BiologyNotes
Form Two

TRANSPORT IN PLANTS AND ANIMALS.

Introduction

- Transport is the movement of substances within an organism.
- All living cells require oxygen and food for various metabolic processes.
- These substances must be transported to the cells.
- Metabolic processes in the cells produce excretory products which should be eliminated before they accumulate.
- The excretory products should be transported to sites of excretion.
- Organisms like amoeba are unicellular.
- They have a large surface area to volume ratio.
- The body is in contact with the environment.
- Diffusion is adequate to transport substances across the cell membrane and within the organism.
- Large multi-cellular organisms have complex structure where cells are far from each other hence diffusion alone cannot meet the demand for supply and removal of substances.
- Therefore an elaborate transport system is necessary.

Transport in plants

- Simple plants such as mosses and liverworts lack specialized transport system.
- Higher plants have specialized transport systems known as the vascular bundle.
- Xylem transports water and mineral salts .
- Phloem transports dissolved food substances like sugars.

Internal structure of roots and root hairs

- The main functions of roots are ;
    - Anchorage
    - absorption.
    - storage
    - gaseous exchange.
- The outermost layer in a root is the piliferous layer.
- This is a special epidermis of young roots whose cells give rise to root hairs.
- Root hairs are microscopic outgrowths of epidermal cells.
- They are found just behind the root tip,

- They are one cell thick for efficient absorption of substances.
- They are numerous and elongated providing a large surface area for absorption of water and mineral salts.
- Root hairs penetrate the soil and make close contact with it.
- Below the piliferous layer is the cortex.
- This is made up of loosely packed, thin walled parenchyma cells.
- Water molecules pass through this tissue to reach the vascuiar bundles.
- In some young plant stems, cortex cells contain chloroplasts.
- The endodermis (starch sheath) is a single layer of cells with starch grains.
- The endodermis has a casparian strip which has an impervious deposit controlling the entry of water and mineral salts into xylem vessels.
- Pericyc1e forms a layer next to the endodermis.
- Next to the pericycle is the vascular tissue.
- In the Dicotyledonous root, xylem forms a star shape in the centre, with phloem in between the arms.
- It has no pith. In monocotyledonous root, xylem alternates with phloem and there is a pith in the centre.

Internal structure of a root hair cell

The Stem

- The main functions of the stem are;
  - support and exposure of leaves and flowers to the environment,
  - conducting water and mineral salts
  - conducting manufactured food from leaves to other parts of the plant.
- In monocotyledonous stems, vascular bundles are scattered all over the stem, while in dicotyledonous stems vascular bundles are arranged in a ring.
- Vascular bundles are continuous from root to stems and leaves.
- The epidermis forms a single layer of cells enclosing other tissues.
- The outer walls of the cells have waxy cuticle to prevent excessive loss of water.
- The cortex is a layer next to the epidermis.
- It has collenchyma, parenchyma and schlerenchyma cells.

Collenchyma

- Is next to the epidermis and has thickened walls at the corners which strengthen the stem.

Parenchyma

- Cells are irregular in shape, thin walled and loosely arranged hence creating intercellular spaces filled with air.
- They are packing tissues and food storage areas.

Sclerenchyma

- Cells are closely connected to vascular bundles.
- These cells are thickened by deposition oflignin and they provide support to plants**.**

Pith

- Is the central region having parenchyma cells.

Absorption of Water and Mineral Salts Absorption of Water

- Root hair cell has solutes in the vacuole and hence a higher osmotic pressure than the surrounding soil water solution.
- Water moves into the root hair cells by osmosis along a concentration gradient.
- This makes the sap in the root hair cell to have a lower osmotic pressure than the surrounding cells.
- Therefore water moves from root hair cells into the surrounding cortex cells by osmosis.
- The process continues until the water gets into the xylem vessels .

Uptake of Mineral Salts

- If the concentration of mineral salts in solution is greater than its concentration in root hair cell, the mineral salts enter the root hair cell by diffusion.
- If the concentration of mineral salts in the root hair cells is greater than in the soil water, the mineral salts enter the root hairs by active transport.
- Most minerals are absorbed in this way.
- Mineral salts move from cell to cell by active transport until they reach the xylem vessel.
- Once inside the xylem vessels, mineral salts are transported in solution as the water moves up due to root pressure, capillary attraction and cohesion and adhesion forces.

Transpiration

- Transpiration is the process by which plants lose water in the form of water vapour into the atmosphere.
- Water is lost through ***stomata, cuticle and lenticels.***
- ***Stomatal transpiration***:
    - This accounts for 80-90% of the total transpiration in plants.
    - Stomata are found on the leaves.

- ***Cuticular transpiration:***
    - The cuticle is found on the leaves, and a little water is lost through it.
    - Plants with thick cuticles do not lose water through the cuticle.

- ***Lenticular transpiration***
    - Is loss' of water through lenticels.
    - These are found on stems of woody plants.
    - Water lost through the stomata and cuticle by evaporation leads to evaporation of water from surfaces of mesophyll cells .
    - The mesophyll cells draw water from the xylem vessels by osmosis.
    - The xylem in the leaf is continuous with xy lem in the stem and root.

Structure and function of Xylem

- Movement of water is through the xylem.
- Xylem tissue is made up of vessels and tracheids.

Xylem Vessels

- Xylem vessels are formed from cells that are elongated along the vertical axis and arranged end to end.
- During development, the cross walls and organelles disappear and a continuous tube is formed.
- The cells are dead and their walls are strengthened by deposition of lignin.
- The lignin has been deposited in various ways.
- This results in different types of thickening
  - Annular.
  - Simple spiral.
  - Double spiral.
  - Reticulate.
- The bordered pits are areas without lignin on xylem vessels and allow passage of water in and out of the lumen to neighbouring cells.

Tracheids

- Tracheids have cross-walls that are perforated.
- Their walls are deposited with lignin.
- Unlike the xylem vessels, their end walls are tapering or chisel-shaped.
- Their lumen is narrower.
- Besides transport of water, xylem has another function of strengthening the plant which is provided by xylem fibres and xylem parenchyma.

Xylem fibres;

- Are cells that are strengthened with lignin.
- They form wood.

Xylem parenchyma:

- These are cells found between vessels.
- They form the packing tissue.

Forces involved in Transportation of Water and Mineral Salts

Transpiration pull

- As water vaporises from spongy mesophyll cells into sub-stomatal air spaces, the cell sap of mesophyll cells develop a higher osmotic pressure than adjacent cells.
- Water is then drawn into mesophyll cells by osmosis from adjacent cells and finally from xylem vessels.
- A force is created in the leaves which pulls water from xylem vessels in the stem and root.
- This force is called ***transpiration pull .***

Cohesion and Adhesion:

- The attraction between water molecules is called cohesion.

- The attraction between water molecules and the walls of xylem vessels is called adhesion.
- The forces of cohesion and adhesion maintain a continuous flow of water in the xylem from the root to the leaves.

Capillarity:

- Is the ability of water to rise in fine capillary tubes due to surface tension.
- Xylem vessels are narrow, so water moves through them by capillarity.

Root Pressure:

- If the stem of a plant is cut above the ground level, it is observed that cell sap continues to come out of the cut surface.
- This shows that there is a force in the roots that pushes water up to the stem.
- This force is known as root pressure.

Importance of Transpiration

- Transpiration leads to excessive loss of water if unchecked.

Some beneficial effects are:

- Replacement of water lost during the process.
- Movement of water up the plant is by continuous absorption of water from the soil.
- Mineral salts are transported up the plant.
- Transpiration ensures cooling of the plant in hot weather.
- Excessive loss of water leads to wilting' and eventually death if water is not available in the soil.

Factors Affecting Transpiration

The factors that affect transpiration are grouped into two.

- i.e. environmental and structural.

Environmental factors

Temperature

- High temperature increases the internal temperature of the leaf .
- which in turn increases kinetic energy of water molecules which increases evaporation.
- High temperatures dry the air around the leaf surface maintaining a high concentration gradient.
- More water vapour is therefore lost from the leaf to the air.

Humidity

- The higher the humidity of the air around the leaf, the lower the rate of transpiration.
- The humidity difference between the inside of the leaf and the outside is called the saturation deficit.
- In dry atmosphere, the saturation deficit is high.

- At such times, transpiration rate is high.

Wind

- Wind carries away water vapour as fast as it diffuses out of the leaves.
- This prevents the air around the leaves from becoming saturated with vapour.
- On a windy day, the rate of transpiration is high.

Light Intensity

- When light intensity is high; more stomata open hence high rate of transpiration.

Atmospheric Pressure

- The lower the atmospheric pressure the higher the kinetic energy of water molecules hence more evaporation.
- Most of the plants at higher altitudes where atmospheric pressure is very low have adaptations to prevent excessive water-loss.

Availability of Water

- The more water there is in the soil, the more is absorbed by the plant and hence a lot of water is lost by transpiration.

Structural Factors

Cuticle

- Plants growing in arid or semi-arid areas have leaves covered with a thick waxy cuticle.

Stomata

- The more the stomata, the higher the rate of transpiration.
- Xerophytes have few stomata which reduce water-loss.
- Some have sunken stomata which reduces the rate of transpiration as the water vapour accumulates in the pits.
- Others have stomata on the lower leaf surface hence reducing the rate of water-loss.
- Some plants have reversed stomatal rhythm whereby stomata close during the day and open at night.
- This helps to reduce water-loss.

Leaf size and shape

- Plants in wet areas have large surface area for transpiration.
- Xerophytes have small narrow leaves to reduce water-loss.
- The photometer can be used to determine transpiration in different environmental conditions.

Translocation of organic compounds

- Translocation of soluble organic products of photosynthesis within a plant is called translocation.
- It occurs in phloem in sieve tubes.
- Substances translocated include glucose, amino acids, vitamins.

- These are translocated to the growing regions like stem, root apex, storage organs e.g. corms, bulbs and secretory organs such as nectar glands.

Phloem

phloem is made up of;

- sieve tubes,
- companion cells
- parenchyma, a packing tissue
- schlerenchyma, a strengthening tissue

Sieve Tubes

- These are elongated cells arranged end to end along the vertical axis.
- The cross walls are perforated by many pores to make a sieve plate.
- Most organelles disappear and those that remain are pushed to the sides of the sieve tube.
- Cytoplasmic strands pass through the pores in the plate into adjacent cells.
- Food substances are translocated through cytoplasmic strands.

Companion Cells

- Companion cells are small cells with large nuclei and many mitochondria.
- They are found alongside each sieve element.
- The companion cell is connected to the tube through plasmodesmata.
- The mitochondria generate energy required for translocation.

Phloem Parenchyma

- These are parenchyma cells between sieve elements.
- They act as packing tissue.

Transport in Animals

The Circulatory System

- Large and complex animals have circulatory systems that consist of tubes, a transport fluid and a means of pumping the fluid.
- ***Blood*** is the transport fluid which contains dissolved substances and cells.
- The tubes are blood vessels through which dissolved substances are circulated around the body.
- The heart is the pumping organ which keeps the blood in circulation.

The types of circulatory system exist in animals: open and closed.

- ***In an open circulatory system***;
  - The heart pumps blood into vessels which open into body spaces known as haemocoel.
  - Blood comes into contact with tissues.
- ***A closed circulatory system***;
  - Found in vertebrates and annelids where the blood is confined within blood vessels and does not come into direct contact with tissues.

Transport in Insects

- In an insect, there is a tubular heart just above the alimentary canal.
- This heart is suspended in a pericardial cavity by ligaments.
- The hearthas five chambers and extends along the thorax and abdomen .
- Blood is pumped forwards into the aorta by waves of contractions in the heart.
- It enters the haemocoel and flows towards the posterior.
- The blood flows back into the heart through openings in each chamber called ostia.
- The ostia have valves which prevent the backflow of blood.
- Blood is not used as a medium for transport of oxygen in insects.
- This is because oxygen is supplied directly to the tissues by the tracheal system.
- The main functions of blood in an insect are to transport nutrients, excretory products and hormones.

Mammalian Circulatory System

- Mammals have a closed circulatory system where a powerful heart pumps blood into arteries.
- The arteries divide into smaller vessels called arterioles.
- Each arteriole divides to form a network of capillaries inside the tissues.
- The capillaries eventually re-unite to form venules, which form larger vessels called veins.
- The veins take the blood back to the heart.
- Blood from the heart goes through the pulmonary artery to the lungs and then back to the heart through pulmonary vein.
- This circulation is called pulmonary circulation.
- Oxygenated blood leaves the heart through the aorta and goes to all the tissues of the body.
- From the tissues, deoxygenated blood flows back to the heart through the vena cava.
- This circulation is called systemic circulation.
- In each complete circulation, the blood flows into the heart twice.
- This is called double circulation.
- Some other animals like fish have a single circulation.
- Blood flows only once through the heart for every complete circuit.

Structure and Function of the Heart

- The heart has four chambers:
- Two artria (auricles) and two ventricles.
- The left and right side of the heart are separated by a muscle wall (septum) so that oxygenated and deoxygenated blood does not mix.
- Deoxygenated blood from the rest of the body enters the heart through the vena cava .
- Blood enters the right atrium, then through tricuspid valve into right ventricle.
- Then via semi-lunar valve to the pulmonary artery to the lungs.
- Oxygenated blood from the lungs enters the heart through pulmonary vein.
- It enters the left atrium of the heart, then through bicuspid valve into left ventricle.

- Then via semi-lunar valves to aorta which takes oxygenated blood round the body.
- A branch of the aorta called coronary artery supplies blood to the heart muscle.
- The coronary vein carries blood from the heart muscle to the pulmonary artery which then takes it to the lungs for oxygenation.

Pumping Mechanism of the heart

- The heart undergoes contraction (systole) and relaxation (diastole).

Systole

- When the ventricular muscles contract, the cuspid valves (tricuspid and bicuspid) close preventing backflow of blood into auricles.
- The volume ofthe ventricles decreases while pressure increases.
- This forces blood out of the heart to the lungs through semi-lunar valves and pulmonary artery, and to the body tissues via semi-lunar valve and aorta respectively.
- At the same time the atria are filled with blood.
- The left ventricle has thicker muscles than the right ventricle, and pumps blood for a longer distance to the tissues.

Diastole

- When ventricular muscles relax, the volume of each ventricle increases while pressure decreases.
- Contractions of atria force the bicuspid and tricuspid valves to open allowing deoxygenated blood from right atrium into right ventricle which oxygenated blood flows from left atrium into the left ventricle.
- Semi-lunar valves close preventing the backflow of blood into ventricles.
- The slight contractions of atria force the , blood flow into ventricles.

The Heartbeat

- The heart is capable of contracting and relaxing rhythmically without fatigue due to its special muscles called cardiac muscles.
- The rhythmic contraction of the heart arise from within the heart muscles without nervous stimulation.
- The contraction is said to be myogenic.
- The heartbeat is initiated by the pacemaker or sino-artrio-node (SAN) which is located in the right atrium.
- The wave of excitation spreads over the walls of atria.
- It is picked by the artrio-ventricular node which is located at the junction:
- Of the atria and ventricles, from where the purkinje tissue spreads the wave to the walls of the ventricles.
- The heart contracts and relaxes rhythmically at an average rate of 72 times per minute.
- The rate of the heartbeat is increased by the sympathetic nerve, while it is slowed down by the vagus nerve.
- Heartbeat is also affected by hormones e.g. adrenaline raises the heartbeat.

Structure and Function of Arteries,Capillaries and Veins

Arteries

- Arteries carry blood away from the heart.
- They carry oxygenated blood except pulmonary artery which carries deoxygenated blood to the lungs.
- Arteries have a thick, muscular wall, which has elastic and collagen fibres that resist the pressure of the blood flowing in them.
- The high pressure is due to the pumping action of the heart.
- The pressure in the arteries originate from the pumping action of the heart.
- The pulse or number of times the heart beats per minute can be detected by applying pressure on an artery next to the bone.
- e.g. by placing the finger/thumb on the wrist.
- The innermost layer of the artery is called endothelium which is smooth.
- It offers least possible resistance to blood flow.
- Have a narrow lumen .
- The aorta forms branches which supply blood to all parts of the body.
- These arteries divide into arterioles which further divide to form capillaries.

Capillaries

- Capillaries are small vessels whose walls are made of endothelium which is one cell thick.
- This provides a short distance for exchange of substances.
- Capillaries penetrate tissues,
- The lumen is narrow therefore blood flowing in capillaries is under high pressure.
- Pressure forces water and dissolved substances out of the blood to form tissue fluid.
- Exchange of substances occurs between cells and tissue fluid.
- Part of the tissue fluid pass back into capillaries at the venule end.
- Excess fluid drains into small channels called lymph capillaries which empty their contents into lymphatic vessels.
- Capillaries join to form larger vessels called venules which in turn join to form veins which transport blood back to the heart.

Veins

- Veins carry deoxygenated blood from the tissues to the heart (except pulmonary vein which carries oxygenated blood from the lungs to the heart).
- Veins have a wider lumen than arteries.
- Their walls are thinner than those of arteries.
- **Blood pressure in the veins is low.**
- Forward flow of blood in veins is assisted by contraction of skeletal muscles, hence the need for exercise.
- Veins have valves along their length to prevent backflow of blood.
- This ensures that blood flows towards the heart.
- The way the valves work can be demonstrated on the arm.

- By pressing on one vein with two fingers, leaving one and pushing blood toward the heart then releasing the latter finger, it can be observed that the part in between is left with the vein not being visible.
- This is because bleed does not flow back towards the first finger.

Diseases and Defects of Circulatory System

Thrombosis

- Formation of a clot in the blood vessels is called thrombosis.
- Coronary thrombosis is the most common.
- It is caused by blockage of coronary artery which supplies blood to the heart.
- Blockage may be due to artery becoming fibrous or accumulation of fatty material on the artery walls.
- Narrow coronary artery results in less blood reaching the heart muscles.
- A serious blockage can result in heart attack which can be fatal.
- Heavy intake of fat, alcohol, being overweight and emotional stress can cause coronary thrombosis.
- A blockage in the brain can lead to a stroke causing paralysis of part of the body, coma or even death.
- A healthy lifestyle, avoiding a lot of fat in meals and avoiding alcohol can control the ***disease.***

Arteriosclerosis

- This condition results from the inner walls having materials being deposited there or growth of fibrous connective tissue.
- This leads to thickening of the wall of the artery and loss of elasticity.
- Normal blood flow is hindered.
- Arteriosclerosis can lead to thrombosis or hypertension.
- A person with hypertension which is also called high blood pressure has his/her blood being pumped more forcefully through the narrow vessels.
- This puts stress on the walls of the heart and arteries.
- Regular exercise, healthy diet and avoiding smoking can help maintain normal blood pressure.

Varicose Veins

- Superficial veins especially at the back of the legs become swollen and flabby due to some valves failing to function properly.
- This results to retention of tissue fluid.
- Regular physical exercise will prevent this condition.
- Repair of valves through surgery can also be done.
- Wearing surgical stockings may ease a mild occurence.

Structure and Function of Blood

Composition of Blood

- The mammalian blood is made up of a fluid medium called plasma with substances dissolved in it.
  - Cellular components suspended in plasma include;
  - erythrocytes (red blood cells),
  - leucocytes (white blood cells)
  - thrombocytes (platelets)
  - blood proteins.

Plasma

- This is a pale yellow fluid consisting of 90% water.
- There are dissolved substances which include;
  - glucose, amino acids, lipids, salts,
  - hormones, urea, fibrinogen,albumen,
  - antibodies, some enzymessuspended cells.
- Serum is blood from which fibrinogen and cells have been removed.

The functions of plasma include:

- Transport of red blood cells which carry oxygen.
- Transport dissolved food substances round the body.
- Transport metabolic wastes like nitrogenous wastes and carbon (IV) oxide in solution about 85% of the carbon (IV) oxide is carried in form of hydrogen carbonates.
- Transport hormones from sites of production to target organs.
- Regulation of pH of body fluids.
- Distributes heat round the body hence regulate body temperature.

Erythrocytes (Red Blood Cells)

- In humans these cells are circular biconcave discs without nuclei.
- Absence of nucleus leaves room for more haemoglobin to be packed in the cell to enable it to carry more oxygen.
- Haemoglobin contained in red blood cells is responsible for the transport of oxygen.
- Haemoglobin + Oxygen =oxyhaemoglobin
- (Hb) + ($4O_2$) __ (HbO_g)
- Oxygen is carried in form of oxyhaemoglobin.
- Haemoglobin readily picks up oxygen in the lungs where concentration of oxygen is high.
- In the tissues, the oxyhaemoglobin breaks down (dissociates) easily into haemoglobin and oxygen.
- Oxygen diffuses out of the red blood cells into the tissues.
- Haemoglobin is then free to pick up more oxygen molecules.
- The biconcave shape increases their surface area over which gaseous exchange takes place.
- Due to their ability, they are able to change their shape to enable themselves squeeze inside the narrow capillaries.
- Co_2+ H_2O carbonic anhydrase

- There are about five million red blood cells per cu bic millimetre of blood.
- They are made in the bone marrow of the short bones like sternum, ribs and vertebrae.
- In the embryo they are made in the liver and spleen.
- Erythrocytes have a life span of about three to four months after which they are destroyed in the liver and spleen.
- Also in the red blood cells is carbonic anhydrase which assists in the transport of carbon (IV) oxide.

Leucocytes (White Blood Cells)

- These white blood cells have a nucleus.
- They are divided into two:
  - Granulocytes (also phagocytes or polymorphs)
  - Agranulocytes .
- White blood cells defend the body against disease.
- Neutrophils form 70% of the granulocytes.
- Others are eosinophils and basophils.
- About 24% agronulocytes are called lymphocytes, while 4% agranulocytes are monocytes.
- The leucocytes are capable of amoebic movement.
- They squeeze between the cells of the capillary wall to enter the intercellular spaces.
- They engulf and digest disease causing organisms (pathogens) by phagocytosis.
- Some white blood cells may die in the process of phagocytosis.
- The dead phagocytes, dead organisms and damaged tissues form pus.
- Lymphocytes produce antibodies which inactivate antigens.

Antibodies include:

- Antitoxins which neutralise toxins.
- Agglutinins cause bacteria to clump together and they die.
- Lysins digest cell membranes of microorganisms.
- Opsonins adhere to outer walls of microorganisms making it easier for phagocytes to ingest them.
- Lymphocytes' are made in the thymus gland and lymph nodes.
- There are about 7,000 leucocytes per cubic millimetre of blood.

Platelets (Thrombocytes)

- Platelets are small irregularly shaped cells formed from large bone marrow cells called megakaryocytes.
- There are about 250,000 platelets per cubic millimetre of blood.
- They initiate the process of blood clotting.
- The process of clotting involves a series of complex reactions whereby fibrinogen is converted into a fibrin clot.
- When blood vessels are injured platelets are exposed to air and they release **thromboplastin (thrombokinase**which initiates the blood clotting process.
- Thromboplastin neutralises heparin the anti-clotting factor in blood and activates prothrombin to thrombin.
- The process requires calcium ions and vitamin K.

- Thrombin activates the conversion of fibrinogen to fibrin which forms a meshwork of fibres on the cut surface to trap red blood cells to form a clot.
- The clot forms a scab that stops bleeding and protects the damaged tissues from entry of micro-organisms.
- Blood clotting reduces loss of blood when blood vessels are injured.
- Excessive loss of blood leads to anaemia and dehydration.
- Mineral salts lost in blood leads to osmotic imbalance in the body.
- This can be corrected through blood transfusion and intravenous fluid.

ABO Blood Groups

- There are four types of blood groups in human beings: A, B, AB and O.
- These are based on types of proteins on the cell membrane of red blood cells.
- There are two types of proteins denoted by the letters A and B which are antigens.
- In the plasma are antibodies specific to these antigens denoted as *a* and *b.*
- A person of blood group A has A antigens on the red blood cells and *b* antibodies in plasma.
- A person of blood group B has B antigens on red blood cells and *a* antibodies in plasma.
- A person of blood group AB has A and B antigens on red blood cells and no antibodies in plasma .
- A person of blood group a has no antigens on red blood cells and *a* and *b* antibodies in plasma.

V
Blood groups

Blood	Antigens	Antibodi
A	A	b
B	B	a
AB	AandB	None
o	None	a and b

Blood Transfusion

Blood transfusion is the transfer of blood from a donor to the circulatory system of the recipient.

A recipient will receive blood from a donor if the recipient has no corresponding antibodies to the donor's antigens.

If the donor's blood and the recipient's blood are not compatible, agglutination occurs whereby red blood cells clump together.

Blood typing

- A person of blood group o can donate blood to a person of any other blood group.
- A person of blood group o is called a universal donor.
- A person of blood group AB can receive blood from any other group.

- A person with blood group AB is called a universal recipient.
- A person of blood group A can only donate blood to another person with blood group A or a person with blood group AB.
- A person of blood group B can only donate blood to somebody with blood group B or a person with blood group AB.
- A person with blood group AB can only donate blood to a person with blood groupAB.
- Blood screening has become a very important step in controlling HIV/AIDS.
- It is therefore important to properly screen blood before any transfusion is done.

Rhesus Factor

- The Rhesus factor is present in individuals with the Rhesus antigen in their red blood cells.
- Such individuals are said to be Rhesus positive (Rh+), while those without the antigen are Rhesus negative (Rh-).
- If blood from an Rh+ individual is introduced into a person who is Rh- , the latter develops antibodies against the Rhesus factor.
- There may not be any reaction after this transfusion.
- However a subsequent transfusion with Rh+ blood causes a severe reaction, and agglutination occurs i.e. clumping of red blood cells.
- The clump can block the flow of blood, and cause death.
- Erythroblastosis foetalis (haemolytic disease of the newborn) results when an Rh-mother carries an Rh+ foetus.
- This arises when the father is Rh+.
- During the latter stage of pregnancy, fragments of Rhesus positive red blood cells of the foetus may enter mother's circulation.
- These cause the mother to produce Rhesus antibodies which can pass across the. placenta to the foetus and destroy foetal red blood cells.
- During the first pregnancy, enough antibodies are not formed to affect the foetus.
- Subsequent pregnancies result in rapid production of Rhesus antibodies by the mother.
- These destroy the red blood cells of the foetus, the condition called haemolytic disease of the newborn.
- The baby is born anaemic and with yellow eyes (jaundiced).
- The condition can be corrected by a complete replacement of baby's blood with safe healthy blood.

Lymphatic System

- The lymphatic system consists of lymph vessels.
- Lymph vessels have valves to ensure unidirectional movement of lymph.
- Lymph is excess tissue fluid i.e. blood minus blood cells and plasma proteins.
- Flow of lymph is assisted by breathing and muscular contractions.
- Swellings called lymph glands occur at certain points along the lymph vessels.
- Lymph glands are oval bodies consisting of connective tissues and lymph spaces.
- The lymph spaces contain lymphocytes which are phagocytic.
- Lymph has the same composition as blood except that it does not contain red blood cells and plasma proteins.
- Lymph is excess tissue fluid.
- Excess tissue fluid is drained into lymph vessels by hydrostatic pressure.
- The lymph vessels unite to form major lymphatic system.
- The main lymph vessels empty the contents into sub-clavian veins which take it to the heart.

Immune Responses

- Immune response is the production of antibodies in response to antigens.
- An antigen is any foreign material or organism that is introduced into the body and causes the production of antibodies.
- Antigens are protein in nature.
- An antibody is a protein whose structure is complementary to the antigen.
- This means that a specific antibody deals with a specific antigen to make it harmless.
- When harmful organisms or proteins invade the body, lymphocytes produce complementary antibodies, while bone marrow and thymus gland produce more phagocytes and lymphocytes respectively.

Types of Immunity

- There are two types of **immunity; natural and artificial.**

Natural Immunity is also called innate immunity.

- **It** is inherited from parent to offspring.

Artificial Immunity can be natural or induced.

- When attacked by diseases like chicken pox, measles and mumps, those who recover from these diseases develop resistance to any subsequent infections of the same diseases.
- This is natural acquired immunity.

Artificial Acquired Immunity:

- When attenuated (weakened) or dead microorganisms are introduced into a healthy person.
- The lymphocytes synthesis the antibodies which are released into the lymph and eventually reach the blood.
- The antibodies destroy the invading organisms.
- The body retains 'memory' of the structure of antigen.
- Rapid response is ensured in subsequent infections.
- Vaccines generally contain attenuated disease causing organisms.

Artificial Passive Acquired Immunity:

- Serum containing antibodies is obtained from another organism, and confers immunity for a short duration.
- Such immunity is said to be passive because the body is not activated to produce the antibodies.

Importance of Vaccination

- A vaccine is made of attenuated, dead or nonvirulent micro-organism that stimulate cells in the immune system to recognise and attack disease causing agent through production of antibodies.
- Vaccination protects individuals from infections of many diseases like smallpox, tuberculosis and poliomyelitis.
- Diseases like smallpox, tuberculosis and tetanus were killer diseases but this is no longer the case.
- Diphtheria Pertussis Tetanus (DPT) vaccine protects children against diphtheria, whooping cough and tetanus.
- Bacille Calmette Guerin (BCG) vaccine is injected at birth to children to protect them against tuberculosis.
- Measles used to be a killer disease but today, a vaccine injected into children at the age of rune months prevents it.
- At birth children are given an inoculation through the mouth of the poliomyelitis vaccine.

Allergic Reactions

- An allergy is a hypersensitive reaction to an antigen by the body.
- The antibody reacts with the antigen violently.
- People with allergies are oversensitive to foreign materials like dust, pollen grains, some foods, some drugs and some air pollutants.
- Allergic reactions lead to production of **histamine** by the body.
- Histamine causes swelling and pain.
- Allergic reactions can be controlled by avoiding the allergen and administration of anti-histamine drugs.

END OF NOTES

Respiration

Meaning and Significance of Respiration

- Respiration is the process by which energy is liberated from organic compounds such as glucose.
- It is one of the most important characteristics of living organisms.
- Energy is expended (used) whenever an organism exhibits characteristics of life, such as feeding, excretion and movement.
- Respiration occurs all the time and if it stops, cellular activities are disrupted due to lack of energy.
- This may result in death e.g., if cells in brain lack oxygen that is needed for respiration for a short time, death may occur.
- This is because living cells need energy in order to perform the numerous activities necessary to maintain life.
- The energy is used in the cells and much of it is also lost as heat.
- In humans it is used to maintain a constant body temperature.

Tissue Respiration

- Respiration takes place inside cells in all tissues.
- Every living cell requires energy to stay alive.
- Most organisms require oxygen of the air for respiration and this takes place in the mitochondria.

Mitochondrion Structure and Function

Structure

- Mitochondria are rod-shaped organelles found in the cytoplasm of cells.
- A mitochondrion has a smooth outer membrane and a folded inner membrane.
- The folding of the inner membrane is called cristae and the inner compartment is called the matrix.

Adaptations of Mitochondrion to its Function

- The matrix contains DNA ribosomes for making proteins and has enzymes for the breakdown of pyruvate to carbon (IV) oxide, hydrogen ions and electrons.
- Cristae increase surface area of mitochondrial inner membranes where attachment of enzymes needed for the transport of hydrogen ions and electrons are found.
- There are two types of respiration:
  - Aerobic Respiration

- Anaerobic. Respiration

Aerobic Respiration

- This involves breakdown of organic substances in tissue cells in the presence of oxygen .
- All multicellular organisms and most unicellular organisms e.g. some bactena respire aerobically.
- In the process, glucose is fully broken down to carbon (IV) oxide and hydrogen which forms water when it combines with the oxygen.
- Energy produced is used to make an energy rich compound known as adenosine triphosphate (ATP).
- It consists of adenine, an organic base, five carbon ribose-sugar and three phosphate groups.
- ATP is synthesised from adenosine diphosphate (ADP) and inorganic phosphate.
- The last bond connecting the phosphate group is a high-energy bond.
- Cellular activities depend directly onATP as an energy source.
- When an ATP molecule is broken down, it yields energy.

Process of Respiration

- The breakdown of glucose takes place in many steps.
- Each step is catalysed by a specific enzyme.
- Energy is released in some of these steps and as a result molecules of ATP are synthesised.
- All the steps can be grouped into three main stages:

Glycolysis.

- The initial steps in the breakdown of glucose are referred to as glycolysis and they take place in the cytoplasm.
- Glycolysis consists of reactions in which glucose is gradually broken down into molecules of a carbon compound called pyruvic acid or pyruvate.
- Before glucose can be broken, it is first activated through addition of energy from ATP and phosphate groups.
- This is referred to as phosphorylation.
- The phosphorylated sugar is broken down into two molecules of a 3-carbon sugar (triose sugar) each of which is then converted into pyruvic acid.
- If oxygen is present, pyruvic acid is converted into a 2-carbon compound called acetyl coenzyme A (acetyl Co A).
- Glycolysis results in the net production of two molecules of ATP.

- The next series of reactions involve decarboxylation i.e. removal of carbon as carbon (IV) oxide and dehydrogenation, removal of hydrogen as hydrogen ions and electrons.
- These reactions occur in the mitochondria and constitute the Tri-carboxylic Acid Cycle (T.C.A.) or Kreb's citric acid cycle.
- The acetyl Co A combines with 4-carbon compound with oxalo-acetic acid to form citric acid - a 6 carbon compound.
- The citric acid is incorporated into a cyclical series of reactions that result in removal of carbon (IV) oxide molecules, four pairs of hydrogen, ions and electrons.
- Hydrogen ions and electrons are taken to the inner mitochondria membrane where enzymes and electron carriers effect release of a lot of energy.
- Hydrogen finally combines with oxygen to form water, and 36 molecules of ATP are synthesised.

Anaerobic Respiration

- Anaerobic respiration involves breakdown of organic substances in the absence of oxygen.
- It takes place in some bacteria and some fungi.
- Organisms which obtain energy by anaerobic respiration are referred to as anaerobes.
- Obligate anaerobes are those organisms which do not require oxygen at all and may even die if oxygen is present.
- Facultative anaerobes are those organisms which survive either in the absence or in the presence of oxygen.
- Such organisms tend to thrive better when oxygen is present e.g. yeast.

Products of Anaerobic Respiration

- The products of anaerobic respiration differ according to whether the process is occurring in plants or animals.

Anaerobic Respiration in Plants

- Glucose is broken down to an alcohol, (ethanol) and carbon (IV) oxide.
- The breakdown is incomplete.
- Ethanol is an organic compound, which can be broken down further in the presence of oxygen to provide energy, carbon (IV) oxide and water.

$$C_6H_{12}O_6 \_ 2C_2H_5OH + 2CO_2 + \text{Energy}$$

(Glucose) (Ethanol) (Carbon (IV) oxide)

Fermentation-

- Is the term used to describe formation of ethanol and carbon (IV) oxide from grains.
- Yeast cells have enzymes that bring about anaerobic respiration.

Lactate Fermentation

- Is the term given to anaerobic respiration in certain bacteria that results in formation of lactic acid.

Anaerobic Respiration in Animals

- Anaerobic respiration in animals produces lactic acid and energy.

$$C_6H_1P6 \_ 2CH_3CHOH.COOH + energy$$

(Glucose) (Lactic acid) + energy

- When human muscles are involved in very vigorous activity, oxygen cannot be delivered as rapidly as it is required.
- The muscle respire anaerobically and lactic acid accumulates.
- A high level of lactic acid is toxic.
- During the period of exercise, the body builds up an oxygen debt.
- After vigorous activity, one has to breathe faster and deeper to take in more oxygen.
- Rapid breathing occurs in order to break down lactic acid into carbon (IV) oxide and water and release more energy.
- Oxygen debt therefore refers to the extra oxygen the body takes in after vigorous exercise.

Practical Activities

To Show the Gas Produced When the Food is burned

- A little food substance e.g., maize flour or meat is placed inside a boiling tube.
- The boiling tube is stoppered using a rubber bung connected to a delivery tube inserted into a test-tube with limewater.
- The food is heated strongly to bum.
- Observations are made on the changes in lime water (calcium hydroxide) as gas is produced.
- The clear lime water turns white due to formation of calcium carbonate precipitate proving that carbon (Iv) oxide is produced.

Experiment to Show the Gas Produced During Fermentation

- Glucose solution is boiled and cooled. Boiling expels all air.
- A mixture of glucose and yeast is placed in a boiling tube, and covered with a layer of oil to prevent entry of air.
- A delivery tube is connected and directed into a test-tube containing lime water.
- The observations are made immediately and after three days the contents are tested for the presence of ethanol.
- A control experiment is set in the same way except that yeast which has been boiled and cooled is used.
- Boiling kills yeast cells.
- The limewater becomes cloudy within 20 minutes.
- This proves that carbon (IV) oxide gas is produced.
- The fermentation process is confirmed after three days when alcohol smell is detected in the mixture.

Experiment to Show Germinating Seeds Produce Heat

- Soaked bean seeds are placed in a vacuum flask on wet cotton wool.
- A thermometer is inserted and held in place with cotton wool .
- The initial temperature is taken and recorded.
- A control experiment is set in the same way using boiled and cooled bean seeds which have been washed in formalin to kill microorganisms.
- Observation is made within three days.
- Observations show that temperature in the flask with germinating seeds has risen.
- The one in the control has not risen.

Comparison Between Aerobic and Anaerobic Respiration

	Aerobic Respiration	*Anaerobic Respiration*
1. Site	In the mitochondria.	In the cytoplasm.
2. Products	Carbon dioxide and water.	Ethanol in plants and lactic acid in animals.
3. Energy yield	38 molecules of A TP (2880 KJ) from each molecule of glucose.	2 molecules of ATP 210KJ from each molecule of glucose.
4. Further reaction	No further reactions on carbon dioxide and water.	Ethanol and lactic acid can be broken down further in the presence of oxygen.

Comparison Between Energy Output in Aerobic and Anaerobic Respiration

- Aerobic respiration results in the formation of simple inorganic molecules, water and carbon (Iv) oxide as the byproducts.
- These cannot be broken down further. A lot of energy is produced.
- When a molecule of glucose is broken down in the presence of oxygen, 2880 KJ of energy are produced (38 molecules of ATP).
- In anaerobic respiration the by products are organic compounds.
- These can be broken down further in the presence of oxygen to give more energy.
- Far less energy is thus produced.
- The process is not economical as far as energy production is concerned.
- When a molecule of glucose is broken down in the absence of oxygen in plants, 210 KJ are produced (2 molecule ATP).
- In animals, anaerobic respiration yields 150 kJ of energy.

Substrates for Respiration

- Carbohydrate, mainly glucose is the main substrate inside cells.

- Lipids i.e. fatty acids and glycerol are also used.
- Fatty acids are used when the carbohydrates are exhausted.
- A molecule of lipid yields much more energy than a molecule of glucose.
- Proteins are not normally used for respiration.
- However during starvation they are hydrolysed to amino acids, dearnination follows and the products enter Kreb's cycle as urea is formed.
- Use of body protein in respiration result to body wasting, as observed during prolonged sickness or starvation.
- The ratio of the amount of carbon (IV) oxide produced to the amount of oxygen used for each substrate is referred to as Respiratory Quotient (RQ) and is calculated as follows:

$$R.Q. = \frac{\text{Amount of carbon (IV) oxide produced}}{\text{Amount of oxygen used}}$$

- Carbohydrates have a respiratory quotient of 1.0 lipids 0.7 and proteins 0.8.
- Respiratory quotient value can thus give an indication of types of substrate used.
- Besides values higher than one indicate that some anaerobic respiration is taking place.

Application of Anaerobic Respiration in Industry and at Home

Industry

- Making of beer and wines.
- Ethanol in beer comes from fermentation of sugar(maltose) in germinating barley seeds.
- Sugar in fruits is broken down anaerobically to produce ethanol in wines.
- In the dairy industry, bacterial fermentation occurs in the production of several dairy products such as cheese, butter and yoghurt.
- In production of organic acids e.g., acetic acid, that are used in industry e.g., in preservation of foods.

Home

- Fermentation of grains is used to produce all kinds of beverages e.g., traditional beer and sour porridge.
- Fermentation of milk.

End of Topic

GASEOUS EXCHANGE IN PLANTS AND ANIMALS

Necessity for Gaseous Exchange in Living Organisms

- Living organisms require energy to perform cellular activities.
- The energy comes from breakdown of food in respiration.
- Carbon (IV) oxide is a by product of respiration and its accumulation in cells is harmful which has to be removed.
- Most organisms use oxygen for respiration which is obtained from the environment.
- Photosynthetic cells of green plants use carbon (Iv) oxide as a raw material for photosynthesis and produce oxygen as a byproduct.
- The movement of these gases between the cells of organisms and the environment comprises gaseous exchange.
- The process of moving oxygen into the body and carbon (Iv) oxide out of the body is called breathing or ventilation.
- Gaseous exchange involves the passage of oxygen and carbon (IV) oxide through a respiratory surface.
- Diffusion is the main process involved in gaseous exchange.

Gaseous Exchange in Plants

- Oxygen is required by plants for the production of energy for cellular activities.
- Carbon (IV) oxide is required as a raw material for the synthesis of complex organic substances.
- Oxygen and carbon (IV) oxide are obtained from the atmosphere in the case of terrestrial plants and from the surrounding water in the case of aquatic plants.
- Gaseous exchange takes place mainly through the stomata.

Structure of Guard Cells

- The stoma (stomata - plural) is surrounded by a pair of guard cells.

- The structure of the guard cells is such that changes in turgor inside the cell cause changes in their shape.
- They are joined at the ends and the cell walls facing the pore (inner walls) are thicker and less elastic than the cell walls farther from the pore (outer wall).
- Guard cells control the opening and closing of stomata.

Mechanism of Opening and Closing of Stomata

- In general stomata open during daytime (in light) and close during the night (darkness).
- Stomata open when osmotic pressure in guard cells becomes higher than that in surrounding cells due to increase in solute concentration inside guard cells. Water is then drawn into guard cells by osmosis.
- Guard cells become turgid and extend.
- The thinner outer walls extend more than the thicker walls.
- This causes a bulge and stoma opens.
- Stomata close when the solute concentration inside guard cells become lower than that of surrounding epidermal cells.
- The water moves out by osmosis, and the guard cells shrink i.e. lose their turgidity and stoma closes.

Proposed causes of turgor changes in guard cells.

Accumulation of sugar.

- Guard cells have chloroplasts while other epidermal cells do not.
- Photosynthesis takes place during daytime and sugar produced raises the solute concentration of guard cells.
- Water is drawn into guard cells by osmosis from surrounding cells.
- Guard cells become turgid and stoma opens.
- At night no photosynthesis occurs hence no sugar is produced.
- The solute concentration of guard cells falls and water moves out of the guard cells by osmosis.
- Guard cells lose turgidity and the stoma closes.

pH changes in guard cells occur due to photosynthesis.

- In day time carbon (IV) oxide is used for photosynthesis. This reduces acidity while the oxygen produced increases alkalinity.
- Alkaline pH favours conversion of starch to sugar.
- Solute concentration increases inside guard cells, water is drawn into the cells by osmosis. Guard cells become turgid and the stoma opens.
- At night when no photosynthesis, Respiration produces carbon (IV) oxide which raises acidity .This favours conversion of sugar to starch. low sugar concentration lead to loss of turgidity in guard cells and stoma closes.

Explanation is based on accumulation of potassium ions

- In day time (light) adenosine triphosphate (ATP) is produced which causes potassium ions to move into guard cells by active transport.
- These ions cause an increase in solute concentration in guard cells that has been shown to cause movement of water into guard cells by osmosis.
- Guard cells become turgid and the stoma opens.
- At night potassium and chloride ions move out of the guard cells by diffusion and level of organic acid also decreases.
- This causes a drop in solute concentration that leads to movement of water out of guard cells by osmosis.
- Guard cells lose turgor and the stoma closes.

Process of Gaseous Exchange in Root Stem and Leaves of Aquatic and Terrestrial Plants

Gaseous Exchange in leaves of Terrestrial Plants

- Gaseous exchange takes place by diffusion.
- The structure of the leaf is adapted for gaseous exchange by having intercellular spaces that are filled.
- These are many and large in the spongy mesophyll.
- When stomata are open,carbon(IV)oxide from the atmosphere diffuses into the substomatal air chambers.
- From here, it moves into the intercellular space in the spongy mesophyll layer.
- The CO_2 goes into solution when it comes into contact with the cell surface and diffuses into the cytoplasm.
- A concentration gradient is maintained between the cytoplasm of the cells and the intercellular spaces.
- CO_2 therefore continues to diffuse into the cells.
- The oxygen produced during photosynthesis moves out of the cells and into the intercellular spaces.
- From here it moves to the substomatal air chambers and eventually diffuses out of the leaf through the stomata.
- At night oxygen enters the cells while CO_2 moves out.

Gaseous exchange in the leaves of aquatic(floating)plants

- Aquatic plants such as water lily have stomata only on the upper leaf surface.
- The intercellular spaces in the leaf mesophyll are large.
- Gaseous exchange occurs by diffusion just as in terrestrial plants.

Observation of internal structure of leaves of aquatic plants

- Transverse section of leaves of an aquatic plant such as Nymphaea differs from that of terrestrial plant.

The following are some of the features that can be observed in the leave of an aquatic plant;

- Absence of cuticle
- Palisade mesophyll cells are very close to each other ie.compact.
- Air spaces (aerenchyma) in spongy mesophyll are very large.
- Sclereids (stone cells) are scattered in leaf surface and project into air spaces.
- They strengthen the leaf making it firm and assist it to float.

Gaseous Exchange Through Stems

Terrestrial Plants

- Stems of woody plants have narrow openings or slits at intervals called **lenticels.**
- They are surrounded by loosely arranged cells where the bark is broken.
- They have many large air intercellular spaces through which gaseous exchange occurs.
- Oxygen enters the cells by diffusion while carbon (IV) oxide leaves.
- Unlike the rest of the bark, lenticels are permeable to gases and water.

Aquatic Plant Stems

- The water lily, *Salvia* and *Wolfia* whose stems remain in water are permeable to air and water.
- Oxygen dissolved in the water diffuses through the stem into the cells and carbon (IV) oxide diffuses out into the water.

Gaseous Exchange in Roots

Terrestrial Plants

- Gaseous exchange occurs in the root hair of young terrestrial plants.
- Oxygen in the air spaces in the soil dissolves in the film of moisture surrounding soil particles and diffuses into the root hair along a concentration gradient.
- It diffuses from root hair cells into the cortex where it is used for respiration.
- Carbon (IV) oxide diffuses in the opposite direction.
- In older roots of woody plants, gaseous exchange takes place through lenticels.

Aquatic Plants

- Roots of aquatic plants e.g. water lily are permeable to water and gases.
- Oxygen from the water diffuses into roots along a concentration gradient.
- Carbon (IV) oxide diffuses out of the roots and into the water.
- The roots have many small lateral branches to increase the surface area for gaseous exchange.
- They have air spaces that help the plants to float.
- Mangroove plants grow in permanently waterlogged soils, muddy beaches and at estuaries.
- They have roots that project above the ground level.
- These are known as breathing roots or pneumatophores.
- These have pores through which gaseous exchange takes place e.g. in *Avicenia* the tips of the roots have pores.
- Others have respiratory roots with large air spaces.

Gaseous Exchange in Animals

- All animals take in oxygen for oxidation of organic compounds to provide energy for cellular activities.
- The carbon (IV) oxide produced as a by-product is harmful to cells and has to be constantly removed from the body.
- Most animals have structures that are adapted for taking in oxygen and for removal of carbon (IV) oxide from the body.
- These are called "respiratory organs".

- The process of taking in oxygen into the body and carbon (IV) oxide out of the body is called breathing or ventilation.
- Gaseous exchange involves passage of oxygen and carbon (IV) oxide through a respiratory surface by diffusion.

Types and Characteristics of Respiratory surfaces

Different animals have different respiratory surfaces.

- The type depends mainly on the habitat of the animal, size, shape and whether body form is complex or simple.
- ***Cell Membrane***: In unicellular organisms the cell membrane serves as a respiratory surface.
- ***Gills:*** Some aquatic animals have gills which may be external as in the tadpole or internal as in bony fish e.g. tilapia.
- They are adapted for gaseous exchange in water.
- ***Skin:*** Animals such as earthworm and tapeworm use the skin or body surface for gaseous exchange.
- The skin of the frog is adapted for gaseous exchange both in water and on land.
- The frog also uses ***epithelium lining of the mouth or buccal cavity*** for gaseous exchange.
- ***Lungs:*** Mammals, birds and reptiles have lungs which are adapted for gaseous exchange.

Characteristics of Respiratory Surfaces

- They are permeable to allow entry of gases.
- They have a large surface area in order to increase diffusion.
- They are usually thin in order to reduce the distance of diffusion.
- They are moist to allow gases to dissolve.
- They are well-supplied with blood to transport gases and maintain a concentration gradient.

Gaseous Exchange in Amoeba

- Gaseous exchange occurs across the cell membrane by diffusion.
- Oxygen diffuses in and carbon (IV) oxide diffuses out.
- Oxygen is used in the cell for respiration making its concentration lower than that in the surrounding water.
- Hence oxygen continually enters the cell along a concentration gradient.
- Carbon (IV) oxide concentration inside the cell is higher than that in the surrounding water thus it continually diffuses out of the cell along a concentration gradient.

Gaseous Exchange in Insects

- Gaseous exchange in insects e.g., grasshopper takes place across a system of tubes penetrating into the body known as the tracheal system.
- The main trachea communicate with atmosphere through tiny pores called spiracles.
- Spiracles are located at the sides of body segments;

- Two pairs on the thoracic segments and eight pairs on the sides of abdominal segments.

- Each spiracle lies in a cavity from which the trachea arises.
- Spiracles are guarded with valves that close and thus prevent excessive loss of water vapour.
- A filtering apparatus i.e. hairs also traps dust and parasites which would clog the trachea if they gained entry.
- The valves are operated by action of paired muscles.

Mechanism of Gaseous Exchange in Insects

- The main tracheae in the locust are located laterally along the length of the body on each side and they are interconnected across.
- Each main trachea divides to form smaller tracheae, each of which branches into tiny tubes called tracheoles.
- Each tracheole branches further to form a network that penetrates the tissues. Some tracheoles penetrate into cells in active tissue such as flight muscles.
- These are referred to as intracellular tracheoles.
- Tracheoles in between the cells are known as intercellular tracheoles.
- The main tracheae are strengthened with rings of cuticle.
- This helps them to remain open during expiration when air pressure is low.

Adaptation of Insect Tracheoles for Gaseous Exchange

- The fine tracheoles are very thin about one micron in diameter in order to permeate tissue.
- They are made up of a single epithelial layer and have no spiral thickening to allow diffusion of gases.
- Terminal ends of the fine tracheoles are filled with a fluid in which gases dissolve to allow diffusion of oxygen into the cells.
- Amount of fluid at the ends of fine tracheoles varies according to activity i.e. oxygen demand of the insect.
- During flight, some of the fluid is withdrawn from the tracheoles such that oxygen reaches muscle cells faster and the rate of respiration is increased.
- In some insects, tracheoles widen at certain places to form air sacs.
- These are inflated or deflated to facilitate gaseous exchange as need arises.
- Atmospheric air that dissolves in the fluid at the end of tracheoles has more oxygen than the surrounding cells of tracheole epithelium'.
- Oxygen diffuses into these cells along a concentration gradient. '
- Carbon (IV) oxide concentration inside the cells is higher than in the atmospheric .
- Air and diffuses out of the cells along a concentration gradient.
- It is then removed with expired air.

Ventilation in Insects

- Ventilation in insects is brought about by the contraction and relaxation of the abdominal muscles.
- In locusts, air is drawn into the body through the thoracic spiracles and expelled through the abdominal spiracles.
- Air enters and leaves the tracheae as abdominal muscles contract and relax.
- **The muscles contract laterally so the** abdomen becomes wider and when they relax it becomes narrow.

- Relaxation of muscles results in low pressure hence inspiration occurs while contraction of muscles results in higher air pressure and expiration occurs.
- In locusts, air enters through spiracles in the thorax during inspiration and leaves through the abdominal spiracles during expiration.
- This results in efficient ventilation.
- Maximum extraction of oxygen from the air occurs sometimes when all spiracles close and hence contraction of abdominal muscles results in air circulating within the tracheoles.
- The valves in the spiracles regulate the opening and closing of spiracles.

Observation of Spiracle in Locust

- Some fresh grass is placed in a gas jar.
- A locust is introduced into the jar.
- A wire mesh is placed on top or muslin cloth tied around the mouth of the beaker with rubber band.
- The insect is left to settle.
- Students can approach and observe in silence the spiracles and the abdominal movements during breathing.
- Alternatively the locust is held by the legs and observation of spiracles is made by the aid of hand lens.

Gaseous Exchange in Bony Fish (e.g, Tilapia)

- Gaseous exchange in fish takes place between the gills and the surrounding water.
- The gills arelocated in an opercular cavity covered by a flap of skin called the operculum.
- Each _gill consists of a number of thin leaf-like lamellae projecting from a skeletal base branchial arch (gill bar) situated in the wall of the pharynx.
- There are four gills within the opercular cavity on each side of the head.
- Each gill is made up of a bony gill arch which has a concave surface facing the mouth cavity (anterior) and a convex posterior surface.
- Gill rakers are bony projections on the concave side that trap food and other solid particles which are swallowed instead of going over and damaging the gill ftlaments.
- Two rows of gill filaments subtend from the convex surface.

Adaptation of Gills for Gaseous Exchange

- Gill filaments are thin walled.
- Gill filaments are very many (about seventy pairs on each gill), to increase surface area.
- Each gill filament has very many gill lamellae that further increase surface area.
- The gill filaments are served by a dense network of blood vessels that ensure efficient transport of gases.
- It also ensures that a favourable diffusion gradient is maintained.
- The direction of flow of blood in the gill lamellae is in the opposite direction to that of the water (counter current flow) to ensure maximum diffusion of gases.

Ventilation

- As the fish opens the mouth, the floor of the mouth is lowered.
- This increases the volume of the buccal cavity.

- Pressure inside the mouth is lowered causing water to be drawn into the buccal cavity.
- Meanwhile, the operculum is closed, preventing water from entering or leaving through the opening.
- As the mouth closes and the floor of the mouth is raised, the volume of buccal cavity decreases while pressure in the opercular cavity increases due to contraction of opercular muscles.
- The operculum is forced to open and water escapes.
- As water passes over the gills, oxygen is absorbed and carbon dioxide from the gills dissolves in the water.

- As the water flows over the gill filaments oxygen in the water is at a higher concentration than that in the blood flowing, in the gill.
- Oxygen diffuses through the thin walls of gill filaments/lamellae into the blood.
- Carbon (IV) oxide is at a higher concentration in the blood than in the water.
- It diffuses out of blood through walls of gill filaments into the water.

Counter Current Flow

- In the bony fish direction of flow of water over the gills is opposite that of blood flow through the gill filaments .
- This adaptation ensures that maximum amount of oxygen diffuses from the water into the blood in the gill filament.
- This ensures efficient uptake of oxygen from the water.
- Where the flow is along the same direction (parallel flow) less oxygen is extracted from the water.

Observation of Gills of a Bony Fish (Tilapia)

- Gills of a fresh fish are removed and placed in a petri-dish with enough water to cover them.
- A hand lens is used to view the gills.
- Gill bar, gill rakers and two rows of gill filaments are observed.

Gaseous Exchange in an Amphibian - Frog

- An adult frog lives on land but goes back into the water during the breeding season.
- A frog uses three different respiratory surfaces.
- These are the ***skin, buccal cavity and lungs.***

Skin

- The skin is used both in water and on land.
- It is quite efficient and accounts for 60% of the oxygen taken in while on land.

Adaptations of a Frog's Skin for Gaseous Exchange

- The skin is a thin epithelium to allow fast diffusion.
- The skin between the digits in the limbs (i.e. webbed feet) increase the surface area for gaseous exchange.
- It is richly supplied with blood vessels for transport of respiratory gases.
- The skin is kept moist by secretions from mucus glands.
- This allows for respiratory gases to dissolve.

- Oxygen dissolved in the film of moisture diffuses across the thin epithelium and into the blood which has a lower concentration of oxygen.
- Carbon (IV) oxide diffuses from the blood across the skin to the atmosphere along the concentration gradient.

Buccal (Mouth) Cavity

- Gaseous exchange takes place all the time across thin epithelium lining the mouth cavity.
- Adaptations of Buccal Cavity for Gaseous Exchange
- It has a thin epithelium lining the walls of the mouth cavity allowing fast diffusion of gases.
- It is kept moist by secretions from the epithelium for dissolving respiratory gases.
- It has a rich supply of blood vessels for efficient transport of respiratory gases.
- The concentration of oxygen in the air within the mouth cavity is higher than that of the blood inside the blood vessels.
- Oxygen, therefore dissolves in the moisture lining the mouth cavity and then diffuses into the blood through the thin epithelium.
- On the other hand, carbon (IV) oxide diffuses in the opposite direction along a concentration gradient.

Lungs

- There is a pair of small lungs used for gaseous exchange.

Adaptation of Lungs

- The lungs are thin walled for fast diffusion of gases.
- Have internal foldings to increase surface area for gaseous exchange.
- A rich supply of blood capillaries for efficient transport of gases.
- Moisture lining for gases to dissolve.

Ventilation

Inspiration

- During inspiration, the floor of the mouth is lowered and air is drawn in through the nostrils.
- When the nostrils are closed and the floor of the mouth is raised, air is forced into the lungs.
- Gaseous exchange occurs in the lungs, oxygen dissolves in the moisture lining of the lung and diffuses into the blood through the thin walls.
- Carbon (IV) oxide diffuses from blood into the lung lumen.

Expiration

- When the nostrils are closed and the floor of mouth is lowered by contraction of its muscles, volume of mouth cavity increases.
- Abdominal organs press against the lungs and force air out of the lungs into buccal cavity.
- Nostrils open and floor of the mouth is raised as its muscles relax.
- Air is forced out through the nostrils.

Gaseous Exchange in a Mammal -Human

- The breathing system of a mammal consists of a pair of **lungs** which are thin-walled elastic sacs lying in the thoracic cavity.
- The thoracic cavity consists of vertebrae, sternum, ribs and intercostal muscles.
- The thoracic cavity is separated from the abdominal cavity by the diaphragm.
- The lungs lie within the thoracic cavity.
- They are enclosed and protected by the ribs which are attached to the sternum and the thoracic vertebrae.
- There are twelve pairs of ribs, the last two pairs are called 'floating ribs' because they are only attached to the vertebral column.
- The ribs are attached to and covered by internal and external intercostals muscles.
- The diaphragm at the floor of thoracic cavity consists of a muscLe sheet at the periphery and a central circular fibrous tissue.
- The muscles of the diaphragm are attached to the thorax wall.
- The lungs communicate with the outside atmosphere through the bronchi, trachea, mouth and nasal cavities.
- The trachea opens into the mouth cavity through the larynx.
- A flap of muscles, the epiglottis, covers the opening into the trachea during swallowing.
- This prevents entry of food into the trachea.
- Nasal cavities are connected to the atmosphere through the external nares(or nostrils)which are lined with hairs and mucus that trap dust particles and bacteria, preventing them from entering into the lungs.
- Nasal cavities are lined with cilia.
- The mucus traps dust particles,
- The cilia move the mucus up and out of the nasal cavities.
- The mucus moistens air as it enters the nostrils.
- Nasal cavities are winding and have many blood capillaries to increase surface area to ensure that the air is warmed as it passes along.
- Each lung is surrounded by a space called the pleural cavity.
- It allows for the changes in lung volume during breathing.
- An internal pleural membrane covers the outside of each lung while an external pleural membrane lines the thoracic wall.
- The pleural membranes secrete pleural fluid into the pleural cavity.
- This fluid prevents friction between the lungs and the thoracic wall during breathing.
- The trachea divides into two bronchi, each of which enters into each lung.
- Trachea and bronchi are lined with rings of cartilage that prevent them from collapsing when air pressure is low.
- Each bronchus divides into smaller tubes, the bronchioles.
- Each bronchiole subdivides repeatedly into smaller tubes ending with fine bronchioles.
- The fine bronchioles end in alveolar sacs, each of which gives rise to many alveoli.
- Epithelium lining the inside of the trachea, bronchi and bronchioles has cilia and secretes mucus.

Adaptations of Alveolus to Gaseous Exchange

- Each alveolus is surrounded by very many blood capillaries for efficient transport of respiratory gases.
- There are very many alveoli that greatly increases the surface area for gaseous exchange.
- The alveolus is thin walled for faster diffusion of respiratory gases.
- The epithelium is moist for gases to dissolve.

Gaseous Exchange Between the Alveoli and the Capillaries

- The walls of the alveoli and the capillaries are very thin and very close to each other.
- Blood from the tissues has a high concentration of carbon (IV) oxide and very little oxygen compared to alveolar air.
- The concentration gradient favours diffusion of carbon (IV) oxide into the alveolus and oxygen into the capillaries .
- No gaseous exchange takes place in the trachea and bronchi.
- These are referred to as dead space.

Ventilation

- Exchange of air between the lungs and the outside is made possible by changes in the volumes of the thoracic cavity.
- This volume is altered by the movement of the intercostal muscles and the diaphragm.

Inspiration

- The ribs are raised upwards and outwards by the contraction of the external intercostal muscles, accompanied by the relaxation of internal intercostal muscles.
- The diaphragm muscles contract and diaphragm moves downwards.
- The volume of thoracic cavity increases, thus reducing the pressure.
- Air rushes into the lungs from outside through the nostrils.

Expiration

- The internal intercostal muscles contract while external ones relax and the ribs move downwards and inwards.
- The diaphragm muscles relaxes and it is pushed upwards by the abdominal organs. It thus assumes a dome shape.
- The volume of the thoracic cavity decreases, thus increasing the pressure.
- Air is forced out of the lungs.
- As a result of gaseous exchange in the alveolus, expired air has different volumes of atmospheric gases as compared to inspired air.

Table 7.1: Comparison of Inspired and Expired Air (% by volume)

Component	*Inspired*	*Expired %*
Oxygen	21	16
Carbon	0.03	4
Nitrogen	79	79
Moisture	Variable	Saturated

Lung Capacity

- The amount of air that human lungs can hold is known as lung capacity.
- The lungs of an adult human are capable of holding 5,000 cm^3 of air when fully inflated.
- However, during normal breathing only about 500 cm^3 of air is exchanged.
- This is known as the tidal volume.
- A small amount of air always remains in the lungs even after a forced expiration.
- This is known as the residual volume.
- The volume of air inspired or expired during forced breathing is called vital capacity.

Control of Rate Of Breathing

- The rate of breathing is controlled by the respiratory centre in the medulla of the brain.
- This centre sends impulses to the diaphragm through the phrenic nerve.
- Impulses are also sent to the intercostal muscles.
- The respiratory centre responds to the amount of carbon (IV) oxide in the blood.
- If the amount of carbon (IV) oxide rises, the respiratory centre sends impulses to the diaphragm and the intercostal muscles which respond by contracting in order to increase the ventilation rate.
- Carbon (IV) oxide is therefore removed at a faster rate.

Factors Affecting Rate of Breathing in Humans

- Factors that cause a decrease or increase in energy demand directly affect rate of breathing.
- Exercise, any muscular activity like digging.
- Sickness
- Emotions like anger, flight
- Sleep.

Effects of Exercise on Rate of Breathing

- Students to work in pairs.
- One student stands still while the other counts (his/her) the number of breaths per minute.
- The student whose breath has been taken runs on the sport vigorously for 10 minutes.
- At the end of 10 minutes the number of breaths per minute is immediately counted and recorded.

- It is noticed that the rate of breathing is much higher after exercise than at rest.

Dissection of a Small Mammal (Rabbit) to Show Respiratory Organs

- The rabbit is placed in a bucket containing cotton wool which has been soakedin chloroform.
- The bucket is covered tightly with a lid.
- The dead rabbit is placed on the dissecting board ventral side upwards.
- Pin the rabbit to the dissecting board by the legs.
- Dissect the rabbit to expose the respiratory organs.
- Ensure that you note the following features.
- Ribs, intercostal muscles, diaphragm, lungs, bronchi, trachea, pleural membranes, thoracic cavity.

Diseases of the Respiratory System

Asthma

- Asthma is a chronic disease characterised by narrowing of air passages.

Causes:

Allergy

- Due to pollen, dust, fur, animal hair, spores among others.
- If these substances are inhaled, they trigger release of chemical substances and they may cause swelling of the bronchioles and bring about an asthma attack.

Heredity

- Asthma is usually associated with certain disorders which tend to occur in more than one member of a given family, thus suggesting' a hereditary tendency.

Emotional or mental stress

- Strains the body immune system hence predisposes to asthma attack.

Symptoms

- Asthma is characterized by wheezing and difficulty in breathing accompanied by feeling of tightness in the chest as a result of contraction of the smooth muscles lining the air passages.

Treatment and Control

- There is no definite cure for asthma.
- The best way where applicable is to avoid whatever triggers an attack (allergen).
- Treatment is usually by administering drugs called bronchodilators.
- The drugs are inhaled, taken orally or injected intravenously depending on severity of attack to relief bronchial spasms.

Bronchitis

- This is an inflammation of bronchial tubes.

Causes

- This is due to an infection of bronchi and bronchioles by bacteria and viruses.
- ***Symptoms***

- Difficulty in breathing.
- Cough that produces mucus.

- ***Treatment***
  - Antibiotics are administered.

Pulmonary Tuberculosis

- Tuberculosis is a contagious disease that results in destruction of the lung tissue.

Causes

- Tuberculosis is caused by the bacterium ***Mycobacterium tuberculosis.***
- Human tuberculosis is spread through droplet infection i.e., in saliva and sputum.
- Tuberculosis can also spread from cattle to man through contaminated milk.
- From a mother suffering from the disease to a baby through breast feeding.
- The disease is currently on the rise due to the lowered immunity in persons with HIV and AIDS (Human Immuno Deficiency Syndrome).
- Tuberculosis is common in areas where there is dirt, overcrowding and malnourishment.

Symptoms

- It is characterised by a dry cough, lack of breath and body wasting.

Prevention

- Proper nutrition with a diet rich in proteins and vitamins to boost immunity.
- Isolation of sick persons reduces its spread.
- Utensils used by the sick should be sterilised by boiling.
- Avoidance of crowded places and living in well ventilated houses.
- Immunisation with B.C.G. vaccine gives protection against tuberculosis.
- This is done a few days after birth with subsequent boosters.

Treatment

- Treatment is by use of antibiotics.

Pneumonia

- Pneumonia is infection resulting in inflammation of lungs.
- The alveoli get filled with fluid and bacterial cells decreasing surface are for gaseous exchange.
- Pneumonia is caused by bacteria and virus.
- More infections occur during cold weather.
- The old and the weak in health are most vulnerable.

Symptoms

- Pain in the chest accompanied by a fever, high body temperatures (39-40°C) and general body weakness.

Prevention

- Maintain good health through proper feeding.
- Avoid extreme cold.

Treatment

- If the condition is caused by pneumococcus bacteria, antibiotics are administered.
- If breathing is difficult, oxygen may be given using an oxygen mask.

Whooping Cough

- Whooping cough is an acute infection of respiratory tract.
- The disease is more common in children under the age of five but adults may also be affected.

Causes

- It is caused by ***Bordetella pertusis***bacteria and is usually spread by droplets produced when a sick person coughs.

Symptoms:

- Severe coughing and frequent vomiting.
- Thick sticky mucus is produced.
- Severe broncho-pneumonia.
- Convulsions in some cases.

Prevention

- Children may be immunised against whooping cough by means of a vaccine which is usually combined with those against diphtheria and tetanus.
- It is called "Triple Vaccine" or ***Diptheria, Pertusis***and ***Tetanus*** **(**DPT).

Treatment

- Antibiotics are administered.
- To reduce the coughing, the patient should be given drugs.

END OF CHAPTER NOTES

Practical Activities

Observation of permanent slides of terrestrial and aquatic leaves and stems

Leaves

- Observation of T.S. of bean and water lily are made under low and 'medium power objectives. Stomata and air space are seen.
- Labelled drawings of each are made.
- The number and distribution of stomata on the lower and upper leaf surface is noted.
- Also the size of air spaces and their distribution.

Stem

- Prepared slides (TS) of stems of terrestrial and aquatic plants such as croton and reeds are obtained.
- Observations under low power and medium power of a microscope are made.
- Labelled drawings are made and the following are noted:
  - Lenticels on terrestrial stems.
  - Large air spaces (aerenchyma) in aquatic stems.

END OF CHAPTER NOTES

Excretion and Homeostasis

Introduction

- ***Excretion***is the process by which living organisms separate and eliminate waste products of metabolism from body cells.
- If these substances were left to accumulate, they would be toxic to the cells.
- ***Egestion*** is the removal of undigested materials from the alimentary canals of animals.
- ***Secretion*** is the production and release of certain useful substances such as hormones, sebum and mucus produced by glandular cells.
- ***Homeostasis*** is a self-adjusting mechanism to maintain a steady state in the internal environment

Excretion in Plants

- Plants have little accumulation of toxic waste especially nitrogenous wastes.
- This is because they synthesise proteins according to their requirements.
- In carbohydrate metabolism plants use carbon *(IV)* oxide released from respiration in photosynthesis while oxygen released from photosynthesis is used in respiration.
- Gases are removed from the plant by diffusion through stomata and lenticels.
- Certain organic products are stored in plant organs such as leaves, flowers, fruits and bark and are removed when these organs are shed.
- The products include tannins, resins, latex and oxalic acid crystals.
- Some of these substances are used illegally.
- Khat, cocaine and cannabis are used without a doctor's prescription and can be addictive.
- Use of these substances should be avoided.

Plant Excretory Products their source and uses

Plant	*Source*	*Use*
Caffeine	Tea and coffee	Mild CNS stimulant.

Quinine	Cinchona tree	Anti malaria-drug.
Tannins	Barks of Acacia, Wattle trees	Tanning hides and skins.
Colchicine	Corms of crocus	Prevents spindle formation in cell division.
Cocaine	Leaves of coca plant	Local anaesthesia.
Rubber	Latex of rubber plant	Used in shoe industry.
Gum	Exudate from acacia	Used in food processing and printing industry.
Cannabis	Flowers, fruits and leaves of *cannabis sativa*	Used in manufacture of drugs.
Nicotine	Leaves of tobacco plant	Manufacture of insecticides. Heart and CNS stimulant.
Papain	Pawpaw (fruits)	Meat tenderiser Treats indigestion.
Khat	*Khatha edulis* (miraa)	Mild stimulant.
Morphine	Opium Poppy plant	Narcotic. Induces sleep / hallucinations.
Strychnine	Seeds of strychnos	CNS stimulant.

Excretory products in animals

Substance	***Origin***
1. Nitrogenous compounds:	Excess amino acids
(i) Ammonia	Deamination of amino acids.
(ii) Urea	Deamination of amino acids; then addition of carbon dioxide.
(iii) Uric acid	Ammonia (from deamination of amino acids).
2. Carbon dioxide	Homeostasis and respiration.
3. Biliverdin and bilirubin	Breakdown of haemoglobin.
4. Water	Osmoregulation.
5. Cholesterol	Excess intake of fats.
6. Hormones	Excess production

Excretion and Homeostasis in Unicellular Organisms

- Protozoa such as amoeba depend on diffusion as a means of excretion.
- They have a large surface area to volume ratio for efficient diffusion.
- Nitrogenous waste and carbon (IV) oxide are highly concentrated in the organism hence they diffuse out.
- In amoeba excess water and chemicals accumulation in the contractile vacuole.
- When it reaches maximum size the contractile vacuole moves to the cell membrane, bursts open releasing its contents to the surroundings.

Excretion in Human Beings

- Excretion in humans is carried out by an elaborate system of specialised organs.
- Their bodies are complex, so simple diffusion cannot suffice.
- Excretory products include nitrogenous wastes which originate from deamination of excess amino acids.

- The main excretory organs in mammals such as human beings include lungs, kidneys, skin and liver.

Structure and function of the human skin

Nerve Endings:

- These are nerve cells which detect changes from the external environment thus making the body to be sensitive to touch, cold, heat and pressure.

Subcutaneous Fat:

- Is a layer beneath the dermis.
- It stores fat and acts as an insulator against heat loss.
- The skin helps in elimination of urea, lactic acid and sodium chloride which are released in sweat.

The Lungs

- Carbon (IV) oxide formed during tissue respiration is removed from the body by the lungs.
- Mammalian lungs have many alveoli which are the sites of gaseous exchange.
- Alveoli are richly supplied with blood and have a thin epithelium.
- Blood capillaries around the alveoli have a high concentration of carbon (Iv) oxide than the alveoli lumen.
- The concentration gradient created causes carbon (IV) oxide to diffuse into the alveoli lumen.
- The carbon (IV) oxide is eliminated through expiration.

Structure and Functions of the Kidneys

- The kidneys are organs whose functions are excretion, osmoregulation and regulation of pH.
- Kidneys are located at the back of the abdominal cavity.
- Each kidney receives oxygenated blood from renal artery,
- while deoxygenated blood leaves through the renal vein.
- Urine is carried by the ureter from the kidney to the bladder, which temporarily stores it.
- From the bladder, the urine is released to the outside via the urethra.

- The opening from the urethra is controlled by a ring-like sphincter muscle.
- A longitudinal section of the kidney shows three distinct regions: a darker outer cortex, a lighter inner medulla and the pelvis.
- The pelvis is a collecting space leading to the ureter which takes the urine to the bladder from where it is eliminated through the urethra.

The Nephron

- A nephron is a coiled tubule at one end of which is a cup-shaped structure called the Bowman's capsule.
- The capsule encloses a bunch of capillaries called the glomerulus.
- The glomerulus receives blood from an afferent arteriole a branch of the renal artery.
- Blood is taken away from the glomerulus by efferent arteriole leading to the renal vein.
- The Bowman's capsule leads to the proximal convoluted tubule that is coiled and extends into a U-shaped part called loop of Henle.
- From the loop of Henle is the distal convoluted tubule that is also coiled.
- This leads to the collecting duct which receives contents of many nephrons.
- Collecting ducts lead to the pelvis of the kidney.

Mechanism of Excretion

- Excretion takes place in three steps:
- Filtration, reabsorption and removal.

Filtration

- The kidneys receive blood from renal artery a branch of the aorta.
- This blood is rich in nitrogenous waste e.g. urea.
- It contains dissolved food substances, plasma proteins,hormones and oxygen.
- Blood flow in capillaries is under pressure due to the narrowness of the capillaries.
- The afferent arteriole entering the glomerulus is wider than the efferent arteriole leaving it.
- This creates pressure in the glomerulus.
- Due to this pressure, dissolved substances such as urea, uric acid, glucose, mineral salts and amino acids are forced out of the glomerulus into the Bowman's capsule.
- Large sized molecules in the plasma such as proteins and red blood cells are not filtered out because they are too large.
- This process of filtration is called ***ultra-filtration or pressure filtration*** and the filtrate is called ***glomerular filtrate.***

Selective Reabsorption

- As the filtrate flows through the renal tubules the useful substances are selectively reabsorbed back into the blood.
- In theproximal convoluted tube all the glucose, all amino acids and some mineral salts are actively reabsorbed by active transport.
- The cells lining this tubule have numerous mitochondria which provide the energy needed.
- Cells of the tubule have microvilli which increases the surface area for re-absorption.
- The tubule is coiled, which reduces the speed of flow of the filtrate e.g. giving more time for efficient re-absorption.
- The tubule is well supplied with blood capillaries for transportation of reabsorbed substances.
- The ascending loop has thick wall and is impermeable to water.
- Sodium is actively pumped out of it towards the descending loop.
- As glomerular filtrate moves down the descending loop, water is reabsorbed into the blood by osmosis in the distal convoluted tubule and in the collecting duct.
- Permeability of the collecting duct and proximal convoluted tubule is increased by anti-diuretic hormone (ADH) whose secretion is influenced by the osmotic pressure of the blood.
- The remaining fluid consisting of water, urea, uric acid and some mineral salts is called urine.
- The urine is discharged into the collecting d ct and carried to the pelvis.
- The loop of Henle is short in semi-aquatic mammals, and long in some mammals like the desert rat.

Removal

- The urine is conveyed from the pelvis to the ureter.
- The ureter carries the urine to the bladder where it is stored temporarily and discharged to the outside through the urethra at intervals.

Common Kidney Diseases

Uraemia

- This is a condition in which concentration of urea in the blood.
- It may be due to formation of cysts in tubules or reduction in blood supply to the glomeruli as a result of contraction of renal artery.

Symptoms

- Symptoms include yellow colouration of skin, smell of urine in breath, nausea and vomiting.
- Treatment includes dialysis to remove excess urea and a diet low in proteins and salts especially sodium and potassium.

Kidney Stones

- Kidney stones are solid deposits of calcium and other salts.
- They are usually formed in the pelvis of the kidney where they may obstruct the flow of urine.

- ***Causes***: the stones are formed due to crystallisation of salts around pus, blood or dead tissue.
- ***Symptoms:*** include blood in urine, frequent urination, pain, chills and fever. Severe pain when urinating.

Treatment

- Use of laser beams to disintegrate the stones.
- Pain killing drugs like morphine.
- Stones can be removed by surgery.
- Taking hot baths and massage.

Nephritis

- Nephritis is the inflation of glomerulus of the kidney.
- ***Causes:*** Bacterial infection, sore throat or tonsillitis, blockage of glomeruli by antibody-antigen complex.
- ***Signs and Symptoms***: include headaches, fever, vomiting, oedema.
- ***Control*** includes dietary restrictions especially salt and proteins.
- Prompt treatment of bacterial infections.

Role of Liver in Excretion

- The liver lies below the diaphragm and it receives blood from hepatic artery and hepatic portal vein.
- Blood flows out of the liver through hepatic vein.
- Excretion of Nitrogenous Wastes
- Excess amino acids cannot be stored in the body, they are deaminated in the liver.
- Hydrogen is added to amino group to form ammonia which combines with carbon (IV) oxide to form urea.
- The urea is carried in the blood stream to the kidneys.
- The remaining carboxyl group, after removal of amino group, is either oxidised to provide energy in respiration.
- or built up into carbohydrate reserve and stored as glycogen or converted into fat and stored.

Breakdown and Elimination of Haemoglobin

- Haemoglobin is released from dead or old red blood cells which are broken down in the liver and spleen.
- Haemoglobin is broken down in the liver and a green pigment biliverdin results which is converted to yellow bilirubin.
- This is taken to the gall bladder and eliminated as bile.

Elimination of Sex Hormones

- Once they have completed their functions, sex hormones are chemically altered by the liver and then taken to the kidney for excretion.

Common Liver Diseases

Cirrhosis

- Cirrhosis is a condition in which liver cells degenerate and are replaced by scar tissue .
- This causes the liver to shrink, harden, become fibrous and fail to carry out its functions.

Causes

- Chronic alcohol abuse, schistosomiasis infection, obstruction of gall-bladder.

Symptoms

- Headache, nausea, vomiting of blood and lack of appetite, weight loss, indigestion and jaundice.

Control and Treatment

- Avoid alcohol consumption and fatty diet.
- Use drugs to kill the schistosomes if that is the cause.

Jaundice

- This is a yellow colouration of the skin and eyes.

Cause:

- Presence of excess bile pigments.
- This happens due to blockage of bile duct or destruction of liver.

Symptoms:

- Yellow pigmentation of skin and eyes, nausea, vomiting and lack of appetite. Itching of skin.

Treatment

- Removal of stones from the gall bladder by surgery.
- Give patient fat-free diet, reduced amount of proteins.
- Give antihistamines to reduce itching.

Homeostasis

- Homeostasis is the maintenance of a constant internal environment.
- The internal environment consists of intercellular or tissue fluid.
- This fluid is the medium in the space surrounding cells.
- Tissue fluid is made by ultra-filtration in the capillaries.

- Dissolved substances in the blood are forced out of the capillaries and into intercellular spaces.
- Cells obtain their requirements from tissue fluid while waste products from cells diffuse out into the tissue fluid.
- Some of the fluid gets back into the blood capillaries while excess fluid is drained into the lymph vessels.
- Cells function efficiently if there is little or no fluctuation in the internal environment.
- The factors that need to be regulated include temperature, osmotic pressure and pH.
- The body works as a self-regulating system and can detect changes in its working conditions bringing about corrective responses.
- This requires a negative feedback mechanism e.g. when body temperature falls below normal, mechanisms are set in place that bring about increase in temperature.
- And when the increase is above normal, mechanisms that lower the temperature are set in place.
- This is called a negative feedback and it restores the conditions to normal.

Neuro-Endocrine System and Homeostasis

- Homeostatic mechanisms are brought about by an interaction between nervous and endocrine systems.
- Nerve endings detect changes in the internal and external environment and relay the information to the brain.
- The hypothalamus and pituitary are endocrine glands situated in the brain.
- The hypothalamus detect changes in the blood.
- The pituitary secretes a number of hormones involved in homeostasis e.g. anti-duretic hormone (ADH).
- The discussion below shows the nature of these interactions.

The Skin and Temperature Regulation

- The optimum human body temperature is 36.8°C.
- A constant body temperature favours efficient enzyme reaction.
- Temperatures above optimum denature enzymes, while temperature below the optimum range inactivate enzymes.
- The skin is involved in regulation of body temperature as follows:
- The skin has receptors that detect changes in the temperature of the external environment.

When the body temperature is above optimum the following takes place:

Sweat:

- Sweat glands secrete sweat onto the skin surface.
- As sweat evaporates it takes latent heat from the body, thus lowering the temperature.

Vasodilation of Arterioles:

- The arterioles near the surface become wider in diameter.
- More blood flows near the surface and more heat is lost to the surrounding by convection and radiation.

Relaxation of hair erector muscle:

- When hair erector muscles relax, the hair lies flat thus allowing heat to escape from the skin surface.

When body temperature is below optimum the following takes place:

Vasoconstriction of Arterioles:

- The arterioles near the surface of the skin become narrower.
- Blood supply to the skin is reduced and less heat is lost to the surroundings.

Contraction of hair erector muscles.

- When hair erector muscles contract, the hair is raised.
- Air is trapped between the hairs forming an insulating layer.
- Animals in cold areas have a ***thick layer of subcutaneous fat***, which helps to insulate the body.
- Besides the role of the skin in thermoregulation as discussed above, the rate of metabolism is lowered when temperature is above optimum and increased when temperature is below optimum.
- The latter increases the temperature to the optimum.
- When this fails, shivering occurs.
- Shivering is involuntary contraction of muscles which helps to generate heat thus raising the body temperature.

Homeostatic Control of Body Temperature in Humans

Body size and Heat Loss

- The amount of heat produced by metabolic reactions in an animal body is proportional to its mass.
- Large animals produce more heat but they lose less due to small surface area to volume ratio.

- Small animals produce less heat and lose a lot, due to large surface area to volume ratio.
- Small animals eat a lot of food in relation .to their size in order to raise their metabolic rate.

Behavioural and Physiological Responses to Temperature Changes

- Animals gain or lose heat to the environment by conduction, radiation and convection.
- Birds and mammals maintain a constant body temperature regardless of the changes in the environment.
- They do this mainly by internally installed physiological mechanisms hence they are **endotherms,** also known as **homoiotherms.**
- At the same time behavioural activities like moving to shaded areas when it is too hot assist in regulating their body temperature.
- Other animals do not maintain a constant body temperature e.g. lizards.
- They are **poikilotherms (ectotherms)** as their temperature varies according to that of surroundings.
- They only regulate body temperature through behavioural means.
- Lizards bask on the rocks to gain heat and hide under rocks when it is too hot.
- Some animals have adaptive features e.g. animals in extreme cold climates have fur and a thick layer of subcutaneous fat like polar bear.
- Those in extremely hot areas have tissue that tolerate high temperatures e.g. camels.
- Some animals avoid cold conditions by **hibernating** e.g. the frog while others avoid dry hot conditions by **aestivation** e.g. kangaroo rat.
- This involves decreasing their metabolic activities.

Skin and Osmoregulation

- Osmoregulation is the control of salt and water balance in the body to maintain the appropriate osmotic pressure for proper cell functioning.
- Sweat glands produce sweat and thus eliminate water and salt from the body.

The Kidney and Osmoregulation

- The kidney is the main organ that regulates the salt and water balance in the body.
- The amount of salt or water reabsorbed into the bloodstream is dependent on the osmotic pressure of the blood.
- When the osmotic pressure of the blood rises above normal due to dehydration or excessive consumption of salt, the osmo-receptors in the hypothalamus are stimulated.
- These cells relay impulses to the pituitary gland which produces a hormone called **anti-diuretic hormone** - ADH (vasopressin) which is taken by the blood to the kidneys.
- The hormone (ADH) makes the distal convoluted tubule and collecting duct more permeable to water hence more water is reabsorbed into the body by the kidney tubules lowering the osmotic pressure in the blood.

- When the osmotic pressure of the blood falls below normal due to intake of a large quantity of water, osmoreceptors in the hypothalamus are less stimulated.
- Less antidiuretic hormone is produced, and the kidney tubules reabsorb less water hence large quantities of water is lost producing dilute urine (diuressis).
- The osmotic pressure of the blood is raised to normal.
- If little or no ADH is produced, the body may become dehydrated unless large quantities of water are consumed regularly.
- **Diabetes insipidus** is a disease that results from the failure of the pituitary gland to produce ADH and the body gets dehydrated.
- A hormone called **Aldosterone** produced by the adrenal cortex regulates the level of sodium ions.
- When the level of sodium ions in the blood is low, adrenal cortex releases aldosterone into the blood.
- This stimulates the loop of Henle to reabsorb sodium ions into the blood.
- Chloride ions flow to neutralise the charge on sodium ions.
- Aldosterone also stimulates the colon to absorb more sodium ions into the blood.
    - If the sodium ion concentration rises above optimum level, adrenal cortex

Notes missing

The liver

- Formation of Red Blood Cells.
- In the embryo, red blood cells are formed in the liver.
- Breakdown and elimination of old and dead blood cells.
- Dead red blood cells are broken down in the liver and the pigments eliminated in bile.
- Manufacture of Plasma Proteins.
- Plasma proteins like albumen, fibrinogen and globulin are manufactured in the liver.
- Storage of blood, vitamins A, K, BI2 and D and mineral salts such as iron' and potassium ions.
- Detoxification. Toxic substances ingested e.g. drugs or produced from metabolic reactions in the body are converted to harmless substances in a process called detoxification.