded in it. The peripheral membrane proteins function in support, communication, enzymes, and molecule transfer in the cell
- alpha helix protein
- gated protein

## Cell Transport:

Passive transport (does not require energy)

- Diffusion
- Osmosis
- Facilitated diffusion

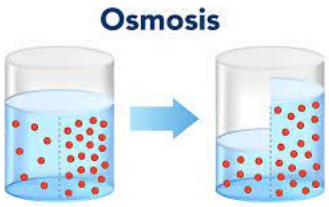
Active transport (requires energy)

- Active transport
- Vesicular transport

**Diffusion (passive):**

- The movement of liquids and gases from an area of higher concentration to an area of lower concentration, along a concentration gradient, until the concentrations are equal.
- Types of diffusion depend on the type of molecule.
    - Lipid soluble molecule (lipophilic):
    - These are able to diffuse through the phospholipid bi-layer
    - E.g fatty acids, oxygen and carbon dioxide
    - Water soluble molecule:
    - Pass through the channel proteins (if they are small enough to fit through)
    - Water can diffuse through membrane because they are small, this will happen slowly because water is polar.
    - E.g. water, sodium ions

**Osmosis (passive):**




- Diffusion of water across a semi-permeable membrane from an area of high water (low solute )concentration to an area of low water (high solute) concentration.
- Water moves through the channel protein
- The concentration depends on how much solute is dissolve in it
- If there is a high concentration of solute it means there is high osmotic pressure
- Hypertonic: higher concentration of solute (water will move into the hypertonic solution in osmosis)
- Hypotonic: lower concentration of solute (water will move out of hypotonic solution in osmosis)
- Isotonic: same solute concentration in both solutions.

**Facilitated diffusion (passive):**

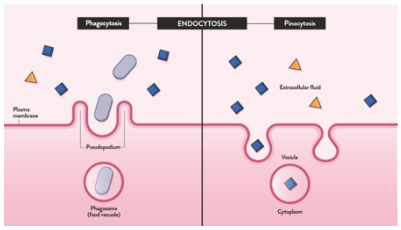
- Is done with larger molecules that are too big for simple diffusion such as glucose and amino acids
- The molecule binds to the binding site of the carrier protein which then charges shape and releases the molecule out on the other side
- Carrier proteins are specific and will only bind to one molecule
- Facilitated diffusion moves with the concentration gradient which is why it doesn't require energy

**Active transport (active):**

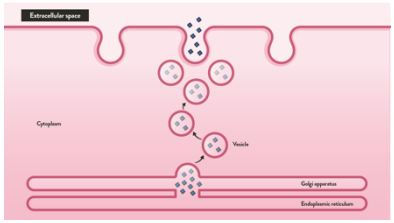
- Movement of substances against the concentration gradient with the use of carrier proteins
- ATP is the form of energy used
- The concentration gradient doesn't control what is passed in and out of the cell so molecules can come in and out of the cell as they like
- The process is the same as facilitated transport

**Vesicular transport (active):**

- Substances move in and out of the cell in vesicles
- 2 types
- Endocytosis:
    - Bringing material into the cell
    - The cell membrane folds around the material and pinches off and forms a vesicle inside the cell
    - Pinocytosis: taking in liquids
    - Phagocytosis: taking in solids
    - This process is used for bigger particles such as proteins or even organisms are
    - E.g. the white blood cell uses phagocytosis to engulf bacteria




- Exocytosis:
    - Pushing material out of the cell
    - A vesicle is formed inside the cell and moves towards the membrane, the vesicle then fuses with the membrane and the contents is passed out
    - E.g. digestive enzymes from lining the small intestine and milk from breast glands are both exported from the cell in this way.




## Bio-Molecules

**Carbohydrates: (CHO)**

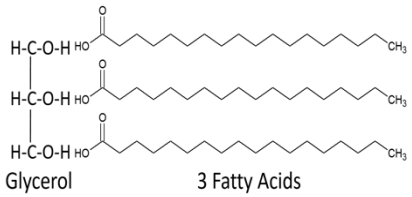
Made up of carbon, hydrogen, and oxygen atoms (CHO). Monosaccharides are the simplest sugars. They can be joined together by condensation to form polysaccharides, releasing water in the process. Polysaccharides and disaccharides can be broken down into monosaccharides by hydrolysis.

- Monosaccharides
    - I single sugar unit.
    - The main energy source for fuelling cell metabolism.
    - Rings with 6 carbon atoms (hexose) are Glucose, Galactose, Fructose
    - Rings with 5 carbon atoms (pentose) are ribose or deoxyribose.
- Disaccharides
    - 2 linked monosaccharides (can be the same or different)
    - Glucose + glucose = maltose

    - Glucose + galactose = lactose
    - Glucose + fructose = sucrose
- Polysaccharides
    - Multiple sugar units joined together by condensation
    - CELLULOSE:
        - Unbranched (one chain with no branches) chains of up to 10,000 glucose molecules.
        - Structural components for cell walls, xylem vessels and wood.
    - STARCH:
        - A branched (chains with branches of other chains connecting) polysaccharide made from chains of 1000 glucose molecules
        - An energy storage molecule, concentrated in starch granules within plant cells. ( e.g. potatoes)
        - Is converted into glucose when needed for energy production.
    - CHITIN:
        - Made from unbranched chains of modified glucose molecules.
        - Each glucose has nitrogen attached.
        - Is found in cell wall of fungi and exoskeletons of arthropods.
    - GLYCOGEN:
        - Branched polysaccharide made from 2000-60000 glucose molecules.
        - It is storage compound in animal tissues and is found in cells of liver and muscle.

**Lipids: (CHO)**

Are non-polar, hydrophobic organic molecules. They are insoluble in water (water repelling). They have higher proportions of hydrogen than carbohydrates and proteins. (are a more concentrated energy source). Proteins and carbohydrates can be converted into fats by enzymes and stored.
Fats are made from 1 glycerol and 3 fatty acid chains. (triglycerides)




Phospholipids are another type of lipid that is used in the membrane of a cell.

**Proteins: (CHON/S)**

the elements that makeup proteins are carbon, hydrogen, oxygen, nitrogen and sometimes sulphur.

Amino acids are joined together by condensation reactions to form polypeptides (proteins). The amino acids are linked with peptide bonds. 20 amino acids linked make a protein.

- There are 9 essential proteins. Essential proteins cannot be made by our body and therefore come from things we eat. E.g. meat, legumes, eggs, etc.
- There are 11 non-essential proteins. Non-essential proteins can be made by our bodies.

**Nucleic Acids:**

Are long chains of nucleotides that store genetic information. Nucleotides are made from a nitrogenous base, a sugar and a phosphate group.

DNA

- Nucleotides ( Deoxyribose sugar + phosphate + base)
- Bases: Adenine -> thymine, Cytosine -> Guanine
- Double helix

RNA

- Nucleotides ( Ribose sugar + phosphate + base)
- Bases: Adenine -> Uracil, Cytosine -> Guanine
- Single stranded

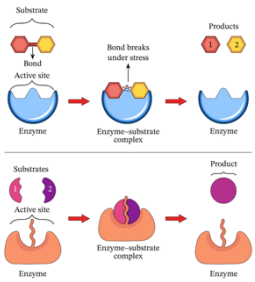
## Cellular processes

**Metabolism:** refers to all the life sustaining chemical reactions that take place in the cell. Two types of reactions:

- Catabolic- large/complex molecules are broken down into small/simple molecules.
- Anabolic- small molecules that build up into bigger ones.

**Enzymes:**

- For a chemical reaction to happen there needs to be enough activation energy (energy required to break the bonds)
- **Enzymes**: biological catalysts that speed up chemical reactions by lowering the activation energy needed. And are not consumed during chemical reactions
- The molecule that an enzyme locks onto is called a **substrate**, enzymes are specific to their complimentary substrate and will not lock on to any others.
- The part where the substrate locks onto the enzyme is called the **active site.** When the are locked together they are an **enzyme- substrate complex.**
- This then results in the **product.**




- E.g. in the digestive system, someone may have ingested bread that has large starch molecules that need to be broken down into monosaccharides. The enzyme amylase helps with this.
- Endergonic reactions: requires more energy than you can get from it. They will absorb energy
- Exergonic reactions: release energy into their surroundings.

**Lock and Key model:**

- Says that the enzyme's active site and the shape of the substrate molecules are complementary to each other. The substrate will fit in the enzyme like a key would fit into a lock. If the substrate doesn't fit, the enzyme cannot act on it.

**Induced fit model:**

- States that a substrate binds to an active site and both will slightly change, creating the ideal fit.

**Factors that affect enzymes:**

- Concentration
    - The higher concentration on enzymes the faster rate of reaction
    - The higher concentration of substrates can also increase the rate of reaction to a certain level. (more substrate comes into contact with enzymes)
- Temperature
    - As temperature increases, rate of reaction increases
    - If the enzyme reaches 40-45 degrees Celsius it will denature and becomes inactivated
    - Optimum temperature: 30- 40 degrees Celsius.
- Ph
    - Enzymes are sensitive to Ph
- Co-enzymes/ Cofactors
    - Some enzymes require co-enzymes before they can catalyse a reaction.
    - Co-enzymes change the shape of the active site so the enzyme and substrate can combine.
    - Co factors: metals ions (e.g., iron)
    - Co-enzymes: organic molecules (e.g., Vitamins)
- Enzyme inhibitors
    - Substances that stop or slow down activity
    - Inhibitors can be used by cells to control reactions so that products are produced in specific amounts.
    - E.g. Drugs (penicillin)

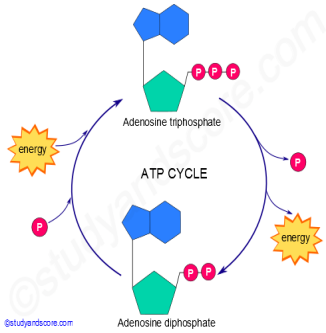
**CELLULAR RESPIRATION:**

C 6 H 12 O 6 + 6 O 2 --> 6 CO 2 + 6 H 2 O + ATP

The energy in glucose is transferred into ATP in a series of enzyme-controlled steps.

Adenosine triphosphate transports chemical energy within the cell for metabolic processes. (e.g. cell division, active transport and cell mobility. It consists of 3 components

- A purine base (adenine)
- A pentose sugar (ribose)
- 3 phosphate groups




The bond between the 2nd and 3rd phosphate groups contains electrons in a high energy state. The energy is released in ATP hydrolysis couples with another reaction the energy is transferred to. The end products are adenosine diphosphate and an inorganic phosphate. Cellular respiration is then just adding a phosphate back onto ADP with energy.

GLYCOLYSIS (is anerobic):

- Happens in the cytoplasm
- Glucose (is a 6 carbon sugar) is broken down into 2 molecules of pyruvate ( a 3 carbon acid).
- 2 ATP molecules are used up in the process of breaking down glucose
- 4 ATP and 2NADH + 2H+ are generated from this stage. (however, 2 ATP are used up so only 2ATP are created)
- When glucose is low, other organic molecules can provide alternative respiratory substrates (materials the enzyme can work on in link reaction)
- Fats -> Glycerol can be used and Proteins -> amino acids can also be used.
- No oxygen is required.

THE LINK REACTION:

- Occurs in the mitochondrial matrix
- Pyruvate enters the mitochondrion and 1 carbon dioxide is removed.
- Coenzyme A (Co A) picks up the remaining 2 carbon fragments of the pyruvate to form acetyl coenzyme A.

KREB CYCLE:

- Happens in the mitochondrial matrix
- The acetyl group passes into a cyclic reaction and combines with a 4-carbon molecule to form a 6-carbon molecule.
- The Co A is released for reuse
- More steps remove carbon as carbon dioxide.
- Output is 6 NADH + 2H+ , 2 FADH2 and 2 ATP

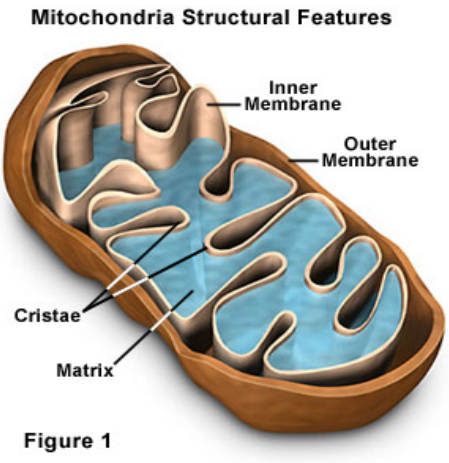
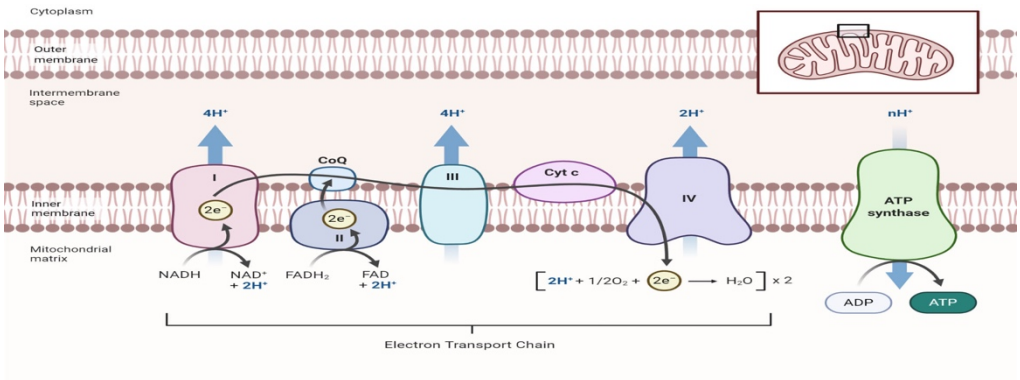


Figure 1

ELECTRON TRANSPORT CHAIN (chemiosmosis or oxidative phosphorylation) :

- Occurs on the mitochondrial cristae.
- NADH delivers its electrons to the first protein in the electron transport chain.
- Energy is slowly released and is used to pump hydrogen ions (protons) to the inter membrane space.

- More electrons are added at the second protein from FADH, which releases more energy to pump more protons into the inter membrane space.
- The electrons are passed to the third protein and their energy is used again to pump more protons.
- This creates a very high concentration of protons in the inter-membrane space.
- The electrons from the third protein combine with oxygen (from breathing) and hydrogen ions (from matrix) to make water.
- ATP synthase is a protein channel that hydrogen ions can flow through from a high concentration (inter membrane space) to a low concentration (matrix).
- When they flow through ATP synthase spins and creates enough energy to create a bond between an ADP and a phosphate.
- Up to 34 ATP can be made during this phase




Anerobic respiration:

- Glycolysis is the first part of anerobic respiration
- Absence of oxygen means pyruvate cannot enter the mitochondria.
- The pyruvate will turn into ethanol and carbon dioxide in plants
- In animals it will turn into lactic acid

Lactic acid Fermentation:

- Skeletal muscles produce ATP in the absence of oxygen using lactic acid fermentation.
- Pyruvate is reduced into lactic acid which dissociates to form lactate and H+.
- Lactate can be metabolised in the muscle or enter circulation and be taken to the liver to replenish carbohydrate stores.

Alcohol fermentation:

- pyruvic acid produced from glycolysis is converted into ethanol and carbon dioxide and the NAD+ is generated from NADH.

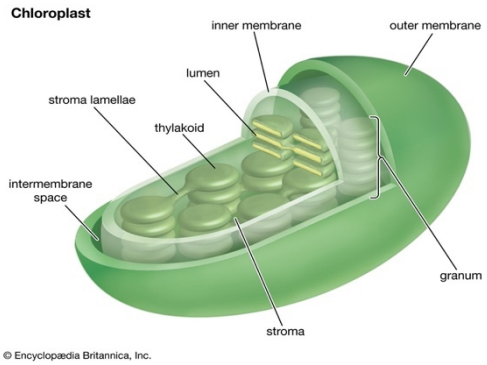
**PHOTOSYNTHESIS:**

6CO2 + 6H2 O + sunlight -> C6 H12 O6 + 6O2

Chloroplast structure + Function:

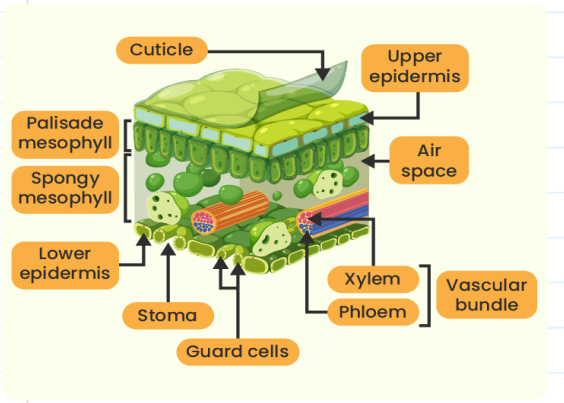
Are oval-shaped cell organelles where photosynthesis takes place. They contain the photosynthetic pigment chlorophyll that captures sunlight and converts it into useful energy, releasing oxygen and water.

- Grana are made up of disk shaped structures called thylakoids. (these consist of the chlorophyll pigments)
- Stroma is the matrix (similar to cytoplasm in cells) where all the organelles are embedded.
- Stroma lamellae connect the stacks of thylakoids together




Leaf structure + function:
The main site for photosynthesis in plants and aids the photosynthesis process. Leaves are structures to maximise the capture of sunlight energy and facilitate the diffusion of gasses in and out of the leaf tissue.

- Gasses enter and leave the leaf through stomata (small pores)
- Inside the leaf, the large air spaces and loose arrangement of the spongy mesophyll which provide a large surface area for gas exchange.




LIGHT-DEPENDENT:
Takes place on the thylakoid membranes in chloroplasts.
Steps:

- Light strikes photosystem II which causes electrons to become exited.
- The electrons travel down the proteins of the electron transport chain.
- Water is then split into Hydrogen ions, electrons and oxygen. The electrons replace the ones that were in photosystem I.
- The electrons continue to travel down the chain and their energy is used to pump hydrogen ions (protons) into the inter thylakoid space.
- This results in high concentration of protons in the thylakoid space and a lower concentration in the stroma.
- The protons will want to move across the concentration gradient by diffusion (from high to low). The only place that lets protons through is ATP synthase.
- This rotates the ATP synthase and joins ADP to a phosphate with energy.
- The ATP will be used in the Calvin cycle to help produce sugar.
- The electrons will then continue to photosystem I.
- Light strikes photosystem I and excites the electrons again.
- These electrons continue down the chain.
- They are then used to reduce NADP+ to form NADPH (which carries electrons to the Calvin cycle).

LIGHT INDEPENDENT (Calvin cycle):
Takes place in the stroma. Enzymes will work with the ATP and NADPH to fix carbon dioxide into molecules that can be used to build glucose. This part of photosynthesis needs the CO2 from the air.
Steps:

- The enzymes in the stroma combine a 5-carbon molecule with a molecule of carbon dioxide (from the outside)
- This creates a 6-carbon molecule that is broken down into 2 three-carbon molecules.
- The ATP and NADHP (energy carriers) give hydrogen to each 3-carbon molecule. This creates 2 molecules of simple sugars.
- The two molecules are joined to make glucose.
- There are 6 molecules of carbon dioxide used at the same time in the Calvin cycle so 6 glucose molecules are made at one time.

AFFECTING FACTORS:

- Light Intensity: Increased light intensity results in a higher rate of photosynthesis. On the other hand, low light intensity results in a lower rate of photosynthesis.
- The concentration of CO2: A higher concentration of carbon dioxide helps in increasing the rate of photosynthesis.
- Temperature: For efficient execution of photosynthesis, it is important to have a temperature range between 25° to 35° C.
- Water: As water is an important factor in photosynthesis, its deficiency can lead to problems in the intake of carbon dioxide. The scarcity of water leads to the refusal of stomatal openings to retain the amount of water they have stored inside.
- Pollution: Industrial pollutants and other particulates may settle on the leaf surface. This can block the pores of stomata which makes it difficult to take in carbon dioxide.

## Multicellular organisms

- *multicellular organisms have a hierarchical structural organisation of cells, tissues, organs and systems*
- *in animals, the exchange of gases between the internal and external environments of the organism is facilitated by the structure of the exchange surface(s), including spiracles, gills, alveoli and skin*
- *in animals, the acquisition and processing of nutrients is facilitated by the structure of the digestive system; animals may have a gastrovascular cavity or a specialised alimentary canal; specialisation of alimentary canals is related to diet, for example, herbivores and carnivores*
- *in animals, the transport of materials within the internal environment for exchange with cells is facilitated by the structure of open and closed circulatory systems according to the different metabolic requirements of organisms and differing environments*
- *in animals, waste such as carbon dioxide, water, nitrogenous compounds and salts are excreted; different types of nitrogenous wastes are produced by the breakdown of proteins; most aquatic animals excrete nitrogenous wastes directly into their surroundings; terrestrial animals require specialised mechanisms*
- *in vascular plants, gases are exchanged via stomata and the plant surface and does not involve the plant transport system*

- *in vascular plants, transport of water and mineral nutrients from the roots occurs via xylem through root pressure, capillary action (adhesion and cohesion of water molecules), transpiration; transport of the products of photosynthesis and some mineral nutrients occurs by translocation in the phloem*

## Gas exchange:

The gasses in our atmosphere cosist of 78% nitrogen, 21% oxygen, and one percent other gases (argon, carbon dioxide, hydrogen ,ect.)
Gas exchange is the process by which oxygen and carbon dioxide are exchanged between the cells of an organism and the environment. Energy is released in cells by the breakdown of sugars and other substances in cellular respiration. As a consequence of cellular respiration oxygen needs to be diffused into the body and carbon dioxide is then diffused out of the body because it is a waste product. The rate of material exchange is a function of its surface area (large membrane surface equates to more material movement). If there is a low SA: Vol ratio the cell will die.

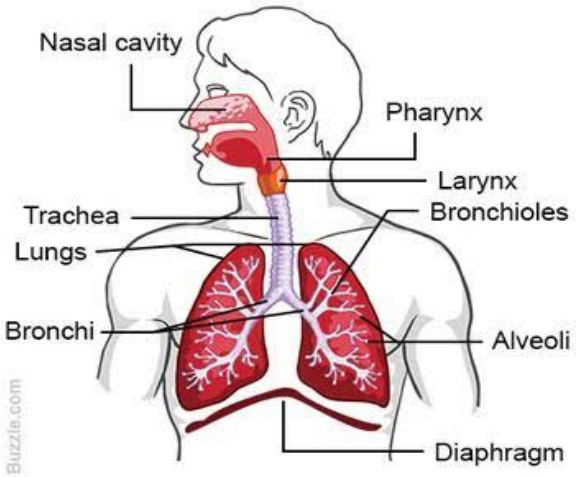
Gas exchange factors:
- The gas exchange surface area is thin.
- High gas exchange surface area
- Moist
- Maintained concentration gradient

Fick's Law: calculates the diffusion rate across gas exchange surfaces.

$$\frac{\text{Surface area x difference in concentration across the membrane}}{\text{Thickness of the membrane}}$$

**IN MAMMALS:**
- Mammals respirate through the pulmonary system.

Inspiration-
- For air to flow into the lungs, air pressure inside lungs must be less than air pressure outside the body.
- To achieve this we increase the volume of the lungs:
    - Diaphragm contracts moving downwards
    - Intercostal muscles contract moving up and outwards. The lungs have a pleural membrane around them (visceral pleura) and a layer of pleural fluid and then another layer of plural



membrane (parietal pleura) is attached to the thoracic cavity. This holds the lungs against the intercostal muscles and diaphragm.
    - This increases the thoracic cavity and therefore, the lung volume increases which means a decrease of pressure in the lungs.
    - Air flows into lungs from a higher pressure (outside body) to a lower pressure (inside lungs) until the pressure becomes equal.
    - Gasses exchange across the alveoli wall. (high O2 in alveoli diffuses into capillaries with low O2) (high CO2 in capillaries diffuse to low CO2 in alveoli)

Expiration-

- For air to flow out of lungs, air pressure inside lungs must be higher than air pressure outside the body.
- To achieve this we decrease the volume of the lungs:
    - Diaphragm relaxes moving upwards
    - Intercostal muscles relax moving down and inwards
    - This decreases lung volume
    - Which increases air pressure inside lungs
    - Air flows out of lungs from a higher pressure (inside lungs) to a lower pressure (outside body) until pressure becomes equal

Adaptations for effective gas exchange:

- Constantly flowing blood in the capillaries
- Large surface area from all the alveoli
- Thin walls of alveoli and capillaries
- Lungs are deep in the body to prevent evaporation of fluids.
- Alveoli walls are moist.

Other mammal adaptations:

- Horses –
    - are obligate nasal breathers meaning they can only breath through their nose.
- Elephants –
    - they have no pleural space. The parietal and visceral pleura and dence connective tissue and are joined by loose connective tissue.
    - The diaphragm is very thick, this allows elephants to be underwater for longer.
- Dolphins –
    - breathe through a single blowhole on top of their head. The blowhole is covered with a flap that creates a watertight seal.
    - They hold their breath underwater, just before reaching surface they start to exhale.
    - During each respiration a dolphin exchanged 80% of its lung air. (more than humans 17%)
    - This allows dolphin to be underwater for up to 12 mins.
    - Heart rate of dolphin is slower while diving
    - Blood id shunted away from tissues that tolerate low oxygen levels to the brain and heart which need constant oxygen.

- Dolphins have more red blood cells and therefore more haemoglobin.

**IN INSECTS:**

Insects transport air throughout their bodies via a system of tracheal tubes. Spiracles allow air to enter and leave the body.

Limiting water loss:

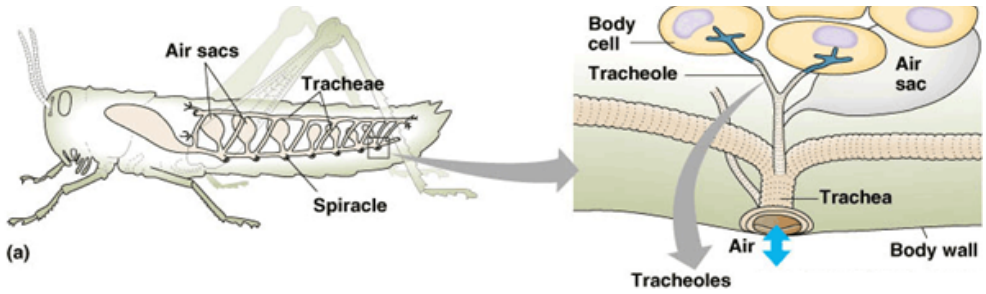
1. Small surface area to volume ratio
2. Have a waterproof exoskeleton.
3. Spiracles can open and close.

The tracheal system:

- Spiracles: round openings that run across the abdomen. They allow oxygen and carbon dioxide to enter and leave. The trachea attaches to these openings.
- Trachea: the network of tubes inside the insects. These connect to tracheoles that can reach every tissue and every cell to exchange the gas.
- As oxygen is needed and carbon dioxide is created the concentration gradients change. Carbon dioxide will have a higher concentration inside and diffuse out and oxygen has a higher concentration outside so will diffuse in.
- Larger insects have air sacs that can contract and expand to assist air moving through tubules.

Adaptations for efficient gas exchange:

- A large number of tracheoles creates a larger surface area.
- The tracheal walls are thin and close to spiracles which creates a short distance for diffusion.
- Use of oxygen and the production of carbon dioxide creates concentration gradients.




**IN FISH:**

- The gills of fish exchange gasses between blood and the environment. Gills are membranous structures supported by cartilaginous or bony struts, they have very large surface area as water flows over the gill surface.
- The percentage of oxygen in air is 21% however in water only about 1% is dissolved. Fish, therefore, have to efficiently extract oxygen from the water.

Adaptations for efficient gas exchange:

- Counter current mechanisms
- Pumping water across gill surface
- Swimming continuously with an open mouth.
- Gills allow for high surface area for gas exchange.

Fish respiratory system:

- The gills are composed of 4 layers of gills on either side of the head. The gills are made from stacks of gills filaments. Along the gill filaments are many gill lamellae that are at 90° to the filament. (this creates the large surface area)
- Water runs through the mouth and flows over the gills and then out of the body.
- The operculum (gill cover) allows water to exit and acts as a pump drawing water past the gill filaments.

Inspiration -

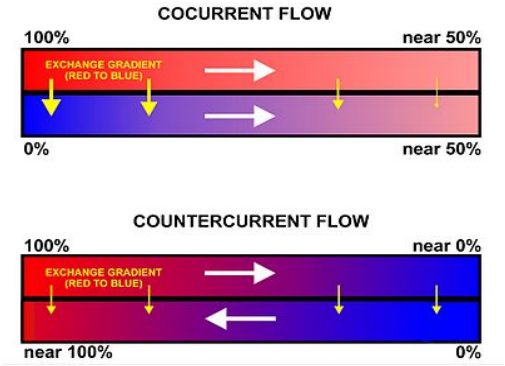
- The mouth cavity expands and oral valve opens taking in water
- The operculum (gill cover) is closed and moved outwards to allow for a lot of water intake

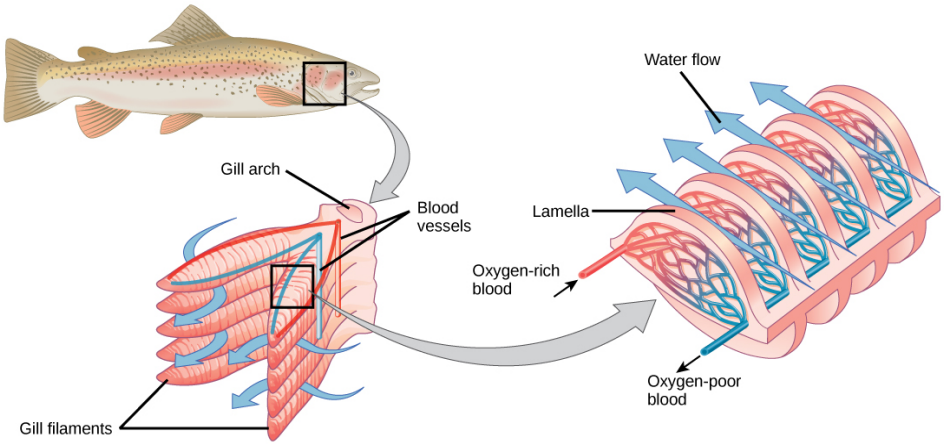
Expiration -

- Oral valve closes and mouth cavity contracts to force water across the gills
- The operculum opens to allows water out.

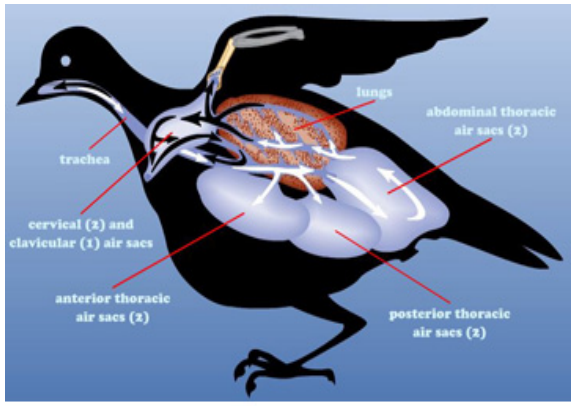
Counter current flow:

- The water that flows over the gills flows in the opposite direction to the flow of the blood in the capillaries.
- This ensures there is never an equilibrium reached (is equilibrium is reached there will be no concentration gradient for diffusion to occur).
- Because of counter-current flow diffusion can occur over the entire length of the lamellae.



**IN BIRDS:**



Click above to see the bird respiration cycle

Birds need efficient respiration and gas exchange because flying takes up a lot of energy (and therefore oxygen) this is why they have unidirectional air flow so their lungs are never waiting for the next breath in, there is a constant supply of air being passed through the lungs. Birds' respiratory system includes the trachea, a small pair of lungs and 9 air sacs.

These air sacs are used as storage for air and allow a continuous flow of air to pass through the lungs in one way flow. The air sacs also connect to pneumatic bones and remove excess heat as it breaths.

Pathway of air:

- On Inhalation 1 air will travel down the trachea through the lung and into the posterior thoracic and abdominal air sacs.
- As the bird exhales the abdomen contracts forcing the air out of the air sacs and into the lungs.
- In the lungs the air passes through parabronchi and air capillaries where the gas exchanges to blood capillaries.
- The air then enters the cervical , clavicular and anterior air sacs where exhalation 2 happens and the air is pushed out of the trachea and nostrils

Adaptations for efficient gas exchange:

- Unidirectional breathing allows a constant flow of oxygen-rich air to the lungs.
- Counter current flow of the air capillaries and blood capillaries.

**IN AMPHIBIANS:**

- Are adapted to live in both water and land.
- Frogs are cold-blooded and therefore use less energy to survive (they don't need to use energy to keep themselves warm)
- Frogs begin their life as tadpoles which respirate through gills and skin.
- Adult frogs can respirate through the skin, their lungs and the lining of their mouth.

Cutaneous respiration: (skin)

- Frogs have thin membranous tissue as skin which is permeable to gasses and contains a large network of blood vessels
- This allows gasses to diffuse through the membrane along their concentration gradients
- This respiration can occur on land and in water.
- This requires moist skin.
- Glands across the skin produce mucus to keep the skin moist
- Cutaneous respiration accounts for about 50% of a frogs respiration and is there only mode during hibernation

Pulmonary respiration: (lungs)

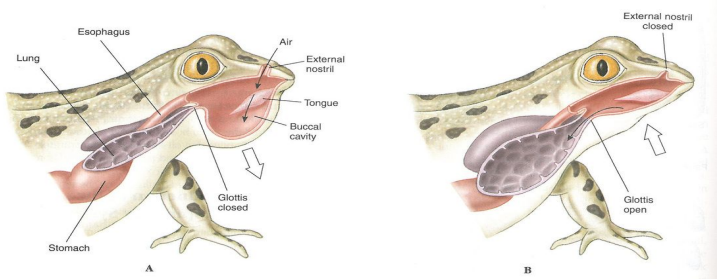
- Frogs use their lungs when they are active and cannot get enough oxygen from cutaneous respiration.

Inspiration-

- The floor of the frog's mouth is lowered causing air to be drawn into the mouth/buccal cavity.
- The frog then closes its mouth and nostril and raises the floor of its mouth which makes the buccal cavity small.
- The causes an increase of pressure in the mouth cavity so the air moves from mouth through the glottis into the frogs lungs
- The gasses diffuse from the lungs (which have a high concentration O2 and low CO2) to blood vessels around the lungs (low concentration of O2, high CO2)

Expiration-

- Muscles around the lungs contract pushing the air out of the lungs




Buccopharyngeal respiration: (lining of the mouth)

- During pulmonary respiration when the air is in the buccal cavity, the lining of the mouth can absorb some of the oxygen from the air in the mouth and give out carbon dioxide. This happens with diffusion.

Adaptations for efficient gas exchange:

- Constantly moist skin from mucus-secreting glands
- The lining of the mouth can absorb gases
- Buccal cavity lowering and lifting.

**IN REPTILES:**

Reptiles' scales prevent them from exchanging gases from the surface of their skin. So they breathe air only through their lungs. Most reptiles do not have a diaphragm thye use intercostal muscles to change the volume of their body cavity. E.g. snakes and lizards. Crocodiles have a diaphragm similar to mammals that can contract to open and decrease pressure in the lungs and pull air into their lungs.

Turtles are unable to breathe like this because of their shell, they do not have intercostal muscles or a diaphragm, they contract a specific pair of flank muscles that helps inspiration or expiration. When turtles hibernate, they do not need much oxygen since their metabolism is slowed down so they extract oxygen from the water. Water will flow over their cloaca (butt) which has many blood vessels where gasses can diffuse from water to blood.

**SIMPLE ANIMALS:**

Exchange gas through simple diffusion or facilitated diffusion of their skin.

## Digestive system:

Human alimentary canal:

**Mouth:**

Chemical –

- Saliva secreting glands, in saliva is amylase enzymes to start the breakdown of starch, saliva for lubrication and to keep the area moist

Mechanical –

- Teeth: incisors for cutting, canines for tearing and molars for grinding and crushing.
- Mastication (is the chewing process that breaks down food into small pieces)
- Tongue: used to move into the bolus at the back of the mouth

**Oesophagus:**

Mechanical –

- Takes food from mouth to stomach (flap at the top called epiglottis closes trachea so food goes down the oesophagus instead of trachea)
- Peristalsis of circular muscles around the oesophagus that moves in a wave-like contractions to push food down into the stomach.

**Stomach:**

Chemical –

- Gastric pits that secrete gastric juice that contains:
    - Mucus: which prevents enzymes and acids from digesting the stomach lining
    - Hydrochloric acid: activates protein enzymes and helps to kill bacteria.
    - Enzymes: protease enzymes (specifically pepsin) that break down proteins.

Mechanical –

- 3 muscles of the stomach contract and churn the food and turn it into chyme
    - Circular, longitudinal and oblique
- Ragae folds in the stomach that increase surface area.

**Small intestine:**

. made up of 3 sections called the duodenum, jejunum and ileum.

Mechanical –

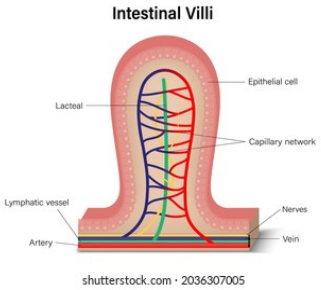
- Circular muscle contraction is called segmentation.

Chemical –

- The pancreas secretes pancreatic juice into the duodenum of the small intestine.
    - Amylase: breaks down starch --> disaccharides
    - Protease: breaks down proteins --> dipeptides
    - Lipase: breaks down lipids --> fatty acids and glycerol
    - Ribonuclease and deoxyribonuclease: breaks down RNA & DNA --> nucleotides.

Absorption –

- Villi:
    - Villi absorb nutrients into the circulatory system and lymph system.
    - Shape + microvilli increase surface area for absorption.
    - Enormous number of villi to further increase surface area
    - 6m long small intestine also helps increase SA.




    - absorbs fatty acids and glycerol diffuses into capillaries and then into the lacteal
    - Capillaries absorb monosaccharides with diffusion through channel proteins (when there is increased exercise or human activity active transport through carrier proteins is used to absorb the maximum amount of nutrients)
    - Capillaries absorb water with osmosis.
    - Capillaries absorb amino acids with active transport because they are large and require ATP.

**Large intestine:**
The small intestine joins the large intestine a the caecum.
Contents is pushed through the large intestine into the rectum with peristalsis.
Excess water is absorbed in the large intestine.

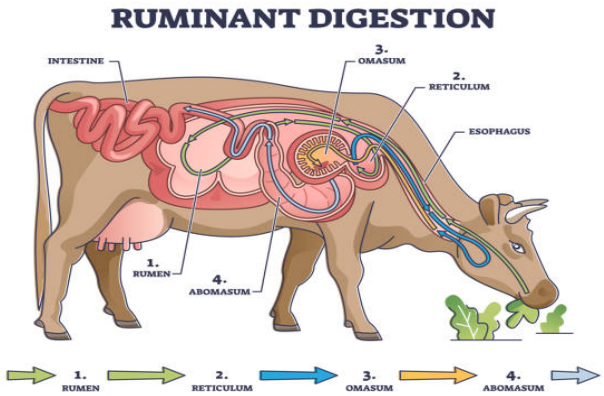
**Carnivore:**
Diet of carnivores contains a lot of animals tissues which contains protein which is easy to digest.

ADAPTATIONS:
- Shorter/ simpler canal
- Sharp strong teeth
- No digestive enzymes in saliva

**Herbivore:**
The diet of herbivores contains a lot of plant cell walls (contains cellulose) which is difficult to digest.

ADAPTATIONS:
- Longer alimentary canal for digesting cellulose
- Cellulase is secreted by microorganisms in the gut to break down cellulose.
- Some herbivores re-chew their foods (ruminants)
- Some herbivores possess fermentation chambers where bacteria can digest cellulose.
- Some herbivores re ingest their faeces.

Ruminant digestive system:




Herbivores that ferment their food. They are hooved mammals and graze grass.

1. Mouth: incisors (to cut grass) , premolars and molars (to grind fibre and cellulose) they use their tongue to wrap around the grass and pull them into their mouth.
2. Oesophagus: peristalsis to move bolus DOWN to the rumen.
3. Rumen: fermentation vat, lining is covered with papillae that provide large surface area for absorption. Contains microorganisms that help digest cellulose and get out nutrients and sugars within plant cells.
4. Reticulum: filters and lets through small pieces, large pieces get regurgitated back to the mouth for further chewing (called rumination) (The oesophagus relaxes which muscles are used to push food UP)
5. Rumen: food from the mouth (now called cud) goes back to the rumen
6. Reticulum: smaller food is filtered again and pass straight to the omasum
7. Omasum: folds create a large surface area to absorb water
8. Abomasum: is the 'true stomach' which has gastric juices (hydrochloric acid, mucus, water and enzymes). The HCL kills microorganisms with release of amino acids which get turned into proteins
9. Small intestine: 40m long. Pancreas secretions increase the pH and secrete enzymes. Villi are also present to increase surface area allowing for maximum absorption. (similar structure of villi in humans)
10. Large intestine: made up of caecum and the colon. Absorbs excess water and minerals. Secondary fermentation of fibre happens in the caecum. Also stores faeces.
11. Anus: circular muscle at the end of the digestive tract. Faeces and expelled through the anus.

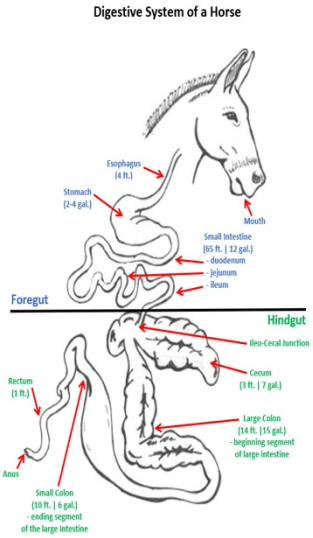
Hindgut digestive system:

Herbivores which use fermentation to have a microbial breakdown of cellulose in the large intestine with the aid of symbiotic bacteria. This is seen in monogastric herbivores and single-chambered stomach animals.
Hindgut animals have a hindgut and a foregut.

- The stomach and small intestine make up the foregut which are responsible for digesting proteins, fats and non-fibrous carbohydrates.
- The hindgut consists of the caecum and colon where the digestion of fibrous carbohydrates takes place. Bacteria helps to synthesize nutrients and convert fibre into useable energy through fermentation.

The foregut -

1. Mouth: grass is eaten. Teeth, tongue and salivary glands. Bolus moves down the oesophagus into the stomach.
2. Stomach: stomach mixes, stores and controls the release of feed into the small intestine. In the stomach secretions of pepsin start digestion.
3. Small intestine: the majority of non structure carbohydrates, protein and fat is digested by enzymes (amylase, protease and lipase) from the pancreas and absorbed. The starch that is not digested goes to the hindgut for fermentation.




The hindgut -

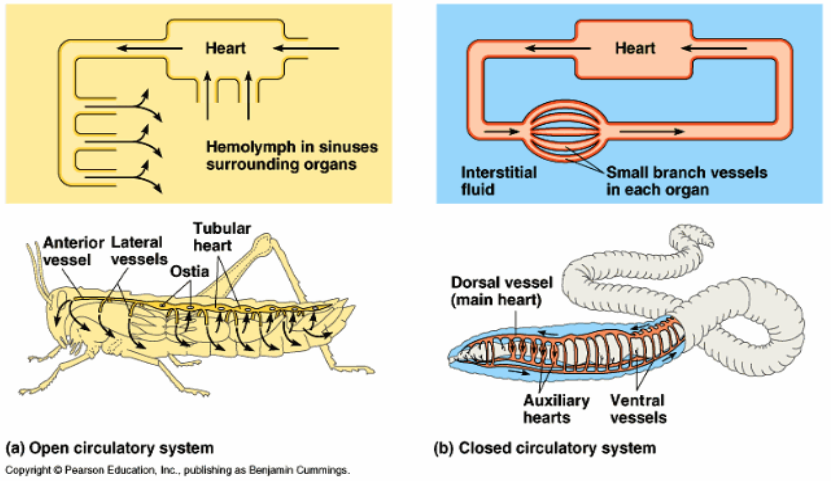
4. Caecum: microbes break down feed that was not digested in the small intestine (fibrous feeds). This is fermentation.
5. Colon: microbial digestion (fermentation) continues, the digestive material is then absorbed. Later in the colon excess water is absorbed
6. Caecotropes: formed by the caecum (fermented material --> high nutrient pellets)
7. Chemotrophs: caecotropes are eaten directly from anus.
8. Fundus (in the stomach): caecotropes stored in the fundus where digestion of microbes provide vitamins and protein.
9. Anus: after second pass faeces are excreted

## Circulatory system:

The system pumps gas and nutrients to all parts of the body. The main components are a pump, vessels and a transport fluid.

| OPEN: Blood flows freely in through he cavities of the body. (organs are in 'pool' of hemolymph) | CLOSED: Blood will flow through vessels inside the body. |
|---|---|
| Advantages:<br>- Requires less energy for distribution.<br>- No diffusion barrier | Advantages:<br>- More efficient<br>- Blood can reach further distances.<br>- More control on oxygen delivery<br>- Higher metabolic rate |
| Disadvantages:<br>- Slower metabolic rate (limited activity level)<br>- Low blood pressure<br>- Blood cannot travel as far. (only feasible in small animals)<br>- Flow cannot be directed | Disadvantages:<br>- Require more energy<br>- Complex network of blood vessels and capillaries |

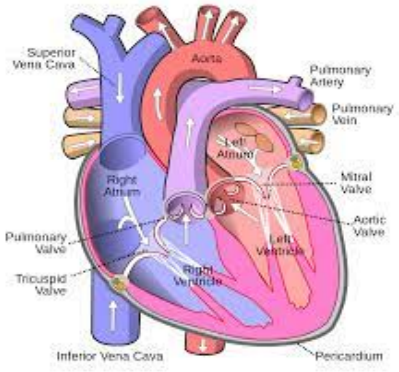
| | |
|---|---|
| - insects, lobsters, and crabs and molluscs such as octopuses, oysters, snails, and slugs | - mammals, birds, reptiles, amphibians |




**Mammal:**

- Has a 4-chambers in heart for effective blood pumping to all over body.

Pathway of blood:




- Comes in through vena cava into right atrium
- Through right atrioventricular valve to right ventricle
- Into pulmonary artery to the lungs (to get oxygenated)
- Back from lungs to the pulmonary veins
- Into left atrium
- Through left atrioventricular valve into left ventricle
- Pump into aorta, then the body.

Components of blood:

- Plasma: makes up most of blood (carries all blood cells and nutrients)
- Red blood cells: hold oxygen and some carbon dioxide
- White blood cells: help with immunity
- Platelets: can clog up holes in blood vessels.

Blood vessels:

- Arteries: pump blood away from the heart ( have muscular and elastic walls to cope with high blood pressure). Aorta -> arteries -> arterioles -> capillaries
- Veins: push blood towards the heart. (have valves and use muscle contractions to push blood up). Vena cava -> veins -> venules -> capillaries.
- Structure of artery:
    - Thin inner layer of epithelial cells that line the blood vessel called the tunica intima/ endothelium. (this is smooth so make sure there is no friction when blood flows through)

    - A central layer called the tunica media is made of elastic tissue and smooth muscle that can stretch and contract.
    - A thick outer layer called the tunica externa is made oe elastic tissue that allows expansion of an artery.
- Structure of vein:
    - Tunica intima
    - Tunica media
    - Thin layer of tunica externa (as less pressure in veins so they don't need to be as thick and elastic)
    - Veins have one way valves that prevent backflow of blood while traveling up to the heart.
    - Veins have a larger lumen (tube part) because there the layers (intima, media and externa) and thinner.

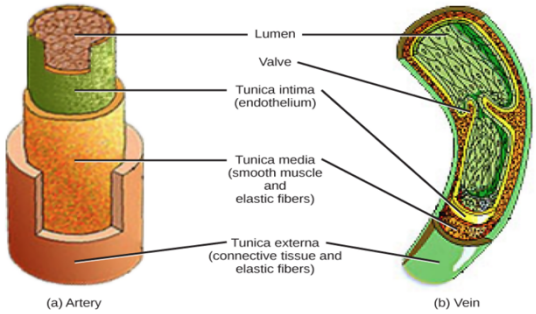



**Figure 40.16** Arteries and veins consist of three layers: an outer tunica externa, a middle tunica media, and an inner tunica intima. Capillaries consist of a single layer of epithelial cells, the tunica intima. (credit: modification of work by NCI, NIH)

Lymphatic system:
The lymphatic system is the system that transports body fluids, such as water or fats (called lymph) back to the heart.
The lymphatic system gathers lymph from small spaces surrounding cells (interstitial space) with small lymph capillaries. The capillaries are close-ended and will gather lymph fluid and bring it through lymph vessels, through lymph nodes into the thoracic duct where the lymph will enter the circulatory system again.
Lymph nodes are places where lymph fluid can be filtered. There are white blood cells (lymphocytes) that attack bacteria or viruses in the lymph.
Lymphatic vessels have muscular walls to slowly push lymph up. They also have valves (like veins) to prevent backflow. Lymph will also be pushed up lymph vessels by muscles around the lymph vessels that contract when we move. When these muscles contract they move lymph up lymph vessels.

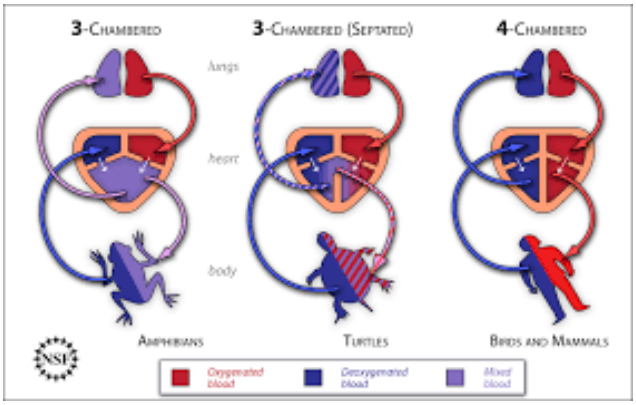
Venom and Poison:
**Venom:** is a toxin that is injected into skin by a sting or bite and absorbed into blood/lymphatic system.
Once venom is injected and it makes its way up to the heart it can cause cell to shrink and die or it can cause your heart to stop beating causing an almost instant death. Some venoms will work by clotting your blood which can also cause death.
When bitten or stung venom can travel into our lymphatic system where it will take time for the lymph and venom to be deposited into the heart.
**Poison:** is ingested, inhaled or absorbed through the skin

**Other vertebrates:**
Fish:
- 2 chambers in the heart. (single circulatory system)
- Unidirectional blood flow.

- Used (deoxygenated) blood comes into the atrium, this goes into the ventricle that pumps blood to the gills. Gills oxygenate the blood and then blood goes straight to the rest of the body.
- This means there is a limited amount of oxygen that can reach some of the cells.

Amphibians:

- 3 chambers in the heart (2 atria, 1 ventricle) (double circulatory system)
- The atria receive blood from body (deoxygenated) and lungs (oxygenated)
- the blood flows to the ventricle where the blood mixes and then gets pumped to the lungs and body.
- This reduces the efficiency of oxygenation
- The advantage is that the ventricle can push blood under high pressure to the body and lungs.




Reptiles:

- Most reptiles –
- 3 chambers (2 atria, 1 ventricle) (double circulatory system)
-
- The ventricle is divided by a partial septum so oxygenated and deoxygenated blood can mix less.
- Crocodiles –
- Have 4 chambers in their heart (2 atria, 2 ventricles) (double circulatory system)
- similar to mammals.
- Can switch on a valve in their heart that sends blood to their stomach when they will be underwater for long periods.

Birds:

- 4 chambers in their heart. (double circulatory system)
- Have similar hearts to mammals however as smaller.

**Simpler organisms:**

Insects:

- Have an open circulatory system
- A dorsal vessel runs along their body. This is divided into a posterior heart that contain intake valves (ostia). And an anterior aorta.
- The open body space is called the hemocoel which is filled with insect blood called hemolymph.
- The hemolymph is pumped forward by the heart, through the aorta and into the head and then flows into the hemocoel.
- The hemolymph re-enters the heart through the ostia and the cycle repeats.

Small living things:

- Some living things will use simple diffusion as their circulatory system.
- When the skin is very thin (2 cells), nutrients can diffuse straight into the cells
- Have no hearts or tubes (blood vessels)

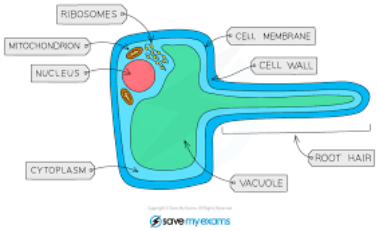
## Transport in Plant:

- A plant has roots, a stem and leaves. The stem is made up of a xylem and a phloem that link all parts of the plant.
- There are 2 types of plants. Monocotyledon and Dicotyledons.
- Monocots have 1 cotyledon in their seed. E.g. Palms, garlic, onions, daffodils, tulips, and lilies
- Dicots have 2 cotyledons in their seed. E.g. trees, shrubs, and wide-leaved flowering plants like sunflowers, magnolias, daisies, and geraniums

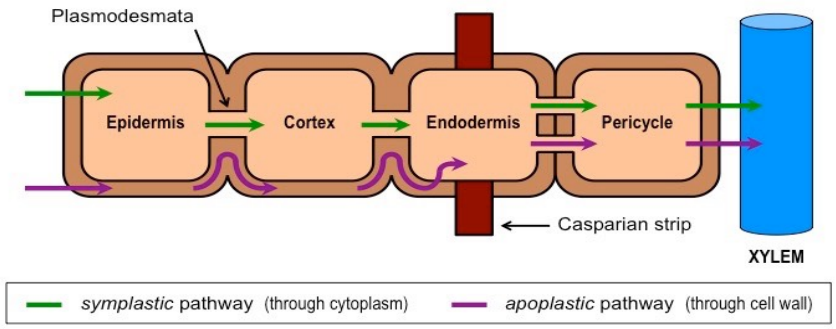
Roots:

The function of a root is to support and anchor the plant as well as absorb water and nutrients from the soil. Roots can also store excess food.

- Roots are the place where water is uptaken and can be a passive or active process.
- Roots have root hairs that increase surface area for absorption of water and nutrients
- Water uptake is through osmosis. H2O will passively transport into the root cell.
- When the plant needs more water potassium pumps will actively pump K+ into the cell (against the concentration gradient)




- This will increase osmotic pressure in the cell so osmosis will work to even the pressure by going into the cell.
- This is how plants will extract extra water from the soil on hot days.
- The H2O will then travel through more plant cells to get to the centre of the root where the xylem is. There are small gaps in the cell wall called plasmodesma to allow water to travel from one cell to another.
- It can travel on a simplistic path of the apoplectic path.
    - Apo plastic is when the water travels through the cell wall
    - Symplastic is simpler and water will travel through the cytoplasm of the cells.
- The Casparian strip is a waxy layer that will force water from the cell wall (travelling apo plastic) into the cytoplasm so it can travel into the xylem easily.



Stem:
The function of the stem is to link the roots to the leaves and provide support for the leaves and reproductive structures.
The stem is made up of bundles containing the xylem and phloem and strengthening fibres. Xylem will be in the middle of the stem and phloem are on the outside.
In monocot plants, vascular bundles are separated throughout the plant. In dicots plants, vascular bundles are organised in ring like patterns.

**Xylem –** transports water and minerals

The xylem is made up of stacks of plant cells called tracheids that are dead and lack cytoplasm and cell organelles. The cells have plasmodesma that connects the cells to each other to become 1 continuous tube. The xylem has strengthening fibres/threads called lignin that work to keep the tube open. Water is a xylem will only travel upward.

How xylems work:

- Xylems can move up with no pump or energy required.

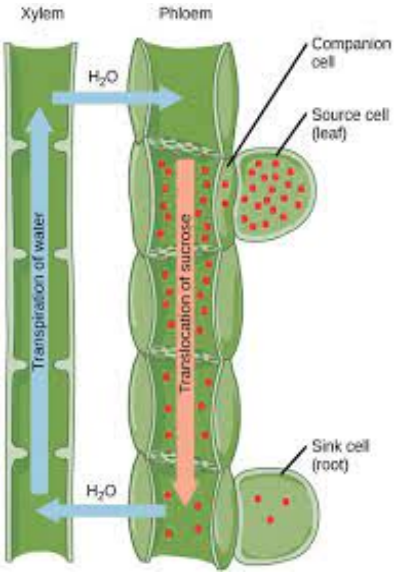
Capillarity:

- The water molecules in the xylem will use **adhesion** to connect with the wall of the xylem vessel. This will happen with hydrogen bonds that connect the water to other molecules. (this happens naturally since they are the attractive forces between the unlike molecules)
- **Cohesion** works where the water molecules attract each other with hydrogen bonds since they are the same substance.

Transpiration:

- At the leaves, water will continuously evaporate out (called transpiration in plants). This leads to a high surface tension and results in negative pressure in the xylem.
- This will pull water up in the xylem (water in the xylem uses capillary action (capillarity) to connect the water and pull up the water.

The transpiration at the leaves will continue and this continues to pull water up the xylem which will continue taking water from the roots and continue taking water from the soil. This cycle will transport water up plants endlessly. (however, at night transpiration stops and water is held in the xylem by cohesion and adhesion)




**Phloem –** transports sap (consists of water, sugars (mainly sucrose), minerals, hormones and amino acids)

The phloem is made up of the sieve cells and the companion cells. These cells are alive and have cytoplasm. The phloem can transport nutrients in 2 direction, up or down.

Sieve cells are long and connect to each other (in a stack) to create the long tube. They connect to each other will sieve plates that have many pores to

enable flow between cells. They have no nuclei and minimal organelles to keep space for materials.

Companion cells provide metabolic support for the sieve cells. These cells have many mitochondria and are responsible for supplying energy for the movement of materials throughout the plant and the sink tissues, and for the facilitation of loading sieve tubes. The sieve cells have plasmodesmata that connect them to the companion cells. They also contain transport protein in the membrane to move materials in and out of the cell.

Translocation (Phloem transport):
The movement of sap in phloem consists of a source ( a plant organ where sugar is made or mobilised) and a sink (a plant organ where sugar is stored or used)

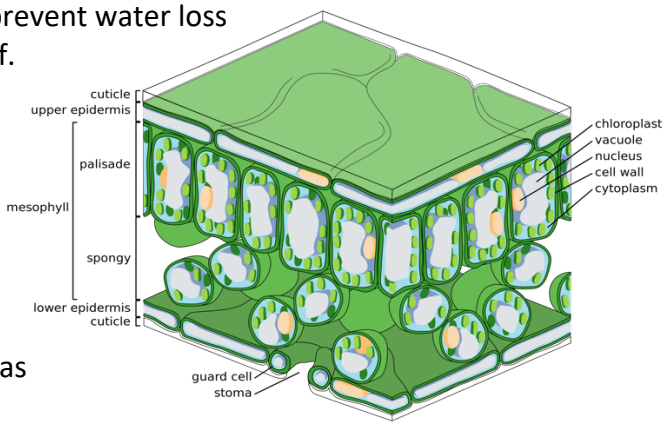
Pressure flow hypothesis

- At the source sugars are pumped by active transport into the companion cells and sieve cells. This increases solute concentration inside sieve tube cells. This causes sieve tubes to take up water by osmosis (the water comes from the xylem).
- The water uptake creates a turgor pressure that forces the sap to move along the tube (like how pressure pushes water through a hose)
- The pressure gradient in sieve tube is reinforced by the unloading of sugar and consequent loss of water by osmosis at the sink. (e.g. root cell)
- Xylem recycles the water from the sink source.

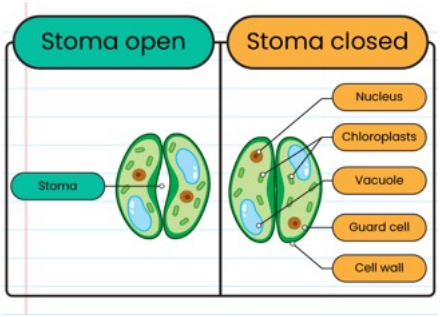
During winter, when many plants have no leaves, the phloem tubes may transport dissolved sucrose and amino acids from the storage organs to other parts of the plant so that respiration can continue During a growth period (Eg during the spring), the storage organs (eg roots) would be the source and the many growing areas of the plant would be the sinks After the plant has grown (usually during the summer), the leaves are photosynthesizing and producing large quantities of sugars; so they become the source and the roots become the sinks – storing sucrose as starch until it is needed again

Leaves:
The function of the leaf is to produce sugars for photosynthesis.

- Waxy cuticle: the hydrophobic layer that helps prevent water loss from transpiration on top and bottom of the leaf.
- Upper epidermis: tightly packed cells to prevent water loss, It is translucent so light can pass through for photosynthesis
- Palisade mesophyll: the major sight of photosynthesis (so many chloroplasts)
- Spongy mesophyll: irregular shaped and loosely packed, have less chloroplasts than palisade mesophyll, air sacs between the cells allow for gas exchange.
- Lower epidermis: similar to upper epidermis



- Stoma: within the lower epidermis, allow for gas exchange (C02 will diffuse in and )2 will diffuse out)



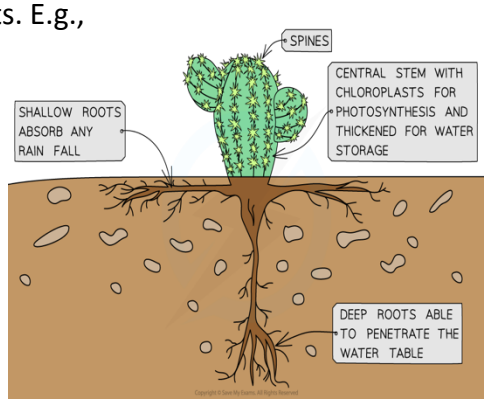

The function of the stoma is to allow for exchange of gasses through the opening and closing of the stoma. It will also assist in taking excess water out of the leaves and allows water to transpirate out.
Stomata are underneath the leaves. They will open during the day (when there is light for photosynthesis to work) to let in CO2 and let out O2. They will usually close during the night, so water does not transpire out.
Stomata are made with 2 guard cells that can open and close. Guard cells have a thin outer cell wall and thicker inner cell wall.
chloroplasts inside the guard cells make glucose which will increase the solute concentration in the cell, so it becomes hypertonic. Potassium pumps also actively pump K+ into the cell against the concentration gradient to further increase osmotic pressure.
Water will then move into the guard cell causing it to swell and open (turgid). When water leaves the cell, they will become straight (flaccid) and close again.

Factors affecting opening and closing:

1. Humidity: when the air is saturated with water vapour (humid), the concentration gradient is less and less water is lost. This means stomata can stay open
2. Light: light causes the potassium ions to pump into the guard cells causing the stomata to open. At night the potassium ions will leave the guard cells causing the stoma to close.
3. Temperature: at higher temperatures, kinetic energy in higher and transpiration occurs faster. Stomata will close to prevent to much water loss.
4. Concentration of C02: low concentrations of C02 will cause stomata to open and high concentration will close stomata.

Plants will also exchange gasses through lenticels. Lenticels permit the exchange of gases between the environment and the internal tissue spaces of the organs (stems and some fruits) .They permit the entrance of oxygen and simultaneously the output of carbon dioxide and water vapour. In apple fruit, lenticels account for up to 21% of the transpiration.

Xerophytes:
Are plants adapted to living in dry weather conditions like desserts. E.g., succulents and cacti
Adaptations –

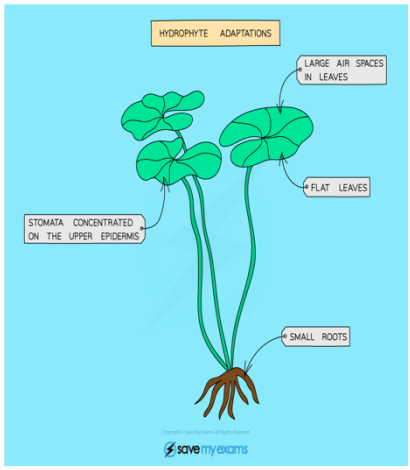



- Very thick cuticles to reduce water loss
- Stoma are closed during the day to cut out transpiration water loss. They will open their stomata at night when air is more humid and air temp is cooler to absorb carbon dioxide.
- Increased water storage
- Reduced number of stomata and sunken away from wind and sun.

- Have deep taproots (one thick roots growing down with small sprouts of it) or wide spreading fibrous roots near the surface.
- Spines that reduce leaf surface area and therefore reduces water loss.

Hydrophytes:
Are plants that live in aquatic environments. E.g., lotus
Types –

- Floating : plants that float on the surface of the water. They are in contact with the water and air.
- Adaptations –
    - Many stoma and always open: the plant doesn't need to waste energy opening and closing the stoma. They can remain open because they don't need to worry about water loss.
    - Broad tough leaves with chloroplasts near the top to maximise sunlight absorption.
    - Air sacs to assist with floatation and increase gas exchange.
    - generally reduced or absent roots present. The only reason for roots in hydrophytes is for anchorage, they are not needed for absorption since water can absorb straight into the leaves through osmosis.




- Submerged : plants that grow below the surface of the water. They are not in contact with the atmosphere
- Adaptations –
    - Thin cuticles so gas exchange can happen easily with diffusion
    - No stomata since gasses can be absorbed straight into the cells of the plant.
    - No xylem as water is transported into the whole plant through osmosis

- Amphibious : plants that grow in shallow water. Their roots, leaves and some of their stem is below water. Some flowering shoots spring above the surface.

Halophytes:
Are plants that tolerate high salinity soil or water. E.g., Salicornia
Adaptations –

- Succulent leaves and stem for storage of water.
- Have salt glands that secrete excess salt.
- Have a thick cuticle to reduce water loss.
- Some may have aerial roots (roots above the ground) for efficient gas exchange.
- Have sunken stomata to reduce water loss from transpiration.