UNIT-I

2 MARKS:

1. Define cell component? (May 2014)

The cell structure comprises individual components with specific functions essential to carry out life's processes. These components include- cell wall, cell membrane, cytoplasm, nucleus, and cell organelles like Nucleolus, Nuclear membrane, Chromosomes, Endoplasmic reticulum, Golgi Bodies, Ribosome, Mitochondria, Lysosomes, Chloroplast, Vacuoles.

2. List the types of blood groups. (May 2014)

There are 4 main blood groups (types of blood) – A, B, AB and O.

- Blood group A – has A antigens on the red blood cells with anti-B antibodies in the plasma
- Blood group B – has B antigens with anti-A antibodies in the plasma
- Blood group O – has no antigens, but both anti-A and anti-B antibodies in the plasma
- Blood group AB – has both A and B antigens, but no antibodies

3. Define action potential? (Dec 2014, Dec 2015, Dec 2017)

An action potential is a rapid rise and subsequent fall in voltage or membrane potential across a cellular membrane with a characteristic pattern. Sufficient current is required to initiate a voltage response in a cell membrane; if the current is insufficient to depolarize the membrane to the threshold level, an action potential will not fire. Examples of cells that signal via action potentials are neurons and muscle cells.

4. What is electrolyte balance? (Dec 2014)

The critical balance between the concentration in the cells and that in the tissue fluid surrounding the cells of the various inorganic ions. The electrolytes mainly in the cells are potassium, magnesium, sulphate and phosphate. Those in the surrounding fluid are mainly sodium, chloride and bicarbonate. This balance is essential to life and is maintained by the active pumping action of the cell membranes.

5. What is Rh factor? (May 2015, May 2016, Nov 2016, May 2018)

Rh factor, also called Rhesus factor, is a type of protein found on the outside of red blood cells. The protein is genetically inherited (passed down from your parents). If you have the protein, you are Rh-positive. If you did not inherit the protein, you are Rh-negative. The majority of people, about 85%, are Rh-positive.

6. Differentiate active transport from passive transport? (May 2015)

Active transport moves molecules and ions from lower concentration to higher concentration with the help of energy in the form of ATP. On the other hand, passive transport moves molecules and ions from a higher concentration to lower concentration without any energy.

7. Define erythropoiesis? (Dec 2015)

It is the formation of red blood cells in blood-forming tissue. In the early development of a fetus, erythropoiesis takes place in the yolk sac, spleen, and liver. After birth, all erythropoiesis occurs in the bone marrow.

8. What are cytosolic receptors? (May 2016)

Cytosolic receptors include the binding sites for steroid hormones, thyroid hormones, vitamin D, and retinoic acids. Historically, these sites were believed to be located only in the cytosol, with ligand binding causing translocation to the cell nucleus and alteration in gene transcription (genomic action) (Figure 4). The responses to activation of these sites typically requires hours to days since the response depends upon a change in protein synthesis.

9. Define depolarization? (Dec 2016)

Depolarization is a process by which cells undergo a change in membrane potential. It is a process of shift in electric charge that results in less negative charge inside the cell.

10. What are Bombay type antibodies? (May 2017)

The Bombay Blood group is a rare blood group, phenotypes of this group lacking H antigen on the red cell membrane and have anti-H in the serum. It fails to express any A, B or H antigen on their red cells or other tissues. In simpler terms, it is quite an abstract type of blood group. In this blood group, no “A” or “B” antigens are identified on red blood cells or in secretions. By definition, that would fit the type “O” blood type. In Bombay phenotype, there is a void of A antigen, B Antigen as well as H antigen. This is how Bombay Blood is identified.

11. What is auto immune disease? Give example. (Dec 2017)

An autoimmune disease is a condition in which your immune system mistakenly attacks your body. It releases proteins called autoantibodies that attack healthy cells. Some autoimmune diseases target only one organ. Type 1 diabetes damages the pancreas. Other diseases, like systemic lupus erythematosus (SLE), affect the whole body. Eg: Type 1 diabetes, Rheumatoid arthritis (RA), Psoriasis/ psoriatic arthritis, Multiple sclerosis.

12. State the reasons for negative potential inside the cell. (Dec 2018)

At rest, potassium ions (K+) can cross through the membrane easily, chloride ions (Cl-) and sodium ions (Na+) have a more difficult time crossing. The negatively charged protein molecules (A-) inside the neuron cannot cross the membrane. In addition, to these selective ion channels, there is a pump that uses energy to move three sodium ions out of the neuron for every two potassium ions it puts in. Finally, when all these forces balance out, and the difference in the voltage between the inside and outside of the neuron is measured, you have the resting potential. The resting membrane potential of a neuron is about -70 mV (mV=millivolt) - this means that the inside of the neuron is 70 mV less than the outside. At rest, there are relatively more sodium ions outside the neuron and more potassium ions inside that neuron.

13. What is rough ER? (May 2019)

It is the series of connected flattened sacs, part of continuous membrane organelle with in cytoplasm of eukaryotic cells, that plays a central role in the synthesis of proteins. The rough endoplasmic reticulum (RER) is so named for the appearance of its outer surface, which is studded with protein-synthesizing particles known as ribosomes.

14. What are granulocytes? (May 2019)

Granulocytes are a category of white blood cells in the innate immune system characterized by the presence of specific granules in their cytoplasm. They are also called polymorphonuclear leukocytes (PMN, PML, or PMNL) because of the varying shape of the nucleus, which is usually lobed into three segments. This distinguishes them from the mononuclear agranulocytes. The term polymorphonuclear leukocyte often refers specifically to "neutrophil granulocytes", the most abundant of the granulocytes; the other types (eosinophils, basophils, and mast cells) have lower numbers of lobes. Granulocytes are produced via granulopoiesis in the bone marrow.

15. Write a note on estimation of RBC? (Dec 2019)

The red blood cell specimen is diluted(usually 200 times) with red cell diluting fluid which does not remove the WBC but allows the red cells to be counted under magnification in a known volume of fluid. Finally, the no. of cells is undiluted blood is calculated and reported as the no. of red cells/µl of whole blood. Blood cell counts can be performed using the hemacytometer.

16. a. Write note on specific and non specific immunity. (Dec 2019)

b. Difference between specific and non specific immunity. (May 2017)

Specific immunity:

- Response is antigen-independent
- There is immediate maximal response
- Not antigen-specific
- Exposure results in no immunologic memory

Non specific immunity

- Response is antigen-dependent
- There is a lag time between exposure and maximal response
- Antigen-specific
- Exposure results in immunologic memory

17. a. Write a note on innate and adaptive immunity? (May 2018)

b. Difference between Innate (Natural) and Adaptive Immunity. (Dec 2018)

Innate Immunity

- Innate immunity is something already present in the body.
- Fights any foreign invader
- Response is Rapid
- Once activated against a specific type of antigen, the immunity remains throughout the life.
- Innate type of immunity is generally inherited from parents and passed to offspring.
- Present at birth

Adaptive immunity

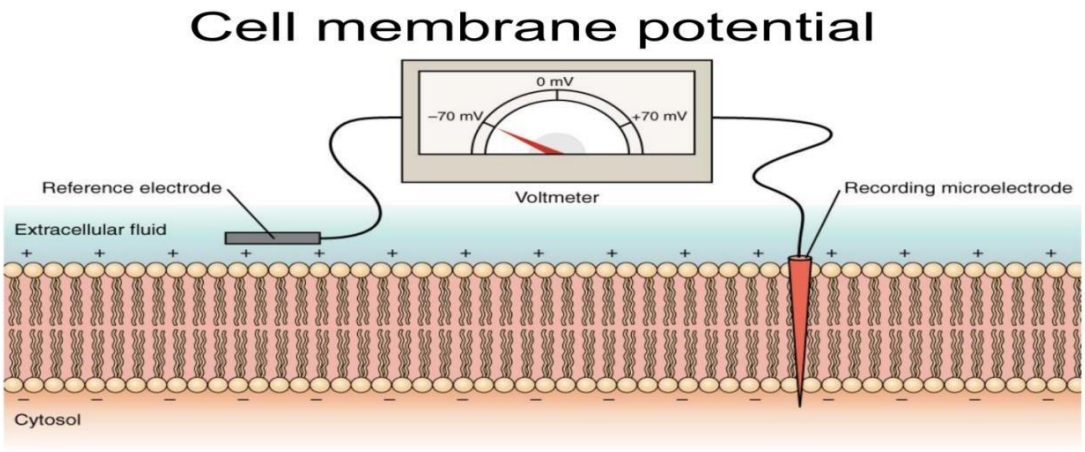
- Adaptive immunity is created in response to exposure to a foreign substance.
- Fight only specific infection
- Response is slow (1-2 weeks)
- The span of developed immunity can be lifelong or short.
- Adaptive immunity is not passed from the parents to offspring, hence it cannot be inherited.
- Develops during a person's lifetime and can be short-lived.

11 MARKS:

1. a. What is the ionic basis of origin of cell membrane potential? Explain. (May 2014)

b. Describe the mechanism of active transport of substances through cell membrane. (May 2015)

- In a resting cell, there is an excess of cation, that is positive charged ions, outside the cell membrane and excess of anion that is negative charged ions inside the cell. By connecting 2 electrodes to a galvanometer and by placing its free ends, one on external surface and another on internal surface, a potential difference will be recorded. This potential difference is called resting membrane potential (RMP) or membrane potential.
- In simple terms, RMP can be defined as potential difference across the resting cell membrane. Typical value of membrane potential ranges from -40mV to -70mV.



Where, ECF- Extra Cellular Fluid, ICF- Intra cellular Fluid

Selective permeability of cell membrane:

- The cell membrane is selectively permeable. The ions that accounts for RMP are:
  - Sodium ions (Na^+) in ECF
  - Potassium ions (K+) in ICF
  - Chlorine ions (Cl-) in ECF
  - Proteins (Pr-) in ICF

- Outside the cell, in ECF, there are plenty of Na+ ions matched by Cl- ions. The cell membrane is permeable to Cl- ions but impermeable to Na+ ions.
- Inside the cell, in ICF, there are plenty of K+ ions matched by Pr- ions. The cell membrane is impermeable to Pr- ions and permeable to K+ ions.

Membrane potential is a phenomenon of cell membrane surface:

- Due to concentration gradient, some K+ ions can migrate from ICF to ECF.
- ICF becomes negatively charged due to deficit of cations. ECF becomes electropositive.

Negatively charged ions of ICF are attracted towards the ECF due to:

- Positivity of external surface
- Chemical gradient

Cations in ECF are attracted towards ICF due to

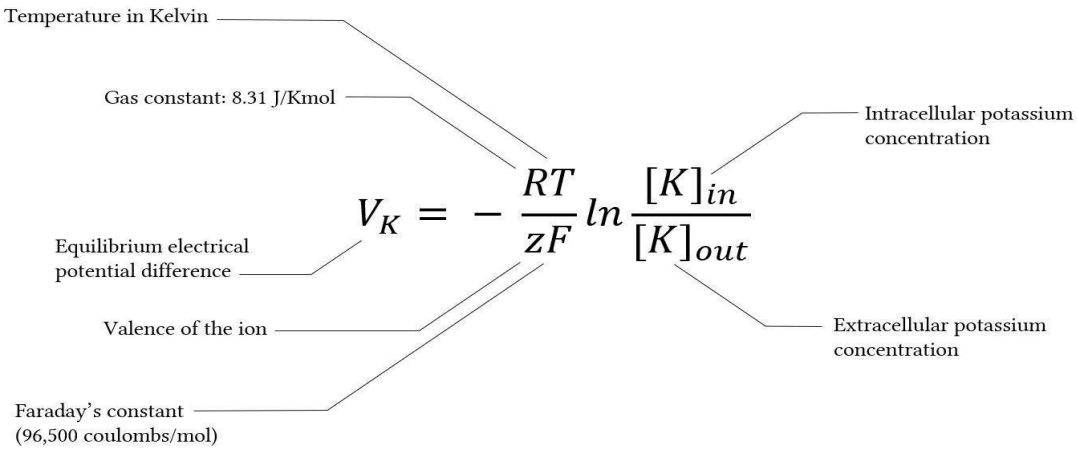
- Negativity of internal surface
- Chemical gradient

- Due to these factors, excess number of cations and anions are found on external and internal surface of cell respectively. Other than the surface of cell, everywhere else, Total no.of cations = Total no.of anions. This indicates that membrane potential is a phenomenon of cell membrane surface.

Sodium-Potassium pump: Na^+ -K^+ ATPase

- Na+ -K+ ATPase is an enzyme that is present in cell. When active, it pumps out 3 Na+ ions out of the cell. And in exchange, it draws in 2 K+ ions from ECF. It helps in maintaining electronegativity of the cell because it draws in only 2 K+ ions for an exchange of 3 Na+ ions.
- RMP is principally due to the difference of concentrations of K+ ions in ECF and ICF. ECF and ICF are separated by semipermeable membrane.
- Potential across the cell membrane is given by Nernst equation

Nernst Equation:



2. What is immune response? Explain in detail about humoral response? (May 2014, Nov 2019)

- Immune response is a bodily response to an antigen that occurs when lymphocytes identify the antigenic molecule as foreign and induce the formation of antibodies and lymphocytes capable of reacting with it and rendering it harmless. It is also called immune reaction.
- In other words, The way the body defends itself against substances it sees as harmful or foreign. In an immune response, the immune system recognizes the antigens (usually proteins) on the surface of substances or microorganisms, such as bacteria or viruses, and attacks and destroys, or tries to destroy, them.
- Cancer cells also have antigens on their surface. Sometimes, the immune system sees these antigens as foreign and mounts an immune response against them. This helps the body fight cancer.

Humoral Immune Responses:

The humoral immune response, also known as the antibody-mediated immune response, targets pathogens circulating in "humors," or extracellular fluids, such as blood and lymph. Antibodies target invading pathogens for destruction via multiple defense mechanisms, including neutralization, opsonization, and activation of the complement system. Patients that are impaired in the production of antibodies suffer from severe and frequent infections by common pathogens and unusual pathogens.

B Cells Are Produced by the Bone Marrow and Circulate through Body Fluids

B lymphocytes, also called B cells, detect pathogens in the blood or lymph system. Although B cells originate in the bone marrow, their name is derived from a specialized organ in birds in which B cells were first discovered, the bursa of Fabricius. After release from the bone marrow, B cells mature in secondary lymphoid tissues, such as the spleen, lymph nodes, tonsils and mucosa-associated lymphoid tissue throughout the body.

B Cells Differentiate into Antibody Releasing Plasma Cells and Memory B Cells

B cells bind to specific parts of a pathogen, called antigens, via their B cell receptors. In addition to antigen binding, B cells require a second signal for activation. This signal can be provided by helper T cells or, in some cases, by the antigen itself. When both stimuli are present, B cells form germinal centers, where they proliferate into plasma cells and memory B cells.

All cells that are derived from a common ancestral B cell (monoclonal) respond to the same antigen. Each plasma cell secretes genetically identical antibodies that circulate in the bloodstream. Memory B cells produce antibodies that are bound to the cell's surface and are highly specific against the antigen that initially led to the production of the memory B cell. Memory B cells are long-lived and enable the organism to react much faster and stronger upon secondary exposure to the same pathogen.

Antibodies Kill Pathogens in Diverse Ways

Antibodies bind to antigens that they encounter in body fluids. The resulting antibody-antigen complex activates three major defense mechanisms: neutralization, opsonization and the complement system.

- ***Neutralization:*** Antibodies "neutralize" a pathogen by interfering with its ability to infect host cells. For example, when an antibody binds to the surface of a virus, it may impair the ability of the virus to attach to or gain entry into target cells, effectively inhibiting the infection.

❖ ***Opsonization:*** Antibodies function as opsonins, which "tag" pathogens for destruction. Specifically, the formation of the antigen-antibody complex attracts and stimulates phagocytic cells that engulf and destroy the pathogen.

❖ ***Complement:*** Antibodies can activate the complement system, which plays a role in both innate and adaptive immunity. The complement system is a sequential cascade of more than 30 proteins. With the help of antibodies, these proteins opsonize pathogens for destruction by macrophages and neutrophils, induce an inflammatory response with the recruitment of additional immune cells, and promote lysis (destruction) of the pathogen.

Disruption of the Humoral Immune System Is Life-Threatening

Humans suffering from humoral immune system disorders are often identified early in life, when the number of antibodies that the infant received from its mother (i.e., passive immunity) decreases. Given the complexity of the humoral immune system, the causes for its malfunction are manifold. However, nearly 80% of patients with a primary immunodeficiency disease involve an antibody disorder. For example, hypogammaglobulinemia is the deficiency, or low number, of all classes of antibodies. Patients have more frequent ear, sinus, and pulmonary infections and suffer from gastrointestinal problems, such as diarrhea, malabsorption, and symptoms of irritable bowel syndrome. In general, the frequency and severity of patient infections increase with age. Infections by unusual pathogens tend to be severe, and infections by common pathogens are often both serious and recurrent.

3. a. With a neat diagram, describe the structure and functions of cell. (Nov 2014, May 2017, May 2018, May 2019)

b. Explain in detail about different models of plasma membrane structure with schematic diagram. (Nov 2019)

➢ The cell is the basic functional in a human meaning that it is a self-contained and fully operational living entity. 0Humans are multicellular organisms with various different types of cells that work together to sustain life.

➢ Other non-cellular components in the body include water, macronutrients (carbohydrates, proteins, lipids), micronutrients (vitamins, minerals) and electrolytes. A collection of cells that function together to perform the same activity is known as tissue.

➢ Masses of tissue work collectively to form an organ that performs specific functions in the body. Despite this structural organization, all activity boils down to the cell – a complex unit that makes life possible.

Parts of the Human Cell

The cell contains various structural components to allow it to maintain life which are known as organelles. All the organelles are suspended within a gelatinous matrix, the cytoplasm, which is contained within the cell membrane. One of the few cells in the human body that lacks almost all organelles are the red blood cells.

The main organelles are as follows:

- Cell Membrane
- Endoplasmic Reticulum
- Golgi Apparatus
- Lysosomes
- Mitochondria
- Nucleus
- Perioxisomes
- Microfilaments And Microtubules

Cell Membrane

- The cell membrane is the outer coating of the cell and contains the cytoplasm, substances within it and the organelle. It is a double-layered membrane composed of proteins and lipids. The lipid molecules on the outer and inner part (lipid bilayer) allow it to selectively transport substances in and out of the cell.

Golgi apparatus

- The Golgi apparatus is a stacked collection of flat vesicles. It is closely associated with the endoplasmic reticulum in that substances produced in the ER are transported as vesicles and fuses with the Golgi apparatus. In this way, the products from the ER are stored in the Golgi apparatus and converted into different substances that are necessary for the cell's various functions.

Lysosomes

- Lysosomes are vesicles that break off from the Golgi apparatus. It varies in size and function depending on the type of cell. Lysosomes contain enzymes that help with the digestion of nutrients in the cell and break down any cellular debris or invading microorganisms like bacteria. A structure that is similar to a lysosome is the secretory vesicle. It contains enzymes that are not used within the cell but emptied outside of the cell, for example the secretory vesicles of the pancreatic acinar cell release digestive enzymes which help with the digestion of nutrients in the gut.

Endoplasmic Reticulum

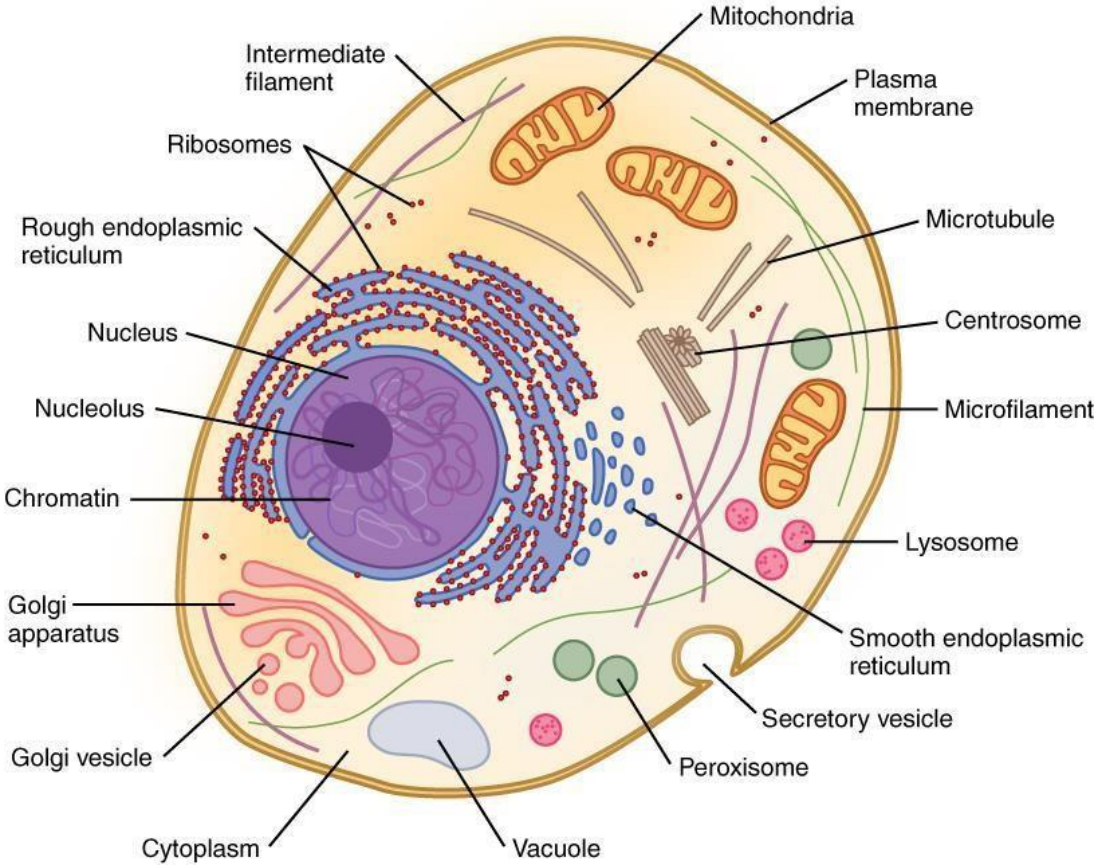
- The endoplasmic reticulum (ER) is a membranous structure that contains a network of tubules and vesicles. Its structure is such that substances can move through it and be kept in isolation from the rest of the cell until the manufacturing processes conducted within are completed. There are two types of endoplasmic reticulum – rough (granular) and smooth (agranular).
- The rough endoplasmic reticulum (RER / granular ER) contains a combination of proteins and enzymes. These parts of the endoplasmic reticulum contain a number of ribosomes giving it a rough appearance. Its function is to synthesize new proteins.
- The smooth endoplasmic reticulum (SER / agranular ER) does not have any attached ribosomes. Its function is to synthesize different types of lipids (fats). The smooth ER also plays a role in carbohydrate and drug metabolism.

Perioxisomes

- These organelles are very similar to the lysosomes and contain enzymes that act together in the form of hydrogen peroxide to neutralize substances that may be toxic to the cell. Perioxisomes are formed directly from the endoplasmic reticulum rather than from the Golgi apparatus like lysosomes.

Mitochondria

- These are the powerhouses of the cell and break down nutrients to yield energy. Apart from producing its own energy, it also produces a high-energy compound called ATP (adenosine triphosphate) which can be used as a simple energy source elsewhere.



- Mitochondria are composed of two membranous layers – an outer membrane that surrounds the structure and an inner membrane that provides the physical sites of energy production. The inner membrane has many infoldings that form shelves where enzymes attach and oxidize nutrients. The mitochondria also contain DNA which allows it to replicate where and when necessary.

Nucleus

- The nucleus is the master control of the cell. It contains genes, collections of DNA, which determines every aspect of human anatomy and physiology. The DNA which is arranged into chromosomes also contains the blueprint specific for each type of cell which

allows for replication of the cell. Within the nucleus is an area known as the nucleolus. It is not enclosed by a membrane but is just an accumulation of RNA and proteins within the nucleus. The nucleolus is the site where the ribosomal RNA is transcribed from DNA and assembled.

Microfilaments and Microtubules

- Microfilaments and microtubules are rigid protein substances that form the internal skeleton of the cell known as the cytoskeleton. Some of these microtubules also make up the centrioles and mitotic 4 spindles within the cell which are responsible for the division of the cytoplasm when the cell divides. The microtubules are the central component of cilia, small hair-like projections that protrude from the surface of certain cells. It is also the central component of specialized cilia like the tail of the sperm cells which beats in a manner to allow the cell to move in a fluid medium.

Functions of the Human Cell

3 major functions of a cell:

1. Energy generation
2. Molecular transport
3. Reproduction.

The function of each organelle has already been discussed but is worth considering in summary.

- The cell membrane allows substances to enter and leave the cell. While certain substance like oxygen can easily diffuse through the cell membrane, others have to actively transported through the process of endocytosis. Small particles are transported by the process of pinocytosis while larger particles are moved by the process of phagocytosis. These functions can become highly specialized to allow cells to perform specific activities, like the macrophages that phagocytose invading bacteria to neutralize it.
- Small and large substances that do not dissolve in the cytoplasm are contained within vesicles. Lysosomes attach to the vesicles and digest this material.
- The endoplasmic reticulum and Golgi apparatus synthesize different substances like proteinand fats as required by the cell or designated according to its specific function. It

utilizes basic nutrient molecules that are either dissolved in the cytoplasm or specific substances contained within vesicles.

- Some nutrients, specifically carbohydrates, are transported to the mitochondria where it is broken down further to yield energy. In the process, high-energy molecules known as ATP (adenosine triphosphate) are manufactured and provide energy for other organelles.
- The genetic material housed in the nucleus provides the blueprint necessary for the production of specific compounds by the endoplasmic reticulum and Golgi apparatus. The genes also help the cell replicate and codes for the formation of new cells.
- Secretory vesicles store some of the enzymes and other specialized substances formed by the endoplasmic reticulum and Golgi apparatus. These stored substances are released from the cell when necessary in order to complete various functions that allow the body to function as a whole.

4. a. Describe in detail about the ABO Blood groups and the estimation of RBC, WBC (Nov 2017)

b. Explain in detail about the estimation of RBC? (Nov 2014, Nov 2016)

Estimation of RBC

- The red blood cells or erythrocytes are circular, biconcave, non nucleated cells containing haemoglobin and are embeded in blood plasma. After birth bone marrow is the main site of formation of red blood corpuscles. These are involved in acting as a carrier of oxygen and carbon dioxide. RBCs also maintain the ionic balance of human physiological system and maintain viscosity of blood. Various pigments like bilirubin and biliverdin are derived from RBC after their degradation.
- The basic principle is that the blood specimen is diluted (usually 200 times) with red cell diluting fluid which does not remove the white blood cells but allows the red cells to be counted under magnification in a known volume of fluid. Finally, the number of cells in undiluted blood is calculated and reported as the number of red cells/µl of whole blood. Blood cell counts can be performed using the hemacytometer.

Significance:

- The red cell count is the number of red cells present in one cubic millimeter of blood. The normal values of the red blood cell count are:

- Woman: 4-5.5 million per cubic millimeter
- Men: 4.5-6.0 million per cubic millimeter
- Infants : 5- 6.5 million per cubic millimeter

- Variations in normal values are observed in pregnancy, severe burns, diseased conditions and it also depends upon altitude. It drops below normal values in anaemia and leukemia and rises above the normal values in polycythemia and dehydration conditions. Therefore, the red cell count is useful in diagnosis.

The procedure to estimate the RBC count is as follows:

- Sterilise the finger tip with cotton plug soaked in spirit and let it dry.
- Take a bold prick with needle to have free flow of blood and draw the blood in a RBC pipette upto 0.5 mark.
- Dip the RBC pipette in red blood cell diluting fluid and suck up diluting fluid upto 101 mark.
- Rotate the pipette equally in your hands to mix the solution well by swirling.
- Take the haemocytometer and place it on the flat surface of the work bench. Place the cover slip on the counting chamber.
- Allow a small drop of diluted blood, hanging from the pipette, to sweep into the counting chamber by capillary action. Make sure that there is no air bubble and the counting chamber must not be flooded.
- Leave the counting chamber on the bench for 3 minutes to allow the cells to settle. Observe the cells by placing the counting chamber on the mechanical stage of the microscope.
- Focus on the centre room of the chamber and start counting the cells from upper left corner of the room. It is advisable to complete all counts of the four squares and then move to the centre square, which is the fifth square to be counted.

Data Analysis:

$$\frac{\text{No. of cells X Dilution factor X Depth factor X Total ruled area}}{\text{Area count}}$$

Where, Dilution factor = 200; Depth factor = 10; Total ruled area = 25; Area count = 5. Thus the number of red blood cells present in one µl of blood sample can be estimated.

Estimation of White blood cell count

- It is an enumeration of white corpuscles or is an leucocyte count. The white blood cells (WBCS) or leucocytes are nucleated actively amoeboid and do not contain haemoglobin and as originated purely from extravascular tissue. They are composed of nucleoproteins and varieties of enzymes. Their number is less and life span is short as compared to red blood cells.
- The WBCs exist in two forms viz. granulocytes and agranulocytes. Granulocytes are further classified as eosinophil, basophil, neutrophil, while agranulocytes shows lymphocytes and monocytes. These varieties possess independent morphological, functional and staining properties. The main function of white blood corpuscles is phagocytosis that is body defence mechanism against foreign particles and invading bacteria. They are also involved in antibody formation in immunological body defence mechanism. It also take part in process of repair in an area of inflammation.
- The basic principle is that the blood is diluted with acid solution which removes the red cells by haemolysis and also accentuates the nuclei of the white cells; thus the counting of the white cells becomes easy. Blood cell counts can be performed using the hemacytometer.

Significance:

- The white cell count is the number of white cell present in one cubic millimeter of blood. The normal values of white blood cell count vary between 5000 to 10,000 per cubic millimeter or 7-11 thousand cells/µl of blood volume in healthy individual.
- Variation in normal values is observed in diseased states. WBC count increases (leucocytosis) in conditions like pneumonia, leukemia, meningitis, small pox etc. while the count decreases (leucopenia) in conditions such as influenza, typhoid, infectious hepatitis etc. Moreover the count rises in pregnancy and during menstruation. Thus, white blood cell count is useful in diagnosis.

The procedure to estimate the WBC count is as follows:

- Sterilize the finger tip with cotton plug soaked in 70% alcohol and let it dry.
- Take a bold prick to have free flow of blood and draw the blood in a WBC pipette up to 0.5 mark.

- Dip the WBC pipette in WBC diluting fluid up to 11 mark and rotate the pipette equally in your hands to mix the solution well by swirling.
- Take the haemocytometer and place it on the flat surface of the work bench. Place the cover slip on the counting chamber.
- Allow a small drop of diluted blood, hanging from the pipette, to sweep into the counting chamber by capillary action. Make sure that there is no air bubble and there is no overfilling beyond the ruled area.
- Leave the counting chamber on the bench for 3 minutes to allow the cells to settle. Observe the cells by placing the counting chamber on the mechanical stage of the microscope.

Focus on one of the corner squares of the counting chamber and count the white cells schematically, starting from the upper left small square of each Square. Repeat the count in all the four corners of the chamber. Apply the margin rules i.e. count the cells lying on two adjacent margins, and discard those on the other two margins.

Data Analysis:

$$\frac{\text{No. of cells X Dilution factor X Depth factor}}{\text{Area count}}$$

Where, Dilution factor = 20, Depth factor = 10, Area count = 4

The number of white blood cells present in one µl of blood specimen is estimated.

Blood grouping:

- Blood typing is a test that determines a person's blood type. The test is essential if you need a blood transfusion or are planning to donate blood. Not all blood types are compatible, so it's important to know your blood group. Receiving blood that's incompatible with your blood type could trigger a dangerous immune response.
- Your blood type is determined by what kind of antigens your red blood cells have on the surface. Antigens are substances that help your body differentiate between its own

cells and foreign, potentially dangerous ones. If your body thinks a cell is foreign, it will set out to destroy it.

The ABO blood typing system groups your blood into one of four categories:

- **Type A** has the A antigen.
- **Type B** has the B antigen.
- **Type AB** has both A and B antigens.
- **Type O** has neither A nor B antigens.

➢ If blood with antigens that you don't have enters your system, your body will create antibodies against it. However, some people can still safely receive blood that isn't their blood type. As long as the blood they receive doesn't have any antigens that mark it as foreign, their bodies won't attack it.

➢ In other words, donations work as follows:

- **O:** Type O individuals can donate blood to anyone, because their blood has no antigens. However, they can only receive blood from other type O individuals (because blood with any antigens is seen as foreign).
- **A:** Type A individuals can donate to other type A individuals and type AB individuals. Type A individuals can receive blood only from other type A individuals and type O individuals.
- **B:** Type B individuals can donate blood to other B individuals and AB individuals. Type B individuals can receive blood only from type B individuals and type O individuals.
- **AB:** Type AB individuals can give blood only to other AB individuals, but can receive blood of any type.

➢ Blood types are further organized by Rh factor:

- **Rh-positive:** People with Rh-positive blood have Rh antigens on the surface of their red blood cells. People with Rh-positive blood can receive Rh-positive or Rh-negative blood.

- **Rh-negative:** People with Rh-negative blood do not have Rh antigens. People with Rh-negative blood can receive only blood that is also Rh-negative.

✓ Together, the ABO and Rh grouping systems yield your complete blood type. There are eight possible types: O-positive, O-negative, A-positive, A-negative, B-positive, B-negative, AB-positive, and AB-negative. While type O-negative has long been considered a universal donor, more recent research suggests that additional antibodies are sometimes present and may cause serious reactions during a transfusion.

✓ Blood typing is done prior to a blood transfusion or when classifying a person's blood for donation. Blood typing is a fast and easy way to ensure that you receive the right kind of blood during surgery or after an injury. If you're given incompatible blood, it can lead to blood clumping, or agglutination, which can be fatal.

✓ Blood typing is especially important for pregnant women. If the mother is Rh-negative and the father is Rh-positive, the child will likely be Rh-positive. In these cases, the mother needs to receive a drug called RhoGAM. This drug will keep her body from forming antibodies that may attack the baby's blood cells if their blood becomes mixed, which often happens during pregnancy.

5. What are the types of immunity? Explain (May 2015, Nov 2015, May 2018)

- The immune system is the body's defense against infections. The immune system attacks germs and helps keep us healthy.
- Many cells and organs work together to protect the body. White blood cells, also called leukocytes, play an important role in the immune system.
- Some types of white blood cells, called phagocytes, chew up invading organisms. Others, called lymphocytes , help the body remember the invaders and destroy them.
- One type of phagocyte is the neutrophil, which fights bacteria. When someone might have bacterial infection, doctors can order a blood test to see if it caused the body to have lots of neutrophils. Other types of phagocytes do their own jobs to make sure that the body responds to invaders.
- The two kinds of lymphocytes are B lymphocytes and T lymphocytes. Lymphocytes start out in the bone marrow and either stay there and mature into B cells, or go to the thymus gland to mature into T cells. B lymphocytes are like the body's military intelligence system — they find their targets and send defenses to lock onto them. T cells are like the soldiers — they destroy the invaders that the intelligence system finds.

- When the body senses foreign substances (called antigens), the immune system works to recognize the antigens and get rid of them.
- B lymphocytes are triggered to make antibodies (also called immunoglobulins). These proteins lock onto specific antigens. After they're made, antibodies usually stay in our bodies in case we have to fight the same germ again. That's why someone who gets sick with a disease, like chickenpox, usually won't get sick from it again.
- This is also how immunizations (vaccines) prevent some diseases. An immunization introduces the body to an antigen in a way that doesn't make someone sick. But it does let the body make antibodies that will protect the person from future attack by the germ.
- Although antibodies can recognize an antigen and lock onto it, they can't destroy it without help. That's the job of the T cells. They destroy antigens tagged by antibodies or cells that are infected or somehow changed. (Some T cells are actually called "killer cells.") T cells also help signal other cells (like phagocytes) to do their jobs.

Antibodies also can:

- Neutralize toxins (poisonous or damaging substances) produced by different organisms.
- Activate a group of proteins called complement that are part of the immune system. Helps to kill bacteria, viruses, or infected cells.
- These specialized cells and parts of the immune system offer the body protection against disease. This protection is called immunity

There are three types of immunity in humans called innate, adaptive, and passive:

- **Innate immunity**

We are all born with some level of immunity to invaders. Human immune systems, similarly to those of many animals, will attack foreign invaders from day one. This innate immunity includes the external barriers of our body — the first line of defense against pathogens — such as the skin and mucous membranes of the throat and gut.This response is more general and non-specific. If the pathogen manages to dodge the innate immune system, adaptive or acquired immunity kicks in.

- **Adaptive (acquired) immunity**

This protect from pathogens develops as we go through life. As we are exposed to diseases or get vaccinated, we build up a library of antibodies to different pathogens. This is sometimes referred to as immunological memory because our immune system remembers previous enemies.

- **Passive immunity**

This type of immunity is "borrowed" from another source, but it does not last indefinitely. For instance, a baby receives antibodies from the mother through the placenta before birth and in breast milk following birth. This passive immunity protects the baby from some infections during the early years of their life.

6. Describe the composition of blood? (Nov 2015)

- Blood is one of the most important components of life. Almost any animal that possesses a circulatory system has blood. From an evolutionary perspective, blood was speculated to have risen from a type of cell that was responsible for phagocytosis and nutrition. Billions of years later, blood and the circulatory system have drastically helped the evolution of more complex lifeforms.
- Blood is a fluid connective tissue that consists of plasma, blood cells and platelets. It circulates throughout our body delivering oxygen and nutrients to various cells and tissues. It makes up 8% of our body weight. An average adult possesses around 5-6 litres of blood.

- **Types of Blood Cells**

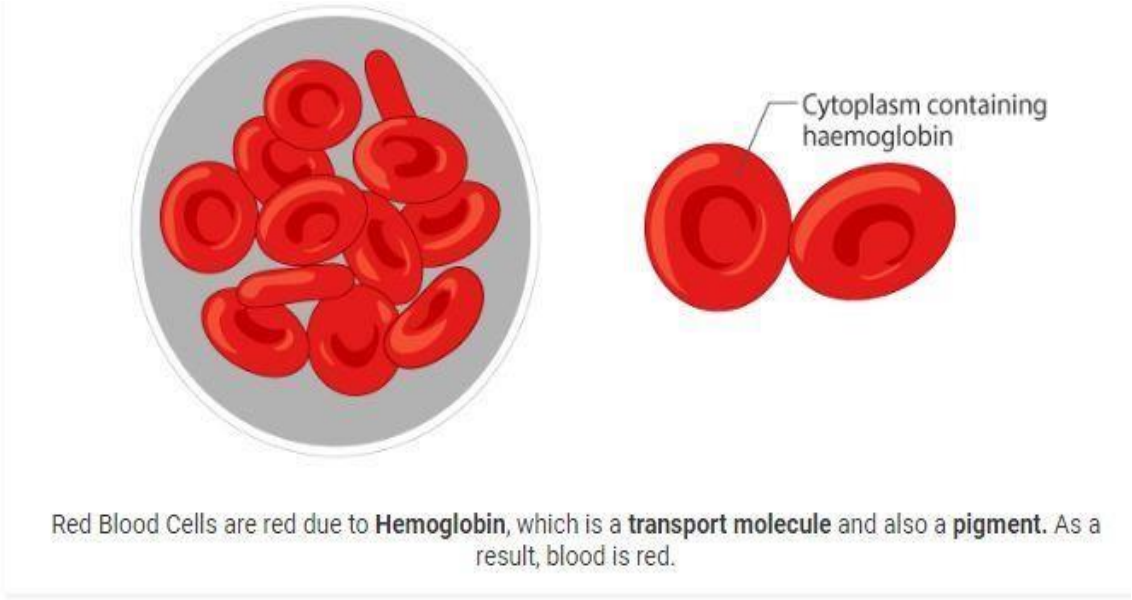
We have seen blood consist of cells known as formed elements of blood. These cells have their own functions and roles to play in the body. The blood cells which circulate all around the body are as follows:

1. Red blood cells (Erythrocytes)

RBCs are the biconcave cells and without nucleus in humans; also known as erythrocytes. RBCs contain the iron-rich protein called haemoglobin; give blood its red colour. RBCs are the most copious blood cell produced in bone marrows. Their main function is to transport oxygen from and to various tissues and organs.

2. White blood cells (Leucocytes)

Leucocytes are the colourless blood cells. They are colourless because it is devoid of haemoglobin. They are further classified as granulocytes and agranulocytes. WBCs mainly contribute to immunity and defence mechanism.



- **Types of White Blood Cells**

There are five different types of White blood cells and are classified mainly based on the presence and absence of granules.

- Granulocytes
- Agranulocytes

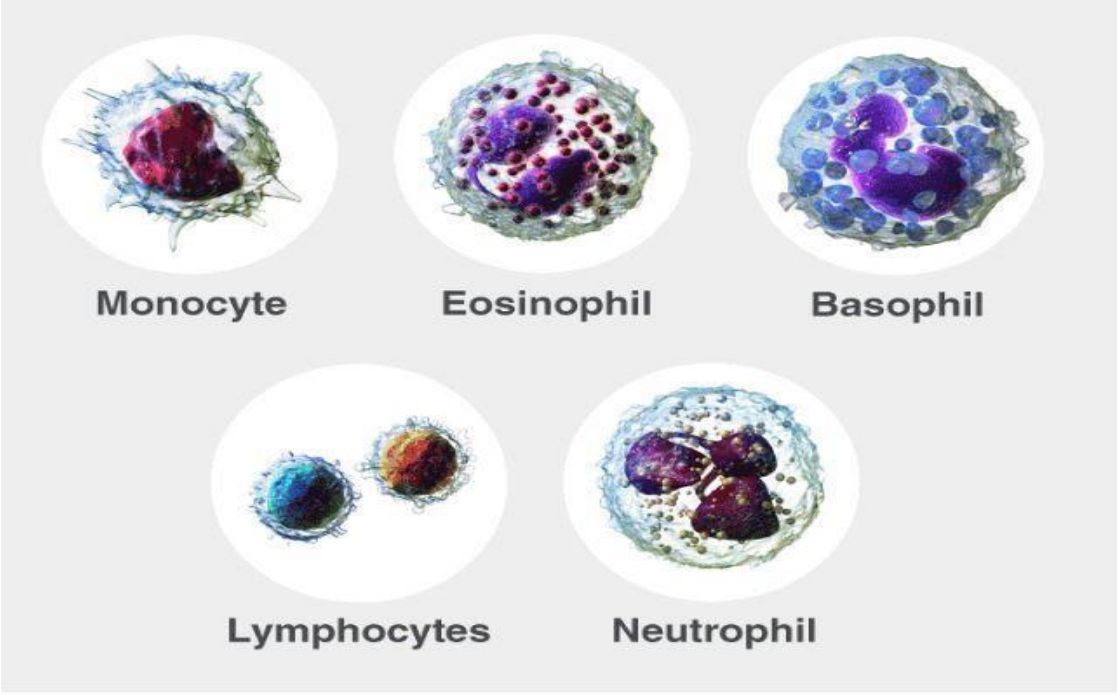
Granulocytes

They are leukocytes, with the presence of granules in their cytoplasm. The granulated cells include- eosinophil, basophil, and neutrophil.

Eosinophils

- They are the cells of leukocytes, which are present in the immune system.

- These cells are responsible for combating infections in parasites of vertebrates and for controlling mechanisms associated with the allergy and asthma.
- Eosinophil cells are small granulocyte, which is produced in the bone marrow and makes 2 to 3 per cent of whole WBCs. These cells are present in high concentrations in the digestive tract.



There are **five types of white blood cells** present in the blood

Basophils

- They are the least common of the granulocytes, ranging from 0.5 to 1 per cent of WBCs.
- They contain large cytoplasmic granules, which plays a vital role in mounting a non-specific immune response to pathogens, allergic reactions by releasing histamine and dilates the blood vessels.
- These white blood cells have the ability to be stained when exposed to basic dyes, hence referred to as basophil.
- These cells are best known for their role in asthma and their result in the inflammation and bronchoconstriction in the airways.

- They secrete serotonin, histamine and heparin.

Neutrophils

- They are normally found in the bloodstream.
- They are predominant cells, which are present in pus.
- Around 60 to 65 per cent of WBCs are neutrophils with a diameter of 10 to 12 micrometres.
- The nucleus is 2 to 5 lobed and cytoplasm has very fine granules.
- Neutrophil helps in the destruction of bacteria with lysosomes, and it acts as a strong oxidant.
- Neutrophils are stained only using neutral dyes. Hence, they are called so.
- Neutrophils are also the first cells of the immune system to respond to an invader such as a bacteria or a virus.
- The lifespan of these WBCs extend for up to eight hours and are produced every day in the bone marrow.

Agranulocytes

They are leukocytes, with the absence of granules in their cytoplasm. Agranulocytes are further classified into monocytes and lymphocytes.

Monocytes

- These cells usually have a large bilobed nucleus, with a diameter of 12 to 20 micrometres.
- The nucleus is generally of half-moon shaped or kidney-shaped and it occupies 6 to 8 per cent of WBCs.
- They are the garbage trucks of the immune system.
- The most important functions of monocytes are to migrate into tissues and clean up dead cells, protect against the bloodborne pathogens and they move very quickly to the sites of infections in the tissues.

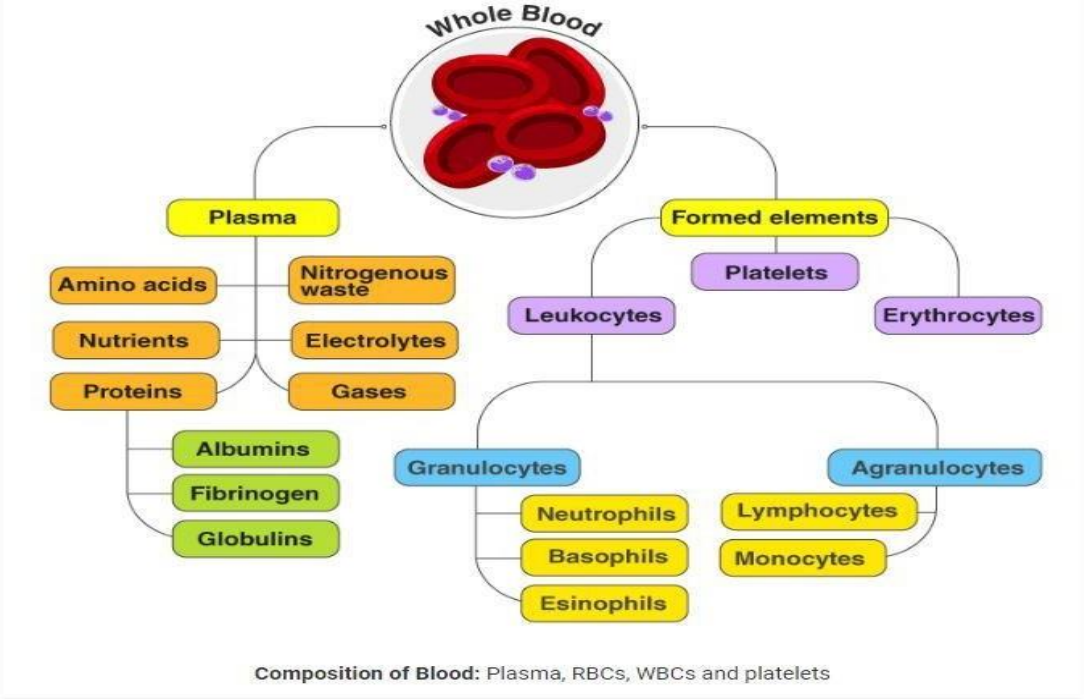
- These white blood cells have a single bean-shaped nucleus, hence referred to as Monocytes.

Lymphocytes

- They play a vital role in producing antibodies.
- Their size ranges from 8 to 10 micrometres.
- They are commonly known as natural killer cells.
- They play an important role in body defence.
- These white blood cells are colourless cells formed in lymphoid tissue, hence referred to as lymphocytes.
- There are two main types of lymphocytes – B lymphocytes and T lymphocytes.
- These cells are very important in the immune systems and are responsible for humoral and cell-mediated immunity.

Platelets (Thrombocytes)

- Thrombocytes are specialized blood cells produced from bone marrow.
- Platelets come into play when there is bleeding or haemorrhage.
- They help in clotting and coagulation of blood. Platelets help in coagulation during a cut or wound.



Composition of Blood: Plasma, RBCs, WBCs and platelets

7. a. Explain the types of immune response? (Nov 2015)

b. What is immune response? Explain in detail about humoral and cell mediated immunity. (Nov 2017, Nov 2019)

- Immune response is the reaction of the cells and fluids of the body to the presence of a substance which is not recognized as a constituent of the body itself.
- There are types of immune response:

1. HUMORAL IMMUNITY
2. CELL-MEDIATED IMMUNITY

HUMORAL IMMUNITY:

Humoral immune response or antibody-mediated response is associated with the B cells, where the role of these cells (B cells) is to identify the antigens or any foreign particle that are present in the circulation in blood or lymph. This immune response is also assisted with helper T cells which along with the B cells get differentiated into plasma B cells that can produce antibodies.

As soon as B cells produce antibodies, they will bind to an antigen; neutralize them and causes phagocytosis or cell lysis (destruction of the cells). The antigen is the foreign

particle, which is usually a carbohydrate or a protein that triggers an immune response, but above that our body has tremendous capability to identify the antigens.

Any kind exposure of antigens leads to the development of secondary immunological response which increases the level of the immune response. The immunoglobulins or antibodies mediate the humoral immunity; these are a particular group of proteins produced by the B-lymphocytes.

These following points can explain the eventual process:

- Antigens triggers to the body.
- Antigens bind to the B cells present in the blood circulation.
- Helper T cells or Interleukins assist the B cells and initiate B cell proliferation which activates plasma B cells.
- Plasma cells carry antibodies which are antigen-specific and have specific binding receptors of the activated B cells.
- These antibodies travel throughout the body and bind to the antigens.
- The B cells after destroying the antigens, produce memory cells which in turn provide future immunity when the same antigen triggers the body again.

The humoral immunity is associated with the B-lymphocytes and is responsible for destroying the pathogens by producing antibodies against it. Humoral immunity is intimately associated with B-lymphocytes, T-lymphocytes and macrophages. Antibodies are present. The functions are It plays a major role in recognizing antigen or any foreign particle and in producing antibodies against it. Humoral immunity is known for working against extracellular pathogens. It secrets antibodies. Humoral immunity is rapid or quick in their response. It mediates hypersensitivity type I, II and III. Humoral immunity is involved in the early stage of graft rejections due to the formation of antibodies.

CELL-MEDIATED IMMUNITY:

T lymphocytes assist the Cell-mediated immunity or cellular immunity. In this type, cytokines have released that help to activate the T cells which further destroys the

infected cell. Likewise the B cells, T cells originate in bone marrow but matures in the thymus and later gets circulate in the bloodstream and lymphoid tissue.

The antigen present on the surface of the antigen-presenting cells (APCs) with the abnormal Major Histocompatibility Complex (MHC) proteins. Abnormal or aberrant MHC molecules are formed from the antigens which have been destroyed or broken down or from any infected virus (exogenous antigens) or the from tumour cells that are actively producing foreign proteins (endogenous antigens).

The cell-mediated immunity is associated with the T-lymphocytes and is responsible for destroying the pathogens or microorganism which have invaded the cells. These are associated with T-lymphocytes, helper T cells, natural killer cells and macrophages. Antibodies are absent. The functions are Cell-mediated immunity is related to T-lymphocytes, which work by identifying viruses and microorganisms, thus destroying them by the cell lysis or phagocytosis or pinocytosis. It is known for working against intracellular pathogens. It secretes cytokines. The Cell-mediated immunity show delay though permanent action against any pathogens. Cell-mediated is the delayed in response and mediates hypersensitivity type IV. Cell-mediated immunity is involved in the rejection of organ transplants.

8. Explain about action potential and its generation and conduction? (May 2016, Nov 2016, Nov 2018)

The **action potential** represents a rapid change in the membrane potential, followed by a rapid return to the resting membrane potential. In other words, a rapid depolarization followed by a rapid repolarization. The action potential is the basis of transmitting signals in nerve cells, inducing muscle contraction and perception of all our senses.

The action potential is caused by the activation of the **voltage-gated ion channels**, most often the Na^+ voltage-gated ion channel. Most commonly, we talk about action potentials as they relate to nerve cells. In nerve cells, at rest, the movement of Na^+ through the membrane is extremely low (very few Na^+ leak channels). However, if the surface (cell membrane) of the neuron receives a graded potential that is sufficient to exceed the set threshold value, the voltage sensitive proteins will respond by changing conformation.

Because the concentration of Na^+ is extremely high on the outside of the cell, the opening of Na^+ channels will cause a rapid influx of Na^+ down its concentration gradient, therefore disrupting the negative membrane potential and resulting in **depolarization**.

The membrane potential will increase rapidly in response to the increased positive charge until the inactivated Na+ voltage-gated channels close. It is important to note that depolarization occurs with minimal changes in the overall concentration of Na^+ or K^+ *(*Only one out of every 100,000 Na^+ ions need to enter the cell to produce a 100 mV change in potential*)*.

Once activated, the protein channel is quick to re-establish a new conformation, but during the interim (about 0.5 msec), the protein allows sodium to pass through the membrane. In the case of the Na+ channel, there are two gates, an activation gate and an inactivation gate. The activation gate is very sensitive to voltage changes and is the basis of threshold. The inactivation gate is slightly delayed compared to the activation gate, which allows for the channel to be permeable for a brief moment.

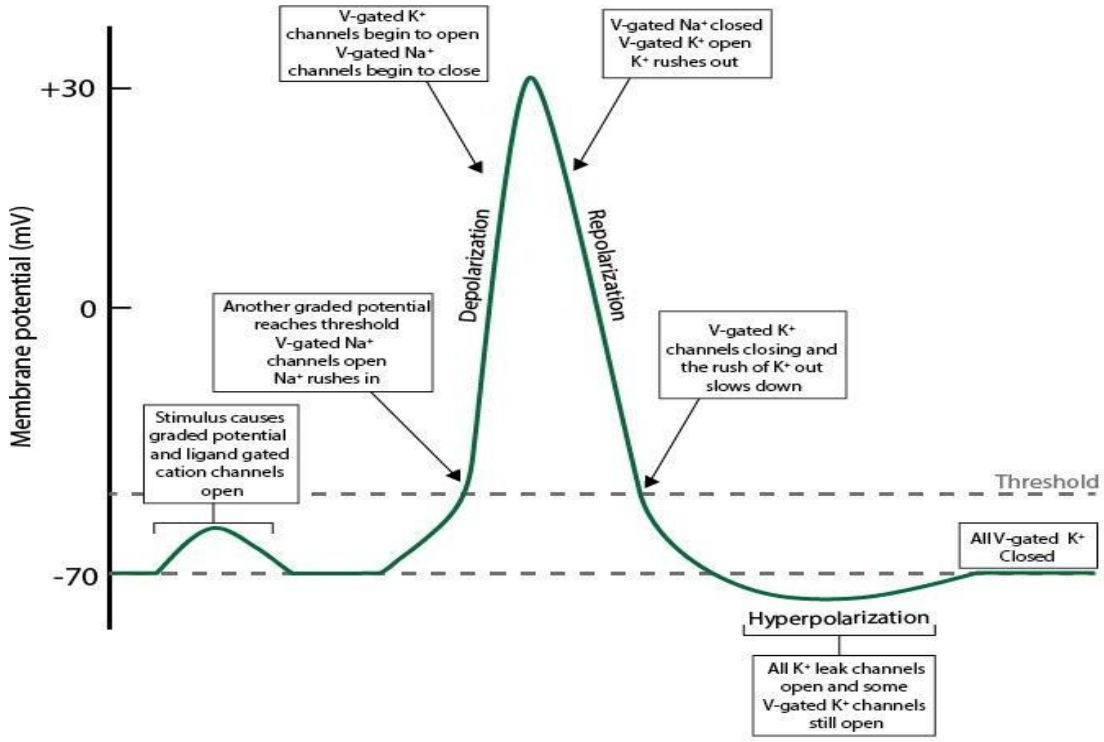
After a slight delay, voltage-gated K^+ channels open, resulting in an efflux of potassium out of the cell. This efflux is in addition to the efflux resulting from K^+ leak channels that are always open. The additional efflux of potassium, in combination with the termination of Na^+ (because the inactivation gate closes) influx reverses the initial depolarization and the membrane potential moves back towards the resting potential (**repolarization**) and even beyond (**hyperpolarization**), after which the K^+ voltage channels close and the resting membrane is reestablished (the potassium channels have only one gate which is activated by depolarization and inactivated by repolarization).

Hyperpolarization occurs because of the additional movement of K^+ through the voltage-gated K^+ channel. Once the voltage-gated K^+ channel closes, the membrane will return to the resting potential established initially by the leak channels for K^+. The small depletions that occur in K^+ and Na^+ concentrations, following each action potential, are then reestablished by the Na^+/K^+ ATPase pump, but this is not necessary for another action potential. In fact, it has been demonstrated that the ion gradients in a neuron are sufficient to be able to generate 10,000 action potentials without replenishment from the Na^+/K^+ ATPase pump.

It is important to note that in order for activation of the Na^+ channels to occur, there needs to be a sufficient stimulus of current that exceeds the **threshold value**. For example, the threshold value for a typical neuron is near -55 mV, while the resting

membrane potential is near -70 mV. If a graded potential is not sufficient to bring the membrane up to the threshold value (-55 mV), then an action potential cannot be initiated. This kind of stimulus is referred to as a sub-threshold stimulus. If the threshold value is exceeded by a given stimulus, the action potential will always occur. This phenomenon is referred to as the all-or-nothing principle. In addition, unlike graded potentials, the action potential cannot be summed or added upon, but once an action potential starts, it becomes self-propagating.

When current stimulus is sufficient to reach the threshold value, an action potential is triggered. Notice that the first stimulus came close but did not exceed threshold. This stimulus failed to initiate an action potential. However, the second stimulus must have exceeded threshold because a relatively large and rapid depolarization occurred, followed by a rapid repolarization.



9. What are autoimmune diseases? Explain the complication of autoimmune diseases with suitable example. (May 2016, May 2017, Nov 2018, May 2019)

Immune system disorders cause abnormally low activity or over activity of the immune system. In cases of immune system overactivity, the body attacks and damages its

own tissues (autoimmune diseases). Immune deficiency diseases decrease the body's ability to fight invaders, causing vulnerability to infections.

In response to an unknown trigger, the immune system may begin producing antibodies that instead of fighting infections, attack the body's own tissues. Treatment for autoimmune diseases generally focuses on reducing immune system activity. Examples of autoimmune diseases include:

- Rheumatoid arthritis.
- Systemic lupus erythematosus (lupus).
- Inflammatory bowel disease (IBD.
- Multiple sclerosis (MS).
- Type 1 diabetes mellitus.
- Guillain-Barre syndrome.
- Chronic inflammatory demyelinating polyneuropathy.
- Psoriasis.
- Graves' disease.
- Hashimoto's thyroiditis.
- Myasthenia gravis.
- Vasculitis.

Rheumatoid Arthritis

Rheumatoid arthritis is the long-lasting, most common type of autoimmune disorder that causes chronic inflammation of the joints and other parts of the body. This occurs when the immune system of individuals mistakenly attacks their joint lining capsule or body tissues. In some people, it is found that Rheumatoid Arthritis (RA) also damages skin, lungs, eyes, kidneys and blood vessels.

Causes of Rheumatoid Arthritis

Human’s immune system is very protective. It releases antibodies when a foreign material like bacteria and fungus enters the human body. Those antibodies fight the foreign material and kill them.

However, in some cases, the immune system mistakenly sends antibodies to attack their lining of joints. This is the root cause of Rheumatoid Arthritis. The reason why the immune system behaves like that is still unknown.

This autoimmune disorder is observed more in women compared to men. Some evidence suggests that people who smoke have more chances of developing Rheumatoid Arthritis.

Diagnosis for Rheumatoid Arthritis

It is difficult to diagnose Rheumatoid Arthritis in the earlier stages because the symptoms might resemble the symptoms of other diseases. Blood tests, x rays, and imaging tests are used to diagnose this disorder.

Rheumatoid Arthritis Symptoms

The symptoms can vary from mild to severe and occurs throughout the body, which includes:

- Fever.
- Joint pains.
- Swollen joints.
- Less flexibility in the joints.
- Morning stiffness or stiffness in joints.

These symptoms usually begin from small joints and later spread to all joints. In the case of 15 to 20 per cent of people, symptoms may be observed in body parts, including the skin, lungs, kidneys, blood vessels, and liver.

Rheumatoid Arthritis Treatment

There is no treatment in particular for Rheumatoid Arthritis. Treatment generally includes a combination of educating the patient, rest, exercise, medications and occasional surgeries.

Medications undergone in treating this disorder are as follows:

- Methotrexate

- Leflunomide
- Sulfasalazine
- Hydroxychloroquine

The main goal of the treatment is:

- Reduce pain
- Reduce swelling
- Help people to stay active
- Prevent joints from more damage.

Rheumatoid Arthritis Diet and Exercise

Diet and exercise are an important part of our lifestyle, and the quality of our life depends on the diet we follow. Getting plenty of exercise helps in coping with rheumatoid arthritis. Exercise can help to reduce the pain, inflammation and stiffness of joints and provides more flexibility.

There are many foods which can reduce inflammation and reduce the joint pains. Many studies have shown that the following foods might prove helpful for the patients suffering from this arthritis disorder.

- Fish
- Ginger
- Turmeric
- Coriander
- Green tea
- Pineapple
- Sour cherries

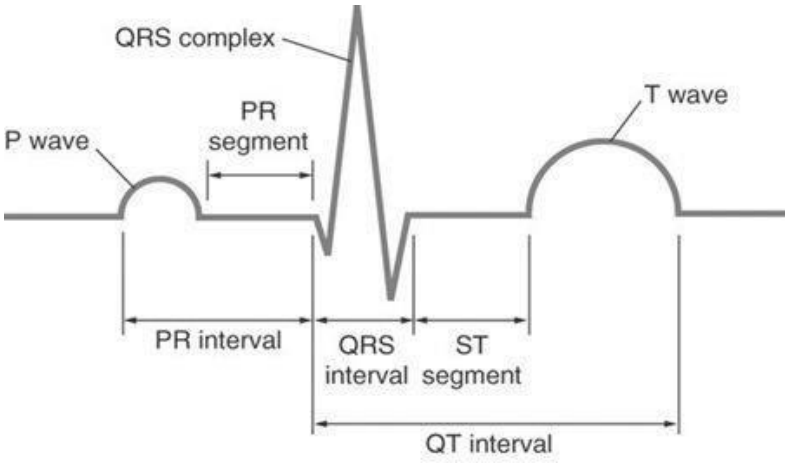
Unit II

2 MARKS:

1. What is systolic and Diastolic blood pressure? (Nov 2016, May 2017)

Blood pressure is measured using two numbers: The first number, called systolic blood pressure, measures the pressure in your arteries when your heart beats. The second number, called diastolic blood pressure, measures the pressure in your arteries when your heart rests between beats.

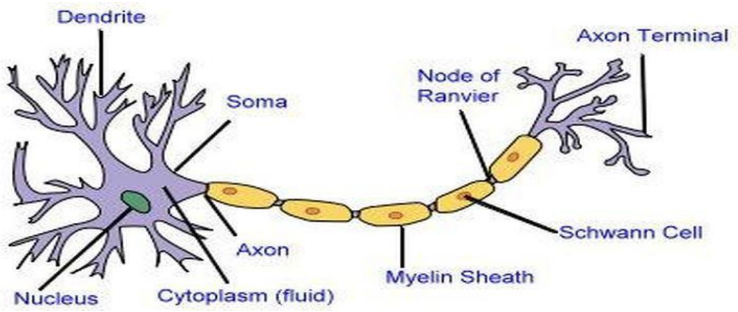
2. Draw the ECG waveform. (Nov 2016, May 2014, Nov 2014)



3. Define all or none law. (May 2015)

The all-or-none law is a principle that states that the strength of a response of a nerve cell or muscle fiber is not dependent upon the strength of the stimulus. If a stimulus is above a certain threshold, a nerve or muscle fiber will fire.

4. Draw a neat labeled diagram of neuron. (May 2015, Nov 2015)



5. How heart sounds are classified? (Nov 2015, Nov 2017)

- Heart sounds has been classified into three classes namely normal signal, systolic murmur signal and diastolic murmur signal.
- In a healthy adult, the heart makes two sounds, commonly described as 'lub' and 'dub. 'The third and fourth sounds may be heard in some healthy people, but can indicate impairment of the heart function. S1 and S2 are high-pitched and S3 and S4 are low-pitched sounds.

6. Define homeostasis? (May 2016, May 2017, May 2018, Nov 2019, May 2014, Nov 2014)

- Homeostasis is any self-regulating process by which an organism tends to maintain stability while adjusting to conditions that are best for its survival.
- Homeostasis is the state of steady internal, physical, and chemical conditions maintained by living systems. This is the condition of optimal functioning for the organism and includes many variables, such as body temperature and fluid balance, being kept within certain pre-set limits.

7. What is Blood Brain Barrier? (Nov 2017)

The blood-brain barrier acts as an additional boundary between the circulating blood and the extracellular space of the brain. The barrier is highly selective, meaning it only allows certain substances to cross from the bloodstream into the brain.

8. What are dendrites? (May 2018, Nov 2019)

Dendrites are tree-like extensions at the beginning of a neuron that help increase the surface area of the cell body. These tiny protrusions receive information from other neurons and transmit electrical stimulation to the soma.

9. Define cardiac output and stroke volume. (Nov 2018)

Cardiac output is the term that describes the amount of blood your heart pumps each minute. Doctors think about cardiac output in terms of the following equation: Cardiac output = stroke volume × heart rate. The definition of stroke volume is

the volume of blood pumped out of the left ventricle of the heart during each systolic cardiac contraction.

10. Which part of the brain is concerned with temperature regulation? (Nov 2018)

Hypothalamus –The hypothalamus has temperature receptor cells which detect changes in the temperature of the blood flowing through the brain. If the temperature is above or below 37°C, the hypothalamus sends electrical nerve impulses to effectors, which are mainly found in the skin.

11. What causes arrhythmia? (May 2019)

Substances in your blood called electrolytes — such as potassium, sodium, calcium and magnesium — help trigger and conduct the electrical impulses in your heart. Electrolyte levels that are too high or too low can affect your heart's electrical impulses and contribute to arrhythmia development.

12. Define neurotransmitter. (May 2019)

A chemical that is released from a nerve cell which thereby transmits an impulse from a nerve cell to another nerve, muscle, organ, or other tissue. A neurotransmitter is a messenger of neurologic information from one cell to another.

11 MARKS:

1. Draw the structure of heart and explain in detail. (Nov 2016, Nov 2015, Dec 2019, Nov 2014)

- The human heart is one of the most important organs responsible for sustaining life. It is a muscular organ with four chambers. The size of the heart is the size of about a clenched fist.
- The human heart functions throughout a person’s lifespan and is one of the most robust and hardest working muscles in the human body.

- The human heart is located between the lungs in the thoracic cavity, slightly towards the left of the sternum (breastbone). It is derived from the embryonic mesodermal germ layer.

Function of Heart:

The function of the heart in any organism is to maintain a constant flow of blood throughout the body. This replenishes oxygen and circulates nutrients among the cells and tissues.

Following are the main functions of the heart:

- One of the primary functions of the human heart is to pump blood throughout the body.
- Blood delivers oxygen, hormones, glucose and other components to various parts of the body, including the human heart.
- The heart also ensures that adequate blood pressure is maintained in the body

There are two types of circulation within the body, namely pulmonary circulation and systemic circulation.

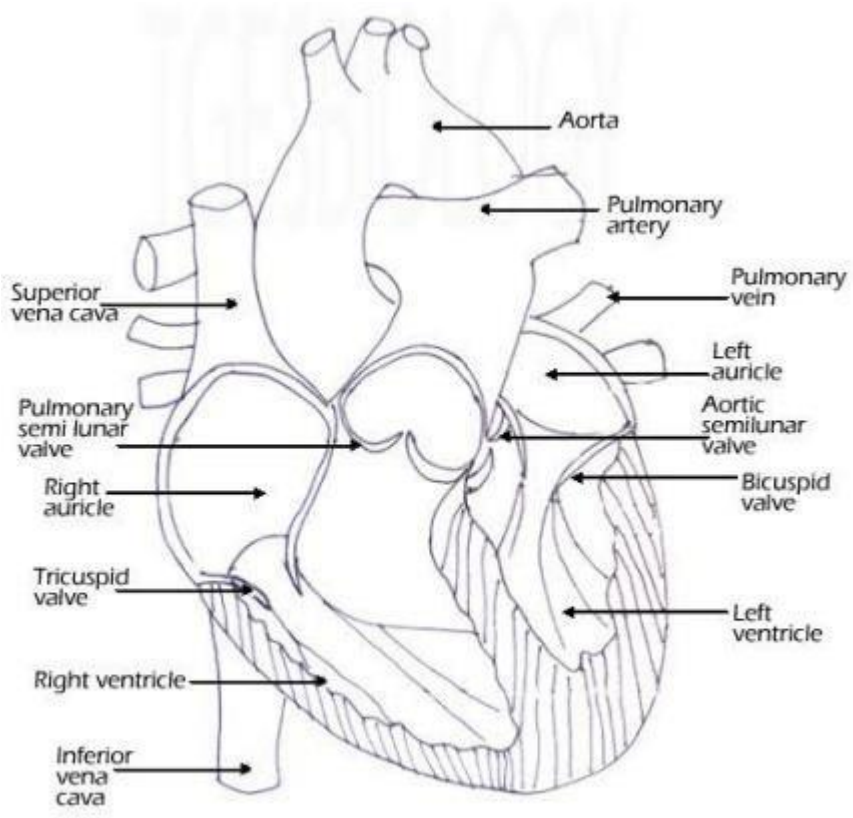
Types of Circulation:

- Pulmonary circulation is a portion of circulation responsible for carrying deoxygenated blood away from the heart, to the lungs and then brings oxygenated blood back to the heart.
- Systemic circulation is another portion of circulation where the oxygenated blood is pumped from the heart to every organ and tissue in the body, and deoxygenated blood comes back again to the heart.
- Now, the heart itself is a muscle and therefore, it needs a constant supply of oxygenated blood. This is where another type of circulation comes into play, the coronary circulation.

- Coronary circulation is an essential portion of the circulation, where oxygenated blood is supplied to the heart. This is important as the heart is responsible for supplying blood throughout the body.
- Moreover, organs like the brain need a steady flow of fresh, oxygenated blood to ensure functionality.

Structure of the Human Heart:

The human heart is about the size of a human fist and is divided into four chambers, namely two ventricles and two atria. The ventricles are the chambers that pump blood and atrium are the chambers that receive blood. Among which both right atrium and ventricle make up the "right heart," and the left atrium and ventricle make up the "left heart." The structure of the heart also houses the biggest artery in the body – the aorta.



Internal structure of heart

The right and the left region of the heart are separated by a wall of muscle called the septum. The right ventricle pumps the blood to the lungs for re-oxygenation through

the pulmonary arteries. The right semilunar valves close and prevent the blood from flowing back into the heart. Then, the oxygenated blood is received by the left atrium from the lungs via the pulmonary veins. Read on to explore more about the structure of the heart.

External Structure of Heart:

One of the very first structures which can be observed when the external structure of the heart is viewed is the pericardium.

Pericardium

The human heart is situated to the left of the chest and is enclosed within a fluid-filled cavity described as the pericardial cavity. The walls and lining of the pericardial cavity are made up of a membrane known as the pericardium.

The pericardium is a fibre membrane found as an external covering around the heart. It protects the heart by producing a serous fluid, which serves to lubricate the heart and prevent friction between the surrounding organs. Apart from the lubrication, the pericardium also helps by holding the heart in its position and by maintaining a hollow space for the heart to expand itself when it is full. The pericardium has two exclusive layers—

- **Visceral Layer:** It directly covers the outside of the heart.
- **Parietal Layer:** It forms a sac around the outer region of the heart that contains the fluid in the pericardial cavity.

Structure of the Heart Wall:

The heart wall is made up of 3 layers, namely:

- **Epicardium** – Epicardium is the outermost layer of the heart. It is composed of a thin-layered membrane that serves to lubricate and protect the outer section.
- **Myocardium** – This is a layer of muscle tissue and it constitutes the middle layer wall of the heart. It contributes to the thickness and is responsible for the pumping action.

- **Endocardium** – It is the innermost layer that lines the inner heart chambers and covers the heart valves. Furthermore, it prevents the blood from sticking to the inner walls, thereby preventing potentially fatal blood clots.

Internal Structure of Heart:

The internal structure of the heart is rather intricate with several chambers and valves that control the flow of blood.

Chambers of the Heart

Vertebrate hearts can be classified based on the number of chambers present. For instance, most fish have two chambers, reptiles and amphibians have three chambers. Avian and mammalian hearts consists of four chambers. Humans are mammals; hence, we have four chambers, namely:

- Left atrium
- Right atrium
- Left ventricle
- Right ventricle

Atria are thin, less muscular walls and smaller than ventricles. These are the blood-receiving chambers that are fed by the large veins.

Ventricles are larger and more muscular chambers responsible for pumping and pushing blood out to the circulation. These are connected to larger arteries that deliver blood for circulation.

The right ventricle and right atrium are comparatively smaller than the left chambers. The walls consist of fewer muscles compared to the left portion, and the size difference is based on their functions. The blood originating from the right side flows through the pulmonary circulation, while blood arising from the left chambers is pumped throughout the body.

Blood Vessels

In organisms with closed circulatory systems, the blood flows within vessels of varying sizes. All vertebrates, including humans, possess this type of circulation. The external structure of the heart has many blood vessels that form a network, with other major vessels emerging from within the structure. The blood vessels typically comprise the following:

- Veins supply deoxygenated blood to the heart via inferior and superior vena cava, and it eventually drains into the right atrium.
- Capillaries are tiny, tube-like vessels which form a network between the arteries to veins.
- Arteries are muscular-walled tubes mainly involved in supplying oxygenated blood away from the heart to all other parts of the body. Aorta is the largest of the arteries and it branches off into various smaller arteries throughout the body.

Valves

Valves are flaps of fibrous tissues located in the cardiac chambers between the veins. They ensure that the blood flows in a single direction (unidirectional). Flaps also prevent the blood from flowing backwards. Based on their function, valves are of two types:

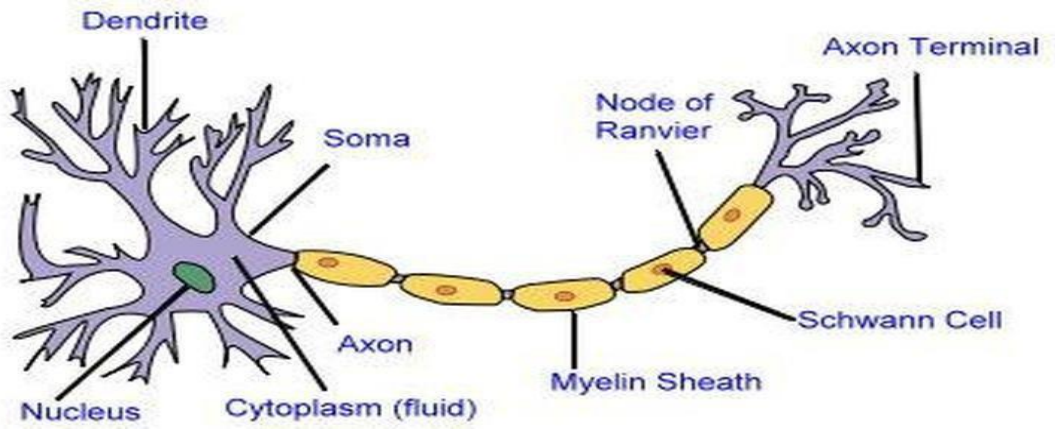
- Atrioventricular valves are between ventricles and atria. The valve between the right ventricle and right atrium is the tricuspid valve, and the one which is found between the left ventricle and left atrium is known as the mitral valve.
- Semilunar valves are located between the left ventricle and aorta. It is also found between the pulmonary artery and right ventricle.

2. a) Explain the structure and function of neuron. (Nov 2016, May 2015, Nov 2015, May 2016, May 2017, Dec 2017, May 2018, May 2019, May 2014)

- Neurons are the building blocks of the nervous system. They receive and transmit signals to different parts of the body. This is carried out in both physical and

electrical forms. There are several different types of neurons that facilitate the transmission of information.

- The sensory neurons carry information from the sensory receptor cells present throughout the body to the brain. Whereas, the motor neurons transmit information from the brain to the muscles. The interneurons transmit information between different neurons in the body.



Neuron Structure:

A neuron varies in shape and size depending upon their function and location. All neurons have three different parts – dendrites, cell body and axon.

Parts of Neuron:

Following are the different parts of a neuron:

Dendrites

These are branch-like structures that receive messages from other neurons and allow the transmission of messages to the cell body.

Cell Body

Each neuron has a cell body with a nucleus, Golgi body, endoplasmic reticulum, mitochondria and other components.

Axon

Axon is a tube-like structure that carries electrical impulse from the cell body to the axon terminals that passes the impulse to another neuron.

Synapse

It is the chemical junction between the terminal of one neuron and dendrites of another neuron.

Neuron Types

There are three different types of neurons:

Sensory Neurons

The sensory neurons convert signals from the external environment into corresponding internal stimuli. The sensory inputs activate the sensory neurons and carry sensory information to the brain and spinal cord. They are pseudounipolar in structure.

Motor Neurons

These are multipolar and are located in the central nervous system extending their axons outside the central nervous system. This is the most common type of neuron and transmits information from the brain to the muscles of the body.

Interneurons

They are multipolar in structure. Their axons connect only to the nearby sensory and motor neurons. The help in passing signals between two neurons.

Neuron Functions:

The important functions of a neuron are:

Chemical Synapse

In chemical synapses, the action potential affects other neurons through a gap present between two neurons known as the synapse. The action potential is carried along the axon to a postsynaptic ending that initiates the release of chemical messengers known as neurotransmitters. These neurotransmitters excite the postsynaptic neurons that generate an action potential of its own.

Electrical Synapse

When two neurons are connected by a gap junction, it results in an electrical synapse. These gaps include ion channels that help in the direct transmission of a positive electrical signal. These are much faster than chemical synapses.

Synapse:

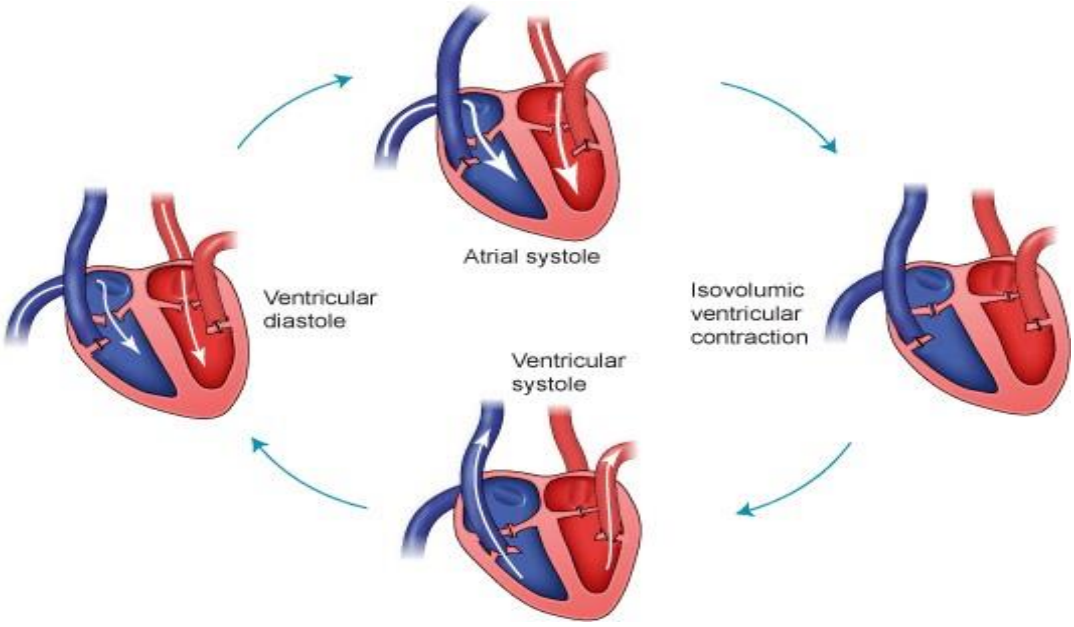
In the nervous system, a synapse is a structure that permits a neuron (or nerve cell) to pass an electrical or chemical signal to another neuron or to the target effector cell ..... In many synapses, the presynaptic part is located on an axon and the postsynaptic part is located on a dendrite or soma.

3. Explain cardiac cycle. Describe the nervous regulation of arterial blood pressure. (May 2015, May 2016, Dec 2017, May 2018, Dec 2019, Nov 2014)

A) Cardiac cycle:

The cardiac cycle is the performance of the human heart from the ending of one heartbeat to the beginning of the next. It consists of two periods: one during which the heart muscle relaxes and refills with blood, called diastole, following a period of robust contraction and pumping of blood, dubbed systole.

It involves the conversion of deoxygenated blood to oxygenated blood in the lungs and pumping it by the heart to the body through the aorta.



Cardiac Cycle Physiology:

The human heart consists of four chambers, comprising left and right halves. Two upper chambers include left and right atria; lower two chambers include right and left ventricles. The key function of the right ventricle is to pump deoxygenated blood through the pulmonary arteries and pulmonary trunk to the lungs. While the left ventricle is responsible for pumping newly oxygenated blood to the body through the aorta.

Cardiac Cycle Phases:

Following are the different phases that occur in a cardiac cycle:

Atrial Diastole: In this stage, chambers of the heart are calmed. That is when the aortic valve and pulmonary artery closes and atrioventricular valves open, thus causing chambers of the heart to relax.

Atrial Systole: At this phase, blood cells flow from atrium to ventricle and at this period, atrium contracts.

Isovolumic Contraction: At this stage, ventricles begin to contract. The atrioventricular valves, valve, and pulmonary artery valves close, but there won't be any transformation in volume.

Ventricular Ejection: Here ventricles contract and emptying. Pulmonary artery and aortic valve close.

Isovolumic Relaxation: In this phase, no blood enters the ventricles and consequently, pressure decreases, ventricles stop contracting and begin to relax. Now due to the pressure in the aorta – pulmonary artery and aortic valve close.

Ventricular Filling Stage: In this stage, blood flows from atria into the ventricles. It is altogether known as one stage (first and second stage). After that, they are three phases that involve the flow of blood to the pulmonary artery from ventricles.

Duration of Cardiac Cycle:

In a normal person, a heartbeat is 72 beats/minute. So, the duration of one cardiac cycle can be calculated as:

1/72 beats/minute=.0139 minutes/beat

At a heartbeat 72 beats/minute, duration of each cardiac cycle will be 0.8 seconds.

Duration of different stages of the cardiac cycle is given below:

- Atrial systole: continues for about 0.1 seconds
- Ventricular systole: continues for about 0.3 seconds
- Atrial diastole: continues for about 0.7 seconds
- Ventricular diastole: continues for about 0.5 seconds

B) Nervous regulation of arterial blood pressure:

- Short-term regulation of blood pressure is controlled by the autonomic nervous system (ANS).
- Changes in blood pressure are detected by baroreceptors. These are located in the arch of the aorta and the carotid sinus.

- Increased arterial pressure stretches the wall of the blood vessel, triggering the baroreceptors. These baroreceptors then feedback to the autonomic nervous system. The ANS then acts to reduce the heart rate and cardiac contractility via the efferent parasympathetic fibres (vagus nerve). This reduces the blood pressure.
- Decreased arterial pressure is detected by baroreceptors, which trigger a sympathetic response. This stimulates an increase in heart rate and cardiac contractility leading to increased blood pressure.

4. Define ECG. Describe the waves, segments and intervals of ECG. Add a note on ECG leads. (May 2017, May 2019, May 2014)

ECG:

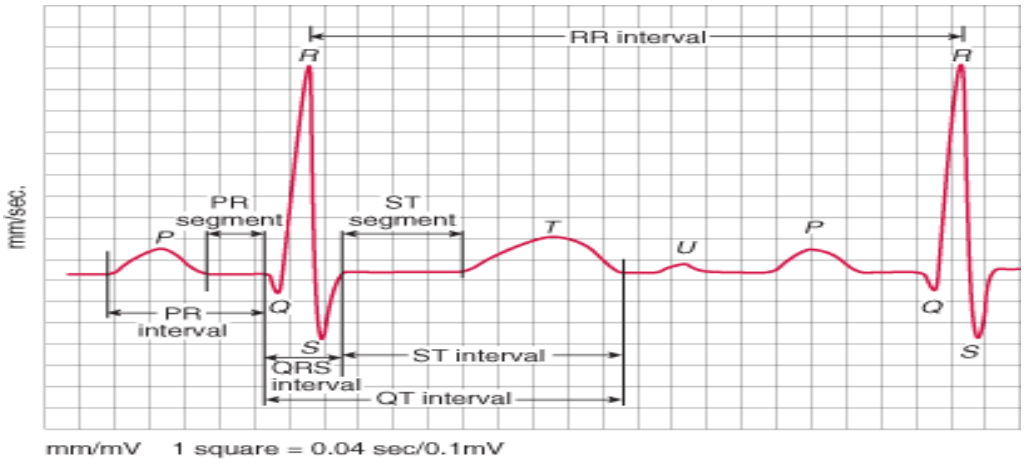
An electrocardiogram (ECG or EKG) is a test that checks how your heart is functioning by measuring the electrical activity of the heart. With each heart beat, an electrical impulse (or wave) travels through your heart. This wave causes the muscle to squeeze and pump blood from the heart.

Intervals:

An interval in an ECG is a *duration of time* that *includes one segment and one or more waves.* The PR (or PQ) interval starts at the start of the P wave and ends at the start of the QRS. It denotes the conduction of the impulse from the upper part of the atrium to the ventricle. The QRS interval covers the QRS complex from beginning to end. [The QRS complex also covers an interval]. The QT interval starts at the start of the QRS and ends at the end of the T wave. It denotes the electrical systole of the heart. Intervals are only described based on their duration of time. You speak of it as duration and so cannot talk about the morphology or depression or elevation of an interval.

Waves:

- P wave = Atrial depolarization. The positive wave of depolarization spreads from the SA node and is conducted throughout the cells of the atria through gap junctions in that connect these cells.
- PR segment = depolarization of the AV node. I.e. When current is passing through the AV node. It's a flat line because the wave is not strong enough to be recorded on the voltmeter.
- PR interval = Wave goes over the atrium and through the AV node and ends just before it activates the ventricles to depolarize.

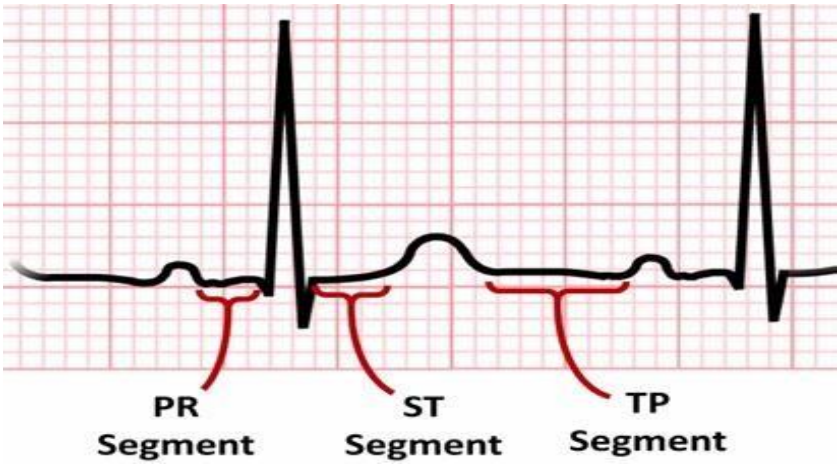


- Q wave = Ventricular Septal Depolarization
- R wave = Resultant or major ventricular muscle depolarization. The resultant vector is directed downward and leftward.

- S wave = Basal Ventricular depolarization, i.e. depolarization of the base of the ventricles. Note the apex of the heart is the L. pointed end. The base of the ventricles connects to the atria.
- ST segment = During the ST segment, all the ventricular myocardium is depolarized. All have positive charges. So there is nothing potential difference to be recorded by the voltmeter (ECG machine). So you have a flat line.
- T wave represents ventricular repolarization.
- QT interval = Important because it captures the beginning of ventricular depolarization through the plateau phase to the ventricular repolarization. It covers the entire ventricular activity. During this time, the action potential was generated and terminated in the ventricular tissue. The beginning of the QRS complex is the start of ventricular systole and that goes until the end of the T wave. Ventricular diastole starts when the T wave ends.
- U wave. Sometimes the electrical activity of the ventricular papillary muscle is out of phase with the rest of the ventricles and will record as a "U" wave that shows after the T wave.

Segments:

A *segment* in an ECG is *the region between two waves.* PR segment starts at the end of the P wave and ends at the start of the QRS complex. The ST segment starts at the end of the QRS wave and ends at the start of the T wave. With segments, you talk about morphology: elevation or depression or progression of segments.



ECG Lead system:

The electrical signals from the heart are measured with surface electrodes. The resulting electrode potential in the heart conducts to the body surface. Standardized electrode positions are used to record the ECG. The three types of electrode systems are

1. Bipolar limb leads or standard leads
2. Augmented unipolar limb leads
3. Chest leads
4. Frank lead system

I) Bipolar Limb leads – Standard Lead I, Lead II and Lead III

This lead system is also known as Einthoven lead system. Two electrodes record the ECG signal. As shown in figure from four body locations of our body namely Right Arm(RA), Left Arm(LA), Right Leg(RL) and Left Leg(LL) potentials are recorded.

II) Augmented Unipolar Leads:

Central terminal relates to the center of the body. Two equal and large resistors are used. Pair of limb electrodes is connected to the resistors. The center joint connection of this resistive network forms the central terminal. The remaining portion of the limb electrode forms the exploratory electrode. In this lead system, a very small increase in ECG voltage can be found.

III) Chest Leads:

V1 – Fourth intercostal space of right sternal margin, V2 – Fourth intercostal space at left sternal margin, V3 – Midpoint between V2 and V4, V4 – Fifth intercostal space at mid – clavicle line, V5 – Same as V4 position but on anterior auxiliary line, V6 – Same as V4 position but on mid auxiliary line.

IV) Frank Lead System:

In this method, the state of heart is studied 3 dimensionally. Here information are got from 12 lead system - 3 Bipolar leads, 3 Unipolar leads, 6 Chest leads. This method is also called as corrected orthogonal lead system.

UNIT-III

Respiratory system

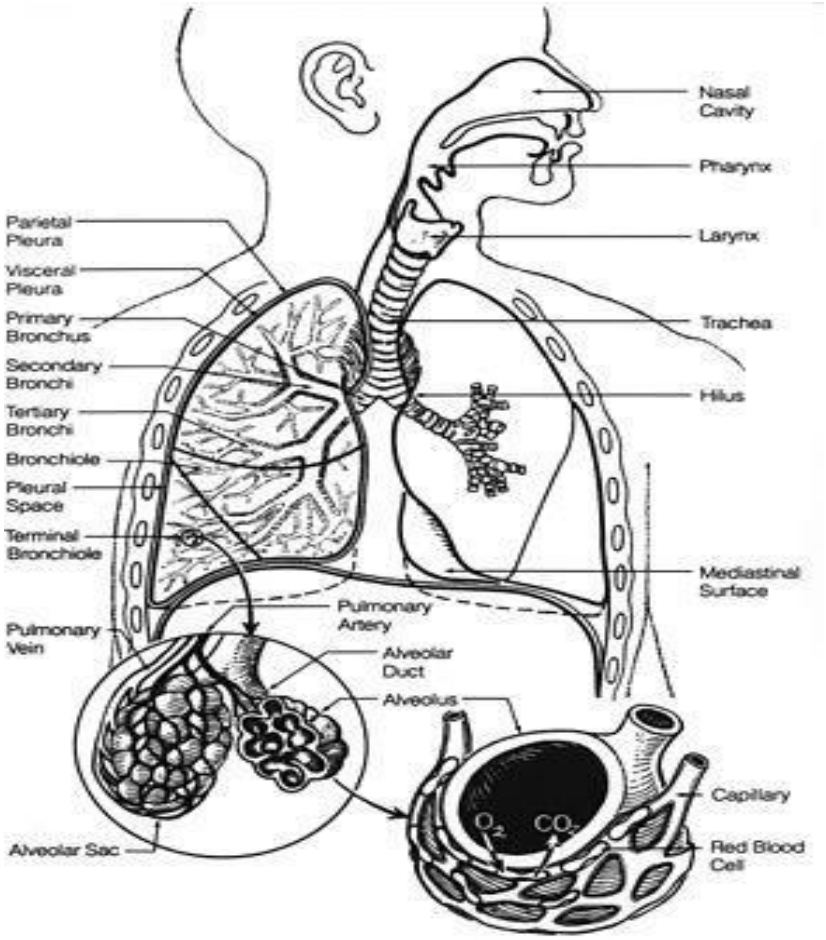
INTRODUCTION

The respiratory system is responsible for one of the essential functions of life, breathing. Breathing enables us to take in oxygen and expel carbon dioxide. Every cell in the body depends on oxygen to function. If the supply of oxygen is impaired in any way, the entire body is affected.

The respiratory system is an intricate arrangement of spaces and passageways that conduct air into the lungs. These spaces include the nasal cavities; the pharynx, which is common to the digestive and respiratory systems; the voice box, or larynx; the windpipe, or trachea; and the lungs themselves, with their conducting tubes and air sacs.

Respiration is also defined as the movement of oxygen from the outside environment to the cells within tissues, and the transport of carbon dioxide in the opposite direction.

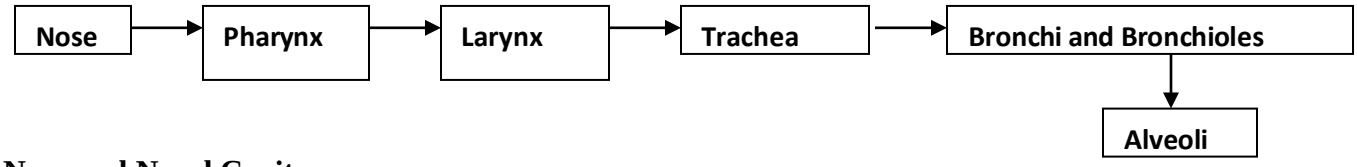
Fig. Human Respiratory system



The respiratory system (also respiratory apparatus, ventilator system) is a biological system consisting of specific organs and structures used for gas exchange. The anatomy and physiology that make this happen varies greatly, depending on the size of the organism, the environment in which it lives and its evolutionary history. Gas exchange in the lungs occurs in millions of small air sacs called alveoli. These microscopic air sacs have a very rich blood supply, thus bringing the air into close contact with the blood. These air sacs communicate with the external environment via a system of airways, or hollow tubes, of which the largest is the trachea, which branches in the middle of the chest into the two main bronchi. These enter the lungs where they branch into progressively narrower secondary and tertiary bronchi that branch into numerous smaller tubes, the bronchioles. Air has to be pumped from the environment into the alveoli or atria by the process of breathing which involves the muscles of respiration.

The cells of the human body require a constant stream of oxygen to stay alive. The respiratory system provides oxygen to the body's cells while removing carbon dioxide, a waste product that can be lethal if allowed to accumulate. There are 3 major parts of the respiratory system: the airway, the lungs, and the muscles of respiration. The airway, which includes the nose, mouth, pharynx, larynx, trachea, bronchi, and bronchioles, carries air between the lungs and the body's exterior. The lungs act as the functional units of the respiratory system by passing oxygen into the body and carbon dioxide out of the body. Finally, the muscles of respiration, including the diaphragm and intercostal muscles, work together to act as a pump, pushing air into and out of the lungs during breathing.

Pathway of Respiratory system:



Nose and Nasal Cavity

The **nose and nasal cavity** form the main external opening for the respiratory system and are the first section of the body's airway—the respiratory tract through which air moves. The nose is a structure of the face made of cartilage, bone, muscle, and skin that supports and protects the anterior portion of the nasal cavity. The nasal cavity is a hollow space within the nose and **skull** that is lined with hairs and mucus membrane. The function of the nasal cavity is to warm, moisturize, and filter air entering the body before it reaches the lungs. Hairs and mucus lining the nasal cavity help to trap dust, mold, pollen and other environmental contaminants before they can reach the inner portions of the body. Air exiting the body through the nose returns moisture and heat to the nasal cavity before being exhaled into the environment.

Mouth

The mouth, also known as the **oral cavity**, is the secondary external opening for the respiratory tract. Most normal breathing takes place through the nasal cavity, but the oral cavity can be used

to supplement or replace the nasal cavity's functions when needed. Because the pathway of air entering the body from the mouth is shorter than the pathway for air entering from the nose, the mouth does not warm and moisturize the air entering the lungs as well as the nose performs this function. The mouth also lacks the hairs and sticky mucus that filter air passing through the nasal cavity. The one advantage of breathing through the mouth is that its shorter distance and larger diameter allows more air to quickly enter the body.

Pharynx

The pharynx, also known as the throat, is a muscular funnel that extends from the posterior end of the nasal cavity to the superior end of the **esophagus** and larynx. The pharynx is divided into 3 regions: the nasopharynx, oropharynx, and laryngopharynx. The **nasopharynx** is the superior region of the pharynx found in the posterior of the nasal cavity. Inhaled air from the nasal cavity passes into the nasopharynx and descends through the oropharynx, located in the posterior of the oral cavity. Air inhaled through the oral cavity enters the pharynx at the **oropharynx**. The inhaled air then descends into the **laryngopharynx**, where it is diverted into the opening of the larynx by the epiglottis. The **epiglottis** is a flap of elastic cartilage that acts as a switch between the trachea and the esophagus. Because the pharynx is also used to swallow food, the epiglottis ensures that air passes into the trachea by covering the opening to the esophagus. During the process of swallowing, the epiglottis moves to cover the trachea to ensure that food enters the esophagus and to prevent choking.

Larynx

The **larynx**, also known as the voice box, is a short section of the airway that connects the laryngopharynx and the trachea. The larynx is located in the anterior portion of the neck, just inferior to the **hyoid bone** and superior to the trachea. Several cartilage structures make up the larynx and give it its structure. The epiglottis is one of the cartilage pieces of the larynx and serves as the cover of the larynx during swallowing. Inferior to the epiglottis is the **thyroid cartilage**, which is often referred to as the Adam's apple as it is most commonly enlarged and visible in adult males. The **thyroid**holds open the anterior end of the larynx and protects the vocal folds. Inferior to the thyroid cartilage is the ring-shaped cricoid cartilage which holds the larynx open and supports its posterior end. In addition to cartilage, the larynx contains special structures known as vocal folds, which allow the body to produce the sounds of speech and singing. The vocal folds are folds of mucous membrane that vibrate to produce vocal sounds. The tension and vibration speed of the vocal folds can be changed to change the pitch that they produce.

Trachea

The trachea, or windpipe, is a 5-inch long tube made of C-shaped hyaline cartilage rings lined with pseudostratified ciliated columnar epithelium. The trachea connects the larynx to the bronchi and allows air to pass through the neck and into the thorax. The rings of cartilage making up the trachea allow it to remain open to air at all times. The open end of the cartilage rings faces posteriorly toward the esophagus, allowing the esophagus to expand into the space occupied by the trachea to accommodate masses of food moving through the esophagus.

The main function of the trachea is filter the inhaled air and to provide a clear airway for air to enter and exit the lungs. In addition, the epithelium lining the trachea produces mucus that traps dust and other contaminants and prevents it from reaching the lungs. Cilia on the surface of the epithelial cells move the mucus superiorly toward the pharynx where it can be swallowed and digested in the gastrointestinal tract.

Bronchi and Bronchioles

At the inferior end of the trachea, the airway splits into left and right branches known as the primary bronchi. The left and right bronchi run into each lung before branching off into smaller secondary bronchi. The secondary bronchi carry air into the lobes of the lungs—2 in the left lung and 3 in the right lung. The secondary bronchi in turn split into many smaller tertiary bronchi within each lobe. The **tertiary bronchi** split into many smaller bronchioles that spread throughout the lungs. Each bronchiole further splits into many smaller branches less than a millimeter in diameter called terminal bronchioles. Finally, the millions of tiny terminal bronchioles conduct air to the alveoli of the lungs.

As the airway splits into the tree-like branches of the bronchi and bronchioles, the structure of the walls of the airway begins to change. The primary bronchi contain many C-shaped cartilage rings that firmly hold the airway open and give the bronchi a cross-sectional shape like a flattened circle or a letter D. As the bronchi branch into secondary and tertiary bronchi, the cartilage becomes more widely spaced and more smooth muscle and elastin protein is found in the walls. The bronchioles differ from the structure of the bronchi in that they do not contain any cartilage at all. The presence of smooth muscles and elastin allow the smaller bronchi and bronchioles to be more flexible and contractile.

The main function of the bronchi and bronchioles is to carry air from the trachea into the lungs. Smooth muscle tissue in their walls helps to regulate airflow into the lungs. When greater volumes of air are required by the body, such as during exercise, the smooth muscle relaxes to dilate the bronchi and bronchioles. The dilated airway provides less resistance to airflow and allows more air to pass into and out of the lungs. The smooth muscle fibers are able to contract during rest to prevent hyperventilation. The bronchi and bronchioles also use the mucus and cilia of their epithelial lining to trap and move dust and other contaminants away from the lungs.

Lungs

The **lungs** are a pair of large, spongy organs found in the thorax lateral to the **heart** and superior to the diaphragm. Each lung is surrounded by a pleural membrane that provides the lung with space to expand as well as a negative pressure space relative to the body's exterior. The negative pressure allows the lungs to passively fill with air as they relax. The left and right lungs are slightly different in size and shape due to the heart pointing to the left side of the body. The left lung is therefore slightly smaller than the right lung and is made up of 2 lobes while the right lung has 3 lobes.

The interior of the lungs is made up of spongy tissues containing many capillaries and around 30 million tiny sacs known as **alveoli**. The alveoli are cup-shaped structures found at the end of the terminal bronchioles and surrounded by capillaries. The alveoli are lined with thin simple squamous epithelium that allows air entering the alveoli to exchange its gases with the blood passing through the capillaries.

Muscles of Respiration

Surrounding the lungs are sets of muscles that are able to cause air to be inhaled or exhaled from the lungs. The principal muscle of respiration in the human body is the diaphragm, a thin sheet of skeletal muscle that forms the floor of the thorax. When the diaphragm contracts, it moves inferiorly a few inches into the abdominal cavity, expanding the space within the thoracic cavity and pulling air into the lungs. Relaxation of the diaphragm allows air to flow back out the lungs during exhalation.

Between the ribs are many small **intercostal muscles** that assist the diaphragm with expanding and compressing the lungs. These muscles are divided into 2 groups: the internal intercostal muscles and the external intercostal muscles. The internal intercostal muscles are the deeper set of muscles and depress the ribs to compress the thoracic cavity and force air to be exhaled from the lungs. The external intercostals are found superficial to the internal intercostals and function to elevate the ribs, expanding the volume of the thoracic cavity and causing air to be inhaled into the lungs.

Pulmonary Ventilation

Pulmonary ventilation is the process of moving air into and out of the lungs to facilitate gas exchange. The respiratory system uses both a negative pressure system and the contraction of muscles to achieve pulmonary ventilation. The negative pressure system of the respiratory system involves the establishment of a negative pressure gradient between the alveoli and the external atmosphere. The pleural membrane seals the lungs and maintains the lungs at a pressure slightly below that of the atmosphere when the lungs are at rest. This results in air following the pressure gradient and passively filling the lungs at rest. As the lungs fill with air, the pressure within the lungs rises until it matches the atmospheric pressure. At this point, more air can be inhaled by the contraction of the diaphragm and the external intercostal muscles, increasing the volume of the thorax and reducing the pressure of the lungs below that of the atmosphere again.

To exhale air, the diaphragm and external intercostal muscles relax while the internal intercostal muscles contract to reduce the volume of the thorax and increase the pressure within the thoracic cavity. The pressure gradient is now reversed, resulting in the exhalation of air until the pressures inside the lungs and outside of the body are equal. At this point, the elastic nature of the lungs causes them to recoil back to their resting volume, restoring the negative pressure gradient present during inhalation.

EXCHANGE OF GASES:

Transportation of Gases

The 2 major respiratory gases, oxygen and carbon dioxide, are transported through the body in the blood. Blood plasma has the ability to transport some dissolved oxygen and carbon dioxide, but most of the gases transported in the blood are bonded to transport molecules. Hemoglobin is an important transport molecule found in red blood cells that carries almost 99% of the oxygen in the blood. Hemoglobin can also carry a small amount of carbon dioxide from the tissues back to the lungs. However, the vast majority of carbon dioxide is carried in the plasma as bicarbonate ion. When the partial pressure of carbon dioxide is high in the tissues, the enzyme carbonic anhydrase catalyzes a reaction between carbon dioxide and water to form carbonic acid. Carbonic acid then dissociates into hydrogen ion and bicarbonate ion. When the partial pressure of carbon dioxide is low in the lungs, the reactions reverse and carbon dioxide is liberated into the lungs to be exhaled.

Homeostatic Control of Respiration

Under normal resting conditions, the body maintains a quiet breathing rate and depth called eupnea. Eupnea is maintained until the body's demand for oxygen and production of carbon dioxide rises due to greater exertion. Autonomic chemo receptors in the body monitor the partial pressures of oxygen and carbon dioxide in the blood and send signals to the respiratory center of the brain stem. The respiratory center then adjusts the rate and depth of breathing to return the blood to its normal levels of gas partial pressures.

INSPIRATION:

Inspiration is the active part of the breathing process, which is initiated by the respiratory control centre in medulla oblongata (Brain stem). Activation of medulla causes a contraction of the diaphragm and 6ransaction6 muscles leading to an expansion of thoracic cavity and a decrease in the pleural space pressure. The diaphragm is a dome-shaped structure that separates the thoracic and abdominal cavities and is the most important muscle of inspiration. When it contracts, it moves downward and because it is attached to the lower ribs it also rotates the ribs toward the horizontal plane, and thereby further expands the chest cavity. In normal quite breathing the diaphragm moves downward about 1 cm but on forced inspiration/expiration total movement could be up to 10 cm. When it is paralysed it moves to the opposite direction (upwards) with inspiration, paradoxical movement. The external 6ransaction6 muscles connect adjacent ribs. When they contract the ribs are pulled upward and forward causing further increase in the volume of the thoracic cavity. As a result fresh air flows along the branching airways into the alveoli until the alveolar pressure equals to the pressure at the airway opening.

EXPIRATION:

Expiration is a passive event due to elastic recoil of the lungs. However, when a great deal of air has to be removed quickly, as in exercise, or when the airways narrow excessively during

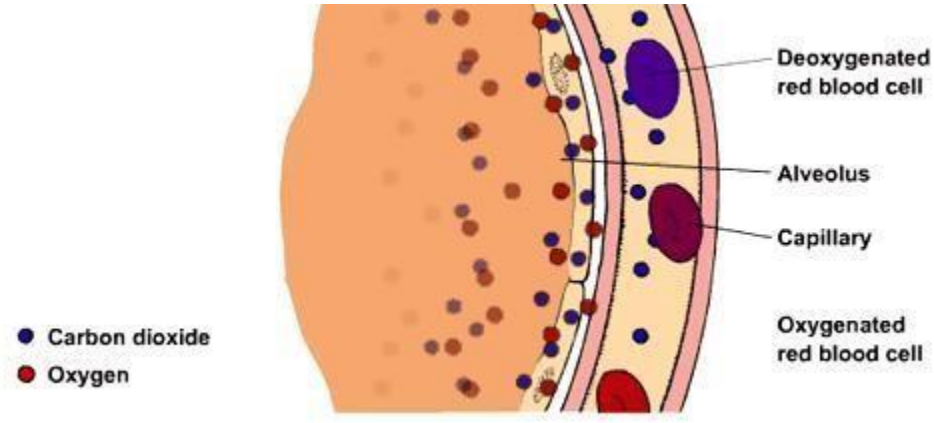
expiration, as in asthma, the internal 7ransaction7 muscles and the anterior abdominal muscles contract and accelerate expiration by raising pleural pressure.

COUPLING OF THE LUNGS AND THE CHEST WALL:

The lungs are not directly attached to the chest wall but they change their volume and shape according to the changes in shape and volume of the thoracic cavity. Pleura covering the surfaces of the lungs (visceral) or the thoracic cavity (parietal) together with a thin (20 μm) layer of liquid between them create a liquid coupling.

The primary function of the respiratory system is to exchange oxygen and carbon dioxide. Inhaled oxygen enters the lungs and reaches the alveoli. The layers of cells lining the alveoli and the surrounding capillaries are each only one cell thick and are in very close contact with each other. This barrier between air and blood averages about 1 micron ($^{1}/_{10,000}$ of a centimeter, or 0.000039 inch) in thickness. Oxygen passes quickly through this air-blood barrier into the blood in the capillaries. Similarly, carbon dioxide passes from the blood into the alveoli and is then exhaled.

Oxygenated blood travels from the lungs through the pulmonary veins and into the left side of the heart, which pumps the blood to the rest of the body. Oxygen-deficient, carbon dioxide-rich blood returns to the right side of the heart through two large veins, the superior vena cava and the inferior vena cava. Then the blood is pumped through the pulmonary artery to the lungs, where it picks up oxygen and releases carbon dioxide.



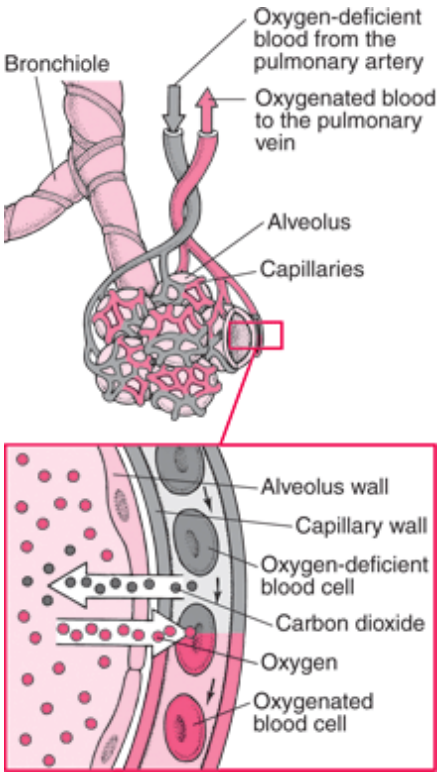
Gas Exchange between Alveoli and Capillaries

To support the exchange of oxygen and carbon dioxide, about 5 to 8 liters (about 1.3 to 2.1 gallons) of air per minute are brought in and out of the lungs, and about three tenths of a liter of oxygen is transferred from the alveoli to the blood each minute, even when the person is at rest. At the same time, a similar volume of carbon dioxide moves from the blood to the alveoli and is exhaled. During exercise, it is possible to breathe in and out more than 100 liters (about 26 gallons) of air per minute and extract 3 liters (a little less than 1 gallon) of oxygen from this air

per minute. The rate at which oxygen is used by the body is one measure of the rate of energy expended by the body. Breathing in and out is accomplished by respiratory muscles.

Gas Exchange between Alveolar Spaces and Capillaries

The function of the respiratory system is to exchange two gases: oxygen and carbon dioxide. The exchange takes place in the millions of alveoli in the lungs and the capillaries that envelop them. As shown below, inhaled oxygen moves from the alveoli to the blood in the capillaries, and carbon dioxide moves from the blood in the capillaries to the air in the alveoli.



Three processes are essential for the transfer of oxygen from the outside air to the blood flowing through the lungs: ventilation, diffusion, and perfusion.

- Ventilation is the process by which air moves in and out of the lungs.
- Diffusion is the spontaneous movement of gases, without the use of any energy or effort by the body, between the gas in the alveoli and the blood in the capillaries in the lungs.
- Perfusion is the process by which the cardiovascular system pumps blood throughout the lungs.

The body's circulation is an essential link between the atmosphere, which contains oxygen, and the cells of the body, which consume oxygen. For example, the delivery of oxygen to the muscle cells throughout the body depends not only on the lungs but also on the ability of the blood to carry oxygen and on the ability of the circulation to transport blood to muscle.

REGULATION OF RESPIRATION:

Oxygen requirement by the body differs depending on the activity. It is lowest at rest and increases during routine activity and further increases in muscular exercise. Similarly production of carbon dioxide also is dependent on the rate of metabolic activity in the body.

Respiratory system has the responsibility of meeting needs of the body by altering the rate and depth of respiration in order to keep the pO_2 and pCO_2 at normal levels.
The regulation of respiration can be brought about by:

1. Neural mechanism.

2. Chemical influence.

3. Non-chemical influence.

The chemical and non-chemical influence has to act through the neural mechanism only (Fig. 4.25).

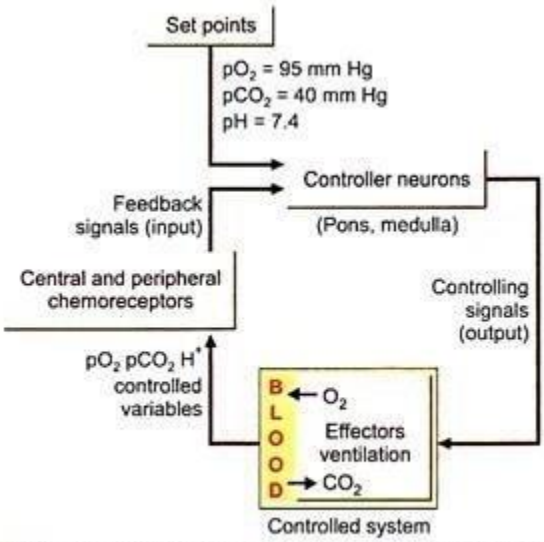


Fig. 4.25: Feedback circuit involved in the regulation of respiration

I. Neural Mechanism of Respiration: Centers are present in brainstem. The brainstem centers are required for rhythmic respiration whether during asleep or awake. The cerebral cortical center is required for voluntary alterations in respiration.

Brainstem centers are present in the reticular formation of pons and medulla oblongata.

In the pons, the centers present are:
i. Pneumotaxic

ii. Apneustic

In medulla oblongata, the centers present are:
i. Inspiratory (dorsomedial group of neurons)

ii. Expiratory (ventrolateral group of neurons)

There is a lot of interconnection between the various centers. The interplay of the different centers is essential for a proper regulation of respiration. The medullary centers are termed as basic centers, whereas the pontine centers are called regulatory centers. The pontine centers act through the medullary centers and bring about smooth rhythmic respiration.

From the medullary centers, which are also spontaneously active, the impulses are sent to spinal cord through the reticulospinal pathway, which ends on the anterior horn cells in spinal cord. Both the phrenic (C3-C5) and 10ransaction10 nerve (T1-T11) take origin from spinal cord and influence the activity of diaphragm and intercostals muscles, respectively.

So if there is a complete transverse section of spinal cord at the level of:
i. C2 segment person dies of respiratory paralysis.

ii. C6 person survives because the diaphragmatic respiration continues.

In a normal person, the inspiratory center (IC) appears to generate impulse on its own. During the course of the generation of impulse, it is presumed that the rate of impulse generation goes on increasing till it reaches a certain point and then there will be sudden cessation of impulse generation. Because of this, IC is known to act as a ramp generator.

The impulses from the apneustic center have a regulatory influence on the inspiratory center. The apneustic center activity in turn is controlled by the impulses coming from the pneumotaxic center and through the vagus nerve from the stretch receptors of lungs.

When the influence by the vagus and pneumotaxic center over the apneustic center is lost, there will be prolonged inspiration and a sudden expiration. This type of breathing is known as apneustic breathing (Fig. 4.26).

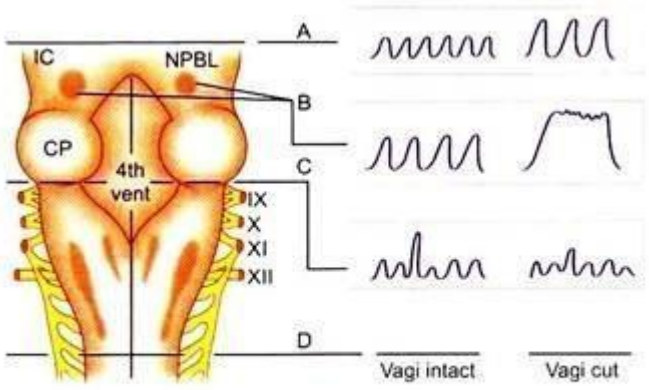


Fig. 4.26: Role of pontine respiratory centers over the medullary centers and also the role of vagus in control of breathing

Sequence of events during normal regulation of respiration by neural mechanism:

i. Onset and gradual increase in the number of impulses production in the inspiratory center because of the ramp generator.

ii. This leads to:

a. Impulses being sent from IC to spinal cord for stimulation of phrenic and intercostals nerves.

b. Reciprocal inhibition of expiratory center by IC.

c. Excitatory impulses from IC sent to pneumotaxic center through multisynaptic pathway.

iii. When inspiration is going on, there will be gradual inhibition of the apneustic center by the impulses coming from the pneumotaxic center and also from the afferent vagal fibers coming from the distended alveoli.

iv. Apneustic center influence over the IC ceases completely. Hence the activity of inspiratory center stops and leads to no inhibition influence over the expiratory center (EC). No more impulses from the inspiratory center to motor neurons in the spinal cord.

v. The muscles of inspiration start relaxing. This starts the process of expiration which normally lasts for about 3 sec.

vi. After this, once again the activity in the IC starts, leading to the next respiratory cycle.

Location of the respiratory centers in CNS for rhythmic respiration can be experimentally studied from the following observations:

1. If 11ransaction is done above pons, the rhythmic respiration continues as usual.

2. If a mid-pontine section is done along with bilateral vagotomy, there will be a prolonged inspiration followed by a sudden short expiration (apneustic type of breathing).

3. If 12ransaction is done between pons and medulla oblongata, though respiration continues on its own, it will be irregular. Sometimes it becomes shallow and sometimes it is deeper. This type of breathing is known as gasping.

4. If 12ransaction is done below medulla (at the beginning of the spinal cord), it leads to complete cessation of breathing.

So by the above studies, it can be concluded that the centers are present in brainstem. The pontine centers play role in smooth and rhythmic respiration.

Hering-Brueur reflex:
Inflation of alveoli brings about cessation of inspiration and expiration commences.

The details are as under:
i. Inflation of alveoli

ii. Leads of stimulation of stretch receptors present in the alveoli.

iii. Afferent impulses are carried by vagal fibers.

iv. Inhibit the activity of the respiratory center, cessation of inspiration.

v. Leads to relaxation of muscles of inspiration.

vi. Expiration commences.

This reflex is not very well seen in adults. The reflex probably helps to prevent over distension of the alveoli.

II. Chemical Influence on Respiration:
This is brought about by the chemoreceptors.

They are called:
i. Peripheral

ii. Central chemoreceptors.

Peripheral Chemoreceptors (Fig. 4.27):

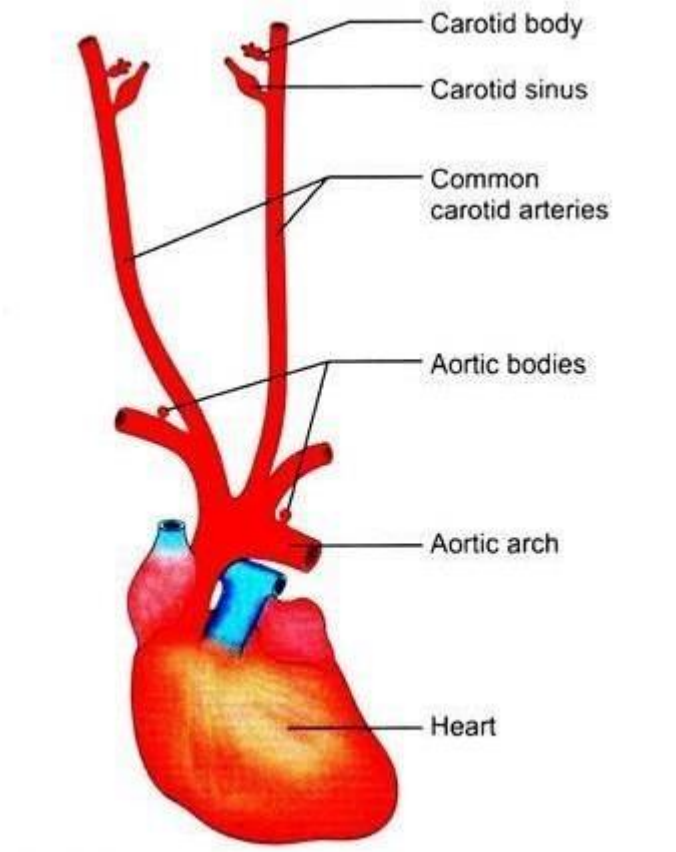


Fig. 4.27: Location of peripheral chemoreceptors

a. Carotid bodies which are present at the branching of internal carotid artery.

b. Aortic bodies are present in the arch of aorta.

From the carotid bodies, the afferent impulses will be carried by the sinus nerve (Fig. 4.28) a branch of glossopharyngeal nerve and from the aortic bodies by the aortic nerve branch of vagus nerve.

The peripheral chemoreceptors respond to:
i. Decrease in pO_2
ii. Increase in H^+
iii. Increase of pCO_2 of blood.
Details of the role of peripheral chemoreceptors in regulation of respiration are shown in Figs 4.29 to 4.33.

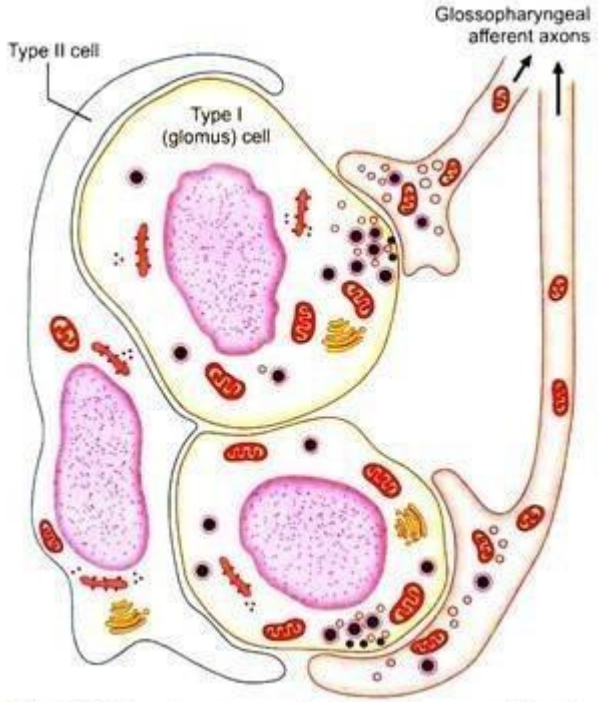


Fig. 4.28: Afferent nerve carrying impulse from carotid body

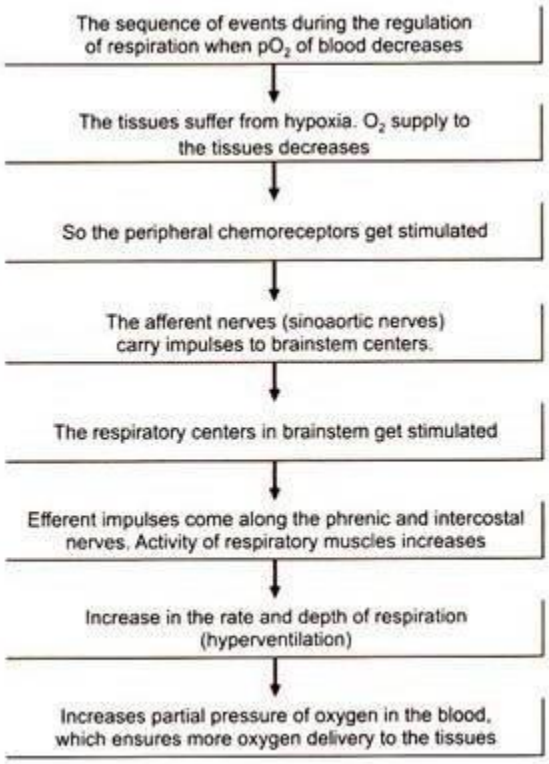


Fig. 4.29: Sequence of events during the regulation of respiration by peripheral chemoreceptors

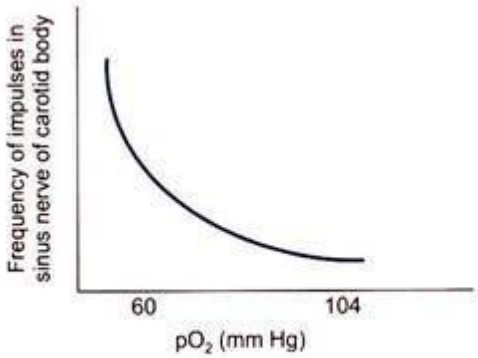


Fig. 4.30: Relationship between pO_2 and frequency of impulses in the sinus nerve from the carotid body

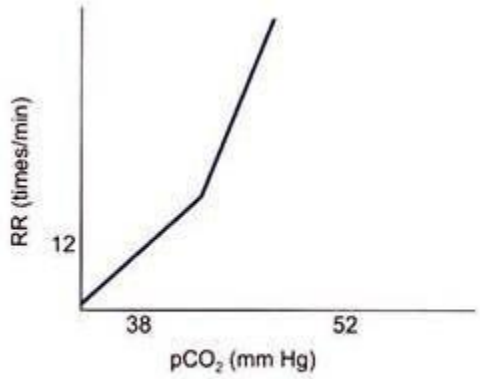


Fig. 4.31: Relationship between pCO_2 and rate of respiration

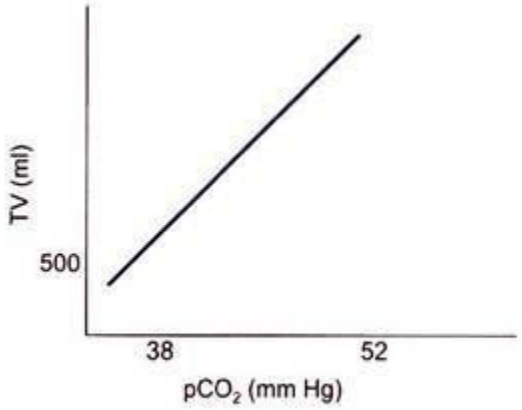


Fig. 4.32: Relationship between pCO_2 and tidal volume

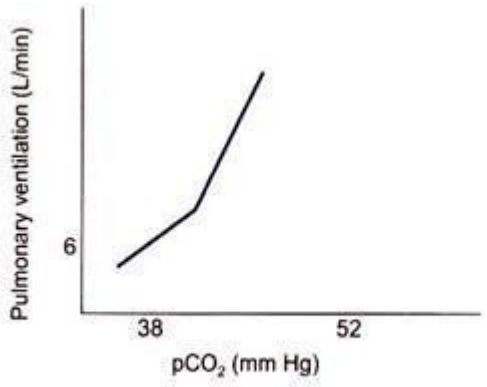


Fig. 4.33: Relationship between pCO_2 and pulmonary ventilation

Central Chemoreceptors:

They are present in the brainstem near the respiratory centers. They are more sensitive to hydrogen ions, but the hydrogen ion of blood cannot stimulate them because the blood brain-barrier is impermeable for the hydrogen ion to diffuse through. Hence, the increase in partial pressure of carbon dioxide forms the stimulus (Fig. 4.34).

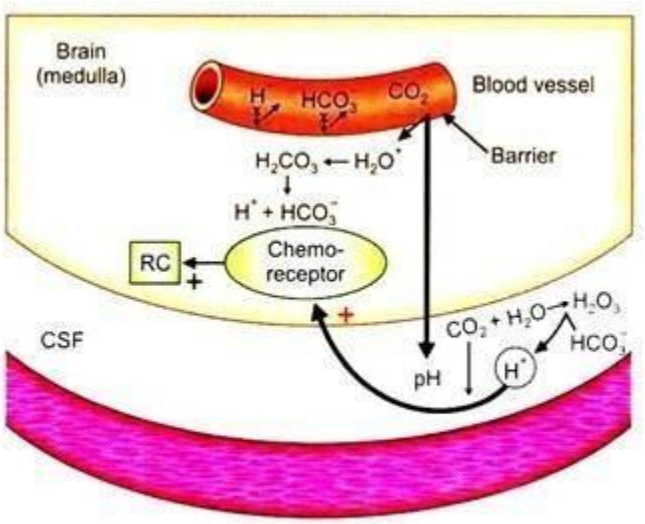


Fig. 4.34: Reactions occurring in the brain and the consequent stimulation of central chemoreceptos

Decreased pO_2, increased pCO_2 together (asphyxia) will have an additive effect on chemoreceptors. Hence there will be maximum respiratory response in such a situation (Fig. 4.35). Asphyxia occurs in conditions, like drowning or strangulation.

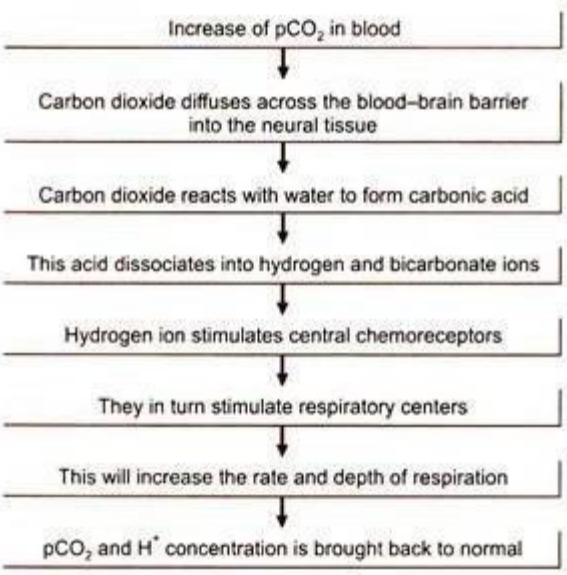


Fig. 4.35: Sequence of events during the regulation of respiration by central chemoreceptors

III. Non-Chemical Influence on Respiration:

Non-chemical influence on respiratory centers pertains to impulses coming from:

i. Baroreceptors

ii. Muscle spindles of respiratory muscles to control depth of respiration.

iii. Pain receptors

iv. Intracranial tension

v. Irritant receptors stimulation in lungs while coughing.

vi. Higher parts of CNS

vii. Irritation of nasal mucosa (sneezing)

viii. Mechanoreceptors in pharynx (deglutition).

ix. Receptors of muscles and joints.

Depending on the location of the receptors influencing the respiratory centers, there will be appropriate alterations in the respiration.

Disturbances of Respiratory Function : The majority of diseases of the respiratory system fall into one of three major categories: (1) obstructive lung diseases; (2) restrictive disorders; and (3) abnormalities of the vasculature. Obstructive lung diseases are most common and primarily

include disorders of the airways, such as asthma, chronic obstructive pulmonary disease (COPD), bronchiectasis, and bronchiolitis. Diseases resulting in restrictive pathophysiology include parenchymal lung diseases, abnormalities of the chest wall and pleura, and neuromuscular disease. Disorders of the pulmonary vasculature include pulmonary embolism, pulmonary hypertension, and pulmonary veno-occlusive disease. Although many specific diseases fall into these major categories, both infective and neoplastic processes can affect the respiratory system and result in myriad pathologic findings, including those listed in the three categories above

CATEGORIES OF RESPIRATORY DISEASE

Category	Examples
Obstructive lung disease	Asthma
	Chronic obstructive pulmonary disease (COPD)
	Bronchiectasis
	Bronchiolitis
Restrictive pathophysiology—parenchymal disease	Idiopathic pulmonary fibrosis (IPF)
	Asbestosis
	Desquamative interstitial pneumonitis (DIP)
	Sarcoidosis
Restrictive pathophysiology—neuromuscular weakness	Amyotrophic lateral sclerosis (ALS)
	Guillain-Barré syndrome
Restrictive pathophysiology—chest wall/pleural disease	Kyphoscoliosis
	Ankylosing spondylitis
	Chronic pleural effusions
Pulmonary vascular disease	Pulmonary embolism
	Pulmonary arterial hypertension (PAH)
Malignancy	Bronchogenic carcinoma (non-small-cell and small-cell)
	Metastatic disease
Infectious diseases	Pneumonia
	Bronchitis
	Tracheitis

:

Disorders can also be grouped according to gas exchange abnormalities, including hypoxemic, hypercarbic, or combined impairment. However, many diseases of the lung do not manifest as gas exchange abnormalities.

As with the evaluation of most patients, the approach to a patient with disease of the respiratory system begins with a thorough history and a focused physical examination. Many patients will subsequently undergo pulmonary function testing, chest imaging, blood and sputum analysis, a variety of serologic or microbiologic studies, and diagnostic procedures, such as bronchoscopy.

Dyspnea and Cough: The cardinal symptoms of respiratory disease are dyspnea and cough. Dyspnea has many causes, some of which are not predominantly due to lung pathology. The words a patient uses to describe shortness of breath can suggest certain etiologies for dyspnea. Patients with obstructive lung disease often complain of "chest tightness" or "inability to get a deep breath," whereas patients with congestive heart failure more commonly report "air hunger" or a sense of suffocation.

Cough generally indicates disease of the respiratory system. The clinician should inquire about the duration of the cough, whether or not it is associated with sputum production, and any specific triggers that induce it. Acute cough productive of phlegm is often a symptom of infection of the respiratory system, including processes affecting the upper airway (e.g., sinusitis, tracheitis), the lower airways (e.g., bronchitis, bronchiectasis), and the lung parenchyma (e.g., pneumonia). Both the quantity and quality of the sputum, including whether it is blood-streaked or frankly bloody, should be determined.

Artificial respiration:

Artificial ventilation, also called artificial respiration is any means of assisting or stimulating respiration, a metabolic process referring to the overall exchange of gases in the body by pulmonary ventilation, external respiration, and internal respiration. It may take the form of manually providing air for a person who is not breathing or is not making sufficient respiratory effort on their own, or it may be mechanical ventilation involving the use of a mechanical ventilator to move air in and out of the lungs when an individual is unable to breathe on their own, for example during surgery with general anesthesia or when an individual is in a coma.

Types

Manual methods:

Mouth-to-mouth resuscitation:

Pulmonary anton ventilation (and hence external parts of respiration) is achieved through manual insufflation of the lungs either by the rescuer blowing into the patient's lungs (mouth-to-mouth resuscitation), or by using a mechanical device to do so. This method of insufflation has been proved more effective than methods which involve mechanical manipulation of the patient's chest or arms, such as the Silvester method.

Mouth-to-mouth resuscitation is also part of cardiopulmonary resuscitation (CPR) making it an essential skill for first aid. In some situations, mouth to mouth is also performed separately, for instance in near-drowning and opiate overdoses. The performance of mouth to mouth in its own is now limited in most protocols to health professionals, whereas lay first aiders are advised to undertake full CPR in any case where the patient is not breathing sufficiently.

Mechanical ventilation

Mechanical ventilation is a method to mechanically assist or replace spontaneous breathing. This may involve a machine called a ventilator or the breathing may be assisted by a registered nurse, physician, physician assistant, respiratory therapist, paramedic, or other suitable person compressing a bag valve mask or set of bellows. Mechanical ventilation is termed "invasive" if it involves any instrument penetrating through the mouth (such as an endotracheal tube) or the skin (such as a tracheostomy tube). There are two main modes of mechanical ventilation within the two divisions: positive pressure ventilation, where air (or another gas mix) is pushed into the trachea, and negative pressure ventilation, where air is, in essence, sucked into the lungs.

Tracheal intubation is often used for short term mechanical ventilation. A tube is inserted through the nose (nasotracheal intubation) or mouth (orotracheal intubation) and advanced into the trachea. In most cases tubes with inflatable cuffs are used for protection against leakage and aspiration. Intubation with a cuffed tube is thought to provide the best protection against aspiration. Tracheal tubes inevitably cause pain and coughing. Therefore, unless a patient is unconscious or anesthetized for other reasons, sedative drugs are usually given to provide tolerance of the tube. Other disadvantages of tracheal intubation include damage to the mucosal lining of the nasopharynx or oropharynx and subglottic stenosis.

In an emergency a Cricothyrotomy can be used by health care professionals, where an airway is inserted through a surgical opening in the cricothyroid membrane. This is similar to a tracheostomy but a cricothyrotomy is reserved for emergency access. This is usually only used when there is a complete blockage of the pharynx or there is massive maxillofacial injury, preventing other adjuncts being used.

Cardiopulmonary resuscitation (CPR):

It’s a life saving medical procedure which is given to someone who is in cardiac arrest. It helps to pump blood around the person's body when their heart can’t. To carry out CPR a person presses up and down on the casualty’s chest (**chest compressions**) and gives them a series of rescue breaths to help save their life when they are in cardiac arrest.

Purpose:

CPR is performed to restore and maintain breathing and circulation and to provide oxygen and blood flow to the heart, brain, and other vital organs. CPR can be performed by trained laypeople or healthcare professionals on infants, children, adolescents, and adults. CPR should be performed if an infant, child, or adolescent is unconscious and not breathing. Respiratory and cardiac arrest can be caused by allergic reactions, an ineffective heartbeat, asphyxiation, breathing passages that are blocked, choking , drowning, drug reactions or overdoses, electric shock, exposure to cold, severe shock, or trauma. In newborns, the most common cause of cardiopulmonary arrest is respiratory failure caused by sudden infant death syndrome (SIDS), airway obstruction (usually from inhalation of a foreign body), sepsis, neurologic disease, or drowning. Cardiac arrest in children over one year of age is most commonly caused by shock

and/or respiratory failure resulting from an accident or injury. CPR is part of the emergency cardiac care system designed to save lives. Many deaths can be prevented by prompt recognition of cardiopulmonary arrest and notification of the emergency medical system (EMS), followed by early CPR, defibrillation (which delivers a brief electric shock to the heart in attempt to get the heart to beat normally), and advanced cardiac life support measures. When performed by a layperson, CPR is designed to support and maintain breathing and circulation until emergency medical personnel arrive and take over. When performed by healthcare personnel, it is used in conjunction with other basic and advanced life support measures.

CPR must be performed within four to six minutes after cessation of breathing to prevent brain damage or death. CPR consists of rescue breathing, which delivers oxygen to the victim's lungs, and external chest compressions, which help circulate blood through the heart to vital organs.

CPR technique differs for infants, children, and adolescents. The American Heart Association and the American Red Cross, the two organizations that provide CPR training and guidelines, distinguish infants, children, and adolescents for the purposes of CPR as follows:

- "Infant" includes neonates (those in the first 28 days of life) and extends to the age of one year.
- "Child" includes toddlers aged one year to children aged eight years.
- "Adult" includes children aged eight years and older.

Because infants and children under the age of eight have smaller upper and lower airways and faster heart rates than adults, CPR techniques are different for them than for older children and adults. Children and adolescents aged eight years and older have reached a body size that can be handled using adult CPR techniques and are thus classified as adults for delivery of CPR and life support. CPR is always begun after assessing the victim and contacting EMS.

Performing CPR on an infant

For an infant, the rescuer opens the airway using a gentle head tilt/chin lift or jaw thrust, places their mouth over the infant's mouth and nose then delivers gentle breaths so that the infant's chest rises with each breath. Chest compressions are delivered by placing two fingers of one hand over the lower half of the infant's sternum slightly below the nipple line and pressing down about one half inch to one inch. Compressions are delivered at a rate of 100 times per minute, giving five chest compressions followed by one rescue breath in successive cycles.

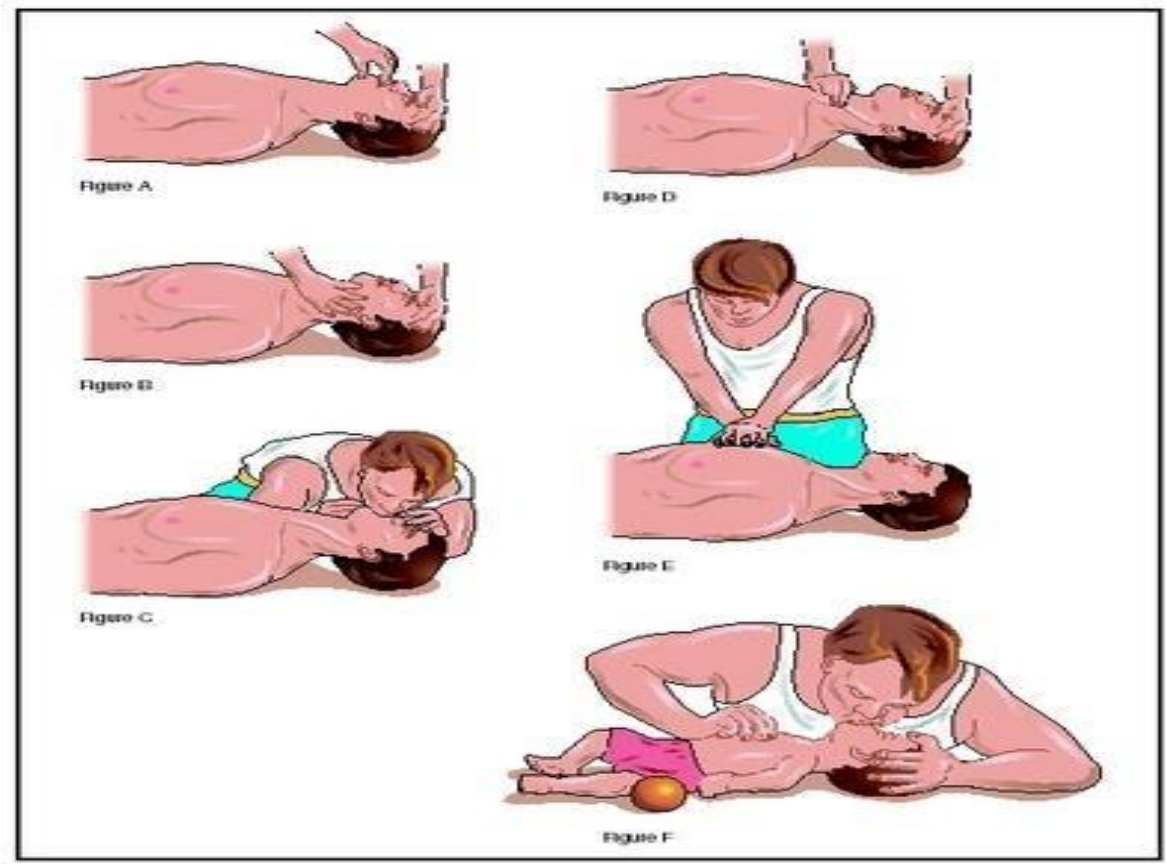
Performing CPR on a child aged one to eight

For a child aged one to eight years, the compression rate is the same—five compressions and one rescue breath. Rescue breaths are delivered using a mouth-to-mouth seal, instead of mouth-to-

mouth-and-nose. Chest compressions are delivered by placing the heel of one hand over the lower half of the sternum and depressing about one to one and one half inches per compression.

Performing CPR on a child aged eight and older

For a child aged eight years and older, and for larger children under age eight, two hands are used for compressions, with the heel of one hand on the lower half of the sternum and the heel of the other hand on top of that hand. The chest is compressed about one and one half to two inches per compression. Rescue breaths are delivered with a mouth-to-mouth seal. The compression rate is 80 to 100 per minute delivered in cycles of 15 compressions followed by two rescue breaths.



CPR in basic life support.

Figure A: The victim should be flat on his back and his mouth should be checked for debris. Figure B: If the victim is unconscious, open airway, lift neck, and tilt head back. Figure C: If victim is not breathing, begin artificial breathing with four quick full breaths. Figure D: Check for carotid pulse. Figure E: If pulse is absent, begin artificial circulation by depressing sternum. Figure F: Mouth-to-mouth resuscitation of an infant.

Pulmonary Function Test:

→ Pulmonary Function analysers are used to evaluate the state of the lungs or the respiratory process.

→ clinically, 3 basic types of measurements are performed.

① Ventilation.

② Distribution.

③ Diffusion.

→ ① Ventilation: It deals with the determination of the ability of the body to displace air volume quantitavely & the speed with which it moves the air. Mostly, spirometers are used in the ventilation measurement.

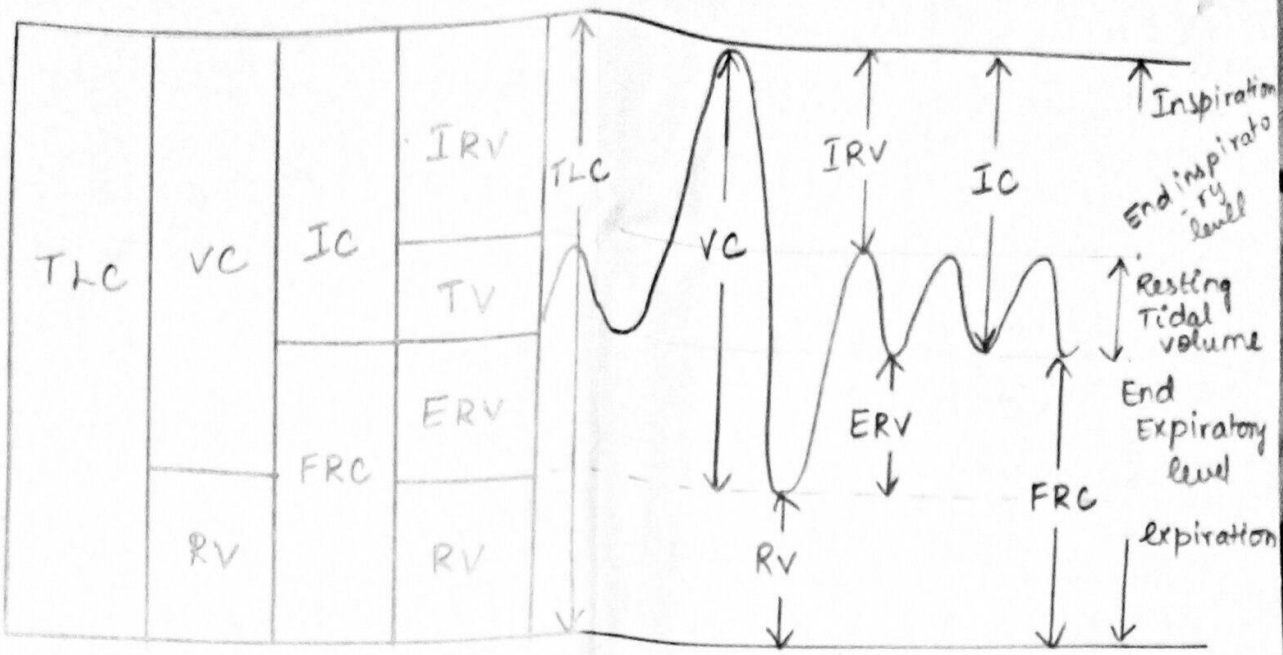
→ ② Distribution: It indicates the degree of lung obstructions for the flow of air & also determine the residual volume of air that can't be removed from the lungs. Pneumotachometers are used to measure the instantaneous rate of volume flow of respired gases.

→ ③ Diffusion: It indicates the lung ability to exchange gas with circulatory system, or the rate at which gas is exchanged with the blood stream. Gas Analysers are used in the diffusion measurement.

Lung volume & capacity:

→ All the pulmonary function analysers are used to determine the lung volume & capacities. These parameters depend on the individual's breathing condition.

→ Unit of Lung volume is (%) & capacity (ml).



→ Total Lung capacity (TLC) ⇒ Amount of gas contained in the lungs at the end of maximal inspiration.

$$TLC = VC + RV$$

→ Vital capacity (VC) ⇒ Greatest volume of gas that can be inspired by voluntary effort after maximum expiration.

→ Residual volume (RV) ⇒ volume of gas remaining in the lungs after a forced expiration.

→ Inspiratory capacity (IC) ⇒ Max. amount of gas that can be inspired after reaching the end expiratory level.

→ Functional Residual capacity (FRC) ⇒ Volume of gas remaining in the lungs at the end of expiratory level.

→ Inspiratory Reserve volume (IRV) ⇒ Extra volume of gas that can be inspired with maximum effort after reaching the normal end of inspiratory level.

$$IRV = VC - (TV + FRC)$$

Expiratory Reserve Volume (ERV) ⇒ Extra volume of gas that can be expired with maximum effort beyond reaching the normal end of expiratory level.

$ERV = FRC - RV$

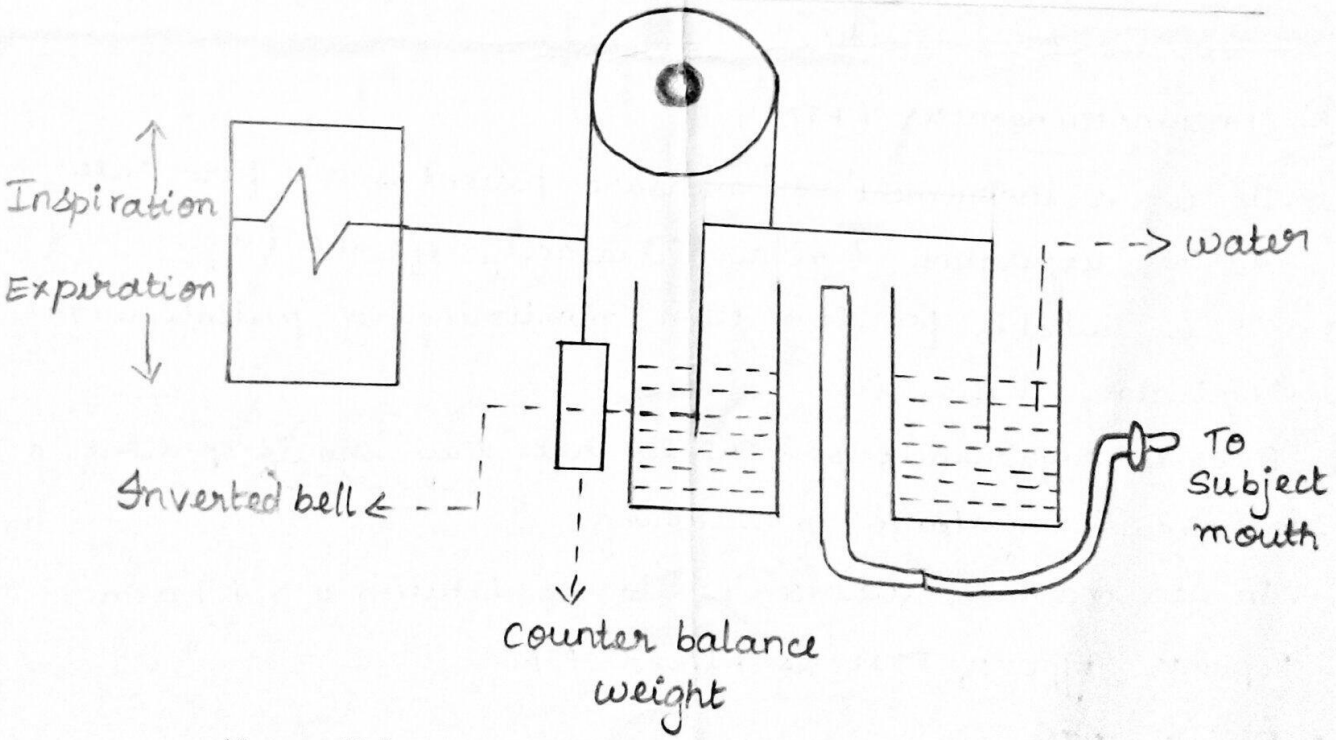
Tidal Volume: volume of gas inspired or expired during each normal quiet breathing is called Tidal Volume.

Dead space: Functional volume of lung that does not participate in gas exchange.

1. Spirometry:

→ Instrument to measure lung volume & capacity is called as spirometer. And the record obtained from this device is called spirogram.

BASIC WATER SEALED SPIROMETER



→ Usually this requires the patient to take a deep breath & then exhale as rapidly & completely as possible. This gives an indication of how much air can be moved by the lungs & how freely air flows.

→ It consists of a water filled cylinder containing an inverted bell.
→ The subject breathes into the system in which air is trapped (bell). As the subject breathes, air movement in or out of the mouthpiece causes the bell to rise (inspiration) or fall (expiration).
→ Since the i/p is air flow, o/p is volume displacement, an electric signal is proportional to volume displacement can be obtained.
→ Transducer have been designed to transform the movement of the bell into electric signal.
→ These are then used to compute the numerical results electronically.
→ From such recording, we can measure the lung volume & capacity.

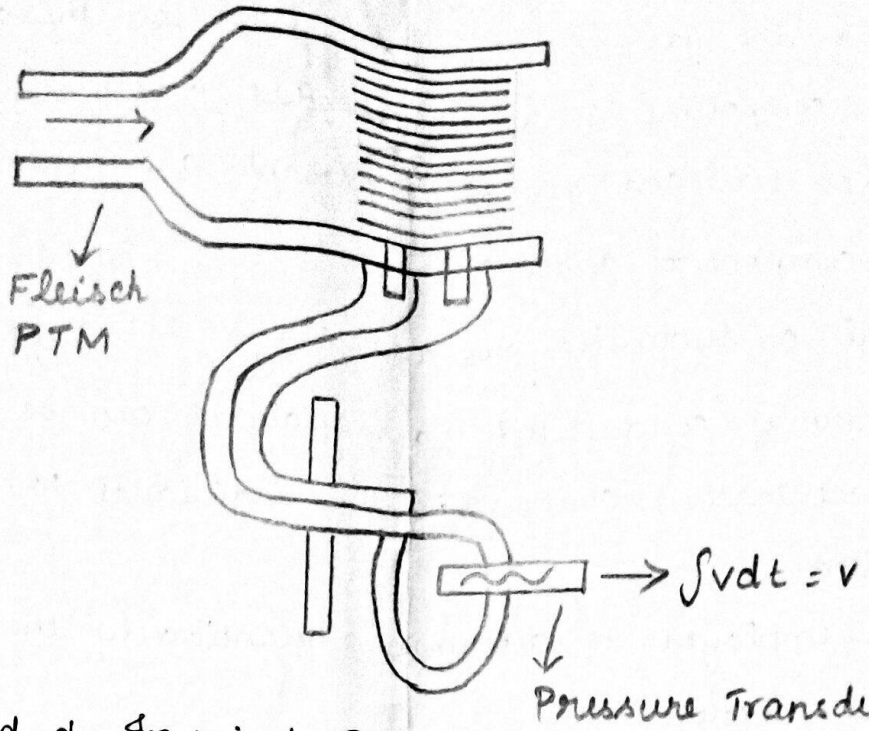
(2) Pneumotachometer (PTM):

→ It is an instrument to measure patient's air flow rate during respiration & vital air capacity of the lung.
→ It is suitable for long term monitoring of patients with respiratory difficulties.
→ A basic requirement of PTM is that they should present a minimum resistance to breathing.
→ An acceptable resistance would be between 0.5 & 1.0 cm.
→ Popular type of PTM is Fleisch PTM.

• Fleisch PTM:

→ Flow Transducers generally used in respiratory studies are the Fleisch type PTM.

Fleisch Pneumotachometer



→ Expired & Inspired Respiratory air is detected with Fleisch PTM.

→ Inside the flowhead, the bundle of capillary tubes creates a very slight resistance.

→ This series of small parallel tubes create a pattern of laminar flow in the air passing through.

→ The differential pressure is directly proportional to air flow rate, which is measured by pressure transducer.

→ The output from pressure sensor is passed through A-D convertor.

→ The digital signals from this are used to give the calibrated flow and volume measurements.

(3) Gas Analysers:

→ Used to determine the quantitative composition of inspired and expired gas and to assess the lung function.

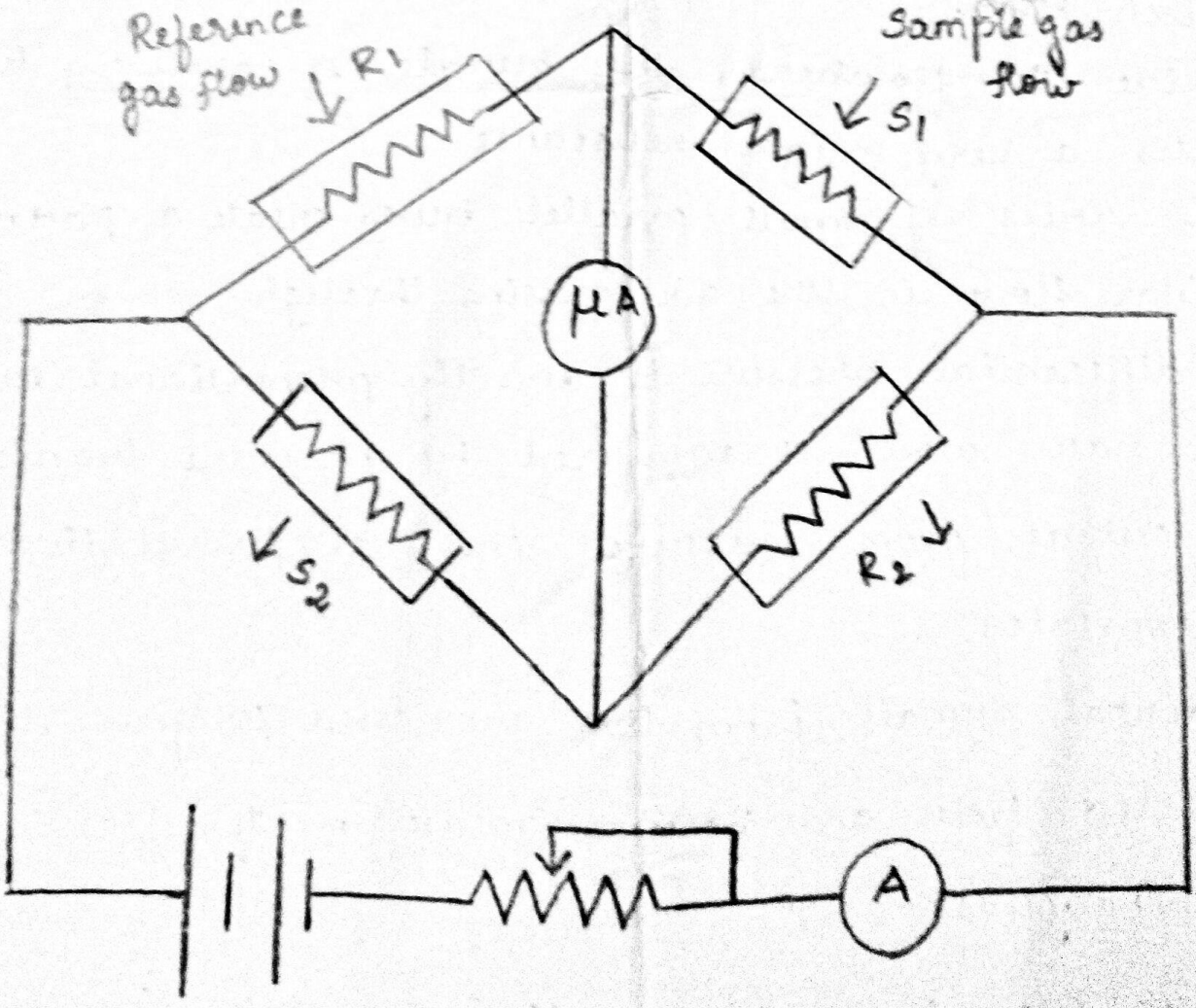
→ They are mostly based on Thermal conductivity of CO_2, infrared absorption of CO_2, Paramagnetic behaviour of O_2.

→ Most of the gas analysers are used for the analysis of single component in a gas mixture & others like mass spectrometer and gas chromatograph are meant for multicomponent analysis.

• Thermal conductivity gas analyser:

→ A thermal conductivity gas analyser can be used to follow CO_2 concentration changes in the individual breathes of a patient.

→ It is employed to determine quantitavely the composition of gas mixtures.



→ When there is a change in composition of a gas stream, then there is a significant variation in thermal conductivity & hence there may be rise or fall of temperature of the heated filament or thermistor situated in the gas stream.

→ There are four platinum filaments, these 4 filament cells are maintained at constant temperature & form the 4 arms of bridge.

→ Two filaments R_1 & R_2 connected in opposite arms act as reference gas arms & the other two filaments S_1 & S_2 act as sample gas arms.

→ Initially, reference gas is made to flow through all the filament cells and the bridge is balanced.

→ When the sample gas is flowing through the sample gas filament cells, the temperature of the filaments in those cells are changed such that if the thermal conductivity of the sample gas is more, then cooling of the filament taking place which changes the resistance of the filament.

→ Thus the bridge is unbalanced & an unbalanced current flowing through the indicating meter which is calibrated in terms of concentration of CO_2.

UNIT 4

GASTRO URINAL SYSTEM

DIGESTION AND ABSORPTION

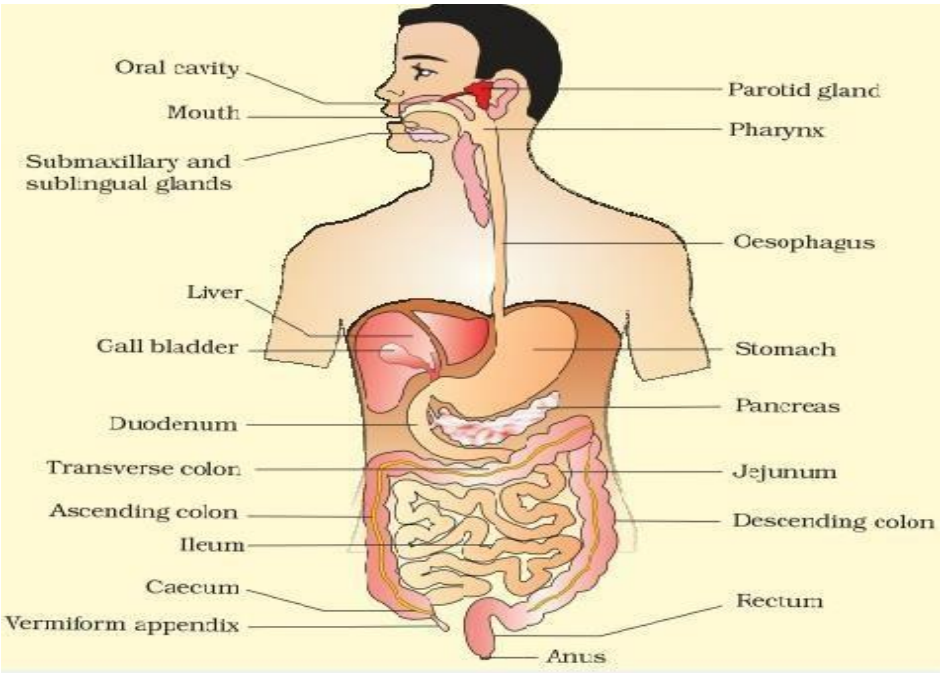
All the living organisms require the presence of energy to do various functions of life. They get this energy from the food they eat. Food is also needed for growth and development of the body. Nutrition is defined as, the substance in total from which an organism derives its energy to do work and other materials for its growth, development and maintenance of life.

DIGESTION:

"The breaking down of complex and insoluble organic substances such as carbohydrates, proteins and fats into simpler and soluble substances like glucose, amino acids and fatty acids respectively so that they can be easily absorbed into the body is known as digestion. This is a hydrolytic process and is carried out by various enzymes".

" Alimentary or Digestive system:

Alimentary or Digestive system: Alimentary canal is a tube present in all higher animals starting from mouth and reaching up to anus. Various glands located on its wall produce digestive juices that help in the process of digestion. Two glands namely liver and pancreas are also associated with it. They also produce the digestive juices. The digested food is also absorbed into the alimentary canal and undigested and indigestible food is passed out of the body through anus.



Salivary glands:

There are three pairs of salivary glands namely parotids, submaxillary (submandibular) and sublingual glands. Their secretion is collectively known as saliva that is poured into the buccal cavity. Saliva usually contains enzymes and mucin. The enzyme present in saliva is known as ptyalin that helps in the digestion of carbohydrates; while mucin helps to lubricate the food for swallowing.

The mouth leads to a funnel-shaped pharynx, which communicates with a long muscular tube called oesophagus. The oesophagus opens into a muscular sac like structure called as stomach. In man, it is somewhat J-shaped and occupies the left side of the abdomen. The stomach opens into the small intestine. The stomach has many glands on its wall. Stomach wall produces gastric juice, which chiefly contains HCl, mucin and two protein digesting enzymes – rennin and pepsin. The muscles of the stomach wall churn and mix the food with gastric juice. Stomach through its pyloric region opens into small intestine. It is differentiated into three regions viz., duodenum, jejunum and ileum. Duodenum is U-shaped and gets the common bile duct and pancreatic duct from the gall bladder and pancreas. Jejunum is longer and more coiled. Ileum is the last part of small intestine and opens into the large intestine. Its wall has numerous long, finger-like projections called villi, which enhance absorption. Small intestine is the main region where digestion and absorption of food occurs. It has large number of tubular glands that produce the intestinal juice containing a number of enzymes, which digest various types of food.

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Digestion of different nutrients is completed in the small intestine by the action of pancreatic juice, intestinal juice and bile juice. The end products of digestion are then absorbed from the small intestine. The small intestine opens into the large intestine. It is comparatively much shorter and wider than the small intestine. It does not have villi. It is also differentiated into three regions: caecum, colon and rectum. Caecum is a small pouch-like structure and its main part is vermiform appendix. However, caecum is very well developed in herbivorous animals like horse and ass. The colon is longest and has four parts; ascending colon, transverse colon, descending colon and pelvic colon. The pelvic colon opens into the rectum. Rectum is the last part of large intestine. Both in colon and rectum most of the water is reabsorbed back while the undigested food is removed from the body as faecal matter through anus. This is known as Egestion.

Glands associated with alimentary canal: Pancreas: It is located in between the loops of duodenum. It is the second largest gland of the body. It secretes pancreatic juice that contains large number of digestive enzymes for digesting starch, lipids, proteins and nucleic acids. The pancreatic juice is released into the pancreatic duct, which joins with the common bile duct. Liver: It is the largest gland of the body lying immediately below the diaphragm in the right upper part of abdomen. The cells of the liver (hepatic cells) produce bile juice that contains bile pigments and bile salts. These bile salts help in the digestion and absorption of fats. Bile juice does not contain any enzyme. Bile juice flows out of the liver through hepatic ducts forming the common bile duct that opens into the duodenum (when the food is present in the duodenum). When there is no food in the duodenum, then bile juice is stored in

the gall bladder. The gall bladder is a small elongated, muscular sac below the liver. When the food comes into duodenum, it contracts to release the bile juice. Digestion of Carbohydrates: Carbohydrates are of three types: polysaccharides, disaccharides and monosaccharides. During the process of digestion both poly-and disaccharides are broken down to monosaccharides and in this form they can be absorbed into the body. Some of these complex carbohydrates are starch and cellulose, present in cereal grains, potato, fruits and tubers; sucrose present in cane sugar; lactose present in milk etc. Enzymes that act on carbohydrates are collectively known as carbohydrases.

In the mouth cavity, the food is mixed with saliva. It contains an enzyme called salivary amylase or ptyalin. Salivary amylase acts on starch and convert it into maltose, isomaltose and small dextrins or `limit dextrin'(disaccharides). Chewing and mastication of food increases the action of salivary amylase on starch by increasing the surface area of food on which the enzyme acts. About 30 percent of starch present in food is hydrolysed in the mouth. The action of salivary amylase continues for sometime even in the stomach but soon HCl present in the gastric juice destroys the entire enzyme.

Salivary Starch---------- > Maltose + Isomaltose + Dextrin Amylase

Pancreatic juice and intestinal juice also contain carbohydrates digesting enzymes. Pancreatic juice contains pancreatic amylase that acts on starch to digest it into maltose, isomaltose and dextrin. Intestinal juice contains number of carbohydrates like maltase, isomaltase and sucrase and lactase. Maltase and isomaltase act on maltose, isomaltose and dextrins and convert into glucose; sucrase acts on sucrose to convert it into glucose and fructose; and lactase acts on lactose to convert it into glucose and the galactose.

Amylase Starch---------- > Maltose + Isomaltose + Dextrin

Digestion of proteins:

Proteins are complex organic compounds made up of single units called amino acids. In the process of digestion, proteins are broken down to amino acids. Enzymes that hydrolyze protein are collectively known as proteases or peptides. Many of these enzymes are secreted in their inactive form or proenzymes. These inactive enzymes are converted to their active form only at the site of action. Protein digestion starts in the stomach. The gastric glands of stomach produce a light coloured, thin and transparent gastric juice. It contains hydrochloric acid and pepsinogen. The H+ ions present in HCl converts pepsinogen into pepsin. The presence of HCl makes the medium highly acidic so that pepsin can act on proteins to convert them into peptones. HCl also helps to kill bacteria and other harmful organisms that may be present along with the food. Calf gastric juice contains another milk coagulating protease, called rennin. It is secreted as inactive pro-rennin. In the presence of HCl, the inactive prorennin is converted into their active form, i.e., rennin. Rennin acts on the casein protein of milk and converts it into paracasein, which in the presence of calcium ions forms calcium paracaseinate (curdling of milk). The function of rennin is then taken over by pepsin and other milk-coagulating enzymes. Adult cows or human infants do not produce rennin.

Digestion of fats: Fat digestion starts only when the food reaches the small intestine. It starts with the action of bile juice from liver. Bile juice contains bile salts, which are secreted by the liver in the bile. Bile salts break down the bigger molecules of fat globules into smaller droplets by reducing the surface tension of fat droplets. This process is known as Lipase is the enzyme that acts on emulsified fats. It is present both in the pancreatic juice and intestinal juice. Lipase converts emulsified fats into diglycerides and monoglycerides releasing fatty acids at each step. At the end of digestion, all fats are converted into fatty acids, glycerol and monoglycerides.

Absorption: During the process of digestion proteins are changed to amino acids, carbohydrates to glucose, fructose and galactose, fats to fatty acids, glycerol and monoglycerides. These end products of digestion are finally absorbed in small intestine. So absorption can be defined as a process by which nutrient molecules are taken into the cells of the body. For this purpose, intestine has vast surface area of absorption by the presence of numerous villi. Further, this area is increased by microvilli present on the free surface of epithelial cells. Passive absorption: When the nutrients are absorbed by simple diffusion, then it is known as passive absorption. Various amino acids and monosaccharides diffuse into the blood capillaries of villi. This is dependent on the fact that these nutrients are more in concentration in the intestine than in the cells. Further, these molecules are small and water soluble. All the amino acids and monosaccharides are not absorbed in this way. Water is absorbed from the intestine to the intestinal cells and finally to the blood by the process of osmosis. This occurs when the solute concentration in the blood is higher (hypertonic). Thus, whenever any solute is absorbed from the intestine, it also results in the absorption of water.

Active absorption: This process occurs against the concentration gradient, i.e., nutrients may be more in intestinal cells than in the lumen of intestine. It requires the expenditure of energy i.e., ATP. Various nutrients like amino acids, glucose, galactose, Na+ ions can be absorbed by active emulsification of fats. transport. After their passive absorption, they are completely absorbed by active transport. For the active absorption of Na+ ions, a mechanism of sodium pump operates in the cell membranes.

Micelles in fat absorption/Role of bile juice in the absorption of fats:

As the fatty acids and glycerol are insoluble in water, the intestine cannot directly absorb them. So they cannot reach the blood stream directly. Instead, they are passed into lymph capillaries of the villi called lacteals. Digested fats are first incorporated into small, spherical droplets called micelles with the help of bile salts and phospholipids in the intestinal lumen. In the lacteals, fats are resynthesised into very small fat molecules called chylomicrons. An obstruction in the bile duct may prevent the entry of bile juice into the small intestine (obstructive jaundice) as a result unabsorbed fats are removed from the body along with the faecal matter. Thus bile plays an important role in the absorption of fats.

Balanced diet: To maintain normal functioning of our body, we need varieties of food so that all the systems are well maintained. A diet, which contains adequate amount of all the essential nutrients, is known as balanced diet. It varies according to age and occupation.

A balanced diet should have the following three qualities: · It must be rich in various essential nutrients like vitamins, minerals and some amino acids. · It should provide enough raw materials needed for the

growth and development, repair and replacement of cells, tissues and organs of the body. · It should provide the necessary energy required by the body.

Disorders of Digestive System:

1. Jaundice: The liver is affected; skin and eyes turn yellow due to the deposit of bile pigment.

2. Vomiting: It is the ejection of stomach contents through the mouth and controlled by the centre in the medulla oblongata.

3. Diarrhoea: Abnormal bowel movement and the faecal discharge with more liquidity, which leads to dehydration.

4. Constipation: the feces are retained within the rectum due to irregular bowel movement.

5. Indigestion: food is not properly digested leading to a feeling of fullness due to inadequate enzyme secretion, anxiety, food poisoning, over eating nd spicy food.

MOVEMENT OF GI TRACT

The digestive tract includes the esophagus (or food tube), stomach, small intestine/bowel, and colon or large intestine/bowel. It begins at the mouth and ends at the anus.

Gut motility is the term given to the stretching and contractions of the muscles in the gastrointestinal (GI) tract. The synchronized contraction of these muscles is called peristalsis. These movements enable food to progress along the digestive tract while, at the same time, ensuring the absorption of the important nutrients.

Techniques of measuring these movements of the gut enable us to recognize the normal patterns of contraction in each of the regions. The types of contraction in the gut differ depending on the region and the type of food which has been eaten. Some contractions cause onward movement of the food, others cause mixing and grinding.

The esophagus, stomach, small intestine, and large intestine are the main regions of the GI tract. They are separated from each other by special muscles, called sphincters, which regulate the movement of ingested material from one part to another. Each part of the GI tract has a unique function to perform in digestion, and each has a distinct type of motility and sensation.

Esophagus and Stomach

Digestion begins in the mouth where food is chewed, mixed with saliva, and swallowed. The esophagus propels food from the mouth to the stomach. The stomach is large enough to temporarily store the food eaten at each meal. Solid food is gradually broken down by powerful muscle contractions in the lower end of the stomach. This muscular activity produces small food particles suitable to enter the small bowel, where processes of nutrient absorption begin.

Different types of food empty from the stomach at different rates; for example, fatty foods take longer to leave the stomach than other foods. Beverages are handled differently by the stomach, emptying more quickly into the small bowel and not requiring break-down into smaller particles. Normally, most of an average-sized meal has left the stomach after about 2 hours.

In the stomach the food stimulates the release of digestive juices (secretions) like hydrochloric acid and digestive enzymes that chemically further break down and mix with the food. The mixture is referred to as chyme.

Small Intestine

The chyme then passes, in a regulated controlled manner, out of the stomach into the small bowel/intestine. In the small intestine, the muscular contractions occur irregularly, varying in strength and type. Here also, the different nutrients in food affect the type of contractions generated. After an average sized meal, the contractions continue for several hours, mixing the food and moving it along the intestine. These types of contractions last until most of the meal residues enter the large intestine. Different foods travel at different rates along the small intestine; for example, foods high in fat travel more slowly than fiber-rich foods.

After most of the food has left the small intestine, a different pattern of contractions appears. Bursts of powerful contraction, occurring about every 90 minutes during fasting and particularly at night, progress slowly down the intestine. These bursts clear residual food and secretions from the upper intestine, and thus act as a "housekeeper" in the intestine.

The average total length of the normal small bowel in adults is about 7 meters/22 feet. The small intestine has 3 segments:

- the duodenum
- the jejunum
- the ileum

Each part or section performs an important role in nutrient absorption.

Duodenum – The chyme first enters into the duodenum where it is exposed to secretions that aid digestion. The secretions include bile salts, enzymes, and bicarbonate. The bile salts from the liver help digest fats and fat soluble vitamins (Vitamin A, D, E, and K). Pancreatic enzymes help digest carbohydrates and fats. Bicarbonate from the pancreas neutralizes the acid from the stomach.

Jejunum – The chyme is then further transited down into the second or middle part of the small intestine, the jejunum. Mainly in the first half of the jejunum, the majority (about 90%) of nutrient absorption occurs involving proteins, carbohydrates, vitamins, and minerals.

Ileum – The ileum is the last section of the small intestine and leads to the large intestine or colon. The ileum mainly absorbs water, bile salts, and vitamin B12.

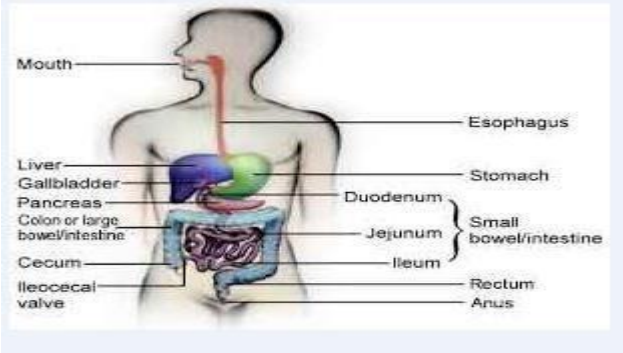
The ileocecal valve is a one way valve located between the ileum and the cecum, which is the first portion of the colon. This valve helps control the passage of contents into the colon and increases the contact time of nutrients and electrolytes (essential minerals) with the small intestine. It also prevents back-flow (reflux) from the colon up into the ileum, and minimizes the movement of bacteria from the large intestine up into the small bowel.

Large Intestine (Colon)

The first portion of the colon, the cecum, is shaped like a pouch, and is the area of storage for the contents arriving from the ileum. The primary function of the large intestine or colon is to absorb fluids and electrolytes, particularly sodium and potassium, and to convert remaining luminal contents into more solid stool. The colon absorbs on average 1-1.5 liters (about 1-1.5 quarts) of fluid every day and has a capacity to adapt its fluid absorption to as much as 5 liters/quarts per day if needed. Another function of the colon is to break down (ferment) dietary fiber to produce short chain fatty acids – substances that can be absorbed and provide added nutrition.

The patterns of contraction in the colon are not as well understood as those in the small intestine. It is known, however, that eating a meal stimulates contractions in the colon – the larger the meal the greater is the response.

Stretching of the rectum by stool produces relaxation of the muscles of the anus and surrounding structures. The rectal contents can then be discharged voluntarily.



STRUCTURE AND FUNCTION OF KIDNEY

the parts of the kidney:

Renal hilus : The renal hilus is an indentation near to the centre of the concave area of the kidney. This is the area of the kidney through which the ureter leaves the kidney and the other structures including blood vessels (illustrated), lymphatic vessels, and nerves tenter/leave the kidney.

Renal capsule : The renal capsule is a smooth, transparent, fibrous membrane that surrounds, encloses, and protects the kidney. Each kidney has it's own renal capsule (outer layer), which helps to maintain the shape of the kidney as well as protecting it from damage. The renal capsule is itself surrounded by a mass of fatty tissue that also helps to protect the kidney by damage by cushioning it in cases of impact or sudden movement.

Holistic Renal cortex : The renal cortex is the outer part of the kidney and has a reddish colour (shown as very pale brown above). It has a smooth texture and is the location of the Bowman's Capsules and the glomeruli, in addition to the proximal and distal convoluted tubules and their associated blood supplies (these structures are part of the kidney nephrons - described in further detail on the page about kidney nephrons

Renal medulla : The renal medulla is the inner part of the kidney. "Medulla" means "inner portion". This area is a striated (striped) red-brown colour.

Renal pyramids : There are approx. 5 - 18 striated triangular structures called "Renal Pyramids" within the renal medulla of each kidney. The apperance of striations is due to many straight tubules and blood vessels within the renal pyramids. Renal pelvis : The renal pelvis is the funnel-shaped basin (cavity) that receives the urine drained from the kidney nephrons via the collecting ducts and then the (larger) papillary ducts.

Renal artery : The renal artery delivers oxygenated blood to the kidney. This main artery divides into many smaller branches as it enters the kidney via the renal hilus. These smaller arteries divide into vessels such as the segmental artery, the interlobar artery, the arcuate artery and the interlobular

artery. These eventually seperate into afferent arterioles, one of which serves each nephron (Urinary_System_Nephron_Diagram.php) in the kidney.

Renal vein : The renal vein receives deoxygenated blood from the peritubular veins within the kidney. These merge into the interlobular, arcuate, interlobar and segmental veins, which, in turn, deliver deoxygenated blood to the renal vein, through which it is returned to the systemic blood circulation (../Blood/Systemic_Circulation.php) system.

Interlobular artery : The interlobular artery delivers oxygenated blood at high pressure to the glomerular capillaries.

Interlobular vein : The interlobular vein receives deoxygenated blood (at lower pressure) that it drains away from the glomerular filteration units and from the Loops of Henle. Kidney nephron : Kidney nephrons are the functional units of the kidneys. That this, it is the kidney nephrons that actually perform the kidney's main functions. There are approx. a million nephrons within each kidney. To find out more about these, visit the page about kidney nephrons

Collecting Duct (Kidney) : The collecting duct labelled in the diagram above is part of the kidney nephron

The distal convoluted tubules* (term explain on the page about kidney nephrons (Urinary_System_Nephron_Diagram.php)) of many nephrons empty into a single collecting duct. Many such collecting ducts unite to drain urine extracted by the kidney into papillary ducts, then into a minor calyx, then the major calyx (at the centre of the kidney), and finally into the ureter through which the urine leaves the kidney en-route to the urinary bladder.

Ureter : The ureter is the structure through which urine is conveyed from the kidney to the urinary bladder.

FUNCTION OF KIDNEY

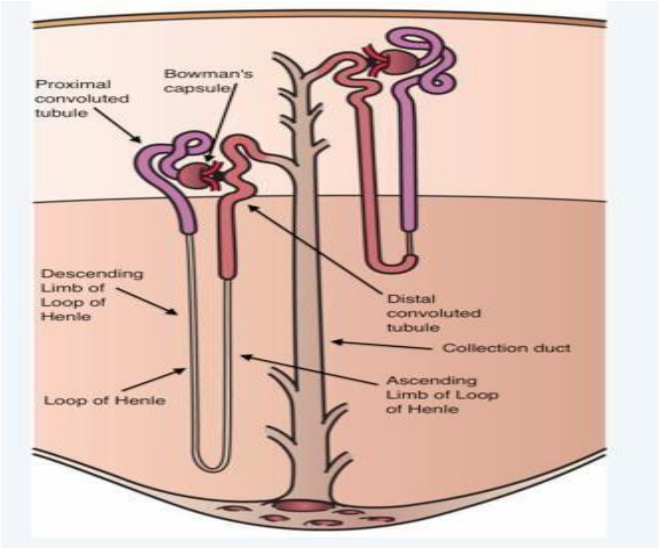
- **Waste excretion**: There are many things your body doesn’t want inside of it. The kidneys filter out toxins, excess salts, and **urea**, a nitrogen-based waste created by cell metabolism. Urea is synthesized in the liver and transported through the blood to the kidneys for removal.
- **Water level balancing**: As the kidneys are key in the chemical breakdown of urine, they react to changes in the body’s water level throughout the day. As water intake decreases, the kidneys adjust accordingly and leave water in the body instead of helping excrete it.
- **Blood pressure regulation**: The kidneys need constant pressure to filter the blood. When it drops too low, the kidneys increase the pressure. One way is by producing a blood vessel-constricting protein (**angiotensin**) that also signals the body to retain sodium and water. Both the constriction and retention help restore normal blood pressure.

- **Red blood cell regulation**: When the kidneys don't get enough oxygen, they send out a distress call in the form of **erythropoietin**, a hormone that stimulates the bone marrow to produce more oxygen-carrying red blood cells.
- **Acid regulation**: As cells metabolize, they produce acids. Foods we eat can either increase the acid in our body or neutralize it. If the body is to function properly, it needs to keep a healthy balance of these chemicals. The kidneys do that, too.

Acute kidney failure is a condition in which the kidneys suddenly lose their ability to function properly. This can occur for many reasons, including:

- Infection
- Blood-clotting disorders
- Decreased blood flow caused by low blood pressure
- Autoimmune kidney disorders
- Urinary tract infections
- Complications from pregnancy
- Dehydration

STRUCTURE AND FUNCTION OF NEPHRON



Function of the Nephrons

STRUCTURE

The nephron is the structural and functional unit of the kidney.[1] Each nephron is composed of a renal corpuscle, the initial filtering component; and a renal tubule that processes and carries away the filtered fluid.[2]

Renal corpuscle

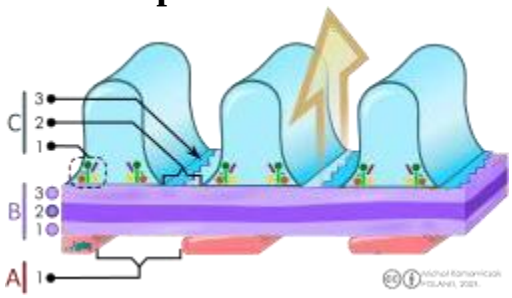


Fig.2) Schematic of the glomerular filtration barrier (GFB). A. The endothelial cells of the glomerulus; 1. endothelial pore (fenestra).
B. Glomerular basement membrane: 1. lamina rara interna 2. lamina densa 3. lamina rara externa
C. Podocytes: 1. enzymatic and structural proteins 2. filtration slit 3. diaphragm

The renal corpuscle is the site of the filtration of blood plasma. The renal corpuscle consists of the glomerulus, and the glomerular capsule or Bowman's capsule.[3] The renal corpuscle has two poles – a vascular pole and a urinary pole
The arterioles from the renal circulation enter and leave the glomerulus at the vascular pole. The glomerular filtrate leaves the Bowman's capsule at the renal tubule at the urinary pole.

Glomerulus

The glomerulus is the network known as a *tuft*, of filtering capillaries located at the vascular pole of the renal corpuscle in Bowman's capsule. Each glomerulus receives its blood supply from an afferent arteriole of the renal circulation. The glomerular blood pressure provides the driving force for water and solutes to be filtered out of the blood plasma, and into the space in Bowman's capsule called Bowman's space.
Only about a fifth of the plasma is filtered in the glomerulus. The rest passes into an efferent arteriole. The diameter of the efferent arteriole is smaller than that of the afferent, and this difference increases the hydrostatic pressure in the glomerulus.

Bowman's capsule

The Bowman's capsule, also called the glomerular capsule, surrounds the glomerulus. It is composed of a visceral inner layer formed by specialized cells called podocytes, and a parietal outer layer composed of simple squamous epithelium. Fluids from blood in the glomerulus are filtered through the visceral layer of podocytes, resulting in the glomerular filtrate.

The glomerular filtrate next moves to the renal tubule, where it is further processed to form urine. The different stages of this fluid are collectively known as the tubular fluid.

Renal tubule

The renal tubule is the portion of the nephron containing the tubular fluid filtered through the glomerulus. After passing through the renal tubule, the filtrate continues to the collecting duct system. [5]

The components of the renal tubule are:

- Proximal convoluted tubule (lies in cortex and lined by simple cuboidal epithelium with brush borders which help to increase the area of absorption greatly.)
- Loop of Henle (hair-pin like, i.e. U-shaped, and lies in medulla)
  - Descending limb of loop of Henle
  - Ascending limb of loop of Henle
    - The ascending limb of loop of Henle is divided into 2 segments: Lower end of ascending limb is very thin and is lined by simple squamous epithelium. The distal portion of ascending limb is thick and is lined by simple cuboidal epithelium.
    - Thin ascending limb of loop of Henle
    - Thick ascending limb of loop of Henle (enters cortex and becomes - distal convoluted tubule.)
- Distal convoluted tubule
- Connecting tubule

Blood from the efferent arteriole, containing everything that was not filtered out in the glomerulus, moves into the peritubular capillaries, tiny blood vessels that surround the loop of Henle and the proximal and distal tubules, where the tubular fluid flows. Substances then reabsorb from the latter back to the blood stream.

The peritubular capillaries then recombine to form an efferent venule, which combines with efferent venules from other nephrons into the renal vein, and rejoins the main bloodstream.

Your nephrons help:

- Remove excess water,wastes and other substances from your blood.
- Return substances like sodium, potassium or phosphorus whenever any of these substances run low in your body.

Each nephron is composed of two main structures: the glomerulus and renal (kidney) tubule.

Functioning of Nephron

1. Filtration: Filtration of blood takes place in Bowman's capsule from the capillaries of glomerulus. The ltrate passes into the tubular part of the nephron. This ltrate contains glucose, amino acids, urea, uric acid, salts and a major amount of water.

2. Re-absorption: As the ltrate ows along the tubule useful substances such as glucose, amino acids, salts and water are selectively re-absorbed into the blood by capillaries surrounding the nephron tubule. The amount of water re-absorbed depends on the need of the body and also on the amount of wastes to be excreted.

3. Urine: The ltrate which remains after re-absorption is called urine. Urine contains dissolved nitrogenous waste, i.e. urea and uric acid, excess salts and water. Urine is collected from nephrons by

the collecting duct to carry it to the ureter.

The Glomerulus

The glomerulus is a tiny blood vessel or capillary, which looks like a ball of yarn. Actual filtering of your blood occurs in the glomerulus.

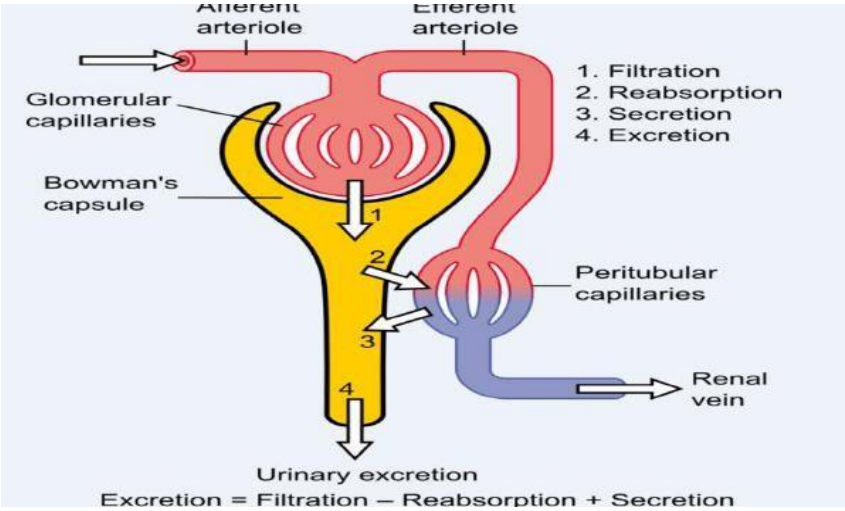
Each of your glomeruli acts like a sieve that helps keep normal proteins and cells in your bloodstream and allows wastes, excess fluid and other substances to pass.

The Tubule

The tubule, also called renal or kidney tubule, is a tiny tube where the wastes, extra fluid and other recyclable substances like sodium and potassium filtered out from the glomerulus pass through.

Your kidneys measure out chemicals like sodium, phosphorus, and potassium and release them back to the blood to return to the body when need arises. In this way, your kidneys regulate the your body's level of these substances. The right balance is necessary for you to function properly.

MACHANISM OF URINE FORMATION



SKIN

Introduction:

* It is the outermost covering of body forms the boundary between the body and external environment.

* It is the heaviest single organ in ou body. i.e., it consumes 16% of our body weight.

* It has the surface area of 1.5 - 2.0 r

* if it take a average square inch of skin (6.5cm^2) holds the 60,000 melanocytes 650 sweat glands, 20 blood vessels and more than thousand nerves.

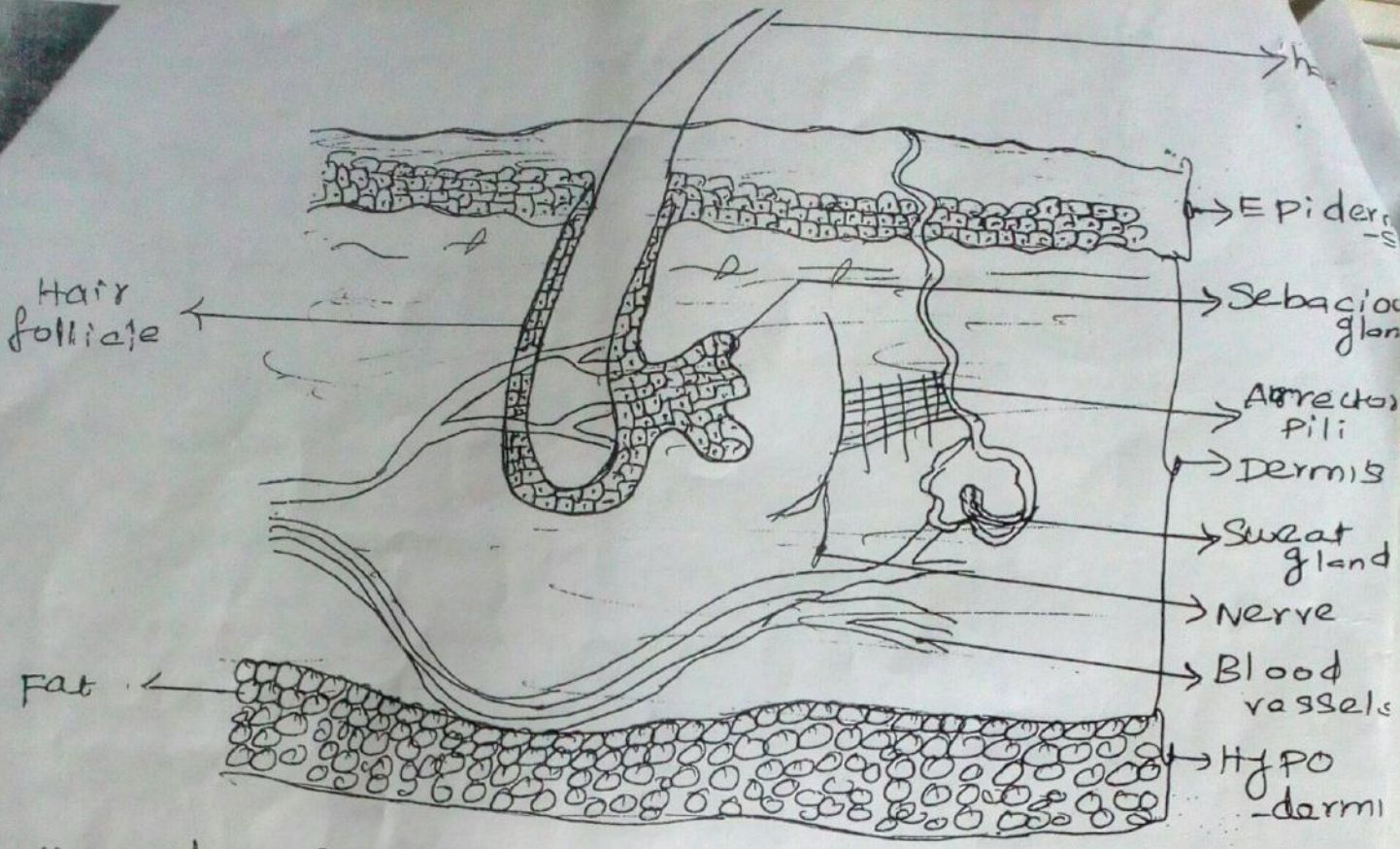
Structure of skin:

Skin is composed of three primary layers.

(i) epidermis - superficial epithelial laye of ectodermal origin. - It provides barrier to infection.

(ii) Dermis - Deep vascular connecting tissue layer of mesodermal origin.

(iii) Hypodermis - Subcutaneous tissue (contain fat (adipose layer), which act as a cushion between the outer layer and underlying soft tissues and bones.



(i) Epidermis:

* It is made up of Stratified Squamous epithelium.

* It is seperated from the dermis by basmar membrane.

* This region has no blood and lymp vessels and it contains melanocytes - Giving colo to the skin.

* Most of the epidermis cell produce protei Substance called keratin. Hence these cells called are keratinocytes.

* But the deepest layer of epidermis produce new cells by mitosis.

* As the new cells formed, oldest cel are pushed to the surface..

* The surface cell will Protect the inn... cells.

* Gradually the size and chemical nature ... Surface cell will altered. And they filled up by keratin. This process called keratinizati...

* During this process, the epidermis divide into five distinct region or strat. They are

a) Stratum cornaum
b) Stratum lucidium
c) Stratum granulosum.
d) Stratum spinosum.
e) stratum basle.

a) Stratum corneum:

* it is the outermost layer of epidermis consisting of dead cells called cornecytes.

* This layer otherwise called as thorny layer of epidermis.

* It is composed of 15-20 layers of flattened cells with no nuclei.

* The purpose of stratum cornaum is to form a barrier to protect underlying tissue from infection, dehydration.

* in this region, living keratinocytes are transformed into non-living cornecytes (dead cells This process called cornification.

b) Stratum lucidium:

* This is the clear layer of dead skin cells in the epidermis.

Stratum granulosum. This layer mostly seen in palms in the hand and sole in the leg. i.e, thick skin.

* It contains 3-5 layer of dead cells.
* cells of stratum lucidum is flattened.
* Thickness of this layer controlled by mitosis.
* This layer surrounded by oily substances.

c) Stratum granulosum:-

* It is the thin layer of epidermis.
* These cells contain keratohyalin granules which are filled with histidine and cystine-rich proteins.
* The main function of keratohyalin granules is to bind the intermediate keratin filaments together.

d) Stratum spinosum:-

* This is the prickel layer of epidermis.
* It is composed of polyhedral keratinocytes. it have large pale-staining nuclei as they are active in synthesizing fibrilar proteins.
* This layer function as a antigen. and have a role in immunity.

e) Stratum basale:-

* It is the deepest layer of epidermis
* It consisting of a single row of columnar or cuboidal epithelial cells.

* it is primarily made up of keratinocyte and stem cells of epidermis.

* Merkel cells also present in basle. The nature of this cell is to sense of light, touch, discrimination of shapes and textures.

(ii) Dermis:-

* Dermis may be divided into a superficial papillary layer and a deeper reticular layer

* It is made up of connective tissue which is dense in superficial part and more in the deeper part of reticular layer.

* The reticular layer merges into subcutaneous tissue. and the papillary layer have the projections with epidermis.

* it is made up of bundles of collagen fibres and also contain elastic fibres, which is reduced in old age causing wrinkling of skin.

* The papillae contain capillary blood vessels & tactile corposules.

* The dermis contains sweat glands, sebaceous glands, hair follicles, and blood vessels & nerves.

(iii) Hypodermis:-

* Hypodermis (or) Subcutaneous tissue contains fat (adipose layer) which insulates the deeper structure from excessive

* It act as a cushion which permits displacement of skin.

* The fat content is greater and is more uniformely distributed in women.

Types of skin cells:

a) Keratinocytes:-

* The most abundant cell type of the epidermis is the keratinocytes.

* These cells are produce keratin protein which provide some of the rigidity of the outer layer of the skin.

* They also form the bulk material of hair follicles. Dandruffs in hair are nothing but the dead keratinocytes.

b) Fibroblasts:

* The dermis is produced largely by fibroblasts which during embryonic developme

* The fibroblasts produce the collagen and elastins.

c) Melanocytes:-

* Melanocytes are cells that are less abundant in epidermis that produce the pigment melanin.

* The pigment made in melanocytes is transferred to the cells of the hair or inner epidermis.

* The melanin granules are injecte the keratinocytes cells.

d) Langerhans of cells:-

* These are star-shaped resistant immune cells, macrophage.

* A macrophage is a cell that protects our body from injury (or) illness.

Blood supply of skin:-

Blood from the skin & return by two channels.

a) via superficial veins:- which may be cooled which passing through.

b) via communicating veins - blood retur through these venous channels may be rewarm by the adjacent arterial blood.

Functions of skin:

1) Protection:-

Skin forms a protective coating and act as a mechanical barrier against the entry of bacteria and other pathogens. The superficial layer has keratinized cells hav free amino acid which are resistant to acti of dilute alkalies and acids. Skin pigme are protect the body against harmful actinic rays of sun.

Through the cutaneous ... subserving the sensation of touch, tempera... and pain. The individual is made aware of changes in the external environment and is warned of the presense of noxious stimuli and this enables protective measur... to be taken

3) Regulation of body temperature:

Skin plays a major role in the regulation of body temperature through vasomotor mechanism. There is vasodilation and vasoconstriction of skin blood vessels in hot and cold weathers respectively. i.e; The average blood flow is about 10ml/100g It may increase to 150ml to 200ml/100g when environmental temperature is very hig... by vasodilation And it may be as 2ml to 3ml/100g on exposure to severe cold by vasoconstriction of blood vessels

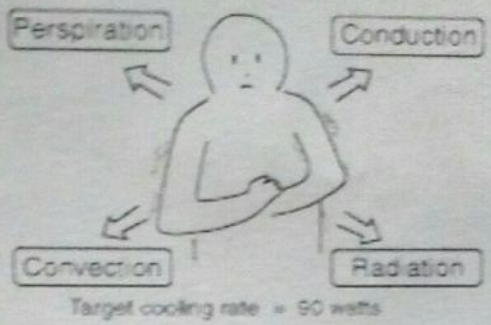
In addition, the cutaneous and Subcutaneous act as non-conductor. Heat loss through the skin may be through

convection
conduction
radiation
evaporation.

Temperature Regulation of the Human Body

The human body has the remarkable capacity for regulating its core temperature somewhere between 98°F and 100°F when the ambient temperature is between approximately 68°F and 130°F according to Guyton. This presumes a nude body and dry air.

The external heat transfer mechanisms are radiation, conduction and convection and evaporation of perspiration. The process is far more than the passive operation of these heat transfer mechanisms, however. The body takes a very active role in temperature regulation.



RADIATION

The heat generated from within the body is given-off to the surrounding atmosphere.

EVAPORATION

When you sweat or when your skin or clothing gets wet, the evaporation of that liquid (i.e., the change from liquid to vapour form) promotes heat loss, and the natural result is a cooling effect.

CONVECTION

Convection is the process of air or water flowing by the skin and carrying away body heat. It's convective heat loss that you try to prevent by staying as still as possible in the water. Staying still, the boundary layer of water next to the skin is heated by the body and remains undisturbed. If you move around in the water, you disrupt that boundary layer of warmer water, and that increases heat loss.

CONDUCTION

The body conducts heat to whatever the skin is in direct contact with. Conductive heat loss occurs when the skin is subjected to either cold air or water, but it is especially critical in water, as your body loses heat about 25 times faster in water than in air of the same temperature.

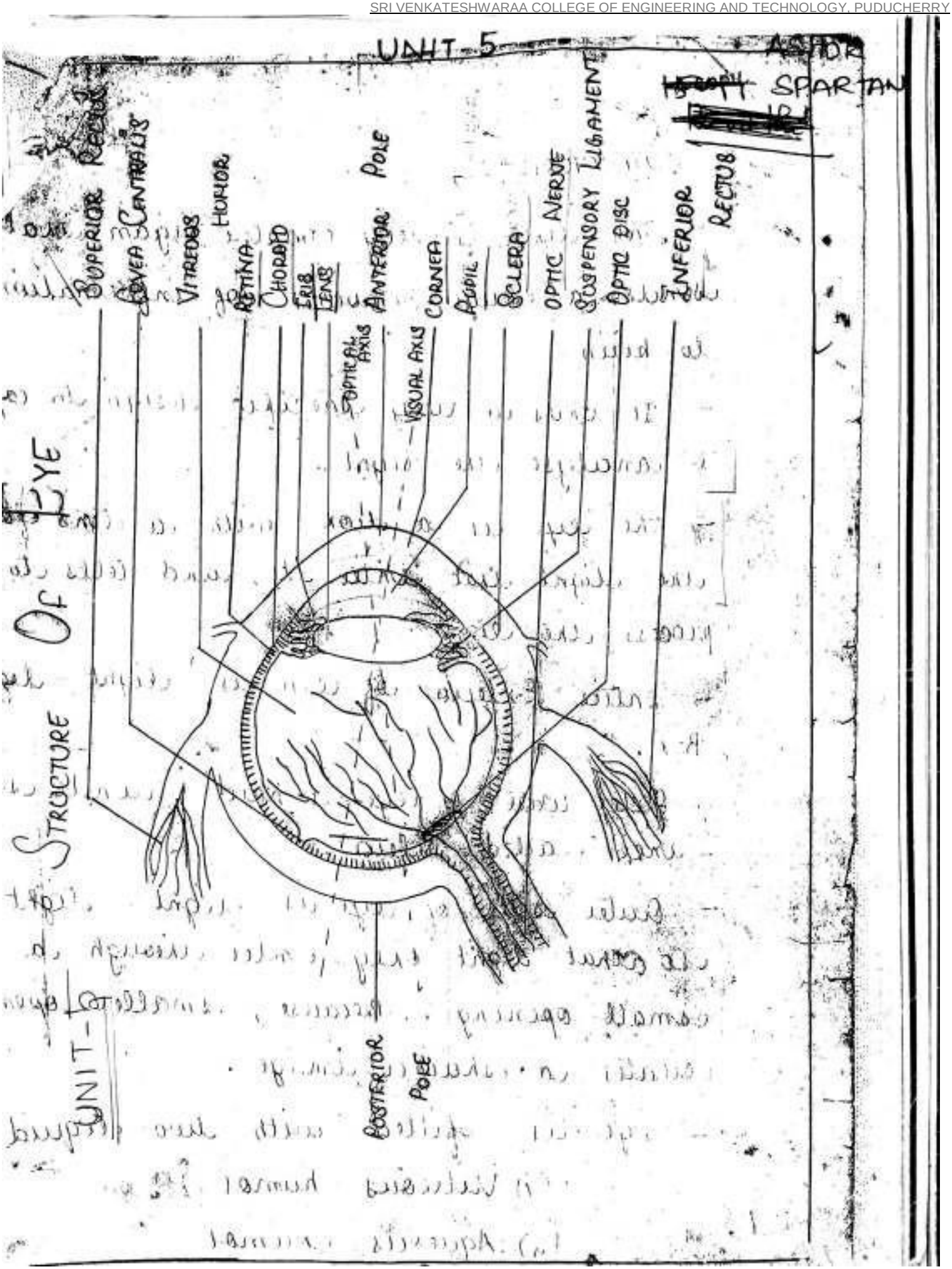
The temperature of the body is regulated by neural feedback mechanisms which operate primarily through the hypothalmus. The hypothalmus contains not only the control mechanisms, but also the key temperature sensors. Under control of these mechanisms, sweating begins almost precisely at a skin temperature of 37°C and increases rapidly as the skin temperature rises above this value. The heat production of the body under these conditions remains almost constant as the skin temperature rises. If the skin temperature drops below 37°C a variety of responses are initiated to conserve the heat in the body and to increase heat production. These include

- Vasoconstriction to decrease the flow of heat to the skin.
- Cessation of sweating.
- Shivering to increase heat production in the muscles.
- Secretion of norepinephrine, epinephrine, and thyroxine to increase heat production
- In lower animals, the erection of the hairs and fur to increase insulation.

UNIT-5

ASHOK SPARTAN

Structure Of Eye



UNIT-5

STRUCTURE :

- The eye is very complex organ that sends a huge amount of information to brain.
- It has a very specific design to capt & analyse the light.
- The eye is a box with a lens focu the light that enter it, and cells to process the light.
- Entire Exterior of eye is light - tigh Box.
- Outer Wall of eye is hard ; white sur - ance called Sclera.
- Outer side of eye is light - tight so that light only enter through a small opening. Because, smaller openi creates a shaper image.
- Eye is filled with two liquids
  (1) Vitreous humor
  (2) Aqueous humor

3

1. **With the aid of neat labelled diagram explain the physiology and anatomy of eye. [NOV/DEC'12]**

INTRODUCTION

The eye is the organ of the sense of sight situated in the orbital cavity and it is supplied by the *optic nerve* (2nd cranial nerve).It is almost spherical in shape and is about 2.5 cm in diameter. Structurally the two eyes are separate but, unlike the ear, some of their activities are coordinated so that they function as a pair. It is possible to see with only one eye but three-dimensional vision is impaired when only one eye is used, especially in relation to the judgement of distance.

Structure

There are three layers of tissue in the walls of the eye. They are:

- the outer fibrous layer: sclera and cornea
- the middle vascular layer or *uveal tract:* choroid, ciliary body and iris
- the inner nervous tissue layer: retina.

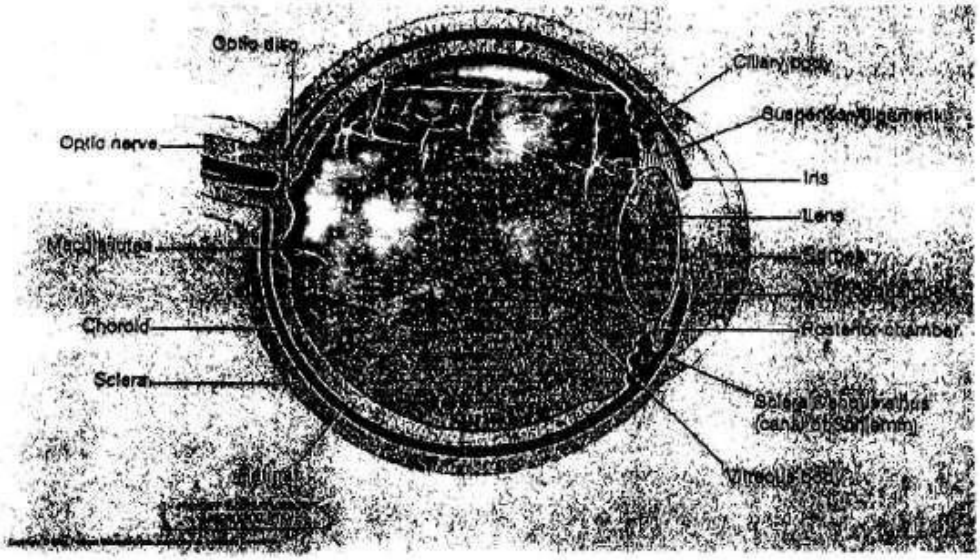


Fig1: Structure of an eye

Structures inside the eyeball are the lens, aqueous fluid(humour) and vitreous body (humour).

Sclera and cornea

The sclera, or white of the eye, forms the outermost layer of tissue of the posterior and lateral aspects of the eye ball and is continuous anteriorly with the transparent *cornea.*

It consists of a firm fibrous membrane that maintains the shape of the eye and gives attachment to the *extraocular* or *extrinsic muscles* of the eye.

Anteriorly the sclera continues as a clear transparent epithelial membrane, the *cornea*. Light rays pass through the cornea to reach the retina. The cornea is convex anteriorly and is involved in *refracting* or bending light rays to focus them on the retina.

Choroid

The choroid lines the posterior five-sixths of the inner surface of the sclera. It is very rich in blood vessels and is deep chocolate brown in colour. Light enters the eye through the pupil, stimulates the nerve endings in the retina and is then absorbed by the choroid.

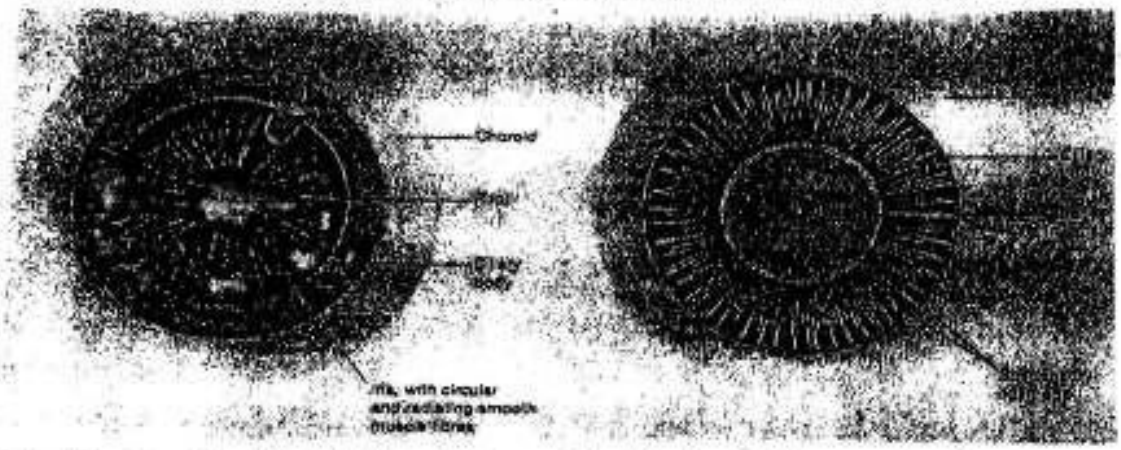


Fig: The choroid, ciliary body and iris. *Fig: The lens and suspensory ligament*

Ciliary body

The ciliary body is the anterior continuation of the choroid consisting of *ciliary muscle* (smooth muscle fibres) and secretory epithelial cells. It gives attachment to the *suspensory ligament* which, at its other end, is attached to the capsule enclosing the lens. Contraction and relaxation of the ciliary muscle changes the thickness of the lens which *bends*, or *refracts* light rays entering the eye to focus them on the retina. The epithelial cells secrete *aqueous fluid* into the anterior segment of the eye, i.e. the space between the lens and the cornea (anterior and posterior chambers).

Iris

The iris is the visible coloured part of the eye and extends anteriorly from the ciliary body, lying behind the cornea in front of the lens. It divides the anterior segment of the eye into

2. **Explain about accommodation neurophysiology of vision. [APR'13, NOV/DEC'13]**

Accommodation of the eyes to light

Close vision

In order to focus on near objects, i.e. within about 6 metres, the eye must make the following adjustments:

- constriction of the pupils
- convergence of the eyeballs
- changing the power of the lens.

Constriction of the pupils.

This assists accommodation by reducing the width of the beam of light entering the eye so that it passes through the central curved part of the lens.

Convergence (movement) of the eyeballs.

Light rays from nearby objects enter the two eyes at different angles and for clear vision they must stimulate *corresponding areas* of the two retinae. Extraocular muscles move the eyes and to obtain a clear image they rotate the eyes so that they *converge* on the object viewed. This coordinated muscle activity is under autonomic control. When there is voluntary movement of the eyes both eyes move and convergence is maintained. The nearer an object is to the eyes the greater the eye rotation needed to achieve convergence, e.g. an individual focusing near the tip of his nose appears to be 'cross-eyed'. If convergence is not complete the eyes are focused on different objects or on different points of the same object. There are then two images sent to the brain and this leads to double vision, *diplopia*. After a period of time during which convergence is not possible the brain tends to ignore the impulses received from the divergent eye.

Changing the power of the lens.

Changes in the thickness of the lens are made to focus light on the retina. The amount of adjustment depends on the distance of the object from the eyes, i.e. the lens is thicker for near vision and at its thinnest when focusing on objects at more than 6 metres' distance. Looking

anterior and *posterior chambers* which contain *aqueous fluid* secreted by the ciliary body. It is a circular body composed of pigment cells and two layers of smooth muscle fibres, one circular and the other radiating. In the centre there is an aperture called the *pupil*.

The iris is supplied by parasympathetic and sympathetic nerves. Parasympathetic stimulation constricts the pupil and sympathetic stimulation dilates it.

The colour of the iris is genetically determined and depends on the number of pigment cells present. Albinos have no pigment cells and people with blue eyes have fewer than those with brown eyes.

Lens

The lens is a *highly elastic* circular biconvex body, lying immediately behind the pupil. It consists of fibres enclosed within a capsule and it is suspended from the ciliary body by the *suspensory ligament*. The lens bends (refracts) light rays reflected by objects in front of the eye. It is the only structure in the eye that can vary its refractory power, achieved by changing its thickness. When the ciliary muscle contracts, it moves forward, releasing its pull on the lens, increasing its thickness. The nearer is the object being viewed the thicker the lens becomes to allow focusing.

Retina

The retina is the innermost layer of the wall of the eye. It is an extremely delicate structure and is especially adapted for stimulation by light rays. It is composed of several layers of nerve cell bodies and their axons, lying on a pigmented layer of epithelial cells which attach it to the choroid. The layer highly sensitive to light is the layer of sensory receptor cells: **rods and cones**.

The retina lines about three-quarters of the eyeball and is thickest at the back and thins out anteriorly to end just behind the ciliary body. Near the centre of the posterior part is the *macula lutea*, or yellow spot. In the centre of the area there is a little depression called the *fovea centralis*, consisting of only cone-shaped cells.

Towards the anterior part of the retina there are fewer cone- than rod-shaped cells. The rods and cones contain photosensitive pigments that convert light rays into nerve impulses.

About 0.5 cm to the nasal side of the *macula lutea* all the 198 nerve fibres of the retina converge to form the ***optic nerve***. The small area of retina where the optic nerve leaves the eye is the ***optic disc*** or ***blind spot***. It has no light sensitive cells.

RETINA - Unit 5

The retina is the innermost layer of the wall of the eye.

→ The image of the object falls on the retina. Thereby the light that enters the retina stimulate the photoreceptors called the rods and cones.

→ These photoreceptors causes chemical changes which are then transmitted as nerve impulses via several synapses to the optic nerve.

→ The optic nerve now carries the impulse to the proper part of the brain and thus the person 'sees'.

The neuronal layers of the retina are as follows

1) Pigment epithelium
2) Photoreceptors
3) Horizontal cells
4) Outer synaptic layer
5) Bipolar cells
6) amacrine cells
7) Inner synaptic layer
8) Ganglion cells
9) Optic nerve fibre

2, 5, 8 → The 3 neuron cells that carry impulse of light.

Rods and Cones:

These are the end organs of vision and are called light receptors or photo receptors.

Rods: Rods are called as rods because of their shape

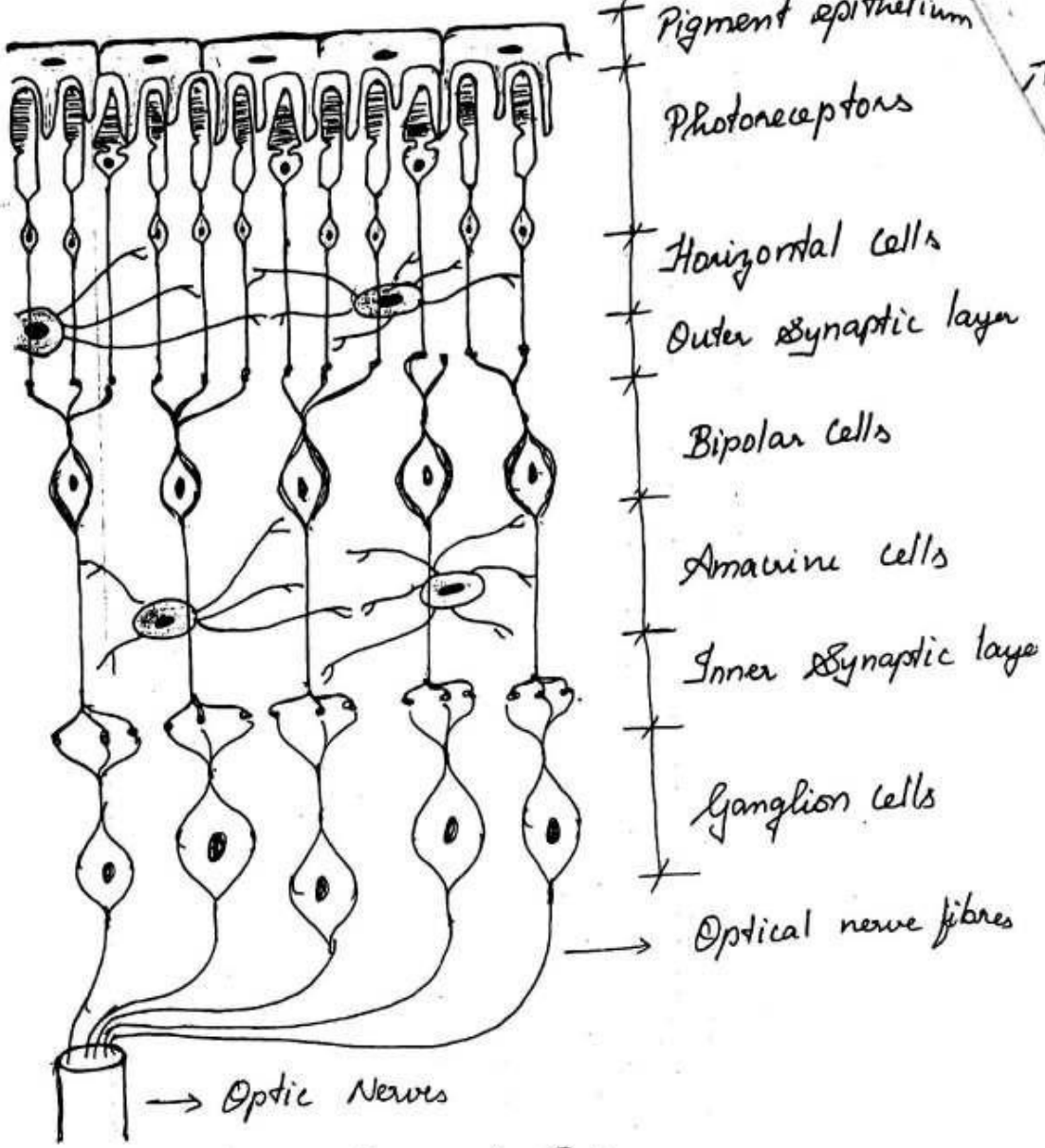


Fig : Layers of Retina

Each rod has 4 segments

1) Outer segment
2) Inner segment
3) Nuclear region
4) Synaptic region.

→ Outer segment contains several disc shaped structures that contain the photopigment rhodopsin.

→ Inner segment produce the pigment rhodopsin that migrates into the outer segment to be stored in the discs.
There are 120 million rods in each retina.

Cones:

Cones are cone shaped structure which also contains the 4 segments like rods

1) Outer segment
2) Inner segment
3) Nuclear region
4) Synapse.

→ There are 6 million cones in each retina
→ It has a pigment called cone pigment in its discs.

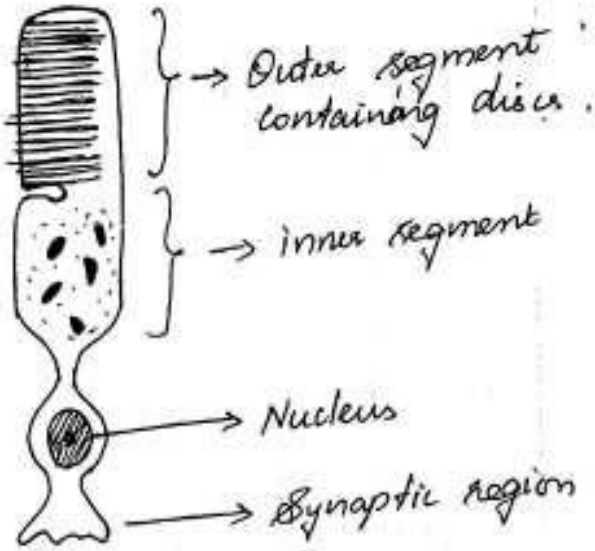


Fig: Structure of Rod

Bipolar and ganglion cells:

✓ As the light strikes the photoreceptors, they get stimulated and develops an electrical impulse.

✓ This impulse is conveyed to the ganglion cells by the bipolar cells at the synaptic region.

✓ There are about 1 million ganglion cells in each retina which means impulse from several photoreceptors converge on a single ganglion cell

✓ In the fovea, ratio between cone to ganglion cell is 1:1. The impulse from single cone is conveyed to single ganglion that leads to enhanced visual acuity.

Horizontal and amacrine cells:

Horizontal cells makes synaptic connection with receptor and bipolar cells thus makes the cells to be ready to receive the impulse.

Amacrine cells makes synaptic connections with bipolar and ganglion cells which aid in making the cells active to receive the impulse.

Optic disc & Optic fibres:

The axons of ganglion cells are collected together into a bundle called optic disc. & exits from the Optic disc as optic nerve fibres.

Optic disc is also called as blind spot since it doesnot contain rods & cones.

Photochemistry of Vision

Introduction:

The chemical changes that occur when the light strikes a rod or a cone are called as photochemical changes

Initially these photochemical changes cause development of impulse in the rods or cones. The impulses are then conveyed by the bipolar cells then to the ganglion cells and eventually by the optic nerve to the appropriate part of the brain.

Vision can be classified into

→ Scotopic vision [Dim light Vision]
→ Photopic vision [Bright light vision]

Scotopic Vision:

Rods are required for dim light or night light vision.

Rods contain a pigment called rhodopsin in the discs of their outer segment.

Rhodopsin is also called as Visual purple.

Rhodopsin molecule is a combination of opsin and Retinal. (ie)

Rhodopsin = Opsin [Protein] + Retinal [aldehyde of Vitamin A]

The protein molecule is called as Scotopsin.

Two forms of retinal occur

1) 11-cis-retinal
2) 11-trans-retinal.

In rhodopsin, the retinal occurs in cis variety.

The changes that occur due to the light are as follows.

1) As light strikes the rod, cis-retinal is converted into trans-retinal
2) This leads to a local electrical change which gives rise to a receptor potential, which
3) marks the beginning of the nerve impulse
3) Separation of opsin and trans-retinal occurs.
4) trans-retinal enters the pigment layer and get converted into cis-retinal.
5) This cis-retinal enters the outer segment and join with opsin to form the rhodopsin.
6) The whole process is called regeneration of rhodopsin and the separation of opsin and trans-retinal is called photodecomposition

Photopic Vision:

Cones are required for photopic or bright light vision, color vision and for acuity of vision.

Cones contain a pigment called 'Cone pigment'

Cone pigment = photopsin + retinal

There are 3 classes of cone pigment

1) red sensitive – 575 nm
2) green sensitive – 535 nm
3) blue sensitive – 430 nm

} – maximum sensitivity.

NEUROPHYSIOLOGY OF VISION

Neuronal pathways that transmit signals generated by from the time light enters the eye until it reaches the area the brain where vision is perceived.

The Optic Nerve leaves the eye and exits the orbit through the optic foramen to enter the cranial cavity.

↓

Just inside the cranial cavity, the two optic nerves connect each other at the optic chiasm.

↓

Axons from the nasal (medial) part of each retina cross through the optic chiasm and project to the opposite side of the brain.

↓

Axons from the temporal part of each retina pass through the optic nerves and project to the brain on the same side of the body without crossing

↓

Beyond the optic chiasm, the route of the ganglionic axons is through the two optic tracts. [Most of the optic tract axons terminate in the thalamus

↓

Neurons from the thalamus form the fibers of the optic radiations, which projects to the visual cortex in the occipital lobe of the brain

↓

The visual cortex is the area of brain where vision is perceived.

↓

The image seen by each eye is the visual field of that eye (Each [illegible]

When light of high intensity strikes the cones, photochemical changes occur in cone pigment similar to rhodopsin in rods.

Color Vision:

Color vision is possible only because of cones.

A normal person can see all wavelengths between violet and red. Visiblity range is between 410nm to 720nm.

When the primary colors are mixed in proper pro or specific proportion, the mixture has a white color & Black color really means absence of color.

A strong red light will stimulate only red sensitive cones but not the other.

Ultimately this leads to see the red light.

Dark Adaptation: (2 marks) (or) (4 marks)

When a person enters a dark room from a bright outdoor, he sees nothing at first but gradually the person begins to see more (ie) he becomes adapted to the dark and this is called as dark adaptation.

As soon as one enters a dark room from bright outdoor, visibility is very poor and the threshold of stimulation of photoreceptors is very high.

This means that the low intensity light that is available in the dark room fails to stimulate the photoreceptors.

As the time passes, visibility improves and the threshold falls.

Upto 20 minutes, the rate of improvement of visibility is high and at around 40th minute, dark adaptation is almost complete.

Light adaptation:

When a person is exposed to very strong light immediately after coming from a dark room, he cannot see anything.

Thereafter, the ability to see increases and the person is said to be developing light adaptation.

Light adaptation is complete within 5 minutes.

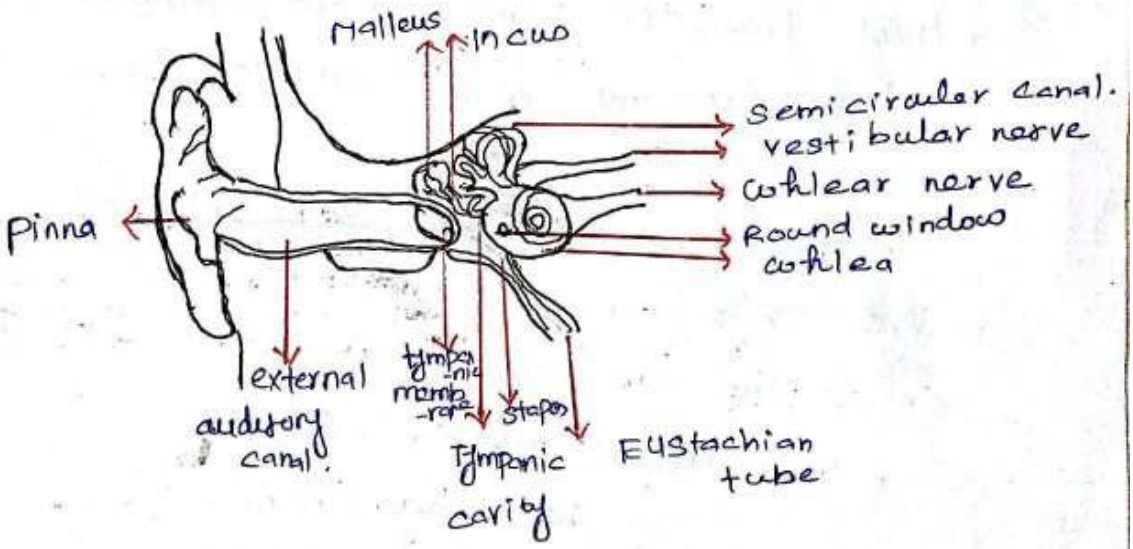
Anatomy of Ear:

* The ear is the organ that detects sound.
* it not only receives sound, but also aids in balance and body position.
* often the entire organ is considered as the ear, sometimes the visible portion only considered as ear.
* in general, the ear is divided into three parts.

1) outer ear
2) Middle ear
3) inner ear.

* All the three are involved in hearing but only the inner ear is responsible for balance.

Structure:



1) Outer ear:

* outer ear is the most external portion of the ear.

* It is composed of pinna (or) auricle and external auditory canal.

* Both structure funnel sound waves towards the ear drum (or) tympanic membrane allowing it to vibrate.

* The pinna also responsible for protecting eardrum against damage.

* Modified sweat glands in the ear canal form ear wax (cerumen)

* Two sets of muscles are associated with the outer ear.

- intrinsic muscles
- extrinsic muscles.

* In some mammals these muscles can adjust the direction of the pinna. ex: elephant.

* In humans, these muscles have very little action.

* These muscles are supplied by the facial nerve. This nerves also supplies sensation to the skin of the ear as well as ear cavity.

* In addition with this
the vagus nerve
mandibular nerve
occipital nerve, all supply the sensations to portion of the outer ear and surrounding skin.

ii) Middle ear:

* The middle ear is an air filled space located in the temporal bone of the skull.
* Air pressure is equalized in this space via the eustachian tube which drains into the naso pharynx. (or) back of the throat and nose.
* This tube is usually closed, except during swallowing, chewing and yawning - it opens.
* There are three small bones (or) ossicles that are located adjacent to the tympanic membrane. They are

malleus
incus
stapes.

* All are attached as the chain to the tympanic membrane and convert sound waves into mechanical vibrations of the three bones.
* The three ossicles transmits sound from tympanic membrane to the secondary tympanic membrane which is situated with in the oval window of inner ear.
* The malleus bone is connected to the mobile portion of the ear drum and transmits vibration produced by sound waves in ear drum to stapes.
* The incus bone is the bridge between malleus and stapes which is connected to the oval window.
* In total the ossicles help in amplification

of sound waves that sensed by the outer ear and form vibration according to the sound wave and then it transmit to inner ear through oval window.

3) Inner ear:

* It is the innermost part of the ear. mainly responsible for sound detection and balance.
* it consist of bony labyrinth, a hallow cavity in the temporal bone of the skull with a three system passages.
  (i) Cohlea – dedicated for hearing
  (ii) vestibule
  (iii) semicircular canals } - dedicated for balance.

(i) Cohlea:

* It is a coiled tube like snail's shell. and contains bony core like a screw.
* The threads of screw called spiral lamina. The cohlea is divided into three channels.
  (a) Scala vestibuli
  (b) Scala tympani
  (c) Cohlear duct.

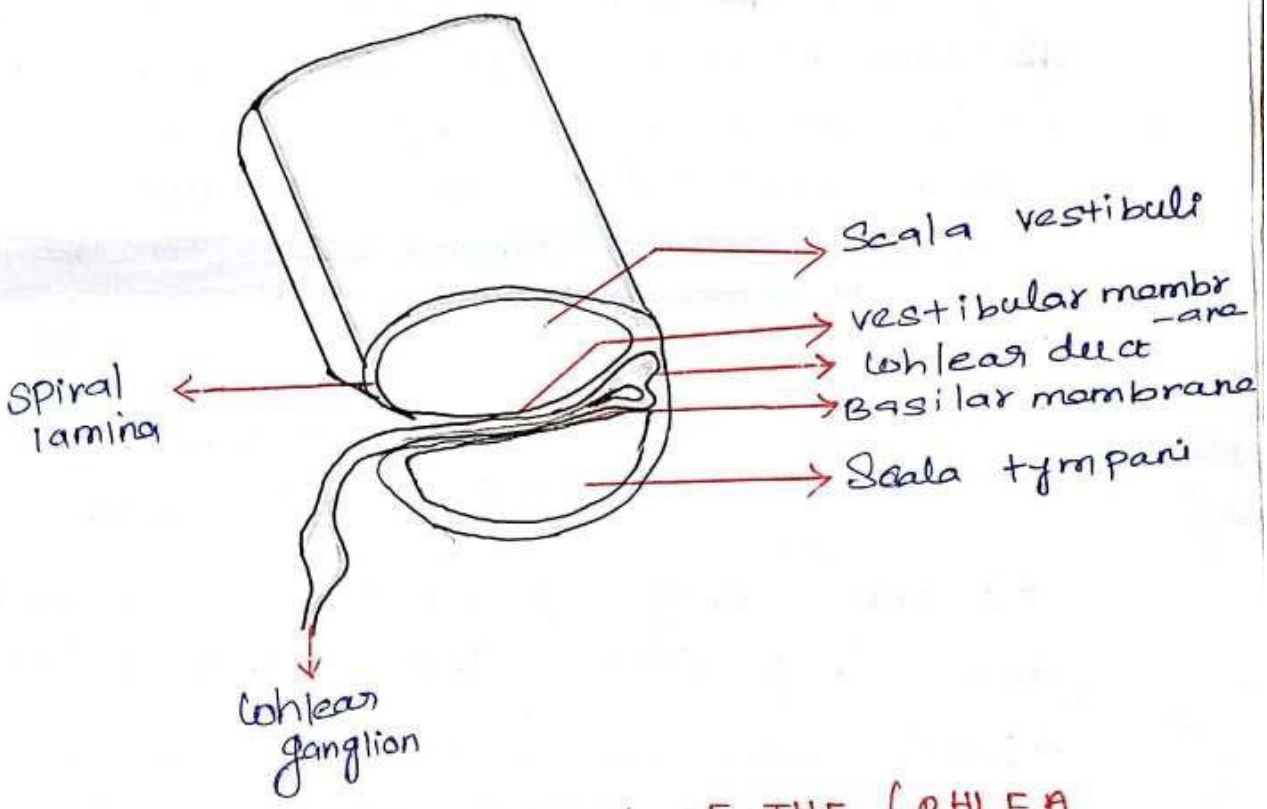
(a) Scala vestibuli:-

The Scala vestibuli extends from the oval window to the apex of the cohlea.

(b) Scala tympani:

The Scala tympani extends in parallel with the Scala vestibuli from the apex, back to the round window.

* The two channels, scala vestibuli and scala tympani filled with perilymph and make the space between the walls of bony and membran -ous labyrinth.
* The wall of membranous labyrinth that lines the scala vestibuli is called vestibular membrane, the wall of membranous labyrinth that lines the scala tympani is the basilar membrane.



CROSS SECTION OF THE COHLEA

(c) Cohlear duct:

* Cohlear duct is formed by the space between the vestibular membrane and basilar membrane is filled with endolymph.

* Inside the cohlear duct is a special organ or organ of corti. It contains specialized sensory cells called hair cells, which have hair like microvilli on their surfaces.
* These haircells have no axons of their own. but each hair cell is associated with axon terminals of sensory neurons in the cell bodies which are located in the cohlear ganglion.
* Axons of the sensory neurons join to form the cohlear nerve. This nerve joins the vestibular nerve to become the vestibulo cohlear nerve which carries action potentials according to the sound waves to the brain.

2) The vestibule:-

* The vestibule has two membranous sacs utricle / saccle } called otolith organs.
* Because they respond to gravitational forces, they also called gravity receptors.
* Each sac has on its inner surface a single patch of sensory cells called macula which is about 2 millimeter in diameter to monitors the position of head.

3) Semicircular canals:

* These canals are lined with cilia and

3. filled with a liquid substance known as endolymph.

* Every time the head moves, the endolymph and moves cilia. This work as a type of motion sensor.
* Movements of cilia are communicated to the brain. AS the result the brain knows how to keep the body balanced.
* The semicircular canal contain three main parts.

Horizontal canal – Detects vertical rotation - up and down on the rock.

posterior canal – Detects rotation on sagittal Plane - forward & backward movement.

Superior canal - Detects head rotation - side-to-side movement.

Mechanism of hearing:-

* The sound waves are directed towards the ear canal by the pinna.
* The waves that enter the canal are concentrated and made to strike against the ear drum (or) tympanic membrane.
* The vibrations are picked up by the malleus on the other side.
* These vibrations are transmitted to the fanestra ovalis (oval window) via the incus and stapes.

* These vibrations travel along the vesti-bular canal to end of the cohlea and then to the typanic canal. The vibrations are also transmitted via the Reisnrer's membrane to the basilar membrane and than to the tympanic canal.
* The vibrations travel along the vestibular and tympanic canals in the opposite direction
* From the basilar membrane, the vibrations are picked up by the sensory hair cells of the organ of corti and transmitted as action potentials to the neurons of the auditory nerve fibres.
* The action potentials are than transmitted as nerve impulses to the auditory cortex of the brain through the auditory nerve.

Flow diagram of hearing

(5)

Vibrations creates Sound waves → collectively auricle → external auditory canal ↓ towards tympanic membrane.

Sound wave strike TM ← TM cause vibration ← TM caused by 3 ossicles. ← Amplified & transfered ← Vibration ← Oval Window

Produces waves in perilymph.

Cohlea

↓

Rubber diaphram

↓

fluid can move

↓

vestibular membrane.

↓ cause vibration

endolymph

↓ displacement in

Basilar membrane

↓

movement of membrane

↓

Moves hair cells

↓ induces

Action potentials in the cochlear nerve.

↓

auditory nerve

↓

auditory cortex (brain).

NEURONAL PATHWAYS FOR HEARING

* The Senses of hearing and Balance are both transmitted by the vestibulocochlear nerve (VIII)
* This nerve functions as two separate nerves, carrying information from two separate but closely related structures.
  (1) The cochlear nerve - involved in hearing
  (2) The Vestibular Nerve - involved in Balance.

The cochlear nerve sends axons to the cochlear nucleus in the brainstem

↓

Neurons in the cochlear nucleus project to other areas of the brainstem and to the inferior colliculus in the midbrain.

↓

Neurons from the inferior colliculus also project to the superior colliculus, where reflexes that turn the head and eyes in Response to loud sounds are initiated

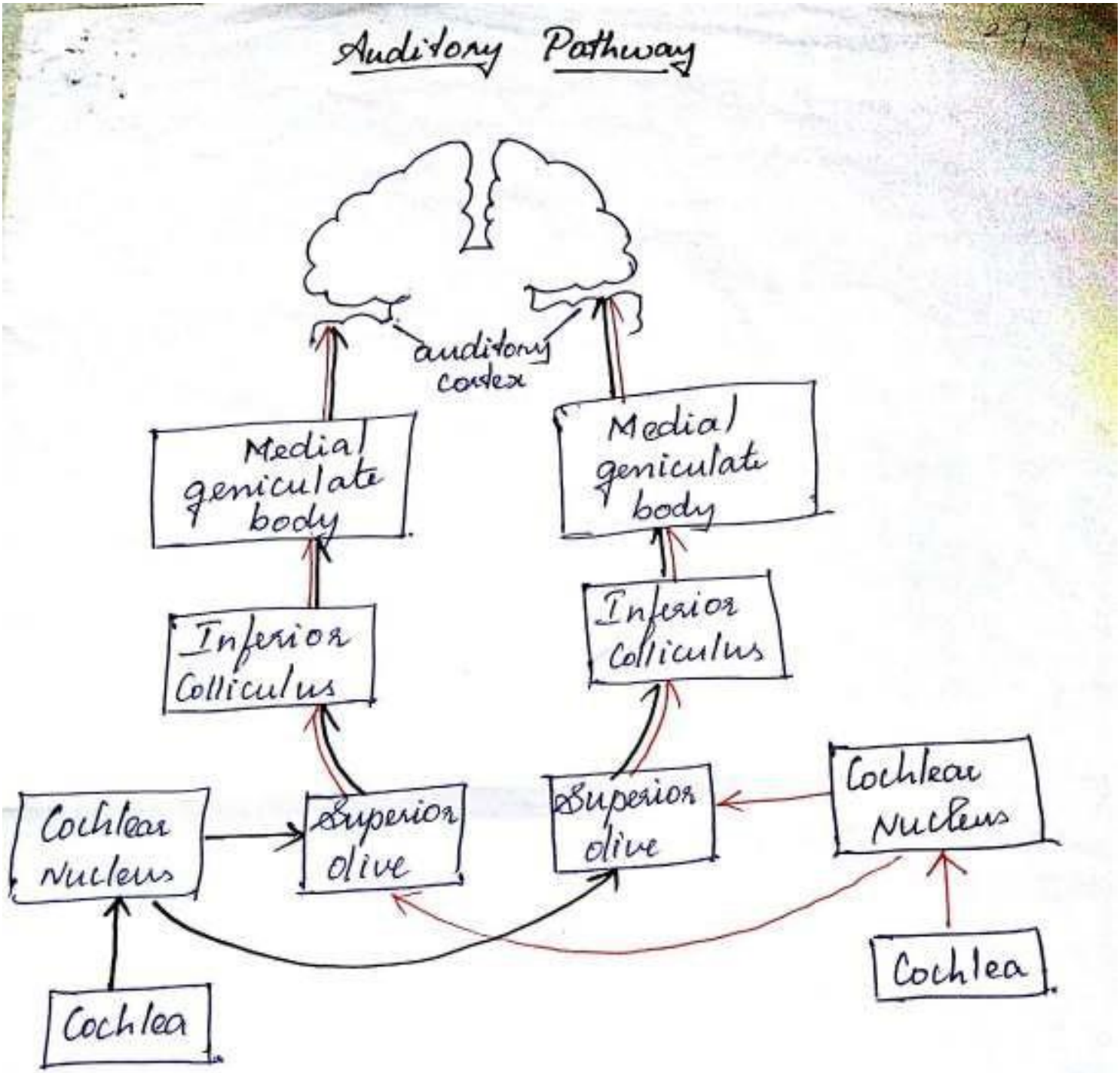
↓

From the inferior colliculus, fibers project to the thalamus and from there to the auditory cortex of the cerebrum.

BALANCE

* The Sense of Balance, or equilibrium, has two components
  (i) static equilibrium: is associated with the vestibule and is involved in evaluating the position of the head relative to gravity.
  (ii) Dynamic equilibrium is associated with the semicircular canals and is involved in evaluating changes in the direction and rate of head movements.

Auditory Pathway

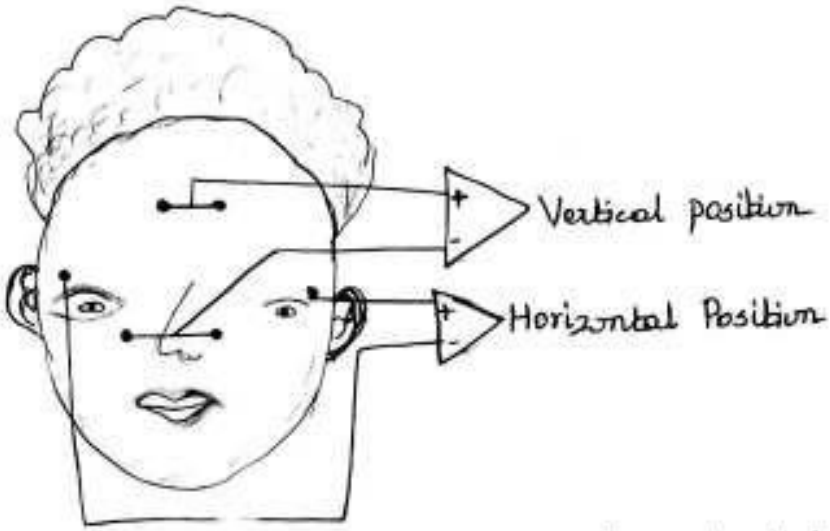


ELECTROOCULOGRAPHY (EOG)

The record of corneal-retinal potentials associated with eye movement is called Electrooculogram.

* The electrode are placed instead into the eye.
* One pair of disc like skin electrodes on either side of eye for horizontal movement of eyes.
* Another pair of electrodes on the forehead and cheeks for recording of vertical movement of eyes.
* The above electrode positions method reduces the cross coupling between the vertical and horizontal pair of electrodes in conjugate electrooculography.
* The outputs from these two pairs are given separately to the preamplifiers and then are recorded.
* During recording, the eye rhythmically rotated as the vision shifts between two fixed points.
* An alternating potential difference of 1mV or more is recorded.
* The source of electrical energy in eye is the corneoretinal potential or electrostatic field which rotates with respect to the eye.
* A commonly observed overshoot artifact in EOG recording of vertical eye movements has been attributed to the motion of the upper eyelid.

RECORDING OF ELECTROOCULOGRAM



Some diseases which affect the steady potential of the eye can be usefully studied using EOG:

* i) The effect of certain drugs on the eye movement system can be determined.
* (ii) The state of the semicircular canal is analysed by EOG.
* (iii) Diagnosis of the neurological disorders may be possible.
* iv) The level of anasthesia can be indicated by the characteristic eye movements.

RECORDERS FOR EOG

Two types of Recorders.

(i) On line Recorders

(ii) Off line Recorders

(1) ONLINE RECORDERS

* The on.line recordes are directly connected with input. Therefore one can get the live recording at the spot itself.

(ii) OFF LINE RECORDERS

* The off line analysis the equipment is not directly connected with the recorder. The input equipment system is used to prepare data for further analysis.

HEARING TESTS

Hearing tests are used to assess ability to hear different sounds and to determine if there are any problems. Hearing tests are carried out for two main reasons:

- As a routine part of a baby's or young child's developmental checks
- To check the hearing of someone who is experiencing hearing problems or has hearing loss

Generally, different tests are used for adults and children but they are all completely painless. The results of some of these tests are recorded on a graph called an audiogram, so that the type of hearing loss can be identified. Common hearing tests include:

- automated Otoacoustic emissions (AOAE) tests

  Otoacoustic emissions (OAE) testing is often used to screen newborns for hearing problems. In this test, a small, soft microphone is placed in the baby's ear canal. Sound is then introduced through a small flexible probe inserted in the baby's ear. The microphone detects the inner ear's response to the sound. This test cannot distinguish between conductive and sensorineural hearing loss.

- automated auditory brainstem response (AABR) tests

  Auditory brain stem response (ABR) testing detects sensorineural hearing loss. In this test, electrodes are placed on your scalp and on each earlobe. Clicking noises are then sent through earphones. The electrodes monitor your brain's response to the clicking noises and record the response on a graph. This test is also called brain stem auditory evoked response (BAER) testing or auditory brain stem evoked potential (ABEP) testing.

- pure tone audiometry tests

  Pure tone audiometry uses a machine called an audiometer to play a series of tones through headphones. The tones vary in pitch (frequency, measured in hertz) and loudness (intensity, measured in decibels). The health professional will control the volume of a tone and reduce its loudness until you can no longer hear it. Then the tone will get louder until you can hear it again. You signal by raising your hand or pressing a button every time you hear a tone, even if the tone you hear is very faint. The health professional will

then repeat the test several times, using a higher-pitched tone each time. Each ear is tested separately. The headphones will then be removed, and a special vibrating device will be placed on the bone behind your ear. Again, you will signal each time you hear a tone.

- bone conduction tests

Use vibrating tuning forks placed in contact with the head. By bypassing the external auditory canal and middle ear, bone conduction tests can help distinguish problems in the inner ear, eighth cranial nerve, and central auditory pathways. The Weber and Rinne tuning fork tests can distinguish between conductive and sensorineural hearing losses. The Weber test may be performed using a 256 or 512 Hz fork. During this test, the stem of a vibrating tuning fork is placed on the head in the midline. If the tone is perceived in the affected ear, this indicates a unilateral conductive hearing loss. In the case of unilateral sensorineural hearing loss, the tone is heard in the unaffected ear instead. In the Rinne test, air and bone conduction tests are compared. In normal hearing tones are louder by air conduction than by bone conduction. In conductive hearing loss, however, the bone-conduction stimulus is perceived as louder. In sensorineural hearing loss both air and bone conduction sounds are diminished, but the air conduction sound is perceived as louder. The Rinne test is most sensitive in detecting mild conductive hearing losses if a 256 Hz fork is used.

HEARING AID

Hearing aids are primarily useful in improving the hearing and speech comprehension of people who have hearing loss that results from damage to the small sensory cells in the inner ear, called hair cells. This type of hearing loss is called sensorineural hearing loss. The damage can occur as a result of disease, aging, or injury from noise or certain medicines.

A hearing aid magnifies sound vibrations entering the ear. Surviving hair cells detect the larger vibrations and convert them into neural signals that are passed along to the brain. The greater the damage to a person's hair cells, the more severe the hearing loss, and the greater the hearing aid

amplification needed to make up the difference. However, there are practical limits to the amount of amplification a hearing aid can provide. In addition, if the inner ear is too damaged, even large vibrations will not be converted into neural signals. In this situation, a hearing aid would be ineffective.

Analogue or digital

Analogue and digital hearing aids look very similar, but they process sound differently. Analogue aids amplify electronic signals, while digital aids use a tiny computer to process sound. This means it is possible to customize the aid to suit your hearing loss very precisely. Many digital aids can be programmed with different settings for different sound environments, for example a quiet living room or a crowded restaurant. Some even switch settings automatically to suit the environment.

Digital hearing aids are designed to reduce background noise, which makes listening in noisy places more comfortable. They are also less likely to 'whistle', or give feedback. Digital hearing aids on the NHS are available as standard on the NHS.

Behind the ear (BTE) hearing aids

BTE aids have an earmould that fits snugly inside your ear, while the rest of the aid rests behind your ear. Some models have twin microphones, which let you switch between all-round sound and a more directional setting that helps you focus on what you want to hear in noisy places.

BTE hearing aids with 'open ear fitting' have a small, soft earpiece at the tip of the tubing instead of an earmould. This type of fitting can be less noticeable than an earmould but is only suitable if your hearing loss is mild or moderate. It can give you a very natural sound.

Receiver in the ear (RITE) hearing aids

Receiver in-the-ear (RITE) (or loudspeaker in-the-ear) aids are often smaller than BTE aids because some part of the device sits inside the ear. Like open ear BTEs, they can be easier to put in than an earmould if you find fiddly tasks awkward.

There are different RITE hearing aids for different levels of hearing loss. If your hearing loss is severe, you may need a type where the receiver sits in an earmould.

In the ear (ITE) hearing aids

These fit entirely into your ear. The working parts are either in a small compartment clipped to the earmould or inside the moulded part itself. ITE aids tend to need repairing more often than BTE aids.

Completely in the canal (CIC) hearing aids

These are even smaller than ITE aids, so they are less visible. They are unlikely to be suitable if you have severe hearing loss or frequent ear infections.

Body worn hearing aids

These have a small box that you clip to your clothes or put in your pocket. This is connected by a lead to the earphone. Some people find the controls less fiddly than those on smaller hearing aids. Some body-worn aids are very powerful.

Bone conduction hearing aids

These are for people with conductive hearing loss or people who can't wear conventional hearing aids. They deliver sound through the skull via vibrations