SENIOR 3 BIOLOGY note.

Instructions:

1. ***Copy all the notes in the other book of nutrition/the old theory book you came with from s.2. in case that book gets done, then you are advised to buy another new book and continue copying from there.***
2. ***Do not mix this work with the notes of ' gaseous exchange and respiration'***
   NB I have added some work of nutrition just help understand where to place this notes.

ABSORPTION OF SOLUBLE FOOD:

Glucose, amino acids, mineral salts and vitamins diffuse through the epithelium of the villi and capillary walls and enter into blood plasma. They are then carried to the liver through the hepatic portal vein.

Fatty acids and glycerol from fat digestion pass into the lacteal of the villi, by pass the liver in lymph vessels and enter the blood through the sub-clavian vein.

Some food substances like vitamins and alcohol are absorbed from the stomach before they reach the small intestines.

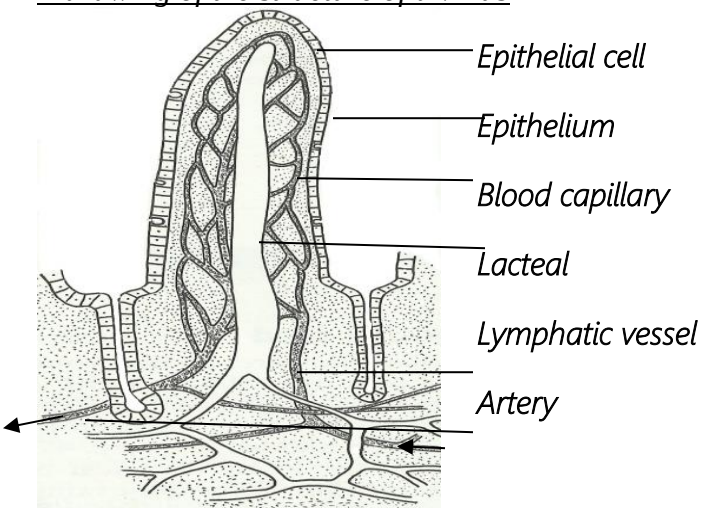
Assimilation of food:

Carbohydrates: In the liver, excess glucose is converted into fats and glycogen and stored. The rest of the glucose is carried by blood to body tissues where it is oxidized during tissue respiration to produce energy.

Proteins: in the liver, excess proteins are deaminated to glycogen and urea. Glycogen is stored in the liver. Some of the amino acids are used to make new cells for growth or repair of worn out tissues. Some of the amino acids are used to make new proteins e.g. enzymes, haemoglobin, antibodies.

Fats: excess fats are stored under the skin or around body organs like the heart and kidneys. The rest of the fats are used to produce energy in the body.

A drawing of the structure of a villus



Adaptations of the villi to their function:

- ✓ The villi are numerous and have numerous micro villi to increase the surface area for absorption of digested food.

- ✓ Each villus is richly supplied with blood capillaries to absorb glucose, amino acids, vitamins and mineral salts.
- ✓ Each villus has a lacteal and is richly supplied with lymph capillaries to absorb fatty acids and glycerol.
- ✓ Have thin epithelium for very fast diffusion of digested food.

Large intestines

- It is made of caecum, Appendix, colon and rectum. The walls of large intestines have no villi but have mucus secreting glands. The main function of large intestines are
- Absorption of water
- Prepare and sores faeces (undigested material, dead cells, bile salts, unwanted mineral salts, bile pigments, etc.)

The colon and rectum

No digestion takes place in the colon since it does not secrete enzymes.
Very little absorption takes place here and its many water and salts from undigested foods
The remaining solid waste of faeces is passed to the rectum by peristalsis

Egestion

The remaining products in the rectum where they are stored temporarily are released or expelled at in intervals via or through the anus when the splinter muscles relax.

Digestion in herbivores-ruminants and non-ruminants.

Herbivores are organisms that feed on plant material. They can be referred to as ruminants or non –ruminants depending on the modification of the stomach, caecum and appendix.

Ruminants: Are animals which that chew cud and their stomach is divided into four chambers (rumen, reticulum, Omasum and abomasum)

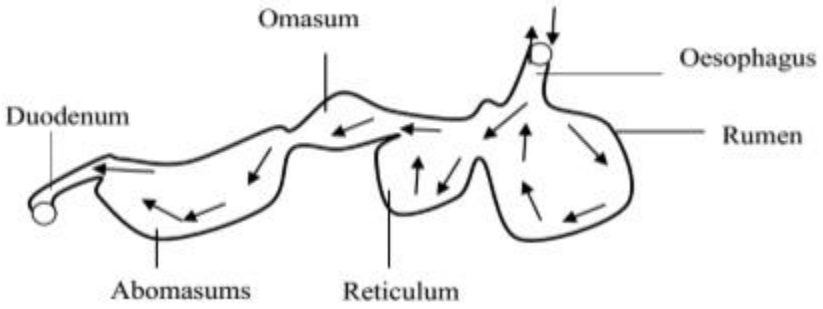
The rumen: This is the large and four chamber where the swallowed food mixed with saliva reaches first .It contains bacteria and protozoa which produce Cellulase enzyme that ferments the food to produce energy and digest the cellulose in the plant cell walls.

Reticulum (honey comb) : This is where the food from the rumen enters for further fermentation .The food is then rolled up into balls and sent back by anti-peristalsis to the mouth where chewing of curd occurs.

Omasum (Psalterium): This is where the partially digested pulp like food is swallowed into. Absorption of water occurs here. The rumen, reticulum and Omasum have tough dead cell living in their inner surface. This is an adaptation for the physical digestion of food.

Abomasum (true stomach): This is where gastric juice is directed from and chemical breakdown of food occurs. Bacteria which participate in fermentation are also digested and some digested food is absorbed in the stomach

Diagram showing the digestive system of a ruminant:



Non-ruminants are animals which do not chew cud e.g. pigs, birds, man, rabbits etc.
Comparison between ruminants and non-ruminants
Similarities:

- ✓ Both have one stomach chamber when young.
- ✓ Digestion of starch, lipids and proteins is completed in the small intestines.
- ✓ Absorption of water occurs in the colon.
- ✓ Food is first broken down mechanically in the mouth.
- ✓ Both exhibit extracellular digestion.

Differences

Ruminant	Non ruminants
✓ Has four stomach chambers ✓ Chew cud ✓ Saliva has no amylase ✓ Can digest coarse fibre ✓ Has small caecum ✓ Most of the digestion occurs in the rumen ✓ Fermentation occurs due to the presence of microbes in the rumen.	✓ Has one stomach chamber ✓ Does not chew cud ✓ Saliva has amylase ✓ Cannot digest coarse fibre ✓ Has a large caecum ✓ Most digestion occurs in the small intestines ✓ Fermentation is not possible due to lack of microbes

Structure of mammalian teeth:

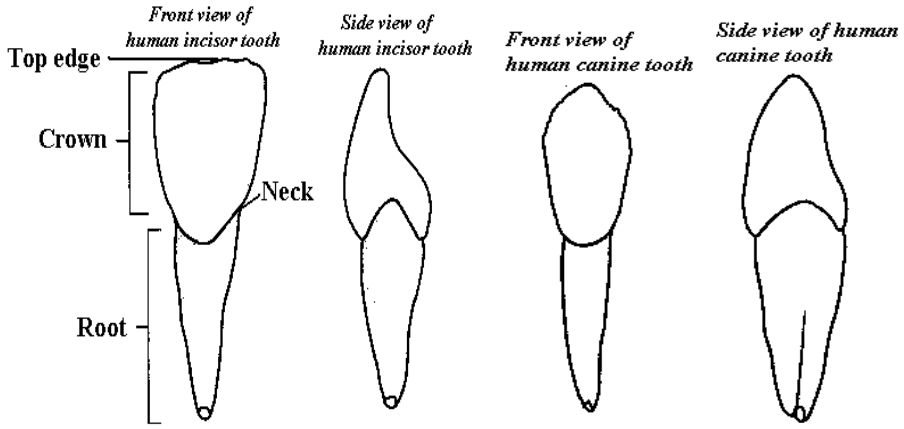
Key vocabulary:

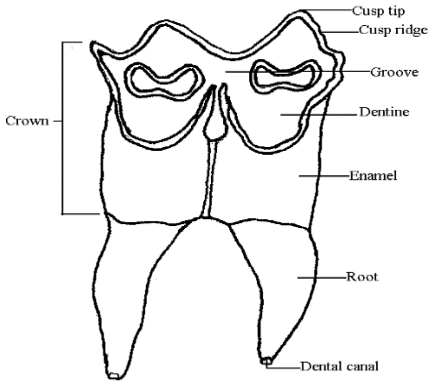
- ✓ ***Teeth*** are bony structures in the mouth. They are fixed in the jaw bones.
- ✓ ***Dentition***: refers to the type, arrangement and number of teeth in the mouth of an organism.
  It also describes the changes that occur in teeth i.e. in man, there are 2 sets of teeth i.e. milk and permanent teeth.
- ✓ Milk teeth (20 teeth) are the 1st set to appear at a stage when the young mammal still feeds on milk and soft solid food. From 5 years, this set of teeth is replaces by another set which is permanent.
- ✓ The ***permanent teeth*** (32 teeth) are the 2nd set and they gradually replace the 1st set. They are more in number and larger in size.
- ✓ ***Wisdom teeth*** are the last 4 permanent teeth to grow and they appear after puberty.
- ✓ Mammals are ***Heterodonts:*** (organism with teeth of different sizes and shapes.)

Types of teeth:

Mammalian teeth are grouped into four: Incisors, Canines, Premolars, and Molars.

External structures of teeth:





A tooth has the following regions when viewed from the surface.

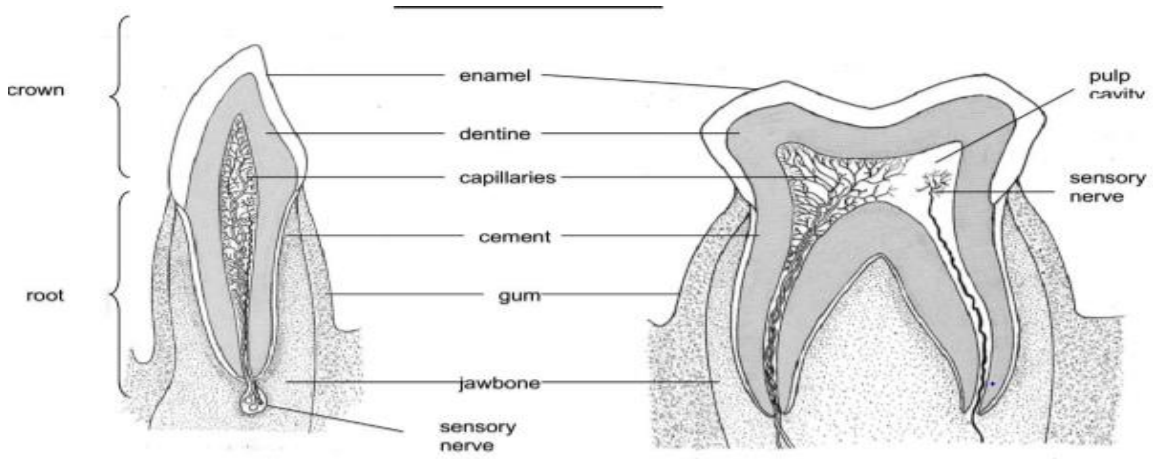
(i) **Crown:** this is the projection above the gum.

(ii) **Root:** this is the part that is embedded into the socket of the jaw.

(iii)**Neck: t**his is the junction between the crown and the root

Type of tooth	***Location***	***Features***	***Function***	***Adaptation to its function***
Incisor	Front of upper & lower jaws	❖ Chisel shaped top surface of the crown ❖ Has one root	Cutting food	1. Sharp flat top edge for cutting grass. 2. Chisel-shaped crown for cutting grass. 3. Crown with hard enamel to resist wearing.
Canine	Behind incisors	❖ Sharp long and pointed crown with sharp edges	Tearing food	1. Sharp pointed crown for tearing food.
Premolar	Behind canines	❖ Crown has a broad top surface with ridges & sharp cusps ❖ Has two roots	Grinding food	(Just as molars)
Molars	Back of the jaw i.e. behind premolars	❖ Crown has a broad top surface with ridges & sharp cusps ❖ Has 3 or 4 roots	Grinding food	1.Broad top surface for grinding grass. 2.Grooves / ridges for grinding grass. 3.Sharp cusps for cutting grass. 4.3 or 4 roots for firm anchorage while grinding.

Internal structure of the tooth



1. Enamel

This is the hardest outer most part of the tooth containing calcium. It protects the tooth and forms a grinding and biting surface. It's made up of non-living tissue. Tooth enamel is the hardest substance in the body.

2. Dentine

This is found beneath the enamel and is found in both the crown and the root. This is the living part of the tooth. It is hard and bone-like but softer than enamel.

3. Pulp cavity

This consists of nerves and blood vessels or capillaries. The capillaries transport nutrients to the tooth and remove waste products. The nerves detect heat, cold and pain.

4. Cement: This is a spongy substance that fixes the tooth in the jaw.

5. Gum: Holds the tooth.

Dental formula

This is a description of the number, type and position of the teeth in one half of the upper and lower jaws.

The names and type of teeth are abbreviated. Dental formulae usually show an adaptation of an animal to a particular diet and its methods of feeding.

Omnivores e.g. man

(a)Milk teeth

$I\frac{2}{2}$ $C\frac{1}{1}$ $P\frac{2}{2}$ $M\frac{0}{0}$ *= 10x2 = 20 teeth*

(b) Permanent teeth

$I\frac{2}{2}$ $C\frac{1}{1}$ $P\frac{2}{2}$ $M\frac{3}{3}$ *= 16x2 = 32 teeth*

Herbivores e.g.

(a)sheep

$I\frac{0}{3}$ $C\frac{0}{1}$ $P\frac{3}{3}$ $M\frac{3}{3}$ = 16x2 = 32 teeth

(b) Horse

$I\frac{3}{3}$ $C\frac{1}{1}$ $P\frac{3}{3}$ $M\frac{3}{3}$ = 20x2 = 40 teeth

(c) Rabbits

$I\frac{2}{1}$ $C\frac{0}{0}$ $P\frac{3}{2}$ $M\frac{3}{3}$ = 14x 2 = 28 teeth

(d) Cow

(e) $I\frac{0}{3}$ $C\frac{0}{1}$ $P\frac{3}{3}$ $M\frac{3}{3}$ = 16x 2 = 32 teeth

Carnivore e.g. dogs, cats

$I\frac{3}{3}$ $C\frac{1}{1}$ $P\frac{4}{4}$ $M\frac{3}{3}$ = 2x2 = 42 teeth

Adaptation of various mammals to their models of feeding:

Adaptations of herbivores:

- ✓ Have hard horny pad instead of upper incisors acts as a chopping board for vegetation.
- ✓ Wide teeth provide large surface area for chewing vegetation.
- ✓ Diastema between the incisors and the premolars increases space for the tongue to manipulate food. Diastema is also used to partially store food during chewing. It allows the tongue to grasp and handle food with ease.
- ✓ Molars and premolars have shapes which allow upper teeth to fit in the lower teeth for grinding food.
- ✓ Ability of the teeth to continuously grow to replace worn out surface caused by chewing.
- ✓ Long, thick muscular tongue for easy turning of vegetation during chewing.
- ✓ Ability to move jaws sideways which allows thorough chewing of vegetation.

Adaptation of carnivores:

Carnivores have many teeth adapted to specific functions and do not grow continuously like herbivorous teeth.

- ✓ Have small chisel shaped canines for stripping off flesh close to the bone/used for gnawing or nibbling.
- ✓ Have long, large and pointed canines for killing and holding the prey. They are also used for self-defense.
- ✓ Have carnassial teeth (the first lower jaw molar and the last upper jaw premolar) have sharp cutting edges to crack bones
- ✓ Have hinge joint between the upper and lower jaws to ensure precise slicing action of the carnassial teeth.

Adaptations of the carnassial teeth of a dog to their function:

- ✓ Cracking bones and slicing flesh.
- ✓ Have cusps for cutting flesh.
- ✓ Hard enamel to break hard bones.
- ✓ Two roots for firm anchorage while cracking bones.

Adaptations of omnivores

- ✓ Incisors have sharp flat edges for biting food.
- ✓ Canines have blunts tops for tearing food.
- ✓ Premolars and molars are broad with cusps and ridges for grinding food.
- ✓ Teeth are arranged close to each other for efficient functioning
- ✓ Have a hinge joint between the upper and lower jaws to allow upward and downward movements with some slight sideways actions during feeding.

Comparison between incisors and molars.

Similarities:

Both have: Roots; Crown; Enamel and Neck

Differences between incisor and molar of an omnivore;

Incisor	**Molar**
✓ Chisel shaped crown ✓ No cusps /ridges ✓ Dentine is not exposed ✓ One root	✓ Broad crown ✓ Has cusps and ridges ✓ Dentine is exposed ✓ Has three or four roots

COMMON DENTAL DISEASES

1. ***Dental Caries***

Dental carries are the holes or cavities that are formed as acid corrodes enamel and eventually the dentine.

Causes

Bacteria digest the carbohydrates (sugars and starch) in food and produce an acid. The acid dissolves enamel, causing a cavity. If the cavity is not treated the decay will progress through the enamel and into the dentine. The pulp cavity is eventually reached. A lot of pain is experienced then (toothache). The bacteria then infect the pulp cavity and the whole tooth decays.

Treatment-depends on the extent of the dental caries:

- ✓ Extraction of the tooth
- ✓ Filling-replacing the dentine with amalgam, a mixture of hard elements e.g. silver and tin.
- ✓ Root canal treatment – this involves surgery and reconstruction. It saves severely damaged teeth. The nerves in the root canal are surgically severed. The tooth is cleaned and filled up with amalgam.

2. Periodontal Diseases

These are diseases of the gum. The gum becomes inflamed and starts bleeding, a condition known as *gingivitis*. Progression of the disease leads to infection of the fibres in the periodontal membranes and the tooth becomes loose. This condition is known as *pyorrhea*.

Causes

- ✓ Poor cleaning of teeth.
- ✓ The accumulation of food particles leading to formation of *plaque*. Saliva produces an invisible film on the teeth. Bacteria and food particles stick to this film, forming plaque
- ✓ Lack of vitamins A and C in the diet.

Treatment

- ✓ Nutrition- by taking adequate balanced diet rich in vitamins A and C.
- ✓ Antibiotic are used to kill the bacteria
- ✓ The plaque is removed/drilled away, a procedure known as scaling.

Care of teeth:

- ✓ Brush the teeth after each meal to avoid bacteria which would cause teeth decay.
- ✓ Avoid eating sugary foods in between meals to avoid bacteria which would cause teeth decay.
- ✓ Avoid eating very cold and very hot foods as they would cause teeth paralysis.
- ✓ Chew fibrous food such as carrot and sugarcane to help exercise the teeth, remove any sugar in teeth crevices and stimulate blood circulation in the teeth due to chewing action. This supplies the teeth with enough nutrients for maintaining strong and health teeth.
- ✓ Avoid extremely hard objects like the bottle tops as this would cause teeth breakage.
- ✓ Eat food rich in vitamin C, vitamin D and calcium to maintain strong and health teeth.
- ✓ Use of a thread or dental floss to clean between teeth.
- ✓ Pay regular visits to the dentist for check-up.
- ✓ Rinsing the mouth with strong salt solution of any mouth wash with antiseptic properties.
- ✓ Taking water with small quantities of fluoride and using toothpaste with minute amounts of fluorides can help prevent dental cavities.

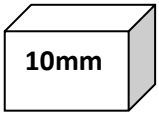
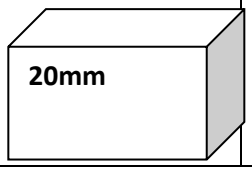
TRANSPORT IN PLANTS AND ANIMAL:

Definition

- **Transport** is the movement of materials from one part of an organism to another.
- **Translocation** is the movement of manufactured food materials from one part of a plant to another through the phloem.

THE USE OF SURFACE AREA TO VOLUME RATIO IN RELATION TO TRANSPORT:

- Small organism have a larger surface area to volume ratio than bigger organism and we can perform a mathematical proof for this.
- Let us perform a mathematical proof to show that small organisms have a large surface area to volume ratio than large ones using the following cubes.

Cube	Surface area	Volume	Surface area: volume
	$SA = 6(side\ x\ side$ $= 6(10x10)$ $= 600mm^2$	$volum = lxwxh$ $= 10x10x10$ $=1000mm^3$	$SA{:}Volume = \frac{surface\ area}{volume}$ $\frac{\text{Surface area}}{\text{Volume}} = \frac{600}{1000}$ $=0.6$
	$SA = 6(side\ x\ side$ $= 6(20x20)$ $= 2400mm^2$	$volum = lxwxh$ $= 20x20x20$ $=8000mm^3$	$\frac{\text{Surface area}}{\text{Volume}} = \frac{2400}{8000}$ $=0.3$

Conclusion from the above calculations.

- Small organisms have large surface area to volume ratio while large organisms have a small surface area to volume ratio.

Why small/unicellular organisms lack a transport system.

- Small organisms have large surface area to volume ratio,
- So, diffusion of materials across the body surface is rapid and effective means of transporting all materials in and out of the whole body.

Why multicellular organisms need a specialized transport system.

Multicellular organisms have a small surface area to volume ratio. So diffusion of materials across the body surface is very slow or impossible. Hence, a specialized transport system is needed in order to effectively:

- ✓ Supply useful material to all cells of the body for their metabolism.
- ✓ Move waste material from deeply located tissues to where they can be eliminated.

The importance of transport in living organisms:

- ✓ Supplies cells with materials they need to carry out various life processes e.g. nutrients, water and oxygen.
- ✓ Moves metabolic wastes products to sites where they are removed from the body because if they accumulate they are poisonous to cells.

The requirements for transport to occur in organisms.

- ✓ Materials to be transported e.g. blood, lymph, nutrients, wastes, gases e.tc.
- ✓ Medium for transport e.g. water or blood.
- ✓ Channels for transport e.g. blood vessels.
- ✓ Energy or driving force.

CELL PHYSIOLOGY (DIFFUSION, OSMOSIS AND ACTIVE TRANSPORT)

Processes by which materials are transported through organisms.

- ✓ Diffusion

- ✓ Osmosis
- ✓ Active transport

Definitions of key terms:-diffusion, osmosis, and active transport.

1. **Diffusion:** is the net movement of a substance from a region where its concentration is high to a region where its concentration is low.
2. **Osmosis** is the net movement of **water molecules** through a **semi permeable membrane** from a region where the water concentration high to a region where the water concentration is low.

→**A semi permeable membrane** is one which allows certain molecules to flow across it but prevent others from doing so, e.g. cell membrane of all cells.

→**A freely permeable structure:** is one that allows the free flow of all molecules of different size across it e.g. the plant cell wall

3. **Active transport** is the movement of molecules from a region of their low concentration to a region of their high concentration using energy.

NB: osmosis and diffusion are forms of passive transport. In passive transport, molecules move down a concentration gradient without using energy from respiration.

A concentration gradient is the difference in concentration between two regions.

BIOLOGICAL SIGNIFICANCE OF DIFFUSION:

- ✓ Gaseous exchange in stomata and respiratory surfaces occurs by diffusion.
- ✓ Enables the uptake of mineral salts from soil down concentration gradient.
- ✓ Absorption of digested food from the gut into blood stream down the concentration gradient.
- ✓ Elimination of waste substances in single celled organisms like amoeba
- ✓ Exchange of useful materials between blood and body cell in capillary bed occurs by diffusion.

BIOLOGICAL SIGNIFICANCE OF OSMOSIS:

- ✓ Absorption of water from the soil by root hairs.
- ✓ Absorption of water in small intestines.
- ✓ Re-absorption of water in the kidney tubules.
- ✓ Osmoregulation in single celled organisms like amoeba.
- ✓ Osmotic uptake of water provides turgidity and hence firmness to herbaceous plants. Herbaceous plants are non woody plants.
- ✓ Absorption of water by seed cells during germination.
- ✓ Regulates opening and closing of stomata through change in turgidity of guard cells.

BIOLOGICAL SIGNIFICANCE OF ACTIVE TRANSPORT

- ✓ Enables root hairs to take up mineral ions from the soil against their concentration gradient.
- ✓ Enable epithelial cells of the small intestines to take certain food nutrients such as glucose against their concentration gradient
- ✓ Enables the selective reabsorption of useful materials in the kidney
- ✓ Maintains the correct concentration of sodium and potassium ions in the nerve cells for the proper functioning of nerves.

Factors which affect the rate of diffusion.

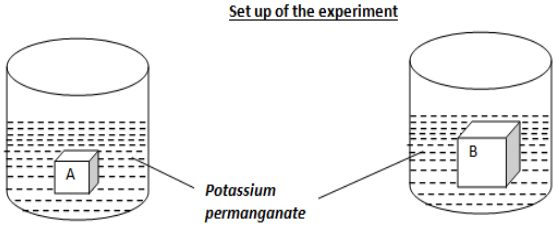
1. **Temperature:** The rate of diffusion increases with increase in temperature. This is because increase in temperature increases the kinetic energy of the diffusing particles which makes particles diffuse faster.

2. **Size of the diffusing particles:** smaller, lighter particles diffuse faster than bigger heavier particles.
3. **Surface area of the area:** diffuser is faster over larger area than over small area over which diffusion occurs
4. **Concentration gradient:** This is the difference in concentration of a substance at two regions. The rate of diffusion increase with increase in the steepness of concentration gradient.
5. **Nature of the diffusing medium:** diffusion is faster in gaseous medium and slowest in solid medium. This is because gas particles are loosely packed and the offer little resistance to the movement of particles than in solids.
6. **Diffusion distance.** Diffusion is faster over thin surfaces than across thick walls.

(a) An experiment to demonstrate the effect surface area to volume ratio on the rate diffusion in solids:

Materials

- Irish potato cubes
- A knife
- Potassium permanganate solution
- Water



Procedure

- Half fill two beakers with potassium perma
- Using a knife, obtain two cubes of differen
- Place the cubes in different beakers and leave them to stand for 30 minutes
- After 30 minutes, remove the cubes and dry them using filter paper.
- Then cut through each cube.
- Using a ruler, measure the extend of penetration of potassium permanganate.

Observation

- Potassium permanganate solution penetrates deeper into the smaller cube than the bigger cube. This is because the smaller cube has a larger surface area to volume ratio than a bigger cube.

Conclusion

- Potassium permanganate diffuses into solids and the rate of diffusion is faster in small solids than bigger solids

Explanation for the difference between the penetrations of coloured dye in the two cubes:

- The dyes penetrated deeper into cube A than Cube B.
- This is because Cube A is small with a large surface area to volume ratio than cube B.

How the problem faced by B would be overcome by a living organism without altering its shape.

- B is larger cube with small surface area to volume ratio. This reduces the rate at materials diffuse from the environment to and from all the tissues. Organism overcomes this problem by developing a specialsed transport system to deliver materials to the deeply located cells of the body.

Words used to describe solution in osmosis: hypotonic, hypertonic and isotonic solution:

- **Hypotonic solution**: is a solution whose solute concentration is lower than that of the cell content or another solution.
- **Hypertonic solution**: is a solution whose solute concentration is higher solute concentration than the cell contents or another solution**.**

- **Isotonic solution**: is a solution whose solute concentration is equal to that of another solution or cell content.
- **Osmotic pressure**: Increase in pressure of solution resulting from inflow of water into the solution by osmosis

OSMOSIS AND CELLS:

Key terms to learn: haemolysis, crenation, plasmolysis, flaccid, turgid, turgidity, wilting.

(a) ***The behavour of animal cells in solution of different concentrations:***

→**Animal cells in hypotonic solution:** animal cells burst when placed in hypotonic solution. This is because water moves from the surrounding hypotonic solution into the cell by osmosis and the animal cells have weak cell membrane, or lack cell wall.

The bursting of red blood cells in hypotonic solution is called **haemolysis.**

→**Animal cells in hypertonic solution:** Animal cells **shrink** when placed in hypertonic solution. This is because water is lost from cells to the surrounding hypertonic solution by osmosis.

The shrinkage of animal cells in hypertonic solution is called **crenation.**

→**Animal cells in isotonic solution**: Animal cells remain unchanged in shape and size when put in an isotonic solution. This is because the cells do not absorb or lose water by osmosis, so they remain intact.

(b) The behavour of plant cells in solutions of different concentrations.

→ **Plant cells in hypotonic solution:** A plant cell becomes turgid/rigid/stiff/firm when placed in a hypotonic solution. This is because the cells gain water from the surrounding hypotonic solution by osmosis. As the cells receive waster by osmosis, their vacuole expands and pushes the cytoplasm and nucleus against the cell wall thereby exerting a pressure called **Turgor pressure**.

The cell does not burst because plant cells have cell walls made of rigid cellulose material which prevents further expansion by exerting **a wall pressure** against the increasing Turgor pressure. A point is reached when Turgor pressure equals to wall pressure and at that point, no more water enters the plant cell.

Turgor pressure is the pressure exerted by cell contents against the cell wall.

Wall pressure is the pressure exerted by the cell wall against the protoplasm/turgor pressure.

→ **Plant cells in hypertonic solution:** (turgid) Plant cells become flaccid when put in hypertonic solution. This is because water is lost from the cell by osmosis: and so Turgor pressure begins to decrease. If this continues, the protoplasm then pull/shrinks away from the cell wall making Turgor pressure to become zero. Therefore, the cell loses turgidity. It becomes soft/ flaccid. This process is called **plasmolysis**.

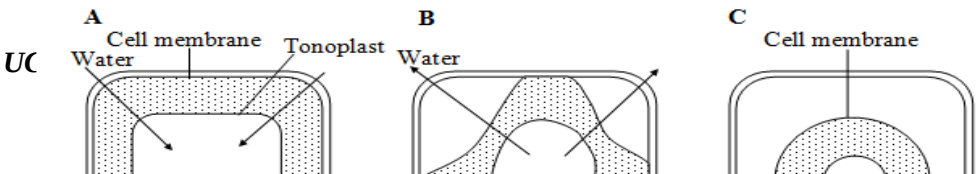
Plasmolysis: is the shrinkage of the cytoplasm and cell membrane away from the cell wall when placed in hypertonic solution.

→When plant cells are placed in an isotonic solution, they remain unchanged in both mass and size. This is because; there is no net uptake of water by osmosis.

Importance of turgor pressure (or turgidity in plants)

1. Provides support to non woody plants (plant parts)
2. Brings about opening of flower to allow pollination and fertilization.
3. Brings about opening and closing of stomata.
4. Brings about unfolding of leaves which ensure maximum absorption of Sunlight for photosynthesis.

Illustration



Terms to learn: Flaccid, turgid, Turgor pressure, wilting and shriveling.

- ✓ **Flaccid:** means soft, flabby and lacking Turgor.
- ✓ **Turgid:** means stiff, firm and having Turgor
- ✓ **Turgor pressure**: is the pressure exerted by the cell contents against the cell wall.
- ✓ **Shriveling**: is process by which leaves fold and loose shape when they lose waster.

WILTING:

Wilting: is the loss of turgidity or rigidity of non-woody parts of plants, characterized by dropping of leaves. This occurs when the turgor pressure of cells of the non woody plant parts falls towards zero; when plant cells lose more water through transpiration than they can absorb from the soil by osmosis.

Recovery from wilting normally occurs at night when it is cold and stomata are closed. This significantly reduces water loss through transpiration. So, plants cells gain more water increasing turgor pressure and giving the cells rigidity.

The significance of wilting in plants:

Dropping of leaves reduces leaf surface area exposed to sunlight; this controls and reduces rate of transpiration; Allowing the plant to conserve water.

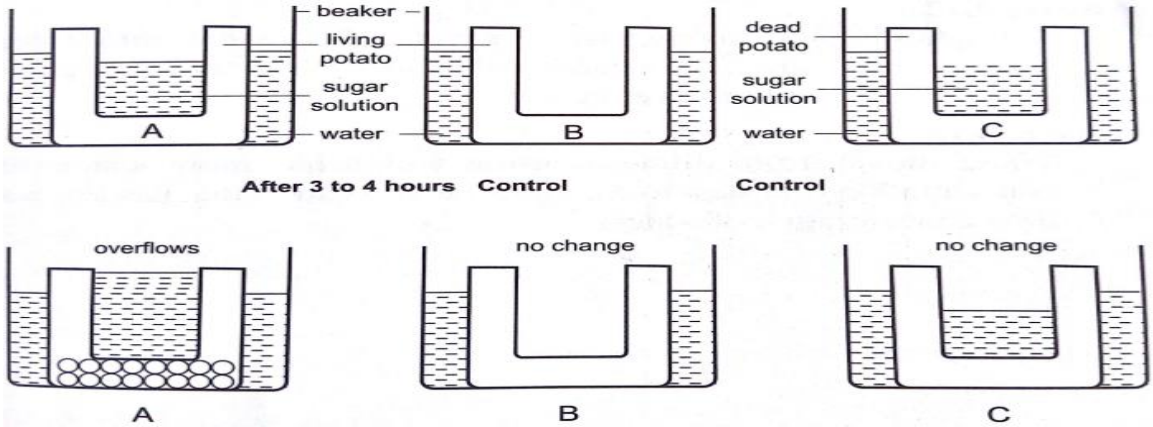
(b) An experiment to demonstrate osmosis in potato tissues (living tisues)

Materials

- ✓ 3 Irish potatoes A, B and C.
- ✓ Knife.
- ✓ Table salt/sugar crystals
- ✓ Source of heat
- ✓ 3 Petri dishes

Setup of the apparatus

At the start



Procedure

-obtain three fresh potatoes and boil one of them to kill its cells.

-peel the three potatoes, cut off to flatten both ends and scoop out a cavity in each.

-Put a little concentrated sugar solution into the cavity of one fresh potato cup A;

-Place a little concentrated sugar solution into the cavity of the boiled potato C.

-Do not add anything in the cavity of the fresh potato B.
-place the three potatoes in beakers containing distilled water.
-The experiment is left to stand for 3-4 hours and the inside of the potatoes is observed.

Observation

The level of the sugar solution in the cavity of the fresh potato A rises and starts to overflow.

No change take place in the cavity of the fresh potato B and boiled potato C.

Conclusion

The living potato tissue acts a semi permeable membrane which allows water to cross from the beaker into the sugar solution by osmosis.

Explanation:

Sugar solution in the cavity of fresh potato A is hypertonic to the contents of adjacent potato cells. So the sugar solution absorb water from the adjacent cells by osmosis. The cells in contact with water take up the water molecules which continues to flow by osmosis across the tissue into the cavity, thereby causing the sugar solution to rise and begin to overflow.

No change takes place in the cavity of boiled potato C because dead cells cannot allow osmosis to occur.

No change takes place in the cavity of fresh potato B due to absence of sugar solution to absorb water from cells by osmosis. Although water molecules pass into the cells of cube C, none emerge into the cavity.

B and C are controls to prove that the results in A are due to the presence of concentrated sugar solution in the cavity and to the action of living cells.

(c) An experiment to demonstrate osmosis using non-living tissue (visking tubing).

Materials

- Visking tubing
- Concentrated sugar solution
- Two beaker
- Distilled water

Set up of apparatus

Procedure

- ✓ Fill a beaker with distilled water.
- ✓ Measure and cut visking tubing 8cm in length.
- ✓ Tie one side of visking tubing is tightly with a string 1cm from the end.
- ✓ Fill the visking tubing about ¾ full with concentrated sugar solution.
- ✓ Tie the open end of the visking tubing tightly with a string.
- ✓ Immerse the visking tubing with the sugar solution into a beaker filled with distilled water.
- ✓ Note the level of water in the beaker.
- ✓ Leave the setup to stand for one hour then note the amount of solution in the visking tubing and the level of water in the beaker.
- ✓ Procedure
- ✓ Repeat procedure one above but this time, fill the visking tubing with distilled water then tie tightly until it is firm and budging. Immerse the visking tubing in a beaker of concentrated sugar solution and leave it to stand for several hours

Observations

- ✓ Visking tubing immersed in distilled water became swollen due to entrance of water while the one immersed in concentrated sugar solution shrunk due to lose of water to the glucose solution.

Conclusion

- ✓ Osmosis is the movement of water from dilute solution to a concentrated solution through a semi permeable membrane
- ✓ It can also be defined as the movement of water from a region of high concentration of water molecules to a region of low concentration of water molecules through a semi permeable membrane.

(d) An experiment to demonstrate to demonstrate diffusion using visking tubing

Materials:

- Visking tubing
- Starch solution
- Dilute iodine solution
- Beakers
- String.

Set up of apparatus:

Procedure

- ✓ Measure and cut a visking tubing 8cm in length
- ✓ Tie one end of the visking tubing tightly using a string about 1cm from the tip
- ✓ Fill the visking tubing with a starch solution and then tie up the end
- ✓ Note the colour of the solution
- ✓ Immerse the visking tube with starch solution into a beaker containing dilute iodine solution.
- ✓ Leave it to stand for 15 minutes as you observe the colour change.

Observation

- ✓ The colour of starch solution in the visking tubing changed from white to blue-black.
- ✓ In the beaker, the colour of iodine solution remained brown.

Explanation:

- ✓ Iodine which is made up of small molecules diffused across the fine pores of the visking tubing into the visking tubing. The presence of iodine made the contents of the visking tubing to turn blue-black.
- ✓ Starch is polymer made up of large molecules which could not diffuse across the fine pores of the visking tubing and its absence in the boiling tube made iodine solution there, to remain brown.
- ✓ The visking tubing acts a semi permeable membrane (selectively permeable membrane) because it only allows iodine molecules to pass through but not starch.

Comparison between diffusion and osmosis.

(a) **Similarities: In both:**

- Are passive processes (energy is not needed)
- Molecules move down concentration gradient
- Equalize the concentration of two regions

(b) **Differences between osmosis and diffusion:**

Diffusion	Osmosis
✓ Movement of molecules of any chemical substance down concentration gradient	✓ Only involve the movement of water molecules down the concentration gradient
✓ Semi permeable membrane not involved	✓ Semi permeable membrane involved

Comparison between osmosis and active transport.

Similarities

- ✓ Both involve a concentration gradient
- ✓ Both occur in living cells
- ✓ Both processes are affected boiling living cells.

Differences between osmosis and active transport:

Osmosis	Active transport
✓ Only solvent molecules involved	✓ Solute molecules involved
✓ Energy in form of ATP not needed	✓ Energy needed
✓ Molecules move down a concentration gradient	✓ Molecules move against a concentration gradient
✓ Semi permeable membrane	✓ Semi permeable membrane not needed
✓ Occurs in both living cells and visking tubing	✓ Occurs in only living cells

Factors affecting the rate of Active Transport

Most factors that affect active transport are those factors that would affect the energy production process in living cells. These include:

1. **Oxygen concentration**

Oxygen is required in respiration process that yields energy for active transport. Under low oxygen concentration, the rate of respiration will be low hence there will be production of little energy leading to low rate of active transport. Increase in oxygen concentration translates into a higher energy production leading to high rate of active transport.

2. **Change in pH**

Change in pH affects the respiratory process which is enzyme controlled reaction. Respiratory enzymes require optimum pH for their efficient activity. Extreme pH conditions will increase lower the rate of active transport since the enzymes controlling respiration will be denatured.

3. **Glucose concentration**

Glucose is the chief respiratory substrate. At low glucose concentration, there will be less production of energy leading to decreased rate of active transport. Rate of active transport increases with increase in glucose concentration due to increase in the rate of energy production.

4. **Temperature**

Temperature affects the enzyme controlled respiration process. At low temperatures, the enzymes are inactive hence the rate of respiration will be low resulting into low rate of active transport since there will be less production of energy. An increase in temperature increases the rate of respiration since the enzymes become more activated. At temperatures beyond 40 degrees Celsius, the enzymes become denatured, respiration stops and so does active transport.

5. **Presence of metabolic inhibitors e. g. cyanide.**

These are substances which act as metabolic poisons. They stop the rate of respiration leading to production of no energy. Active transport is, thus, stopped.

TRANSPORT INPLANTS

The materials that need to be transported in plants.

- Water for photosynthesis and support.
- Mineral salts for process growth.
- Organic substances/food.

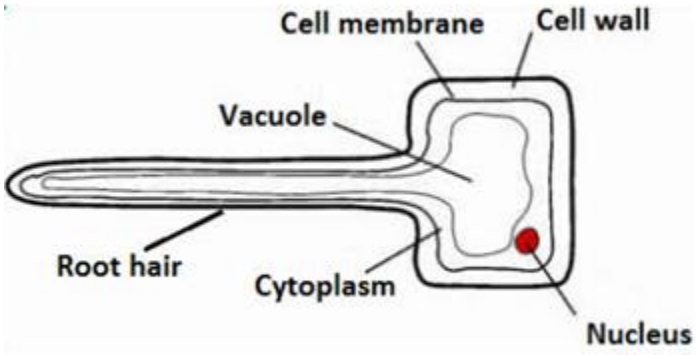
Internal structure of a root hair:

A root hair is a cellular extension of a specialized epidermal cell of plant root.

A specialized epidermal cell of plant root with tubular extension called a root hair cell.

The root

Hairs are fund on young roots just behind the root tip. The region where root hairs are found is called piliferous layer.

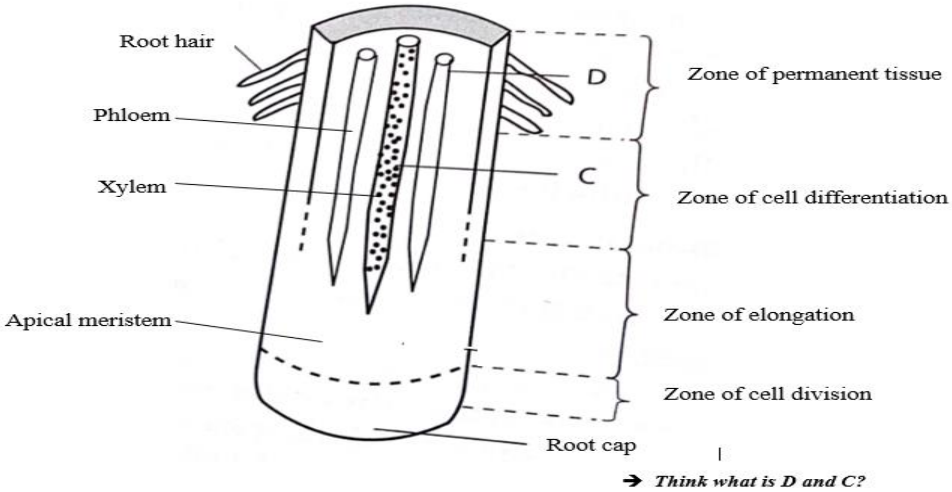


Adaptations of the root hair for absorption of water and mineral salts.

1. Are thin walled providing a reduced distance for faster uptake of water and mineral salts.
2. Are fine and able to bend around soil particles, penetrate into soil crevices and make close contact with water soil.
3. Are numerous to provide a large surface area for absorption of water and ions.
4. Has numerous mitochondria for production of enough energy used in active transport.
5. Lack cuticle which makes them permeable to water.
6. Are continuously replaces by new cells once they die.

Internal structure of roots and stems:

(a) Longitudinal section of a dicotyledonous root tip



Appearance of cells in various zones:

1. **Zone of cell division:** cells have thin walls, dense cytoplasm, and no vacuoles.
2. **Zone of cells elongation:** cells are enlarged to maximum size, vacuoles start forming and enlarging.
3. **Zone of cell differentiation:** cells attain their permanent size, have large vacuoles and have thickened cell walls. In this region, cells differentiate into tissues specialized for specific functions e.g. piliferous layer, cortex, vascular bundles, endodermis and Pericycle are tissues that form in this region
4. **Zone of permanent tissues.** Zone of differentiated cells with permanent shape and size.

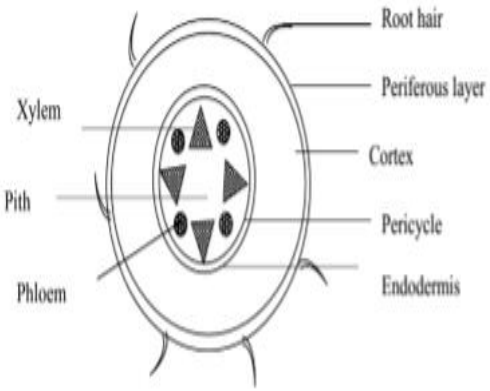
Importance of the parts shown:

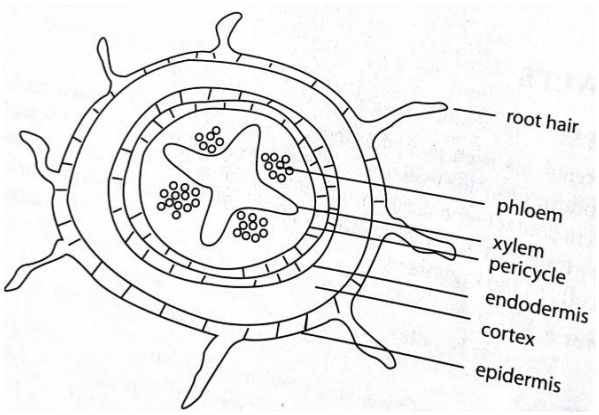
Root cap: protect the apical meristem as the root tip is pushed into the soil.

1. **Apical meristem**: brings about primary growth.

2. **Xylem:** transports water and mineral salts.
3. **Phloem:** transports food.
4. **Root hair:** absorbs water and mineral salts.

(b) Transverse section of monocot root **transverse section of dicot root**





<u>DESCRIPTION OF THE TRANSVERSE SECTION OF ROOT</u>:

Epidermis:

- ✓ The outermost layer, and is only one cell thick.
- ✓ Epidermis of young roots has specialsed epidermal cells called root hair cells. A root hair cell is an epidermal cell with tubular extensions called a root hair.
- ✓ The part of the root epidermis that gives rise to root hairs is called **piliferous layer**.
- ✓ In older parts of a root, a tissue called cork replaces the piliferous layer.

Cortex

- ✓ Found between the cortex and endodermis.
- ✓ The cortex is made up of parenchyma cells
- ✓ The inner most layer of the cortex is called endodermis.

Endodermis:

- ✓ Possess starch grain.
- ✓ Has casparian strip which has an impervious deposit on the radial and cross walls.

Pericycle

- ✓ A layer of cells just beneath the endodermis and surrounds the conducting tissues.
- ✓ The Pericycle produces secondary roots (lateral roots) which push their way through the cortex and epidermis.

Conducting tissue/ vascular bundles

- ✓ Conducting tissues form the vascular bundles and is composed of the xylem and phloem at the centre of the root.
- ✓ Xylem transports water and mineral salts while the phloem transport manufactured food from leaves to the rest of the plant.

→**In dicot root,** the xylem occupies the centre of the root where it forms a star shape. The phloem and cambium is located between the two rays of the star shaped xylem.

→**In monocot root**, the xylem and phloem are arranged to form a ring in which the xylem tissue alternates with the phloem tissue.

Pith

- ✓ Is the central region of root/stem.
- ✓ Has parenchyma cells which store air, water and food substances.

Cambium

- ✓ The cambium is a tissue between the xylem and phloem which is capable of repeated cell division.

- ✓ The cambium adds more xylem to its inside and phloem to its outside.

Comparison of a dicot root and a monocot root

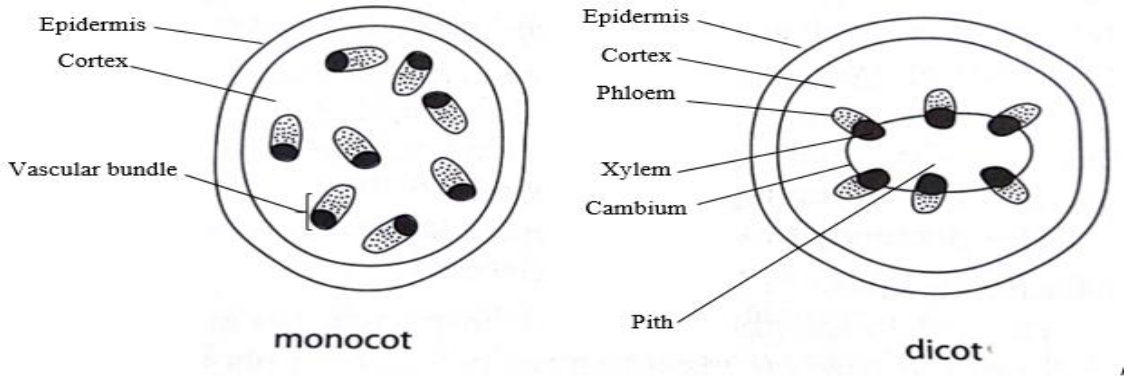
a) Similarities: Both

1. Contain epidermis
2. Have Cortex
3. Contain cambium
4. Have Xylem and phloem

(b). Differences

Monocotyledonous root	Dicotyledonous root
✓ Xylem is round shaped	✓ Xylem is star shaped
✓ Has many xylem tissues	✓ Has one xylem
✓ Phloem alternates with xylem	✓ Phloem is located between two rays of star shaped xylem

The internal structure of dicot and monocot stem



- Note description of tissues, see roots. (Most of the tissues in roots are similar.)

Differences between dicot and monocot stems.

Monocot stem	Dicot stem
1. Pith absent	**1.** Has central pith
2. Cambium absent	**2.** Has cambium
3. Vascular bundles scattered throughout the cortex of stem	**3.** Vascular bundles are arranged in circular way ring

The functions of the parts identified in internal structure of stems/roots

Functions of the epidermis:

- Protects inner cells from damage.
- Also absorbs water and mineral salts in roots.

Functions of the cortex:

- Food and water storage.
- Transport water and mineral salts to the xylem.

Functions of the endodermis:

- Controls movement of water mineral salts into the xylem.

Pericycle: produces lateral roots

Phloem Transports. food around the plant.

Xylem: Transports water and mineral salts in plants

Functions of the cambium:

- ✓ Have cells which divide repeatedly by mitosis to form new cells which replace worn out xylem and phloem
- ✓ Responsible for secondary growth (increase in girth) of the plant
- ✓ Pith Spongy tissue for food and water storage
- ✓ Also has air spaces occupied by air for respiration

Comparison of a dicot stem and dicot root.

Similarities; Both have

- ✓ Epidermis.
- ✓ Cortex
- ✓ Xylem and phloem tissues (vascular bundles)

Differences:

Dicot stem	Dicot root
1. Has cambium ring	1. Has no cambium
2. Has cuticle	2. Lacks cuticle
3. Has no root hairs	3. Has root hairs
4. Vascular bundles not at the centre	4. Vascular bundles at the centre
5. Has pith	5. Has no pith
6. Has lenticels	6. Lacks lenticels
7. Has node and internode	7. Lacks nodes ad internodes

How water moves from the soil up to the leaves where it is used for photosynthesis. (Or how plants maintain a transpiration stream)

- ✓ Root hairs absorb water from the soil solution by osmosis.
- ✓ Water is then transported across the root cortex cells again by osmosis.
- ✓ Water then enters the root xylem after crossing the endodermis by active transport which provides root pressure.
- ✓ Water moves up the plant through the xylem in form of a continuous stream (or a transpiration stream) under the influence of: **capillarity, root pressure, cohesion and adhesion, and transpiration pull.**

However, the main forces maintaining the transpiration stream are transpiration pull and capillarity

Transpiration pull:

Transpiration pull is a suction force set up by transpiration, which pulls a stream of water up the plant xylem from roots to leaves. Water evaporates from the spongy mesophyll cells into the sub-stomatal air space; making the contents of the spongy mesophyll cells more concentrated than the adjacent cells. This brings about the osmotic flow of water into the spongy mesophyll from the surrounding cells which in turn take water from the xylem vessel in leaf vein there by setting a transpiration pull; which pulls more water up the xylem from roots to leaves.

Cohesion and adhesion:

Cohesion: This is a force of attraction btn like molecules keeping them together. Due to great cohesive force, water molecules attract one another in such a way that they always stick together btn water molecules cause water molecules to attract each other thereby sticking together.

This prevents breaking of the water column in the xylem vessel thereby maintaining a transpiration stream (continuous column of water moving up in xylem)

Adhesion: Adhesion is a force of attraction btn unlike substances. Water molecules are also attracted to the walls of the xylem vessels in which the water is flows by a force known as adhesive force. The great adhesive force btn water molecules and the walls of xylem vessel cause water molecules to stick onto the walls of the xylem vessels and maintains a continuous flow of water up the xylem from roots to leaves.

Capillarity:

Capillarity is the tendency of water to rise in very narrow tubes. The lumen of the xylem vessels is very narrow which enables water to rise by capillarity. Capillarity is assisted by adhesion and cohesion forces to maintain the transpiration pull.

Root pressure:
This is a forces generated by the root cortex cells and forces water into and up the plant xylem. The energy used to develop root pressure originates from the endodermal cells. In that, the endodermis actively secrete minerals into the xylem. The osmotic pressure of the xylem content is increased, generating water potential gradient which forces water into xylem by osmosis. . This in turn, creates a hydrostatic pressure gradient in the xylem which forces water up the xylem.
Note: Root pressure is thought to be responsible for guttation.

What happens to the water and mineral salts that a plant takes up through its roots?
Most of the water is used as raw material to make food in photosynthesis.
Some of the water is used to provide support to non-woody plant through turgidity of cells.
Much of the water is lost by transpiration through stomata in leaves, lenticels in older woody stems and through epidermis where the cuticle is thin.
Some water may lost by guttation.

Absorption and movement of mineral salts from the soil up to the leaves of flowering plants:
Roots absorb mineral salts in form of ions in solution. The ions may be absorbed by diffusion if there is a concentration gradient. They can be absorbed by active transport against their concentration gradient, if they are more concentrated in the root-hair cell than they are in the soil.
The ions are then distributed in solution of water to all plant parts through the xylem because of capillarity, transpiration pull, root pressure, cohesion and adhesion.
Note:
The uptake of water from the soil by root hairs differs from uptake of mineral salts from the soil by the same root hairs in the way that: water is absorbed by osmosis while mineral salts are absorbed by diffusion or active transport.
Mineral salts are distributed through the xylem in solution form, dissolved in water in way as water as described above.

(a) An experiment to demonstrate root pressure:
Materials
- ✓ Very leafy, Potted plant
- ✓ Knife
- ✓ Rubber tubing
- ✓ Coloured water
- ✓ Narrow glass tube
- ✓ Timer
- ✓ Retort stand

Setup

Procedure

- ✓ Select a well-watered leafy potted plant.
- ✓ Cut the stem of the plant just above the soil level.
- ✓ Attach a glass tube to the cut end using rubber tubing.
- ✓ Pour coloured water in the glass tube.
- ✓ Add little oil to the water in the glass tube to prevent from evaporating from the glass tube.
- ✓ The setup is left for about 2 hours as you observe the water level in the glass tube.

Observation

- Sap exudes from the cut surface
- Coloured water rises in the glass tube

Conclusion There is a pressure or force originating from the root causing exuding of sap and upward movement of coloured water in the glass tube.

(b) An experiment to show that water travels up the plant through the xylem

A small plant with light coloured flowers is placed in a beaker of water containing a dye. It is allowed to remain in the water for about 24 hours and then flowers are observed. The dye will appear in flowers and along veins of the leaves.

Cut the stem and roots across and place a section of each under a microscope. It is seen that xylem is dyed. This shows that the xylem conducts water from roots to leaves.

Structure and adaptations of the xylem tissue:

***(a)* Structure of the xylem:**

The xylem is a non-living tissue which consist of the xylem vessel and tracheids.

The vessels: are tubular, non-living, have bordered pits, have walls impregnated with lignin.

The tracheids: are modified xylem cells, have lignified pitted walls, are non-living, have tapering ends and are perforated across walls.

***(b)* Function of the xylem:**

- ✓ Offer support in woody plants.
- ✓ Transports water and mineral salts.

***(c)* Adaptation of the xylem:**

- ✓ Xylem has a very narrow lumen so that water can rise by capillarity.
- ✓ The xylem is non-living reducing resistance to water flow.
- ✓ The walls of the xylem are impregnated with lignin to make them strong so that they do not collapse, and keep them open at all times.
- ✓ There are bordered pits which allow lateral movement of water into neighboring cells.
- ✓ Walls of Xylem element are made of lignin and cellulose to keep them open at all times.
- ✓ Made up of long cells joined end to end, and the end wall is lost to allow continuous flow of water.
- ✓ Walls are impermeable to water.

TRANSLOCATION

Translocation is the transport of products of photosynthesis and its takes place in the sieve tubes of the phloem.

Structure and adaptions of the phloem:

Structure of the phloem:

Adaptations of the phloem:

- ✓ Sieve tube elements have cytoplasmic strands over which materials flow.
- ✓ End walls of sieve plates have numerous pores to allow passage of substances from one element to another.
- ✓ Cytoplasm of sieve tube elements has no or less organelles to provide more space for the movement of materials.
- ✓ Along each sieve tube element, there is a companion cell with numerous mitochondria that produce enough energy used for active transportation of food materials.
- ✓ Plasmodesmata pits allow movement of materials btn sieve tubes.

Mechanism of translocation:

One of the most widely held theories to account for the movement of solutes in phloem is the mass flow hypothesis: which explains that:

→In the leaf cells:

- Sucrose is made leading to accumulation of sugar; which brings about a fall in the water potential of the cell sap; which cause intake of water by osmosis; and a high turgor pressure then builds up in the leaf cell.

→In root cell:

- Sugar is used in respiration or stored as starch; causing a rise in the water potential of to root cell sap; then water flows out of the root cell by osmosis; creating a region of low turgor pressure.
- So, turgor pressure is high at source and low at the sink.

→In the sieve tube:

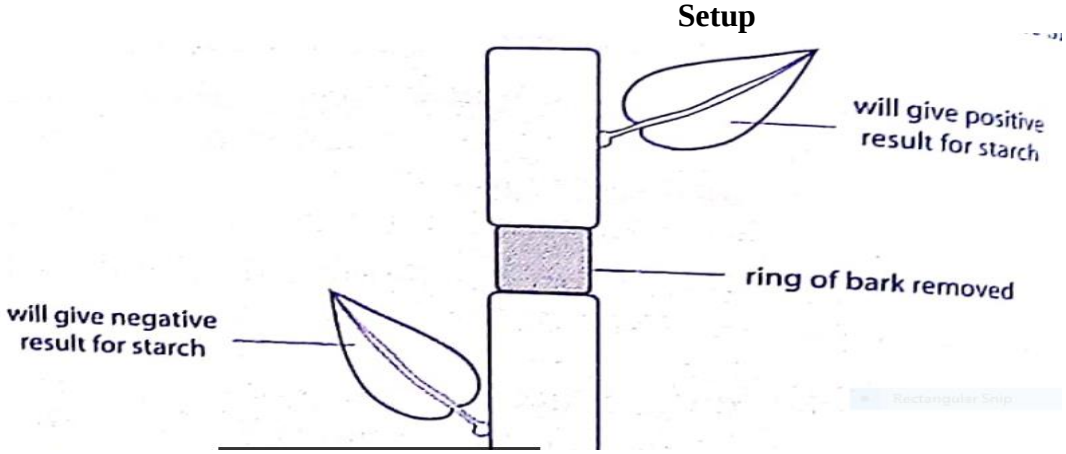
- Liquid is forced to flow from a region of high turgor pressure to a region of low turgor pressure.

An experiment to show that food made by leaves passes down the stem through the phloem:

Method:

- Put a woody-potted plant in light for about six hours.
- Detach one leaf and test it for starch to confirm that the leaves contain starch.
- Now, remove a ring of the bark from the stem between leaves.
- Keep the plant in a dark room for 48hours to destarch the leaves.
- Test the leaves for starch. Observe the point above the ring.

Setup



Results:

- Leaves from above the ring turn blue-black showing that they have not lost starch since it could not move down as the phloem was removed.
- Leaves below the ring and the unringed plant stain brown with iodine.
- Region just above the ring swells.

TRANSPIRTION AND GUTTATION:

✓ **Transpiration**: is the process by which plants lose water in form of water vapour to the atmosphere.

✓ **Guttation**: is the loss of water from plants in form of water droplets.

The mechanism of transpiration in plants.

Most transpiration occurs through stomata of leaves but evaporation also occurs through lenticels and cuticles in stems and flowers. There are three types of transpiration and the way each occurs are explained below:

Stomatal transpiration (transpiration through the stomata)

✓ Turgor pressure in the mesophyll cells forces water outwards through the cell walls; onto the outer surface of the cells walls.

✓ Water evaporates from the outer spongy mesophyll cells into the intercellular air spaces.

✓ Thereafter, the water vapour diffuses out of the leaf through the stomata into the atmosphere.

Note: Stomatal transpiration accounts for 90% of the total transpiration in plants.

Lenticular transpiration (transpiration through lenticels)

Turgor pressure forces water outwards through the cells walls; onto the outer surface of cork cells.

Water evaporates from the outer surface of the cork cells and diffuses out of the lenticels into the atmosphere.

Note: Lenticels are pores found on the bark of woody stems and roots. They comprise of loosely packed cork cells that allow free circulation of air. Lenticular transpiration accounts for about 5% of the total transpiration in plants.

Cuticular transpiration (transpiration through the thin cuticles)

A thin cuticle allows water to evaporate from the epidermal cells into the atmosphere. Cuticular transpiration accounts for about 2% of the total transpiration.

How plants benefit from transpiration.

1. Cools the plant in hot weather through latent heat of vaporization.
2. Sets up a transpiration pull, which distributes water in xylem to all plant parts.
3. Causes distribution of mineral salts because water which is distributed by the transpiration pull contains dissolved salts.
4. Provides support to non woody plant parts (& herbaceous plants) through turgidity of cells.
5. Causes opening of the stomata and flowers due to turgidity of cells.
6. Causes unfolding of leaves through turgidity of cells.
7. Means by which excess water is eliminated from the plant.

Disadvantages of transpiration:

- Excessive water loss reduces photosynthesis which causes reduced growth in plants.
- Causes wilting (loss of turgidity or rigidity of non woody plant plants characterized by dropping of leaves).
- Causes reduced yield and wastes plant energy.

FACTORS WHICH AFFECT THE RATE OF TRANSPIRATION.

Many factors affect transpiration and these factors are divided into environmental factors and structural factors**.**

The **environmental factors** affecting transpiration:-

1. **Temperature**:

The rate of transpiration increases with increase in temperature and decreases with decrease in temperature. Temperature affects the rate of transpiration because it provides latent heat of vaporization. At high temperature, the rate of transpiration is high because there is more energy evaporation of water from the leaf. At low temperature the rate of transpiration is low because there is less energy for evaporation of water from the leaf.

2. **Light intensity:**

Light intensity is the strength light received by the earth's surface. The rate of transpiration increases with increase in light intensity and decreases with decrease in light intensity. Light affects the rate of transpiration because light controls opening of the stomata and also provides energy for evaporation of water.

At low light intensity, the rate of transpiration is low because the stomata opens less and there is less energy for evaporation of water. At high light intensity, the rate of transpiration is high because the stomata opens wider and there is more energy for evaporation of water.

3. **Wind speed:**

Wind is moving air. The rate of transpiration increases with increase in wind speed. Wind affects the rate of transpiration because wind sweeps away moisture from the leaf surface increasing the diffusion gradient. The rate of transpiration is high in windy air than in still air.

In windy conditions, the rate of transpiration is high because wind sweeps away evaporated water vapour creating more space/increasing the diffusion gradient which allows more water vapour to escape from the leaf. In still air, the rate of transpiration is low because there is no wind and water vapour accumulates around the leaf surface leaving less space and reducing diffusion gradient hence little or no water vapour can escape from the leaf as the air around the leaf is already saturated with water vapour)

4. **Humidity:**

Humidity is the amount of water vapour in the atmosphere. The rate of transpiration increases with decrease in humidity.

When humidity is low, the rate of transpiration is high because the surrounding air is dry and so there is more space for water vapour from the leaf to occupy.

When relative humidity is high, the rate of transpiration is low because the surrounding air is moist and saturated with vapour. This means that there is very little space in air for water vapour from the leaves to occupy which reduces the rate of transpiration.

5. **Water supply:**

The rate of transpiration increases with increase in the amount of water in the soil and reduces with decrease in amount of water in the soil.

The structural factors which affect the rate of transpiration include

6. **Leaf size:**

If plant has many broad leaves, the rate of transpiration will be high because there is large total surface area of the leaf exposed.

If a plant has few and narrow leaves, the rate of transpiration will be low due to the small total surface area of the leaf exposed.

7. **<u>Number of stomata</u>**

The more the number of stomata on the leaf surface, the higher the rate of transpiration. This is because there are more openings on the leaf surface through which the water vapour escapes.

8. **Nature of the cuticle (Thickness and shininess of the cuticle)**

Cuticle is a waxy water proof layer secreted by the epidermis. Only small amounts of water diffuse through the cuticle. The thinner the cuticle, the higher the rate of transpiration because thin cuticle have short diffusion distance which allows more water vapour to diffuse through compared to thicker cuticles.

Shinny and reflect away a lot of heat. This reduces evaporation of water from the leaf hence reducing the rate of transpiration.

XEROPHYTES:

Xerophytes are plants growing in hot and dry places e.g. desert plants.

Challenges faced by xerophytes.

- ✓ Water shortage
- ✓ Excess water loss

ADAPTATIONS OF XEROPHYTES:

(a) Adaptive features which enable the plant reduce water loss (transpiration)

- ✓ Having fewer stomata that are smaller in size.
- ✓ Having few leaves that are reduced in size (reduced to thorns or spines).
- ✓ Having stomata that are sunken to trap humid air around stomata.
- ✓ Having a reversed stomatal rhythm which reduces transpiration because the stomata opens when there is less energy for evaporation.
- ✓ Having less or no stomata on the upper epidermis of leaves as this side get more sunlight directly.
- ✓ Shedding of leaves during very hot season to reduce surface area for transpiration.
- ✓ Having with a thick waxy and shiny cuticle to reduce water loss by evaporation.
- ✓ Having hairy leaves to trap moist air.
- ✓ Rolling leaves during hot weather to reduce SA available for transpiration.

(b) Adaptive features to obtain and retain water:

- ✓ Have thick and fleshy stems and branches for water storage.
- ✓ Have deep penetrating roots that absorb underground water far below the surface.
- ✓ Have superficial roots which grow extensively close to the surface providing a large surface area for water absorption in shallow rains.

(c) An experiment to show that water vapour is given off mainly through leaves during transpiration.

Materials

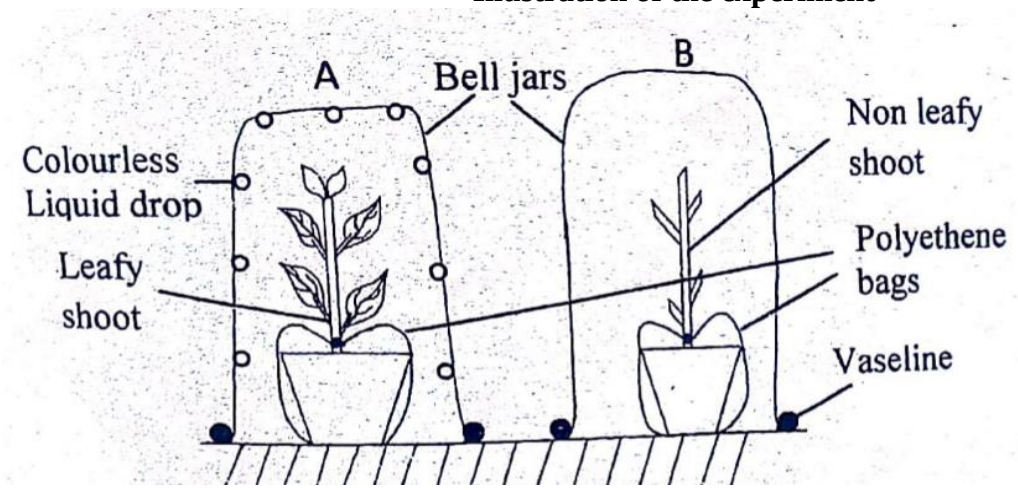
- Healthy watered potted plant with a leafy shoot.
- Healthy dry potted plant with a non-leafy shoot.
- Two bell jars
- Vaseline
- Two Polyethene bags

- Strings
- Anhydrous copper (II) sulphate

Procedure

- A pot containing the plant with a dry leafy shoot is tightly covered with a Polyethene bag. This is done in order to prevent evaporation of soil water which would interfere with the results. The shoot should dry to prevent moisture which would interfere with the results.
- The plant is then covered with a bell jar. The bell is used to collect any droplets of water.
- The base of the bell jar is smeared with Vaseline to prevent atmospheric moisture from entering the bell jar.
- Design a control experiment by setting up the apparatus in the similar way as above but using a potted plant with dry non-leafy shoot.
- The shoots must be dry to avoid moisture which would interfere with results.
- ✓ The set are placed in light for about 2 hours.

Illustration of the experiment



Observation:

- ✓ Droplets of a colourless liquid are seen in the bell jar with leafy shoot. The liquid turns anhydrous cobalt chloride from blue to pink (or anhydrous copper (II) sulphate from white to blue)
- ✓ No liquid droplets collect in the bell jar with a non-leafy shoot.

Conclusion:

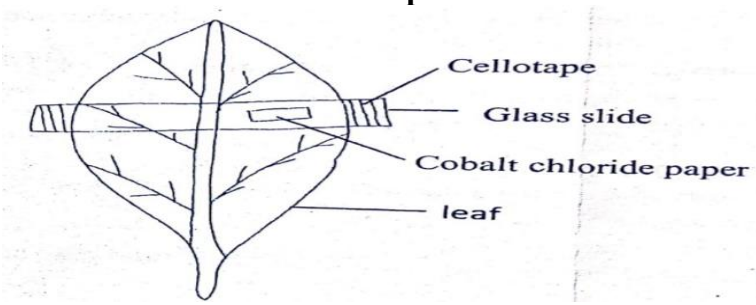
- ✓ Water vapour is given off mainly by leaves during transpiration.

(d) An experiment to show that more transpiration occurs on the lower epidermis than on upper epidermis of the leaf.

Materials

- Potted plant
- Anhydrous cobalt chloride papers
- Cellotape.
- Two glass slides

Set up



Procedure:

- ✓ Place pieces of cobalt chloride paper on the upper and lower epidermis of the leaf still attached on the healthy growing plant. The leaf should remain attached on the growing plant so that it stays alive and continue to get water from the plant.
- ✓ The cobalt chloride papers are then covered by glass slides which are then tied by use of Cellotape or rubber bands.
- ✓ The apparatus set up and left to stand for some time in sunlight.
- ✓ Observe each piece of cobalt chloride paper and record the time each piece takes to turn pink.

Observation

- ✓ The cobalt chloride paper on the lower leaf surface turns from blue to pink before that on the upper leaf surface.

Explanation

- ✓ Cobalt chloride paper turns blue due to the water produced during transpiration.
- ✓ More stomata are located on the lower epidermis of the leaf, so more transpiration occurs there.

Conclusion

- ✓ More transpiration occurs in the lower leaf surface than on the upper epidermis in the case of a typical terrestrial plant.

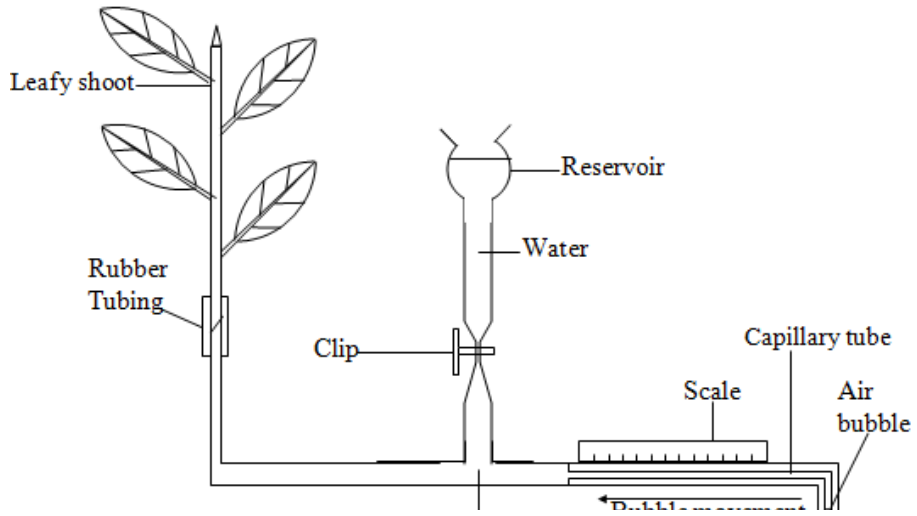
THE POTOMETER

(e) An experiment to investigate the rate of transpiration by means of a potometer

<u>Materials:</u>

- ✓ A leafy shoot.
- ✓ Stop watch
- ✓ Potometer

Set up the Potometer



Procedu

- ✓ T ner. The stem is cut under w
- ✓ The Potometer is filled with water; and the cut end of the shoot is fitted into the rubber tubing.
- ✓ The stem should be thick enough to fit tightly into the rubber stopper and the point of contact between the stem and rubber stopper should be sealed with Vaseline; to prevent evaporation of water from the Potometer which would falsify the result. In other wants, it is to ensure water is only lost from the leafy shoot.
- ✓ Remove the potometer with the leafy shoot from the water and mount them in a fixed position. The end of the capillary tube should rest in a beaker of water.

- ✓ Place the potometer in a given environmental condition under investigation e.g. Place the potometer in a windy place
- ✓ Introduce an air bubble into the capillary tube by removing the beaker of water at the end of the capillary tube.
- ✓ Record the distance moved by the air bubble and record your results in the table.
- ✓ Calculate the rate of water uptake as follows

Rate of water uptake = $\frac{\text{distance moved by the air bubble (cm)}}{\text{Time taken (minutes)}}$

Repeat he procedure again but this time, place the potometer with the shoot in air is still and calculate the rate of water uptake by the same shoot.

Observation

- Bubble moves faster and covers longer distance when the shoot is placed in a windy place than when in still air.

Conclusion

- The rate of transpiration is faster in windy air than in still air.

NB.

Other factors and how they can be investigated using a potometer;

Temperature/light intensity can be investigated by placing the setup in the hot sun then in the cool place for example inside the class room. Calculate the rate of water uptake as described in the case of wind.

Humidity can be investigated by placing the plant in a humid environment for instance by covering the leaves in a Polyethene bag and then leaving it without a Polyethene bag to compare. Calculate the rate of water uptake as described before.

We can also vary the amount of light intensity by adjusting the distance of the shoot from the light source. When light source is nearer, the light intensity is high and the reverse is true.

Question on potometer

What does the potometer measure?

- ✓ The potometer measures directly the rate of water uptake.
- ✓ It also indirectly measures the rate of transpiration since evaporation of water from the leaf leads to the replacement of this water by its water uptake.

Why the measure of water uptake is not an accurate measure of water loss (limitations of the potometer)

- Because, evaporation alone cannot account for the movement of water through a plant. Plants take up water for some other reasons e.g.
- Some water is taken up to maintain Turgor pressure of cells.
- Some water is used as a raw material in photosynthesis.
- So, the volume of water lost is slightly less than the volume of water taken I by root hairs.

Outline the assumptions, sources of error and precautions taken when using a potometer.

Assumptions	✓ All the water absorbed by the plant is lost during transpiration. ✓ Most the water is lost through the leaves ✓ Root pressure is negligible
Sources of error	✓ Cutting the stem straight rather than in slanting way. ✓ Recording observation in different time intervals. ✓ Effect of other climatic factors which usually vary during the investigation ✓ Using a shoot with very few leaves gives un measurable water loss ✓ Cutting the shoot out side water.
Precautions taken	✓ Whole apparatus must be filled with water. ✓ The shoot must be cut under water with slanting cut. ✓ Shoot used must have many leaves to have a measurable water loss.

	✓ The shoot should be transferred into potometer water immediately after cutting it. ✓ The stem in the stopper must be air-tight

Why plants are able to survive without a complex circulatory system.

- Need less oxygen
- CO_2 produced in respiration is used in photosynthesis, and O_2 produced in photosynthesis is used in respiration.
- Water is absorbed from soil by root hairs and conducted up to the leaves by xylem.
- Most waste material are stored in leaves and bark of stem which fall and are eliminated

TRANSPORT IN ANIMALS

Forms of blood circulatory system found in animals.

1. **Open circulation**: Blood flows out of tubular blood vessels and gets into open cavities called sinuses present between organs e.g. arthropods.

2. **Closed circulatory system:** blood is always contained in closed tubes called blood vessels e.g. in all vertebrates. There two types (single and double):

(a) Single closed circulation: type of closed circulation where blood flows through the heart once in each complete circle of the body e.g. in fish.

(b) Double closed circulation: type of closed circulation whereby blood flows through the heart twice in each complete cycle of the body e.g. in mammals. It involves both systemic circulation and pulmonary circulation.

(i) **Pulmonary circulation**: transportation of blood btn the heart and the lungs

(ii) **Systemic circulation**: transportation of blood btn the heart and all other body parts except the lungs.

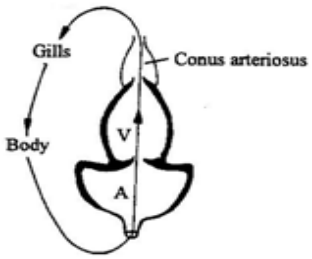
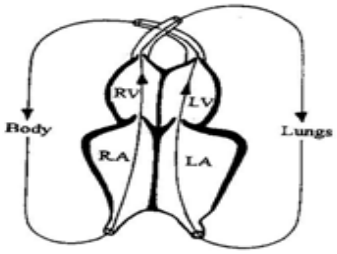


Illustration of: Single circulation



Double circulation

Disadvantages of single circulation:

- ✓ Blood flows at low pressure and delays delivery of oxygen to vital organs which makes the organism less active.

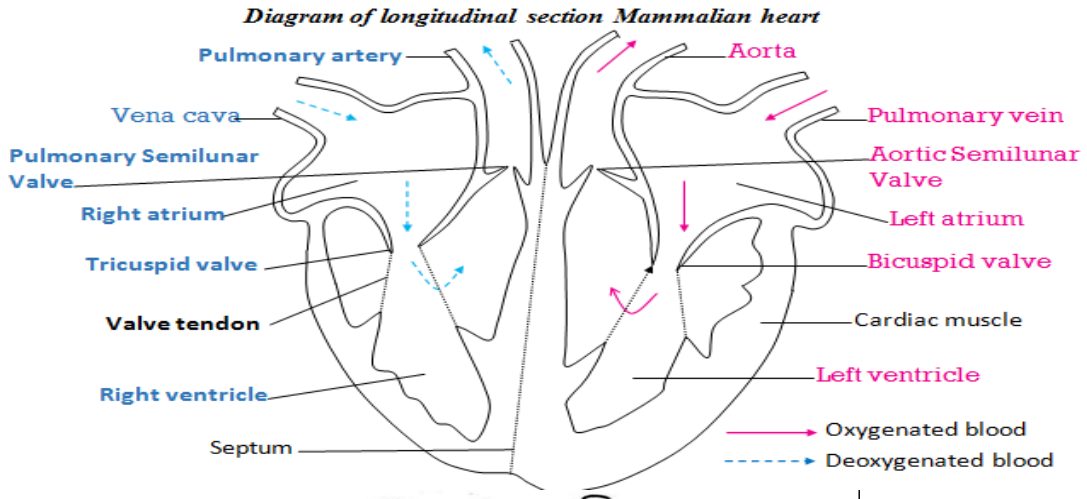
The structures involved in transport in animals.

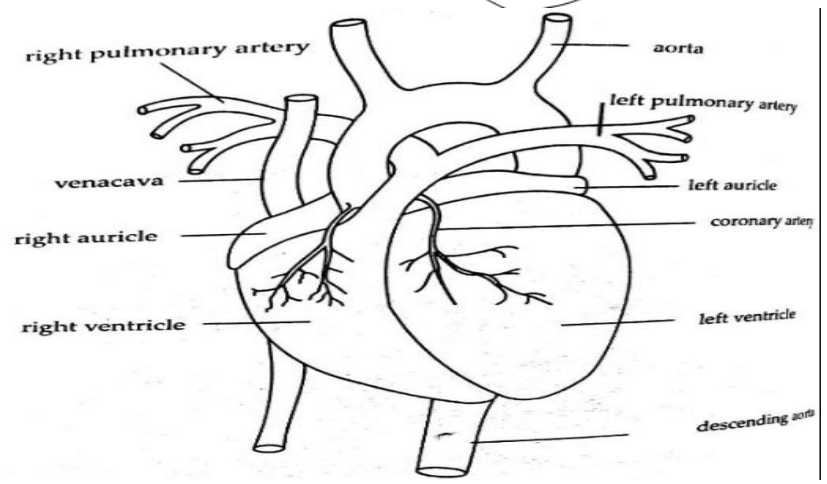
- ✓ The heart
- ✓ Blood vessels: artery, veins and capillaries
- ✓ Lymphatic vessels.

Note: Transport fluids in animals: blood, plasma, tissue fluid and lymph.

Structure of the mammalian heart

(a) External view of the human heart:





Internal structure of the heart:

The heart is a muscular pumping organ situated in thoracic cavity in between the two lungs.

The heart is protected and surrounded by tough membrane called Pericardium which encloses the pericardial fluid.

Internally, the heart is divided into two sides, the left and right side which are completely separated by the septum. The septum prevents blood on the right side from mixing with blood on the left side.

Each side consists of a small upper chamber called atrium (plural- atria) and a larger lower chamber called ventricle. This makes a mammalian heart is a four chambered organ. The atria (also called auricles) are thin walled and receive blood into the heart which they pump to the ventricles.

The ventricles are thick walled and pump blood out of the heart through the aorta and pulmonary artery.

The heart is made up of special muscle called cardiac muscle. This muscle contract and relaxes on its own without fatigue to pump blood to all parts of the body.

There valves between the atria and ventricles called atria-ventricular valves.

The valves between right atrium and right ventricle are tricuspid while the valves between left atrium and ventricle are bicuspid or mitral valve.

The other valves in the heart are Semilunar valves located at base of main arteries (aorta and pulmonary artery). When they open, the allow blood from ventricles into the arteries and away from the heart.

The valve allows the flow of blood only in one direction from atria to ventricles and from ventricles to pulmonary artery or aorta.

THE CARDIAC CYCLE (HOW THE MAMMALIAN HEART WORKS)

The function of the heart is to receive and pump blood. The heart receives blood when its muscle relaxes and pumps blood when its muscles contract. The relaxation of the heart is called diastole and its contraction is called systole. These two processes take place in a repeated sequence called cardiac cycle.

Cardiac cycle: The term cardiac cycle refers to the sequence of contraction and relaxation of the heart during which blood is pumped around the body. The cycle (also known as **heartbeat**) consists two phases: (i) **systoles** and (ii) **diastoles**. The heart beat count of a normal person is 72 counts per minute.

The main events in the cardiac cycle outline below.

Diastolic beat:

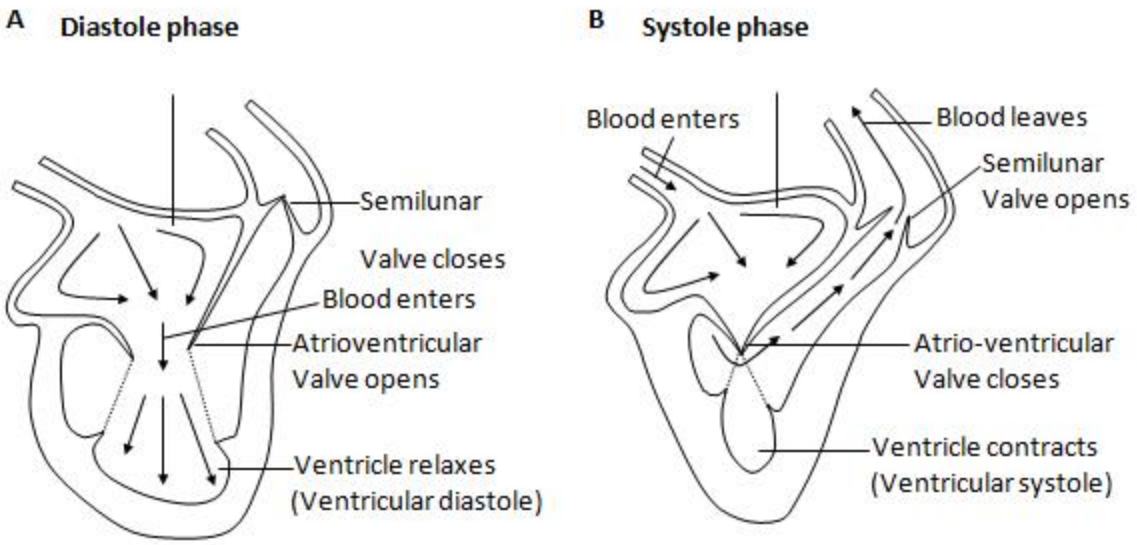
- ✓ Diastole refers to the phase when the ventricles relax while atria contract, in order to allow blood flow in. During this phase, the ventricular volume increases and pressure reduces.
- ✓ When the right auricles contract, the tricuspid valve deoxygenated blood flow from the right auricles into the right ventricles. At the same time, the left ventricle contract and the bicuspid valve opens to allow oxygenated blood flow into the left ventricle.
- ✓ Semi-lunar valves close to prevent blood from flowing back into the relaxed ventricles.

Systolic beat:

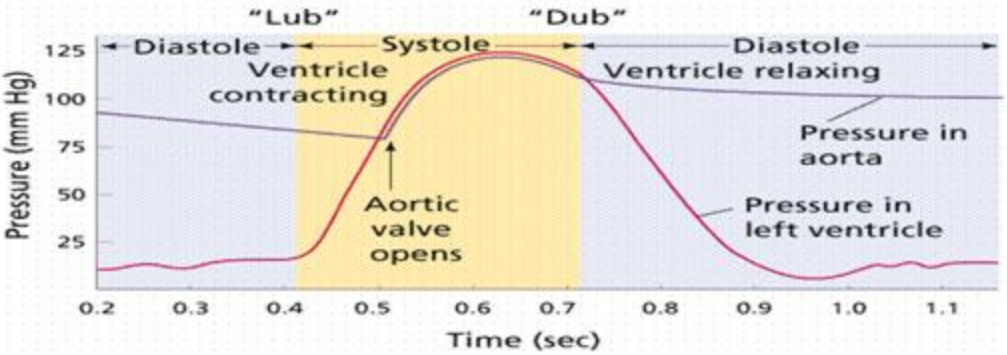
- ✓ Systole refers to the phase when the ventricles contract to force blood into the arteries while auricles are relaxed. During this phase ventricular volume is reduced while pressure is increased.
- ✓ When the left ventricle contract, the bicuspid valve closes to prevent the back flow of blood in the relaxed auricle. At the same time, the right ventricle contract and tricuspid valve is closed.
- ✓ The volume of the ventricles reduces and pressure is increased forcing blood out of the heart.
- ✓ Deoxygenated blood flows through the open semi-lunar valve through the pulmonary artery to the lungs while oxygenated blood flows through the open semilunar valve to the aorta and into tissues of the body. The contraction of the ventricles develops a pressure which is felt in arteries.

The systolic phase of the ventricles together with the contractions of the arteries builds up a hydrostatic pressure known as **blood pressure**, which moves the blood along the vessels. The heartbeat rate of a normal adult person at rest is about 72 times per minute. The heart beat is affected by hormones, state of health, age, nervous stimulation, body size and exercise.

Illustrations of the Cardiac cycle



Graph showing variation in blood pressure in the heart



Note:

- ✓ **Pulse:** is rhythmic expansion of arteries due to the successive out pouring of blood from the heart into them.
- ✓ **Blood pressure:** The resistance offered by the lumen of the artery to blood flow.
- ✓ **Hypertension:** The condition when blood pressure is higher than normal.

Adaptations of the mammalian heart to its functions:

- Has valves which open to allow blood flow in one direction and close when blood tries to flow back in a wrong direction.
  -Bicuspid and tricuspid valves which prevent back flow of blood into the auricles when the ventricles contract.
  -Semilunar valves which prevent blood in arteries from flowing back into the heart when ventricle are relaxed.
- Has inbuilt system which controls its contraction and relaxation.
- Contraction are rhythmic and arises from within the muscles of the heart without nervous stimulation i.e. it is myogenic.
- Ability of the muscles to contract an relax continuously with fatigue.
- Cardiac muscle has numerous mitochondria to generate enough energy for muscle contraction.
- Has atria which are chambers surrounded by thin cardiac muscles to receives blood and pumps it to the ventricles
- Ventricles are chambers surrounded by thick cardiac muscle which pumps blood into arteries.
- Aorta and pulmonary veins lead blood a ways from the heart.
- Has vena cava and pulmonary vein which leads the blood back into the heart
- Cardiac artery supplies the cardiac muscle with oxygenated blood
- Coronary vein returns deoxygenated blood from the cardiac muscle back to the heart.
- Pericardium is the tough outer covering of the heart protects the heart

- Fat layer protects and cushions the heart
- Valve tendons are inelastic tissues which prevents the valves turning inside into the auricles.
- Has a septum which separates deoxygenated blood on the right side from mixing with oxygenated blood on the left side.

GENERAL BLOOD CIRCULATION

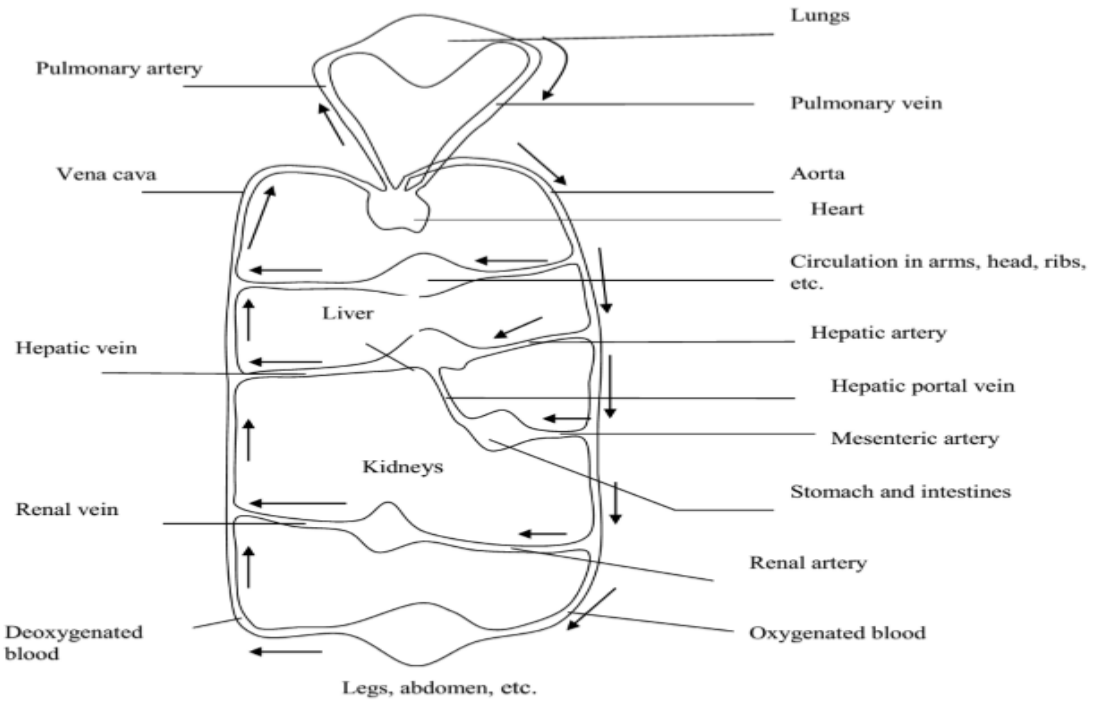
Mammals exhibit double circulation: meaning blood flows twice through heart in order to complete one cycle. i.e.

The oxygenated blood pumped by the right ventricle is transported through pulmonary artery to lungs where CO_2 is exchanged for O_2 through diffusion forming oxygenated blood. The oxygenated blood returns back to the heart through pulmonary vein. This transportation of blood btn the heart and the lungs is called **pulmonary circulation** and the vessels involved are called pulmonary vessels.

The oxygenated blood from left ventricle is transported through aorta to different body parts (cells and tissues) where O_2 is exchanged for CO_2 through diffusion forming deoxygenated blood. This deoxygenated blood returned back to the heart through vena-cava. This transportation of blood between all other body parts and the heart is called **systemic circulation**.

Arteries convey blood to body tissues, veins return blood to the heart from body tissues and capillaries provide a link between arteries and veins.

Diagram show general circulation of blood in mammals



Questions:

1. **(a) Why does the left ventricle have thicker wall than the right ventricle?**

The left ventricle walls are much thicker than right ventricle walls in order to generate enough pressure to pump blood to all parts of the body.

(b)Explain the behavour of valves during diastole and systole phases.

- Semilunar valves open to allow blood into arteries.
- Bicuspid and tricuspid valves close to prevent blood flowing into atria.

(c) How is the blood flow maintained in veins and capillaries?

Unlike blood in arteries, blood in veins and capillaries flows under very low pressure. Its flow is aided by the following.

- Pumping action of arteries
- Breathing movements
- Contraction of muscles which squeeze blood in capillaries and veins

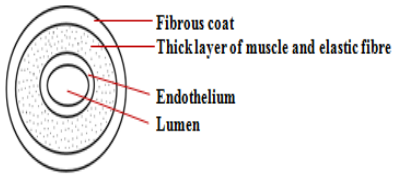
- Gravity from parts above the heart
- Presence of valves in veins which prevent back flow of blood.

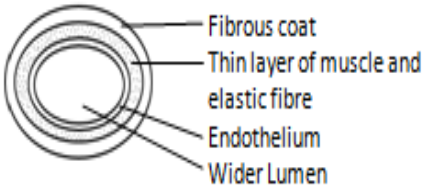
BLOOD VESSELS

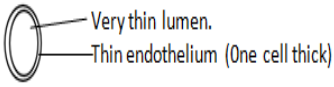
There are three main types of blood vessels: artery, vein and blood capillary.

- ✓ **Artery:** A blood vessel which carries blood away from the heart.
- ✓ **Vein:** A blood vessel which carries blood towards the heart.
- ✓ **Capillary: A** blood vessel which carries blood from an artery to a vein and allows exchange of materials with tissues.

Illustrations:







Artery *vein* *blood capillary*

Comparison of arteries, veins and capillaries:

Similarities

- All carry blood
- All have a lumen/ are tubular
- All have endothelium cells.

Differences:

Arteries	Veins	Capillaries
1. Carry blood away from the heart	1. Carry blood toward the heart	1. Carry blood from arteries to veins
2. Carry oxygenated blood except the pulmonary artery	2. Carry deoxygenated blood except pulmonary vein	2. Oxygen diffuses out as carbon dioxide diffuse into them.
3. Transport blood under very high pressure	3. Blood flow smoothly/steadily but under low pressure	3. Blood flows at high pressure of blood for filtration of substances
4. Have a pulse	4. Have no pulse	4. Have no pulse
5. Have no valves except at the base of aorta and pulmonary artery at the point where they leave the heart	5. Have valves	5. No valves
6. Have thick, muscular & elastic walls	6. Have thinner, slightly muscular walls	6. Are one cells thick.
7. Have narrow lumen	7. Have larger lumen	7. Have very narrow lumen/microscopic lumen
8. Are located deep in the body	8. Are located nearer the skin in the body	8. Are located in tissues.

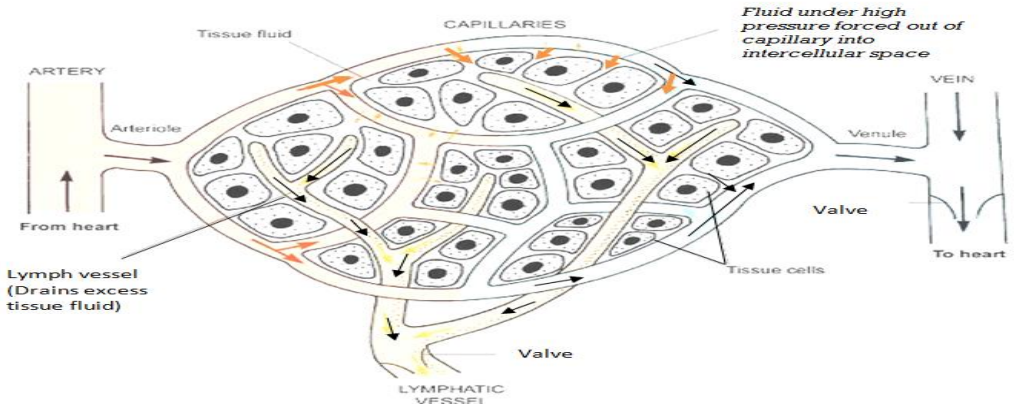
Adaptations of blood vessels to their functions.

Blood vessel	Adaptation
Arteries	1. Thick muscular walls to withstand and maintain high blood pressure 2. An outer fibrous coat for strength and protection. 3. Narrow lumen to maintain blood flow at high blood pressure inside them 4. More elastic fibres for stretching to withstand high blood pressure 5. Endothelium provides a smooth surface that minimizes resistance to blood flow.

Veins	1. Have valves to prevent back flow of blood/ ensure blood flows in one direction despite its low pressure. 2. Wider lumen to reduce resistance to blood flow at a low pressure 3. Have thin walls with elastic fibres to stretch and maintain blood flow at low pressure 4. Endothelium provides a smooth surface that minimizes resistance to blood flow.
Capillaries	1. Are thin walled to provide short distance. 2. Capillaries are numerous forming a dense network t increase surface area for exchange of materials 3. Have narrow lumen to maintain high blood pressure for ultrafiltration of substances. 4. Capillaries are porous to facilitate exchange of substance between blood and tissue fluid. 5. Have small diameter to enable them penetrate the tissues 6. Endothelium provides a smooth surface that minimizes resistance to blood flow.

Capillaries and exchange of materials between blood and body tissues:

The capillaries are the sites across which the exchange of substances between the blood and tissues takes place. due high blood pressure, which develops because of the pumping action of the heart and narrowness hence resistance of the blood capillaries, a fluid called **tissue fluid** flows from blood into intercellular spaces between the body tissues and provides a medium for the exchange of materials between blood and tissues. Useful materials (such as nutrients, hormones, enzymes and oxygen) enter the cells and the cells shed their excretory products into the tissue fluid. Tissue fluid is formed by the process called **ultrafiltration.**



How capillaries differ from other blood vessels?

- ✓ Capillaries are non-elastic, their walls are one cell thick, and are permeable unlike other blood vessels.

Components of blood and their functions

- ✓ **Blood** is a liquid tissue which made up cells suspended in plasma and acting as a medium of transport in animals.

Main functions of blood.

1. **Acts as a medium for transport of materials to and from other tissue:**

-transports oxygen to tissues and carbon dioxide from tissues to lung to be excreted.
Transports digested food from intestines to tisues.
Transports wastes from tissues to various organs to be excreted.
-transports hormones to organism which they affect.

2. In regulation of body temperature: blood distributes heat produced in muscle and liver to all other organs.
3. Protects/defends the body:

-has white corpuscle which feed on and destroy bacteria.
-contains antibodies which destroys antigens.

-protects the body when cut or wounded by forming a clot.

The major components of blood and their functions

The main components of blood are red blood cells, white blood cells, platelets and plasma.

Blood plasma is the pale yellow watery medium of blood. The main components of plasma are

- ✓ Water (92%)
- ✓ Nutrients like glucose, amino acids, and fatty acids, vitamins and mineral salts. The mineral salts are in form of ions like sodium, chloride, hydrogen carbonate ions
- ✓ Waste substance like urea and carbon dioxide
- ✓ Hormones like adrenaline and insulin
- ✓ Enzymes and antibodies
- ✓ Blood proteins such as globulins, albumins, and fibrinogen

Serum: is blood plasma without fibrinogen.

FUNCTIONS OF BLOOD COMPONENTS:

Component	Function
Blood plasma	✓ Transports waste products of metabolism such as urea and CO_2 to excretory organs for elimination. ✓ Distributes heat evenly within in the body tissues. ✓ Transports useful substances like antibodies, nutrients and hormones to body tissues.
Red blood cells.	✓ Transport oxygen from lungs to body tissues ✓ Converts carbon dioxide to hydrogen carbonate. This makes it easy for CO_2 to be transported in plasma.
White blood cells.	✓ Protect the body from infection. They do so in two ways **-Phagocytes** seek, engulf and digest disease causing germs. **-Lymphocytes** produce antibodies which destroy disease causing germs.
Platelets (thrombocytes)	✓ Involved in blood clotting when injuries occurs on the skin.

Compare red blood cells, white blood cells and platelets (descriptive features of blood cells)

Red blood cells	White blood cells	Platelets
1. Biconcave disc shape	1. Irregular shape which can change	1. Cell fragments
2. Have no nucleus	2. Have nucleus	2. No nucleus
3. Cytoplasm filled with haemoglobin	3. Some have granules in their cytoplasm, some without granule. Never contain haemoglobin	3. Composed of the cytoplasm enclosed by cell membrane. No haemoglobin.
4. Very many in number in blood	4. Fewer than red blood cells.	4. Few in number
5. People with severe anaemia or malaria have fewer RBCs.	5. People with infection such as malaria have more WBCs but those with HIV infection have fewer WBCs	5. -number not affected by infections.
6. Their number increase with altitude	6. Their number is not affected by altitude	6. -
7. Smaller than white blood cells	7. Larger than RBCs	7. Very tiny
8. Made in red bone marrow such as the ribs and vertebrae	8. Lymphocytes are made in bone marrow but migrate to the lymph nodes	8. Made in the red bone marrow

9. Transports oxygen and very little carbon dioxide	9. Defend the body from disease	9. Responsible for blood clotting

Adaptation of white blood cells and red blood cells to their functions.

Blood cell	Adaptive features
White blood cells/ leucocytes	• Capable phagocytosis where they engulf and digest germs • Ability to produce antibodies • Diapedesis: ability to squeeze through endothelium of capillary walls and enter the intercellular space
Red blood cells/erythrocytes	• Contain haemoglobin which has high affinity for oxygen. • Lack nucleus providing more space for carrying oxygen • Have biconcave shape increasing surface area for carrying oxygen • Numerous increasing amount of oxygen and carbon dioxide carried • Thin cell membrane for faster diffusion of gases • Flexible to allow them squeeze through blood capillaries • Contain enzyme carbonic anhydrase for transportation of carbon dioxide

Note:

- ✓ **In infants,** red blood cells are manufactured in the liver and spleen. In adults, they are synthesized within the **myeloid tissue** of the red bone marrow of short bones by a process known as **erythropoiesis**.
- ✓ **In the embryo**, leucocytes are manufactured in the **thymus gland**, liver and spleen. In adults, they are produced in the lymph glands, bone narrow and spleen. The function of leucocytes is to defend the body against diseases.

How leucocytes defend the body

White blood cells defend the body in two ways:

- **Phagocytosis:** whereby they seek, engulf and destroy pathogens by feeding on them.
- **Immune response**: involves production of antibodies in response to a specific antigens. **Antibodies** are proteins produced by white blood cells/lymphocytes and they destroy or inactivate the antigens.

Platelets and mechanism of blood clotting

Platelets

The platelets are known as **thrombocytes**. They are irregularly shaped, non-nucleated cell fragments formed from large bone narrow cells called **megakaryotes**. They have a lifespan of approximately 4 days. The concentration of platelets in the blood is about $2.5\text{-}4.0\times10^5$/ml of blood. The platelets facilitate **blood clotting** (production of a semisolid material that covers a wound).

IMPORTANCE OF BLOOD CLOTTING:

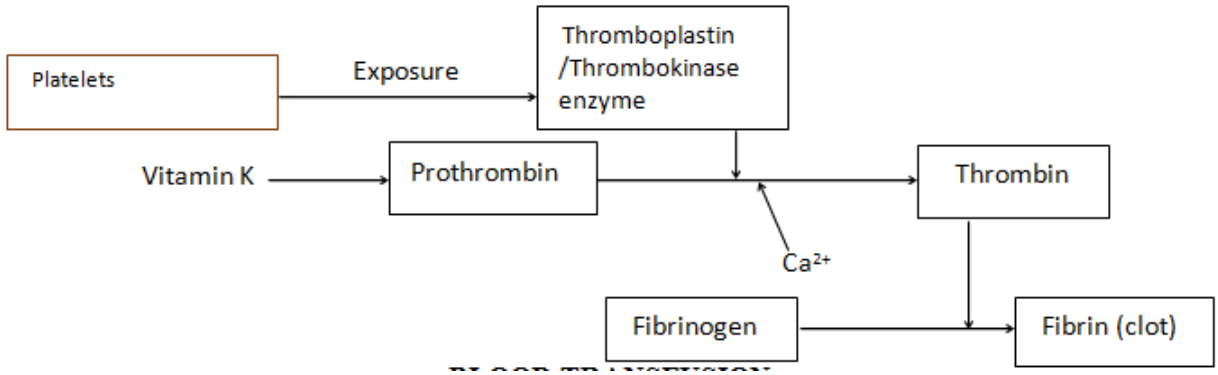
1. Prevents invasion by pathogens.
2. Prevents further loss of blood.
3. Initiates healing by forming a protective scab on the wound while the new skin forms.

<u>Mechanism of blood clotting</u>

<u>When platelets get exposed to air at a cut, they produce</u> thrombokinase (**thromboplastin**); which activate prothrombin to thrombin; in the presence of calcium ions and vitamin K.

Thrombin then converts a soluble plasma protein called **fibrinogen** to its insoluble form called **fibrin** which forms a meshwork of fibres that entangle the blood cells to form a **clot**.

<u>Illustration of blood clotting</u>



BLOOD GROUPS AND BLOOD TRANSFUSION

There are four blood groups

- Blood group A
- Blood group B
- Blood group AB
- Blood group O

(b)Explain how blood transfusion can be done correctly.

Blood transfusion is the process of putting donated blood into a recipient. The knowledge of antigen and antibodies is important in blood transfusion.

Antigens:

- The red blood cells of humans have a special protein called antigen e.g antigen A and antigen B.
- The type of antigen determines/corresponds to the type of blood group of a person as shown below.

Antibodies

- Blood plasma contains another type of protein called antibodies which are complementary to antigens A and B.
- Antibodies are named as antibody a and antibody b.
- A person with antigen A will have antibody b
- While a person with antigen B will have antibody a.
- A person of blood group O, who has no antigen has both antibodies a and b are present.
- A person of blood group AB contains no antibodies in his blood serum.

Blood group	Antigen	Antibody
A	A	B
B	B	A
AB	AB	None
O	None	a and b

Antigen and antibodies that correspond to each other will never be found in the same individual because if this occurs it will cause agglutination/sticking together or clumping of red blood cells. This blocks blood vessels. Therefore following precautions must therefore be taken before blood transfusion:

- The recipient must be given compatible blood to avoid agglutination
- Donor's blood must be well screened for the presence of any infective agent. Only blood from a healthy person is used.

Table showing how donor's blood is accepted by recipient

Donor's blood group	Recipient's blood group			
	O : anti a & b	A: anti. b	B: anti a	AB : no antibody
O^{0}	√	√	√	√
A^{A}	**X**	√	**X**	√
B^{B}	**X**	**X**	√	√

AB A & B	**X**	**X**	**X**	√

From the table,

- People of **blood group AB** are described as universal recipient because they can receive blood from all blood groups.
- People of **blood group O** are described as universal donors because they can donate recipients of all the four blood groups

(c) **Circumstance that call for a blood transfusion /importance of blood transfusion:**

Blood transfusion is done to save lives of people who:

- Have lost much blood after an injury or accident or at child birth or during surgery
- Have become anaemic due to diseases such as malaria.

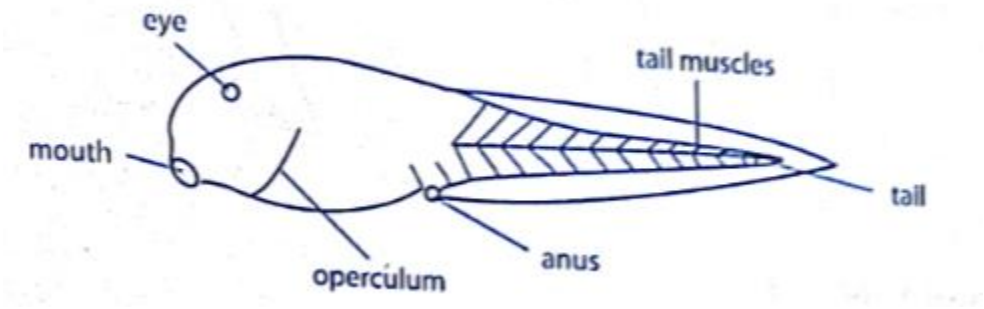
BLOOD CIRCULATION IN THE TAIL OF A TADPOLE.

The tail of toad pole is broad and transparent with blood capillaries forming a network in it.

Blood circulates in these capillaries.

The blood flows in the tail to supply oxygen and nutrients needed to produce energy needed by the tail for movement to enable the tadpole to swim in water.

Diagram illustrating the flow of blood in the tail of a tad pole.



DISORDERS OF CIRCULATORY SYSTEM.

1. **Hypertension (High blood Pressure):**

It results from narrowing of arterial lumen and reduced elasticity of arterial walls in old age. This disorder is also associated with heavy drinking, smoking, taking of large quantities of salt and general body stress. It can cause rupturing of capillaries and general heart failure. It is a silent killer.

2. **Coronary Artery disease,** (CAD):

Atherosclerosis. The supply of the blood to heart muscles is affected. It is .caused by deposits of Calcium, fat, cholesterol and fibrous tissues to make the lumen of arteries narrower. When a clot blocks blood from reaching tissues of the heart, the tissue experiences shortage of oxygen and nutrient supply. Carbon dioxide and nitrogenous wastes are not efficiently removed causing a heart attack. In severe cases of heart attack, some cardiac cells die leading to cardiac failure and death.

3. **Coronary thrombosis:**

Thrombosis is the formation of blood clots in blood vessels. So, coronary thrombosis is the clotting of blood in a coronary artery, resulting in heart attack.

4. **Angina Pectoris:**

Caused due to arteriosclerosis, when no enough oxygen is reaching the heart muscle due to which the person experiences acute chest pain.

5. **Heart attack:** Caused when the heart muscle is suddenly damaged by an inadequate blood supply.
6. **Cardiac arrest:** The state in which the heart stops beating.
7. **Arteriosclerosis (atheroma):**

The state of hardening of arteries; brought about by fat deposits on the walls of arteries, fibrous tissues forming in the walls of arteries or degenerating artery walls and consequent loss of elasticity. It causes hypertension. Medics have established some relationship between the disease and overweight, emotional stress, lack of exercise, alcohol and smoking.

8. **Varicose veins:**

Refers to prominently swollen veins which may appear below the knees or back of legs.it is brought about by failure of some valves in veins to function causing blood to accumulate in veins. The disease can be controlled by regular physical exercise of the body

IMMUNITY

9. Define the terms immunity, infection, disease, pathogen, antigen and antibodies.

Immunity	Ability of the body to fight infections.
Infection	Entry of pathogens into the body.
Disease	A state of being un well, with a set of defined signs and symptoms. **Note.** Signs are disease indicators which can that can be observed by doctor e.g red eyes. Symptoms are disease indicators perceived by the patient.
Pathogen	A virus or any microorganism that can cause disease.
Antigen	Any substance that cause an immune response. Pathogens have antigens which usually proteins but sometimes carbohydrates on their skin.
Antibody	Protein produced by lymphocytes in body in an immune response, to destroy the specific antigen. These are usually proteins called immunoglobins.

TYPES OF IMMUNITY.

→**Innate immunity:** The inborn ability of an individual to fight diseases. It forms the first line of defense for the body e.g. phagocytes, HCl in the stomach, intact skin, flushing action of the urethra. All forms of innate immunity are nonspecific.

→**Acquired or adoptive immunity:** immunity that develops latter during one's life time. It can be active or passive and both offer protection against a specific pathogen.

(a) Active immunity: Involves the body making its own antibodies and natural killer cells to fight antigens. There are two types of active immunity:-

(i) Active natural immunity: Involves the body making its own antibodies and memory killer cells as a result of having had a disease. The memory killer cells quickly recognize and destroy the antigen upon repeated infection with the same pathogen. Hence a person cannot fall sick in a repeated attack.

(ii) Active artificial immunity: Involves the body making its own antibodies and memory killer cells resulting from vaccination or immunization. **A vaccine** contains antigen of living, weakened, or dead pathogen used to stimulate the body to recognize and destroy specific disease antigens.

(b) Passive immunity: involves an organism using antibodies made by another organism to destroy a certain disease antigen. There are two types of passive immunity.

(i) **Passive natural immunity**: involves the foetus using maternal antibodies crossing via the placenta and breast milk.

(ii) **Passive artificial immunity**: involves giving an individual antibodies cultured and extracted from other organism e.g. in case of injection.

<u>Additional notes:</u>

- Active immunity whether natural or artificial is does not provide immediate protection but one advantage is, it is long lived.
- Passive immunity whether natural or arterial provides immediate protection but its disadvantage is, it is short lived.
- Natural immunities are cheap while artificial immunity often expensive.
- **Immunization** (**vaccination**) is the procedure of providing immunity by using **vaccines.**
- **A vaccine** is a substance containing weakened pathogens that stimulate the immune system to produce **antibodies**. Poliomyelitis, smallpox and measles can be prevented by immunization. A person cannot be immunized against AIDS. Instead of boosting the immune system, the HIV suppresses it by killing the helper T-cells.

Components of the human immune system.

An immune system refers to all body parts involved in recognition and destruction of disease antigens.

It is made up of the following:

- Bone marrow which produce white blood cells

- White blood cells especially phagocytes and lymphocytes
- Tissues of the lymphatic system: like lymph nodes, tonsils, thymus and spleen which accommodate lymphocytes.

Allergic reactions:

This refers to hyper sensitive reaction to an antigen by the body. It occurs when the reaction between an antibody and an antigen produces a violent reaction or causes severe damages the body. Examples of allergic reactions include: sneezing, vomiting, itching, vomiting or rashes on the skin.

FORMATION OF TISSUE FLUID AND LYMPH

Formation of tissue fluid

Tissue fluid is made of water and dissolved substances that leave blood capillaries by **ultrafiltration** and diffusion.

When blood flows along the arterial end of the capillary network, a high blood pressure develops due to the pumping action of the heart, narrowness and hence resistance of the blood capillaries.

The resulting high blood pressure forces a fluid part of blood with its dissolved blood components (except plasma proteins and blood cells) to filters through the fine pores of the blood capillaries.

The fluid passes into the intercellular spaces in tissue where it bathes cells. This filtration under high pressure is called **ultrafiltration**.

The fluid formed in intercellular spaces in the tissues by ultrafiltration is known as the **tissue** or **intercellular fluid**.

Formation of lymph

Tissue fluid becomes lymph once it enters the lymphatic vessel. So, lymph formation depends formation of tissue fluid.

As the tissue fluid flows through intercellular spaces, useful materials such as nutrients, hormones, enzymes and oxygen enter the cells. The cells shed their excretory products into the tissue fluid.

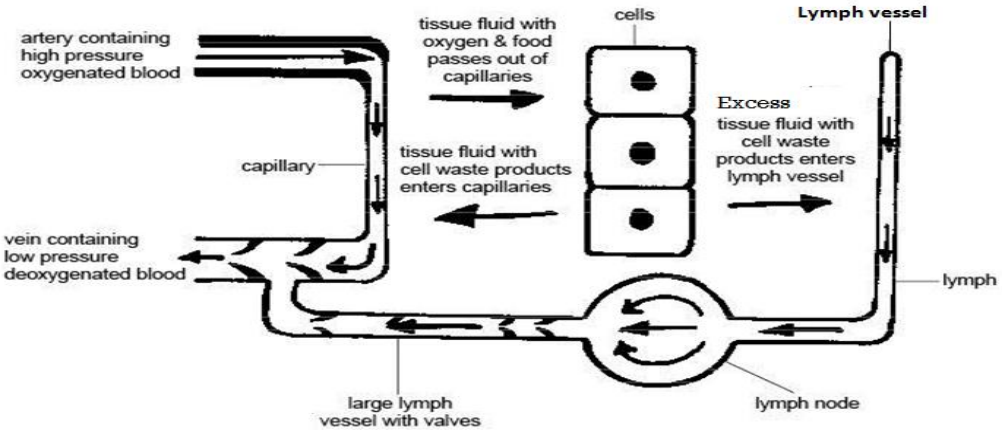
So, tissue fluid reaches the venous end of the capillary network, blood contains more solutes than the tissue fluid. In other words, the osmotic pressure of the blood is higher than the blood (hydrostatic) pressure. Therefore, the tissue fluid flows back to the blood stream through capillary walls by osmosis.

More fluid filters out of blood capillary then returns to them by reabsorption.

The excess tissue fluid drains into **lymph vessels (lymphatics)** and it becomes lymph.

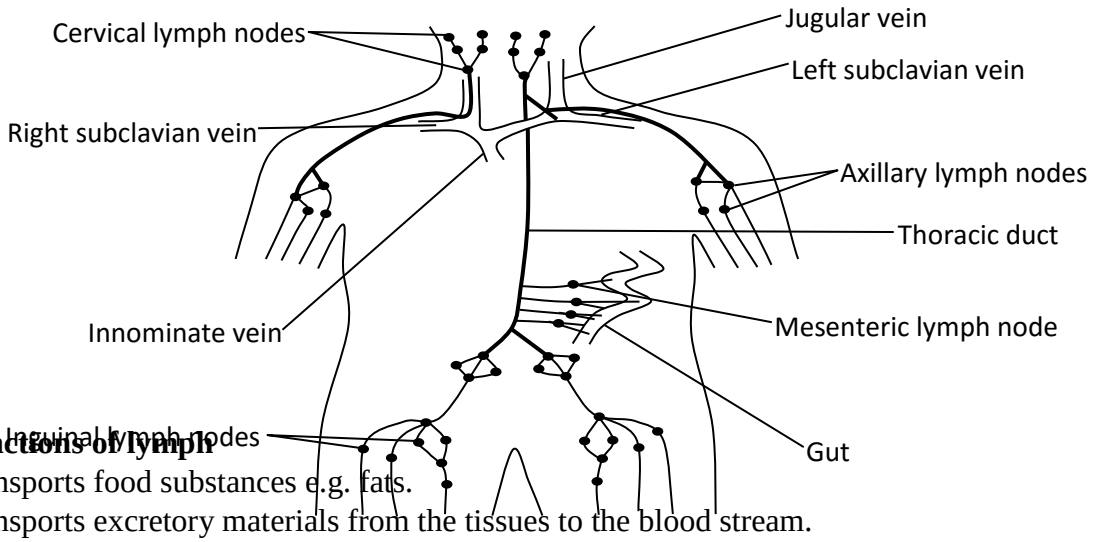
Thus **lymph** is a milky fluid derived from tissue fluid that do not drain back into the capillaries but flows into the lymphatic system.

Illustration for formation of tissue and lymph



t side of the head, chest and right arm combine to form the right lymphatic duct, which joins circulation at the **right subclavian vein**. The lymph vessels from the rest of the body join to form the **thoracic duct**, which joins circulation at the **left subclavian vein**. The subclavian veins shed the lymph into the **innominate veins** that discharge it into circulation via the superior vena cava.

The human lymphatic system



Functions of lymph

- Transports food substances e.g. fats.
- Transports excretory materials from the tissues to the blood stream.
- Transports lymphocytes/white blood cells produced in lymph nodes to blood stream. These white blood cells defend the body against diseases.
- Macrophages (phagocytes in the lymph nodes) protect the body by destroying antigens before they reach the blood stream.

The movement of lymph is facilitated by:

- The valves that prevent its backflow.
- The hydrostatic pressure with which the tissue fluid leaves the arterioles. This enables the pushing of lymph along the lymphatic system.
- The contractions of the skeletal muscles around the lymph vessels. Thus exerting a pressure on the lymph within them pushing it forward.
- Inspiration, which reduces pressure in the chest to facilitate the flow of lymph towards the heart.
- The rhythmic contractions of the lymph vessels that help to move the lymph into the veins.

Differences between blood and lymph

Blood	Lymph
1. Has three types of cells	1. Has one type of cell (lymphocyte)
2. Contains haemoglobin/red blood cells	2. Has no haemoglobin
3. Flows faster	3. Flows slowly
4. Has less fats	4. Has more fats
5. Has plasma proteins	5. Lacks plasma proteins
6. Transported by blood vessels	6. Transported by lymph vessels
7. Does not form by ultrafiltration	7. Forms by ultrafiltration

8. Pumped by the heart	8. Not pumped by the heart

Comparison between the blood vascular system and lymphatic system

(a) Similarities:

- Both consist of a system of vessels
- Both contain fluid
- Both have valves
- Both contain cells

(b) **Differences:**

Blood vascular system	Lymphatic system
1. Lacks the heart thus, no pumping mechanism.	1. Has a heart to provide a pumping mechanism
2. Lymph flows in one direction only	2. Blood flows in two directions: away from the heart through arteries and towards the heart through veins.
3. Have three types of blood vessels: arteries , veins and capillaries	3. Has only lymphatic vessel.
4. Have valve only in veins and at bases of the major arteries (aorta and PV only)	4. Have valves throughout the lymphatics
5. Never contain lymph nodes	5. Has lymph nodes
6. Blood flows faster at higher pressure	6. Lymph flows slowly
7. Medium for transport is blood plasma	7. Medium for transport is lymph
8. Has red blood cells and plasma proteins	8. Lacks red blood cells and plasma proteins

ELEPHANTIASIS

This is a disorder of the lymphatic system. It is caused by microscopic round worm called filarial worm scientifically known as **Wuchereria bancrofti** which is spread by the Culex mosquito.

The worms enter and block the lymph vessels and obstruct the flow of lymph. As a with s result that the affected part usually limbs becomes swollen very huge proportions to resemble those of the elephants hence the name elephantiasis.

Differences between the transport system of higher plants and animals:

Transport system of plants	Transport system of animals
1. The medium of transport is water	1. The medium of transport is blood and lymph
2. The conducting vessels are the xylem and phloem, the xylem is nonliving	2. The conducting vessels are arteries, veins, capillaries and lymphatics and are all living
3. No valve are involved two way transport in the phloem is possible	3. Have valves therefore transport is one way.
4. The xylem transport water and salts while the phloem transport manufacture food	4. All vessels can transport the same materials i.e. nutritive molecules, respiratory gases etc.
5. There is no pump involved in moving the fluid	5. There is a muscular pumping the heart involved in moving the fluid
6. Materials transported do not circulate with the exception of water	6. Materials transport actually circulate