PART-A

1. What is Membrane Potential. (A/M 2018, N/D 2017) (OR) Define the following: Membrane Potential and Action Potential. (A/M-2017, 15, 11)

Membrane potential:

- The Difference between the concentration of molecules and charge inside and outside the cell during resting and Action potential is known as Membrane potential.

Action potential:

- When a cell membrane is excited, the Permeability of the membrane changes so that the sodium ions are allowed to enter inside the cell.
- Meanwhile potassium ions are leaving the cell but are unable to move as rapidly as the sodium ions. Therefore the cell has a slightly positive potential on the inside due to the imbalance of potassium ions.

2. Define the role of cytoskeleton in cell. (N/D 2017)

- A **cytoskeleton** is present in all cells of all domains of life (archaea, bacteria, eukaryotes). It is a complex network of interlinking filaments and tubules that extend throughout the cytoplasm, from the nucleus to the plasma membrane.
- The cytoskeletal systems of different organisms are composed of similar proteins. It is a network of protein fibers supporting cell shape and anchoring organelles within the cell. The three main **structural** components of the **cytoskeleton** are microtubules (formed by tubulins), microfilaments (formed by actins) and intermediate filaments.
- All three components interact with each other non-covalently.
- Through a series of intercellular proteins, the **cytoskeleton** gives a cell its shape, offers support, and facilitates movement through three main components: microfilaments, intermediate filaments, and microtubules.

3. What is Nernst potential? (N/D 2016)

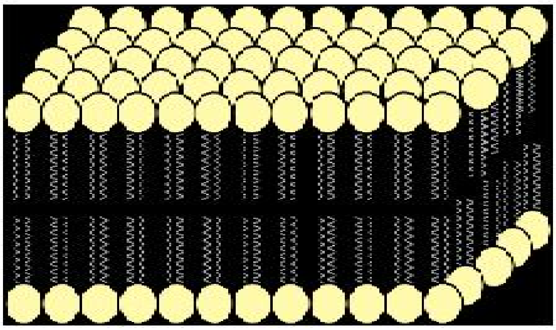
In a biological membrane, the reversal **potential** (also known as the **Nernst potential**) of an ion is the membrane **potential** at which there is no net (overall) flow of that particular ion from one side of the membrane to the other. Equilibrium refers to the fact that the net ion flux at a particular voltage is zero.

4. What are Peroxisomes and its functions? (M/J-2016)

Peroxisomes are very small organelles 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.

A major function of the peroxisome is the breakdown of very long chain fatty acids through beta-oxidation. In animal cells, the long fatty acids are converted to medium chain fatty acids, which are subsequently shuttled to mitochondria where they are eventually broken down to carbon dioxide and water.

5. What is Fluid Mosaic Model of Membrane? (A/M 2015)



The fluid mosaic model explains various observations regarding the structure of functional cell membranes. The cell membrane is a two-dimensional liquid that restricts the lateral diffusion of membrane components. Such domains are defined by the existence of regions within the membrane with special lipid and protein composition that promote the formation of lipid rafts or protein and glycoprotein complexes.

6. Highlight the changes occur during Active Potential in the Nerve Cell. (N/D-2013) (or) Write a short note on nerve Action Potential. (N/D-2015)

- A stimulus is received by the dendrites of a nerve cell. This causes the Na^+ channels to open. If the opening is sufficient to drive the interior potential from -70 mV up to -55 mV, the process continues.
- Having reached the action threshold, more Na^+ channels (sometimes called voltage-gated channels) open. The Na^+ influx drives the interior of the cell membrane up to about +30 mV. The process to this point is called depolarization.
- The Na^+ channels close and the K^+ channels open. Since the K^+ channels are much slower to open, the depolarization has time to be completed. Having both Na^+ and K^+channels open at the same time would drive the system toward neutrality and prevent the creation of the action potential.
- With the K^+ channels open, the membrance begins to repolarize back toward its rest potential.

- The repolarization typically overshoots the rest potential to about -90 mV. This is called hyper polarization and would seem to be counterproductive, but it is actually important in the transmission of information. Hyper polarization prevents the neuron from receiving another stimulus during this time, or at least raises the threshold for any new stimulus. Part of the importance of hyper polarization is in preventing any stimulus already sent up an axon from triggering another action potential in the opposite direction. In other words, hyper polarization assures that the signal is proceeding in one direction.
- After hyper polarization, the Na^+/K^+ pump eventually brings the membrane back to its resting state of -70 mV

7. How will you calculate the membrane potential when two univalent positive ions are involved? (N/D 2015)

The **Goldman–Hodgkin–Katz** voltage equation, more commonly known as the **Goldman equation**, is used in cell membrane physiology to determine the reversal potential across a cell's membrane, taking into account all of the ions that are permeant through that membrane.

$$V_m = \frac{RT}{F}\ln\left(\frac{p_K[K^+]_o + p_{Na}[Na^+]_o + p_{Cl}[Cl^-]_i}{p_K[K^+]_i + p_{Na}[Na^+]_i + p_{Cl}[Cl^-]_o}\right)$$

$\boldsymbol{V_m}$ is the membrane potential.
R is the universal gas constant.
T is the temperature in Kelvin.
F is the Faraday's constant.
$\boldsymbol{p_K}$ is the membrane permeability for K.
$\boldsymbol{p_{Na}}$ is the relative membrane permeability for Na^+.
$\boldsymbol{p_{Cl}}$ is the relative membrane permeability for Cl^-.

8. Define homeostasis. (N/D-2014), (JAN 2015)

Homeostasis is the human body keeping a constant internal temperature. The **definition** of **homeostasis** is the ability or tendency to maintain internal stability in an organism to compensate for environmental changes. An example of **homeostasis** is the human body keeping an average temperature of 98.6 degrees.

9. Difference between Depolarization and Hyper-polarization. (N/D-2014, 13)

Depolarization:

Polarization refers to the membrane potential. When the nerve is resting, it has a membrane potential of about -75 mV, that it is "polarized".

When the nerve receives excitatory signals, the membrane potential becomes less negative, so we say it "depolarizes" from its resting "polarized" level. Depolarization occurs when sodium channels open and Na+ ions enter the cell. The depolarization can drive the membrane potential as high as +50 mV.

Repolarization:

Eventually, though, the Na channels close and the membrane potential starts to "repolarize" - that is return towards it resting value. In addition, potassium channels open allowing K+ ions to exit the cell. This contributes to the "repolarization" phase.

Hyperpolarization:

The addition K channels stay open even when the membrane potential reaches the resting level. So, the potential goes even more negative than resting. This is "hyperpolarization". It may goes as low as -90 mV.

10. Write short notes on Endoplasmic reticulum.

- Endoplasmic reticulum is a network of membranes found throughout the cell and connected to the nucleus.
- There are two types of endoplasmic reticulum: rough endoplasmic reticulum (rough ER) and smooth endoplasmic reticulum (smooth ER).
- 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.

11. List four major functions of membrane proteins.

- Transduction Proteins: Move molecules across the membrane.
- Membrane Receptor Proteins: Receive chemical signals.
- Enzymes: Facilitate reactions; may be involved in transport or signal transduction (in receptor proteins).
- Attachment or Adhesion Proteins: Bind to proteins outside the cell (extracellular matrix) or binds to other cells (cell to cell junctions). Basically, it helps cells stick to each other and their surroundings.
- Cell Recognition Molecules: Identity tag of the cell. One of a class of glycol proteins or glycol lipids that project above the plasma membrane and that identifies a cell as non-self (foreign) or self (belonging to one’s own body tissue).

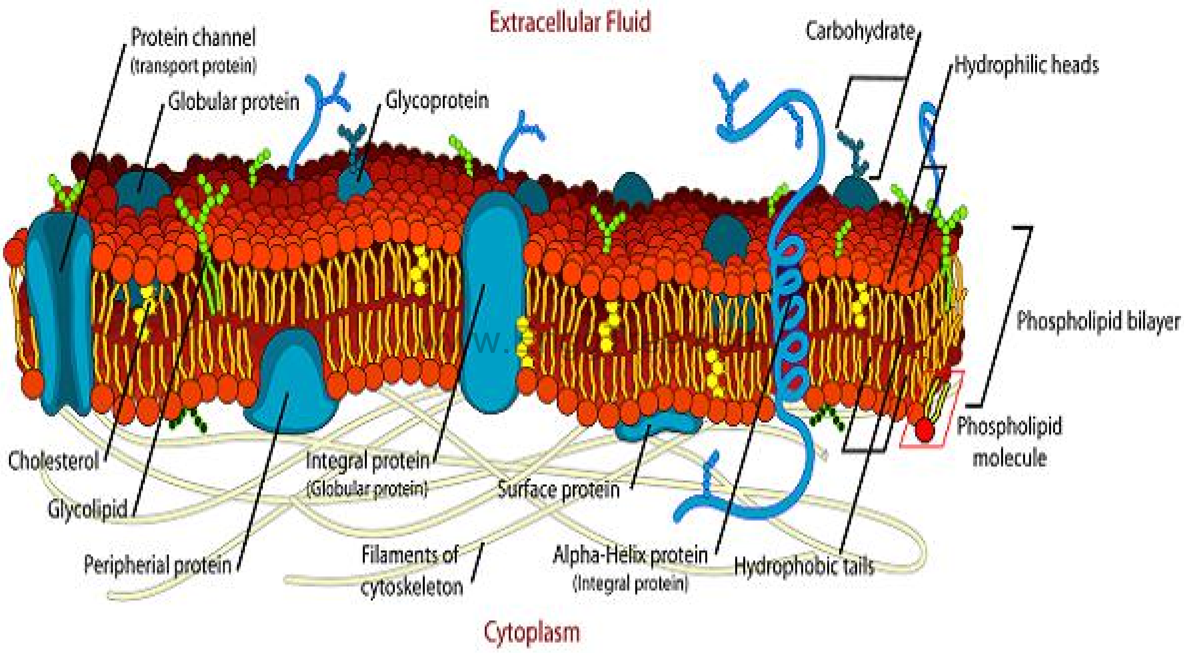
12. What is Hayem's fluid?

- ✓ Sodium chloride 0.5 Gm
- ✓ Sodium sulphate 2.5 Gm
- ✓ Mercuric perchloride 0.25 Gm

13. What are the functions of Ribosomes in a cell?

- ✓ Ribosomes are a cell structure that makes protein. Protein is needed for many **cell** functions such as repairing damage or directing chemical processes.
- ✓ Ribosomes can be found floating within the cytoplasm or attached to the endoplasmic reticulum.

14. Outline the structure and function of plasma membrane.



All cells are surrounded by a plasma membrane. The membrane is composed of a phosphor lipid bi-layer arranged back-to-back. The membrane is also covered in places with cholesterol molecules and proteins. The plasma membrane is selectively permeable and regulates which molecules are allowed to enter and exit the cell.

15. Differentiate action potential from resting potential.

Resting potential:

- ➢ "Resting potential" is the electrical state when a cell is not actively being excited. A nerve and muscle cell at resting potential has a membrane with established amounts of sodium (Na+) and potassium (K+) ions on either side, leaving the inside of the neuron negatively charged relative to the outside.

Action potential:

- When a cell membrane is excited, the permeability of the membrane changes so that the sodium ions are allowed to enter inside the cell.
- Meanwhile potassium ions are leaving the cell but are unable to move as rapidly as the sodium ions. Therefore the cell has a slightly positive potential on the inside due to the imbalance of potassium ions.

16. What is Barr body?

A Barr body can be defined as a small dark stained mass of X chromosome, which is inactive and are found only in the female cells. It is present in the nuclei of all cells except the germ cells. It is also called as sex chromatin as it indicates the presence of sex hormone.

17. What is facilitated diffusion? Give an example.

- ✓ Facilitated diffusion is a process whereby a substance passes through integral membrane protein that spans the width of the membrane. The force that drives the molecule from one side of the membrane to the other is the force of diffusion.
- ✓ **Example:** K+ ions are passing through a membrane using a potassium transport protein. The ions are moving down a concentration gradient so the process is a diffusion of K ions.

18. Define acute inflammation and which cell is involved in this process.

- ✓ During an immune response, often a set of processes occur that create a condition known as inflammation. Two types acute inflammation and chronic inflammation.
- ✓ Acute inflammation begins within seconds to minutes following the injury of tissues.
- ✓ White blood cell involved in the process of acute inflammation.

19. Define – Cell, Tissue and Organs.

Cell:

The **cell** is the basic structural, functional, and **biological** unit of all known living organisms. A **cell** is the smallest unit of life. **Cells** are often called the "building blocks of life". The study of **cells** is called **cell biology**.

Tissue:

Tissue is a cellular organizational level between cells and a complete organ. A **tissue** is an ensemble of similar cells and their extracellular matrix from the same origin that together carry out a specific function. Organs are then formed by the functional grouping together of multiple **tissues**.

Organs:

A group of tissues in a living **organism** has been adapted to perform a specific function. In higher animals, **organs** are grouped into **organ** systems; e.g., the Esophagus, stomach, and liver are **organs** of the digestive system.

20. What are the cell organelles?

- Nucleus
- Mitochondria
- Ribo-somes
- Endo plasmic reticulum
- Golgi apparatus
- lysosomes and
- The cytoskeleton

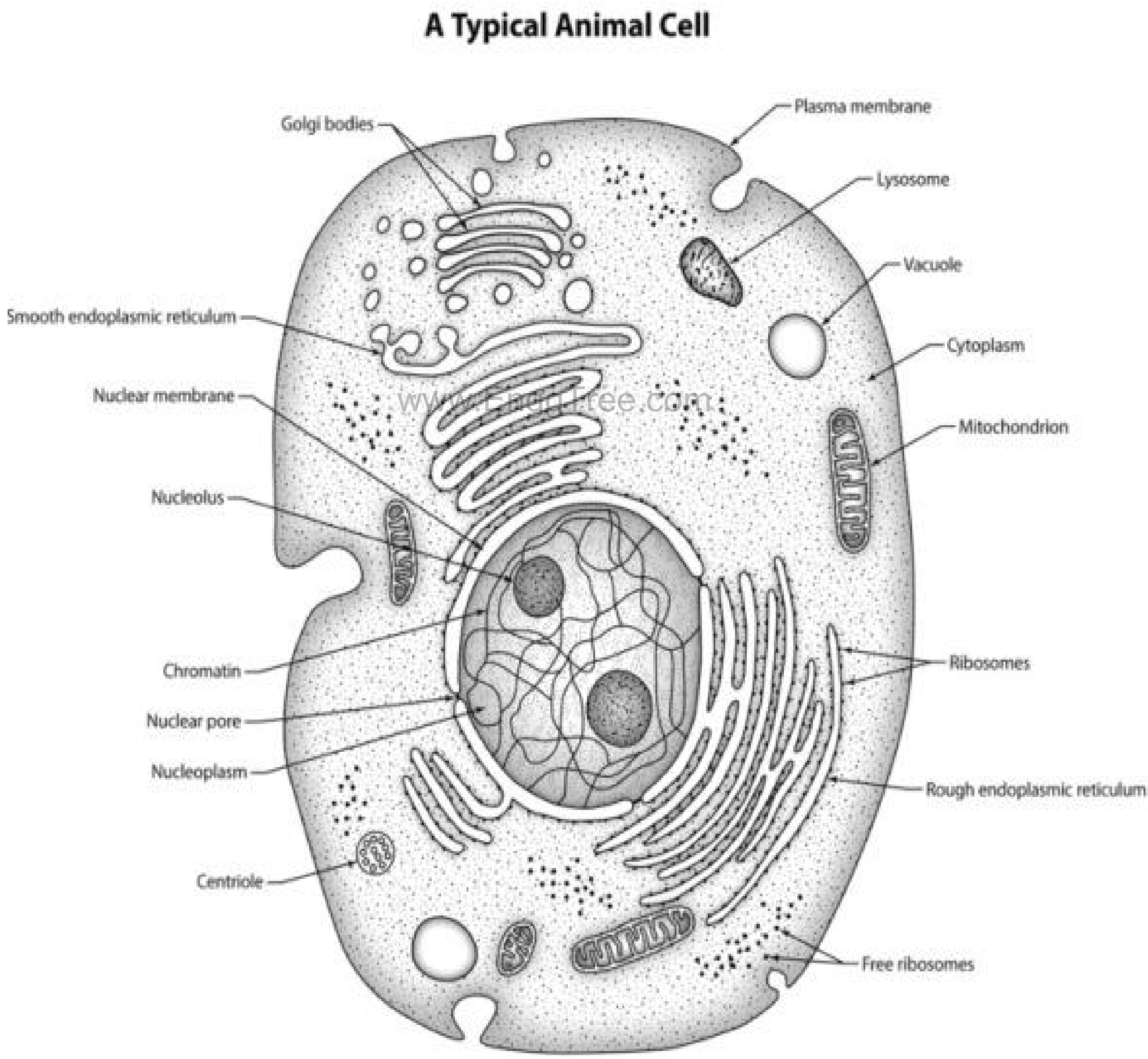
21. What are the stages of cell division.

- ➢ Interphase
- ➢ Prophase
- ➢ Metaphase
- ➢ Anaphase
- ➢ Telophase
- ➢ Cytokinesis.

PART-B

1. **(a) Describe the structural organization of the cell membrane with a suitable illustration. (N/D-2010) (or) What are functions of mitochondria and endoplasmic reticulum in a cell. (N/D-2010) (or) Discuss the structure of cell with a neat sketch. (N/D-2011) (or) Draw the structure of eukaryotic cell and label its components. Explain the function of all its components. (A/M-2011) (or) With a neat sketch explain the function of each components of cell. (Dec-2009) (A/M-2017, 15) (N/D 2016), (JAN 2015).**

Parts of the Human Cell:



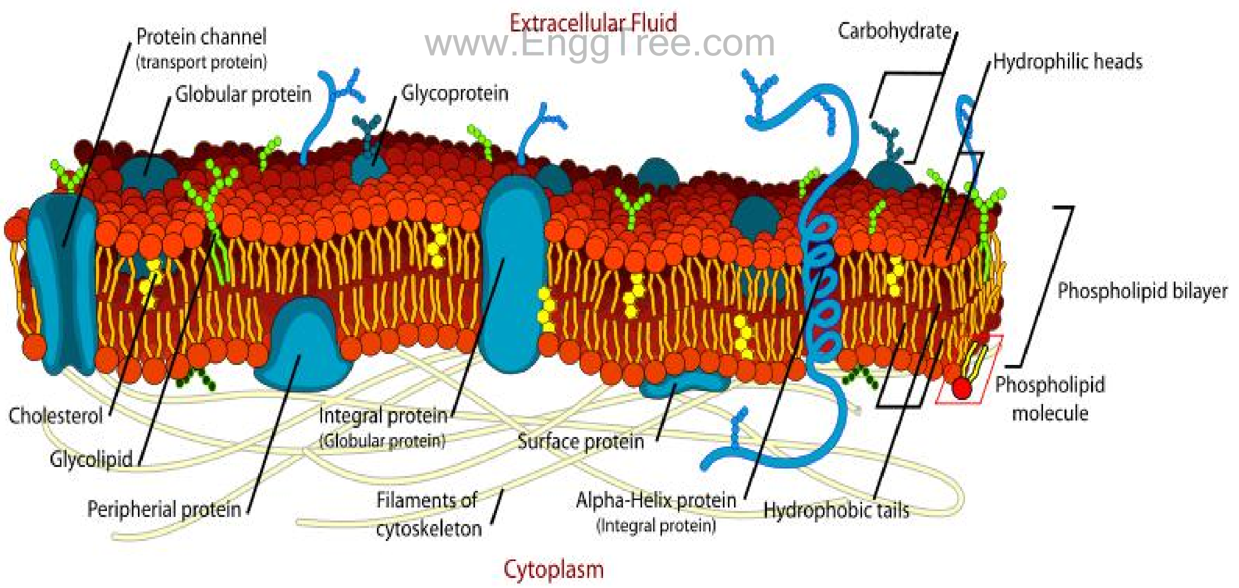
Cells are the body's smallest functional units. They are grouped together to form Tissues, each of which has a specialised function, e.g. blood, muscle, bone. Different tissues are grouped together to form organs ,e.g. the heart, stomach and brain.

Organs are grouped together to form systems, each of which performs a particular function that maintains homeostasis and contributes to the health of the individual. For example, the digestive system is responsible for taking in, digesting and absorbing food, which involves a number of organs, including the stomach and intestines. The structure and functions of cells and types of tissue are explored in this chapter.

The human body develops from a single cell called the zygote, which results from the fusion of the ovum and the spermatozoon. Cell division follows and, as the fetus grows, cells with different structural and functional specialisations develop, all with the same genetic make-up as the zygote. Individual cells are too small to be seen with the naked eye. However, they can be seen when thin slices of tissue are stained in the laboratory and magnified using a microscope.

A cell consists of a plasma membrane enclosing a number of organelles suspended in a watery fluid called cytosol. They include: the nucleus, mitochondria, ribosomes, endo plasmic reticulum, Golgi apparatus, lysosomes and the cytoskeleton. The cell contents, excluding the nucleus, is the cytoplasm, i.e. the cytosol and other organelles.

Plasma membrane



The plasma membrane consists of two layers of phospholipids with proteins and sugars embedded in them. In addition to phospholipids, the lipid cholesterol is also present. The phospholipid molecules have a head, which is electrically charged and hydrophilic (meaning 'water loving'), and a tail which has no charge and is hydrophobic (meaning 'water hating').

The phospholipid bilayer is arranged like a sandwich with the hydrophilic heads aligned on the outer surfaces of the membrane and the hydrophobic tails forming a central water-repelling layer. These differences influence the transfer of substances across the membrane.

Membrane proteins

Those proteins that extend all the way through the membrane provide channels that allow the passage of, for example, electrolytes and non-lipid soluble substances. Protein molecules on the surface of the plasma membrane are shown in Figure. The membrane proteins perform several functions:

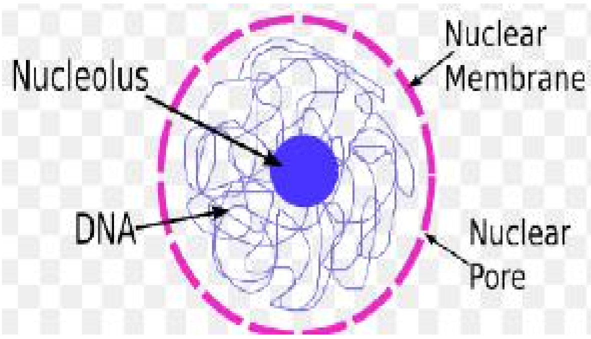
- ✓ Branched carbohydrate molecules attached to the outside of some membrane protein molecules give the cell its immunological identity.
- ✓ They can act as receptors (specific recognition sites) for hormones and other chemical messengers
- ✓ Some are enzymes.
- ✓ Trans-membrane proteins form channels that are filled with water and allow very small, water-soluble ions to cross the membrane.
- ✓ Some are involved in pumps that transport substances across the membrane.

Cytoplasm

It is present within the cell membrane. This contains the cell organelle like nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, Lysosomes, centrosomes, microsomes and ribosomes.

<u>Organelles</u>

Nucleus



All body cells have a nucleus, with the exception of mature erythrocytes (red blood cells). Skeletal muscle fibres and some other cells contain several nuclei. The nucleus is the largest organelle and is contained within the nuclear envelope, a membrane similar to the plasma membrane but with tiny pores through which some substances can pass between it and the cytoplasm. The nucleus contains the body's genetic material, in the form of deoxyribonucleic acid (DNA); this directs all its metabolic activities. In a non-dividing cell DNA is present as a fine network of threads called

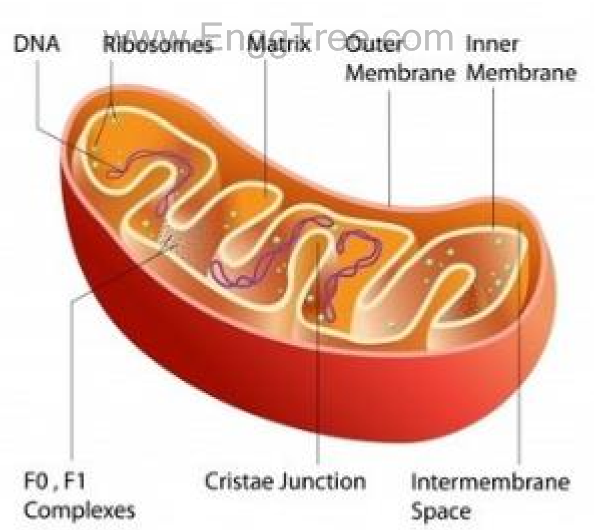
Chromatin, but when the cell prepares to divide the chromatin forms distinct structures called chromo-somes

A related substance, ribonucleic acid (RNA) is also found in the nucleus. There are different types of RNA, not all found in the nucleus, but which are in general involved in protein synthesis. Within the nucleus is a roughly spherical structure called the nucleolus, which is involved in synthesis (manufacture) and assembly of the components of ribosomes.

Mitochondria

- Mitochondria are shaped perfectly to maximize their productivity. They are made of two membranes. The **outer membrane** covers the organelle and contains it like a skin.
- The **inner membrane** folds over many times and creates layered structures called **cristae**. The fluid contained in the mitochondria is called the **matrix**.

The folding of the inner membrane increases the surface area inside the organelle. Since many of the chemical reactions happen on the inner membrane, the increased surface area creates more space for reactions to occur. If you have more space to work, you can get more work done.



Mitochondria are membranous, sausage-shaped structures in the cytoplasm, sometimes described as the 'power house' of the cell.They are central to aerobic respiration, the processes by which chemical energy is made available in the cell. This is in the form of ATP, which releases energy when the cell breaks it down. Synthesis of ATP is most efficient in the final stages of aerobic respiration, a process which requires oxygen. The most active cell types have the greatest number of mitochondria, e.g. liver, muscle and spermatozoa.

FUNCTION

- Mitochondria are known as the powerhouses of the cell. The most important function of the mitochondria is to produce energy. The simpler molecules of nutrition are sent to the mitochondria to be processed and to produce charged molecules. These charged molecules combine with oxygen and produce ATP molecules. This process is known as oxidative phosphorylation.
- Mitochondria help the cells to maintain proper concentration of calcium ions within the compartments of the cell.
- The mitochondria also help in building certain parts of blood and hormones like testosterone and estrogen.
- The liver cells mitochondria have enzymes that detoxify ammonia.

Ribosomes

These are tiny granules composed of RNA and protein. They synthesise proteins from amino acids, using RNA as the template. When present in free units or in small clusters in the cytoplasm, the ribosomes make proteins for use within the cell. These include the enzymes required for metabolism. Metabolic pathways consist of a series of steps, each driven by a specific enzyme. Ribosomes are also found on the outer surface of the nuclear envelope and rough endoplasmic reticulum where they manufacture proteins for export from the cell.

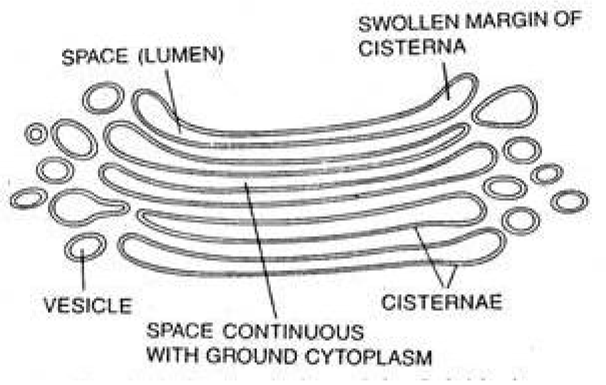
Endoplasmic reticulum (ER)

Endoplasmic reticulum is an extensive series of interconnecting membranous canals in the cytoplasm .There are two types: smooth and rough. Smooth ER synthesises lipids and steroid hormones, and is also associated with the detoxification of some drugs. Some of the lipids are used to replace and repair the plasma membrane and membranes of organelles.

Rough ER is studded with ribosomes. These are the site of synthesis of proteins, some of which are ‘exported’ from cells, i.e. enzymes and hormones that leave the parent cell by exocytosis to be used by cells elsewhere.

Golgi apparatus

The Golgi apparatus consists of stacks of closely folded flattened membranous sacs. It is present in all cells but is larger in those that synthesise and export proteins. The proteins move from the endoplasmic reticulum to the Golgi apparatus where they are ‘packaged’ into membrane-bound vesicles.



The vesicles are stored and, when needed, they move to the plasma membrane and fuse with it. The contents are expelled (secreted) from the cell. This process is called **exocytosis**.

Lysosomes

Lysosomes are small membranous vesicles pinched off from the Golgi apparatus. They contain a variety of enzymes involved in breaking down fragments of organelles and large molecules (e.g. RNA, DNA, carbohydrates, proteins) inside the cell into smaller particles that are either recycled, or extruded from the cell as waste material.

Lysosomes in white blood cells contain enzymes that digest foreign material such as microbes.

Cytoskeleton

This consists of an extensive network of tiny protein fibres.

✓ **Microfilaments.**

These are the smallest fibres. They provide structural support, maintain the characteristic shape of the cell and permit contraction, e.g. actin in muscle cells.

✓ **Microtubules.**

These are larger contractile protein fibres that are involved in movement of:

- Organelles within the cell
- Chromosomes during cell division
- Cell extensions .

✓ **Centrosome.**

This directs organisation of microtubules within the cell. It consists of a pair of Centrioles (small clusters of microtubules) and plays an important role in cell division.

✓ **Cell extensions.**

These project from the plasma mem-brane in some types of cell and their main components are microtubules, which allow movement. They include:

- **Microvilli** – tiny projections that contain microfilaments. They cover the exposed surface of certain types of cell, e.g. absorptive cells that line the small intestine. By greatly increasing the surface area, microvilli make the structure of these cells ideal for their function – maximising absorption of nutrients from the small intestine.
- **Cilia** – microscopic hair-like projections containing microtubules that lie along the free borders of some cells. They beat in unison, moving substances along the surface, e.g. mucus upwards in the respiratory tract.
- **Flagella** – single, long whip-like projections, containing microtubules, which form the 'tails' of spermatozoa that propel them through the female reproductive tract.

2. Discuss in detail about the transport of substances across the cell membrane.

Transport of substances across cell membranes

The structure of the plasma membrane provides it with the property of selective permeability, meaning that not all substances can cross it. Those that can, do so in different ways depending on their size and characteristics.

i) Passive transport

This occurs when substances can cross the semi-permeable plasma and organelle membranes and move down the concentration gradient (downhill) without using energy.

Diffusion

Small molecules diffuse down their concentration gradient:

- Lipid-soluble materials, e.g. oxygen, carbon dioxide, fatty acids and steroids, cross the membrane by dissolving in the lipid part of the membrane
- Water-soluble materials, e.g. sodium, potassium and calcium, cross the membrane by passing through water-filled channels.

Facilitated diffusion

This passive process is used by some substances that are unable to diffuse through the semi-permeable membrane unaided, e.g. glucose, amino acids. Specialised protein carrier molecules in the membrane have specific sites that attract and bind substances to be transferred, like a lock and key mechanism. The carrier then changes its shape and deposits the substance on the other side of the membrane.

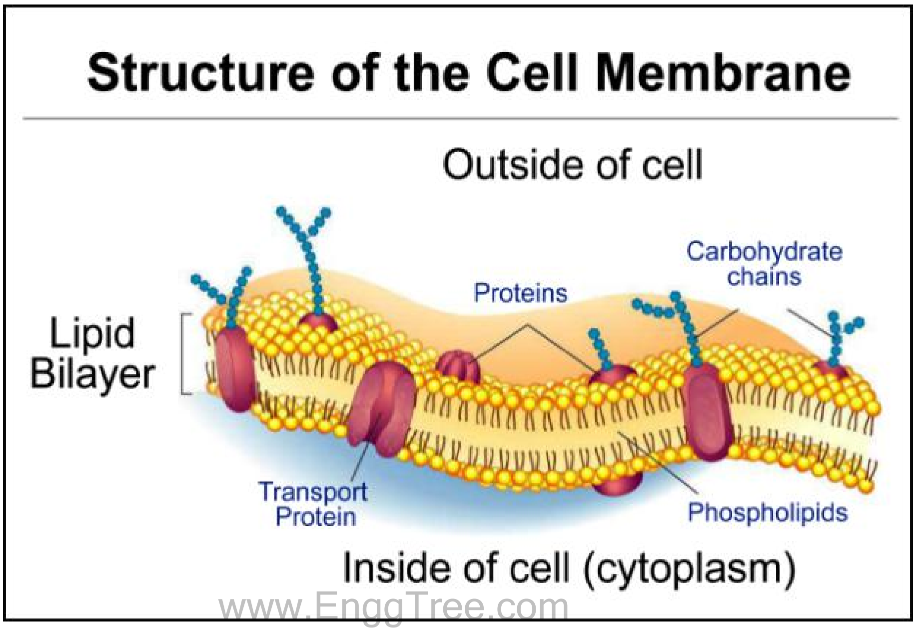
The carrier sites are specific and can be used by only one substance. As there are a finite number of carriers, there is a limit to the amount of a substance which can be transported at any time. This is known as the transport maximum.

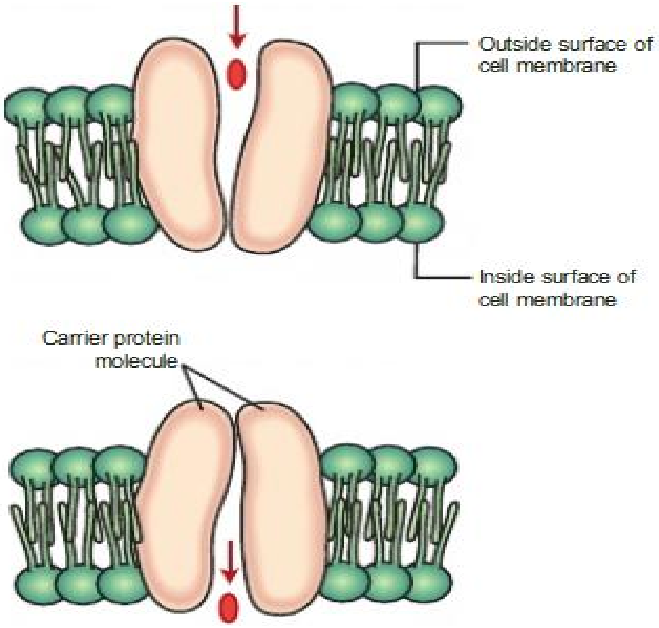
Osmosis

Osmosis is passive movement of water down its concentration gradient towards equilibrium across a semi-permeable.

ii) Active transport

This is the transport of substances up their concentration gradient (uphill), i.e. from a lower to a higher concentration. Chemical energy in the form of ATP drives





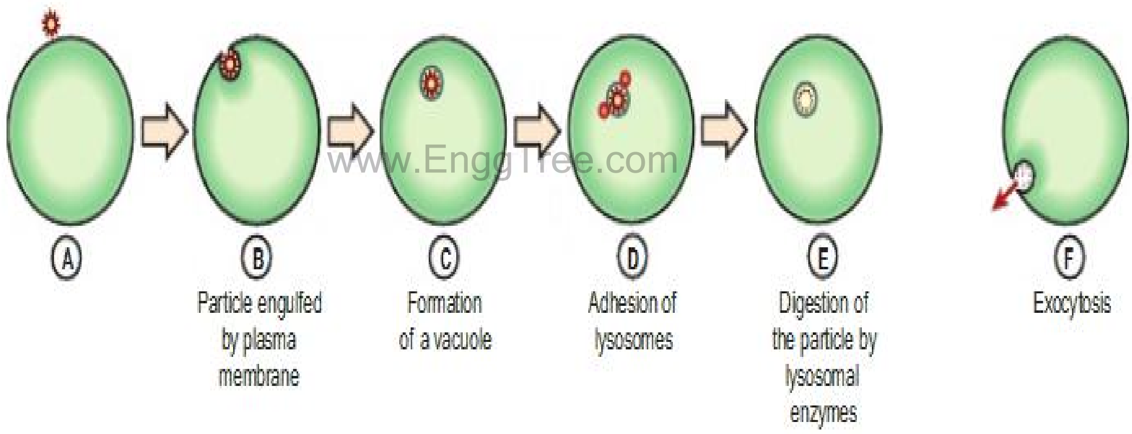
specialised protein carrier molecules that transport sub-stances across the membrane in either direction. The carrier sites are specific and can be used by only one substance; therefore the rate at which a sub-stance is transferred depends on the number of sites available.

The sodium–potassium pump

All cells possess this pump, which indirectly supports other transport mechanisms such as glucose uptake, and is essential in maintaining the electrical gradient needed to generate action potentials in nerve and muscle cells. This active transport mechanism maintains the unequal concentrations of sodium (Na+) and potassium (K+) ions on either side of the plasma membrane.

It may use up to 30% of cellular ATP (energy) requirements. Potassium levels are much higher inside the cell than outside – it is the principal intracellular cation. Sodium levels are much higher outside the cell than inside – it is the principal extracellular cation. These ions tend to diffuse down their concentration gradients, K+ outwards and Na+ into the cell. In order to maintain their concentration gradients, excess Na+is constantly pumped out across the cell membrane in exchange for K+.

(iii)Bulk transport



Bulk transport across plasma membranes. A–E. Phagocytosis. F. Exocytosis.

Transfer of particles too large to cross cell membranes occurs by pinocytosis ('cell-drinking') or phagocytosis('cell-eating'). These particles are engulfed by extensions of the cytoplasm which enclose them, forming a membrane-bound vacuole. Pinocytosis allows the cell to bring in fluid. In phagocytosis larger particles (e.g. cell fragments, foreign materials, microbes) are taken into the cell. Lysosomes then adhere to the vacuole membrane, releasing enzymes which digest the contents.

Extrusion of waste material by the reverse process through the plasma membrane is called exocytosis . Vesicles formed by the Golgi apparatus usually leave the cell in this way, as do any indigestible residues of phagocytosis.

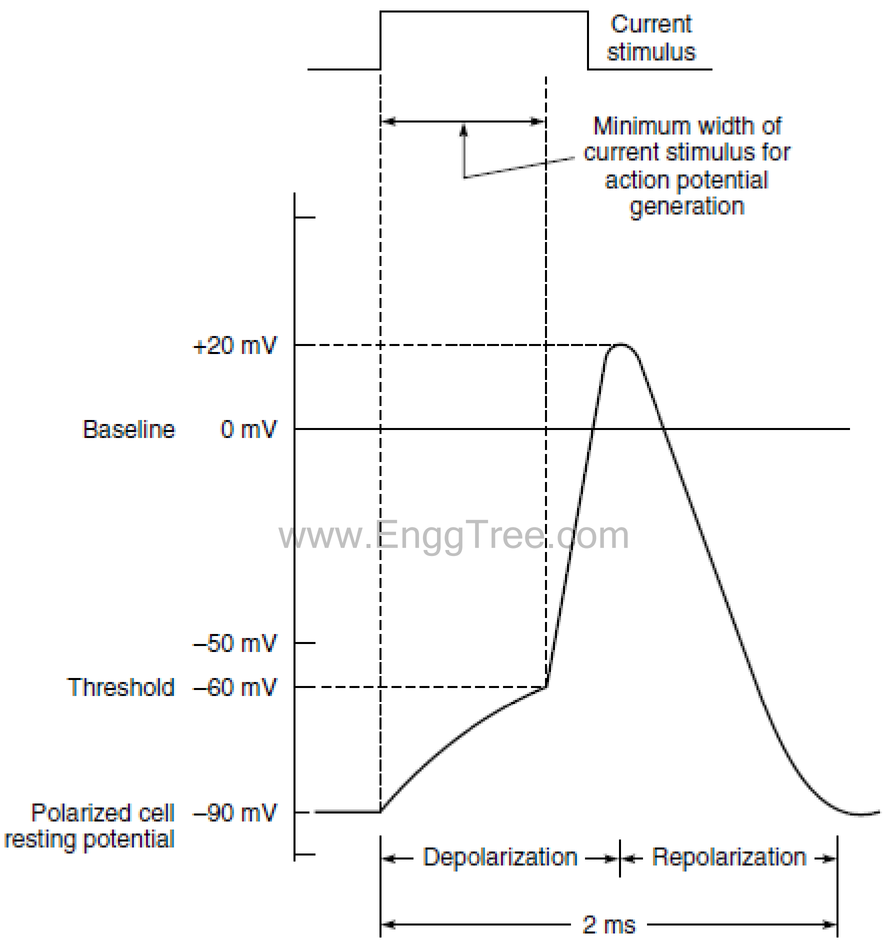
3. Discuss the generation of the action potential in cell with appropriate waveform. (A/M 2017) (or) Explain in detail the mechanism of electric generation in the cell. (M/J-2016) or) Discuss the methods of measuring membrane potentials and action potentials.(N/D-2015) (or) Describe the electrical events that occur during action potential generation. Describe the steps involved in skeletal muscle contraction. (N/D-2015) (or) Elaborate about action potential, its generation and conduction. (N/D 2014).

- Bioelectric potentials are generated at a cellular level and the source of these potentials is ionic in nature. A cell consists of an ionic conductor separated from the outside environment by a semi-permeable membrane which acts as a selective ionic filter to the ions. This means that some ions can pass through the membrane freely where as others cannot do so.
- All living matter is composed of cells of different types. Human cells may vary from 1 micron to 100 microns in diameter, from 1 mm to 1 m in length, and have a typical membrane thickness of 0.01 micron.
- Surrounding the cells of the body are body fluids, which are ionic and which provide a conducting medium for electric potentials. The principal ions involved with the phenomena of producing cell potentials are sodium (Na^+), potassium (K^+) and chloride (Cl^-). The membrane of excitable cells readily permits the entry of K^+ and Cl^- but impedes the flow of Na^+ even though there may be a very high concentration gradiant of sodium across the cell membrane.

- This results in the sodium is a positive ion, in its resting state, a cell has a negative charge along the inner surface of its membrane and a positive charge along the outer portion. The unequal charge distribution is a result of certain electrochemical reactions and processes occurring within the living cell and the potential measured is called the **resting potential**.
- The cell in such a condition is said to be polarized. A decrease in this resting membrane potential difference is called **depolarization**. The distribution of positively charged ions on the outer surface and negatively charged ions inside the cell membrane results in the difference of potential across it and the cell becomes, in effect, a tiny biological battery.
- Experiments have shown that the internal resting potential within a cell is approximately –90 mV with reference to the outside of the cell. When the cell is excited or stimulated, the outer side of the cell membrane becomes momentarily negative with

respect to the interior. This process is called **depolarization** and the cell potential changes to approximately +20 mV.

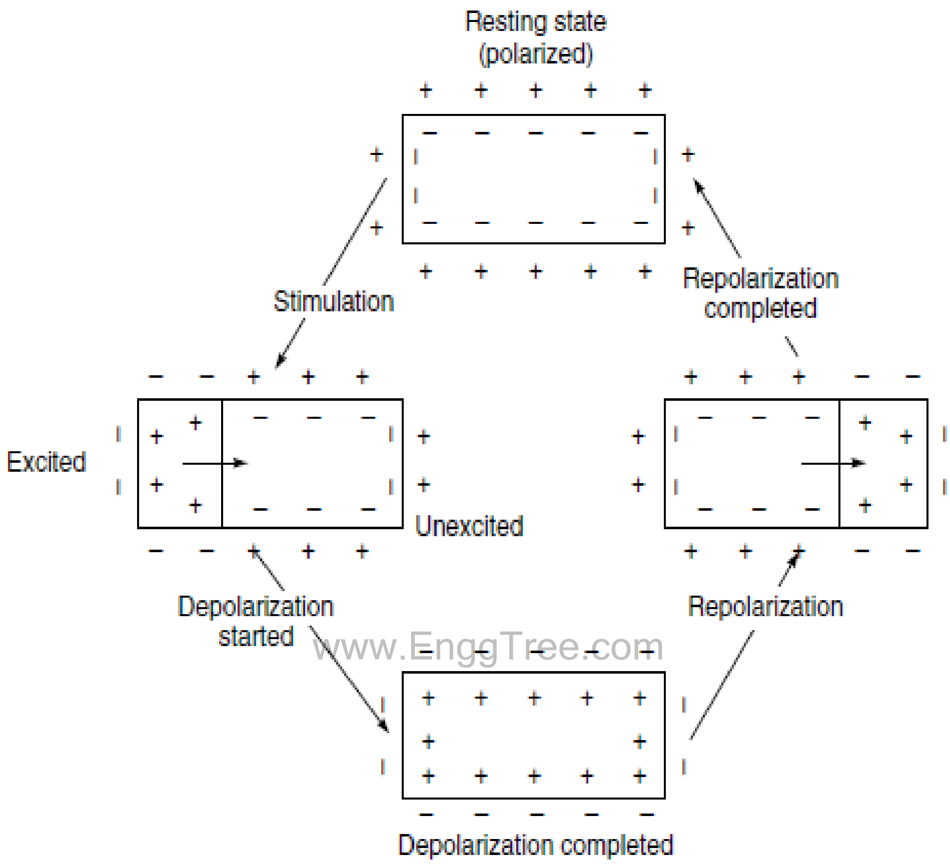
- Repolarization then takes place a short time later when the cell regains its normal state in which the inside of the membrane is again negative with respect to the outside. Repolarization is necessary in order to re-establish the resting potential. This discharging and recharging of the cell produces the voltage waveforms which can be recorded by suitable methods using microelectrodes. A typical cell potential waveform so recorded is shown in Figure.



A typical cell potential waveform

- The wave of excitation while propagating in the muscle causes its contraction. The contraction wave always follows the excitation wave because of its lower velocity. This phenomenon is found with the skeletal muscles, the heart muscle and the smooth muscles. In its turn, every contraction (movement) of a muscle results in the production of an electric voltage.

- This voltage occurs in the muscle in such a way that the moving muscle section is always negative with respect to its surroundings. These voltages are called action potentials because they are generated by the action of the muscles.
- After complete contraction, repolarization takes place resulting in the relaxation of the muscle and its returning to the original state. Figure 2.2 shows electrical activity associated with one contraction in a muscle.



Electrical activity associated with one contraction in a muscle

- The currents involved in bioelectricity are unlike the currents involved in electronics. Bioelectric currents are due to positive and negative ion movement within a conductive fluid. The ions possess finite mass and encounter resistance to movement within the fluid for they have limited speeds.
- The cell action potential, therefore, shows a finite rise time and fall time. It may be noted that a cell may be caused to depolarize and then re-polarize by subjecting the cell membrane to an ionic current. However, unless a stimulus above a certain minimum value is applied, the cell will not be depolarized and no action potential is generated. This value is known as the stimulus threshold.
- After a cell is stimulated, a finite period of time is required for the cell to return to its pre-stimulus state. This is because the energy associated with the action potential is

developed from metabolic processes within the cell which take time for completion. This period is known as refractory period.

- The bioelectric signals of clinical interest, which are often recorded, are produced by the coordinated activity of large groups of cells. In this type of synchronized excitation of many cells, the charges tend to migrate through the body fluids towards the still unexcited cell areas.
- Such charge migration constitutes an electric current and hence sets up potential differences between various portions of the body, including its outer surface. Such potential differences can be conveniently picked up by placing conducting plates (electrodes) at any two points on the surface of the body and measured with the help of a sensitive instrument. These potentials are highly significant for diagnosis and therapy.

4. Write a brief notes about a Cell to Cell Signalling.

Cell Signaling

- All cells receive and respond to signals from their surroundings
- Signaling molecules that are secreted on the surface of one cell and bind to receptors expressed by the other cells
- The binding of most signaling molecules to their receptors initiates a series of intracellular reactions that regulate of the cell behaviour including metabolism, movement, proliferation and differentiation
- The ligand is the signaling molecule.
- It may be a hormone, a growth factor/cytokine ,a steroid, a polypeptide, or other type of molecule. It has no activity of its own, but must bind to a macromolecule
- Which is known as a receptor
- Receptor when activated by lig and ,the receptor causes a change in the target cell in which it is expressed

Signaling molecules

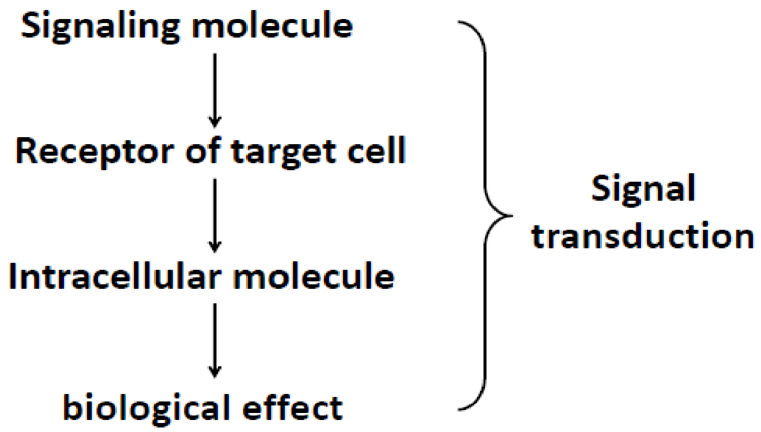
Signaling molecules, which are released by signal-producing cells, reach and transfer biological signals to their target cells to initiate specific cellular responses.

- Extracellular molecules
- Intracellular molecules

Cell to Cell signaling

Most signaling molecules are secreted by one cell and bind to cell surface receptors expressed by a target cell.

The steroid hormones are small hydrophobic molecules that diffuse across the plasma membrane of their target cells and bind to intracellular receptors.



Cell Cell signaling is divided into three general categories

- Endocrine
- Paracrine
- Autochrine

signaling based on the distance over which signals are transmitted

Endocrine signal

- Secreted by endocrine cells.
- Reach target cells by blood circulation.
- Time of action is long.
- Such as insulin, thyroxine, adrenalin

Paracrine signaling (local chemical mediators)

- Secreted by common cells.
- Reach neighboring target cells by passive diffusion.
- Time of action is short.

Synaptic signal (neurotransmitters)

- Secreted by neuronal cells.
- Reach another neuron by synaptic gap.
- Time of action is short.
- Such as Acetylcholine (Ach), noradrenaline

Gaseous signal

- Simple structure, half life is short and active in chemistry .
- Such as NO, CO.

- NO is amajor paracrine signaling molecule in the nervous,immune and circulary system
- NO is synthesized from the aa arginine by the enzyme nitric oxide synthase.

Autocrine signal

- Act back to their own cells.
- Such as GF, cytokine, interferon, interleukin.

Direct cell to cell signaling, some signaling molecules remain bound to the cell surface and act as a ligands. these kinds off signaling take place during embryonic development

Receptor

Receptors are specific membrane or intracellular proteins, which are able to recognize and bind to corresponding ligand molecules, Receptor when activated by ligand ,the receptor causes a change in the target cell in which It is expressed.

Function of receptor

- ✓ Recognize the special ligand
- ✓ Binding to special ligand
- ✓ Signal transduction ligand

A small molecule that binds specifically to a larger one; for example, a hormone is the ligand for its specific protein receptor.

Properties of binding of Hormone and Receptor

- Highly specificity
- Highly affinity
- Saturation
- Reversible binding
- Special function model.

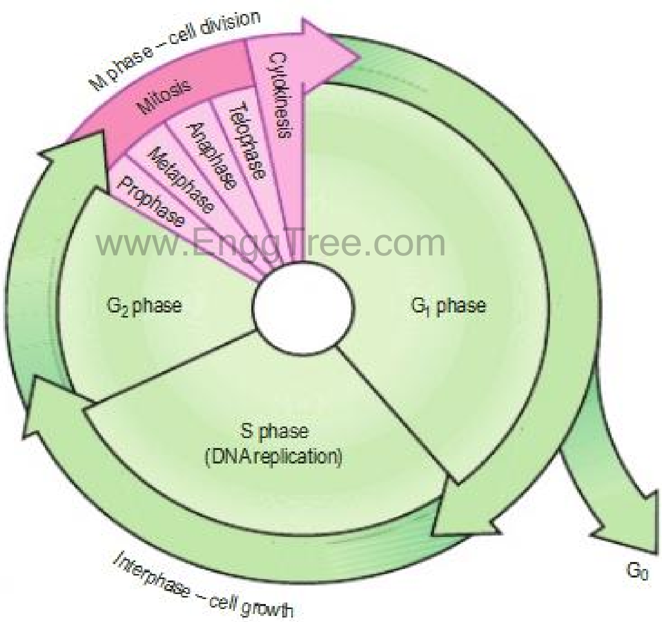
5. Explain in detail about the cell division.

The cell cycle

Many damaged, dead, and worn out cells can be replaced by growth and division of other similar cells. The frequency with which cell division occurs varies with differ-ent types of tissue.

This is normally carefully regulated to allow effective maintenance and repair of body tissues. At the end of their natural lifespan, ageing cells are programmed to ‘self destruct’ and their components are removed by phagocytosis; a process known as apoptosis

Cells with nuclei have 46 chromosomes and divide by mitosis,a process that results in two new genetically identical daughter cells. The only exception to this is the formation of gametes (sex cells), i.e. ova and spermatozoa, which takes place by meiosis .



The period between two cell divisions is known as the cell cycle, which has two phases that can be seen on light microscopy: mitosis (M phase) and interphase .

Interphase

This is the longer phase and three separate stages are recognised:

- First gap phase (G1) – the cell grows in size and volume. This is usually the longest phase and most variable in length. Sometimes cells do not continue The cells, tissues and organisation of the body round the cell cycle but enter a resting phase (G0); during this time cells carry out their specific functions, e.g. Secretion, absorption.

- Synthesis of DNA (S phase) – the chromosomes replicate forming two identical copies of DNA . Therefore, following the S phase, the cell now has 92 chromosomes, i.e. Enough DNA for two cells and is nearly ready to divide by mitosis.
- Second gap phase – (G2) there is further growth and preparation for cell division.

Mitosis

This is a continuous process involving four distinct stages visible by light microscopy.

(i)Prophase

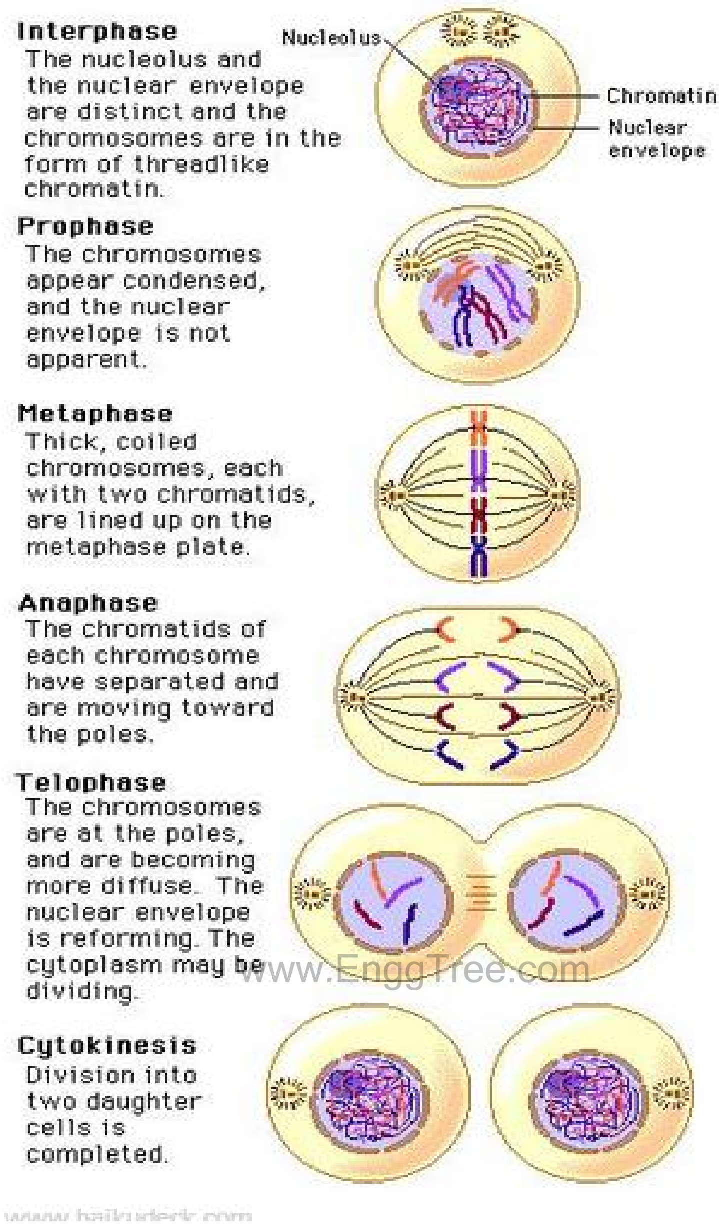
During this stage the replicated chromatin becomes tightly coiled and easier to see under the micro-scope. Each of the original 46 chromosomes (called a chromatid at this stage) is paired with its copy in a double chromosome unit. The two chromatids are joined to each other at the centromere. The mitotic apparatus appears; this consists of two centrioles separated by the mitotic spindle, which is formed from microtubules. The centrioles migrate, one to each end of the cell, and the nuclear envelope disappears.

(ii)Metaphase.

The chromatids align on the centre of the spindle, attached by their centromeres.

(iii)Anaphase

The centromeres separate, and one of each pair of sister chromatids (now called chromosomes again) migrates to each end of the spindle as the microtubules that form the mitotic spindle contract.



The stages of mitosis.

Telophase.

The mitotic spindle disappears, the chromo-somes uncoil and the nuclear envelope reforms.Following telophase, cytokinesis occurs: the cytosol, intracellular organelles and plasma membrane split forming two identical daughter cells.

6. Write a brief notes about the types of specialized tissues and functions.

Tissues consist of large numbers of the same type of cells and are classified according to the size, shape and functions of their constituent cells. There are four main types of tissue each with subtypes. They are:

a) Epithelial tissue or epithelium
b) Connective tissue
c) Muscle tissue
d) Nervous tissue.

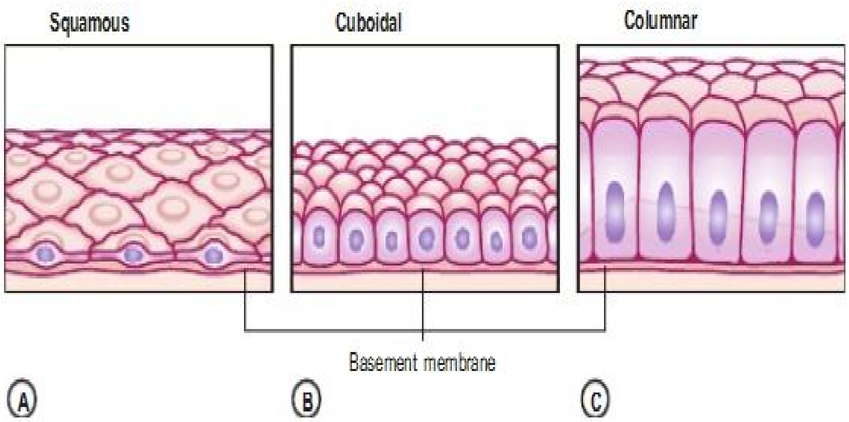
a) Epithelial tissue

This tissue type covers the body and lines cavities, hollow organs and tubes. It is also found in glands. The structure of epithelium is closely related to its functions, which include:

- Protection of underlying structures from, for example, dehydration, chemical and mechanical damage
- Secretion
- Absorption.

The cells are very closely packed and the intercellular substance, the matrix, is minimal. The cells usually lie on a basement membrane , which is an inert connective tissue made by the epithelial cells themselves. Epithelial tissue may be:

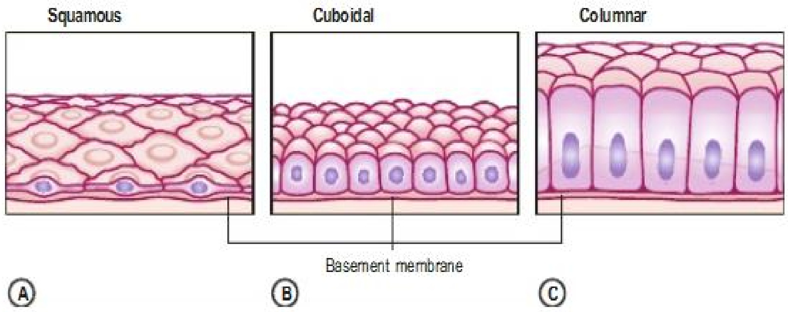
- Simple: a single layer of cells
- Stratified: several layers of cells.



Simple epithelium. A. Squamous. B. Cuboidal. C.Columnar

i)Simple epithelium

Simple epithelium consists of a single layer of identical cells and is divided into three main types. It is usually found on absorptive or secretory surfaces, where the single layer enhances these processes, and seldom on sur-faces subject to stress. The types are named according to the shape of the cells, which differs according to their functions. The more active the tissue, the taller the cells.



Simple epithelium. A. Squamous. B. Cuboidal. C. Columnar

✓ **Squamous (pavement) epithelium**

This is composed of a single layer of flattened cells. The cells fit closely together like flat stones, forming a thin and very smooth membrane across which diffusion occurs easily. It forms the lining of the following structures:

- Heart–where it is known as Endocardium
- (i) Blood vessels

  (ii) Lymph vessels – where it is also known as endothelium alveoli of the lungs
- Lining the collecting ducts of nephrons in the kidneys.

✓ **Cuboidal epithelium**

This consists of cube-shaped cells fitting closely together lying on a basement membrane . It forms the kidney tubules and is found in some glands such as the thyroid. Cuboidal epithelium is actively involved in secretion, absorption and/or excretion.

✓ **Columnar epithelium**

This is formed by a single layer of cells, rectangular in shape, on a basement membrane. It lines many organs and often has adaptations that make it well suited to a specific function. The lining of the stomach is formed from simple columnar epithelium without surface structures. The free surface of the columnar epithelium lining the small intestine is covered with micro-villi .

Microvilli provide a very large surface area for absorption of nutrients from the small intestine. In the trachea, columnar epithelium is ciliated and also contains goblet cells that secrete mucus.

This means that inhaled particles that stick to the mucus layer are moved towards the throat by cilia in the respiratory tract. In the uterine tubes, ova are propelled along by ciliary action towards the uterus.

ii) Stratified epithelia

Stratified epithelia consist of several layers of cells of various shapes. Continual cell division in the lower (basal) layers pushes cells above nearer and nearer to the surface, where they are shed. Basement membranes are usually absent. The main function of stratified epithelium is to protect underlying structures from mechanical wear and tear. There are two main types: stratified squamous and transitional.

- ✓ **Stratified squamous epithelium**

  This is composed of several layers of cells. In the deepest layers the cells are mainly columnar and, as they grow towards the surface, they become flattened and are then shed.

- ✓ **Keratinised stratified epithelium.**

This is found on dry surfaces subjected to wear and tear, i.e. skin, hair and nails. The surface layer consists of dead epithelial cells that have lost their nuclei and contain the protein keratin

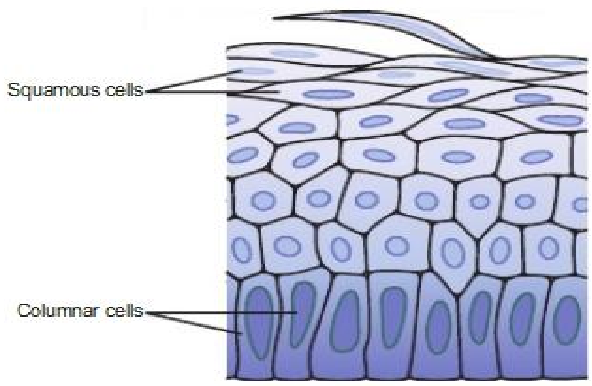
This forms a tough, relatively waterproof protective layer that prevents drying of the live cells underneath. The surface layer of skin is rubbed off and is replaced from below

- ✓ **Non-keratinised stratified epithelium**

This protects moist surfaces subjected to wear and tear, and prevents them from drying out, e.g. the conjunctiva of the eyes, the lining of the mouth, the pharynx, the oesophagus and the vagina.

iii) Transitional epithelium

This is composed of several layers of pear-shaped cells. It lines several parts of the urinary tract including the bladder and allows for stretching as the bladder fills.



Stratified epithelium

b) Connective tissue

Connective tissue is the most abundant tissue in the body. The connective tissue cells are more widely separated from each other than in epithelial tissues, and intercellular substance (matrix) is present in considerably larger amounts. There are usually fibres present in the matrix, which may be of a semisolid jelly-like consistency or dense and rigid, depending upon the position and function of the tissue. The fibres form a supporting network for the cells to attach to. Most types of connective tissue have a good blood supply. Major functions of connective tissue are:

- ✓ Binding and structural support

- ✓ Protection
- ✓ Transport
- ✓ Insulation.

i) Cells in connective tissue

Connective tissue, excluding blood, is found in all organs supporting the specialised tissue. The differ-ent types of cell involved include: fibroblasts, fat cells, macrophages, leukocytes and mast cells.

✓ **Fibroblasts.**

Fibroblasts are large cells with irregular processes. They manufacture collagen and elastic fibres and a matrix of extracellular material. Very fine collagen fibres, sometimes called reticulin fibres are found in highly active tissue, such as the liver and reticular tissue.

Fibroblasts are particularly active in tissue repair (wound healing) where they may bind together the cut surfaces of wounds or form granulation tissue following tissue destruction. The collagen fibres formed during wound healing shrink as they age, sometimes interfering with the functions of the organ involved and with adjacent structures.

✓ **Fat cells.**

Fats cells are also known as adipocytes, these cells occur singly or in groups in many types of connective tissue and are especially abundant in adipose tissue. They vary in size and shape according to the amount of fat they contain.

✓ **Macrophages.**

These are large irregular-shaped cells with granules in the cytoplasm. Some are fixed, i.e. attached to connective tissue fibres, and others are motile. They are an important part of the body's defence mechanisms because they are actively phagocytic, engulfing and digesting cell debris, bacteria and other foreign bodies.

Their activities are typical of those of the monocyte–macrophage defence system, e.g. monocytes in blood, Kupffer cells in liver sinusoids, sinus-lining cells in lymph nodes and spleen, and microglial cells in the brain.

✓ **Leukocytes.**

White blood cells are normally found in small numbers in healthy connective tissue but neu-trophils migrate in significant numbers during infection when they play an important part in tissue defence. Plasma cells develop from B-lymphocytes, a type of white blood cell. They synthesise and secrete specific defensive antibodies into the blood and tissues

✓ **Mast cells.**

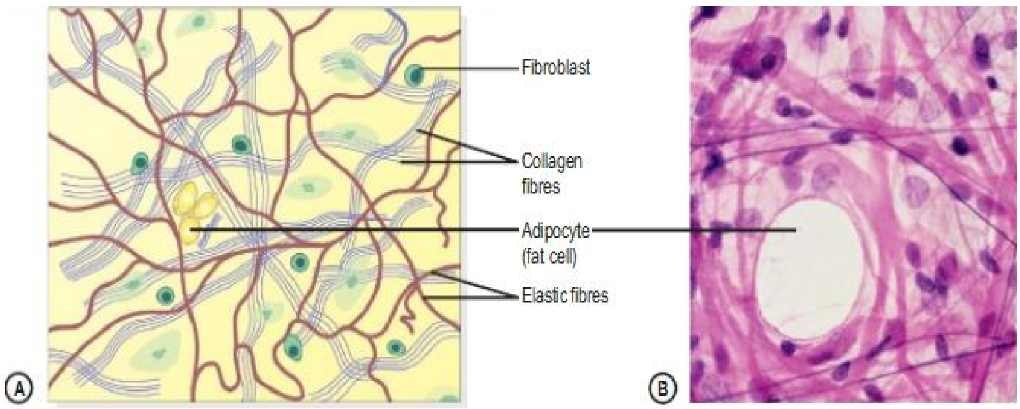
These are similar to basophil leukocytes. They are found in loose connective tissue, under the fibrous capsule of some organs, e.g. liver and spleen, and in considerable numbers round blood vessels. Their cytoplasm is packed with granules containing heparin, histamine and other substances, which are released when the cells are damaged by disease or injury.

Release of the granular contents is called degranulation. Histamine is involved in local and general inflammatory reactions, it stimulates secretion of gastric juice and is associated with development of allergies and hypersensi-tivity states. Heparin prevents coagulation of blood, which helps to maintain blood flow through inflamed tissues, supplying cells with oxygen and glucose and bringing additional protective leukocytes to the area.

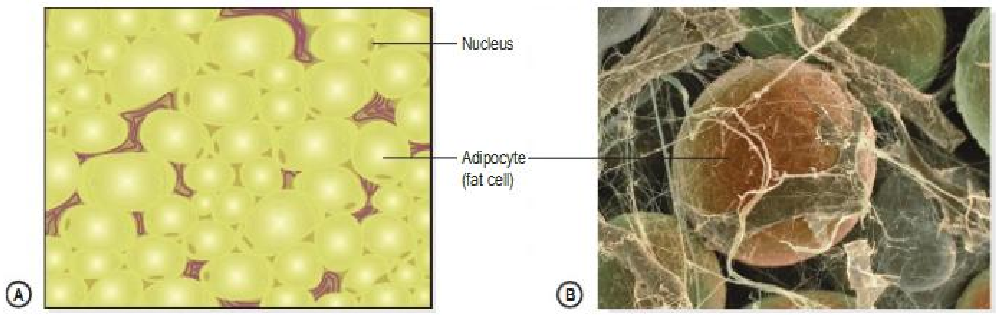
ii) Loose (areolar) connective tissue

This is the most generalised type of connective tissue. The matrix is semisolid with many fibroblasts and some fat cells (adipocytes), mast cells and macrophages widely separated by elastic and collagen fibres. It is found in almost every part of the body, providing elasticity and tensile strength. It connects and supports other tissues, for example:

- under the skin
- between muscles
- supporting blood vessels and nerves
- in the alimentary canal
- in glands supporting secretory cells.



Loose (areolar) connective tissue. A. Diagram of basic structure. B. Light micrograph



Adipose tissue. A. Diagram of basic structure. B. Coloured scanning electron micrograph of fat cells surrounded by strands of connective tissue.

iii) Adipose tissue

Adipose tissue consists of fat cells (adipocytes), con-taining large fat globules, in a matrix of areolar tissue. There are two types: white and brown.

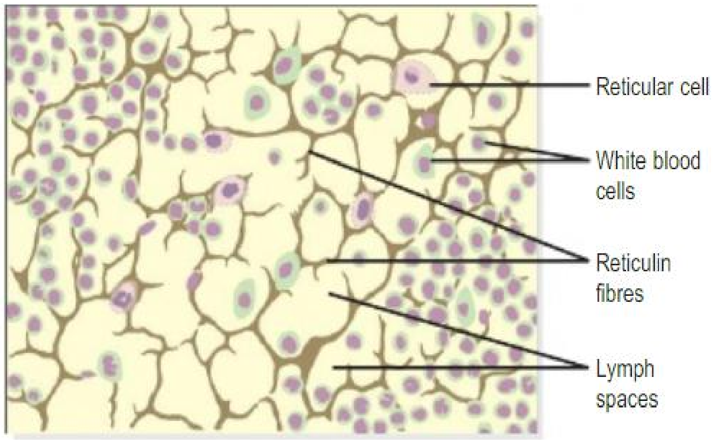
✓ **White adipose tissue.**

This makes up 20–25% of bodyweight in adults with a normal body mass index(BMI); more is present in obesity and less in those whoare underweight. Adipose tissue secretes the hormone leptin. The kidneys and eyeballs are supported byadipose tissue, which is also found between muscle fibres and under the skin, where it acts as a thermal insulator and energy store.

✓ **Brown adipose tissue.**

This is present in the newborn. It has a more extensive capillary network than white adipose tissue. When brown tissue is metabolised, it produces less energy and considerably more heat than other fat, contributing to the maintenance of body temperature. Some-times small amounts are present in adults.

iv) Reticular tissue

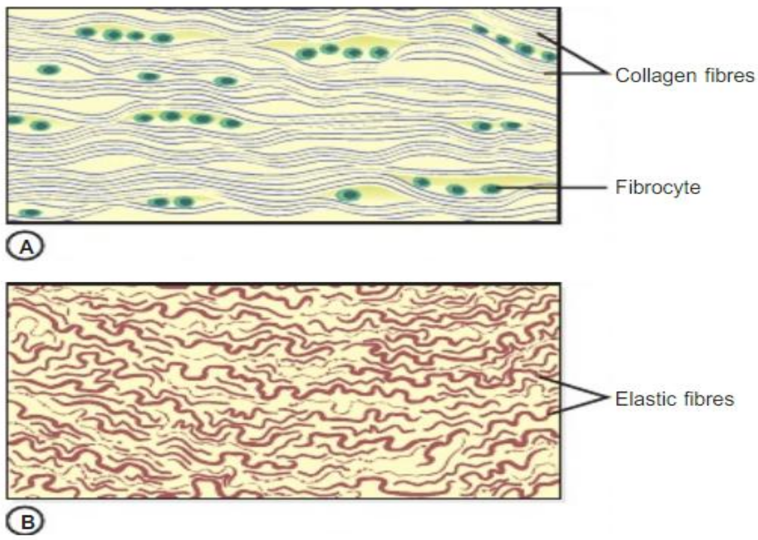


Reticular tissue

Reticular tissue has a semisolid matrix with fine branching reticulin fibres. It contains reticular cells and white blood cells (monocytes and lymphocytes). Reticular tissue isfound in lymph nodes and all organs of the lymphatic system.

v) Dense connective tissue

This contains more fibres and fewer cells than loose connective tissue.



Dense connective tissue. A. Fibrous tissue. B. Elastictissue.

✓ **Fibrous tissue**

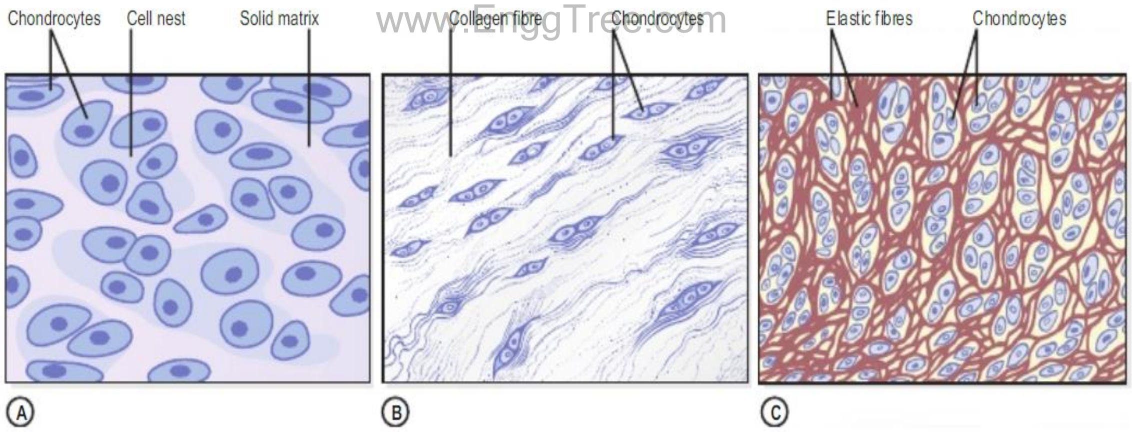
This tissue is made up mainly of closely packed bundles of collagen fibres with very little matrix. Fibro-cytes (old and inactive fibroblasts) are few in number and lie in rows between the bundles of fibres. Fibrous tissueis found:

- Forming ligaments, which bind bones together
- as an outer protective covering for bone, called periosteum
- as an outer protective covering of some organs,e.g. the kidneys, lymph nodes and the brain
- forming muscle sheaths, called muscle fascia, which extend beyond the muscle to become the tendon that attaches the muscle to bone.

✓ **Elastic tissue**

Elastic tissue is capable of considerable extension and recoil. There are few cells and the matrix consists mainly of masses of elastic fibres secreted by fibroblasts. It is found in organs where stretching or alteration of shape is required, e.g. in large blood vessel walls, the trachea and bronchi, and the lungs.

vi) Cartilage



Cartilage. A. Hyaline cartilage. B. Fibrocartilage. C. Elastic fibrocartilage.

Cartilage is firmer than other connective tissues. The cells (chondrocytes) are sparse and lie embedded in matrix rein-forced by collagen and elastic fibres. There are three types: hyaline cartilage, fibro cartilage and elastic fibr ocartilage.

✓ **Hyaline cartilage**

Hyaline cartilage is a smooth bluish-white tissue. Thechondrocytes are arranged in small groups within cellnests and the matrix is solid and smooth. Hyaline carti-lage provides flexibility, support and smooth surfaces formovement at joints. It is found:

- on the ends of long bones that form joints
- forming the costal cartilages, which attach the ribs tothe sternum
- forming part of the larynx, trachea and bronchi.

✓ **Fibro cartilage**

This consists of dense masses of white collagen fibres in a matrix similar to that of hyaline cartilage with the cells widely dispersed. It is a tough, slightly flexible, supporting tissue found:

- as pads between the bodies of the vertebrae, the intervertebral discs
- between the articulating surfaces of the bones of theknee joint, called semilunar cartilages
- on the rim of the bony sockets of the hip and shoulder joints, deepening the cavities without restricting movement.

✓ **Elastic fibro cartilage**

This flexible tissue consists of yellow elastic fibres lying in a solid matrix with chondrocytes lying between the fibres. It provides support and maintains shape of, e.g. the pinna or lobe of the ear, the epiglottis and part of the tunica media of blood vessel walls.

vii) Bone

Bone cells (osteocytes) are surrounded by a matrix of collagen fibres strengthened by inorganic salts, especially calcium and phosphate. This provides bones with their characteristic strength and rigidity. Bone also has considerable capacity for growth in the first two decades of life,and for regeneration throughout life. Two types of bone can be identified by the naked eye:

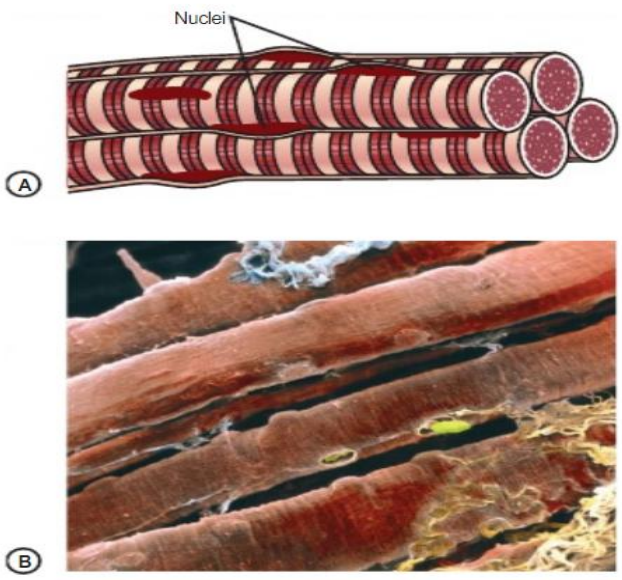
- ✓ Compact bone – solid or dense appearance
- ✓ Spongy or cancellous bone –'spongy' or fine honeycomb appearance.

c) Muscle tissue

This tissue is able to contract and relax, providing movement within the body and of the body itself. Muscle con-traction requires a blood supply that will provide sufficient oxygen, calcium and nutrients and remove waste products. There are three types of specialised contractile cells, also known as fibres: skeletal muscle, smooth muscle and cardiac muscle.

i) Skeletal muscle

This type is described as skeletal because it forms those muscles that move the bones (of the skeleton), striated because striations (stripes) can be seen on microscopic examination and voluntary as it is under conscious control.



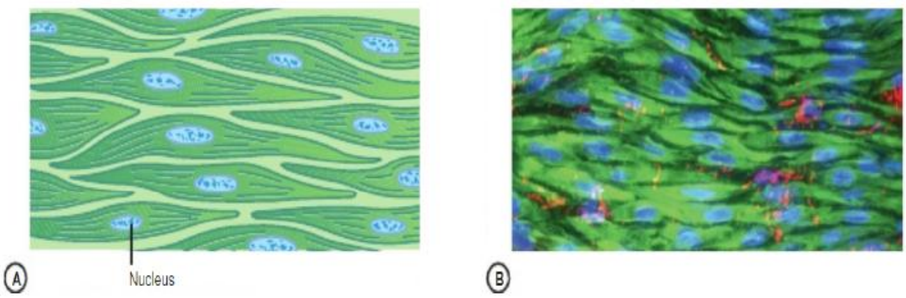
Skeletal muscle fibres. A.Diagram. B.Coloured scanning electron micrograph of skeletal muscle fibres and connective tissue fibres.

Although most skeletal muscle moves bones, the diaphragm is made from this type of muscle to accommodate a degree of voluntary control in breathing. In reality,many movements can be finely coordinated, e.g. writing, but may also be controlled subconsciously.

For example, maintaining an upright posture does not normally require thought unless a new loco motor skill is being learned, e.g.skating or cycling, and the diaphragm maintains breathing while asleep.

These fibres (cells) are cylindrical, contain several nuclei and can be up to 35 cm long. Skeletal muscle contraction is stimulated by motor nerve impulses originating in the brain or spinal cord and ending at the neuromuscular junction .

ii) Smooth muscle



Smooth muscle.

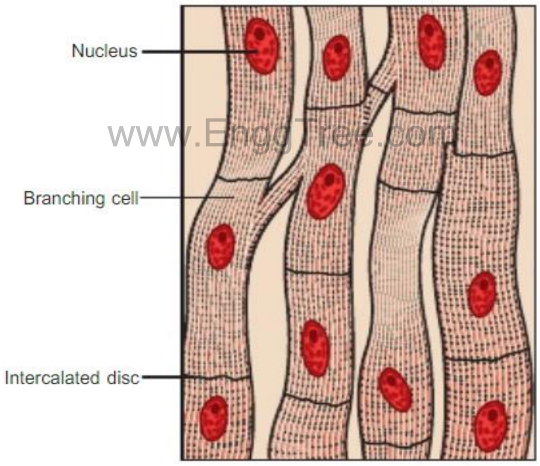
Smooth muscle is also described as non-striated, visceral or involuntary. It does not have striations and is not under conscious control. Some smooth muscle has the intrinsic ability to initiate its own contractions (automaticity), e.g.peristalsis. It is innervated by the autonomic nervous system.

Additionally, autonomic nerve impulses, some hormones and local metabolites stimulate its contraction. A degree of muscle tone is always present, meaning that smooth muscle is only completely relaxed for short periods. Contraction of smooth muscle is slower and more sustained than skeletal muscle. It is found in the walls of hollow organs:

- Regulating the diameter of blood vessels and parts of the respiratory tract
- Propelling contents along, e.g.The ureters, ducts of glands and the alimentary tract
- Expelling contents of the urinary bladder and uterus.

When examined under a microscope, the cells are seen to be spindle shaped with only one central nucleus. Bundles of fibres form sheets of muscle, such as those found in thewalls of the above structures.

iii) Cardiac muscle



Cardiac muscle

This is only found only in the heart wall. It is not under conscious control but, when viewed under a microscope, cross-stripes (striations) characteristic of skeletal muscle can be seen. Each fibre (cell) has a nucleus and one or more branches.

The ends of the cells and their branches are in very close contact with the ends and branches of adjacent cells. Microscopically these ‘joints’, or Intercalated discs , appear as lines that are thicker and darker than the ordinary cross-stripes. This arrangement gives cardiac muscle the appearance of a sheet of muscle rather than a very large number of individual fibres. This is significant when the heart contracts as a wave of contraction spreads from cell to cell across the intercalated discs, which means that the cardiac muscle fibres do not need to be stimulated individually.

The heart has an intrinsic pacemaker system, which means that it beats in a coordinated manner without external nerve stimulation, although the rate at which it beats is influenced by autonomic nerve impulses, some hormones, local metabolites and other substances.

d) Nervous tissue

Two types of tissue are found in the nervous system:

- Excitable cells – these are called neurons and they initiate, receive, conduct and transmit information
- Non-excitable cells – also known as glial cells , these support the neurones.

PART A

1. What is meant by skeletal system?

The adult human **skeletal system** consists of 206 bones, as well as a network of tendons, ligaments and cartilage that connects them. The **skeletal system** performs vital functions i.e support, movement, protection, blood cell production, calcium storage and endocrine regulation which used to enable us to survive.

2. Definition of bone.

Bone is the substance that forms the skeleton of the body. It is composed chiefly of calcium phosphate and calcium carbonate. It also serves as a storage area for calcium, playing a large role in calcium balance in the blood.

The 206 bones in the body serve several other purposes. They support and protect internal organs (for example, the skull protects the brain and the ribs protect the lungs). Muscles pull against bones to make the body move. Bone marrow, the soft, spongy tissue in the center of many bones, makes and stores blood cells.

3. Describe the functions of bone.

Functions of bones

The functions of bones include:

- Providing the body framework.
- Giving attachment to muscles and tendons.
- Allowing movement of the body as a whole and of parts of the body, by forming joints that are moved by muscles.
- Forming the boundaries of the cranial, thoracic and pelvic cavities, and protecting the organs they contain.
- Haemopoiesis, the production of blood cells in redbone marrow.
- Mineral storage, especially calcium phosphate –the mineral reservoir within bone is essential for maintenance of blood calcium levels, which must be tightly controlled.

4. What are the functions of skull?

Functions of the skull

The various parts of the skull have specific and different functions:

- The cranium protects the brain.

- The bony eye sockets protect the eyes and give attachment to the muscles that move them.
- The temporal bone protects the delicate structures of the inner ear
- The sinuses in some face and skull bones give resonance to the voice.
- The bones of the face form the walls of the posterior part of the nasal cavities and form the upper part of the air passages.
- The maxilla and the mandible provide alveolar ridges in which the teeth are embedded.
- The mandible, controlled by muscles of the lower face, allows chewing.

5. Discuss about the functions of skull bones.

- ✓ The **Frontal** bone is **one** of the major cranial bones. It comprises the forehead (squama frontalis) and the upper orbit of the eye (pars orbitalis). The front of the top of the head roughly covers the frontal lobes of the brain.
- ✓ The **Parietal** bones form the largest part of the top and sides of the cranium. There are **two** parietal bones and each one is shaped roughly like a curved rectangle.
- ✓ There are **two Temporal** bones in the cranium, each supports part of the face known as the temple. The temporal bones are crucial in the anatomy of the ear.
- ✓ The **Ethmoid** bone differs from the other bones in the cranium in that it is a spongy bone opposed to a hard bone. The name derives from the Greek ethnos meaning sieve and divides the nasal cavity from the brain
- ✓ There are 2 **Sphenoid** bones, each is situated behind the eyes at the base of the skull in front of the Temporals. Because of the way it is shaped and situated the Sphenoid bone has contact with all the other cranial bones.
- ✓ The **Occipital** bone forms the back of the skull and the base of the cranium. The bone is pierced by a large oval hole(the foramen magnum) through which runs the spinal cord.

6. What is synovial fluid?

Synovial fluid

This is a thick sticky fluid, of egg-white consistency, which fills the synovial cavity. It:

- ✓ Nourishes the structures within the joint cavity

- ✓ Contains phagocytes, which remove microbes and Cellular debris
- ✓ Acts as a lubricant
- ✓ Maintains joint stability
- ✓ Prevents the ends of the bones from being Separated, as does a little water between two glass Surfaces.

7. What is meant by muscle cells?

- ✓ Muscle cells are specialised contractile cells, also called *fibres*. The three types of muscle tissue, *smooth*, *cardiac* and *skeletal.*
- ✓ Each differ in structure, location and physiological function.
- ✓ Smooth muscle and cardiac muscle are not under voluntary control and Skeletal muscles, which are under voluntary control, are attached to bones via their tendons and move the skeleton.
- ✓ Like cardiac (but not smooth) muscle, skeletal muscle is *striated* (striped), and the stripes are seen in a characteristic banded pattern when the cells are viewed under the microscope.

8. What are the two types of respiration?

Blood provides the transport system for O_2 and Co_2 between the lungs and the cells of the body.

- ✓ Exchange of gases between the blood and the lungs is called **external respiration**
- ✓ Exchange of gases between the blood and the cells **internal respiration**.

9. Mention the parts of respiratory system.

The organs of the respiratory system are:

- ✓ Nose
- ✓ Pharynx
- ✓ Larynx
- ✓ Trachea
- ✓ Two bronchi (one bronchus to each lung)
- ✓ Bronchioles and smaller air passages
- ✓ Two lungs and their coverings, the pleura
- ✓ Muscles of breathing – the inter costal muscles and The diaphragm.

10. What is the ventilation perfusion ratio.

The ventilation-perfusion ratio is the ratio between the amount of air getting to the alveoli (the alveolar ventilation, V, in ml/min) and the amount of blood being sent to the lungs (the cardiac output or Q - also in ml/min). Calculating the V/Q ratio is quite easy -

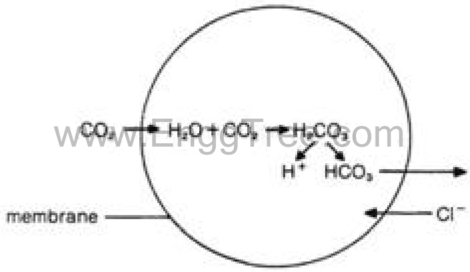
$$V/Q = \text{alveolar ventilation/cardiac output}$$

$$V/Q = (4\ l/min)/(5\ l/min)$$

$$V/Q = 0.8$$

11. What is chloride shift.

When CO_2 enters the blood from the tissues, it passes into the red blood cell and is converted by carbonate dehydratase to bicarbonate (HCO_3^-); HCO_3^- ion passes out into the plasma, whereas Cl^- migrates into the red blood cell. Reverse changes occur in the lungs when CO_2 is eliminated from the blood.



12. Write short notes on larynx.

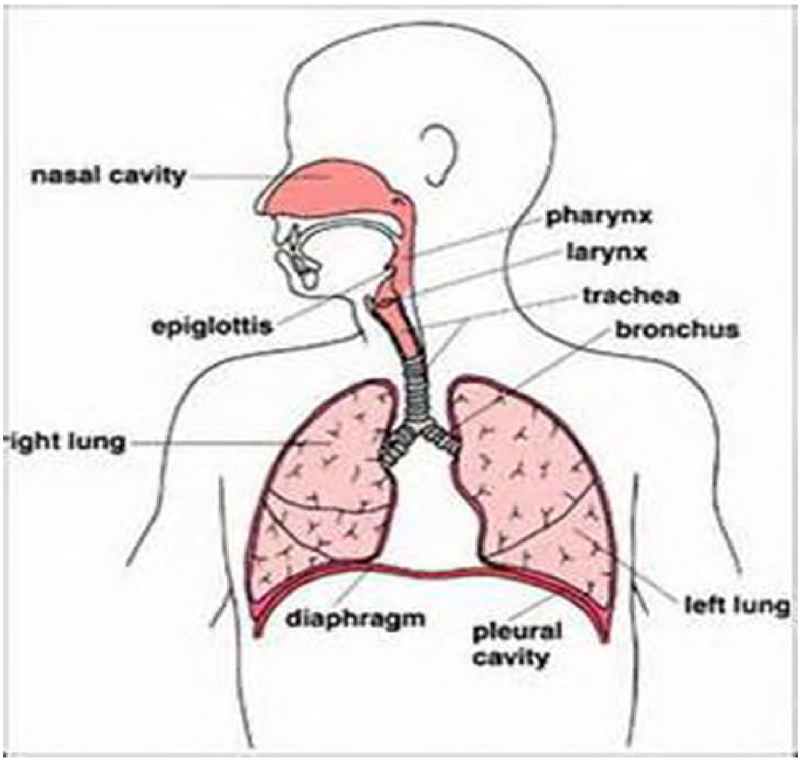
From the pharynx, air enters into the larynx, commonly called the voice box. The larynx is part of the upper respiratory tract that has two main functions:

- ✓ A passageway for air to enter into the lungs, and a source of vocalization. The larynx is made up of the hyoid bone and cartilage, which helps regulate the flow of air.
- ✓ The epiglottis is a flap-like cartilage structure contained in the larynx that protects the trachea against food aspiration.

13. What is respiratory exchange rate? (NOV/DEC-2013)

The **respiratory exchange ratio** (RER) is the **ratio** between the amount of carbon dioxide (CO_2) produced in metabolism and oxygen (O_2) used. Humans typically inhale more molecules of oxygen than they exhale of carbon dioxide. The **ratio** is determined by comparing exhaled gasses to room air.

14. Draw a schematic diagram of respiratory system and label various parts.



15. What is respiratory quotient.

Respiratory quotient is the ratio of the volume of carbon dioxide evolved to that of oxygen consumed by an organism, tissue, or cell in a given time.

16. State Boyle's law and its significance with respect to respiratory system.

Boyle's Law states that at a constant temperature, volume of a gas is inversely proportional to the pressure.

When you breathe, the lungs expand, the pressure in your lungs is greater than outside and so air exists your lungs outside by diffusion, to balance out the pressure in your lungs with atmospheric pressure.

17. Inhalation (breathing in) is said to be an active movement. Why?

Inspiration or inhalation is an active process which requires contraction of the skeletal muscles. The diaphragm creates pressure difference between the abdominal cavity and the intra-pleural space, while there is some tension in the diaphragm

18. What are the causes for Asthma?

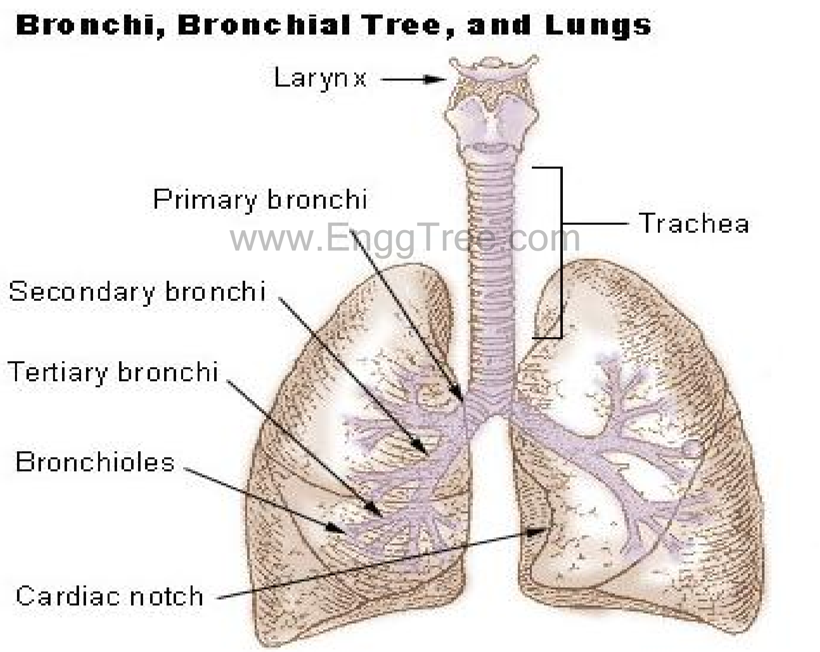
Asthma triggers are different from person to person and can include: Airborne allergens, such as pollen, animal dander, mold, cockroaches and dust mites. Respiratory infections, such as the common cold. Physical activity (exercise-induced asthma)

19. Write short notes on respiratory centers.

The **respiratory centers** (RCs) are located in the medulla oblongata and pons, which are parts of the brainstem.

The RCs receive controlling signals of neural, chemical and hormonal nature and control the rate and depth of **respiratory** movements of the diaphragm and other **respiratory** muscles.

20. Give the arrangement of bronchi and their branches in the lungs.

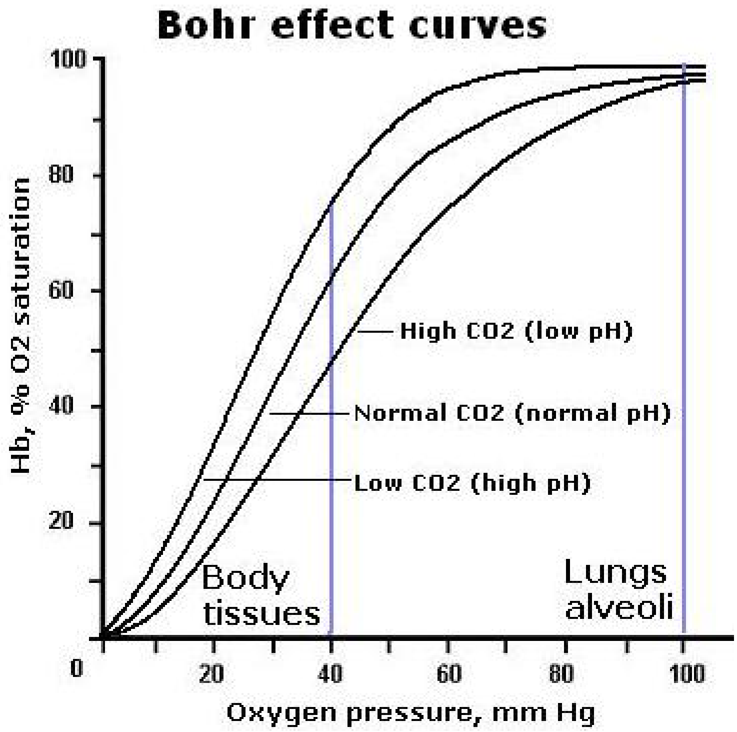


21. Describe structure of bronchiole. What changes take place in it in chronic smokers?

The mucus is normally swept out of the **lungs** by the cilia on the epithelial cells lining the trachea, **bronchi** and bronchioles. However, cigarette **smoke** contains harmful chemicals that **damage** these cells, leading to a build-up of mucus and a smoker's cough. **Smoke** irritates the **bronchi**, causing bronchitis.

22. What is Bohr effect?(M/J-2014)

An effect by which an increase of carbon dioxide in the blood and a decrease in pH results in a reduction of the affinity of hemoglobin for oxygen.



23. What happens to respiration during sleep apnea? (M/J-2016)

Obstructive sleep apnea is the most common type of sleep apnea. It occurs when the soft tissue in the back of your throat relaxes during sleep and blocks the airway, often causing you to snore loudly.

PART B

1. Write a brief notes about the bone types and its structure.

Types of bones

Bones are classified as long, short, irregular, flat and sesamoid.

- **Long bones**

These consist of a shaft and two extremities. As the name suggests, these bones are longer than they are wide. Most long bones are found in the limbs; examples include the femur, tibia and fibula.

- **Short, irregular, flat and sesamoid bones.**

These have no shafts or extremities and are diverse in shape and size. Examples include:

- ✓ Short bones – carpals (wrist)

- ✓ Irregular bones – vertebrae and some skull bones
- ✓ Flat bones – sternum, ribs and most skull bones
- ✓ Sesamoid bones – patella (knee cap).

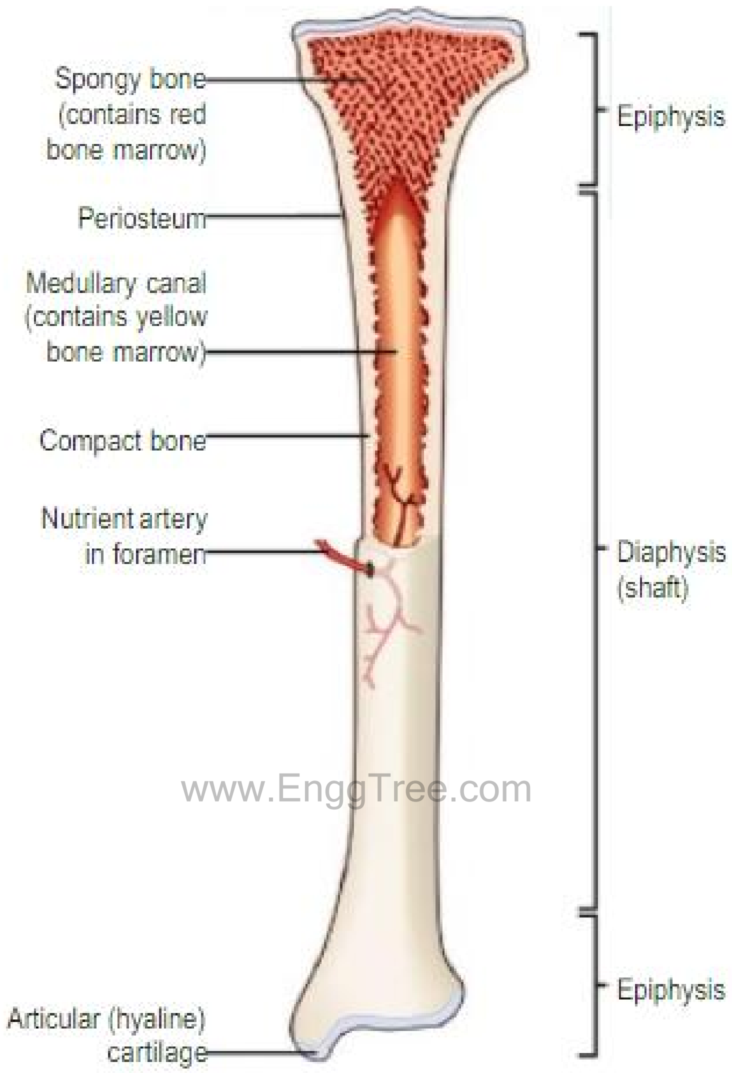
Bone types	Description	Example(s)
1.**Long Bones**	✓ '**Long bones**' are longer than they are wide, i.e. **length > diameter**. ✓ They consist of a shaft - which is the main (long) part and variable number of endings (extremities), depending on the joints formed at one or both ends of the long bone. ✓ Long bones are usually somewhat curved - contributing to their mechanical strength.	✓ Femur (leg bone) ✓ Tibia (leg bone) ✓ Fibula (leg bone) ✓ Humerus (arm bone) ✓ Ulna (arm bone) ✓ Radius (arm bone)
2. **Short Bones**	✓ '**Short bones**' can be approximately cube-shaped, i.e. **length is similar to width / depth / diameter**. ✓ The most obvious examples are the carpal bones (of the hands / wrists) and the tarsal bones (of the feet / ankles).	✓ Scaphoid bone (wrist bone) ✓ Lunate bone (wrist bone) ✓ Hamate bone (wrist bone) and other wrist bones = **carpal bones** ✓ Cuboid bone (ankle bone) ✓ First Cuniform bone (ankle bone) ✓ Second Cuniform bone

		(ankle bone) and other ankle bones = **tarsal bones**
3. **Flat Bones**	✓ '**Flat bones**' have a thin shape and, in some cases, provide mechanical protection to soft tissues beneath or enclosed by the flat bone e.g. cranial bones that protect the brain. ✓ Flat bones also have extensive surfaces for muscle attachments e.g. scapulae (shoulder) bones.	✓ Cranial bones (protecting the brain) e.g. ✓ Frontal bone ✓ Parietal bones ✓ Sternum (protecting organs in the thorax) ✓ Ribs (protecting organs in the thorax) ✓ Scapulae (should er blades).
4. **Irregular Bones**	✓ '**Irregular bones**' have complicated shapes that cannot be classified as 'long', 'short' or 'flat'. ✓ Their shapes are due to the functions they fulfill within the body e.g. providing major mechanical support for the body yet also protecting the spinal cord (in the case of the vertebrae).	✓ Atlas bone ✓ Axis bone and other vertebrae ✓ Hyoid bone ✓ Sphenoid bone ✓ Zygomatic bones and other facial bones.

5. **Sesamoid Bones**	✓ '**Sesamoid bones**' develop in some tendons in locations where there is considerable friction, tension, and physical stress. ✓ Typical areas in which they may form include the palms of the hands and the soles of the feet. ✓ The presence, location and and quantity of sesamoid bones varies considerably from person to person. ✓ Most sesamoid bones are un-named.	✓ Only one type of sesamoid bone is present in all normal human skeletons so has a name. ✓ That is the **patella** (singular), **patellae**(plural). Patellae are also called 'kneecaps'. ✓ Complete human skeletons include 2 of these, one in each leg.

Bone structure

(i) Long bones



A mature long bone: partially sectioned

- ✓ These have a diaphysis (shaft) and two epiphyses (extremities). The diaphysis is composed mainly of compact bone with a central medullary canal, containing fatty ellow bone marrow.
- ✓ The epiphyses consist of an outer covering of compact bone with spongy (cancellous) bone inside.
- ✓ The diaphysis and epiphyses are separated by epiphyseal cartilages, which ossify when growth is complete. Long bones are almost completely covered by a vascular membrane, the periosteum, which has two layers. The outer layer is tough and fibrous, and protects the bone underneath.

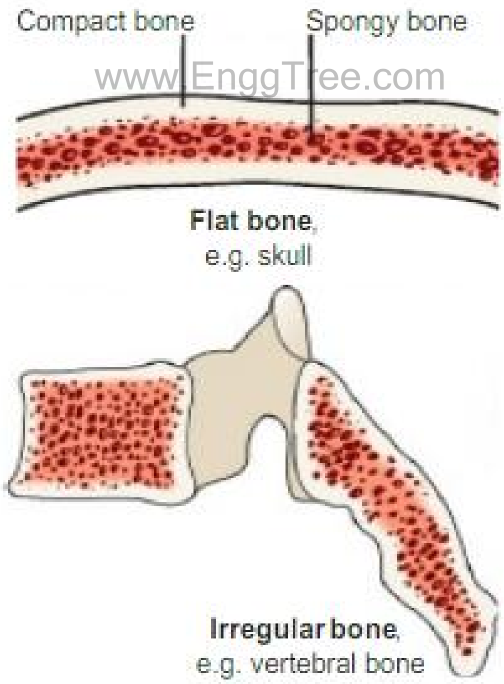
- ✓ The inner layer contains osteoblasts and osteoclasts, the cells responsible for bone production and breakdown, and is important in repair and remodelling of the bone. The periosteum covers the whole bone except within joint cavities, allows attachments of tendons and is continuous with the joint capsule.
- ✓ Hyaline cartilage Replaces periosteum on bone surfaces that form joints. Thickening of a bone occurs by the deposition of new bone tissue under the periosteum.

Blood and nerve supply

One or more nutrient arteries supply the bone shaft; the epiphyses have their own blood supply, although in the mature bone the capillary networks arising from the two are heavily interconnected.

The sensory nerve supply usually enters the bone at the same site as the nutrient artery, and branches extensively throughout the bone. Bone injury is, therefore, usually very painful.

(ii) Short, irregular, flat and sesamoid bones



Sections of flat and irregular bones

These have a relatively thin outer layer of compact bone, with spongy bone inside containing red bone marrow. They are enclosed by periosteum except the inner layer of the cranial bones where it is replaced by dura mater.

2. What are the types of bone cells and tissues.

Bone is a strong and durable type of connective tissue. Its major constituent (65%) is a mixture of calcium salts, mainly calcium phosphate. This inorganic matrix gives bone great hardness, but on its own would be brittle and prone to shattering.

The remaining third is organic material, called osteoid, which is composed mainly of collagen. Collagen is very strong and gives bone slight flexibility.

Bone cells

There are three types of bone cell:

- ✓ Osteoblast
- ✓ Osteocytes
- ✓ Osteoclast.

Osteoblasts

These bone-forming cells are responsible for the deposition of both inorganic salts and osteoid in bone tissue. They are therefore present at sites where bone is growing, repairing or remodelling, e.g.:

- ➢ In the deeper layers of periosteum
- ➢ In the centres of ossification of immature bone

- ➢ At the ends of the diaphysis adjacent to the epiphyseal cartilages of long bones
- ➢ At the site of a fracture.

As they deposit new bone tissue around themselves, they eventually become trapped in tiny pockets (lacunae) in the growing bone, and differentiate into osteocytes

Osteocytes

These are mature bone cells that monitor and maintain bone tissue, and are nourished by tissue fluid in the canaliculi that radiate from the central canals.

Osteoclasts

These cells break down bone, releasing calcium and phosphate. They are very large cells with up to 50 nuclei, which have formed from the fusion of many monocytes.

The continuous remodelling of healthy bone tissue is the result of balanced activity of the bone's osteoblast and osteoclast populations. Osteoclasts are found in areas of the bone where there is active growth, repair or remodelling,

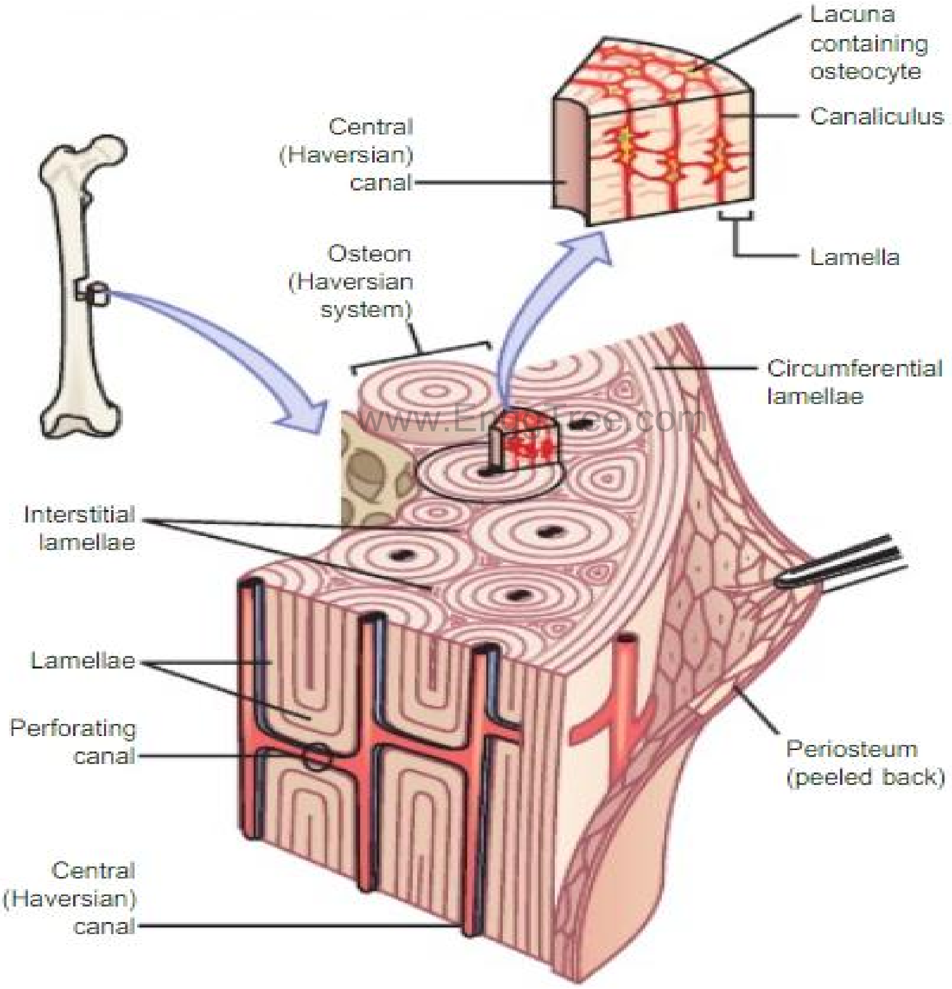
e.g.:

➢ Under the periosteum, maintaining bone shape during growth and to remove excess callus formed during healing of fractures.

➢ Round the walls of the medullary canal during growth and to canalise callus during healing.

Compact (cortical) bone

Compact bone makes up about 80% of the body bone mass. It is made up of a large number of parallel tube-shaped units called osteons (Haversian systems), each of which is made up of a central canal surrounded by a series of expanding rings, similar to the growth rings of a tree.



Microscopic structure of compact bone

❖ Osteons tend to be aligned the same way that force is applied to the bone, so for example in the femur (thigh bone), they run from one epiphysis to the other. This gives the bone great strength.

- The central canal contains nerves, lymphatics and blood vessels, and each central canal is linked with neigh-bouring canals by tunnels running at right angles between them, called perforating canals.
- The series of cylindrical plates of bone arranged around each central canal are called lamellae. Between the adjacent lamellae of the osteon are strings of little cavities called lacunae, in each of which sits an osteocyte.
- Lacunae communicate with each other through a series of tiny channels called canali-culi, which allows the circulation of interstitial fluid through the bone, and direct contact between the osteo-cytes, which extend fine processes into them.
- Between the osteons are interstitial lamellae, the rem-nants of older systems partially broken down during remodelling or growth of bone.

Spongy (cancellous, trabecular) bone

- To the naked eye, spongy bone looks like a honey comb. Microscopic examination reveals a framework formed from trabeculae (meaning 'little beams'), which consist of a few lamellae and osteocytes interconnected by canal-iculi.
- Osteocytes are nourished by interstitial fluid diffusing into the bone through the tiny canaliculi. The spaces between the trabeculae contain red bone marrow. In addition, spongy bone is lighter than compact bone, reducing the weight of the skeleton.

3. Describe the process of bone formation.

Development of bone tissue

The formation of bone is called ossification. During the fetal stage of development this occurs by two processes: intramembranous ossification and endochondral ossification.

Intramembranous ossification involves the formation of bone from connective tissue whereas endochondral ossification involves the formation of bone from cartilage.

Intramembranous Ossification

- ✓ During **intramembranous ossification**, compact and spongy bone develops directly from sheets of mesenchymal (undifferentiated) connective tissue. The flat bones of the face, most of the cranial bones, and the clavicles (collarbones) are formed via intramembranous ossification.

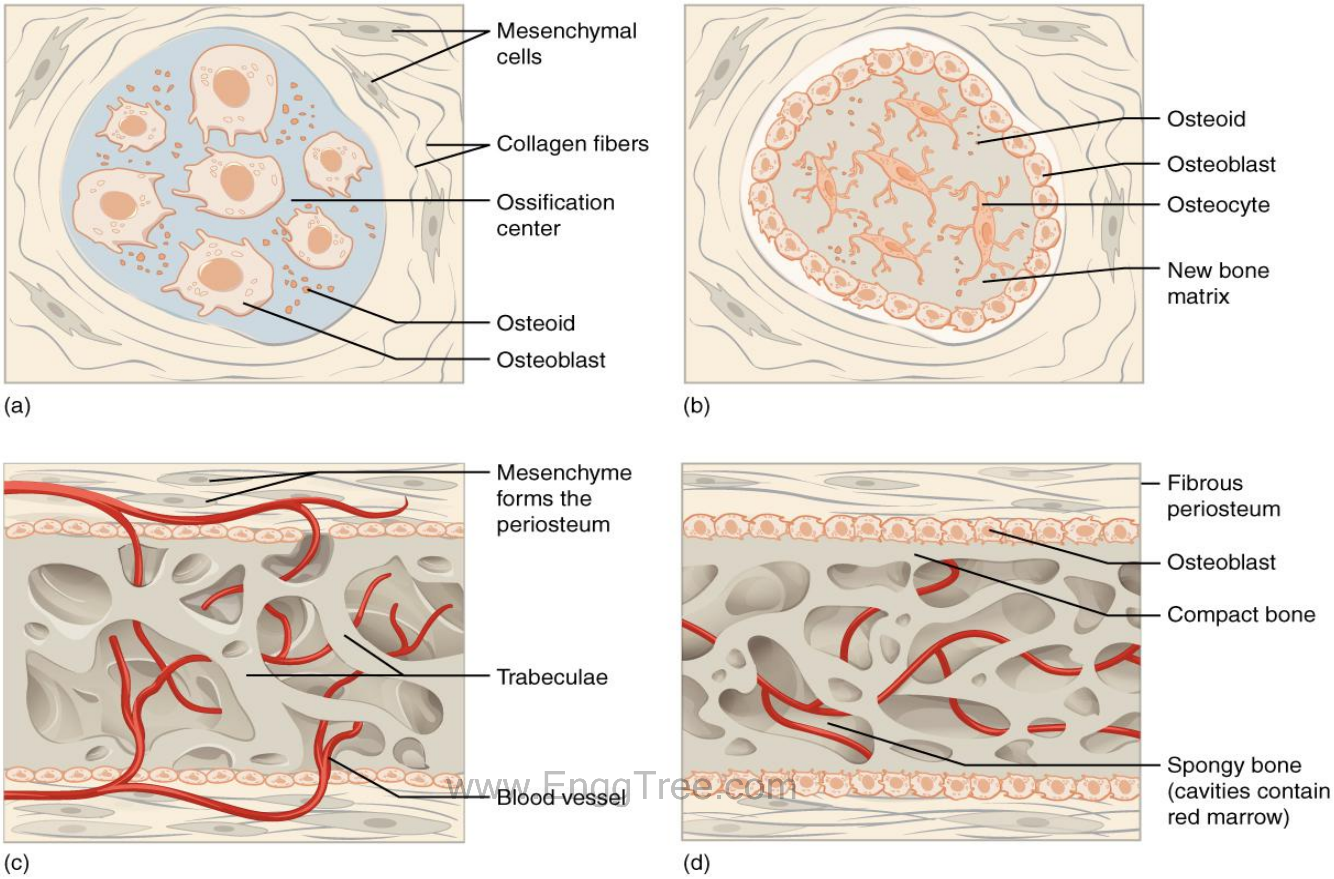


Figure 1. Intramembranous Ossification. Intramembranous ossification follows four steps. (a) Mesenchymal cells group into clusters, and ossification centers form. (b) Secreted osteoid traps osteoblasts, which then become osteocytes. (c) Trabecular matrix and periosteum form. (d) Compact bone develops superficial to the trabecular bone, and crowded blood vessels condense into red marrow.

- ✓ The process begins when mesenchymal cells in the embryonic skeleton gather together and begin to differentiate into specialized cells (Figure 1**a**). Some of these cells will differentiate into capillaries, while others will become osteogenic cells and then osteoblasts. Although they will ultimately be spread out by the formation of bone tissue, early osteoblasts appear in a cluster called an **ossification center**.

- ✓ The osteoblasts secrete **osteoid**, uncalcified matrix, which calcifies (hardens) within a few days as mineral salts are deposited on it, thereby entrapping the osteoblasts within. Once entrapped, the osteoblasts become osteocytes (Figure 1**b**). As osteoblasts transform into osteocytes, osteogenic cells in the surrounding connective tissue differentiate into new osteoblasts at the edges of the growing bone.

- ✓ Several clusters of osteoid unite around the capillaries to form a trabecular matrix, while osteoblasts on the surface of the newly formed spongy bone become the cellular layer of the periosteum (Figure 1**c**). The periosteum then secretes compact bone superficial to the spongy bone. The spongy bone crowds nearby blood vessels, which eventually condense into red bone marrow (Figure 1**d**). The new bone is constantly also remodeling under the action of osteoclasts (not shown).

- ✓ Intramembranous ossification begins *in utero* during fetal development and continues on into adolescence. At birth, the skull and clavicles are not fully ossified nor are the sutures of the skull closed. This allows the skull and shoulders to deform during passage through the birth canal. The last bones to ossify via intramembranous ossification are the flat bones of the face, which reach their adult size at the end of the adolescent growth spurt.

Endochondral Ossification

In **endochondral ossification**, bone develops by *replacing* hyaline cartilage. Cartilage does not become bone. Instead, cartilage serves as a template to be completely replaced by new bone. Endochondral ossification takes much longer than intramembranous ossification. Bones at the base of the skull and long bones form via endochondral ossification.

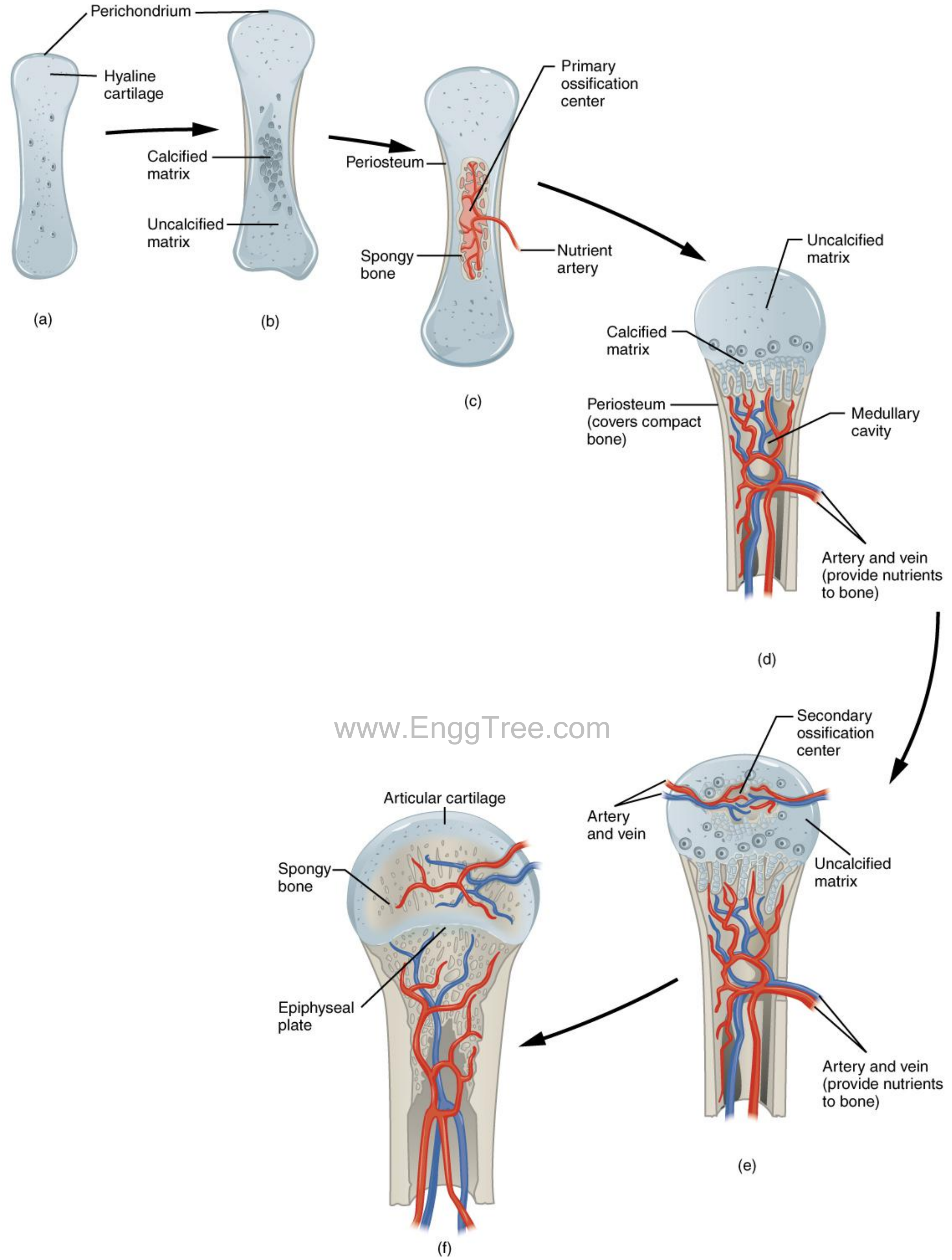


Figure 2. Endochondral Ossification. Endochondral ossification follows five steps. (a) Mesenchymal cells differentiate into chondrocytes. (b) The cartilage model of the future bony skeleton and the perichondrium form. (c) Capillaries penetrate cartilage. Perichondrium transforms into periosteum.

Periosteal collar develops. Primary ossification center develops. (d) Cartilage and chondrocytes continue to grow at ends of the bone. (e) Secondary ossification centers develop. (f) Cartilage remains at epiphyseal (growth) plate and at joint surface as articular cartilage.

- ✓ In a long bone, for example, at about 6 to 8 weeks after conception, some of the mesenchymal cells differentiate into chondrocytes (cartilage cells) that form the cartilaginous skeletal precursor of the bones (Figure 2**a**).
- ✓ This cartilage is a flexible, semi-solid matrix produced by chondroblasts and consists of hyaluronic acid, chondroitin sulfate, collagen fibers, and water. As the matrix surrounds and isolates chondroblasts, they are called chondrocytes.
- ✓ Unlike most connective tissues, cartilage is avascular, meaning that it has no blood vessels supplying nutrients and removing metabolic wastes.
- ✓ All of these functions are carried on by diffusion through the matrix from vessels in the surrounding **perichondrium**, a membrane that covers the cartilage, Figure 2**a**).As more and more matrix is produced, the cartilaginous model grow in size.
- ✓ Blood vessels in the perichondrium bring osteoblasts to the edges of the structure and these arriving osteoblasts deposit bone in a ring around the diaphysis – this is called a bone collar (Figure 2b).
- ✓ The bony edges of the developing structure prevent nutrients from diffusing into the center of the hyaline cartilage. This results in chondrocyte death and disintegration in the center of the structure.
- ✓ Without cartilage inhibiting blood vessel invasion, blood vessels penetrate the resulting spaces, not only enlarging the cavities but also carrying osteogenic cells with them, many of which will become osteoblasts.
- ✓ These enlarging spaces eventually combine to become the medullary cavity. Bone is now deposited within the structure creating the **primary ossification center (Figure** 2c**).**
- ✓ While these deep changes are occurring, chondrocytes and cartilage continue to grow at the ends of the structure (the future epiphyses), which increases the structure's length at the same time bone is replacing cartilage in the diaphyses.
- ✓ This continued growth is accompanied by remodeling inside the medullary cavity (osteoclasts were also brought with invading blood vessels) and overall

lengthening of the structure (Figure 2d). By the time the fetal skeleton is fully formed, cartilage remains at the epiphyses and at the joint surface as articular cartilage.

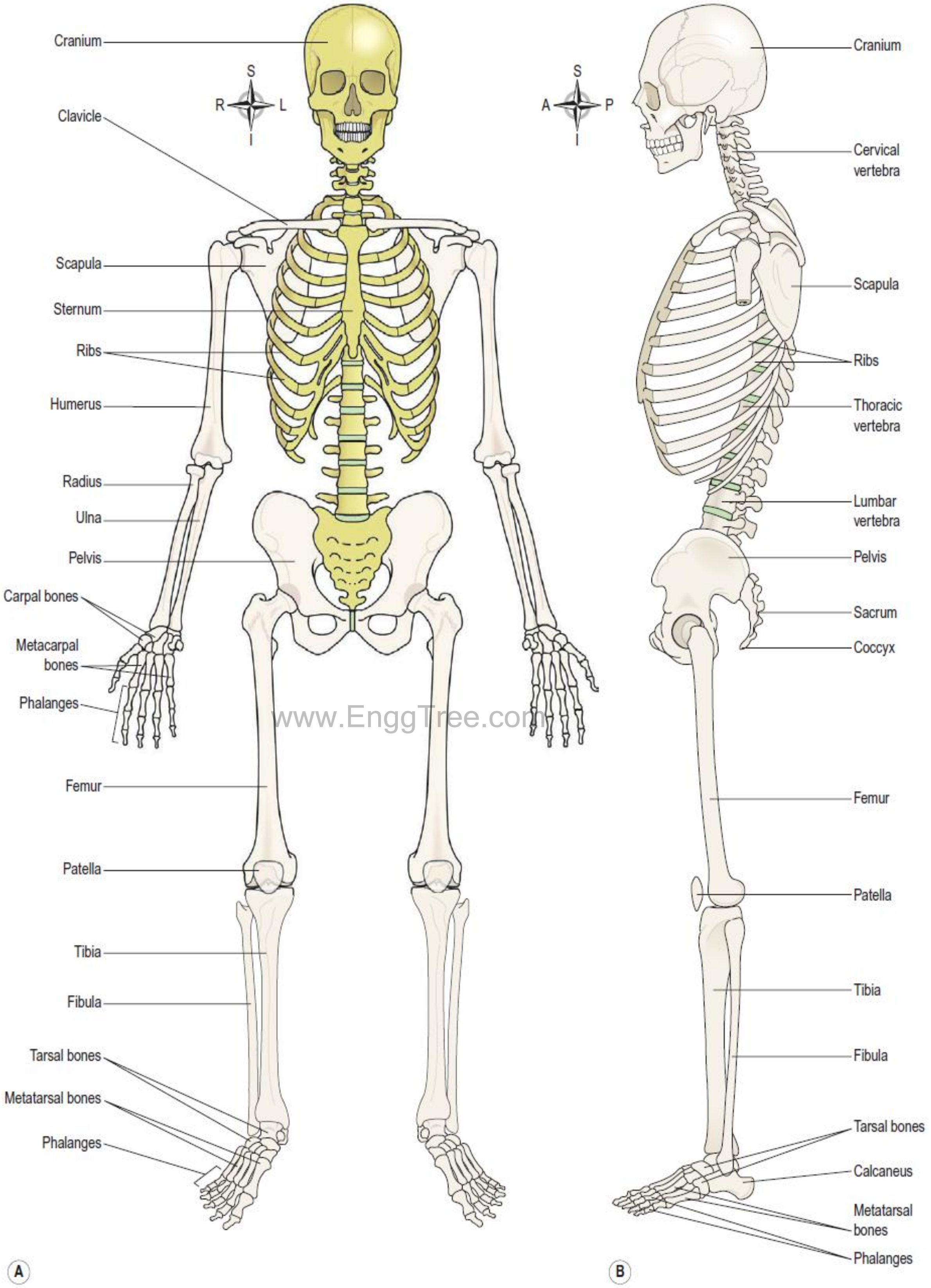
- ✓ After birth, this same sequence of events (matrix mineralization, death of chondrocytes, invasion of blood vessels from the periosteum, and seeding with osteogenic cells that become osteoblasts) occurs in the epiphyseal regions, and each of these centers of activity is referred to as a **secondary ossification center**(Figure 2**e**).
- ✓ Throughout childhood and adolescence, there remains a thin plate of hyaline cartilage between the diaphysis and epiphysis known as the **growth** or **epiphyseal plate** (Figure 2f). Eventually, this hyaline cartilage will be removed and replaced by bone to become the **epiphyseal line**.

4. Explain in detail about the divisions of skeleton.

Division of Skeleton

- ✓ The bones of the skeleton are divided into two groups: **the axial skeleton and the appendicular skeleton**.

- ✓ The **axial skeleton** consists of **the skull, vertebral column, ribs and sternum**. Together the bones forming these structures constitute the central bony core of the body, the axis.
- ✓ The axial skeleton of the adult consists of 80 bones, including the **skull**, the **vertebral column**, and the **thoracic cage**.
- ✓ The skull is formed by 22 bones. Also associated with the head are an additional seven bones, including the **hyoid bone** and the **ear ossicles** (three small bones found in each middle ear).
- ✓ The vertebral column consists of 24 bones, each called a **vertebra**, plus the **sacrum** and **coccyx**.
- ✓ The thoracic cage includes the 12 pairs of **ribs**, and the **sternum**, the flattened bone of the anterior chest.
- ✓ The **appendicular skeleton** includes all bones **of the upper and lower limbs**, plus the bones that attach each limb to the axial skeleton. There are 126 bones in the appendicular skeleton of an adult.



The skeleton. Axial skeleton in gold, appendicular skeleton in brown.

A. Anterior view. B. Lateral view.

Axial skeleton

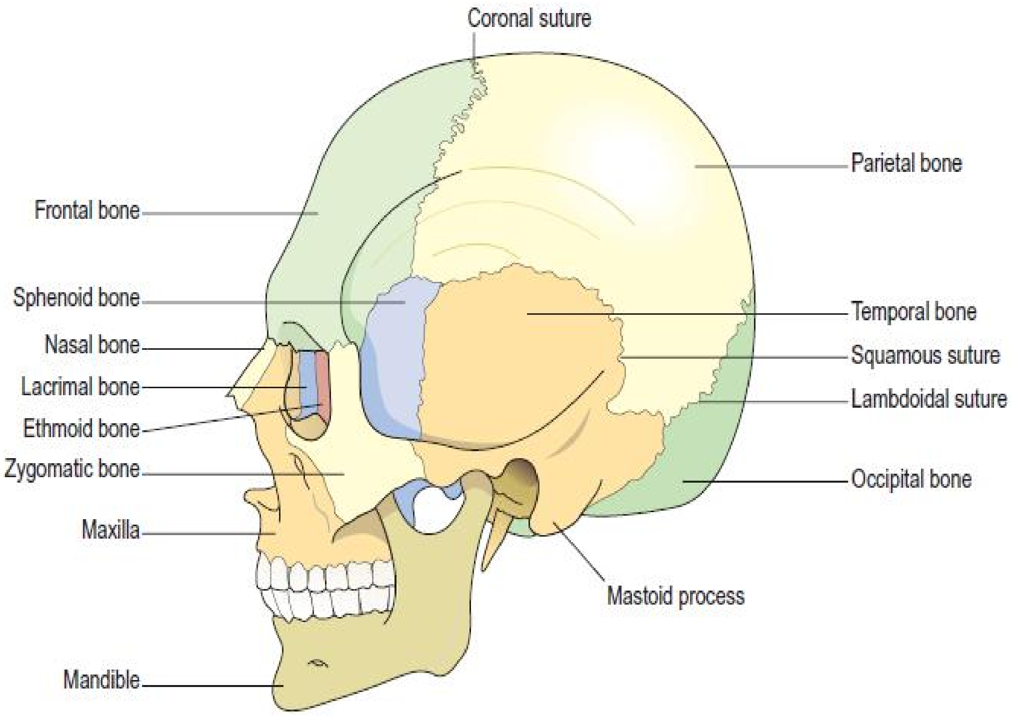
i) Skull

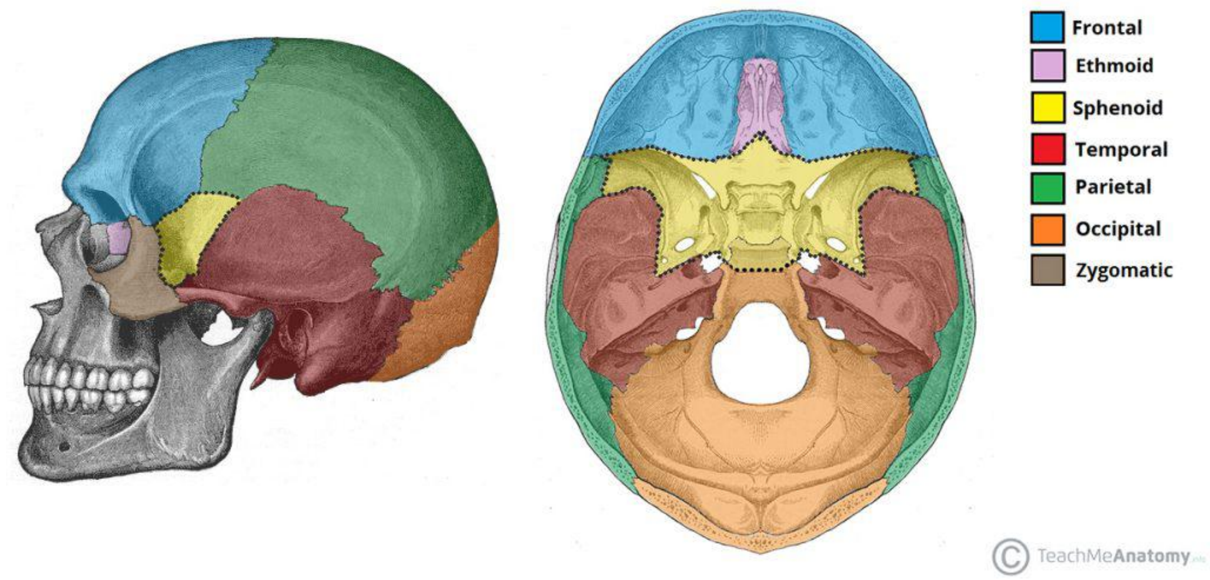
The skull rests on the upper end of the vertebral column and its bony structure is divided into two parts: **the cranium and the face**.

- **Cranium**

The cranium is formed by a number of flat and irregular bones that protect the brain. It has a *base* upon which the brain rests and a *vault* that surrounds and covers it. The periosteum lining the inner surface of the skullbones forms the outer layer of dura mater. In the mature skull the joints (*sutures*) between the bones are immovable. The bones have numerous perforations (e.g. foramina, fissures) through which nerves, blood and lymph vessels pass. The bones of the cranium are:

- ✓ 1 frontal bone
- ✓ 2 parietal bones
- ✓ 2 temporal bones
- ✓ 1 occipital bone
- ✓ 1 sphenoid bone
- ✓ 1 ethmoid bone.





Bones of the Cranium and face

- **Face**

The skeleton of the face is formed by 14 bones in addition to the frontal bone already described. The relationships between the bones:

- Maxilla (2)
- Zygomatic (2)
- Mandible (1)
- Nasal (2)
- Platine (2)
- Inferior nasal concha (2)
- Lacrimal (2)
- Vomer (1)

ii) Vertebral column

There are 26 bones in the vertebral column. Twenty-four separate vertebrae extend downwards from the occipital bone of the skull; then there is the *sacrum*, formed from five fused vertebrae, and lastly the *coccyx*, or tail, which is formed from between three and five small fused vertebrae.

The vertebral column is divided into different regions. The first seven vertebrae, in the neck, form the cervical spine; the next 12 vertebrae are the thoracic spine, and the next five the lumbar spine, the lowest vertebra of which articulates with the sacrum. Each vertebra is identified by the first letter of its region in the spine, followed by a number indicating its position. For example, the topmost vertebra is C1, and the third lumbar vertebra is L3.

Functions of the vertebral column

These include:

- ✓ Collectively the vertebral foramina form the vertebral canal, which provides a strong bony protection for the delicate spinal cord lying within it
- ✓ The pedicles of adjacent vertebrae form intervertebral foramina, one on each side, providing access to the spinal cord for spinal nerves, blood vessels and lymph vessels
- ✓ The numerous individual bones with their intervertebral discs allow movement of the whole column
- ✓ Support of the skull
- ✓ The intervertebral discs act as shock absorbers, protecting the brain
- ✓ Formation of the axis of the trunk, giving attachment to the ribs, shoulder girdle and upper limbs, and the pelvic girdle and lower limbs.

iii) Thoracic cage

The thorax (thoracic cage) is formed by the sternum anteriorly, twelve pairs of ribs forming the lateral bony cages, and the twelve thoracic vertebrae.

- ➢ **Sternum (breast bone)**

This flat bone can be felt just under the skin in the middle of the front of the chest. The *manubrium* is the uppermost section and articulates with the clavicles at the *sterno clavicular joints* and with the first two pairs of ribs. The *body* or *middle portion* gives attachment to the ribs. The *xiphoid process* is the inferior tip of the bone. It gives attachment to the diaphragm, muscles of the anterior abdominal wall and the *linea alba.*

- ➢ **Ribs**

The 12 pairs of ribs form the lateral walls of the thoracic cage. They are elongated curved bones that articulate posteriorly with the vertebral column. Anteriorly, the first seven pairs of ribs articulate directly with the sternum and are known as the *true ribs*. The next three pairs articulate only indirectly.

In both cases, *costal cartilages* attach the ribs to the sternum. The lowest two pairs of ribs, referred to as *floating ribs*, do not join the sternum at all, their anterior tips being free. Each rib forms up to three joints with the vertebral column. Two of these joints are formed between facets on the head of the rib and facets on the bodies of two vertebrae, the one above the rib and the one below.

Ten of the ribs also form joints between the tubercle of the rib and the transverse process of (usually) the lower vertebra. The inferior surface of the rib is deeply grooved, providing a channel along which intercostal nerves and blood vessels run. Between each rib and the one below are the intercostal muscles, which move the rib cage during breathing.

Because of the arrangement of the ribs, and the quantity of cartilage present in the ribcage, it is a flexible structure that can change its shape and size during breathing. The first rib is firmly fixed to the sternum and to the 1^{st} thoracic vertebra, and does not move during inspiration. Because it is a fixed point, when the intercostal muscles contract, they pull the entire ribcage upwards towards the first rib.

iv) Auditory Ossicles

- Malleus (2)
- Incus (2)
- Stapes (2)

v) Hyoid bone

This is an isolated horseshoe-shaped bone lying in the soft tissues of the neck just above the *larynx* and below the *mandible.*It does not articulate with any other bone, but is attached to the styloid process of the temporal bone by ligaments. It supports the larynx and gives attachment to the base of the tongue.

Appendicular Skeleton

The appendicular skeleton includes the bones of the shoulder girdle, the upper limbs, the pelvic girdle, and the lower limbs.

i) The Bones of the Shoulder Girdle

The **pectoral** or **shoulder girdle** consists of the scapulae and clavicles. The shoulder girdle connects the bones of the upper limbs to the axial skeleton. These bones also provide attachment for muscles that move the shoulders and upper limbs.

ii) Bones of the Upper Limbs

The **upper limbs** include the bones of **the arm (humerus), forearm (radius and ulna), wrist, and hand.**

The only bone of the arm is the **humerus**, which articulates with **the forearm bones–the radius** and **ulna–at the elbow joint**. The ulna is the larger of the two forearm bones.

The wrist, or carpus, consists of **eight carpal bones**. The eight carpal bones of the wrist are the **S**caphoid, **L**unate, **T**riquetral, **P**isiform, **T**rapezoid, **T**rapezium, **C**apitate, **H**amate.

The hand includes 8 bones in the wrist, 5 bones that form the palm, and 14 bones that form the fingers and thumb. The wrist bones are called **carpals**. The bones that form the palm of the hand are called **metacarpals**. The **phalanges** are the bones of the fingers.

iii) The Bones of the Pelvis

The **pelvic girdle** is a ring of bones attached to the vertebral column that connects the bones of the lower limbs to the axial skeleton. The pelvic girdle consists of the right and left hip bones. Each hip bone is a large, flattened, and irregularly shaped fusion of three bones: the ilium, ischium, and pubis.

Female and Male Pelvis. The female and male pelvises differ in several ways due to childbearing adaptations in the female.

- The female pelvic brim is larger and wider than the male's.
- The angle of the pubic arch is greater in the female pelvis (over 90 degrees) than in the male pelvis (less than 90 degrees).
- The male pelvis is deeper and has a narrower pelvic outlet than the female's.

iv) The Bones of the Lower Limbs

The **lower limbs** include the bones of **the thigh, leg, and foot**. The femur is the only bone of the thigh. It articulates with the two bones of the leg–the larger tibia (commonly known as the shin) and smaller fibula. The thigh and leg bones articulate at the knee joint that is protected and enhanced by the patella bone that supports the quadriceps tendon. The bones of the foot include the tarsus, metatarsus, and phalanges.

Foot Bones. The bones of the foot consist of the tarsal bones of the ankle, the phalanges that form the toes, and the metatarsals that give the foot its arch. As in the hand, the foot has five metatarsals, five proximal phalanges, five distal phalanges, but only four middle phalanges (as the foot's "big toe" has only two phalanges).

Ankle Bones. The ankle, or tarsus, consists of seven tarsal bones: the calcaneus, talus, cuboid, navicular, and three cuneiforms.

Foot Arches. The arches of the foot are formed by the interlocking bones and ligaments of the foot. They serve as shock-asborbing structures that support body weight and distribute stress evenly during walking.

- The longitudinal arch of the foot runs from the calcaneus to the heads of the metatarsals, and has medial and lateral parts.
- The transverse arch of the foot runs across the cuneiforms and the base of the metatarsal bones.

5. Explain in detail about the structure and functions of the respiratory system? Discuss about the regulation of respiration.

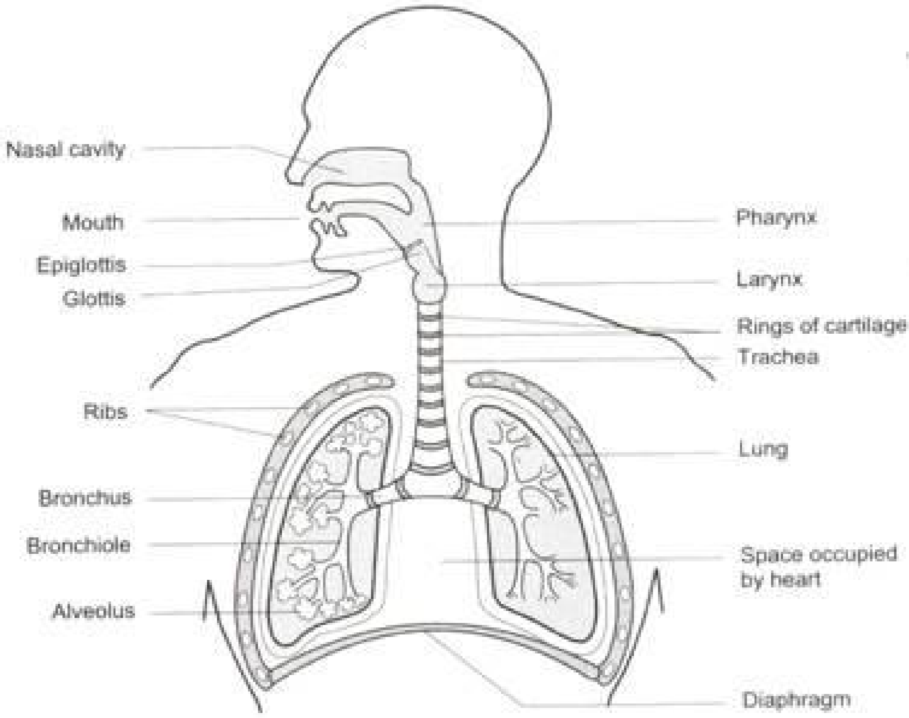
<u>**Structural divisions of the respiratory system**</u>

Nasal cavity - pharynx - larynx - trachea - bronchi - bronchioles - alveoli – Lungs.

The respiratory system consists of the following parts, divided into the upper and lower respiratory tracts:

Parts of the Upper Respiratory Tract

- **Mouth, nose & nasal cavity:** The function of this part of the system is to warm, filter and moisten the incoming air.
- **Pharynx:** Here the throat divides into the trachea (wind pipe) and oesophagus (food pipe). There is also a small flap of cartilage called the epiglottis which prevents food from entering the trachea.
- **Larynx:** This is also known as the voice box as it is where sound is generated. It also helps protect the trachea by producing a strong cough reflex if any solid objects pass the epiglottis.



Human respiratory system

Parts of the Lower Respiratory Tract

- **Trachea:** Also known as the windpipe this is the tube which carries air from the throat into the lungs. It ranges from 20-25mm in diameter and 10-16cm in length. The inner membrane of the trachea is covered in tiny hairs called cilia, which catch particles of dust which we can then remove through coughing. The trachea is surrounded by 15-20 C-shaped rings of cartilage at the front and side which help protect the trachea and keep it open. They are not complete circles due to the position of the oesophagus immediately behind the trachea and the need for the trachea to partially collapse to allow the expansion of the oesophagus when swallowing large pieces of food.
- **Bronchi:** The trachea divides into two tubes called bronchi, one entering the left and one entering the right lung. The left bronchi is narrower, longer and more horizontal than the right. Irregular rings of cartilage surround the bronchi, whose walls also consist of smooth muscle. Once inside the lung the bronchi split several ways, forming tertiary bronchi.
- **Bronchioles:** Tertiary bronchi continue to divide and become bronchioles, very narrow tubes, less than 1 millimeter in diameter. There is no cartilage within the bronchioles and they lead to alveolar sacs.

- **Alveoli:** Individual hollow cavities contained within alveolar sacs (or ducts). Alveoli have very thin walls which permit the exchange of gases Oxygen and Carbon Dioxide. They are surrounded by a network of capillaries, into which the inspired gases pass. There are approximately 3 million alveoli within an average adult lung.
- **Diaphragm:** The diaphragm is a broad band of muscle which sits underneath the lungs, attaching to the lower ribs, sternum and lumbar spine and forming the base of the thoracic cavity.

- **Intercostal muscles:**There are 11 pairs of inter costal muscles occupying the spaces between the 12 pairs of ribs. They are arranged in two layers as external and internal inter costal muscles.
  - ✓ **External Intercostal Muscles:** These extend downwards and forwards from the lower border of the rib above to the upper border of the rib below. They are involved in inspiration.
  - ✓ **Internal Intercostal Muscles**: These extend downwards and backwards from the lower border of the rib above to the upper border of the rib below, crossing the external inter costal muscle fibres at right angles. The internal intercostals are used when expiration becomes active, as in exercise.

    The first rib is fixed. Therefore, when the external inter costal muscles contract they pull all the other ribs towards the first rib. The ribcage moves as a unit, upwards and outwards, enlarging the thoracic cavity. The intercostals muscles are stimulated to contract by the *intercostals nerves*.

Regulation of respiration:

- Respiration is controlled by the areas of the brain that stimulate the contraction of the diaphragm and the intercostals muscles. These areas called respiratory centers.
- The Dorsal medullary inspiratory center, located in the medulla oblongata, generates rhythmic nerve impulses that stimulate contraction of the inspiratory muscles(diaphargm and external intercostals muscles).
- Ventral medullary respiratory center are associated with expiration. Normally, expiration occurs when these muscle relax, but when breathing is rapid, the inspiratory center facilitates expiration by stimulating the expiratory muscles(internal intercoastal muscles and abdominal muscles).

- Medulla Respiratory centers

Inspiratory central(Dorsal respiratory group)

- ✓ It forces the inspiration
- ✓ Phrenic nerve-stimulates the diapharm to contract)
- ✓ Intercostal nerves - stimulates the external intercostals muscle to contract

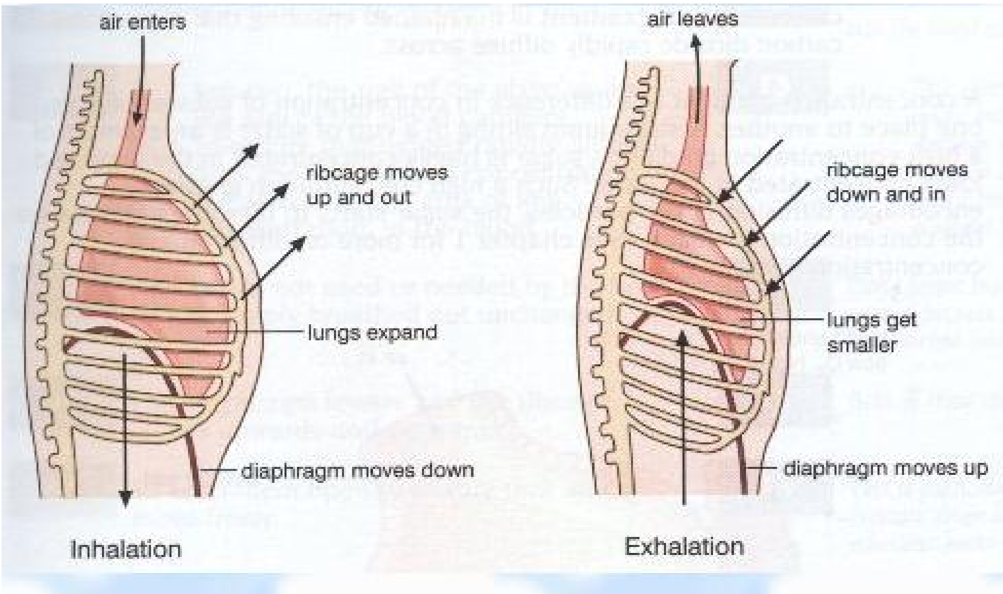
Expiratory central(ventral respiratory group)

- ✓ It forced expiration
- ✓ Phrenic nerve- stimulates the diaphargm to relax
- ✓ Intercostal nerves - stimulates the internal intercostals to contract and external intercostals muscle to relax

Pons respiratory centers:

- ✓ Pneumotaxiccenter- slightly inhibits medulla, causes shorter, shallower, quicker breaths.
- ✓ Apneusticcenter- stimulates the medulla, causes longer, deeper, slower breaths.

<u>Process of inspiration and expiration</u>



Process of inspiration (breathing in)

1. external inter costal muscles **contract**
2. ribs and sternum move up and out
3. width of thorax increases front to back and side to side
4. diaphragm **contracts**

5. diaphragm moves down, flattening
6. depth of thorax increases top to bottom so the...
    - ✓ **volume of thorax increases.**
    - ✓ **pressure** between the pleural surfaces decreases.
    - ✓ lungs expand to fill thoracic cavity.
    - ✓ air pressure in alveoli is **less** than atmospheric pressure.
    - ✓ air is forced in by the higher external atmospheric pressure.

As the lungs fill with air the stretch receptors send impulses to the expiratory part of the respiration centre to end breathing in.

Process of expiration (breathing out)

1. External inter costal muscles relax
2. ribs and sternum move down and in
3. width of thorax decreases front to back and side to side
4. diaphragm relaxes
5. diaphragm moves up
6. depth of thorax decreases top to bottom. So the ...
    - ✓ volume of thorax decreases.
    - ✓ pressure between the pleural surfaces increases.
    - ✓ lung tissue recoils from sides of thoracic cavity
    - ✓ air pressure in alveoli is more than atmospheric pressure.
    - ✓ air is forced out.

As the air leaves, the stretch receptors are no longer stimulated. The inhibition of breathing in (via the expiratory part of the centre) stops so breathing in can start again.

6. **Explain about the mechanisms of breathing.**

Exchange of gases

Although breathing involves the alternating processes of inspiration and expiration, gas exchange at the respiratory membrane and in the tissues is a continuous and ongoing process. Diffusion of oxygen and carbon dioxide depends on pressure differences, e.g. between atmospheric air and the blood, or blood and the tissues.

Composition of air

- Air is a mixture of gases: nitrogen, oxygen, carbon dioxide, water vapour and small quantities of inert gases.
- Each gas in the mixture exerts a part of the total pressure proportional to its concentration, i.e. the *partial pressure*. This is denoted as, e.g. Po_2, PCo_2.

Alveolar air

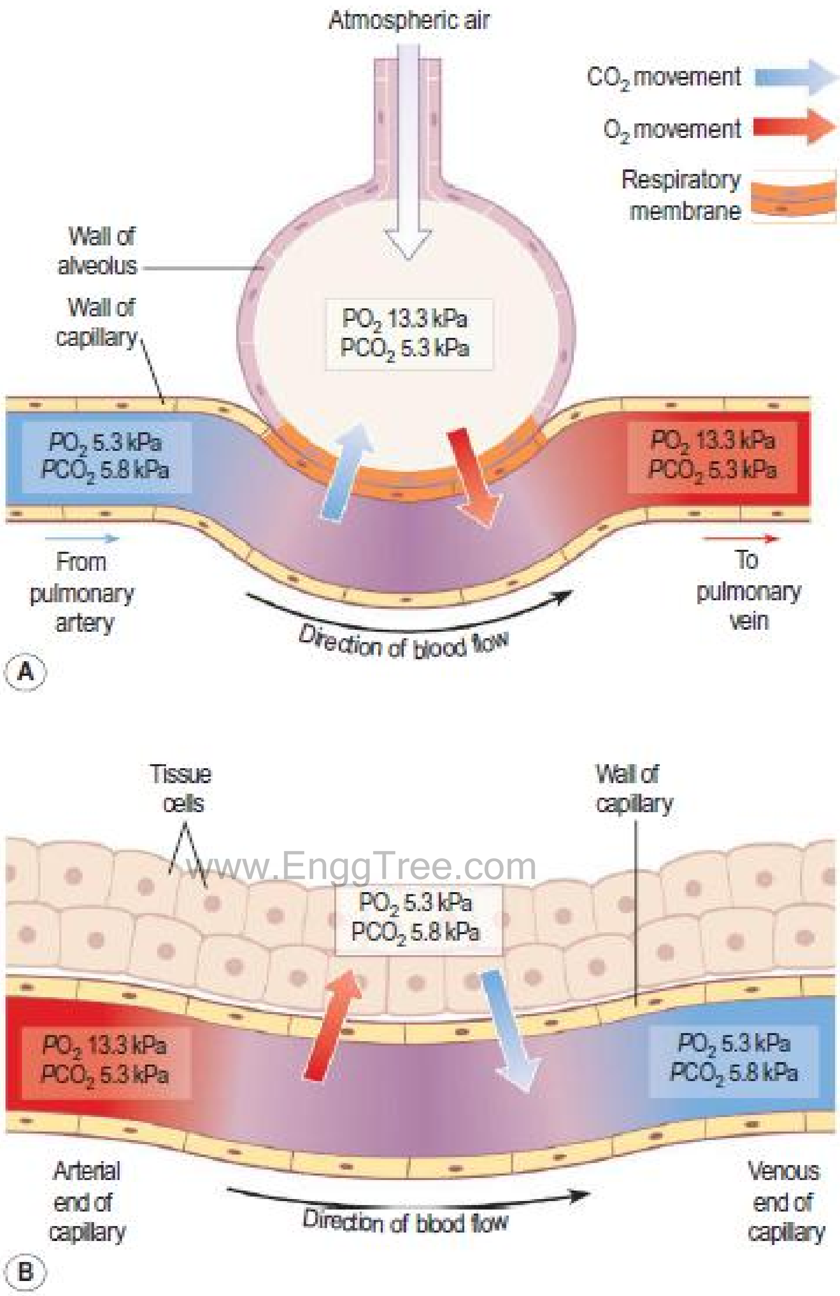
- The composition of alveolar air remains fairly constant and is different from atmospheric air. It is saturated with water vapour, and contains more carbon dioxide and less oxygen.
- Saturation with water vapour provides 6.3 kPa (47 mmHg) thus reducing the partial pressure of all the other gases present.

- Gaseous exchange between the alveoli and the bloodstream is a continuous process, as the alveoli are never empty, so it is independent of the respiratory cycle.

Diffusion of gases

- Exchange of gases occurs when a difference in partial pressure exists across a semi-permeable membrane.
- Gases move by diffusion from the higher concentration to the lower until equilibrium is established.
- Atmospheric nitrogen is not used by the body so its partial pressure remains unchanged and is the same in inspired and expired air, alveolar air and in the blood.
- These principles govern the diffusion of gases in and out of the alveoli across the respiratory membrane (*external respiration*) and across capillary membranes in the tissues (*internal respiration*).

External respiration

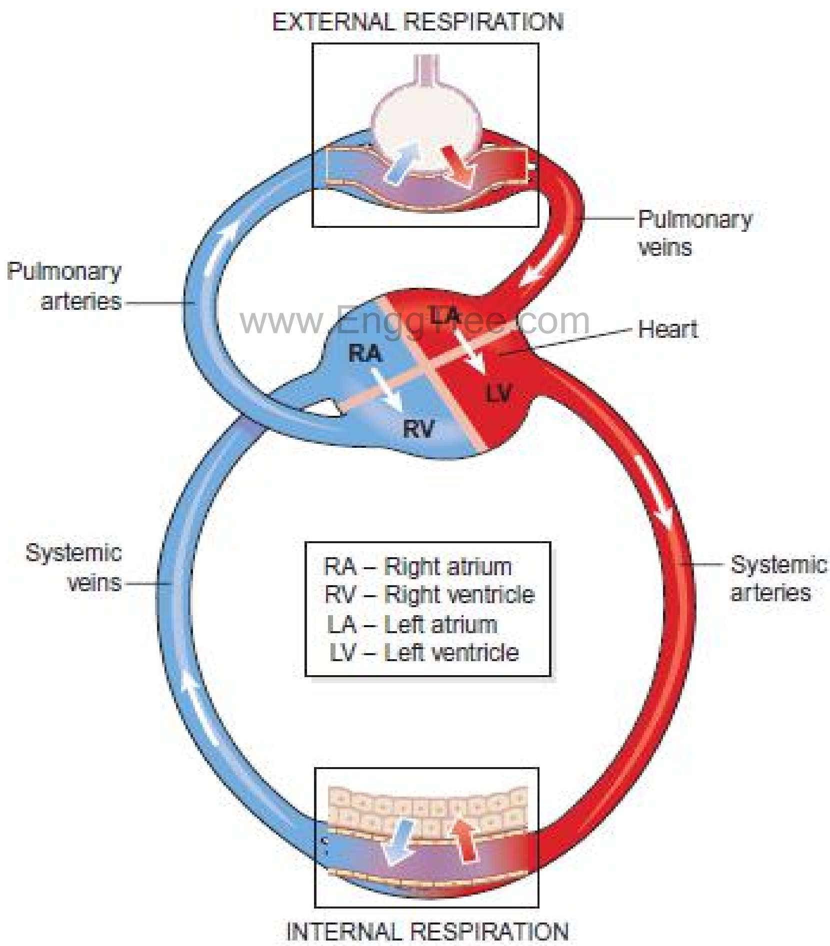


Respiration. A. External respiration. B. Internal respiration.

- This is exchange of gases by diffusion between the alveoli and the blood in the alveolar capillaries, across the respiratory membrane.
- Each alveolar wall is one cell thick and is surrounded by a network of tiny capillaries (the walls of which are also only one cell thick).
- The total area of respiratory membrane for gas exchange in the lungs is about equivalent to the area of a tennis court.

- Venous blood arriving at the lungs in the pulmonary artery has travelled from all the tissues of the body, and contains high levels of Co_2 and low levels of O_2.
- Carbon dioxide diffuses from venous blood down its concentration gradient into the alveoli until equilibrium with alveolar air is reached.
- By the same process, oxygen diffuses from the alveoli into the blood.
- The relatively slow flow of blood through the capillaries increases the time available for gas exchange to occur.
- When blood leaves the alveolar capillaries, the oxygen and carbon dioxide concentrations are in equilibrium with those of alveolar air.

Internal respiration



Summary of external and internal respiration

- This is exchange of gases by diffusion between blood in the capillaries and the body cells.

- Gas exchange does not occur across the walls of the arteries carrying blood from the heart to the tissues, because their walls are too thick.
- Po_2 of blood arriving at the capillary bed is therefore the same as blood leaving the lungs.
- Blood arriving at the tissues has been cleansed of its CO2 and saturated with O2 during its passage through the lungs, and therefore has a higher *P*O2 and a lower *P*CO2 than the tissues.
- This creates concentration gradients between capillary blood and the tissues, and gas exchange therefore occurs.
- O2 diffuses from the bloodstream through the capillary wall into the tissues.
- CO2 diffuses from the cells into the extracellular fluid, then into the bloodstream towards the venous end of the capillary.

Transport of gases in the bloodstream

Oxygen and carbon dioxide are carried in the blood in different ways.

Oxygen

Oxygen is carried in the blood in:

- ✓ Chemical combination with haemoglobin as *oxyhaemoglobin* (98.5%)

- ✓ Solution in plasma water (1.5%).

- Oxyhaemoglobin is unstable, and under certain conditions readily dissociates releasing oxygen.
- Factors that increase dissociation include low O_2 levels, low pH and raised temperature.
- In active tissues there is increased production of carbon dioxide and heat, which leads to increased release of oxygen.
- In this way oxygen is available to tissues in greatest need. Whereas oxyhaemoglobin is bright red, deoxygenated blood is bluish purple in colour.

Carbon dioxide

Carbon dioxide is one of the waste products of metabolism. It is excreted by the lungs and is transported by three mechanisms:

- ✓ As bicarbonate ions (hco3−) in the plasma (70%)
- ✓ Some is carried in erythrocytes, loosely combined with haemoglobin as *carbamino haemoglobin* (23%)
- ✓ Some is dissolved in the plasma (7%).

- Carbon dioxide levels must be finely managed, as either an excess or a deficiency leads to significant disruption of acid-base balance.
- Sufficient Co_2 is essential for the bicarbonate buffering system that protects against a fall in body pH.
- Excess Co_2 on the other hand reduces blood pH, because it dissolves in body water to form carbonic acid.

Lung volumes and capacities:

- ✓ **Tidal volume (TV).**
  This is the amount of air passing into and out of the lungs during each cycle of breathing (about 500 mL at rest).
- ✓ **Inspiratory reserve volume (IRV).**
  This is the extra volume of air that can be inhaled into the lungs during maximal inspiration, i.e. over and above normal TV.
- ✓ **Inspiratory capacity (IC).**
  This is the amount of air that can be inspired with maximum effort. It consists of the tidal volume (500 ml) plus the inspiratory reserve volume.
- ✓ **Functional residual capacity (FRC).**

  This is the amount of air remaining in the air passages and alveoli at the end of quiet expiration. Tidal air mixes with this air, causing relatively small changes in the composition of alveolar air.
  As blood flows continuously through the pulmonary capillaries, this means that exchange of gases is not interrupted between breaths, preventing moment-to-moment changes in the concentration of blood gases. The functional residual volume also prevents collapse of the alveoli on expiration.
- ✓ **Expiratory reserve volume (ERV).**
  This is the largest volume of air which can be expelled from the lungs during maximal expiration.
- ✓ **Residual volume (RV).**
  This cannot be directly measured but is the volume of air remaining in the lungs after forced expiration.
- ✓ **Vital capacity (VC).**
  This is the maximum volume of air which can be moved into and out of the lungs:
  - ✓ VC = Tidal volume + IRV + ERV

✓ **Total lung capacity (TLC).**

This is the maximum amount of air the lungs can hold. In an adult of average build, it is normally around 6 litres. Total lung capacity represents the sum of the vital capacity and the residual volume.

It cannot be directly measured in clinical tests because even after forced expiration, the residual volume of air still remains in the lungs.

✓ **Alveolar ventilation.**

This is the volume of air that moves into and out of the alveoli per minute. It is equal to the tidal volume minus the anatomical dead space, multiplied by the respiratory rate:

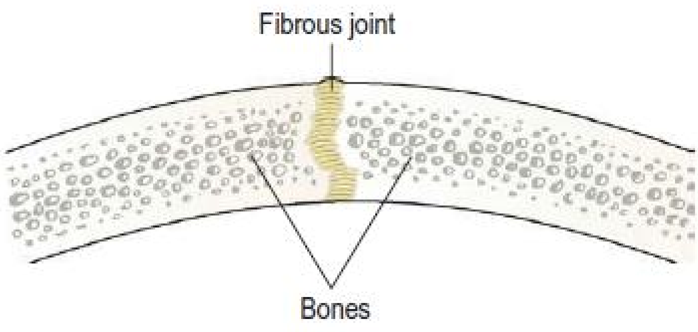
$$\begin{aligned}\text{Alveolar ventilation} &= \text{TV} - \text{anatomical dead space} \times \\ &\quad \text{respiratory rate} \\ &= (500 - 150)\ \text{mL} \times 15\ \text{per minute} \\ &= 5.25\ \text{litres per minute}\end{aligned}$$

Lung function tests are carried out to determine respiratory function and are based on the parameters outlined above. Results of these tests can help in diagnosis and monitoring of respiratory disorders.

7. What are the types of Joints? and their function

A joint is the site at which any two or more bones articulate or come together. Joints allow flexibility and move-ment of the skeleton and allow attachment between bones.

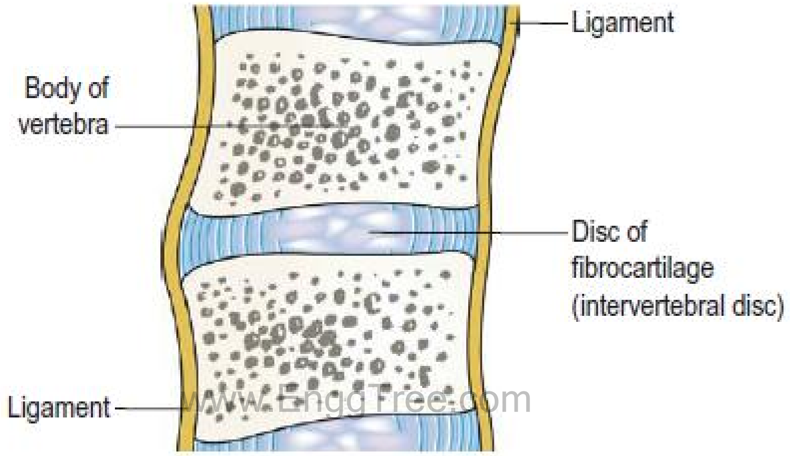
a) Fibrous joints (fixed)



Suture (fibrous joint) of the skull.

- The bones forming these joints are linked with tough, fibrous material. Such an arrangement often permits no movement. For example, the joints between the skull bones, the sutures, are completely immovable, and the healthy tooth is cemented into the mandible by the periodontal ligament.
- The tibia and fibula in the leg are held together along their shafts by a sheet of fibrous tissue called the inter osseous membrane. This fibrous joint allows a limited amount of movement and stabilises the alignment of the bones.

b) Cartilaginous joints (slightly moveable)

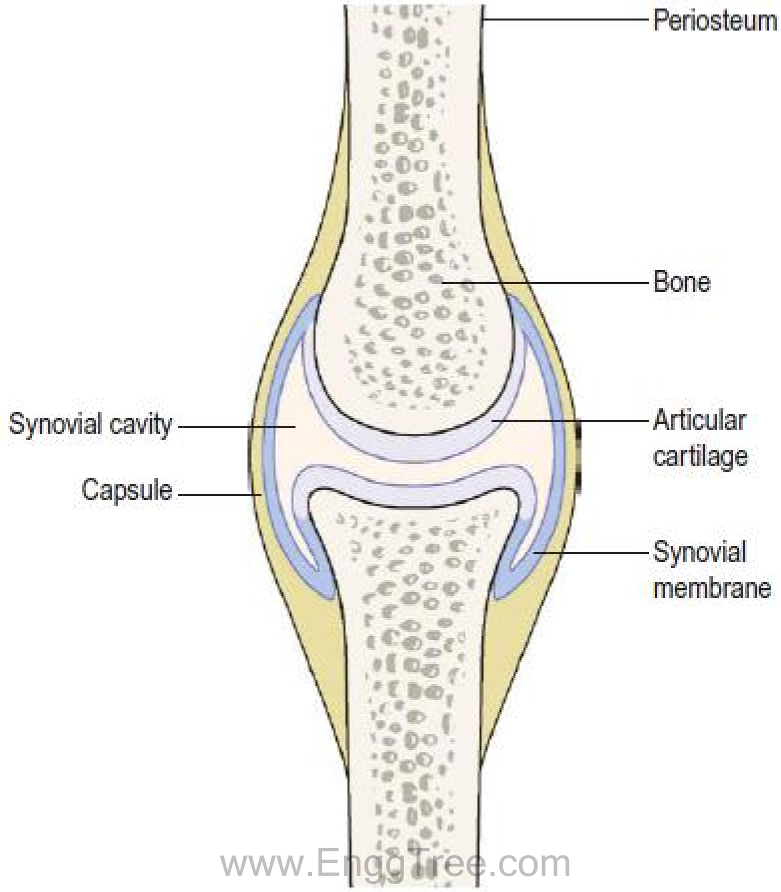


The cartilaginous joint between adjacent vertebral bodies.

- These joints are formed by a pad of tough fibro cartilage that acts as a shock absorber. The joint may be immova-ble, as in the cartilaginous epiphyseal plates, which in thegrowing child links the diaphysis of a long bone to theepiphysis.
- Some cartilaginous joints permit limited movement, as between the vertebrae, which are separated by the intervertebral discs, or at the symphysispubis , which is softened by circulating hormones during pregnancy to allow for expansion during childbirth.

c) Synovial joints (including freely movable)

Synovial joints are characterised by the presence of a space or capsule between the articulating bones. The ends of the bones are held close together by a sleeve of fibrous tissue, and lubricated with a small amount of fluid. Synovial joints are the most moveable of the body.



The basic structure of a synovial joint.

Movements at synovial joints

Movement at any given joint depends on various factors, such as the tightness of the ligaments holding the joint together, how well the bones fit and the presence or absence of intra capsular structures. Generally, the more stable the joint, the less mobile it is.

Types of synovial joint

Synovial joints are classified according to the range of movement possible or to the shape of the articulating parts of the bones involved.

i) Ball and socket joints

The head of one bone is ball-shaped and articulates with a cup-shaped socket of another. The joint allows for a wide range of movement, including flexion, extension, adduction, abduction, rotation and circumduction. Examples include the shoulder and hip.

ii) Hinge joints

The articulating ends of the bones fit together like a hinge on a door, and movement is therefore restricted to flexion and extension. The elbow joint is one example, permitting only flexion and extension of the forearm. Other hinge joints include the knee, ankle and the joints between the phalanges of the fingers and toes (interphalangeal joints).

iii) Gliding joints

The articular surfaces are flat or very slightly curved and glide over one another, but the amount of movement possible is very restricted; this group of joints is the least movable of all the synovial joints. Examples include the joints between the carpal bones in the wrist, the tarsal bones in the foot, and between the processes of the spinal vertebrae (note that the joints between the vertebral bodies are the cartilaginous discs).

iv) Pivot joints

These joints allow a bone or a limb to rotate. One bone fits into a hoop-shaped ligament that holds it close to another bone and allows it to rotate in the ring thus formed. For example, the head rotates on the pivot joint formed by the dens of the axis held within the ring formed by the transverse ligament and the odontoid process of the atlas.

v) Condyloid joints

A condyle is a smooth, rounded projection on a bone and in a condyloid joint it sits within a cup-shaped depression on the other bone. Examples include the joint between the condylar process of the mandible and the temporal bone, and the joints between the metacarpal and phalangeal bones of the hand, and between the metatarsal and phalangeal bones of the foot. These joints permit flexion, extension, abduction, adduction and circumduction.

vi) Saddle joints

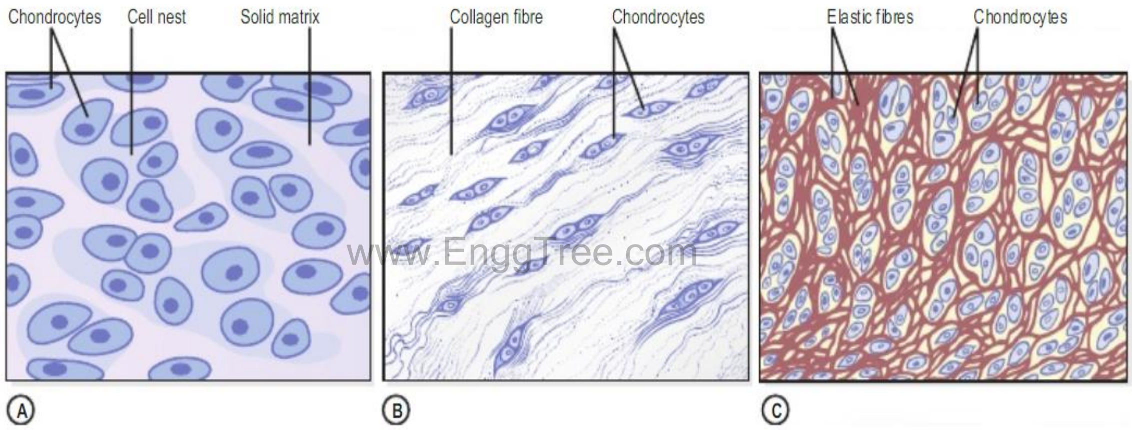
The articulating bones fit together like a man sitting on a saddle. The most important saddle joint is at the base of the thumb, between the trapezium of the wrist and the first metacarpal bone. The range of movement is similar to that at a condyloid joint but with additional flexibility; *opposition* of the thumb, the ability to touch each of the fingertips on the same hand, is due to the nature of the thumb joint.

Functions of Joints

- ✓ Joints connect bones within your body, bear weight and enable you to move.
- ✓ They are made up of bone, muscles, synovial fluid, cartilage and ligaments. Joints aren't all alike, however. Hinge joints are found in your elbows and knees, while ball-and-socket joints are needed for the hips and shoulders.
- ✓ Different joints provide unique points of stability and mobility. Understanding the functions of your joints and how your lifestyle and overall health affect them can help if you develop conditions like arthritis, osteoarthritis or gout.

8. Explain about the cartilage types and its functions.

Cartilage



Cartilage. A. Hyaline cartilage. B. Fibrocartilage. C. Elastic fibrocartilage.

Cartilage is firmer than other connective tissues. The cells (chondrocytes) are sparse and lie embedded in matrix rein-forced by collagen and elastic fibres. There are three types: hyaline cartilage, fibro cartilage and elastic fibr ocartilage.

- ✓ **Hyaline cartilage**

Hyaline cartilage is a smooth bluish-white tissue. Thechondrocytes are arranged in small groups within cellnests and the matrix is solid and smooth. Hyaline carti-lage provides flexibility, support and smooth surfaces formovement at joints. It is found:

- on the ends of long bones that form joints
- forming the costal cartilages, which attach the ribs tothe sternum
- forming part of the larynx, trachea and bronchi.

- ✓ **Fibro cartilage**

This consists of dense masses of white collagen fibres in a matrix similar to that of hyaline cartilage with the cells widely dispersed. It is a tough, slightly flexible, supporting tissue found:

- as pads between the bodies of the vertebrae, the intervertebral discs
- between the articulating surfaces of the bones of theknee joint, called semilunar cartilages
- on the rim of the bony sockets of the hip and shoulder joints, deepening the cavities without restricting movement.

- ✓ **Elastic fibro cartilage**

This flexible tissue consists of yellow elastic fibres lying in a solid matrix with chondrocytes lying between the fibres. It provides support and maintains shape of, e.g. the pinna or lobe of the ear, the epiglottis and part of the tunica media of blood vessel walls.

Functions:

- ✓ The mechanical properties of articular cartilage in load bearing joints such as knee and hip have been studied extensively at macro, micro and nano-scales.

- ✓ These mechanical properties include the response of cartilage in frictional, compressive, shear and tensile loading.
- ✓ Cartilage is resilient and displays viscoelastic properties.
- ✓ Lubricin, a glycoprotein abundant in cartilage and synovial fluid, plays a major role in bio-lubrication and wear protection of cartilage.
- ✓ Cartilage has limited repair capabilities: Because chondrocytes are bound in lacunae, they cannot migrate to damaged areas.
- ✓ Therefore, cartilage damage is difficult to heal. Also, because hyaline cartilage does not have a blood supply, the deposition of new matrix is slow.
- ✓ Damaged hyaline cartilage is usually replaced by fibrocartilage scar tissue. Over the last years, surgeons and scientists have elaborated a series of cartilage repair procedures that help to postpone the need for joint replacement.

9. **Briefly explain the Muscle structure and its movements.**

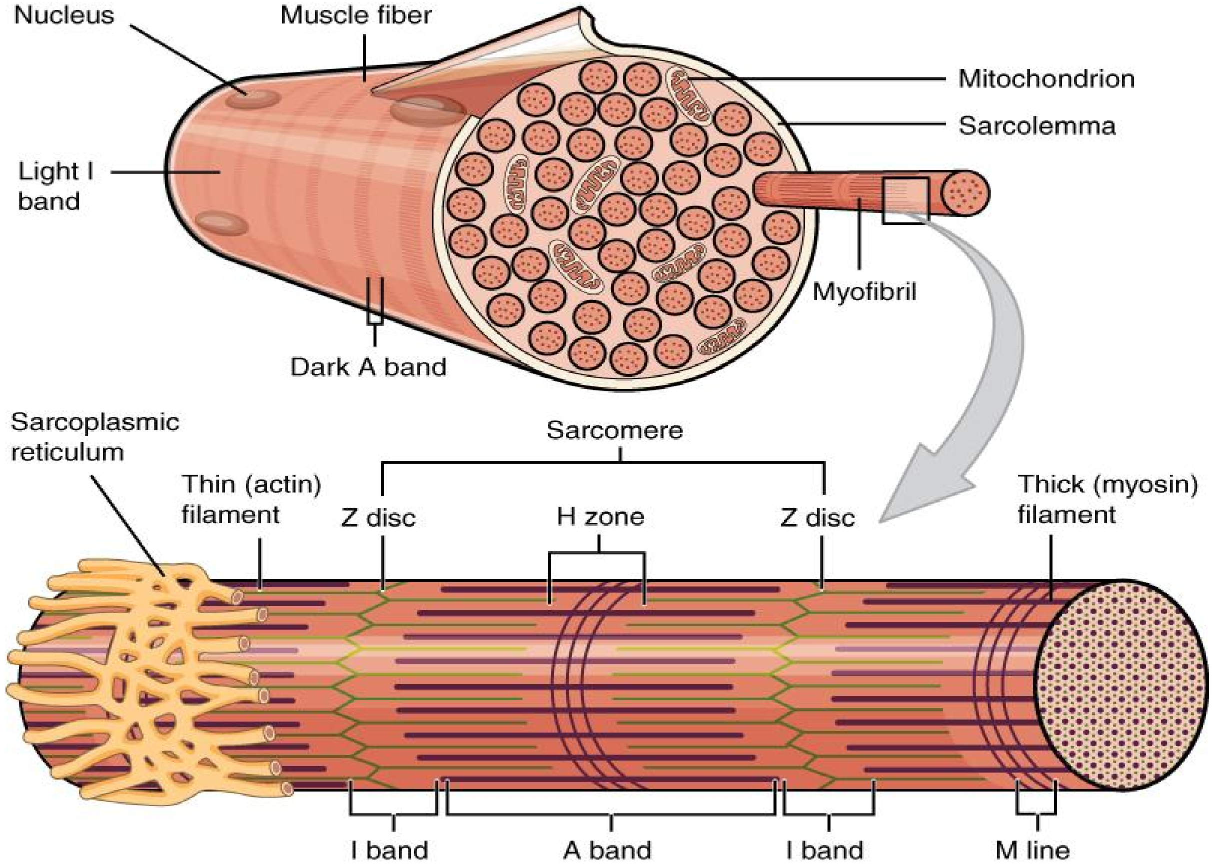
- A skeletal muscle may sometimes contain hundreds of thousands of muscle fibres as well as blood vessels and nerves. Throughout the muscle, providing internal structure and scaffolding, is an extensive network of connective tissue.
- The entire muscle is covered in a connective tissue sheath called the **Epimysium**. Within the muscle, the cells are collected into separate bundles called **Fascicles**, and each fascicle is covered in its own connective tissue sheath called the **Perimysium**.
- Within the fascicles, the individual muscle cells are each wrapped in a fine connective tissue layer called the **Endomysium**. Each of these connective tissue layers runs the length of the muscle.
- They bind the fibres into a highly organised structure, and blend together at each end of the muscle to form the **Tendon**, which secures the muscle to bone. Often the tendon is rope-like, but sometimes it forms a broad sheet called an **Aponeurosis**, e.g. the occipitofrontalis muscle.
- The multiple connective tissue layers throughout the muscle are important for transmitting the force of contraction from each individual muscle cell to its points of attachment to the skeleton. The fleshy part of the muscle is called the **Belly**.

Skeletal muscle cells (fibres)

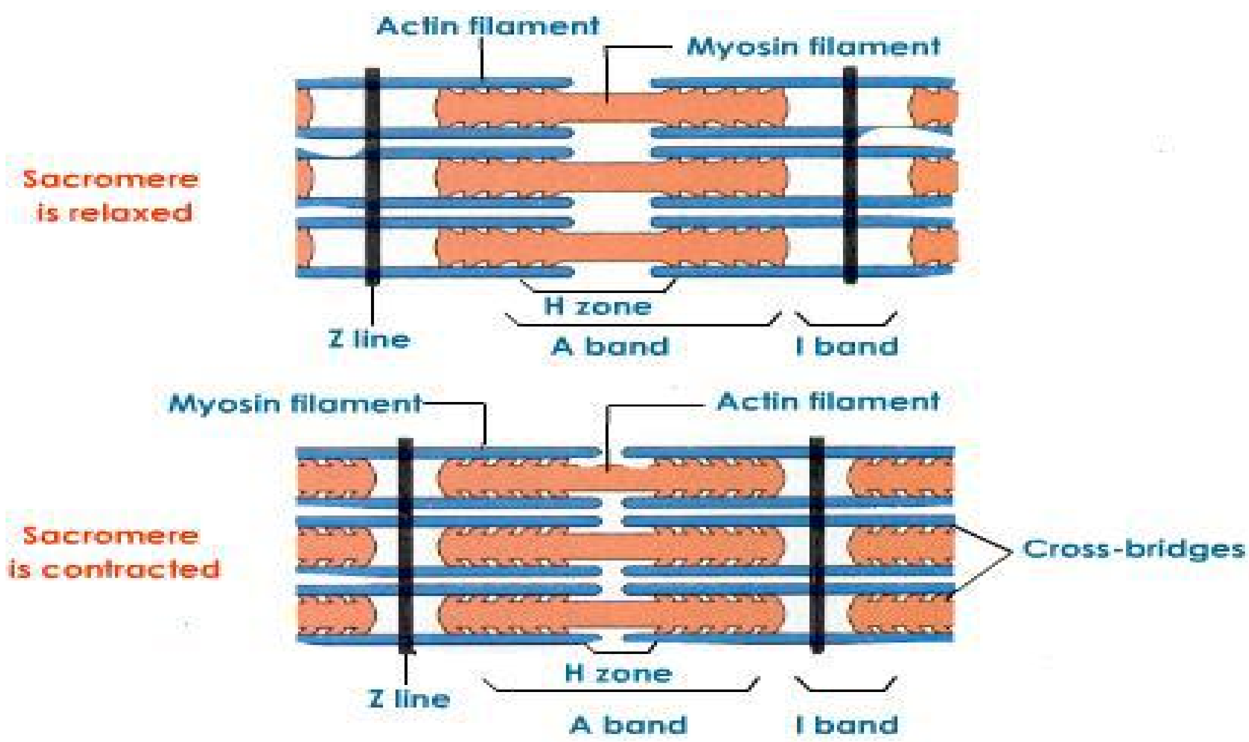
Contraction of a whole skeletal muscle occurs because of coordinated contraction of its individual fibres.

i) Structure

- Under the microscope, skeletal muscle cells are seen to be roughly cylindrical in shape, lying parallel to one another, with a distinctive banded appearance consisting of alternate dark and light stripes.
- Individual fibres may be very long, up to 35 cm in the longest muscles. Each cell has several nuclei (because the cells are so large), found just under the cell membrane **(The Sarcolemma)**.
- The cytoplasm of muscle cells, also called **Sarcoplasm**, is packed with tiny filaments running longitudinally along the length of the muscle; these are the contractile filaments.



Structure of Muscle and muscle fibers



Sacromere relaxation and contraction

- There are also many mitochondria essential for producing Adenosine Triphosphate (ATP) from glucose and oxygen to power the contractile mechanism.
- Also present is a specialized oxygen-binding substance called **Myoglobin**, which is similar to the haemoglobin of red blood cells and stores oxygen within the muscle.
- In addition, there are extensive intracellular stores of calcium, which is released into the sarcoplasm by nervous stimulation of muscle and is essential for the contractile activity of the myofilaments.

Actin, myosin and sarcomeres:

- ✓ There are two types of contractile myo filament within the muscle fibre, called thick and thin, arranged in repeating units called sarcomeres.
- ✓ The thick filaments, which are made of the protein myosin, correspond to the dark bands seen under the microscope.
- ✓ The thin filaments are made of the protein actin. Where only these are present, the bands are lighter in appearance.
- ✓ Each sarcomere is bounded at each end by a dense stripe, the Z line, to which the actin fibres are attached, and lying in the middle of the sarcomere are the myosin filaments, overlapping with the actin.

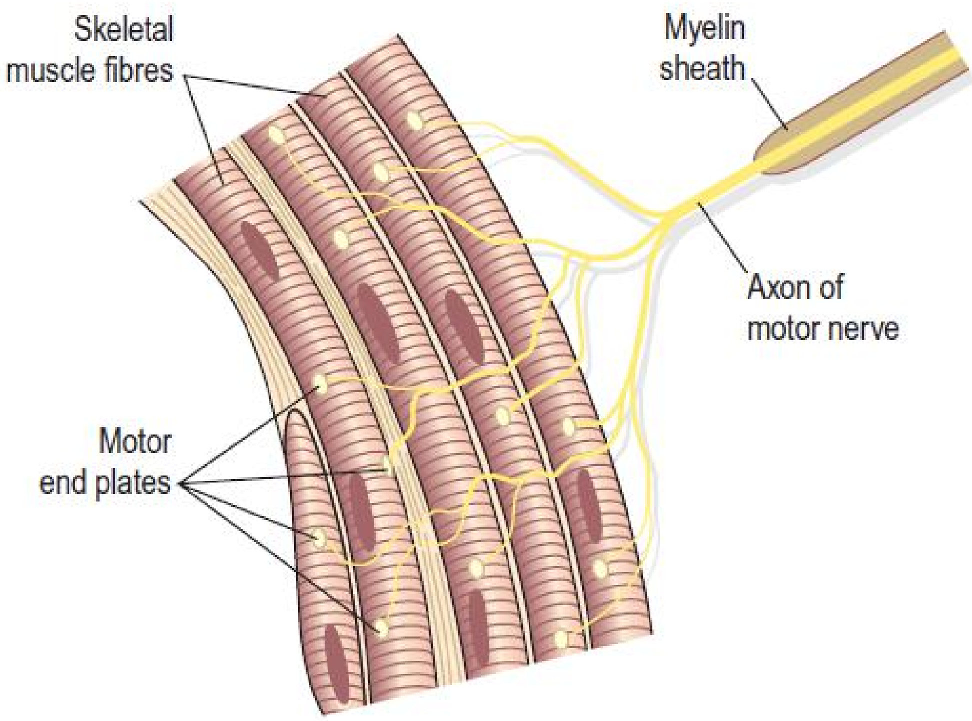
***ii)* Contraction**

- The skeletal muscle cell contracts in response to stimulation from a nerve fibre, which supplies the muscle cell usually about halfway along its length. The name given to a synapse between a motor nerve and a skeletal muscle fibre is the neuromuscular junction.
- When the action potential spreads from the nerve along the sarcolemma, it is conducted deep into the muscle cell through a special network of channels that run through the sarcoplasm, and releases calcium from the intracellular stores.
- Calcium triggers the binding of myosin to the actin filament next to it, forming so-called cross-bridges. ATP then provides the energy for the two filaments to slide over each other, pulling the Z lines at each end of the sarcomere closer to one another, shortening the sarcomere.
- This is called the sliding filament theory. If enough fibres are stimulated to do this at the same time, the whole muscle will shorten (contract).

- The muscle relaxes when nerve stimulation stops. Calcium is pumped back into its intracellular storage areas, which breaks the cross-bridges between the actin and myosin filaments.
- They then slide back into their starting positions, lengthening the sarcomeres and returning the muscle to its original length.

The neuromuscular junction

- The axons of motor neurones, carrying impulses to skeletal muscle to produce contraction, divide into a number of fine filaments terminating in minute pads called synaptick nobs.
- The space between the synaptic knob and the muscle cell is called the synaptic cleft.
- Stimulation of the motor neuron releases the neurotransmitter acetylcholine (ACh), which diffuses across the synaptic cleft and binds to acetylcholine receptors on the postsynaptic membrane on the motor end plate (the area of the muscle membrane directly across the synaptic cleft).
- Acetylcholine causes contraction of the muscle cell.



The neuromuscular junction.

Motor units

- Each muscle fibre is stimulated by only one synaptic knob, but since each motor nerve has many synaptic knobs, it stimulates a number of muscle fibres.
- The figure shows an electron micrograph of a motor nerve and two of its motor end plates.
- One nerve fibre and the muscle fibres it supplies constitute a motor unit. Nerve impulses cause serial contraction of motor units in a muscle, and each unit contracts to its full capacity.
- The strength of the contraction depends on the number of motor units in action at a particular time. Some motor units contain large numbers of muscle fibres, i.e. one nerve serves many muscle cells.
- This arrangement is associated with large-scale, powerful movements, such as in the legs or upper arms. Fine, delicate control of muscle movement is achieved when one motor unit contains very few muscle fibres, as in the muscles controlling eye movement.

UNIT III

CARDIOVASCULAR AND LYMPHATIC SYSTEMS

Cardiovascular:

- ✓ Components of Blood and functions
- ✓ Blood Groups and importance
- ✓ Structure of Heart
- ✓ Conducting System of Heart
- ✓ Properties of Cardiac Muscle
- ✓ Cardiac Cycle
- ✓ Heart Beat
- ✓ Types of Blood vessel

- ✓ Regulation of Heart rate and Blood pressure.

Lymphatic:

- ✓ Parts and Functions of Lymphatic systems
- ✓ Types of Lymphatic organs and vessels.

PART-A

1. Give the Composition of blood. (M/J 2017)

Blood is classified as a connective tissue and consists of two main components:

- ✓ Plasma, which is a clear extracellular fluid
- ✓ Formed elements, which are made up of the blood cells and platelets.

The Formed elements are so named because they are enclosed in a plasma membrane and have a definite structure and shape. All formed elements are cells except for the platelets, which are tiny fragments of bone marrow cells.

Formed elements are:

- ✓ Erythrocytes, also known as red blood cells (**RBCs**).
- ✓ Leukocytes, also known as white blood cells (**WBCs**).
- ✓ Platelets.

2. List the stages in the Genesis of an RBC. (N/D 2016)

- ✓ Erythropoietic stem cell
- ✓ Proerythroblast
- ✓ Early Normoblast
- ✓ Intermediate Normoblast
- ✓ Late Normoblast
- ✓ Reticupocyte
- ✓ Mature RBC.

3. What are the different types of white blood cells? (M/J-2016)

- ➢ Granulocytes
  - Neutrophils.
  - Eosinophils.
  - Basophils.
- ➢ Agranulocytes.
  - Lymphocytes.
  - Monocytes.

4. Write short notes on functions of blood.

➢ **Red Blood Cells** carry oxygen around the body and remove carbon dioxide and other waste products; they give blood its red colour.

- **White Blood Cells** are part of the immune system (the body's natural defence mechanism) and help fight infection.
- **Platelets** help the blood clot (thicken) to stop bleeding.

5. Write short notes on Blood groups.

There are four main blood groups defined by the ABO system:

- 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.

6. What is Hayem's fluid?

- Sodium chloride 0.5 Gm
- Sodium sulphate 2.5 Gm
- Mercuric perchloride 0.25 Gm

7. Write any two role of WBC.

Function: Fights against infection:

1) Phagocytic
2) Produce Antibodies

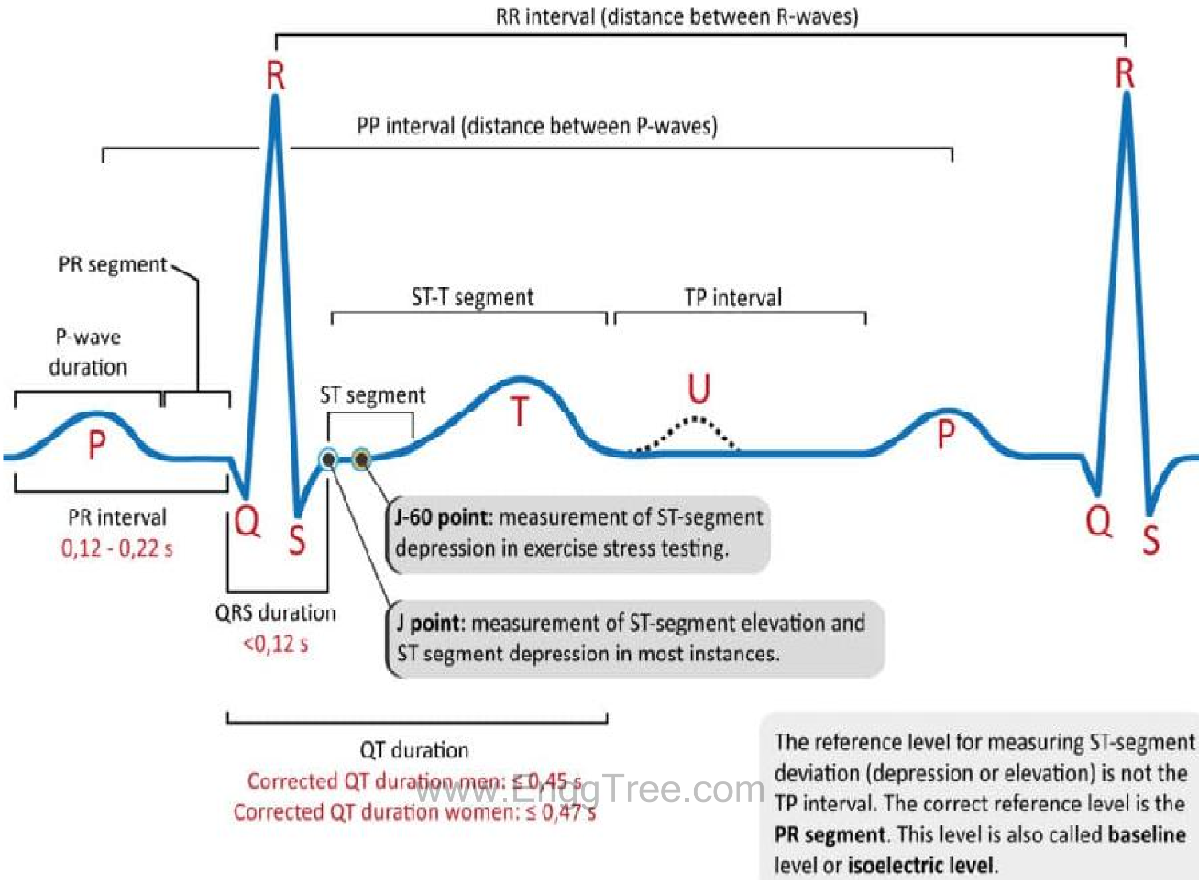
8. What is the significant feature used to identify platelet?

- A normal platelet count is 150,000 to 450,000 platelets per micro-liter of blood.
- Risk for spontaneous bleeding develops if a platelet count falls below 10,000 to 20,000.

10. Write short note on ECG.

- An electrocardiogram is a test that measures the electrical activity of the heartbeat. With each beat, an electrical impulse (or "wave") travels through the heart.
- The right and left atria or upper chambers make the first wave called a "P wave" — following a flat line when the electrical impulse goes to the bottom chambers.
- The right and left bottom chambers or ventricles make the next wave called a "QRS complex." The final wave or "T wave" represents electrical recovery or return to a resting state for the ventricles.

11. Describe a normal ECG curve, What is the time duration for one cardiac cycle. (A/M-2011), (A/M-2017, 2015)



At a normal heart rate of 75 beats per minute, one cardiac cycle lasts **0.8 second.**

Cardiac cycle:

The cardiac cycle refers to the sequence of mechanical and electrical events that repeats with every heartbeat. It includes the phase of relaxation diastole and the phase of contraction systole. "Ventricular diastole," begins when the ventricles starts to relax.

12. What is pericardium?

Pericardium is the membrane enclosing the heart, consisting of an outer fibrous layer and an inner double layer of serous membrane.

13. Why the sino atrial node is called the pacemaker of the heart?

SA node is the natural pacemaker of the heart. It controls the heart rate by generating electrical impulses and then sending electrical signals through the heart muscle, causing the heart to contract and pump blood throughout the body.

14. Compare pulmonary and systematic circulation. (N/D-2014)

Systemic circulation is the movement of blood from the heart through the body to provide oxygen and nutrients, and bringing deoxygenated blood back to the heart.

Oxygen-rich blood from the lungs leaves the pulmonary circulation when it enters the left atrium through the pulmonary veins.

15. Differentiate between systolic and diastolic pressure. (N/D-2015)

- Systolic pressure is peak pressure in the arteries, which occurs near the end of the cardiac cycle when the ventricles are contracting.
- Diastolic pressure is minimum pressure in the arteries, which occurs near the beginning of the cardiac cycle when the ventricles are filled with blood.

16. What is chronotropic action of heart? M/J-2016

Chronotropic drugs may change the heart rate and rhythm by affecting the electrical conduction system of the heart and the nerves that influence it, such as by changing the rhythm produced by the sinoatrial node. Positive chronotropes increase heart rate; negative chronotropes decrease heart rate.

17. Name the components of coronary circulations. (N/D-2016)

Coronary circulation is the circulation of blood in the blood vessels of the heart muscle (myocardium). The vessels that deliver oxygen-rich blood to the myocardium are the coronary arteries.

The vessels that remove the deoxygenated blood from the heart muscle are known as cardiac veins. These include the great cardiac vein, the middle cardiac vein, the small cardiac vein, the smallest cardiac veins, and the anterior cardiac veins.

18. Properties of cardiac muscle

Properties of Cardiac Cells. The **muscle** cells of the **heart** are unique and responsible for the electrical stimulation that leads to proper mechanical function. Myocardial cells have several different electro physiologic **properties**:

- Automaticity - generating periodical electrical oscillations
- Conductivity – transmission of impulses
- Contractility – contraction of heart muscle
- Rhythmicity – inherent property of rhythmic contraction

- Refractory period – during systole the heart does not respond to any other stimuli.

20. Write short note about Erythroblastosis fetails.

The Rh system is responsible for the most severe form of the disease, which can occur when an Rh-negative woman (a woman whose blood cells lack the Rh factor) conceives an Rh-positive fetus.

Sensitization of the mother's immune system (immunization) occurs when fetal red blood cells that carry the Rh factor (an antigen in this context) cross the placental barrier and enter the mother's bloodstream.

They stimulate the production of antibodies, some of which pass across the placenta into fetal circulation and lyse, or break apart, the red blood cells of the fetus (hemolysis).

21. What is lymphatic system?

The lymphatic system is part of the vascular system and an important part of the immune system, comprising a network of lymphatic vessels that carry a clear fluid called lymph directionally towards the heart.

Lymphatic organs: thymus, spleen, tonsils, and appendix

22. What are the functions of lymphatic system?

The lymphatic system has multiple interrelated functions: It is responsible for the removal of interstitial fluid from tissues. It absorbs and transports fatty acids and **fats** as chyle from the digestive system. It transports **white blood cells** to and from the lymph nodes into the bones.

23. Define – blood pressure.

Blood pressure (BP) is the pressure of circulating blood on the walls of blood vessels. Blood pressure is usually expressed in terms of the systolic pressure (maximum during one heart beat) over diastolic pressure (minimum in between two heart beats) and is measured in millimeters of mercury (mmHg), above the surrounding atmospheric pressure.

Normal range of BP : 120 millimetres of mercury (16 kPa) systolic, and 80 millimetres of mercury (11 kPa) diastolic, abbreviated "120/80 mmHg".

24. How does the brain regulate your heart rate?

Medulla – The primary role of the medulla is **regulating** our involuntary life sustaining functions such as breathing, swallowing and **heart rate**. As part of the **brain** stem, it also helps transfer neural messages to and from the **brain** and spinal cord. It is located at the junction of the spinal cord and **brain**

25. Define – Heart rate.

The number of heart beats per unit of time, usually per minute. The heart rate is based on the number of contractions of the ventricles (the lower chambers of the heart). The heart rate may be too fast (tachycardia) or too slow (bradycardia).

The pulse is a bulge of an artery from waves of blood that course through the blood vessels each time the heart beats. The pulse is often taken at the wrist to estimate the heart rate.

PART B

1. Give an account of the composition and functions of blood cell.

Formation of Blood Cells:

Blood cells are synthesised mainly in red bone marrow. Some lymphocytes, additionally, are produced in lymphoid tissue. In the bone marrow, all blood cells originate from *pluripotent* (i.e. capable of developing into one of a number of cell types) *stem cells* and go through several developmental stages before entering the blood.

Different types of blood cell follow separate lines of development. The process of blood cell formation is called **Haemopoiesis**. For the first few years of life, red marrow occupies the entire bone capacity and, over the next 20 years, is gradually replaced by fatty yellow marrow that has no haemopoietic function.

In adults, haemopoiesis in the skeleton is confined to flat bones, irregular bones and the ends (*epiphyses*) of long bones, the main sites being the sternum, ribs, pelvis and skull.

Composition, functions of blood cells:

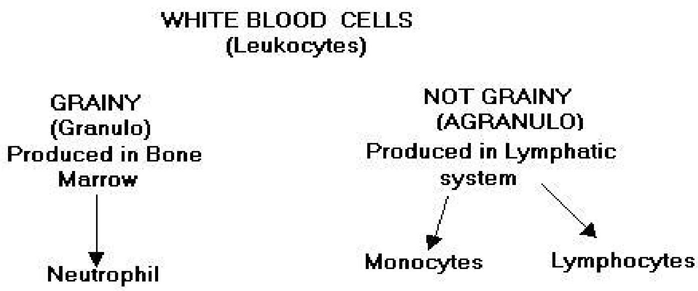
There are three types of blood cell.

- Erythrocytes (red cells)
- Platelets (thrombocytes)
- Leukocytes (white cells).

i) Red Blood Cells—Erythrocytes

- Live about 120 days, have no nucleus.
- Produced in Red Bone Marrow (In Skull, ribs, vertebrae, and long bones)
- "Myeloid" stem cells form RBCs. These stem cells are called Erythroblasts. Erythroblasts will differentiate into Erythrocytes.
- Produces about 5 million every second.
- RBC contains a protein called **HEMOGLOBIN.**
- Haemoglobin contains iron (gives blood its red color).
- Picks up oxygen in the lungs (cooler blood)
- It combines with oxygen in lungs and releases it in the warmer tissues.
- Approximately 200,000,000 Hemoglobin molecules in one RBC.
- RBCs are destroyed in the spleen; some parts of Hemoglobin are released so that iron can be recycled and the Hemoglobin is converted into a bile pigment and excreted by the liver.

ii) White Blood Cells – Leukocytes



- Larger than RBCs.
- They have a nucleus.
- Less numerous than RBCs (700:1).
- Do not have a definite shape (amoeboid shape).
- Function: (Fights against infection).

1) Phagocytic.

2) Produce Antibodies.

Types of White Blood Cells

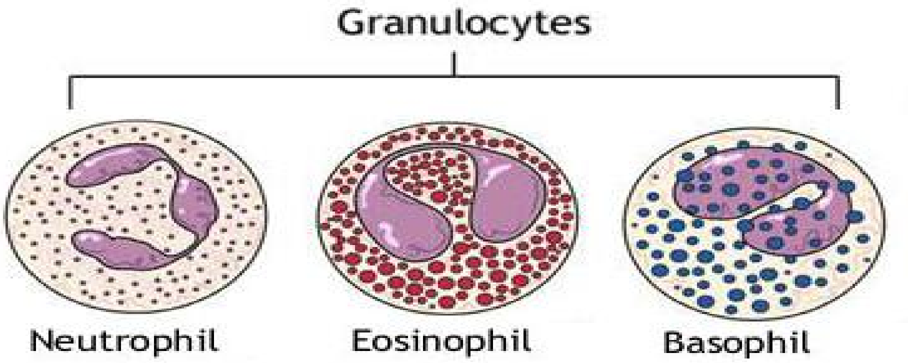
a) Granulocytes

b) Agranulocytes

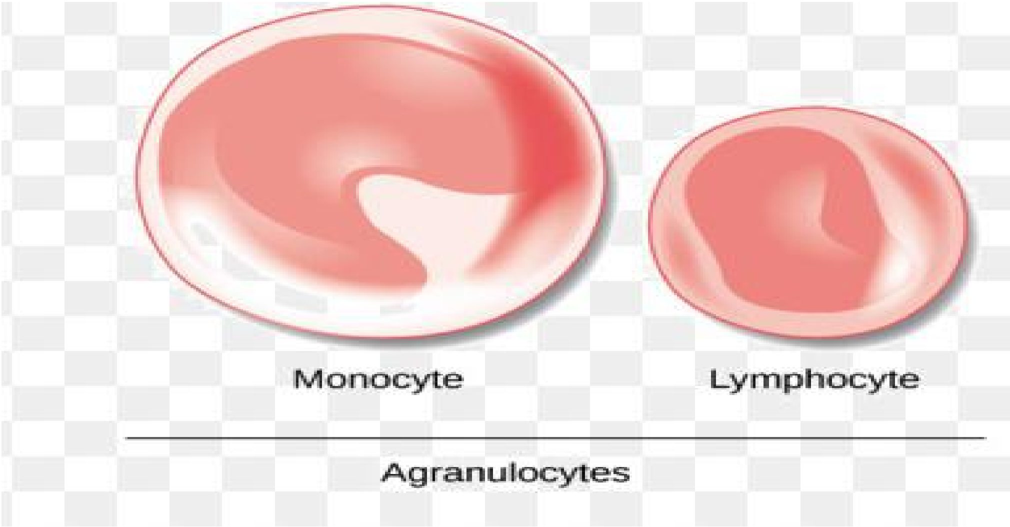
a) Granulocytes

- Have grains or granules in their cytoplasm.
- Formed in Bone Marrow.
- 60 – 70 % of Leukocytes (WBC) are Granulocytes.

Example: NEUTROPHIL – Phagocytize and digest bacteria.



b) Agranulocytes



- No granules in cytoplasm.
- Produced by lymphoid tissue after originating in RB Marrow.
- 25-30 % of Leukocytes (WBC).

Example: Monocytes and Lymphocytes.

Lymphocytes:

1) B-Lymphocytes - Produced in the bone and lymphoid tissue. Produce antibodies to fight infection.

2) T-Lymphocytes - Produced in the Thymus - Deactivate virus-containing cells.

Monocytes:

1) Largest WBC.

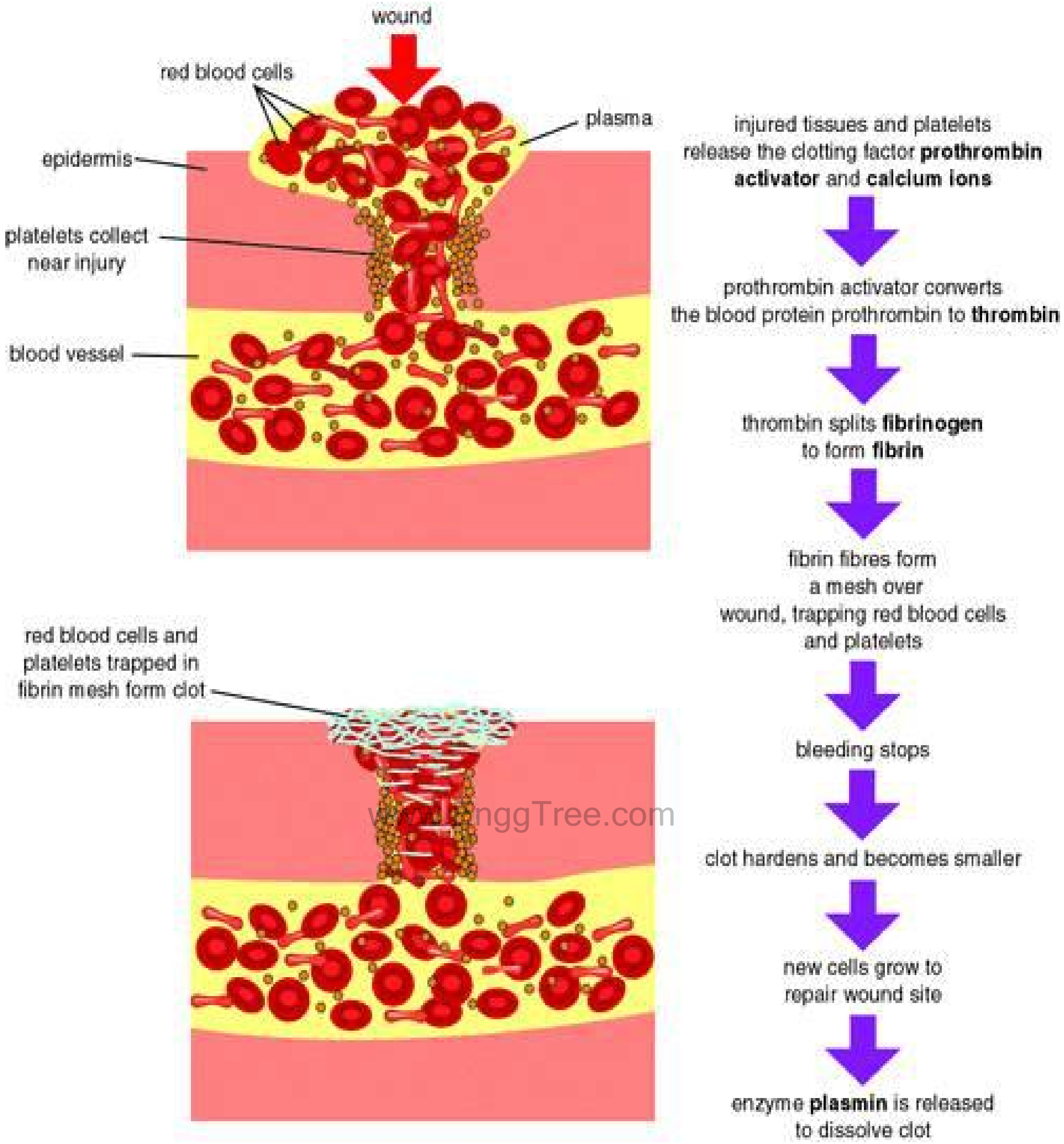
2) Take up residence in tissues.

3) Differentiate into larger macrophages which phagocytize microbes and stimulate other WBC.

iii) Platelets (Thrombocytes)

- Produce 2 billion a day.
- Broken fragments of larger cells
- Very important role in blood clotting.

<u>Blood Clotting-</u>



Blood clotting process

Need three things in blood for blood to clot

1) Prothrombin – Plasma protein.
2) Fibrinogen – Plasma protein.
3) Platelets.

- Platelets clump at the site of the “leak” and partially close it. The platelets and the injured tissue together release an enzyme called Thrombo plastin (prothrombin activator)
- Thrombo plastin converts a blood protein (prothrombin) (produced by the liver) to a new substance called Thrombin. Calcium is needed for this process.

- Prothrombin (activator protein) is made up of Vitamin K. If Vitamin K is missing from diet, then it can cause haemorrhaging (bleeding) disorders to occur.
- Thrombin acts as an enzyme that breaks the ends off another blood protein called Fibrinogen (also produced by the liver).
- Fibrinogen is then converted into FIBRIN.
- Fibrin has sticky ends and forms a lattice or network over the leak. Blood cells get trapped and form a clot.
- Fibrin clot is only temporarily present. As soon as the blood vessel repair is initiated, an enzyme called Plasmin destroys the fibrin network.

iv) Plasma

The constituents of plasma are water (90–92%) and dissolved and suspended substances, including:

- Plasma proteins.
- Inorganic salts.
- Nutrients, principally from digested foods.
- Waste materials.
- Hormones.
- Gases.

a) Plasma proteins

- ✓ Plasma proteins, which make up about 7% of plasma, are normally retained within the blood, because they are too big to escape through the capillary pores into the tissues.
- ✓ They are largely responsible for creating the osmotic pressure of blood , which keeps plasma fluid within the circulation. If plasma protein levels fall, because of either reduced production or loss from the blood vessels, osmotic pressure is also reduced, and fluid moves into the tissues (oedema) and body cavities.
- ✓ Plasma viscosity (thickness) is due to plasma proteins, mainly albumin and fibrinogen. Plasma proteins, with the exception of immunoglobulins, are formed in the liver.

Albumins.

These are the most abundant plasma proteins (about 60% of total) and their main function is to maintain normal plasma osmotic pressure. Albumins also act as carrier molecules for free fatty acids, some drugs and steroid hormones.

- **Globulins.**

Their main functions are:

- ✓ As *antibodies* (immunoglobulins), which are complex proteins produced by lymphocytes that play an important part in immunity. They bind to, and neutralise, foreign materials (antigens) such as microorganisms.
- ✓ Transportation of some hormones and mineral salts, e.g. thyroglobulin, carries the hormone thyroxine and transferrin carries the mineral iron • inhibition of some proteolytic enzymes, e.g. α2 macroglobulin inhibits trypsin activity.

- **Clotting factors.**

These are responsible for coagulation of blood. *Serum* is plasma from which clotting factors have been removed. The most abundant clotting factor is *fibrinogen.*

b) Electrolytes

These have a range of functions, including muscle contraction (e.g. Ca^{2+}), transmission of nerve impulses (e.g. Ca^{2+} and Na^+), and maintenance of acid–base balance (e.g. phosphate, PO_4^{3-}). The pH of blood is maintained between 7.35 and 7.45 (slightly alkaline) by an ongoing buffering system.

c) Nutrients

The products of digestion, e.g. glucose, amino acids, fatty acids and glycerol, are absorbed from the alimentary tract. Together with mineral salts and vitamins they are used by body cells for energy, heat, repair and replacement, and for the synthesis of other blood components and body secretions.

d) Waste products

Urea, creatinine and uric acid are the waste products of protein metabolism. They are formed in the liver and carried in blood to the kidneys for excretion. Carbon dioxide from tissue metabolism is transported to the lungs for excretion.

These are chemical messengers synthesised by endocrine glands. Hormones pass directly from the endocrine cells into the blood, which transports them to their target tissues and organs elsewhere in the body, where they influence cellular activity.

e) Gases

Oxygen, carbon dioxide and nitrogen are transported round the body dissolved in plasma. Oxygen and carbon dioxide are also transported in combination with haemoglobin in red blood cells. Most oxygen is carried in combination with haemoglobin and most carbon dioxide as bicarbonate ions dissolved in plasma. Atmospheric nitrogen enters the body in the same way as other gases and is present in plasma but it has no physiological function.

2. Briefly explain about the Blood groups and its importance. (Antigens and antibodies)

Blood group is identified by antigens and antibodies in the blood. Antibodies are part of body's natural defences against invading substances such as germs.

Antigens are protein molecules found on the surface of red blood cells. Antibodies are proteins found in plasma. Antibodies recognise anything foreign in body and alert immune system to destroy it.

The ABO system

There are four main blood groups defined by the ABO system:

- ✓ **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.

Receiving blood from the wrong ABO group can be life threatening. For example, the anti-A antibodies in a recipient with group B blood will attack the group A cells if transfused to them. This is why group A blood must never be given to a group B person.

As group O red blood cells don't have any A or B antigens, it can safely be given to any other group.

The Rh system:

Red blood cells sometimes have another antigen, a protein known as the RhD antigen. If this is present, your blood group is RhD positive. If it's absent, your blood group is RhD negative. This means you can be one of eight blood groups:

- ➢ A RhD positive (A^{+ve})
- ➢ A RhD negative (A^{-ve})
- ➢ B RhD positive (B^{+ve})

- B RhD negative (B^{-ve})
- RhD positive (O^{+ve})
- RhD negative (O^{-ve})
- AB RhD positive (AB^{+ve})
- AB RhD negative (AB^{-ve})

In most cases, O RhD negative blood (O^{-}) can safely be given to anyone. It's often used in medical emergencies when the blood type isn't immediately known. It's safe for most users because it doesn't have any A, B or RhD antigens on the surface of the cells, and is compatible with every other ABO and RhD blood group.

Blood group testing:

A blood sample is needed and will be drawn from a vein.

The test to determine your blood group is called ABO typing. Your blood sample is mixed with antibodies against type A and B blood, and the sample is checked to see whether or not the blood cells stick together (agglutinate). If blood cells stick together, it means the blood reacted with one of the antibodies.

The second step is called back typing. The liquid part of your blood without cells (serum) is mixed with blood that is known to be type A and type B. Persons with type A blood have anti-B antibodies, and those with type B blood have anti-A antibodies. Type O blood contains both types of antibodies. These two steps can accurately determine your blood type.

Blood typing is also done to tell whether or not you have a substance called Rh factor on the surface of your red blood cells. If you have this substance, you are considered Rh+ (positive). Those without it are considered Rh- (negative). Rh typing uses a method similar to ABO typing.

- If you have type A blood, you can only receive types A and O blood.
- If you have type B blood, you can only receive types B and O blood.
- If you have type AB blood, you can receive types A, B, AB, and O blood.
- If you have type O blood, you can only receive type O blood.

Type O blood can be given to anyone with any blood type. That is why people with type O blood are called universal blood donors.

Blood typing is especially important during pregnancy. If the mother is found to be Rh-, the father should also be tested. If the father has Rh+ blood, the mother needs to receive a treatment to help prevent the development of substances that may harm the unborn baby.

If you are Rh+, you can receive Rh+ or Rh- blood. If you are Rh-, you can only receive Rh- blood.

Normal Results:

ABO typing:

If your blood cells stick together when mixed with:

- Anti-A serum, you have type A blood.
- Anti-B serum, you have type B blood.
- Both anti-A and anti-B serums, you have type AB blood.
- If your blood cells do not stick together when anti-A and anti-B are added, you have type O blood.

Back typing:

- ✓ If the blood clumps together only when B cells are added to your sample, you have type A blood.
- ✓ If the blood clumps together only when A cells are added to your sample, you have type B blood.

- ✓ If the blood clumps together when either types of cells are added to your sample, you have type O blood.
- ✓ Lack of blood cells sticking together when your sample is mixed with both types of blood indicates you have type AB blood.

RH typing:

- ✓ If your blood cells stick together when mixed with anti-Rh serum, you have type Rh-positive blood.
- ✓ If your blood does not clot when mixed with anti-Rh serum, you have type Rh-negative blood.

The importance of grouping

The grouping is very important when it comes to having a blood transfusion. If blood is given to a patient that has a blood type that is incompatible with the blood type of the blood that the patient receives, it can cause intravenous clumping in the patient's blood which can be fatal.

The patient's body can start producing antibodies that attack the antigens on the blood cells in the blood that was given to the patient. For example, a patient who is blood group B has naturally occurring Anti-A antibodies in the blood.

If this (blood group B) patient receives blood group A blood, the Anti-A antibodies in the blood of the patient will cause the blood group A blood cells to clump intravenously which is life threatening.

Similarly, a patient who is blood group A has naturally occurring Anti-B antibodies in the blood. If this (blood group A) patient receives blood group B blood, the Anti-B antibodies in the blood of the patient will cause the blood group B blood cells to clump intravenously which is life threatening.

Blood group O can be given safely to any other blood group is there are no naturally occurring antibodies in the blood of someone who is blood group O. Considering that a person can be either blood group A, B, AB or O and is either blood group RhD positive (also denoted as +) or RhD negative (also denoted as -), this means that a person can be one of eight blood groups: A^+ (A RhD positive), A^- (A RhD negative), B^+, B^-, AB^+, AB^-, O^+, O^-.

The rarest blood groups amongst the population that donate blood in the UK are AB-, whereas the most common are O+. People who are blood group RhD positive, can be given either RhD positive or RhD negative blood, but people with RhD negative blood can only receive RhD negative blood.

Pregnant women and blood grouping

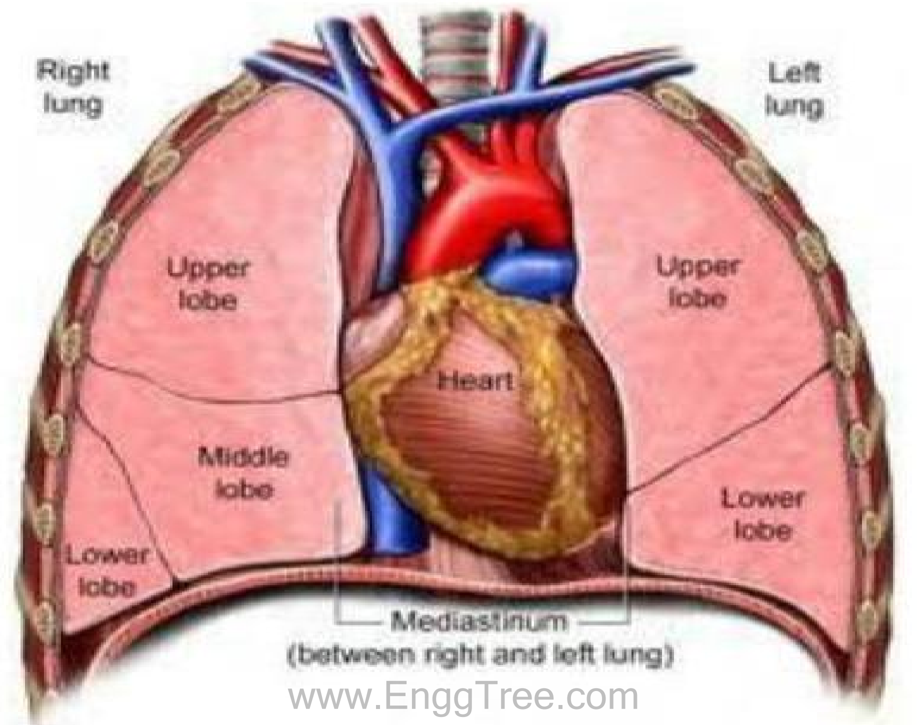
Blood typing is particularly important for pregnant women, where the father of the baby has the RhD positive blood group and the mother of the baby has the RhD negative blood group.

If the baby has the RhD positive blood group, it may cause medical complications. In this case a special drug is administered to the mother to stop the mother's body producing antibodies against the baby's blood cells.

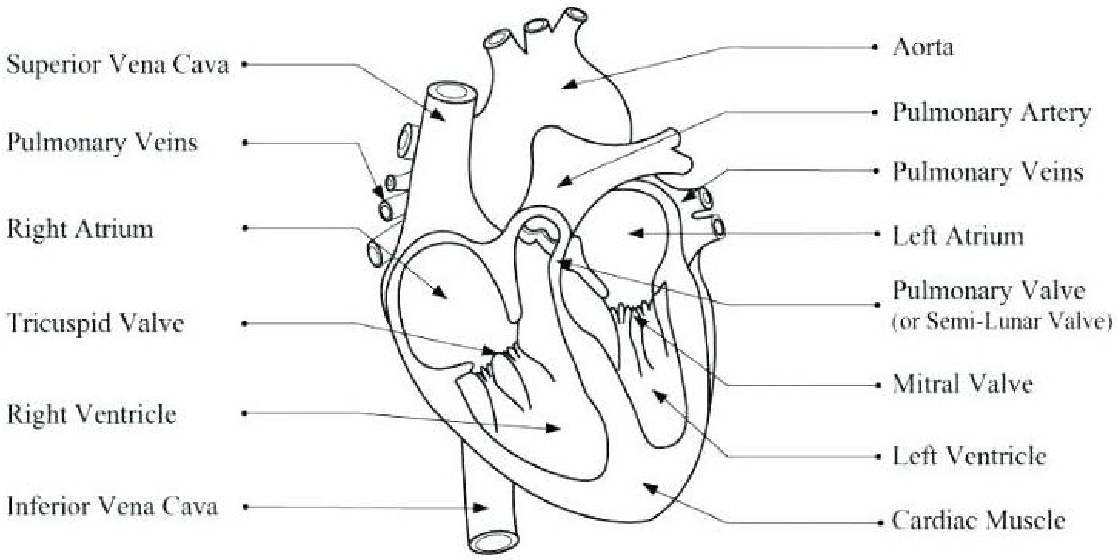
3. Describe the anatomy of human heart with neat sketch. Explain about operation of heart valves. (A/M-2017, N/D-2014).

- The heart is a roughly cone-shaped hollow muscular organ. It is about 10 cm long and is about the size of the owner's fist.
- It weighs about 225 g in women and is heavier in men (about 310 g).

Position of the heart in the thorax.



Internal View of Human Heart



- The heart lies in the thoracic cavity in the mediastinum (the space between the lungs). It lies obliquely, a little more to the left than the right, and presents a base above, and an *apex* below.
- The apex is about 9 cm to the left of the midline at the level of the 5th inter costal space, i.e. a little below the nipple and slightly nearer the midline.
- The base extends to the level of the 2nd rib.

Superior Vena Cava

- The superior vena cava is one of the two main veins bringing de-oxygenated blood from the body to the heart.
- Veins from the head and upper body feed into the superior vena cava, which empties into the right atrium of the heart.

Inferior Vena Cava

- The inferior vena cava is one of the two main veins bringing de-oxygenated blood from the body to the heart.
- Veins from the legs and lower torso feed into the inferior vena cava, which empties into the right atrium of the heart.

Right Atrium

- The right atrium receives de-oxygenated blood from the body through the superior vena cava (head and upper body) and inferior vena cava (legs and lower torso).
- The sino atrial node sends an impulse that causes the cardiac muscle tissue of the atrium to contract in a coordinated, wave-like manner.
- The tricuspid valve, which separates the right atrium from the right ventricle, opens to allow the de-oxygenated blood collected in the right atrium to flow into the right ventricle.

Right Ventricle

- The right ventricle receives de-oxygenated blood as the right atrium contracts.
- The pulmonary valve leading into the pulmonary artery is closed, allowing the ventricle to fill with blood.
- Once the ventricles are full, they contract. As the right ventricle contracts, the tricuspid valve closes and the pulmonary valve opens.

- The closure of the tricuspid valve prevents blood from backing into the right atrium and the opening of the pulmonary valve allows the blood to flow into the pulmonary artery toward the lungs.

Left Atrium

- The left atrium receives oxygenated blood from the lungs through the pulmonary vein.
- As the contraction triggered by the sino atrial node progresses through the atria, the blood passes through the mitral valve into the left ventricle.

Left Ventricle

- The left ventricle receives oxygenated blood as the left atrium contracts.
- The blood passes through the mitral valve into the right ventricle.
- The aortic valve leading into the aorta is closed, allowing the ventricle to fill with blood.
- Once the ventricles are full, they contract.
- As the left ventricle contracts, the mitral valve closes and the aortic valve opens.
- The closure of the mitral valve prevents blood from backing into the left atrium and the opening of the aortic valve allows the blood to flow into the aorta and flow throughout the body.

Tricuspid Valve

- The tricuspid valve separates the right atrium from the right ventricle.
- It opens to allow the de-oxygenated blood collected in the right atrium to flow into the right ventricle.
- It closes as the right ventricle contracts, preventing blood from returning to the right atrium; thereby, forcing it to exit through the pulmonary valve into the pulmonary artery.

Mitral Value

- The mitral valve separates the left atrium from the left ventricle.
- It opens to allow the oxygenated blood collected in the left atrium to flow into the left ventricle.
- It closes as the left ventricle contracts, preventing blood from returning to the left atrium; thereby, forcing it to exit through the aortic valve into the aorta.

Pulmonary Artery

- The pulmonary artery is the vessel transporting de-oxygenated blood from the right ventricle to the lungs. A common misconception is that all arteries carry oxygen-rich blood. It is more appropriate to classify arteries as vessels carrying blood away from the heart.
- **The pulmonary valve** separates the right ventricle from the pulmonary artery.
- It controls the backflow of de-oxygenated blood from the pulmonary artery to the right ventricle.

Pulmonary Vein

- The pulmonary vein is the vessel transporting oxygen-rich blood from the lungs to the left atrium. A common misconception is that all veins carry de-oxygenated blood.
- It is more appropriate to classify veins as vessels carrying blood to the heart.

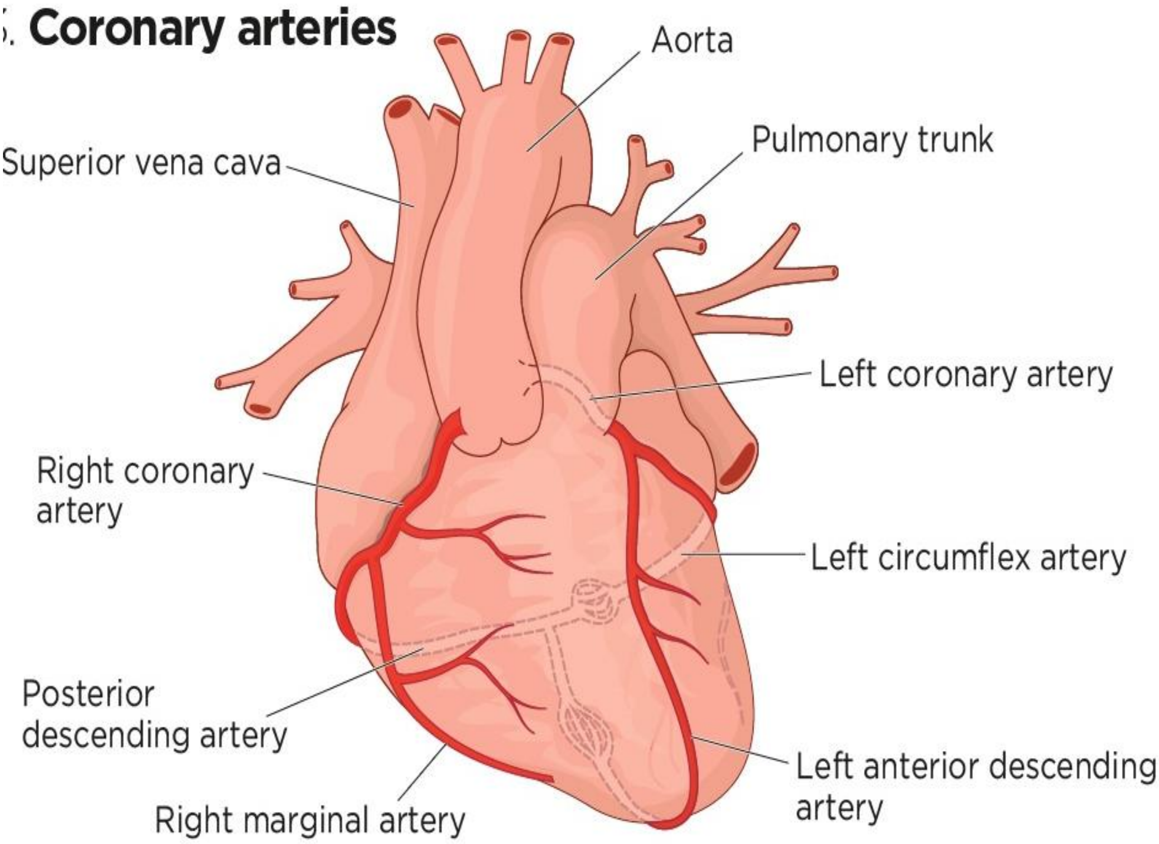
Aorta

- The aorta is the largest single blood vessel in the body. It is approximately the diameter of your thumb. This vessel carries oxygen-rich blood from the left ventricle to the various parts of the body.
- The **Aortic valve** separates the left ventricle from the aorta.
- It closes as the ventricles relax, preventing blood from returning to the heart.

Coronary blood vessels

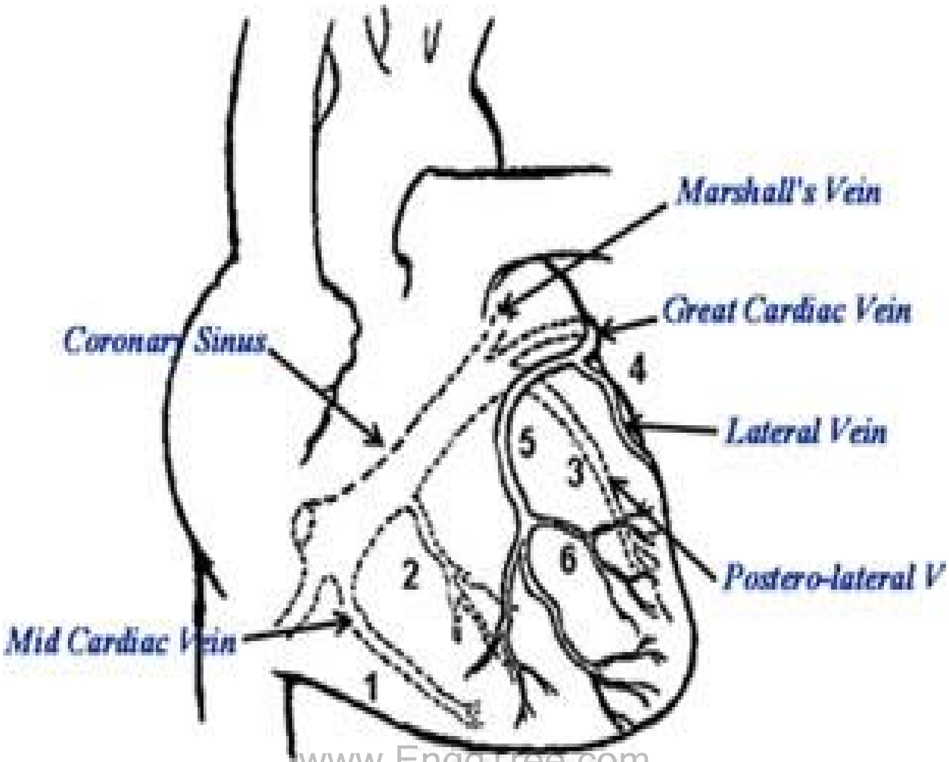
i) Coronary Arteries

- Heart is composed primarily of cardiac muscle tissue that continuously contract and relaxes: it must have a constant supply of oxygen and nutrients.
- The coronary arteries are the network of blood vessels that carry oxygen and nutrient-rich blood to the cardiac muscle tissue.
- The blood leaving the left ventricle exits through the aorta, the body’s main artery.
- Two coronary arteries, referred to as the “left” and “right” coronary arteries, emerge from the beginning of the aorta, near the top of the heart.
- The initial segment of the left coronary artery is called the left main coronary.



- It branches into two slightly smaller arteries: the left anterior descending coronary artery and the left circumflex coronary artery.
- Left anterior descending coronary artery is embedded in the surface of the front side of the heart.
- Left circumflex coronary artery circles around the left side of the heart and is embedded in the surface of the back of the heart.
- The coronary arteries branch into progressively smaller vessels.
- The larger vessels travel along the surface of the heart and the smaller branches-capillaries, penetrate the heart muscle.
- In the capillaries, the red blood cells provide oxygen and nutrients to the cardiac muscle tissue and bond with carbon dioxide and other metabolic waste products, taking them away from the heart for disposal through the lungs, kidneys and liver.

ii) coronary sinus



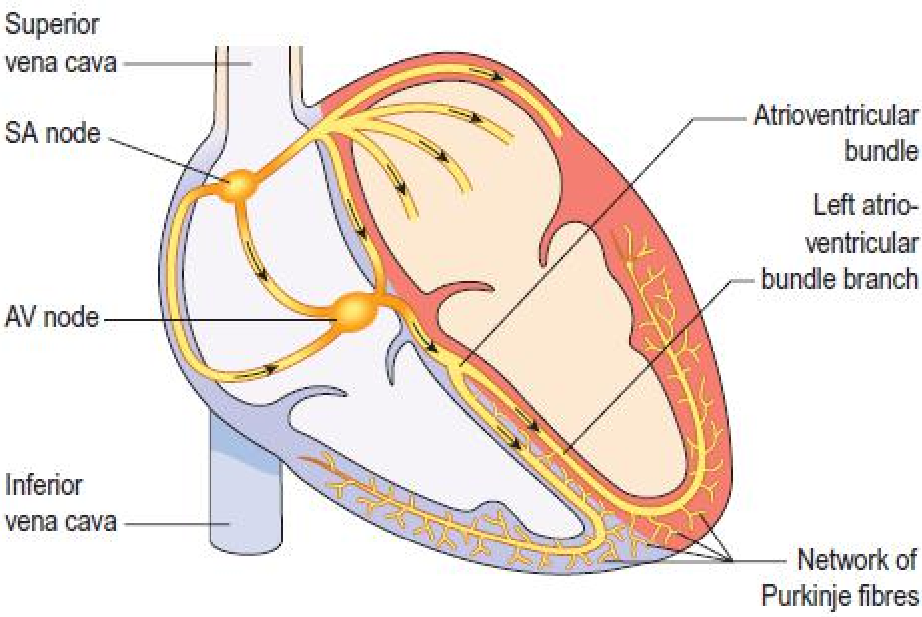
The **coronary** sinus is a collection of **veins** joined together to form a large vessel that collects blood from the heart muscle (myocardium). It delivers less-oxygenated blood to the right atrium, as do the superior and inferior vena cava.

4. Explain in detail about the Conducting system of heart. (or) Define cardiac cycle. Describe various events of cardiac cycle. Explain the events of the cardiac cycle with suitable illustration? (N/D-2010) (M/J-2016)

- The heart possesses the property of **autorhythmicity**, which means it generates its own electrical impulses and beats independently of **nervous or hormonal control**, i.e. it is not reliant on external mechanisms to initiate each heartbeat.
- However, it is supplied with both sympathetic and parasympathetic nerve fibres, which increase and decrease respectively the intrinsic heart rate.
- In addition, the heart responds to a number of circulating hormones, including adrenaline (epinephrine) and thyroxine.

- Small groups of specialised neuromuscular cells in the myocardium initiate and conduct impulses, causing coordinated and synchronised contraction of the heart muscle.

Sinoatrial node (SA node) or Natural Pacemaker



The conducting system of the heart.

This small mass of specialised cells lies in the wall of the right atrium near the opening of the superior vena cava. The sinoatrial cells generate these regular impulses because they are electrically unstable.

This instability leads them to discharge **(depolarise)** regularly, usually between 60 and 80 times a minute. This depolarisation is followed by recovery **(repolarisation)**, but almost immediately their instability leads them to discharge again, setting the heart rate.

Because the SA node discharges faster than any other part of the heart, it normally sets the heart rate and is called the **pacemaker** of the heart. Firing of the SA node triggers **Atrial contraction**.

Atrioventricular node (AV node)

This small mass of neuromuscular tissue is situated in the wall of the atrial septum near the atrioventricular valves. Normally, the AV node merely transmits the electrical signals from the atria into the ventricles.

There is a delay here; the electrical signal takes 0.1 of a second to pass through into the ventricles. This allows the atria to finish contracting before the ventricles start.

The AV node is used for the transmission of impulses from the atria. The **AV node** serves as an electrical relay station, slowing the electrical current sent by the sinoatrial (SA) **node.** i.e (40–60 beats per minute).

Atrioventricular bundle (AV bundle or bundle of His)

This mass of specialised fibres originates from the AV node. The AV bundle crosses the fibrous ring that separates atria and ventricles then, at the upper end of the ventricular septum, it divides into *right* and *left bundle branches*.

Within the ventricular myocardium the branches break up into fine fibres, called the **Purkinje fibres**. The AV bundle, bundle branches and Purkinje fibres transmit electrical impulses from the AV node to the apex of the myocardium where the wave of ventricular contraction begins, then sweeps upwards and outwards, pumping blood into the pulmonary artery and the aorta.

Nerve supply to the heart

The heart is influenced by autonomic (sympathetic and parasympathetic) nerves originating in the *cardiovascular centre* in the **medulla oblongata**.

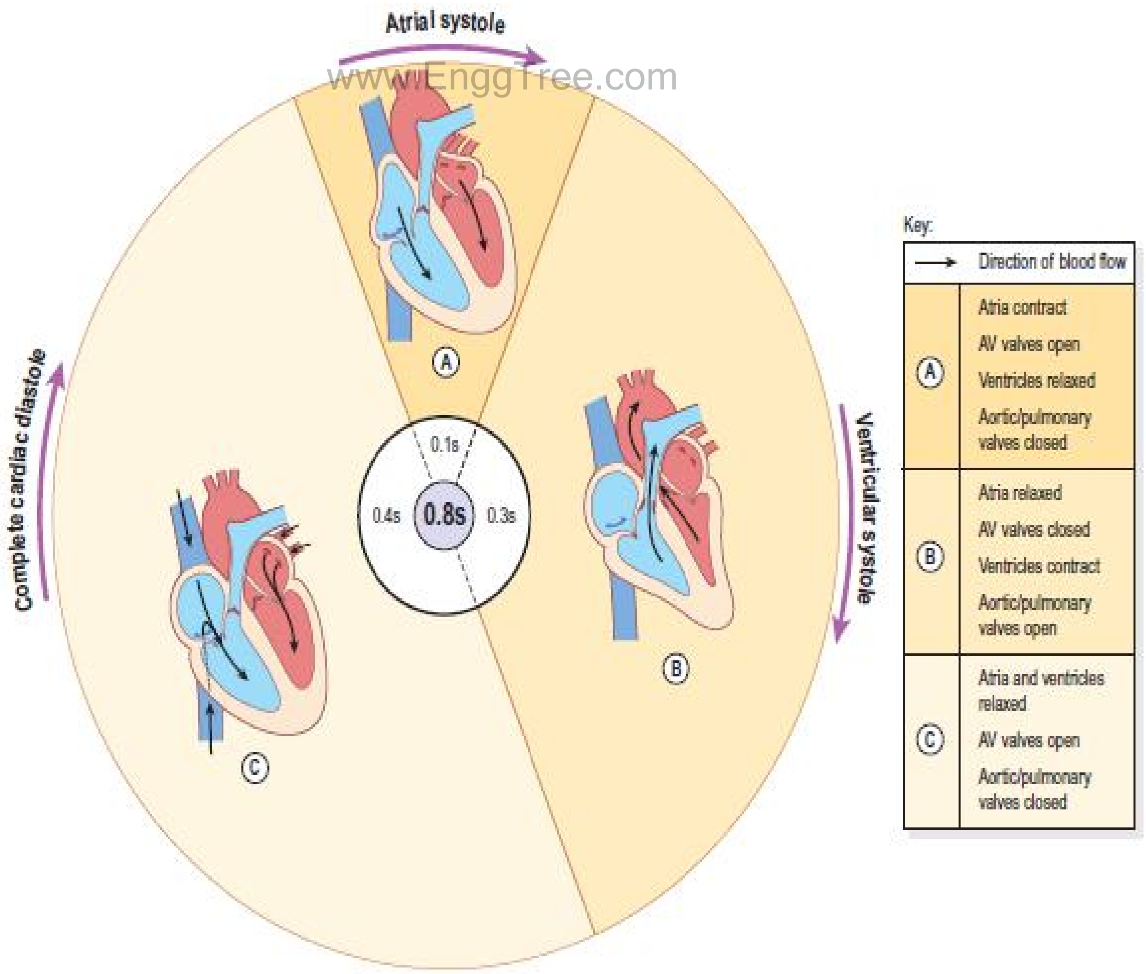
The **vagus nerve (parasympathetic)** supplies mainly the SA and AV nodes and atrial muscle. Vagal stimulation reduces the rate at which impulses are produced, decreasing the rate and force of the heartbeat.

Sympathetic nerves supply the SA and AV nodes and the myocardium of atria and ventricles, and stimulation increases the rate and force of the heartbeat.

The Cardiac Cycle

- Cardiac events appearing from the beginning of one heart beat to the beginning of next heart beat and repeating themselves successively.
- Throughout the cardiac cycle, blood pressure increases and decreases.
- The cardiac cycle is coordinated by a series of electrical impulses that are produced by specialized heart cells found within the sinoatrial node and the atrioventricular node.
- The cardiac muscle is composed of myocytes which initiate their own contraction without help of external nerves (with the exception of modifying the heart rate due to metabolic demand).

- Under normal circumstances, each cycle takes approximately one second.
- The pumping action of the heart (heartbeat) is controlled by the heart's electrical system or the **cardiac conduction system**. This is a group of **specialised cells** located in the wall of the heart which send electrical impulses to the cardiac muscle causing it to contract.
- When the cardiac muscle contracts the volume in the chamber decrease, so the pressure in the chamber increases, so the blood is forced out. Cardiac muscle contracts about 75 times per minute, pumping around 75 cm^3 of blood from each ventricle each beat (the stroke volume). It does this continuously for up to 100 years. There is a complicated sequence of events at each heartbeat called the cardiac cycle.
- Cardiac muscle is myogenic, which means that it can contract on its own, without needing nerve impulses. Contractions are initiated within the heart by the sino-atrial node (SAN, or pacemaker) in the right atrium. This extraordinary tissue acts as a clock, and contracts spontaneously and rhythmically about once a second, even when surgically removed from the heart.



Cardiac cycle

The cardiac cycle has three stages:

- **Atrial Systole**:

  The SAN contracts and transmits electrical impulses throughout the atria, which both contract, pumping blood into the ventricles. The ventricles are electrically insulated from the atria, so they do not contract at this time.

- **Ventricular Systole**:

  The electrical impulse passes to the ventricles via the atrioventricular node (AVN), the bundle of His and the Purkinje fibres. These are specialised fibres that do not contract but pass the electrical impulse to the base of the ventricles, with a short but important delay of about 0.1s.

  The ventricles therefore contract shortly after the atria, from the bottom up, squeezing blood upwards into the arteries. The blood can't go into the atria because of the atrioventricular valves, which are forced shut with a loud "lub".

- **Diastole**

  The atria and the ventricles relax, while the atria fill with blood. The semilunar valves in the arteries close as the arterial blood pushes against them, making a "dub" sound.

  The events of the three stages are shown in the diagram. The pressure changes show most clearly what is happening in each chamber. Blood flows because of pressure differences, and it always flows from a high pressure to a low pressure.

The PCG (or phonocardiogram) is a recording of the sounds the heart makes. The cardiac muscle itself is silent and the sounds are made by the valves closing. The first sound (**lub**) is the atrio ventricular valves closing and the second (**dub**) is the semi-lunar valves closing.

The ECG (or electrocardiogram) is a recording of the electrical activity of the heart. There are characteristic waves of electrical activity marking each phase of the cardiac cycle. Changes in these ECG waves can be used to help diagnose problems with the heart.

5. Give an account of the Cardiac muscles.

The heart wall is composed of three layers of tissues:

- ✓ Pericardium (outermost layer)
- ✓ Myocardium (middle layer) and
- ✓ Endocardium (innermost layer).

Pericardium (or) Epicardium

- The pericardium is the outermost layer and is made up of two sacs. The outer sac (the fibrous pericardium) consists of fibrous tissue and the inner (the serous pericardium) of a continuous double layer of serous membrane.
- The epicardium is composed primarily of loose connective tissue, including elastic fibers and adipose tissue.
- The epicardium functions to protect the inner heart layers and also assists in the production of pericardial fluid.
- This fluid fills the pericardial cavity and helps to reduce friction between pericardial membranes.
- Also found in this heart layer are the coronary blood vessels, which supply the heart wall with blood.
- The inner layer of the epicardium is in direct contact with the myocardium.

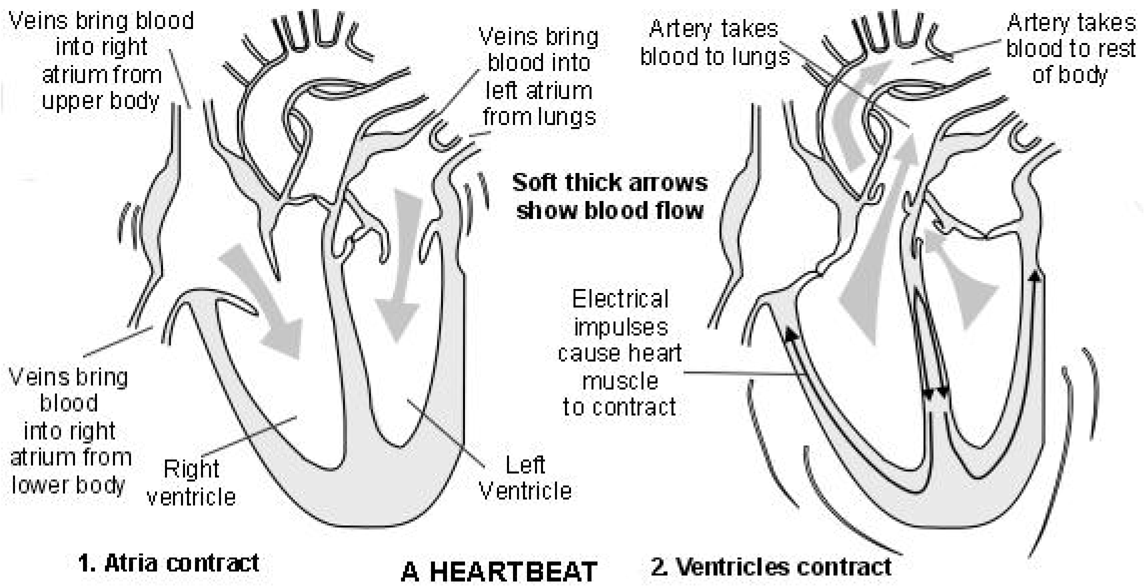
Myocardium

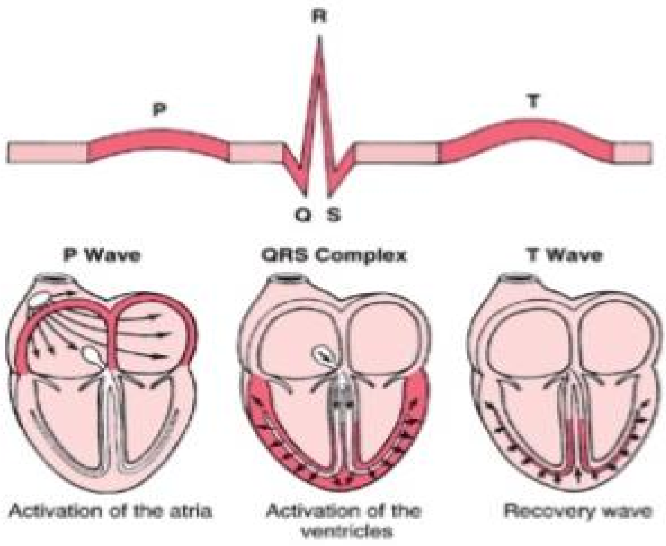
- Myocardium (myo-cardium) is the middle layer of the heart wall. It is composed of cardiac muscle fibers, which enable heart contractions.
- The myocardium is the thickest layer of the heart wall, with its thickness varying in different parts of the heart.
- The myocardium of the left ventricle is the thickest as this ventricle is responsible for generating the power needed to pump oxygenated blood from the heart to the rest of the body.
- Cardiac muscle contractions are under the control of the peripheral nervous system, which directs involuntary functions including heart rate.
- Cardiac conduction is made possible by specialized myocardial muscle fibers. These fiber bundles, consisting of the atrioventricular bundle and Purkinje fibers, carry electrical impulses down the center of the heart to the ventricles.
- These impulses trigger the muscle fibers in the ventricles to contract.

Endocardium

- Endocardium (endo-cardium) is the thin inner layer of the heart wall. This layer lines the inner heart chambers, covers heart valves, and is continuous with the endothelium of large blood vessels.
- The endocardium of heart atria consists of smooth muscle, as well as elastic fibers. An infection of the endocardium can lead to a condition known as endocarditis.
- Endocarditis is typically the result of an infection of the heart valves or endocardium by certain bacteria, fungi, or other microbes. Endocarditis is a serious condition that can be fatal.

6. **Write short note about heart beat.**





The electrical activity spreads through the walls of the atria and causes them to contract. This forces blood into the ventricles. The SA node sets the rate and **rhythm** of your **heartbeat**. Normal **heart rhythm** is often called normal sinus **rhythm** because the SA (sinus) node fires regularly.

The heartbeat consists of alternating contractions and relaxations of the heart. It you listen to the heart with a stethoscope you hear the sounds often described as "**lubb-dupp**".

There are four stages to each heartbeat:

- ✓ Each atrium relaxes so that blood can enter. Blood flows from the body by the vena cava into the :right atrium. At the same time, blood flows from the lungs via the pulmonary vein into the left :atrium.
- ✓ The atrio-ventricular valves open and both ventricles relax. The atria contract and blood flows from the right atrium into the right ventricle and from the left atrium into the left ventricle.
- ✓ The ventricles contract and the atrio-ventricular valves snap shut to stop blood flowing back into the atria. This is the first sound ("lubb") of the heartbeat that can be heard with a stethoscope.
- ✓ The semi-lunar valves open and blood is pumped out of the right ventricle to the lungs. At the same time, blood is pumped out of the left ventricle into the aorta and so to the rest of the body. When the ventricles stop contracting the semi-lunar valves snap shut to stop blood flowing backwards.

This is the second sound ("dupp") of the heartbeat. Blood flows into the atria again as they relax and the cycle is repeated.

When a valve is broken and fails to close completely some blood may flow backwards after each heartbeat. A trained veterinarian hears this with a stethoscope as a "**heart murmur**".

The period of the heart beat when the ventricles are contracting and sending a wave of blood down the pulmonary artery and aorta is called **systole**. The period when the ventricles are relaxing is called **diastole**.

7. Explain about the types of blood vessels and their functions.

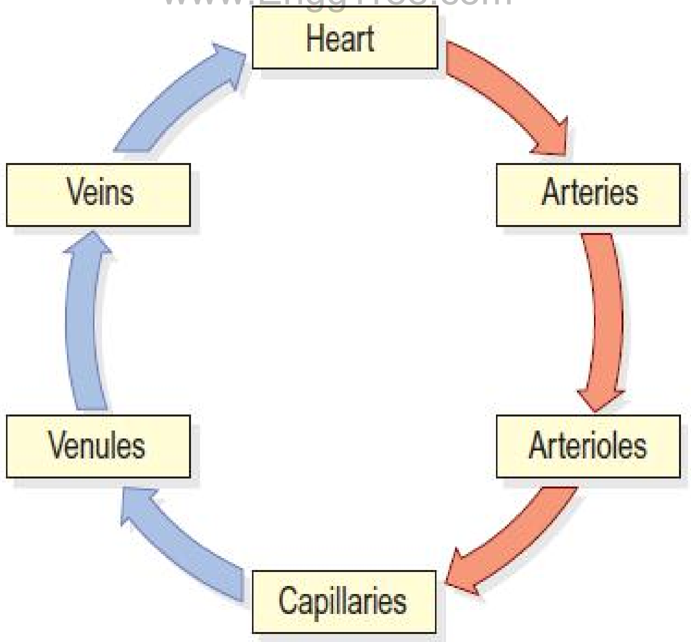
Blood vessels

Blood vessels vary in structure, size and function, and there are several types:

a) Arteries and arterioles

b) Capillaries

c) Venules and veins.



The relationship between the heart and the different types of blood vessel.

a) Arteries and arterioles

These blood vessels transport blood away from the heart. They vary considerably in size and their walls consist of three layers of tissue:

- **Tunica Adventitia** - Outer layer of fibrous tissue.
- **Tunica Media** - Middle layer of smooth muscle and elastic tissue.
- **Tunica Intima** - Inner lining of squamous Epithelium called **Endothelium**.

- The amount of muscular and elastic tissue varies in the arteries depending upon their size and function.
- In the large arteries, including the aorta, sometimes called elastic arteries, the tunica media contains more elastic tissue and less smooth muscle.
- This allows the vessel wall to stretch, absorbing the pressure wave generated by the heart as it beats.
- These proportions gradually change as the arteries branch many times and become smaller until in the *arterioles* (the smallest arteries) the tunica media consists almost entirely of smooth muscle.
- This enables their diameter to be precisely controlled, which regulates the pressure within them.
- Systemic blood pressure is mainly determined by the resistance these tiny arteries offer to blood flow, and for this reason they are called *resistance vessels*.
- Arteries have thicker walls than veins to with stand the high pressure of arterial blood.

Anastomoses and end-arteries

- *Anastomoses* are arteries that form a link between main arteries supplying an area, e.g. the arterial supply to the palms of the hand and soles of the feet, the brain, the joints and, to a limited extent, the heart muscle.
- If one artery supplying the area is occluded, anastomotic arteries provide a *collateral circulation*. This is most likely to provide an adequate blood supply when the occlusion occurs gradually, giving the anastomotic arteries time to dilate.
- An *end-artery* is an artery that is the sole source of blood to a tissue, e.g. the branches from the circulus arteriosus (circle of Willis) in the brain or the central artery to the retina of the eye.
- When an end-artery is occluded the tissues it supplies die because there is no alternative blood supply.

b) Capillaries and sinusoids

- The smallest arterioles break up into a number of minute vessels called *capillaries*. Capillary walls consist of a single layer of endothelial cells sitting on a very thin basement membrane, through which water and other small molecules can pass.
- Blood cells and large molecules such as plasma proteins do not normally pass through capillary walls. The capillaries form a vast network of tiny vessels that link the smallest arterioles to the smallest venules.
- Their diameter is approximately that of an erythrocyte (7 μm). The capillary bed is the site of exchange of substances between the blood and the tissue fluid, which bathes the body cells and, with the exception of those on the skin surface and in the cornea of the eye, everybody cell lies close to a capillary.
- Entry to capillary beds is guarded by rings of smooth muscle (*precapillary sphincters*) that direct blood flow. Hypoxia (low levels of oxygen in the tissues), or high levels of tissue wastes, indicating high levels of activity, dilate the sphincters and increase blood flow through the affected beds.
- In certain places, including the liver and bone marrow, the capillaries are significantly wider and leakier than normal.
- These capillaries are called *sinusoids* and because their walls are incomplete and their lumen is much larger than usual, blood flows through them more slowly under less pressure and can come directly into contact with the cells outside the sinusoid wall.

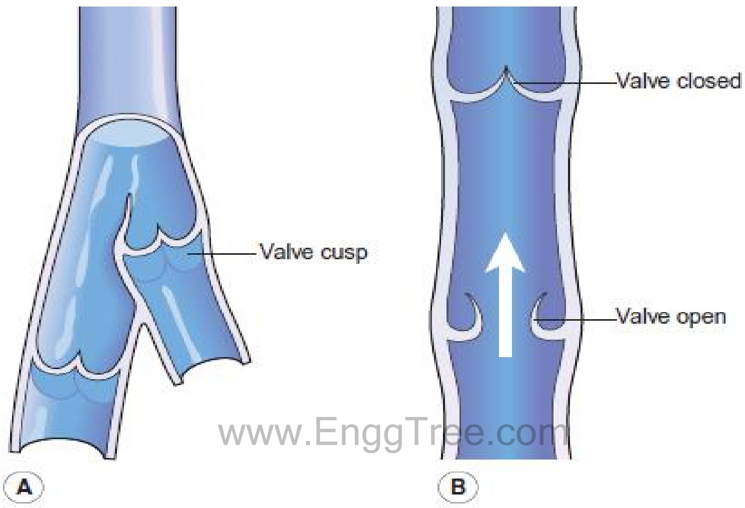
- This allows much faster exchange of substances between the blood and the tissues, useful, for example, in the liver, which regulates the composition of blood arriving from the gastrointestinal tract.

Capillary refill time

- When an area of skin is pressed firmly with a finger, it turns white (blanches) because the blood in the capillaries under the finger has been squeezed out.
- Normally it should take less than two seconds for the capillaries to refill once the finger is removed, and for the skin to turn pink again.
- Although the test may produce unreliable results, particularly in adults, its use in children can be useful and a prolonged capillary refill time suggests poor perfusion or dehydration.

c) Veins and venules

- Vein returns blood at low pressure to the heart. The walls of the veins are thinner than arteries but have the same three layers of tissue. They are thinner because there is less muscle and elastic tissue in the tunica media, as veins carry blood at a lower pressure than arteries.
- When cut, the veins collapse while the thicker-walled arteries remain open. When an artery is cut blood spurts at high pressure while a slower, steady flow of blood escapes from a vein. Some veins possess *valves*, which prevent backflow of blood, ensuring that it flows towards the heart.



Interior of a vein. A. The valves and cusps. B. The direction of blood flow through a valve

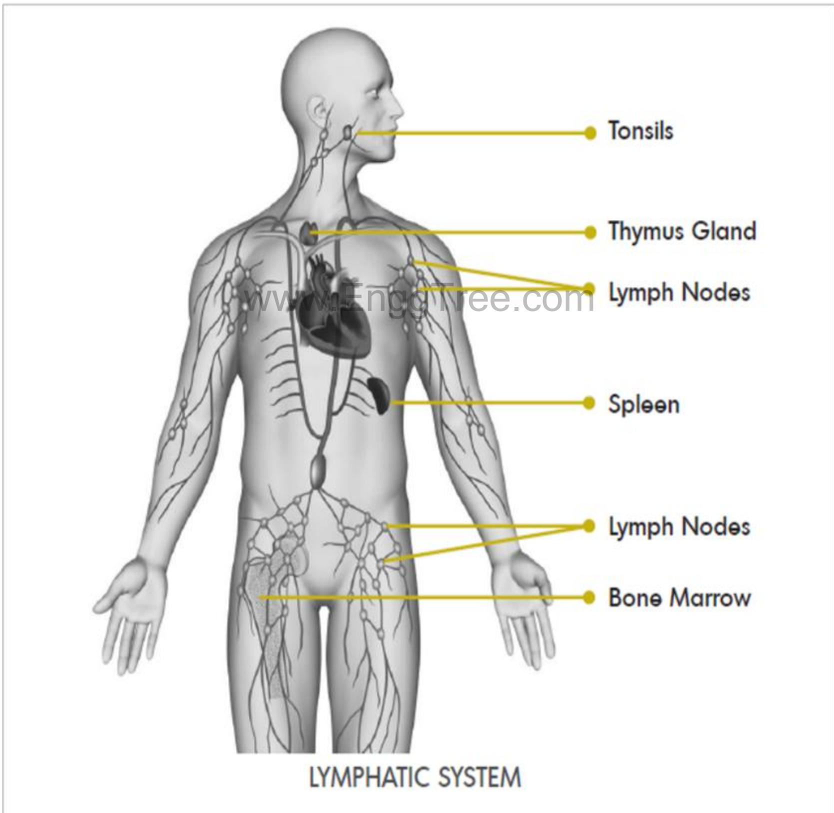
- They are formed by a fold of tunica intima and strengthened by connective tissue. The cusps are *semilunar* in shape with the concavity towards the heart. Valves are abundant in the veins of the limbs, especially the lower limbs where blood must travel a considerable distance against gravity when the individual is standing.
- They are absent in very small and very large veins in the thorax and abdomen. Valves are assisted in maintaining one-way flow by skeletal muscles surrounding the veins. The smallest veins are called *venules*.
- Veins are called *capacitance vessels* because they are distensible, and therefore have the capacity to hold a large proportion of the body's blood. At any one time, about two-thirds of the body's blood is in the venous system.

- This allows the vascular system to absorb (to an extent) sudden changes in blood volume, such as in haemorrhage; the veins can constrict, helping to prevent a sudden fall in blood pressure.

Blood supply

The outer layers of tissue of thick-walled blood vessels receive their blood supply via a network of blood vessels called the *vasa vasorum*. Thin-walled vessels and the endothelium of the others receive oxygen and nutrients by diffusion from the blood passing through them.

8. What are the functions of lymphatic system? Explain about the lymphatic organs and vessels.



The lymphatic system is a network of delicate tubes throughout the body. It drains fluid (called lymph) that has leaked from the blood vessels into the tissues and empties it back into the bloodstream via the lymph nodes.

The main roles of the lymphatic system include:

- Managing the fluid levels in the body
- Reacting to bacteria
- Dealing with cancer cells

- Dealing with cell products that otherwise would result in disease or disorders
- Absorbing some of the fats in our diet from the intestine.

The lymph nodes and other lymphatic structures like the spleen and thymus hold special white blood cells called lymphocytes. These can rapidly multiply and release antibodies in response to bacteria, viruses, and a range of other stimuli from dead or dying cells and abnormally behaving cells such as cancer cells.

Lymphatic vessels

The lymphatic vessels are found everywhere in our body. Generally, more active areas have more of them.

The smaller lymphatic vessels, which take up the fluids, are called lymph capillaries. The larger lymphatic vessels have muscles in their walls which helps them gently and slowly pulsate. These larger lymphatic vessels also have valves that stop the lymph flowing back the wrong way.

Lymph vessels take the lymph back to the lymph nodes (there are about 700 of these in total), which are found in our arm pit and groin as well as many other areas of the body such as the mouth, throat and intestines.

The fluid that arrives in the lymph nodes is checked and filtered. Most of it continues on to where the lymphatic system from most of our body (the left arm, tummy, chest, and legs) empties out at the left shoulder area. Lymph from the right arm and face and part of the right chest empties into the blood at the right shoulder area.

Lymphatic Ducts

The two main lymphatic ducts are the “thoracic duct” and “right lymphatic duct”. After filtration by the lymph nodes, the lymph is emptied by lymphatic vessels into these two ducts.

Thoracic duct is the large lymphatic duct. It drains lymph from the pelvis, abdomen, left half of thorax, left arm, head and neck. It poursits contents into the left subclavian vein.

Right lymphatic duct is a small dilated lymph vessel about 1cm long. It drains lymph from the right half of thorax, right arm and head and neck.it empties into the veins at the right side of the root of the neck.

Lymphatic organs

a) Spleen

Spleen is a dark purple coloured lymphoid structure. It is highly vascular and bean shaped and measures about 12cm in length. It is present in the left side of the abdominal cavity below the diaphragm.

Function:

- spleen produces all types of blood cells during foetal life
- RBC's are destroyed in the spleen
- Histocytes of spleen ingest and destroy foreign particles including bacteria
- Spleen serves as a reservoir of blood
- It also produces antibodies

b) Thymus

The thymus gland contains lymphoid tissue. It lies in the thorax behind the sternum but infront of heart and arch of aorta. It weighs about 10 to 15 gms at birth and it grows until puberty. Later it gradually decreases in size and shrinks. The thymus takes part in the production of T- lymphocytes.

c) Tonsils

Tonsils are collections of lymphoid tissue. There are two tonsils, one on each side of the pharynx between the pillars of fauces. Tonsils are supplied witrh blood and lymphatic vessels. The surface of tonsil is covered with mucous membrane which is studded with crypts. Lymphocytes are present in the fluid on the surface of tonsil and also in the crypts.

d) Appendix

The vermiform appendix is a fine tube, closed at one end, which leads from the caecum. It is usually about 13cm long and has the same structure as the walls of the colon but contains more lymphoid tissue.

Peyer's patches

There are numerous lymph nodes in the mucous membrane at irregular intervals throughout the length of the small intestine. The smaller ones are known as "Solitary lymphatic follicles" and there are about 20 or 30 larger nodes situated towards the distal end of the ileum which are called “Aggregated lymphatic follicles (Peyer’s patches)”.

8. Explain the mechanism involved in the control of blood pressure.

Blood pressure is controlled in two ways:

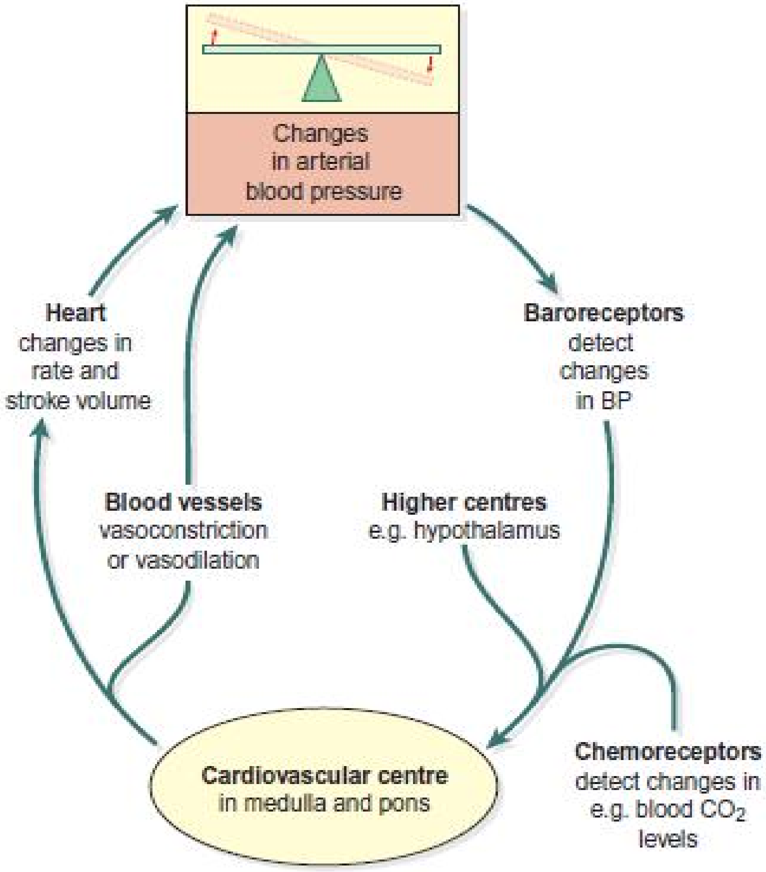
a) Short-term control, on a moment-to-moment basis, which mainly involves the baroreceptor reflex, also chemoreceptors and circulating hormones.

b) Long-term control, which involves regulation of blood volume by the kidneys and the renin–angiotensin– aldosterone system.

a) Short-term blood pressure regulation

The cardiovascular centre (CVC) is a collection of interconnected neurones in the medulla and pons of the brain stem. The CVC receives, integrates and coordinates inputs from:

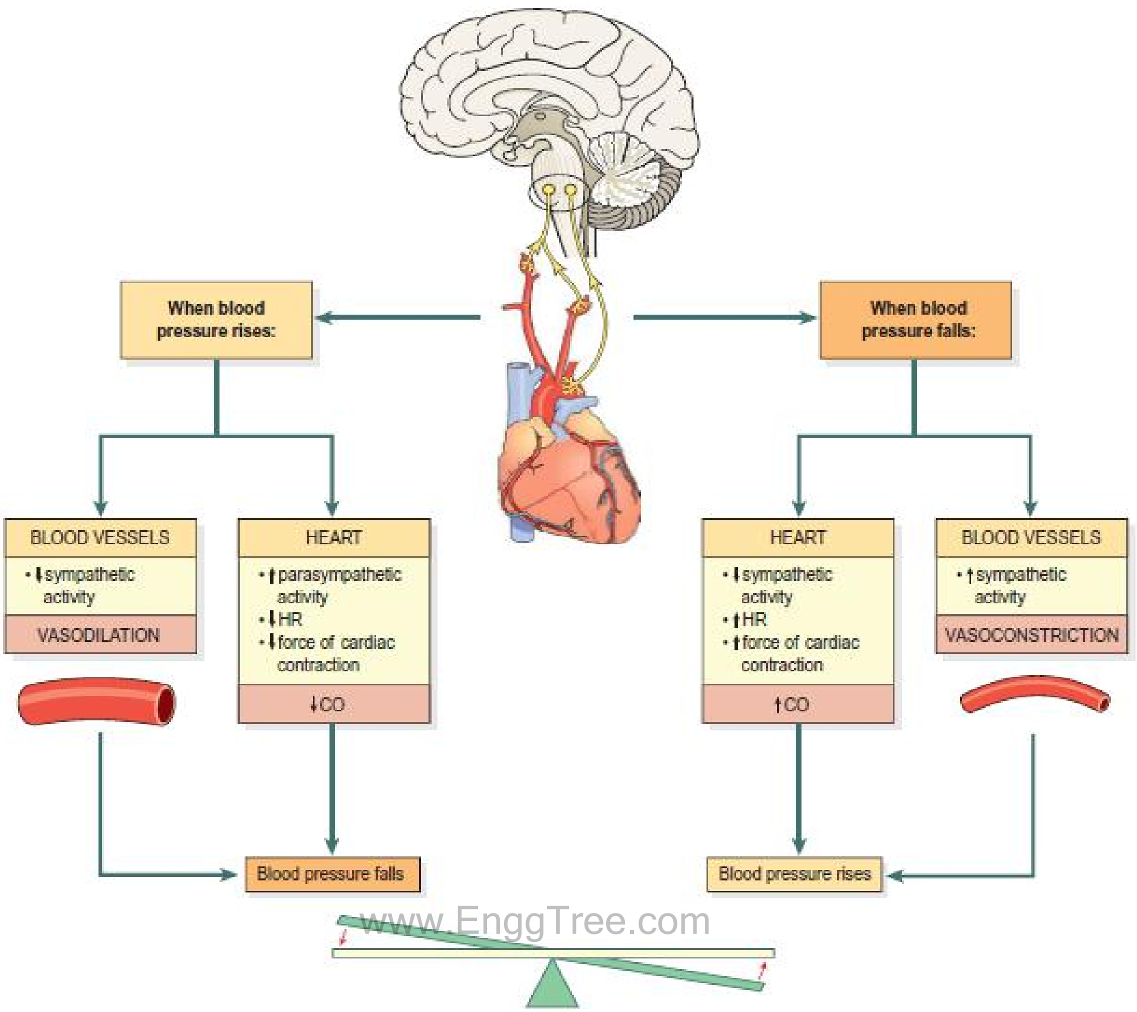
- Baroreceptors (pressure receptors)
- Chemoreceptors
- Higher centres in the brain.



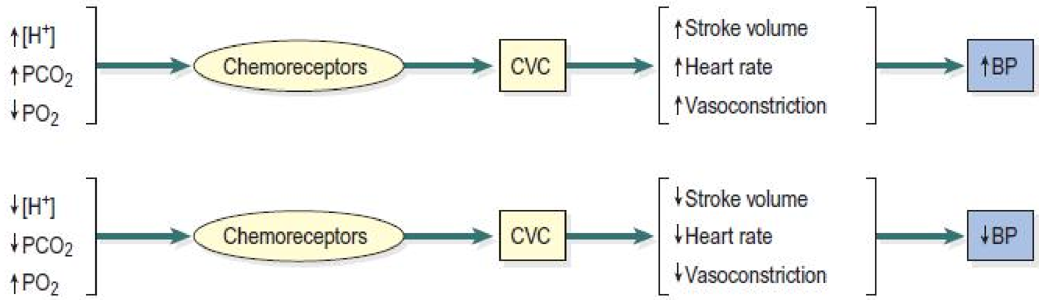
The main mechanisms in blood pressure control.

The CVC sends autonomic nerves (both sympathetic and parasympathetic) to the heart and blood vessels. It controls BP by slowing down or speeding up the heart rate and by dilating or constricting blood vessels. Activity in these fibres is essential for control of blood pressure.

Baroreceptors



The baroreceptor reflex.



The relationship between stimulation of chemoreceptors and arterial blood pressure.

Within the wall of the aortic and carotid sinuses are *baroreceptors*, nerve endings sensitive to stretch (pressure), which are the body's principal moment-to moment regulatory mechanism for controlling blood pressure. A rise in blood pressure in these arteries stimulates the baroreceptors, increasing their input to the CVC.

The CVC responds by increasing parasympathetic nerve activity to the heart; this slows the heart down. At the same time, sympathetic stimulation to the blood vessels is inhibited, causing vasodilation. The net result is a fall in systemic blood pressure.

Conversely, if pressure within the aortic arch and carotid sinuses falls, the rate of baro receptor discharge also falls. The CVC responds by increasing sympathetic drive to the heart to speed it up.

Sympathetic activity in blood vessels is also increased, leading to vasoconstriction. Both these measures counteract the falling blood pressure. Baroreceptor control of blood pressure is also called the *baroreceptor reflex*.

Chemoreceptors

These are nerve endings situated in the carotid and aortic bodies, and are primarily involved in control of respiration. They are sensitive to changes in the levels of carbon dioxide, oxygen and the acidity of the blood (pH).

Rising blood CO_2, falling blood O_2 levels and or falling arterial blood pH all indicate failing tissue perfusion. When these changes are detected by the chemoreceptors, they send signals to the CVC, which then increases sympathetic drive to the heart and blood vessels, pushing blood pressure up to improve tissue blood supply.

Because respiratory effort is also stimulated, blood oxygen levels rise as well. Chemoreceptor input to the CVC influences its output only when severe disruption of respiratory function occurs or when arterial BP falls to less than 80 mmHg.

Similar chemoreceptors are found on the brain surface in the medulla oblongata, and they measure carbon dioxide / oxygen levels and pH of the surrounding cerebrospinal fluid. Changes from normal activate responses similar to those described above for the aortic/carotid receptors.

Higher centres in the brain

Input to the CVC from the higher centres is influenced by emotional states such as fear, anxiety, pain and anger that may stimulate changes in blood pressure.

The hypothalamus in the brain controls body temperature and influences the CVC, which responds by adjusting the diameter of blood vessels in the skin. This important mechanism regulates conservation and loss of heat so that core body temperature remains in the normal range .

b) Long-term blood pressure regulation

Slower, longer lasting changes in blood pressure are effected by the *renin–angiotensin–aldosterone* system (RAAS) and the action of *antidiuretic hormone* (ADH). Both of these systems regulate blood volume, thus influencing blood pressure.

In addition, *atrial natriuretic peptide* (ANP), a hormone released by the heart itself, causes sodium and water loss from the kidney and reduces blood pressure, opposing the activities of both ADH and the RAAS.

Pressure in the pulmonary circulation

Pulmonary blood pressure is much lower than in the systemic circulation. This is because although the lungs receive the same amount of blood from the right ventricle as the rest of the body receives from the left ventricle, there are so many capillaries in the lungs that pressure is kept low.

If pulmonary capillary pressure exceeds 25 mmHg, fluid is forced out of the bloodstream and into the airsacs (*pulmonary oedema*), with very serious consequences. Autoregulation in the pulmonary circulation makes sure that blood flow through the vast network of capillaries is directed through well-oxygenated airsacs.

UNIT IV

NERVOUS AND ENDOCRINE SYSTEMS AND SENSE ORGANS

Nervous:

- Cells of Nervous systems
- Types of Neuron and Synapses
- Mechanisms of Nerve impulse

Brain:

- Parts of Brain
- Spinal Cord
- Tract and Pathways of Spines
- Reflex Mechanism
- Classification of Nerves
- Autonomic Nervous systems and its functions.

Endocrine system:

- Pituitary and
- Thyroid gland

Sense Organs:

- Eye and
- Ear.

PART-A

1. What is nervous system?
2. What are the types of neurons?
3. Define – Meninges.
4. What are the functions of Brain?
5. Distinguish between sympathetic and parasympathetic nervous system.
6. Define Otosclerosis.
7. What is an audiogram? Also mention the types of hearing loss
8. Write short notes on lacrimal gland?
9. What are the functions of the attenuation reflex?
10. How does the detection of sound and of movement in inner ear happens?

PART-B

1. Enumerate the structure and function of nervous tissue.
2. Explain about the mechanism of nerve impulse.
3. Write in detail about the anatomy of Brain.
4. Explain in detail about the anatomy and physiology of spinal cord.

5. Discuss about the functional pathway of spinal cord and its reflex mechanism.
6. Discuss about the Endocrine glands and functions. (or) write a short note about Pituitary and thyroid gland.
7. Explain the mechanism involved in the hearing sound.
8. Draw the structure of human eye. Explain the functional properties of each part of eye.

PART-A

1. **What is nervous system?**

   The nervous system consists of the brain, the spinal cord and peripheral nerves.

   The parts of the nervous system are grouped as follows:

   - ✓ The **central nervous system (CNS)**, consisting of the brain and the spinal cord
   - ✓ The **peripheral nervous system (PNS)**, consisting of all the nerves outside the brain and spinal cord.

2. **What are the types of neurons?**

   There are many types of specialized neurons.

- ✓ **Sensory neurons** (afferent) respond to one particular type of stimulus such as touch, sound, or light and all other stimuli affecting the cells of the sensory organs, and also converts it into an electrical signal via transduction, which is then sent to the spinal cord or brain.
- ✓ **Motor neurons** (efferent) receive signals from the brain and spinal cord to control everything from muscle contractions to glandular output. Inter neurons connect neurons to other neurons within the same region of the brain or spinal cord in neural networks.

3. **Define – Meninges.**

   Membranous coverings of brain and spinal cord (CNS) is known as the **Meninges** provide protection. The brain and spinal cord are completely surrounded by three layers of this meninges tissue, which is lying between the skull and the brain, and between the vertebral foramina and the spinal cord.

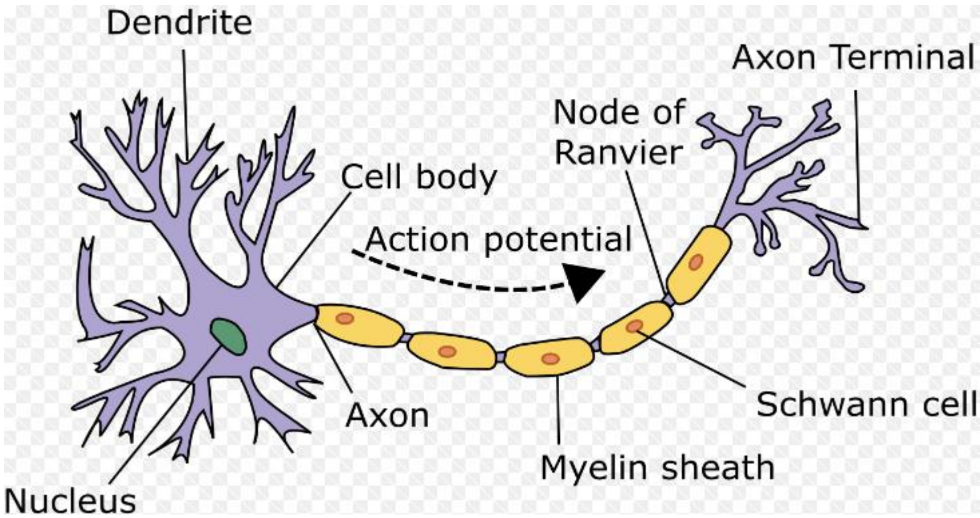
   Three layers are Named from outside inwards they are the:

   - ❖ Dura mater
   - ❖ Arachnoid mater
   - ❖ Pia mater.

4. **Write short notes on All or none law.**

   The all-or-none law is the principle that the strength by which a nerve or muscle fiber responds to a stimulus is independent of the strength of the stimulus. If that stimulus exceeds the threshold potential, the nerve or muscle fiber will give a complete response; otherwise, there is no response.

5. **Write short note on structure of neuron.**



6. **Write short note on saltatory conduction.**

Saltatory conduction is the propagation of action potentials along myelinated axons from one node of Ranvier to the next node, increasing the conduction velocity of action potentials.

7. **What are the functions of Cerebrospinal fluid (CSF)?**

The brain contains four irregular-shaped cavities, or *ventricles*, containing cerebrospinal fluid (CSF). They are:

- Right and left lateral ventricles
- Third ventricle
- Fourth ventricle.

Functions of cerebrospinal fluid:

- ✓ CSF supports and protects the brain and spinal cord by maintaining a uniform pressure around these vital structures and acting as a cushion or shock absorber between the brain and the skull.
- ✓ It keeps the brain and spinal cord moist and there may be exchange of nutrients and waste products between CSF and the interstitial fluid of the brain.
- ✓ CSF is thought to be involved in regulation of breathing as it bathes the surface of the medulla where the central respiratory chemo receptors are located.

8. **What is Stretch and tendon reflex?**

➢ The **stretch reflex** (**myotatic reflex**) is a muscle contraction in response to stretching within the muscle. It is a monosynaptic reflex which provides automatic regulation of skeletal muscle length. When a muscle lengthens, the muscle spindle is stretched and its nerve activity increases.

- In a **Golgi tendon reflex**, skeletal muscle contraction causes against (a muscle whose contraction moves a part of the body directly) muscle to simultaneously lengthen and relax. This reflex is also called the **inverse myotatic reflex**, because it is the inverse of the stretch reflex.

9. What are the functions of Brain?

The brain controls our thoughts, memory and speech, movement of the arms and legs, and the function of many organs within our **body**. The central **nervous** system (CNS) is composed of the brain and spinal cord.

10. Where the brain is located in human body?

The cerebrum is the largest part of the brain; the outer part is called the **cerebral cortex**. The **cerebellum** is about the size of a pear. The brain stem is located at the bottom of the brain, above the neck, where it connects the brain to the spinal cord.

11. What is nerve impulse?

A nerve impulse is a signal transmitted along a nerve fibre. It consists of a wave of electrical depolarization that reverses the potential difference across the nerve cell membranes.

12. Distinguish between sympathetic and parasympathetic nervous system.

Sympathetic nervous system

- The sympathetic nervous system prepares the body for intense physical activity and is often referred to as the fight-or-flight response.
- Control the body's response during perceived threat.

Parasympathetic nervous system

- The parasympathetic nervous system has almost the exact opposite effect and relaxes the body and inhibits or slows many high energy functions.
- Control the body's response while at rest.

13. Write note on neurotransmission.

- Neurotransmission also called **synaptic transmission**, is the process by which signaling molecules called neurotransmitters are released by a neuron (the **presynaptic** neuron), and bind to and activate the receptors of another neuron (the **postsynaptic** neuron).
- Neurotransmission is essential for the process of communication between two neurons. Synaptic transmission relies on: the availability of the neurotransmitter; the release of the neurotransmitter by **exocytosis**.

14. Brief on cranial nerves and their functions.

The cranial nerves are the 12 pairs of nerves that leave the brain via their own individual apertures in the skull.

Functions of the Cranial Nerves

i. **Olfactory (Smell)**
ii. **Optic (Sight)**
iii. **Oculomotor (Moves eyelid and eyeball and adjusts the pupil and lens of the eye)**
iv. **Trochlear (Moves eyeballs)**
v. **Trigeminal (Facial muscles incl. chewing; Facial sensations)**
vi. **Abducens (Moves eyeballs)**
vii. **Facial (Taste, tears, saliva, facial expressions)**
viii. **Vestibulocochlear (Auditory)**
ix. **Glossopharyngeal (Swallowing, saliva, taste)**
x. **Vagus (Control of PNS e.g. smooth muscles of GI tract)**
xi. **Accessory (Moving head & shoulders, swallowing)**
xii. **Hypoglossal (Tongue muscles - speech & swallowing)**

15. What is role of interneurons in the nervous system?

Interneurons create neural circuits, enabling communication between sensory or motor neurons and the central nervous system (CNS).

16. How functionally ANS differs from CNS?

- The central nervous system is composed of millions of nerve and glial cells, together with blood vessels and a little connective tissue. The nerve cells, or neurons, are characterized by many processes and are specialized for reception and transmission of signals.

- The autonomic nervous system controls smooth muscle of the viscera (internal organs) and glands.

17. What are the two major synapses?

There are two types of synapses:

- Electrical synapses
- Chemical synapses

18. What is an audiogram? Also mention the types of hearing loss

An *audiogram* is a graph that shows the softest sounds a person can hear at different pitches or frequencies. An "O" often is used to represent responses for the right ear and an "X" is used to represent responses for the left ear.

The audiogram shown above on the left indicates the different degrees of hearing loss.

There are four types of hearing loss:

- Auditory Processing Disorders.
- Conductive.
- Sensorineural.
- Mixed.

19. Define Otosclerosis.

Otosclerosis is an abnormal growth of bone near the middle ear. It can result in hearing loss. This is an inherited disease. Otosclerosis can result in conductive and/or sensorineural hearing loss.

The primary form of hearing loss in otosclerosis is conductive hearing loss (CHL) whereby sounds reach the ear drum but are incompletely transferred via the ossicular chain in the middle ear, and thus partly fail to reach the inner ear (cochlea).

20. How will you test the hearing ability of a person? What is the standard level for a normal human beings? (or) How is Hearing Tested?

- Audiometry involves the testing of hearing.
- Humans can generally hear sounds with frequencies between 20 Hz and 20,000 Hz.

21. Define Electrooculoography.

Electrooculography (EOG/E.O.G.) is a technique for measuring the corneo-retinal standing potential that exists between the front and the back of the human eye. The resulting signal is called the **electrooculogram**. Primary applications are in ophthalmological diagnosis and in recording eye movements.

22. What is accommodation?

The **accommodation** reflex is a reflex action of the **eye**, in response to focusing on a near object, then looking at distant object (and vice versa), comprising coordinated changes in vergence, lens shape and pupil size (**accommodation**).

23. How does the detection of sound and of movement in inner ear happens?

The ear is the sense organ that enables us to hear. Hearing can be defined as the perception of sound energy via the brain and central nervous system. Hearing consists of two components: identification of sounds (what the sound is) and localisation of those sounds (where the sounds are coming from). The ear is divided into three main parts – the outer ear, the middle ear, and the inner ear.

The inner ear is filled with fluid. The inner ear also contains the receptors for sound which convert fluid motion into electrical signals known as action potentials that are sent to the brain to enable sound perception. The airborne sound waves must therefore be channelled toward and transferred into the inner ear for hearing to occur.

The role of the outer and middle ear is to transmit sound to the inner ear. They also help compensate for the loss in sound energy that naturally occurs when the sound waves pass from air into water by amplifying the sound energy during the process of sound transmission. In addition to converting sound waves into nerve action potentials, the inner ear is also responsible for the sense of equilibrium, which relates to our general abilities for balance and coordination.

24. What is myopia?

Myopia, also known as nearsightedness, is a common type of refractive error where close objects appear clearly, but distant objects appear blurry.

25. What are the structure present in the middle ear?

The middle ear consists of the tympanic cavity, the auditory ossicles and the eustachian tube. The boundary between the middle and inner ear is the oval window.

The auditory ossicles are attached to the wall of the tympanic cavity by many ligaments and mucosal folds.

The tympanic cavity is located within the petrous temporal bone, and can be divided into dorsal, middle and ventral parts.

26. Write short notes on lacrimal gland?

The **lacrimal-glands** are paired, almond-shaped **glands**, one for each eye, that secrete the aqueous-layer of the tear film. They are situated in the upper-outer portion of each orbit, in the **lacrimal** fossa of the orbit formed by the frontal-bone. The gland continually secretes tears which moisten, lubricate, and protect the surface of the eye. Inflammation of the **lacrimal-glands** is called dacryoadenitis.

27. What are the biological significance of retina?

The retina is a light-sensitive layer at the back of the eye that covers about 65 percent of its interior surface. Photosensitive cells called rods and cones in the retina convert incident light energy into signals that are carried to the brain by the optic nerve. In the middle of the retina is a small dimple called the fovea or fovea centralis. It is the center of the eye's sharpest vision and the location of most color perception.

28. What is conduction deafness?

Conductive hearing loss occurs when there is a problem conducting sound waves anywhere along the route through the outer ear, tympanic membrane (eardrum), or middle ear (ossicles). This type of hearing loss may occur in conjunction with sensorineural hearing loss (mixed hearing loss) or alone.

29. Define the role of vitreous body.

The vitreous body is the clear gel that fills the space between the lens and the retina of the eyeball of humans. It is often referred to as the vitreous humour or simply "the vitreous".

Vitreous humor fills much of the eye, allowing light to pass through the lens to the retina and helping the eye to keep its round shape. The space the vitreous humor fills is called the vitreous body.

30. Write a short note on presbyopia.

Presbyopia is a long-sightedness caused by loss of elasticity of the lens of the eye, occurring typically in middle and old age.

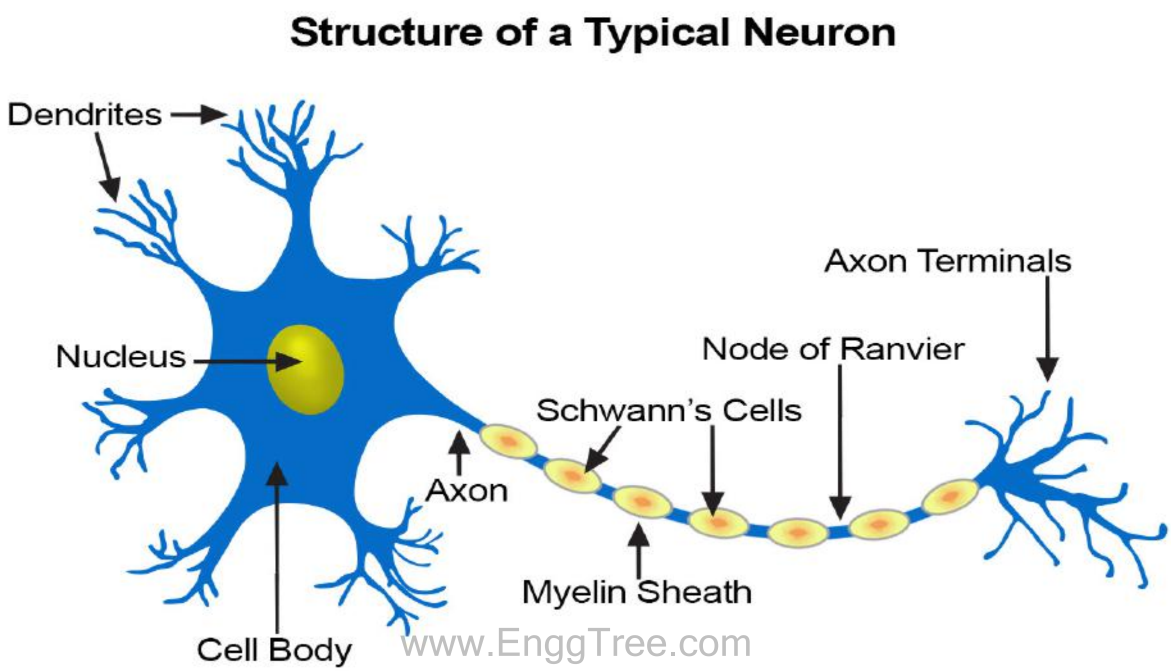
31. What are the functions of the attenuation reflex?

The acoustic **reflex** (also known as the stapedius **reflex**, middle-ear-muscles (MEM) **reflex**, **attenuation reflex**, or auditory **reflex**) is an involuntary muscle contraction that occurs in the middle ear in response to high-intensity sound stimuli or when the person starts to vocalize.

PART-B

1. Enumerate the structure and function of nervous tissue.

Nervous tissue is a component of nervous system, is made up of many neurons and supportive cells, called Neuroglia. The main function of nervous tissue is to perceive stimuli and generate nerve impulses to various organs of the body. **Neurons**



- ✓ Neurons, or nerve cells, carry out the functions of the nervous system by conducting nerve impulses. They are highly specialized and **Amitotic**. This means that if a neuron is destroyed, it cannot be replaced because neurons do not go through **Mitosis**. The image below illustrates the structure of a typical neuron.
- ✓ Each neuron has three basic parts:
  - cell body (soma),
  - one or more dendrites, and
  - a single axon.

Cell Body

In many ways, the cell body is similar to other types of cells. It has a **Nucleus** with at least one nucleolus and contains many of the typical cytoplasmic organelles. It lacks centrioles, however. Because centrioles function in cell division, the fact that neurons lack these organelles is consistent with the amitotic nature of the cell.

Cell bodies form the **grey matter** of the nervous system and are found at the periphery of the brain and in the centre of the spinal cord.

Dendrites

Dendrites and axons are cytoplasmic extensions, or processes, that project from the cell body and they form the **white matter** of the cell body. They are sometimes referred to as fibers. Dendrites are usually, but not always, short and branching, which increases their surface area to receive signals from other neurons.

The number of dendrites on a neuron varies. They are called **Afferent** processes because they transmit impulses to the neuron cell body. There is only one axon that projects from each cell body. It is usually elongated and because it carries impulses away from the cell body, it is called an **Efferent** process.

Axon

- ✓ An axon may have infrequent branches called **Axon Collaterals**. Axons and axon collaterals terminate in many short branches or telodendria. The distal ends of the telodendria are slightly enlarged to form synaptic bulbs.
- ✓ Many axons are surrounded by a segmented, white, fatty substance called myelin or the myelin sheath. Myelinated fibers make up the white matter in the CNS, while cell bodies and unmyelinated fibers make the gray matter. The unmyelinated regions between the myelin segments are called the nodes of Ranvier.
- ✓ In the peripheral nervous system, the myelin is produced by Schwann cells. The cytoplasm, nucleus, and outer cell membrane of the Schwann cell form a tight covering around the myelin and around the axon itself at the nodes of Ranvier. This covering is the neurilemma, which plays an important role in the regeneration of nerve fibers.
- ✓ In the CNS, oligodendrocytes produce myelin, but there is no neurilemma, which is why fibers within the CNS do not regenerate.
- ✓ Functionally, neurons are classified as afferent (sensory), efferent (motor), or interneurons (association neurons) according to the direction in which they transmit impulses relative to the central nervous system.
- ✓ Afferent, or sensory neurons carry impulses from peripheral sense receptors to the CNS. They usually have long dendrites and relatively short axons.
- ✓ Efferent, or motor neurons transmit impulses from the CNS to effector organs such as muscles and glands. Efferent neurons usually have short dendrites and long axons.
- ✓ Interneurons, or association neurons, are located entirely within the CNS in which they form the connecting link between the afferent and efferent neurons. They have short dendrites and may have either a short or long axon.

- ✓ The point of communication between one neuron and another is called a **synapse.** Synapses are generally directional in function, with activity at the end foot of the sending cell (**presynaptic cell**) affecting the behavior of the receiving cell (**postsynaptic cell**). In most neurons, the postsynaptic membrane is usually on the cell body or dendrites, but synapses between axons also occur.
- ✓ Most neurons have several dendrites and one axon. Because of their multiple processes, these are termed **multipolar neurons.** Simpler **unipolar** (one-process) and **bipolar** (two-process) neurons are much less common in vertebrate than in invertebrate nervous systems.

Neuroglia

Neuroglia cells do not conduct nerve impulses, but instead, they support, nourish, and protect the neurons. They are far more numerous than neurons and, unlike neurons, are capable of mitosis. There are four types:

- Astrocytes
- Oligodendrocytes
- Ependymal cells and
- Microglia.

2. Explain about the mechanism of nerve impulse.

The nerve impulse (action potential)

- ➢ An impulse is initiated by stimulation of sensory nerve endings or by the passage of an impulse from another nerve. Transmission of the impulse, or action potential, is due to the movement of ions across the nerve cell membrane.
- ➢ In the resting state the nerve cell membrane is **polarized** due to differences in the concentrations of ions across the plasma membrane. This means that there is a different electrical charge on each side of the membrane, which is called the **resting membrane potential**.
- ➢ At rest the charge on the outside is positive and inside it is negative. The principal ions involved are:
    - Sodium (Na^+), the main extracellular cation
    - Potassium (K^+), the main intracellular cation.
- ➢ In the resting state there is a continual tendency for these ions to diffuse along their concentration gradients, i.e. K^+ outwards and Na^+ into cells. When stimulated, the permeability of the nerve cell membrane to these ions changes.

- Initially Na+ floods into the neurone from the extracellular fluid causing **Depolarisation**, creating a **Nerve Impulse Or Action Potential**.
- Depolarisation is very rapid, enabling the conduction of a nerve impulse along the entire length of a neurone in a few milliseconds. It passes from the point of stimulation in one direction only, i.e. away from the point of stimulation towards the area of resting potential.
- The one-way direction of transmission is ensured because following depolarisation it takes time for **Repolarisation** to occur.
- Almost immediately following the entry of Na+, K+ floods out of the neurone and the movement of these ions returns the membrane potential to its resting state. This is called the **Refractory Period** during which restimulation is not possible.
- The action of the **Sodium–Potassium Pump** expels Na+ from the cell in exchange for K+ returning levels of Na+ and K+ to the original resting state, repolarizing the neurone.

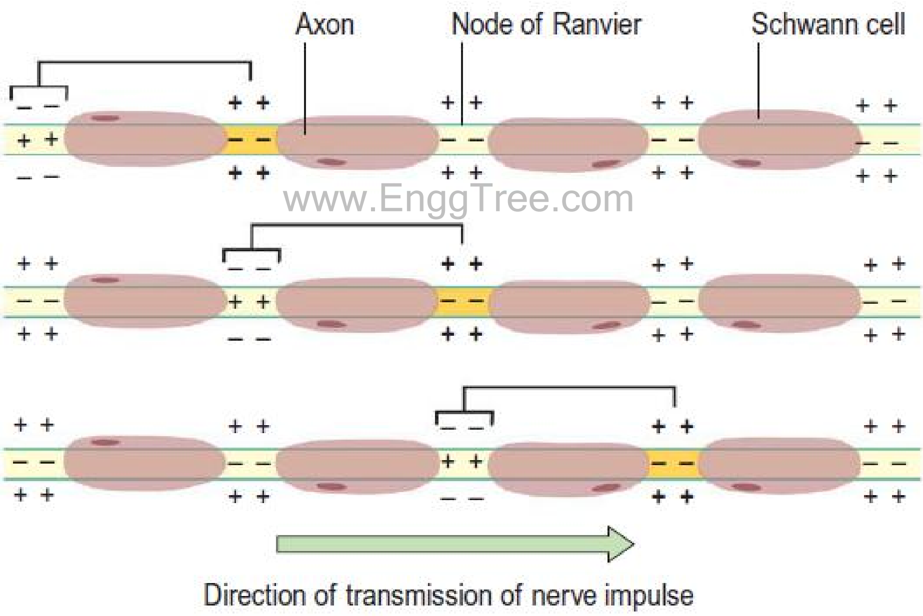


Figure Saltatory conduction of an impulse in a myelinated nerve fibre.

- In myelinated neurones, the insulating properties of the myelin sheath prevent the movement of ions. Therefore electrical changes across the membrane can only occur at the gaps in the myelin sheath, i.e. at the nodes of **Ranvier**.
- When an impulse occurs at one node, depolarisation passes along the myelin sheath to the next node so that the flow of current appears to 'leap' from one node to the next. This is called **saltatory conduction**.
- The speed of conduction depends on the diameter of the neurone: the larger the diameter, the faster the conduction.

- In addition, myelinated fibres conduct impulses faster than unmyelinated fibres because saltatory conduction is faster than continuous conduction, or *simple propagation*.
- The fastest fibres can conduct impulses to, e.g., skeletal muscles at a rate of 130 metres per second while the slowest impulses travel at 0.5 metres per second.

The synapse and neurotransmitters

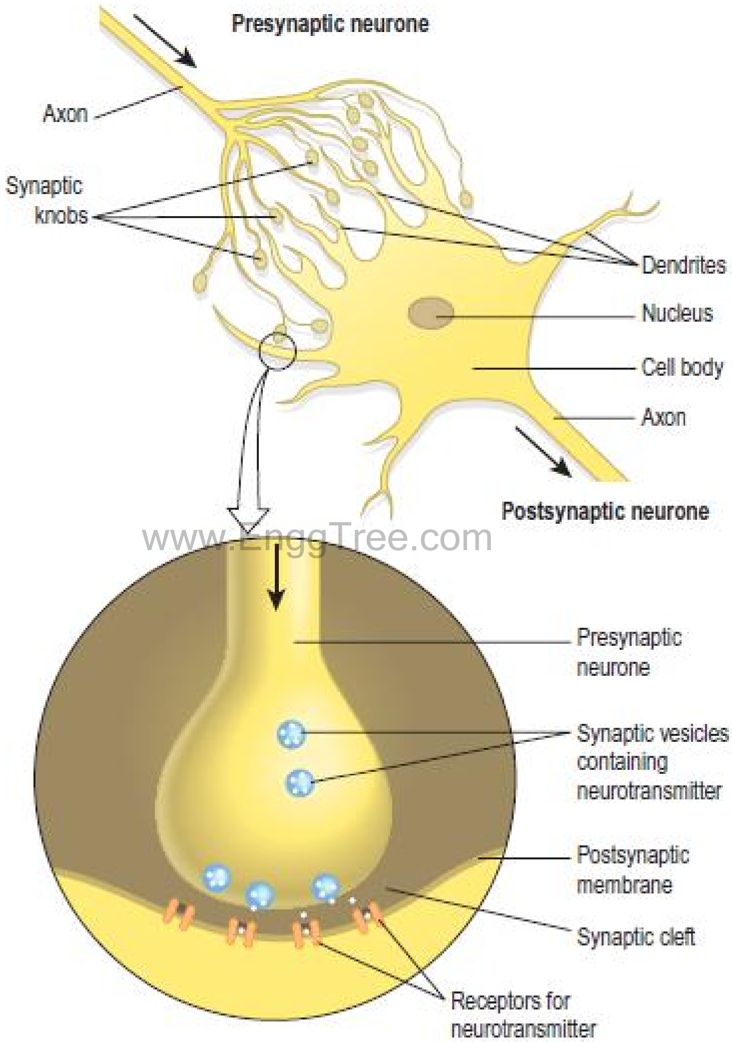


Figure Diagram of a synapse. Arrows show direction of nerve impulse.

- There is always more than one neurone involved in the transmission of a nerve impulse from its origin to its destination, whether it is sensory or motor. There is no physical contact between two neurones.
- The point at which the nerve impulse passes from the *presynaptic neurone* to the *postsynaptic neurone* is the **synapse**. At its free end, the axon of the presynaptic

neurone breaks up into minute branches that terminate in small swellings called **synaptic knobs**, or terminal boutons.

- These are in close proximity to the dendrites and the cell body of the postsynaptic neurone. The space between them is the **synaptic cleft**.
- Synaptic knobs contain spherical membrane bound *synaptic vesicles*, which store a chemical, the *neurotransmitter* that is released into the synaptic cleft.
- Neurotransmitters are synthesised by nerve cell bodies, actively transported along the axons and stored in the synaptic vesicles. They are released by exocytosis in response to the action potential and diffuse across the synaptic cleft.
- They act on specific receptor sites on the postsynaptic membrane. Their action is short lived, because immediately they have acted on the postsynaptic cell such as a muscle fibre, they are either inactivated by enzymes or taken back into the synaptic knob.
- Some important drugs mimic, neutralise (antagonise) or prolong neurotransmitter activity. Neurotransmitters usually have an excitatory effect on postsynaptic receptors but they are sometimes inhibitory.
- There are more than 50 neurotransmitters in the brain and spinal cord including noradrenaline (norepinephrine), adrenaline (epinephrine), dopamine, histamine, serotonin, gamma aminobutyric acid (GABA) and acetylcholine.

- Other substances, such as enkephalins, endorphins and substance P, have specialised roles in, for example, transmission of pain signals. Figure summarises the main neurotransmitters of the peripheral nervous system.
- Somatic nerves carry impulses directly to the synapses at skeletal muscles, the *neuromuscular junctions* stimulating contraction. In the autonomic nervous system, efferent impulses travel along two neurons (preganglionic and postganglionic) and across two synapses to the effector tissue, i.e. cardiac muscle, smooth muscle and glands, in both the sympathetic and the parasympathetic divisions.

3. Write in detail about the Nerves functions and its classification.

A nerve consists of numerous neurones collected into bundles (bundles of nerve fibres in the central nervous system are known as *tracts*). For example large nerves such as the sciatic nerves contain tens of thousands of axons. Each bundle has several coverings of protective connective tissue:

- **Endoneurium** is a delicate tissue, surrounding each individual fibre, which is continuous with the septa that pass inwards from the perineurium
- **Perineurium** is a smooth connective tissue, surrounding each *bundle* of fibres
- **Epineurium** is the fibrous tissue which surrounds and encloses a number of bundles of nerve fibres. Most large nerves are covered by epineurium.

<u>Sensory or afferent nerves</u>

Sensory nerves carry information from the body to the spinal cord. The impulses may then pass to the brain or to connector neurones of reflex arcs in the spinal cord.

Sensory receptors

Specialised endings of sensory neurones respond to different stimuli (changes) inside and outside the body.

i) Somatic, cutaneous or common senses.

These originate from the skin. They are: pain, touch, heat and cold. Sensory nerve endings in the skin are fine branching filaments without myelin sheaths. When stimulated, an impulse is generated and transmitted by the sensory nerves to the brain where the sensation is perceived.

ii) Proprioceptor senses.

These originate in muscles and joints. Impulses sent to the brain enable perception of the position of the body and its parts in space maintaining posture and balance.

iii) Special senses.

These are sight, hearing, balance, smell and taste.

iv) Autonomic afferent nerves.

These originate in internal organs, glands and tissues, e.g. baroreceptors involved in the control of blood pressure, chemoreceptors involved in the control of respiration, and are associated with reflex regulation of involuntary activity and visceral pain.

<u>Motor or efferent nerves</u>

Motor nerves originate in the brain, spinal cord and autonomic ganglia. They transmit impulses to the effector organs: muscles and glands. There are two types:

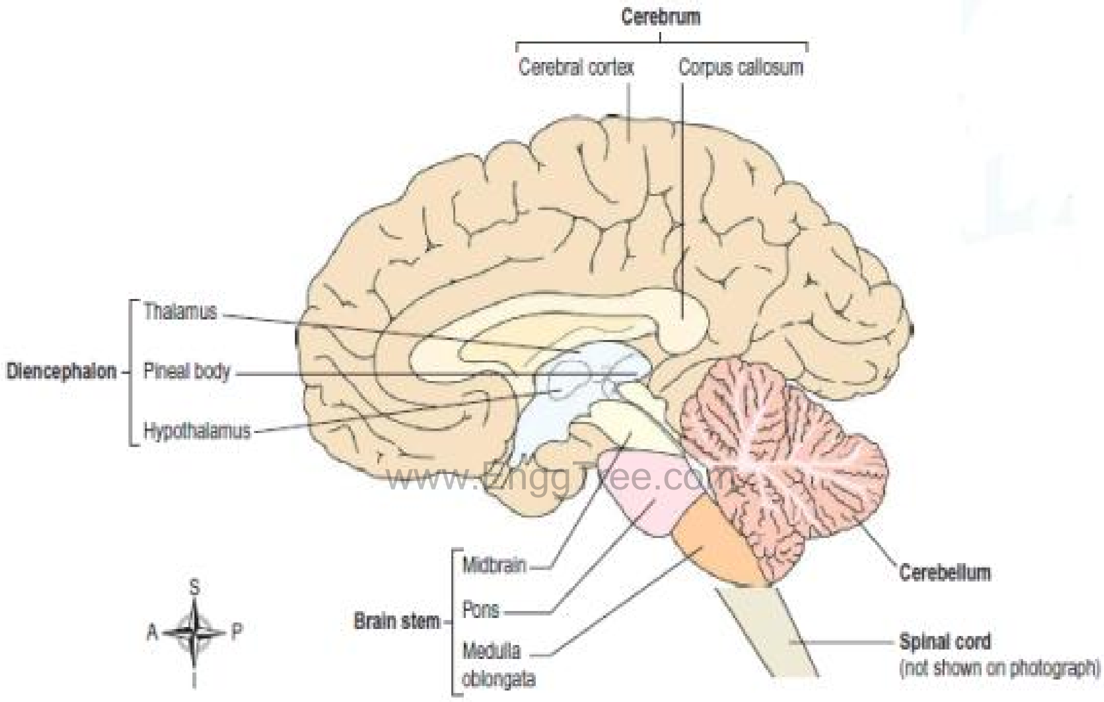
- **Somatic nerves** – involved in voluntary and reflex skeletal muscle contraction

➢ **Autonomic nerves** (sympathetic and parasympathetic) – involved in cardiac and smooth muscle contraction and glandular secretion.

Mixed nerves

In the spinal cord, sensory and motor nerves are arranged in separate groups, or *tracts*. Outside the spinal cord, when sensory and motor nerves are enclosed within the same sheath of connective tissue they are called **Mixed Nerves**.

4. Write in detail about the anatomy of Brain.



The brain is a large organ weighing around 1.4 kg that lies within the cranial cavity. Its parts are:

a) Cerebrum

b) Diencephalon

- ➢ Thalamus
- ➢ Hypothalamus
- ➢ Epithalamus (along with the pineal gland),
- ➢ Subthalamus

c) Brain stem

- ➢ Midbrain
- ➢ Pons

- Medulla oblongata

d) Cerebellum.

a) The Cerebrum:

- Also known as the cerebral cortex, the cerebrum is the largest part of the human brain, and it is associated with higher brain function such as thought and action.
- Nerve cells make up the gray surface, which is a little thicker than our thumb. White nerve fibers beneath the surface carry signals between nerve cells in other parts of the brain and body.
- Its wrinkled surface increases the surface area, and is a six-layered structure found in mammals, called the **Neocortex**.
- It is divided into four sections, called "**Lobes**". They are:
  - ✓ Frontal lobe
  - ✓ Parietal lobe
  - ✓ Occipital lobe and
  - ✓ Temporal lobe.

Functions Of The Lobes:

Frontal Lobe

The frontal lobe lies just beneath our forehead and is associated with our brain's ability to reason, organize, plan, speak, move, make facial expressions, serial task, problem solve, control inhibition, spontaneity, initiate and self-regulate behaviors, pay attention, remember and control emotions.

Parietal Lobe

The parietal lobe is located at the upper rear of our brain, and controls our complex behaviors, including senses such as vision, touch, body awareness and spatial orientation. It plays important roles in integrating sensory information from various parts of our body, knowledge of numbers and their relations, and in the manipulation of objects. Portions are involved with our visuospatial processing, language comprehension, the ability to construct, body positioning and movement, neglect/inattention, left-right differentiation and self-awareness/insight.

Occipital Lobe

The occipital lobe is located at the back of our brain, and is associated with our visual processing, such as visual recognition, visual attention, spatial analysis (moving in a 3-D world) and visual perception of body language; such as postures, expressions and gestures.

Temporal Lobe

The temporal lobe is located near our ears, and is associated with processing our perception and recognition of auditory stimuli (including our ability to focus on one sound among many, like listening to one voice among many at a party), comprehending spoken language, verbal memory, visual memory and language production (including fluency and word-finding), general knowledge and autobiographical memories.

A deep furrow divides the cerebrum into two halves, known as the left and right hemispheres. And, while the two hemispheres look almost symmetrical, each side seems to function differently. The right hemisphere is considered our creative side, and the left hemisphere is considered our logical side. A bundle of axons, called the corpus callosum, connects the two hemispheres.

b) Diencephalon

The main structures of the diencephalon include the hypothalamus, thalamus, epithalamus (along with the pineal gland), and subthalamus. Also located within the diencephalon is the third ventricle, one of the four brain ventricles or cavities filled with cerebrospinal fluid. Each part has its own role to play.

- **Thalamus**

The thalamus assists in sensory perception, regulation of motor functions, and control of sleep and wake cycles. The brain has two thalamus sections. The thalamus acts as a relay station for almost all sensory information (with the exception of smell).

Before the sensory information reaches your brain's cortex, it stops at the thalamus first. The sensory information travels to the area (or nuclei) that specialize in dealing with that sensory information and then that information passes to the cortex for further processing.

The thalamus processes information it receives from the cortex as well. It passes that information on to other parts of the brain and plays a big role in sleep and consciousness.

- **Hypothalamus**

The hypothalamus is small, about the size of an almond, and serves as the control center for many autonomic functions through the release of hormones. This part of the brain is also responsible for maintaining homeostasis, which is your body's attempt to maintain normal balance, for example, body temperature and blood pressure.

The hypothalamus receives a steady stream of information about these types of factors. When the hypothalamus recognizes an unanticipated imbalance, it enacts a mechanism to rectify that disparity.

As the main area that regulates hormone secretion and the control of hormone release from the pituitary gland, the hypothalamus has widespread effects on the body and behavior.

➢ **Epithalamus**

Located in the rear or bottom area of the diencephalon that includes the pineal gland, the epithalamus aids in sense of smell and helps to regulate sleep and wake cycles.

The pineal gland is an endocrine gland that secretes the hormone melatonin, which is thought to play an important role in the regulation of circadian rhythms responsible for sleep and wake cycles.

➢ **Subthalamus**

A portion of the subthalamus is made of tissues from the midbrain. This area is densely interconnected with the basal ganglia structures that are part of the cerebrum, which assists in motor control.

C) Brain Stem

The brain stem is located beneath the limbic system. It is responsible for vital life functions such as breathing, heartbeat, and blood pressure. The brain stem is made of the midbrain, pons, and medulla.

➢ **Pons**

The primary role of the pons is to serve as a bridge between various parts of the nervous system, including the cerebellum and cerebrum. Many important nerves that originate in the pons, such as the trigeminal nerve, responsible for feeling in the face, as well as controlling the muscles that are responsible for biting, chewing, and swallowing.

It also contains the abducens nerve, which allows us to look from side to side and the vestibularcochlear nerve, which allows to hear. As part of the brainstem, a section of the lower pons stimulates and controls the intensity of breathing, while a section of the upper pons decreases the depth and frequency of breaths. The pons is also associated with the control of sleep cycles, and controls respiration and reflexes. It is located above the medulla, below the midbrain, and just in front of the cerebellum.

➢ **Medulla**

The primary role of the medulla is regulating our involuntary life sustaining functions such as breathing, swallowing and heart rate. As part of the brain stem, it also helps transfer neural messages to and from the brain and spinal cord. It is located at the junction of the spinal cord and brain.

- **Midbrain**

The midbrain is the area of the brain situated around the cerebral aqueduct between the cerebrum above and the pons below. It consists of nuclei and nerve fibres (tracts), which connect the cerebrum with lower parts of the brain and with the spinal cord. The nuclei act as relay stations for the ascending and descending nerve fibres and have important roles in auditory and visual reflexes.

d) The Cerebellum

The cerebellum, or “little brain”, is similar to the cerebrum with its two hemispheres and highly folded surface. It is associated with regulation and coordination of movement, posture, balance and cardiac, respiratory and vasomotor centers.

5. Explain in detail about the anatomy and physiology of spinal cord.

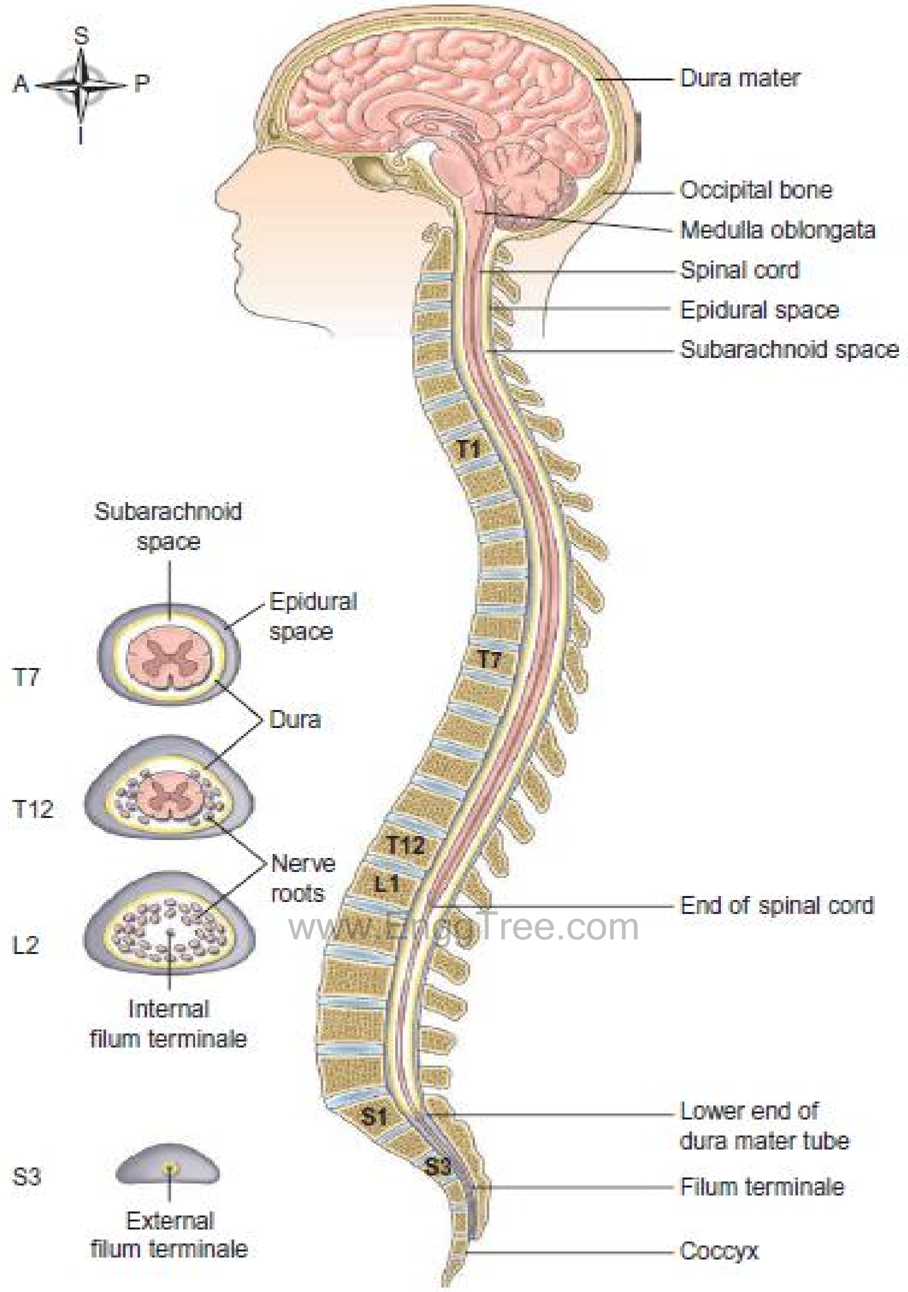


Figure shows Sections of the vertebral canal showing the epidural space.

- The spinal cord is the elongated, almost cylindrical part of the **central nervous system**, which is suspended in the vertebral canal surrounded by the meninges and cerebrospinal fluid.
- The spinal cord is continuous above with the medulla oblongata and extends from the upper border of the atlas (first cervical vertebra) to the lower border of the 1st lumbar vertebra.

- It is approximately 45 cm long in adult males, and is about the thickness of the little finger. A specimen of cerebrospinal fluid can be taken using a procedure called *lumbar puncture*.
- Except for the cranial nerves, the spinal cord is the nervous tissue link between the brain and the rest of the body. Nerves conveying impulses from the brain to the various organs and tissues descend through the spinal cord.
- At the appropriate level they leave the cord and pass to the structure they supply. Similarly, sensory nerves from organs and tissues enter and pass upwards in the spinal cord to the brain.
- Some activities of the spinal cord are independent of the brain and are controlled at the level of the spinal cord by *spinal reflexes*.
- To facilitate these, there are extensive neurone connections between sensory and motor neurones at the same or different levels in the cord.
- The spinal cord is incompletely divided into two equal parts, anteriorly by a short, shallow **median fissure** and posteriorly by a deep narrow septum, the *posterior* **median septum**.

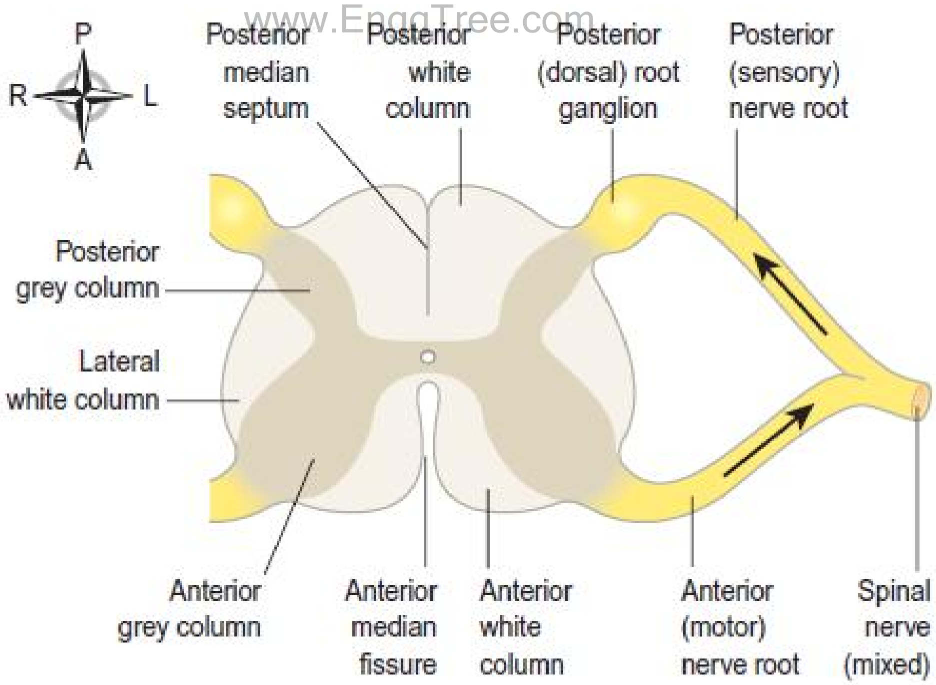


Figure shows a transverse section of the spinal cord showing Nerve roots on one side.

- A cross-section of the spinal cord shows that it is composed of grey matter in the centre surrounded by white matter supported by neuroglia. Figure shows the parts of the spinal cord and the nerve roots on one side. The other side is the same.

Grey matter

- The arrangement of grey matter in the spinal cord resembles the shape of the letter H, having *two posterior*, *two anterior* and *two lateral columns*.
- The area of grey matter lying transversely is the *transverse commissure* and it is pierced by the central canal, an extension from the fourth ventricle, containing cerebrospinal fluid.
- The nerve cell bodies may belong to:
    - **Sensory neurones**, which receive impulses from the periphery of the body
    - **Lower motor neurones**, which transmit impulses to the skeletal muscles
    - **Connector neurones**, also known as interneurones linking sensory and motor neurones, at the same or different levels, which form spinal reflex arcs. One neurone to another, there is a **synapse**.

Posterior columns of grey matter

These are composed of cell bodies that are stimulated by sensory impulses from the periphery of the body. The nerve fibres of these cells contribute to the white matter of the cord and transmit the sensory impulses upwards to the brain.

Anterior columns of grey matter

These are composed of the cell bodies of the lower motor neurones that are stimulated by the upper motor neurons or the connector neurones linking the anterior and posterior columns to form reflex arcs. The *posterior root* (*spinal*) *ganglia* are formed by the cell bodies of the sensory nerves.

White matter

- The white matter of the spinal cord is arranged in three *columns* or *tracts*; anterior, posterior and lateral. These tracts are formed by sensory nerve fibres ascending to the brain, motor nerve fibres descending from the brain and fibres of connector neurones.
- Tracts are often named according to their points of origin and destination, e.g. spinothalamic, corticospinal.

6. Discuss about the functional pathway of spinal cord and its reflex mechanism.

Functional Pathway Of Spinal Cord

Sensory nerve tracts in the spinal cord

Neurones that transmit impulses towards the brain are called sensory (afferent, ascending). There are two main sources of sensation transmitted to the brain via the spinal cord.

(i) The skin.

Sensory receptors (nerve endings) in the skin are stimulated by pain, heat, cold and touch, including pressure. The nerve impulses generated are conducted by three neurones to the sensory area in the *opposite hemisphere of the cerebrum* where the sensation and its location are perceived.

Crossing to the other side, or decussation, occurs either at the level of entry into the cord or in the medulla.

(ii) The tendons, muscles and joints.

Sensory receptors are specialised nerve endings in these structures, called *proprioceptors*, and they are stimulated by stretch. Together with impulses from the eyes and the ears, they are associated with the maintenance of balance and posture, and with perception of the position of the body in space. These nerve impulses have two destinations:

- By a three-neurone system, the impulses reach the sensory area of the opposite hemisphere of the cerebrum
- By a two-neurone system, the nerve impulses reach the cerebellar hemisphere on the same side.

Motor nerve tracts in the spinal cord

Neurones that transmit nerve impulses away from the brain are motor (efferent or descending) neurones. Stimulation of the motor neurones results in:

- Contraction of skeletal (**voluntary**) muscle, or
- Contraction of smooth (**involuntary**) muscle, cardiac muscle and the secretion by glands controlled by nerves of the autonomic nervous system.

Voluntary muscle movement

The contraction of muscles that move the joints is, in the main, under conscious (voluntary) control, which means that the stimulus to contract originates at the level of consciousness in the cerebrum. However, skeletal muscle activity is regulated by output from the midbrain, brain stem and cerebellum. This involuntary activity is associated with coordination of muscle activity, e.g. when very fine movement is required and in the maintenance of posture and balance.

Efferent nerve impulses are transmitted from the brain to other parts of the body via bundles of nerve fibres (tracts) in the spinal cord. The *motor pathways* from the brain to the muscles are made up of two neurones. These pathways, or tracts, are either:

- Pyramidal (corticospinal), or
- Extrapyramidal.

The upper motor neurone.

This has its cell body (Betz's cell) in the primary motor area of the cerebrum. The axons pass through the internal capsule, pons and medulla. In the spinal cord they form the lateral corticospinal tracts of white matter and the fibres synapse with the cell bodies of the lower motor neurones in the anterior columns of grey matter.

The axons of the upper motor neurons make up the pyramidal tracts and decussate in the medulla oblongata, forming the pyramids.

The lower motor neurone.

This has its cell body in the anterior horn of grey matter in the spinal cord. Its axon emerges from the spinal cord by the anterior root, joins with the incoming sensory fibres and forms the mixed spinal nerve that passes through the intervertebral foramen.

Near its termination in skeletal muscle the axon branches into many tiny fibres, each of which is in close association with a sensitive area on the muscle fibre membrane known as a *motor end plate* and .

The motor end plates of each nerve and the muscle fibres they supply form a *motor unit*. The neurotransmitter that transmits the nerve impulse across the neuromuscular junction (synapse) to stimulate a skeletal muscle fibre is *acetylcholine*. Motor units contract as a whole and the strength of the muscle contraction depends on the number of motor units in action at any time.

The lower motor neurone is the *final common pathway* for the transmission of nerve impulses to skeletal muscles. The cell body of this neurone is influenced by a number of upper motor neurones originating from various sites in the brain and by some neurones which begin and end in the spinal cord.

Some of these neurons stimulate the cell bodies of the lower motor neurone while others have an inhibiting effect. The outcome of these influences is smooth, coordinated muscle movement, some of which is voluntary and some involuntary.

Involuntary muscle movement

Upper motor neurones.

These have their cell bodies in the brain at a level *below* the cerebrum, i.e. in the midbrain, brain stem, cerebellum or spinal cord. They influence muscle activity that maintains posture and balance, coordinates skeletal muscle movement and controls muscle tone.

Spinal reflexes.

These consist of three elements:

- Sensory neurones
- Connector neurones (or interneurones) in the spinal cord
- Lower motor neurones.

- In the simplest *reflex arc* there is only one of each type of the neurones above. A *reflex action* is an involuntary and immediate motor response to a sensory stimulus. Many connector and motor neurones may be stimulated by afferent impulses from a small area of skin.
- For example, the pain impulses initiated by touching a very hot surface with the finger are transmitted to the spinal cord by sensory fibres in mixed nerves. These stimulate many connector and lower motor neurons in the spinal cord, which results in the contraction of many skeletal muscles of the hand, arm and shoulder, and the removal of the finger.
- Reflex action happens very quickly; in fact, the motor response may occur simultaneously with the perception of the pain in the cerebrum. Reflexes of this type are invariably protective but they can occasionally be inhibited. For example, if a precious plate is very hot when lifted every effort will be made to overcome the pain to prevent dropping it.

Stretch reflexes.

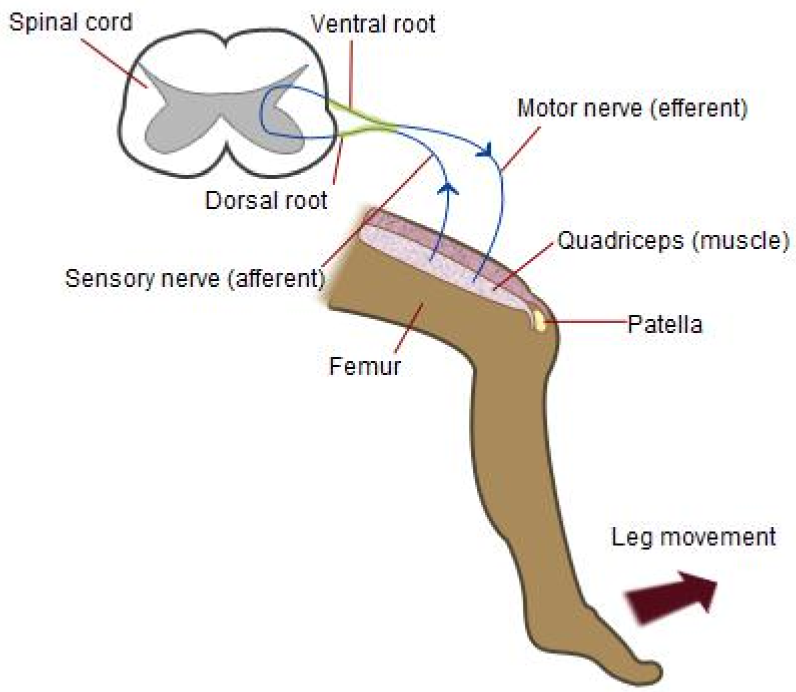


Figure shows The knee jerk reflex

- Only two neurones are involved. The cell body of the lower motor neurone is stimulated directly by the sensory neurone, with no connector neurone in between.
- The *knee jerk* is one example, but this type of reflex can be demonstrated at any point where a stretched tendon crosses a joint. By tapping the tendon just below the knee when it is bent, the sensory nerve endings in the tendon and in the thigh muscles are stretched.

- This initiates a nerve impulse that passes into the spinal cord to the cell body of the lower motor neurone in the anterior column of grey matter on the same side. As a result the thigh muscles suddenly contract and the foot kicks forward. This is used as a test of the integrity of the reflex arc.
- This type of reflex also has a protective function – it prevents excessive joint movement that may damage tendons, ligaments and muscles.

Autonomic reflexes.

These include the pupillary light reflex when the pupil immediately constricts, in response to bright light, preventing retinal damage.

PERIPHERAL NERVOUS SYSTEM

7. Write a brief details about the peripheral nerves system(PNS).

This part of the nervous system consists of:

- 31 pairs of **spinal nerves** that originate from the spinal cord
- 12 pairs of **cranial nerves**, which originate from the brain
- The **autonomic nervous system**.

Most of the nerves of the peripheral nervous system are composed of sensory fibres that transmit afferent impulses from sensory organs to the brain, or motor nerve fibres that transmit efferent impulses from the brain to the effector organs, e.g. skeletal muscles, smooth muscle and glands.

Spinal nerves

Thirty-one pairs of spinal nerves leave the vertebral canal by passing through the intervertebral foramina formed by adjacent vertebrae. They are named and grouped according to the vertebrae with which they are associated:

- 8 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 1 coccygeal.

Although there are only seven cervical vertebrae, there are eight nerves because the first pair leaves the vertebral canal between the occipital bone and the atlas (first cervical vertebra) and the eighth pair leaves below the last cervical vertebra. Thereafter the nerves are given the name and number of the vertebra immediately *above*.

The lumbar, sacral and coccygeal nerves leave the spinal cord near its termination, at the level of the 1st lumbar vertebra, and extend downwards inside the vertebral canal in the subarachnoid space, forming a sheaf of nerves which resembles a horse's tail, the *cauda equina*.

These nerves leave the vertebral canal at the appropriate lumbar, sacral or coccygeal level, depending on their destination.

Nerve roots

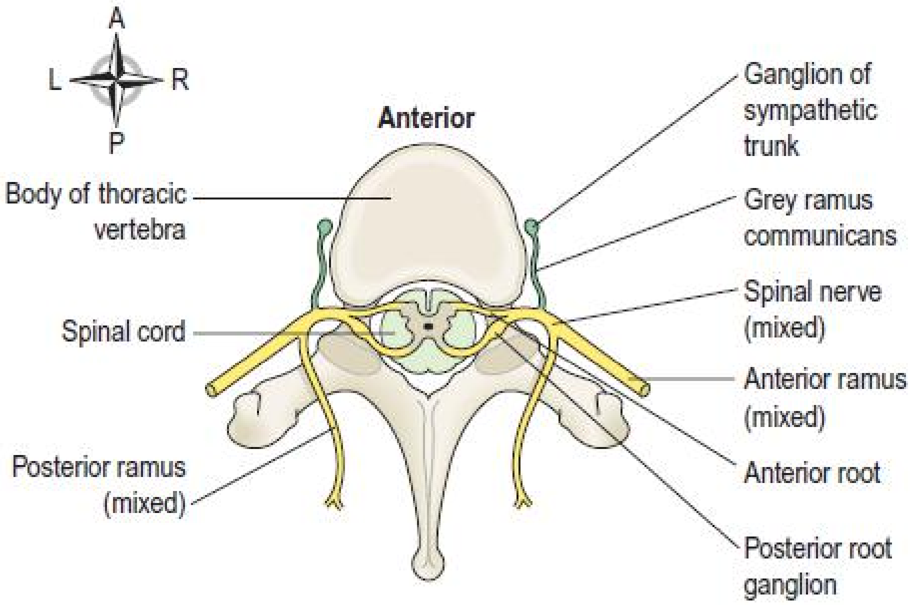


Figure shows The relationship between sympathetic and mixed spinal nerves

- The spinal nerves arise from both sides of the spinal cord and emerge through the intervertebral foramina. Each nerve is formed by the union of a *motor* (anterior) and a *sensory* (posterior) *nerve root* and is, therefore, a *mixed nerve*.
- Thoracic and upper lumbar (L1 and L2) spinal nerves have a contribution from the sympathetic part of the autonomic nervous system in the form of a *preganglionic fibre* (neurone).
- Bones and joints are supplied by adjacent nerves. The *anterior nerve root* consists of motor nerve fibres, which are the axons of the lower motor neurones from the anterior column of grey matter in the spinal cord and, in the thoracic and lumbar regions, *sympathetic nerve fibres*, which are the axons of cells in the lateral columns of grey matter.
- The *posterior nerve root* consists of sensory nerve fibres. Just outside the spinal cord there is a *spinal ganglion* (posterior, or dorsal, root ganglion), consisting of a little cluster of cell bodies.
- Sensory nerve fibres pass through these ganglia before entering the spinal cord. The area of skin whose sensory receptors contribute to each nerve is called a *dermatome*.
- For a very short distance after leaving the spinal cord the nerve roots have a covering of *dura* and *arachnoid maters*. These terminate before the two roots join to form the mixed spinal nerve. The nerve roots have no coveringof pia mater.

Branches

Immediately after emerging from the intervertebral foramen, spinal nerves divide into branches, or *rami*: a ramus communicans, a posterior ramus and an anterior ramus. The *rami communicante* are part of preganglionic sympathetic neurones of the autonomic nervous system.

The *posterior rami* pass backwards and divide into smaller medial and lateral branches to supply skin and muscles of relatively small areas of the posterior aspect of the head, neck and trunk.

The *anterior rami* supply the anterior and lateral aspects of the neck, trunk and the upper and lower limbs.

Plexuses

In the cervical, lumbar and sacral regions the anterior rami unite near their origins to form large masses of nerves, or *plexuses*, where nerve fibres are regrouped and rearranged before proceeding to supply skin, bones, muscles and joints of a particular area.

This means that these structures have a nerve supply from more than one spinal nerve and therefore damage to one spinal nerve does not cause loss of function of a region.

Moreover, they lie deep within the body, often under large muscles, and are therefore well protected from injury. In the thoracic region the anterior rami do not form plexuses.

There are five large plexuses of mixed nerves formed on each side of the vertebral column. They are the:

- ✓ cervical plexuses
- ✓ brachial plexuses
- ✓ lumbar plexuses
- ✓ sacral plexuses
- ✓ coccygeal plexuses.

Thoracic nerves

The thoracic nerves *do not* intermingle to form plexuses. There are 12 pairs and the first 11 are the *intercostal nerves*. They pass between the ribs supplying them, the intercostals muscles and overlying skin. The 12th pair comprises the *subcostal nerves*. The 7th–12th thoracic nerves also supply the muscles and the skin of the posterior and anterior abdominal walls.

Cranial nerves

There are 12 pairs of cranial nerves originating from nuclei in the inferior surface of the brain, some sensory, some motor and some mixed. Their names suggest their distribution or function, which, in the main, is generally related to the head and neck. They are numbered using Roman numerals according to the order they connect to the brain, starting anteriorly. They are:

i. **Olfactory (Smell)**
ii. **Optic (Sight)**
iii. **Oculomotor (Moves eyelid and eyeball and adjusts the pupil and lens of the eye)**
iv. **Trochlear (Moves eyeballs)**
v. **Trigeminal (Facial muscles incl. chewing; Facial sensations)**
vi. **Abducens (Moves eyeballs)**
vii. **Facial (Taste, tears, saliva, facial expressions)**
viii. **Vestibulocochlear (Auditory)**
ix. **Glossopharyngeal (Swallowing, saliva, taste)**
x. **Vagus (Control of PNS e.g. smooth muscles of GI tract)**

xi. **Accessory (Moving head & shoulders, swallowing)**
xii. **Hypoglossal (Tongue muscles - speech & swallowing)**

8. **Discuss about the Endocrine glands and functions. (or) write a short note about Pituitary and thyroid gland.**

ENDOCRINE SYSTEM

The Endocrine system consists of glands widely separated from each other with no physical connections. Endocrine glands are groups of secretory cells surrounded by an extensive network of capillaries that facilitates diffusion of *hormones* (chemical messengers) from the secretory cells into the bloodstream.

They are also referred to as *ductless glands* because hormones diffuse directly into the bloodstream. Hormones are then carried in the bloodstream to *target tissues* and *organs* that may be quite distant, where they influence cell growth and metabolism.

Homeostasis of the internal environment is maintained partly by the autonomic nervous system and partly by the endocrine system. The autonomic nervous system is concerned with rapid changes, while endocrine control is mainly involved in slower and more precise adjustments.

Although the hypothalamus is classified as a part of the brain rather than an endocrine gland, it controls the pituitary gland and indirectly influences many others. The ovaries and the testes secrete hormones associated with the reproductive system after puberty. The placenta that develops to nourish the developing fetus during pregnancy also has an endocrine function.

The main endocrine glands and many other organs and tissues also secrete hormones as a secondary function e.g. adipose tissue produces leptin, involved in the regulation of appetite; the heart secretes Atrial Natriuretic Peptide (ANP) that acts on the kidneys.

Other hormones do not travel to remote organs but act locally e.g.prostaglandins. Changes in endocrine functions that accompany ageing are explored. Problems that arise when abnormalities occur are usually caused by the over or under-activity of endocrine glands and are explained in the final sections of this chapter.

Overview of hormone action

When a hormone arrives at its target cell, it binds to a specific *receptor*, where it acts as a switch influencing chemical or metabolic reactions inside the cell. Receptors for peptide hormones are situated on the cell membrane and those for lipid-based hormones are located inside cells.

The level of a hormone in the blood is variable and self-regulating within its normal range. A hormone is released in response to a specific stimulus and usually its action reverses or negates the stimulus through a *negative feedback mechanism*.

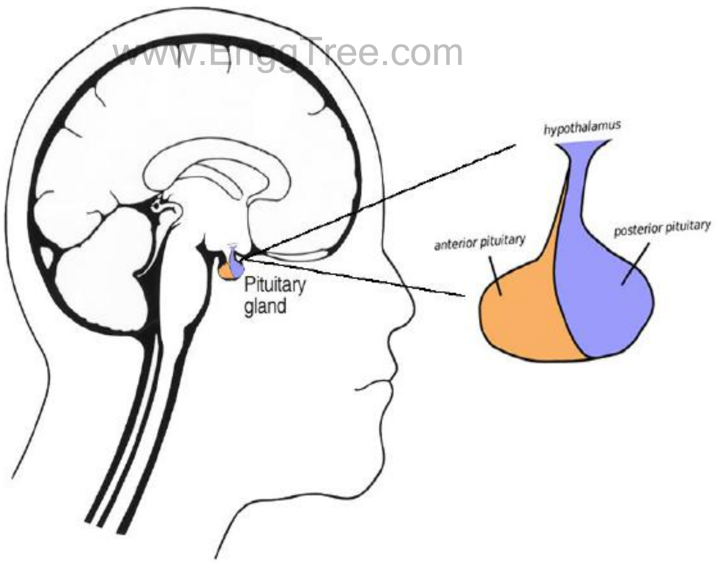
This may be controlled either indirectly through the release of hormones by the hypothalamus and the anterior pituitary gland, e.g. steroid and thyroid hormones, or directly by blood levels of the stimulus, e.g. insulin and glucagon and determined by plasma glucose levels.

The effect of a *positive feedback mechanism* is amplification of the stimulus and increasing release of the hormone until a particular process is complete and the stimulus ceases, e.g. release of oxytocin during labour.

PITUITARY GLAND:

The **pituitary gland** is a tiny organ, the size of a pea, found at the base of the brain. Also called as "master **gland**" of the body, it produces many hormones that travel throughout the body, directing certain processes or stimulating other **glands** to produce other hormones.

It's attached to the hypothalamus by a stalk like structure. The hypothalamus is a small area of your brain. It's very important in controlling the balance of your bodily functions. It controls the release of hormones from the pituitary gland.



The pituitary gland can be divided into two different parts: the anterior and posterior lobes.

Anterior lobe

The anterior lobe of your pituitary gland is made up of several different types of cells that produce and release different types of hormones, including:

- **Growth hormone.** regulates growth and physical development. It can stimulate growth in almost all of your tissues. Its primary targets are bones and muscles.
- **Thyroid-stimulating hormone.** activates your thyroid to release thyroid hormones. Your thyroid gland and the hormones it produces are crucial for metabolism.
- **Adrenocorticotropic hormone.** stimulates your adrenal glands to produce cortisol and other hormones.
- **Follicle-stimulating hormone.** is involved with estrogen secretion and the growth of egg cells in women. It's also important for sperm cell production in men.
- **Luteinizing hormone.** is involved in the production of estrogen in women and testosterone in men.
- **Prolactin.** helps women who are breastfeeding produce milk.
- **Endorphins.** Have pain-relieving properties and are thought to be connected to the "pleasure centers" of the brain.
- **Enkephalins.** are closely related to endorphins and have similar pain-relieving effects.
- **Beta-melanocyte-stimulating hormone.** helps to stimulate increased pigmentation of your skin in response to exposure to ultraviolet radiation.

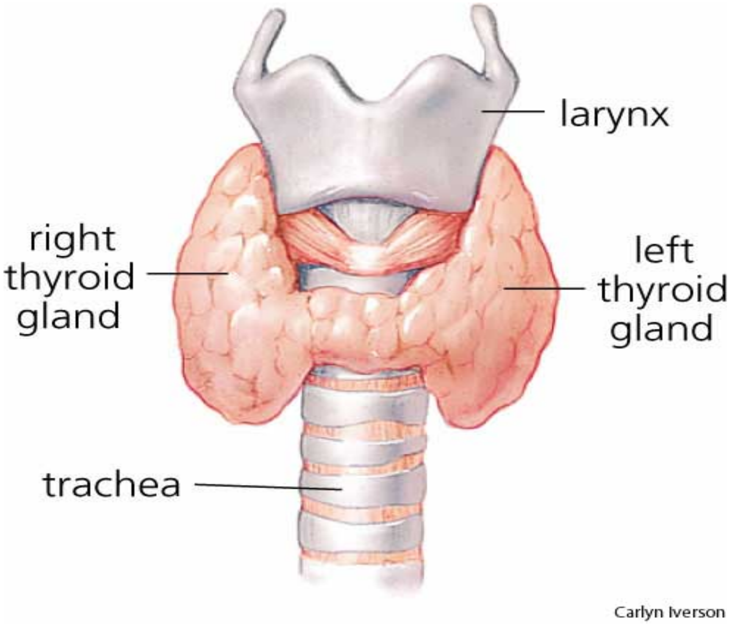
Posterior lobe

The posterior lobe of the pituitary gland also secretes hormones. These hormones are usually produced in your hypothalamus and stored in the posterior lobe until they're released.

Hormones stored in the posterior lobe include:

- **Vasopressin.** This is also called antidiuretic hormone. It helps your body conserve water and prevent dehydration.
- **Oxytocin.** This hormone stimulates the release of breast milk. It also stimulates contractions of the uterus during labor.

THYROID GLAND:



The thyroid gland is a vital hormone gland: It plays a major role in the metabolism, growth and development of the human body. It helps to regulate many body functions by constantly releasing a steady amount of thyroid hormones into the bloodstream. If the body needs more energy in certain situations – for instance, if it is growing or cold, or during pregnancy – the thyroid gland produces more hormones.

This organ (medical term: glandula thyreoidea) is found at the front of the neck, under the voice box. It is butterfly-shaped: The two side lobes lie against and around the windpipe (trachea), and are connected at the front by a narrow strip of tissue.

The thyroid weighs between 20 and 60 grams on average. It is surrounded by two fibrous capsules. The outer capsule is connected to the voice box muscles and many important vessels and nerves. There is loose connective tissue between the inner and the outer capsule, so the thyroid can move and change its position when we swallow.

The thyroid tissue itself consists of a lot of small individual lobules that are enclosed in thin layers of connective tissue. These lobules contain a great number of small vesicles (sacs) – called follicles – which store thyroid hormones in the form of little droplets.

The thyroid gland produces three hormones:

- Tri iodothyronine, also known as T3

- Tetraiodothyronine, also called thyroxine or T4
- calcitonin

Strictly speaking, only T3 and T4 are proper thyroid gland. They are made in what are known as the follicular epithelial cells of the thyroid.

Iodine is one of the main building blocks of both hormones. Our bodies can't produce this trace element, so we need to get enough of it in our diet. Iodine is absorbed into our bloodstream from food in bowel. It is then carried to the thyroid gland, where it is eventually used to make thyroid gland

Sometimes our bodies need more thyroid hormone, and sometimes they need less. To make the exact right amount of hormones, the thyroid gland needs the help of another gland: the pituitary gland. The pituitary gland "tells" the thyroid gland whether to release more or less hormones into the bloodstream. Also, a certain amount of thyroid hormones are attached to transport proteins in the blood. If the body needs more hormones, T3 and T4 can be released from the proteins in the blood and do their job.

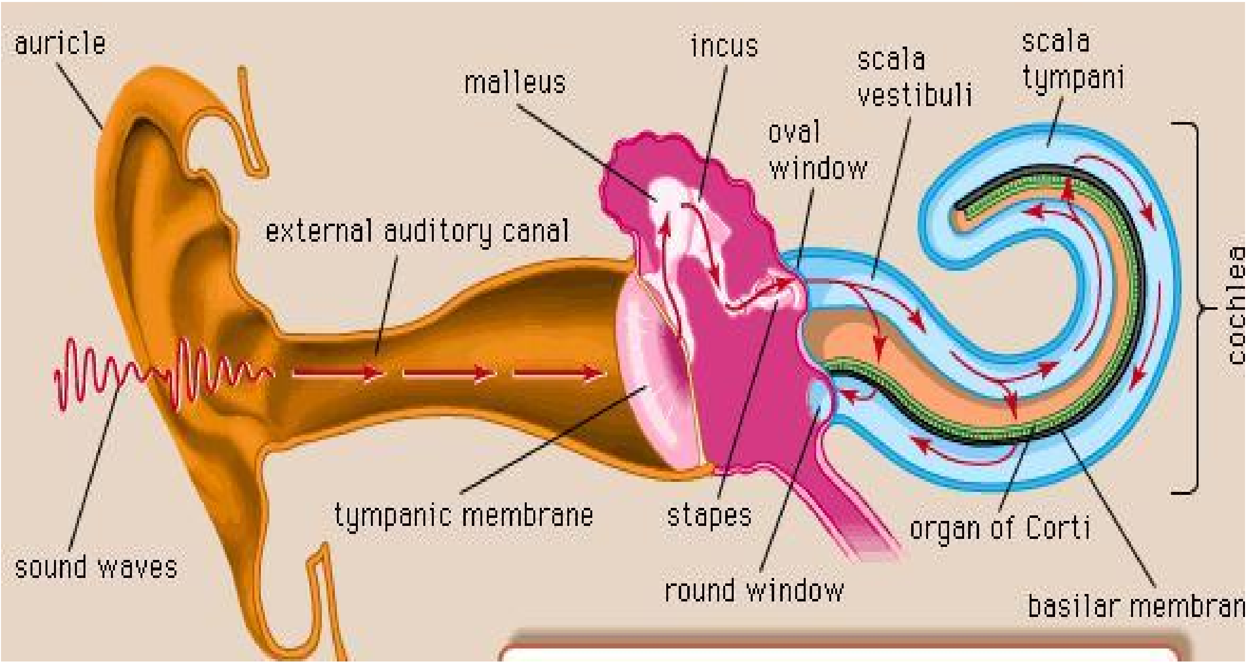
The third hormone produced by the thyroid gland is called calcitonin. Calcitonin is made by C-cells. It is involved in calcium and bone metabolism.

T3 and T4 increase the basal metabolic rate. They make all of cells in the body work harder, so the cells need more energy too. This has the following effects, for example:

- Body temperature rises
- Faster pulse and stronger heartbeat
- Food is used up more quickly because energy stored in the liver and muscles is broken down
- The brain matures (in children)
- Growth is promoted (in children).
- Activation of the nervous system leads to improved concentration and faster reflexes

An overactive thyroid (also known as hyperthyroidism) occurs if the thyroid gland makes too many hormones. An underactive thyroid (hypothyroidism) is where the gland doesn't make enough hormones. Both of these imbalances can lead to a great number of symptoms.

9. Explain the mechanism involved in the hearing sound.



- 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 tympanum.
- The vibrations are picked up by the malleus on the other side.
- These vibrations are transmitted to the fenestra ovalis via the incus and the stapes.
- The vibrations that strike the oval window are amplified 22 times more than those that struck the tympanum.
- These vibrations travel along the vestibular canal to the end of the cochlea and then to the tympanic canal. The vibrations are also transmitted via the Reisnner's membrane to the basilar membrane and then to the tympanic canal.
- Note that the vibrations travel along the vestibular and tympanic canals in the opposite directions.
- 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 exact mechanism of transformation of the sound waves into the action potentials is not known.
- The action potentials are then transmitted as nerve impulses to the auditory cortex of the brain through the auditory nerve.

Hearing, or **auditory perception** is the ability to perceive sound by detecting vibrations, changes in the pressure of the surrounding medium through time, through an organ such as the ear.

Sound may be heard through solid, liquid, or gaseous matter.[2] It is one of the traditional five senses; partial or total inability to hear is called hearing loss.

In humans and other vertebrates, hearing is performed primarily by the auditory system: mechanical waves, known as vibrations are detected by the ear and transduced into nerve impulses that are perceived by the brain (primarily in the temporal lobe). Like touch, audition requires sensitivity to the movement of molecules in the world outside the organism. Both hearing and touch are types of mechanosensation

Hearing mechanism:

There are three main components of the human ear: the outer ear, the middle ear, and the inner ear.

Outer ear

- The outer ear includes the pinna, the visible part of the ear, as well as the ear canal which terminates at the eardrum, also called the tympanic membrane. The pinna serves to focus sound waves through the ear canal toward the eardrum.
- Because of the asymmetrical character of the outer ear of most mammals, sound is filtered differently on its way into the ear depending on what vertical location it is coming from. This gives these animals the ability to localize sound vertically.
- The eardrum is an airtight membrane, and when sound waves arrive there, they cause it to vibrate following the waveform of the sound.

Middle ear

- The middle ear consists of a small air-filled chamber that is located medial to the eardrum. Within this chamber are the three smallest bones in the body, known collectively as the ossicles which include the malleus, incus and stapes (sometimes referred to colloquially as the hammer, anvil and stirrup respectively).

- They aid in the transmission of the vibrations from the eardrum to the inner ear. The purpose of the middle ear ossicles is to overcome the impedance mismatch between air and water, by providing impedance matching.
- Also located in the middle ear are the stapedius and tensor tympani muscles which protect the hearing mechanism through a stiffening reflex. The stapes transmits sound waves to the inner ear through the oval window, a flexible membrane separating the air-filled middle ear from the fluid-filled inner ear.
- The round window, another flexible membrane, allows for the smooth displacement of the inner ear fluid caused by the entering sound waves.

Inner ear

- The inner ear consists of the cochlea, which is a spiral-shaped, fluid-filled tube. It is divided lengthwise by the organ of Corti, which is the main organ of mechanical to neural transduction.
- Inside the organ of Corti is the basilar membrane, a structure that vibrates when waves from the middle ear propagate through the cochlear fluid – endolymph.

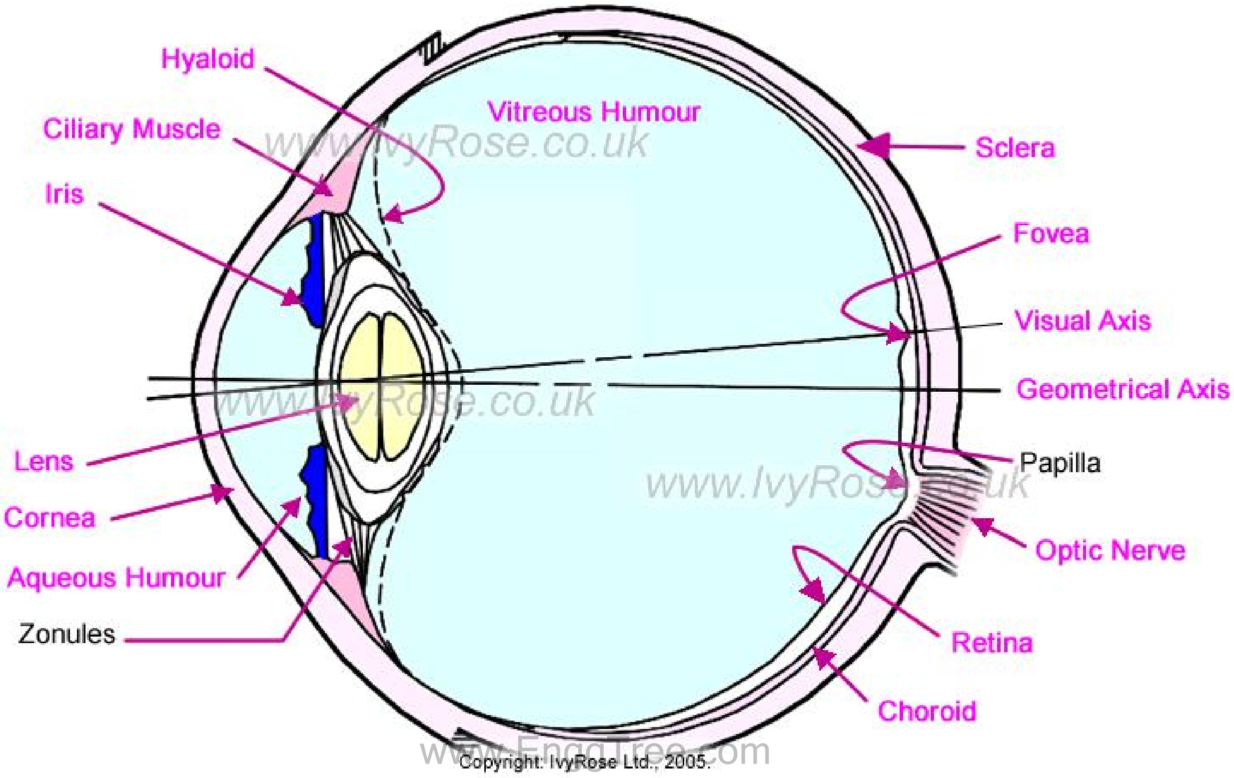
- The basilar membrane is tonotopic, so that each frequency has a characteristic place of resonance along it. Characteristic frequencies are high at the basal entrance to the cochlea, and low at the apex.
- Basilar membrane motion causes depolarization of the hair cells, specialized auditory receptors located within the organ of Corti.
- While the hair cells do not produce action potentials themselves, they release neurotransmitter at synapses with the fibers of the auditory nerve, which does produce action potentials.
- In this way, the patterns of oscillations on the basilar membrane are converted to spatiotemporal patterns of firings which transmit information about the sound to the brainstem.

Hearing loss:

- Conductive hearing loss
- Sensorineural hearing loss

- Mixed hearing loss

10. Draw the structure of human eye. Explain the functional properties of each part of eye.



Eye Parts

Cornea

The cornea is the outer covering of the eye. This dome-shaped layer protects your eye from elements that could cause damage to the inner parts of the eye. There are several layers of the cornea, creating a tough layer that provides additional protection. These layers regenerate very quickly, helping the eye to eliminate damage more easily.

The cornea also allows the eye to properly focus on light more effectively. Those who are having trouble focusing their eyes properly can have their corneas surgically reshaped to eliminate this problem.

Sclera

The sclera is commonly referred to as the "whites" of the eye. This is a smooth, white layer on the outside, but the inside is brown and contains grooves that help the tendons of the eye attach properly.

The sclera provides structure and safety for the inner workings of the eye, but is also flexible so that the eye can move to seek out objects as necessary.

Pupil

The pupil appears as a black dot in the middle of the eye. This black area is actually a hole that takes in light so the eye can focus on the objects in front of it.

Iris

The iris is the area of the eye that contains the pigment which gives the eye its color. This area surrounds the pupil, and uses the dilator pupillae muscles to widen or close the pupil.

This allows the eye to take in more or less light depending on how bright it is around you. If it is too bright, the iris will shrink the pupil so that they eye can focus more effectively.

Conjunctiva Glands

These are layers of mucus which help keep the outside of the eye moist. If the eye dries out it can become itchy and painful. It can also become more susceptible to damage or infection. If the conjunctiva glands become infected the patient will develop "pink eye."

Lacrimal Glands

These glands are located on the outer corner of each eye. They produce tears which help moisten the eye when it becomes dry, and flush out particles which irritate the eye. As tears flush out potentially dangerous irritants, it becomes easier to focus properly.

Lens

The lens sits directly behind the pupil. This is a clear layer that focuses the light the pupil takes in. It is held in place by the ciliary muscles, which allow the lens to change shape depending on the amount of light that hits it so it can be properly focused.

Retina

The light focuses by the lens will be transmitted onto the retina. This is made of rods and cones arranged in layers, which will transmit light into chemicals and electrical pulses. The retina is located in the back of the eye, and is connected to the optic nerves that will transmit the images the eye sees to the brain so they can be interpreted.

The back of the retina, known as the macula, will help interpret the details of the object the eye is working to interpret. The center of the macula, known as the fova will increase the detail of these images to a perceivable point.

Ciliary Body

Ciliary body is a ring-shaped tissue which holds and controls the movement of the eye lens, and thus, it helps to control the shape of the lens.

Choroid

The choroid lies between the retina and the sclera, which provides blood supply to the eye. Just like any other portion of the body, the blood supply gives nutrition to the various parts of the eye.

Vitreous Humor

The vitreous humor is the gel located in the back of the eye which helps it hold its shape. This gel takes in nutrients from the ciliary body, aqueous humor and the retinal vessels so the eye can remain healthy. When debris finds its way into the vitreous humor, it causes the eye to perceive "floaters," or spots that move across the vision area that cannot be attributed to objects in the environment.

Aqueous Humor

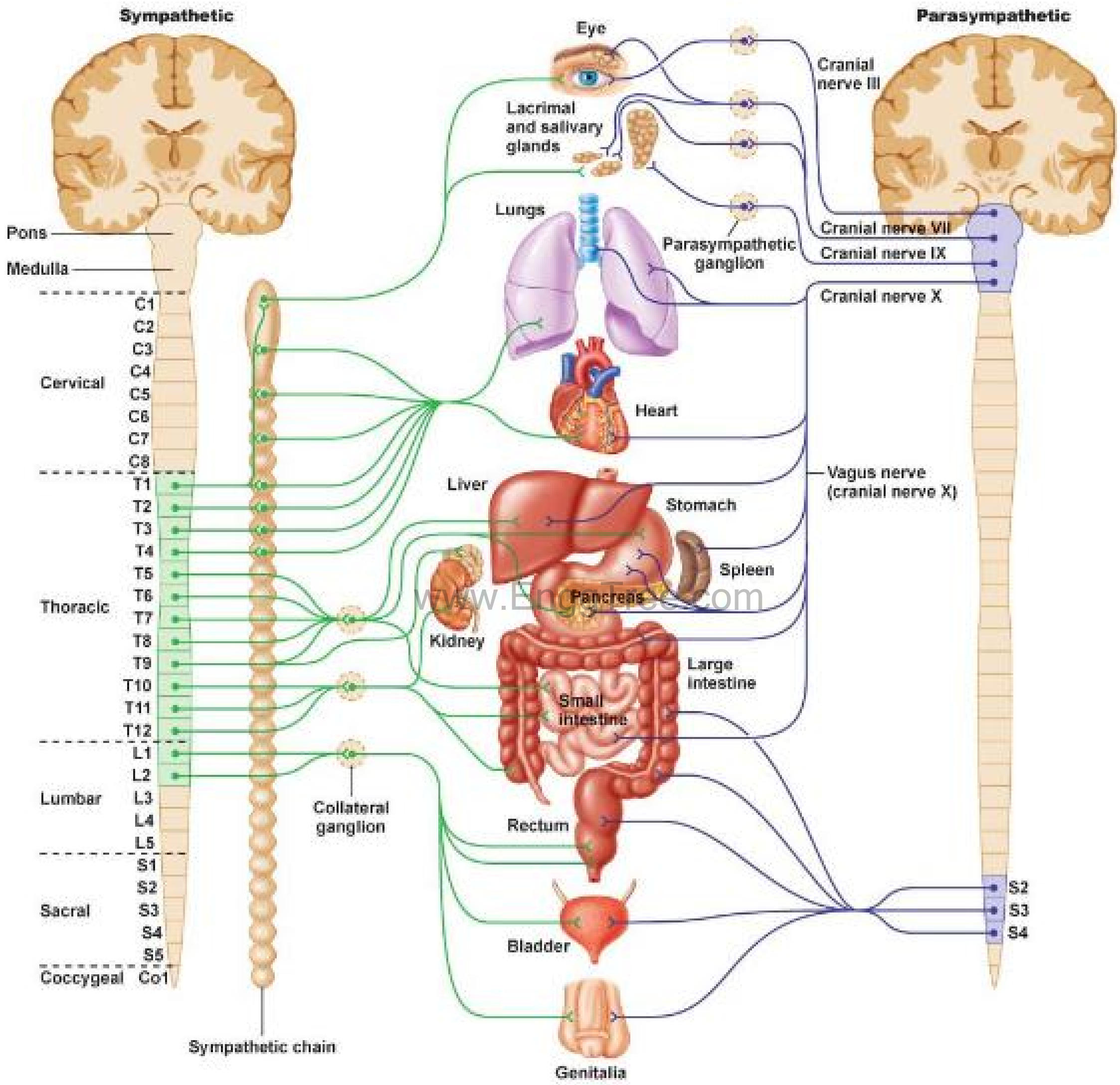
The aqueous humor is a watery substance that fills the eye. It is split into two chambers. The anterior chamber is located in front of the iris, and the posterior chamber is directly behind it. These layers allow the eye to maintain its shape. This liquid is drained through the Schlemm canal so that any buildup in the eye can be removed. If the patient's aqueous humor is not draining properly, they can develop glaucoma.

11. Draw a diagram of autonomic nervous system connection and compare functions of sympathetic and parasympathetic nervous system.

The autonomic or involuntary part of the nervous system controls involuntary body functions. Although stimulation does not occur voluntarily, the individual can sometimes be conscious of its effects, e.g. an increase in their heart rate.

The autonomic nervous system is separated into two divisions:

- **sympathetic (thoracolumbar outflow)**
- **parasympathetic (craniosacral outflow).**



The sympathetic nervous system

- The nerve fibers of the sympathetic system innervate smooth muscle, cardiac muscle, and glandular tissue. Accordingly, sympathetic system stimulation is a critical component of the fight or flight response.
- The cell bodies of sympathetic fibers traveling toward the ganglia (preganglionic fibers) are located in the thoracic and lumbar spinal nerves. These thoraco-lumbar fibers

then travel only a short distance within the spinal nerve (composed of an independent mixture of fiber types) before leaving the nerve as myelinated white fibers that synapse with the sympathetic ganglia that lie close to the side of the vertebral column.

- The sympathetic ganglia lie in chains that line both the right and left sides of the vertebral column, from the cervical to the sacral region. Portions of the sympathetic preganglionic fibers do not travel to the vertebral ganglionic chains, but travel instead to specialized cervical or abdominal ganglia. Other variations are also possible.
- For example, preganglionic fibers can synapse directly with cells in the adrenal medulla. In contrast to the parasympathetic system, the preganglionic fibers of the sympathetic nervous system are usually short, and the sympathetic postganglionic fibers are long fibers that must travel to the target tissue.
- The sympathetic postganglionic fibers usually travel back to the spinal nerve via unmyelineted or gray rami before continuing to the target effector organs. With regard to specific target organs and tissues, sympathetic stimulation of the pupil dilates the pupil. The dilation allows more light to enter the eye and acts to increase acuity in depth and peripheral perception.
- Sympathetic stimulation acts to increase heart rate and increase the force of atrial and ventricular contractions. Sympathetic stimulation also increases the conduction velocity of cardiac muscle fibers. Sympathetic stimulation also causes a dilation of systemic arterial blood vessels, resulting in greater oxygen delivery.

- Sympathetic stimulation of the lungs and smooth muscle surrounding the bronchi results in bronchial muscle relaxation. The relaxation allows the bronchi to expand to their full volumetric capacity and thereby allow greater volumes of air passage during respiration.
- The increased availability of oxygen and increased venting of carbon dioxide are necessary to sustain vigorous muscular activity. Sympathetic stimulation can also result in increased activity by glands that control bronchial secretions.
- Sympathetic stimulation of the liver increases glycogenolysis and lipolysis to make energy more available to metabolic processes. Constriction of gastrointestinal sphincters (smooth muscle valves or constrictions) and a general decrease in gastrointestinal motility assure that blood and oxygen needed for more urgent needs (such as fight or flight) are not wasted on digestive system processes that can be deferred for short periods.

- The fight or flight response is a physical response; a strong stimulus or emergency causes the release of a chemical called nor-adrenaline (also called norepinephrine) that alternately stimulates or inhibits the functioning of a myriad of glands and muscles. Examples include the acceleration of the heartbeat, raising of blood pressure, shrinkage of the pupils of the eyes, and the redirection of blood away from the skin to muscles, brain, and the heart.
- Sympathetic stimulation results in renin secretion by the kidneys and causes a relaxation of the bladder. Accompanied by a constriction of the bladder sphincter, sympathetic stimulation tends to decrease urination and promote fluid retention.
- Acetylcholine is the neurotransmitter most often found in the sympathetic preganglionic synapse. Although there are exceptions (e.g., sweat glands utilize acetylcholine), epinephrine (noradrenaline) is the most common neurotransmitter found in postganglionic synapses.

The parasympathetic nervous system

- Parasympathetic fibers innervate smooth muscle, cardiac muscle, and glandular tissue. In general, stimulation via parasympathetic fibers slows activity and results in a lowering of metabolic rate and a concordant conservation of energy.
- Accordingly, the parasympathetic nervous sub-system operates to return the body to its normal levels of function following the sudden alteration by the sympathetic nervous subsystem; the so-called "rest and digest" state.
- Examples include the restoration of resting heartbeat, blood pressure, pupil diameter, and flow of blood to the skin. The preganglionic fibers of the parasympathetic system derive from the neural cell bodies of the motor nuclei of the occulomotor (cranial nerve: III), facial (VII), glossopharyngeal (IX), and vagal (X) cranial nerves.
- There are also contributions from cells in the sacral segments of the spinal cord. These cranio-sacral fibers generally travel to a ganglion that is located near or within the target tissue. Because of the proximity of the ganglia to the target tissue or organ, the postganglionic fibers are much shorter.
- Parasympathetic stimulation of the pupil from fibers derived from the occulomotor (cranial nerve: III), facial (VII), and glossopharyngeal (IX) nerves constricts or narrows the pupil. This reflexive action is an important safeguard against bright light that could otherwise damage the retina.

- Parasympathetic stimulation also results in increased lacrimal gland secretions (tears) that protect, moisten, and clean the eye. The vagus nerve (cranial nerve: X) carries fibers to the heart, lungs, stomach, upper intestine, and ureter. Fibers derived from the sacrum innervate reproductive organs, portions of the colon, bladder, and rectum.
- With regard to specific target organs and tissues, parasympathetic stimulation acts to decrease heart rate and decrease the force of contraction. Parasympathetic stimulation also reduces the conduction velocity of cardiac muscle fibers.
- Parasympathetic stimulation of the lungs and smooth muscle surrounding the bronchi results in bronchial constriction or tightening. Parasympathetic stimulation can also result in increased activity by glands that control bronchial secretions.
- Parasympathetic stimulation usually causes a dilation of arterial blood vessels, increased glycogen synthesis within the liver, a relaxation of gastrointestinal sphincters (smooth muscle valves or constrictions), and a general increase in gastrointestinal motility (the contractions of the intestines that help food move through the system).
- Parasympathetic stimulation results in a contracting spasm of the bladder. Accompanied by a relaxation of the sphincter, parasympathetic stimulation tends to promote urination.
- The chemical most commonly found in both pre- and postganglionic synapses in the parasympathetic system is the neurotransmitter acetylcholine.

PART-A

1. What is the function of Digestive system?

- The function of the digestive system is to break down the foods you eat, release their nutrients, and absorb those nutrients into the body.
- Although the small intestine is the workhorse of the system, where the majority of digestion occurs, and where most of the released nutrients are absorbed into the blood or lymph, each of the digestive system organs makes a vital contribution to this process.

2. What are the parts of the digestive system?

The digestive system can be divided into two main parts:

- The alimentary tract and accessory organs.
- The alimentary tract of the digestive system is composed of the **Mouth, Pharynx, Esophagus, Stomach, Small And Large Intestines, Rectum And Anus**.
- Associated with the alimentary tract are the following accessory organs: **Salivary Glands, Liver, Gallbladder, And Pancreas**.

3. Briefly explain about absorption.

- Digested food molecules are **absorbed** in the **small intestine**. This means that they pass through the wall of the small intestine and into our **bloodstream**. Once in the bloodstream, the digested food molecules are carried around the body to where they are needed.
- Only small, soluble substances can pass across the wall of the small intestine. Large insoluble substances cannot pass through.
- The inside wall of the small intestine needs to be **thin**, with a really **big surface area**. This allows absorption to happen quickly and efficiently. To get a big surface area, the inside wall of the small intestine is lined with tiny **villi** (one of them is called a **villus**). These stick out and give a big surface area. They also contain blood capillaries to carry away the absorbed food molecules.

4. What is peristalsis?

- Peristalsis is a series of muscle contractions that occur in your digestive tract. Peristalsis is also seen in some organs that connect the kidneys to the bladder.
- Peristalsis is an automatic and important process. It moves:

- Food through the digestive system.
- Urine from the kidneys into the bladder
- Bile from the gallbladder into the duodenum.

5. Write the organic constitutent of saliva.

- Mucus that serves as a lubricant
- Amylase-initiates the digestion of starch
- Lingual lipase-begins digestion of fat
- Electrode solution (sodium,chloride,potassium,hydrogen carbonate)- moistens food.
- Proteins& enzymes: Statherins,Proline- rich Proteins (PRPs), Histatins, Cystatins, Lysozyme, Salivary perioxidase.

6. What are the two types of nephrons?

- There are two types of nephrons: Superficial cortical nephrons, which have their glomeruli in the outer cortex. They have shorter loops of Henle, which dip only into the outer medulla.
- Juxtamedullary nephrons, which have their glomeruli near the corticomedullary border.

7. What are the arrangements of layers of GI tract?

- The GI tract contains four layers: the innermost layer is the **mucosa**, underneath this is the **submucosa**, followed by the **muscularispropria** and finally, the outermost layer - the **adventitia**.

8. Name the digestive enzymes of Pancreas.

Pancreatic juice, composed of the secretions of both ductal and acinar cells, is made up of the following digestive enzymes: Trypsinogen, which is an inactive(zymogenic) protease that, once activated in the duodenum into trypsin, breaks down proteins at the basic amino acids.

9. What do you understand by Glomercular filtration.

Glomerular filtration is the process by which the kidneys filter the blood, removing excess wastes and fluids. Glomerular filtration rate (GFR) is a calculation that determines how well the blood is filtered by the kidneys, which is one way to measure remaining kidney function.

10. Give the important processes involved in the digestive and gastro intestinal functions.

- The digestive tract (or gastrointestinal tract) is a long twisting tube that starts at the mouth and ends at the anus.
- It is made up of a series of muscles that coordinate the movement of food and other cells that produce enzymes and hormones to aid in the breakdown of food.

- Along the way are three other organs that are needed for digestion: the liver, gallbladder, and the pancreas.

11. Contrast saliva with HCL in respond to digestion.

- **Saliva** contains the enzyme amylase, also called ptyalin, which is capable of breaking down starch into simpler sugars such as maltose and dextrin that can be further broken down in the small intestine.
- The parietal cells of the stomach produce HCl and secrete it primarily in response to ingested protein or fat. An HCl supplement may improve digestion of meals containing protein, fat, and carbohydrate.

12. How does the stomach protect itself from the damaging effects of HCL?

Your stomach protects itself from being digested by its own enzymes, or burnt by the corrosive hydrochloric acid, by secreting sticky, neutralising mucus that clings to the stomach walls. If this layer becomes damaged in any way it can result in painful and unpleasant stomach ulcers.

13. What is a metanephrogenic mass?

- The mesenchyme covering the distal end of the metanephric diverticulum;
- it gives rise to the nephrons of the permanent kidneys.

14. Write short note on movements of stomach.

- Two types of movement (motility) occur in the stomach: peristalsis and segmentation (mixing).
- Food is propelled through the small intestine by peristalsis, which is a wavelike series of muscular contractions.
- Segmentation is mix the chyme with the digestive juices and bring particles of food into contact with the wall where they can be absorbed.

15. What is the function of bile?

- **Bile** contains **bile** acids, which are critical for digestion and absorption of fats and fat-soluble vitamins in the small intestine.
- Many waste products, including bilirubin, are eliminated from the body by secretion into **bile** and elimination in feces.

16. What are the roles of angiotensin and aldosterone in blood pressure regulation?

Aldosterone is a hormone produced in the outer section (cortex) of the adrenal glands, which sit above the kidneys. It plays a central role in the regulation of blood pressure mainly by acting on organs such as the kidney and the colon to increase the amount of salt (sodium) reabsorbed into the bloodstream and the amount of another salt called potassium removed in the urine. Aldosterone also causes water to be reabsorbed along with sodium; this increases blood volume and therefore blood pressure.

17. Define net filtration pressure.

- The **net filtration pressure** is the **pressure** which determines the movement of fluid between capillaries and interstitial fluid. It is the difference between the capillary hydrostatic **pressure** and the osmotic **pressure**.

PART B

1. Discus s the anatomy of GI system with a neat sketch.(OR) Draw the diagram of the various parts involved in the digestive system.

Alimentary Canal Or The Gastrointestinal (GI) Tract

This is essentially a long tube through which food passes. It commences at the mouth and terminates at the anus, and the various organs along its length have different functions. The parts are:

a. **Mouth**
b. **Pharynx**
c. **Esophagus**
d. **Stomach**
e. **Small intestine**
f. **Large intestine**
g. **Rectum and anal canal.**

Accessory organs

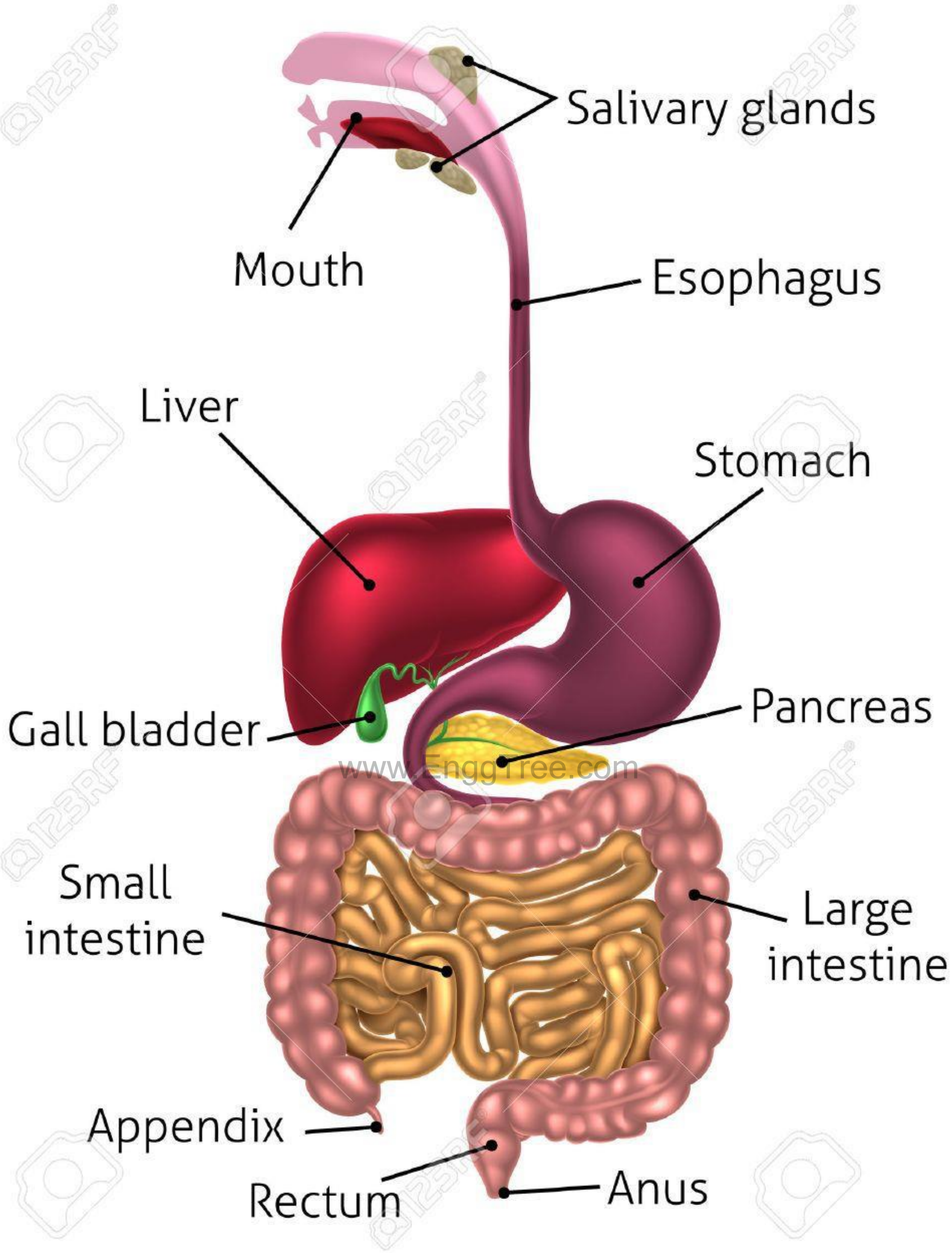
Various secretions are poured into the alimentary tract, some by glands in the lining membrane of the organs. They consist of:

h. **Three pairs of salivary glands**
i. **The pancreas**
j. **The liver and biliary tract.**

The organs and glands are linked physiologically as well as anatomically in that digestion and absorption occur in stages, each stage being dependent upon the previous stage or stages.

a. Oral cavity or mouth

- ✓ The oral cavity or mouth is responsible for the intake of food. It is lined by a stratified squamous oral mucosa with keratin covering those areas subject to significant **Abrasion**, such as the tongue, hard palate and roof of the mouth.
- ✓ **Mastication** refers to the mechanical breakdown of food by chewing and chopping actions of the teeth. The tongue, a strong muscular organ, manipulates the food bolus to come in contact with the teeth.
- ✓ It is also the sensing organ of the mouth for touch, temperature and taste using its specialised sensors known as papillae.



- ✓ **Insalivation** refers to the mixing of the oral cavity contents with salivary gland secretions. The mucin (a glycoprotein) in saliva acts as a lubricant. The oral cavity also plays a limited role in the digestion of carbohydrates.
- ✓ The enzyme serum amylase, a component of saliva, starts the process of digestion of complex carbohydrates. The final function of the oral cavity is

absorption of small molecules such as glucose and water, across the mucosa. From the mouth, food passes through the pharynx and oesophagus via the action of swallowing.

b. Pharynx

- ✓ The pharynx is divided for descriptive purpose into three parts, the nasopharynx, oropharynx and laryngopharynx. The nasopharynx is important in respiration.
- ✓ The oropharynx and laryngopharynx are passages common to both the respiratory and the digestive systems. Food passes from the oral cavity into the pharynx then to the oesophagus below, with which it is continuous.

c. Oesophagus

- ✓ The oesophagus is a muscular tube of approximately 25cm in length and 2cm in diameter. It extends from the pharynx to the stomach after passing through an opening in the diaphragm.
- ✓ The wall of the oesophagus is made up of inner circular and outer longitudinal layers of muscle that are supplied by the oesophageal nerve plexus. This nerve plexus surrounds the lower portion of the oesophagus.
- ✓ The oesophagus functions primarily as a transport medium between compartments.

d. Stomach

- ✓ The stomach is a J shaped expanded bag, located just left of the midline between the oesophagus and small intestine. It is divided into four main regions and has two borders called the greater and lesser curvatures.
- ✓ The first section is the cardia which surrounds the cardial orifice where the oesophagus enters the stomach.
- ✓ The fundus is the superior, dilated portion of the stomach that has contact with the left dome of the diaphragm. The body is the largest section between the fundus and the curved portion of the J.
- ✓ This is where most gastric glands are located and where most mixing of the food occurs. Finally the pylorus is the curved base of the stomach.
- ✓ Gastric contents are expelled into the proximal duodenum via the pyloric sphincter. The inner surface of the stomach is contracted into numerous

longitudinal folds called rugae. These allow the stomach to stretch and expand when food enters. The stomach can hold up to 1.5 litres of material. The functions of the stomach include:

1. The short-term storage of ingested food.
2. Mechanical breakdown of food by churning and mixing motions.
3. Chemical digestion of proteins by acids and enzymes.
4. Stomach acid kills bugs and germs.
5. Some absorption of substances such as alcohol.

Most of these functions are achieved by the secretion of stomach juices by gastric glands in the body and fundus. Some cells are responsible for secreting acid and others secrete enzymes to break down proteins.

e. Small intestine

- ✓ The small intestine is composed of the duodenum, jejunum, and ileum. It averages approximately 6m in length, extending from the pyloric sphincter of the stomach to the ileo-caecal valve separating the ileum from the caecum.
- ✓ The small intestine is compressed into numerous folds and occupies a large proportion of the abdominal cavity.

- ✓ The duodenum is the proximal C-shaped section that curves around the head of the pancreas. The duodenum serves a mixing function as it combines digestive secretions from the pancreas and liver with the contents expelled from the stomach.
- ✓ The start of the jejunum is marked by a sharp bend, the duodenojejunal flexure. It is in the jejunum where the majority of digestion and absorption occurs.
- ✓ The final portion, the ileum, is the longest segment and empties into the caecum at the ileocaecal junction.
- ✓ The small intestine performs the majority of digestion and absorption of nutrients. Partly digested food from the stomach is further broken down by enzymes from the pancreas and bile salts from the liver and gallbladder.
- ✓ These secretions enter the duodenum at the Ampulla of Vater. After further digestion, food constituents such as proteins, fats, and carbohydrates are broken down to small building blocks and absorbed into the body’s blood stream.

- The lining of the small intestine is made up of numerous permanent folds called plicaecirculares. Each plica has numerous villi (folds of mucosa) and each villus is covered by epithelium with projecting microvilli (brush border).
- This increases the surface area for absorption by a factor of several hundred. The mucosa of the small intestine contains several specialised cells.
- Some are responsible for absorption, whilst others secrete digestive enzymes and mucous to protect the intestinal lining from digestive actions.

f. Colon (large intestine)

- The colon is a 6-foot long muscular tube that connects the small intestine to the rectum. The large intestine is made up of the cecum, the ascending (right) colon, the transverse (across) colon, the descending (left) colon, and the sigmoid colon, which connects to the rectum.
- The appendix is a small tube attached to the cecum. The large intestine is a highly specialized organ that is responsible for processing waste so that emptying the bowels is easy and convenient.
- Stool, or waste left over from the digestive process, is passed through the colon by means of peristalsis, first in a liquid state and ultimately in a solid form. As stool passes through the colon, water is removed.
- Stool is stored in the sigmoid (S-shaped) colon until a "mass movement" empties it into the rectum once or twice a day.
- It normally takes about 36 hours for stool to get through the colon. The stool itself is mostly food debris and bacteria. These bacteria perform several useful functions, such as synthesizing various vitamins, processing waste products and food particles, and protecting against harmful bacteria.
- When the descending colon becomes full of stool, or feces, it empties its contents into the rectum to begin the process of elimination.

g. Rectum

- The rectum (Latin for "straight") is an 8-inch chamber that connects the colon to the anus. It is the rectum's job to receive stool from the colon, to let the person know that there is stool to be evacuated, and to hold the stool until evacuation happens.

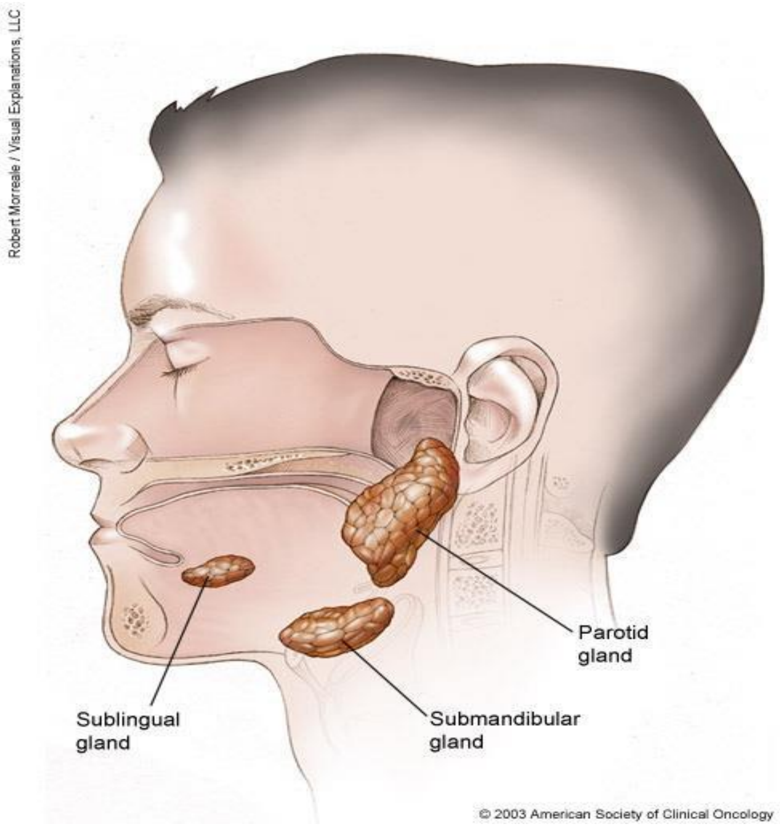
- ✓ When anything (gas or stool) comes into the rectum, sensors send a message to the brain. The brain then decides if the rectal contents can be released or not.
- ✓ If they can, the sphincters relax and the rectum contracts, disposing its contents. If the contents cannot be disposed, the sphincter contracts and the rectum accommodates so that the sensation temporarily goes away.

h. Anus

- ✓ The anus is the last part of the digestive tract. It is a 2-inch long canal consisting of the pelvic floor muscles and the two anal sphincters (internal and external).
- ✓ The lining of the upper anus is specialized to detect rectal contents. It lets you know whether the contents are liquid, gas, or solid. The anus is surrounded by sphincter muscles that are important in allowing control of stool.
- ✓ The pelvic floor muscle creates an angle between the rectum and the anus that stops stool from coming out when it is not supposed to. The internal sphincter is always tight, except when stool enters the rectum.
- ✓ It keeps us continent when we are asleep or otherwise unaware of the presence of stool. When we get an urge to go to the bathroom, we rely on our external sphincter to hold the stool until reaching a toilet, where it then relaxes to release the contents.

Accessory organs

Salivary glands



- ✓ Three pairs of salivary glands - **Parotids, Submandibular, Sublingual -** complex gland with numerous acini lined by secretory epithelium.

- ✓ specialised ducts.- occurs in response to the taste, smell or even appearance of food.
- ✓ moisten the mouth - slightly different compositions.

(i) Parotids

- ✓ large, irregular shaped glands located under the skin on the side of the face. - secrete 25% of saliva - situated below the zygomatic arch (cheekbone) and cover part of the mandible (lower jaw bone).
- ✓ An enlarged parotid gland can be easier felt when one clenches their teeth.
- ✓ rich in proteins.
- ✓ Immunoglobins - help to fight microorganisms and a-amylase proteins start to break down complex carbohydrates.

(ii) Submandibular

- ✓ 70% of the saliva in the mouth - found in the floor of the mouth, in a groove along the inner surface of the mandible.

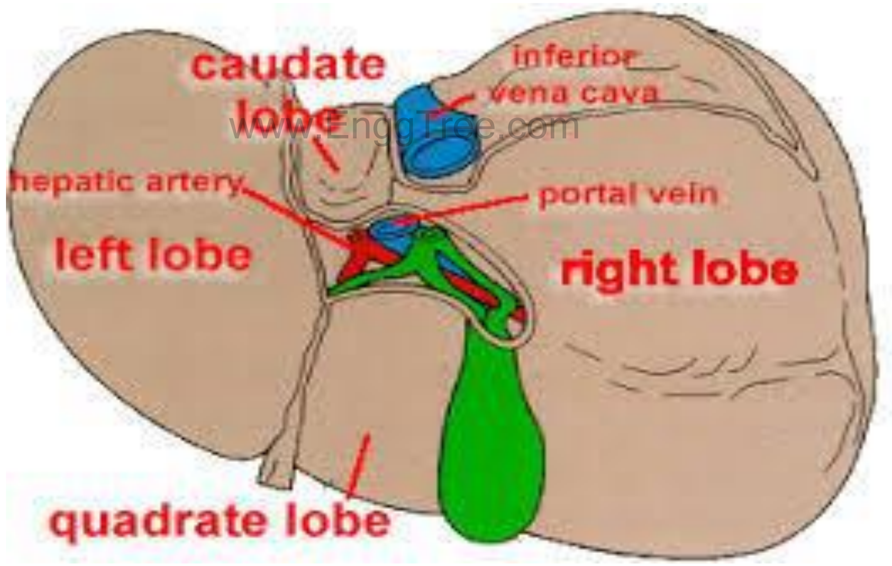
- (thick) secretion, rich in mucin and with a smaller amount of protein.
- Mucin is a glycoprotein that acts as a lubricant.

(iii) Sublingual

- smallest salivary glands, covered by a thin layer of tissue at the floor of the mouth.
- 5% of the saliva and their secretions are very sticky due to the large concentration of mucin.
- The main functions are to provide buffers and lubrication.

i) Liver

- The liver is a large, reddish-brown organ situated in the right upper quadrant of the abdomen.
- surrounded by a strong capsule
- divided into four lobes namely the right, left, caudate and quadrate lobes.



- important functions. It acts as a mechanical filter **by filtering blood** that travels from the intestinal system.
- It detoxifies several metabolites including the **breakdown of bilirubin and oestrogen**.
- In addition, the liver has synthetic functions, **producing albumin and blood clotting factors**.
- its main roles in digestion are in the **production of bile and metabolism of nutrients.**

- All nutrients absorbed by the intestines pass through the liver and are **processed before traveling** to the rest of the body.
- The bile produced by cells of the liver, enters the intestines at the duodenum.
- Here, **bile salts break down lipids into smaller particles** so there is a greater surface area for digestive enzymes to act.

j) Gall bladder

- hollow, pear shaped organ - posterior surface of the liver's right lobe.
- It consists of a fundus, body and neck.
- It empties via the cystic duct into the biliary duct system.
- storage and concentration of bile.
- Bile is a thick fluid that contains enzymes to help **dissolve fat** in the intestines. Bile **is produced by the liver but stored in the gallbladder** until it is needed.
- Bile is released from the gall bladder by **contraction of its muscular** walls in response to hormone signals from the duodenum in the presence of food.

k) Pancreas

- lobular, pinkish-grey organ - lies behind the stomach.

- Its head with duodenum and its tail extends to the spleen.
- 15cm in length with a long, slender body connecting the head and tail segments.
- both exocrine and endocrine functions. Endocrine refers to production of hormones which occurs in the Islets of Langerhans. The Islets produce insulin, glucagon and other substances and these are the areas damaged in diabetes mellitus.
- The exocrine (secretrory) portion makes up 80-85% of the pancreas and is the area relevant to the gastrointestinal tract.It is made up of numerous acini (small glands) that secrete contents into ducts which eventually lead to the duodenum.
- The pancreas secretes fluid rich in carbohydrates and inactive enzymes such as trypsinogen, chymotrypsinogen . Secretion is triggered by the hormones released by the duodenum in the presence of food.
- Pancreatic enzymes include carbohydrases, lipases, nucleases and proteolytic enzymes that can break down different components of food. These are

secreted in an inactive form to prevent digestion of the pancreas itself. The enzymes become active once they reach the duodenum.

2. **Explain the mechanism involved in the digestion and write how is the energy absorbed by the system.**

Digestion and absorption both can be performed in small intestine.

Digestion

i) Digestion of proteins:

- ✓ Pancreatic juices such as Trypsinogen and chymotrypsinogen are inactive enzyme precursors activated by enterokinase, an enzyme in the microvilli,
- ✓ which converts them into the active proteolytic enzymes trypsin and chymotrypsin. These enzymes convert polypeptides to tripeptides, dipeptides and amino acids.
- ✓ It is important that they are produced as inactive precursors and are activated only upon their arrival in the duodenum, otherwise they would digest the pancreas.

ii) Digestion of carbohydrates:

Pancreatic amylase converts all digestible polysaccharides (starches) not acted upon by salivary amylase to disaccharides.

iii) Digestion of fats:

- ✓ Lipase converts fats to fatty acids and glycerol. To aid the action of lipase, bile salts emulsify fats, i.e. reduce the size of the globules, increasing their surface area.
- ✓ **Chemical digestion** associated with enterocytes Alkaline intestinal juice (pH 7.8–8.0) assists in raising the pH of the intestinal contents to between 6.5 and 7.5. The enzymes that complete chemical digestion of food at the surface of the enterocytes are:
    - ✓ Peptidases
    - ✓ Lipase
    - ✓ Sucrase,
    - ✓ Maltase and
    - ✓ Lactase.
- ✓ Peptidases such as trypsin break down polypeptides into smaller peptides and amino acids. Peptidases are secreted in an inactive form from the pancreas (to

prevent them from digesting it) and must be activated by enterokinase in the duodenum.

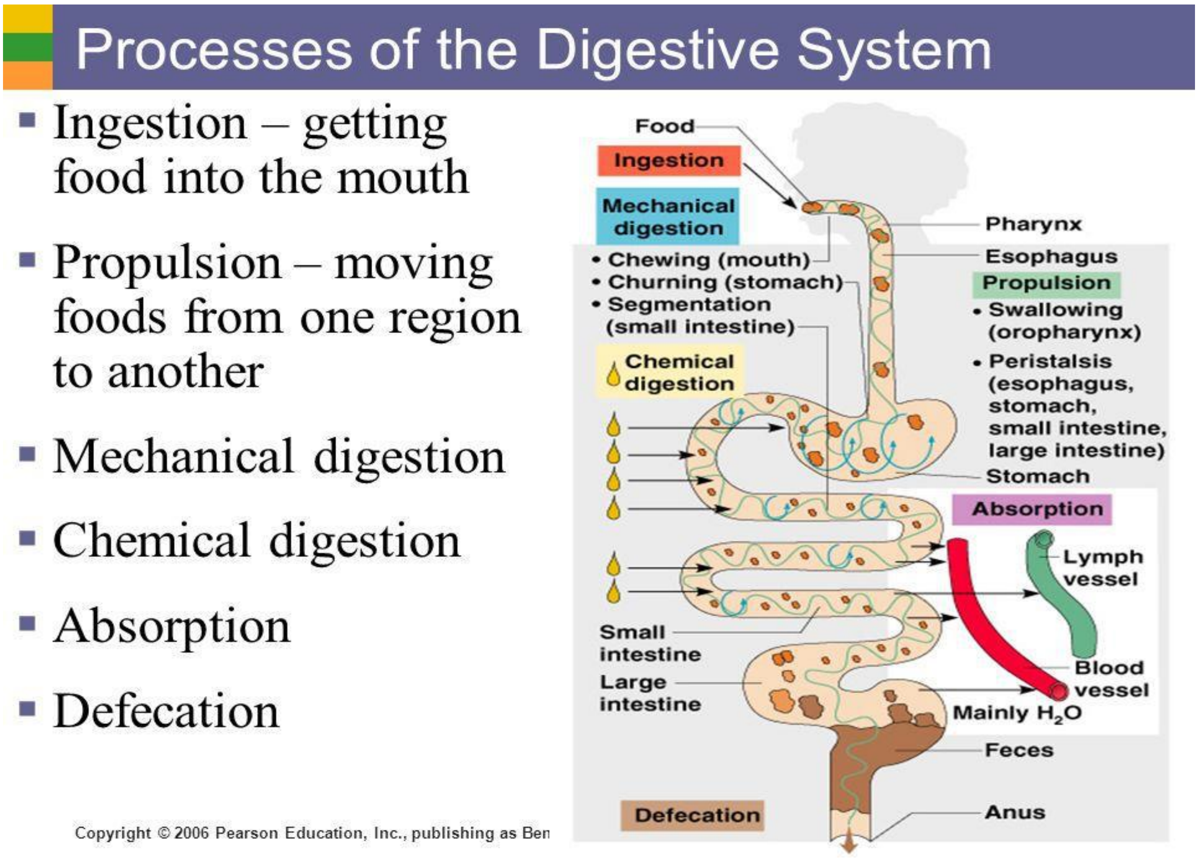
- ✓ The final stage of breakdown of all peptides to amino acids takes place at the surface of the enterocytes. Lipase completes the digestion of emulsified fats to fatty acids and glycerol in the intestine.
- ✓ Sucrase, maltase and lactase complete the digestion of carbohydrates by converting disaccharides such as sucrose, maltose and lactose to monosaccharides at the surface of the enterocytes.

<u>Absorption</u>

Absorption of nutrients

- ✓ Absorption of nutrients from the small intestine through the enterocytes occurs by several processes, including diffusion, osmosis, facilitated diffusion and active transport.
- ✓ Water moves by osmosis; small fat -soluble substances, e.g. fatty acids and glycerol, are able to diffuse through cell membranes; while others are generally transported inside the villi by other mechanisms.
- ✓ Monosaccharides and amino acids pass into the blood capillaries in the villi. Fatty acids and glycerol enter the lacteals and are transported along lymphatic vessels to the thoracic duct where they enter the circulation.

- ✓ A small number of proteins are absorbed unchanged, e.g. antibodies present in breast milk and oral vaccines, such as poliomyelitis vaccine. Other nutrients such as vitamins, mineral salts and water are also absorbed from the small intestine into the blood capillaries.
- ✓ Fat -soluble vitamins are absorbed into the lacteals along with fatty acids and glycerol. Vitamin B12 combines with intrinsic factor in the stomach and is actively absorbed in the terminal ileum.
- ✓ The surface area through which absorption takes place in the small intestine is greatly increased by the circular folds of mucous membrane and by the very large number of villi and microvilli present.
- ✓ It has been calculated that the surface area of the small intestine is about five times that of the whole body surface. Large amounts of fluid enter the alimentary tract each day. Of this, only about 1500 mL is not absorbed by the small intestine, and passes into the large intestine.



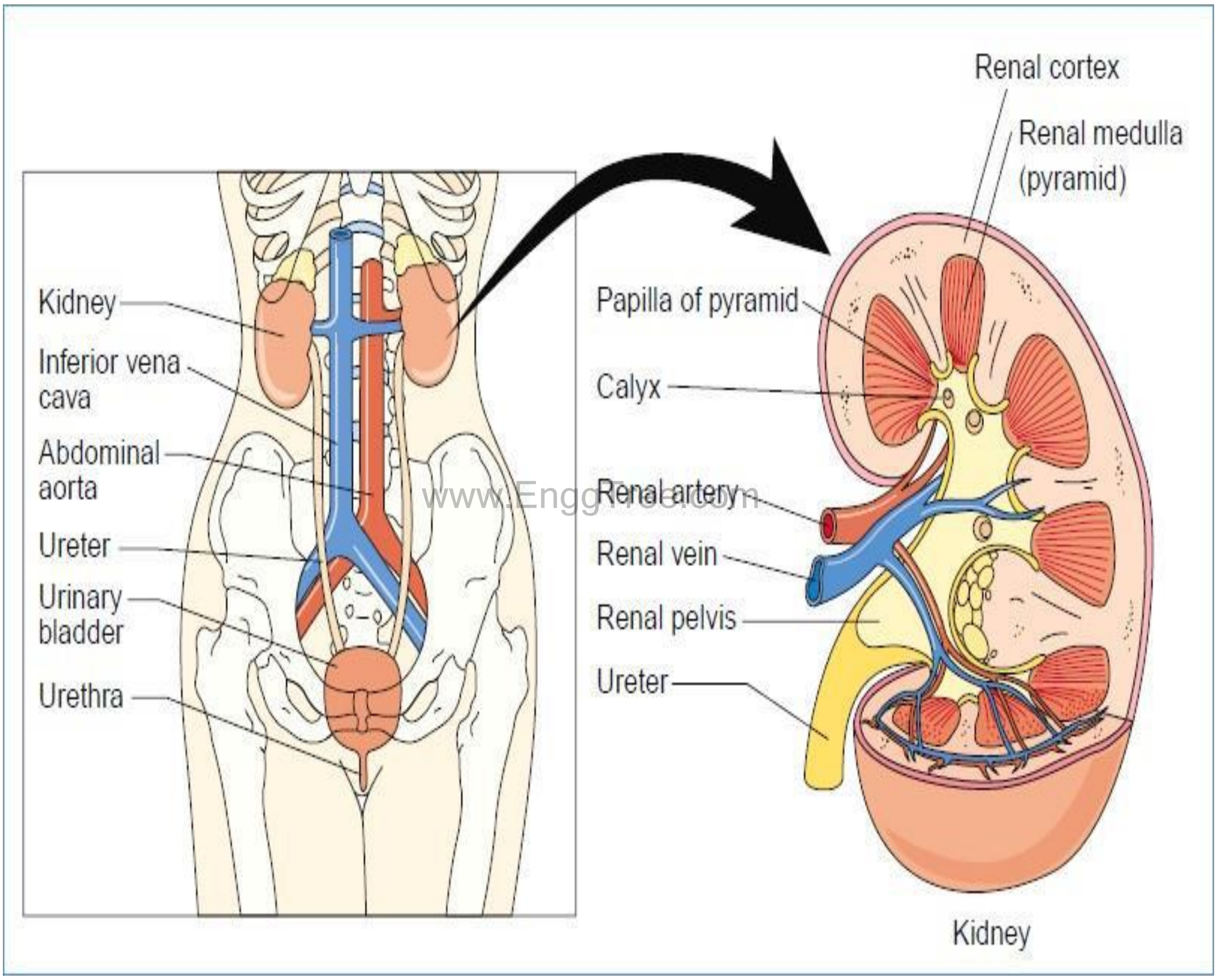
3. Discuss the anatomy of human kidney with a neat sketch.

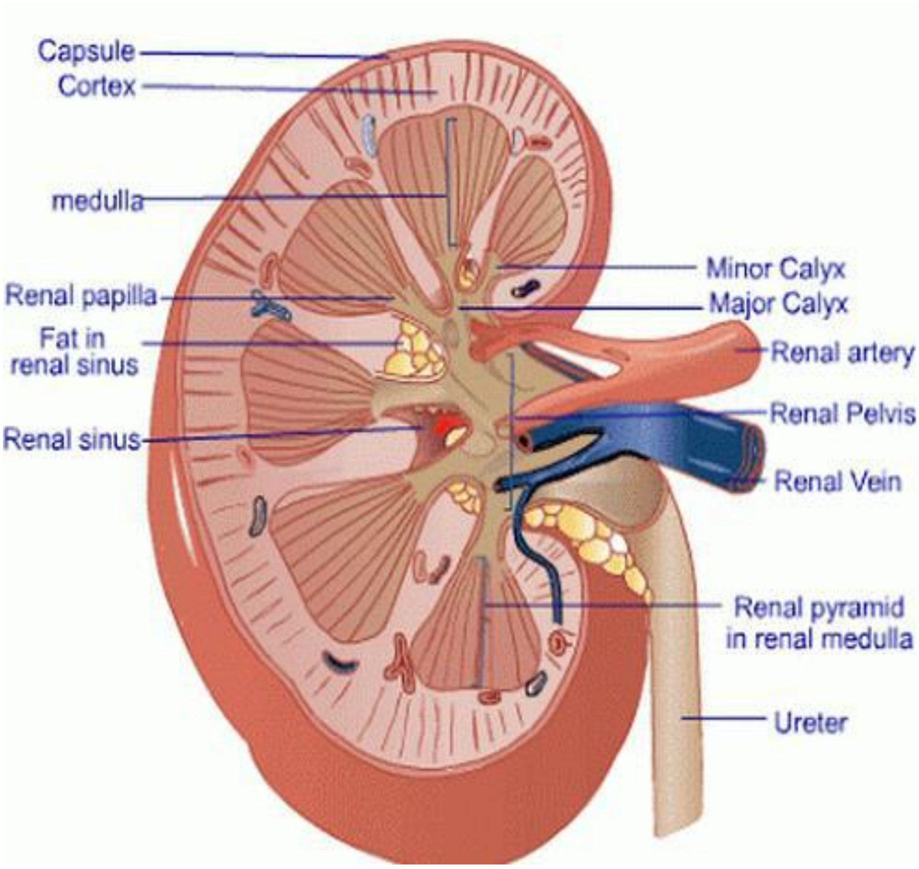
Urinary System

The urinary system is the main excretory system and consists of the following structures:

- Two kidneys, which secrete urine.
- Two ureters that convey the urine from the kidneys to the urinary bladder.
- The urinary bladder, which collects and stores urine.
- The urethra through which urine leaves the body.

Structure of kidney:





Structure of kidney

- ✓ Kidneys are bean-shaped organs, about 11 cm long, 6 cm wide, 3 cm thick and weigh 150 g. The kidneys lie on the posterior abdominal wall, one on each side of the vertebral column, behind the peritoneum and below the diaphragm.
- ✓ The right kidney is usually slightly lower than the left, probably because of the considerable space occupied by the liver.

i) 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 enter/leave the kidney.

ii) 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.

iii) 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.

iv) 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.

v) Renal pyramids:

There are approx. 5 - 18 striated triangular structures called "Renal Pyramids" within the renal medulla of each kidney. The appearance of striations is due to many straight tubules and blood vessels within the renal pyramids.

vi) 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..

vii) 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 interlobular artery, the arcuate artery and the interlobular artery. These eventually separate into afferent arterioles, one of which serves each nephron in the kidney.

viii) Renal vein:

The renal vein receives deoxygenated blood from the peritubular veins within the kidney. These merge into the interlobular, arcuate, interlobular and segmental veins, which, in turn, deliver deoxygenated blood to the renal vein, through which it is returned to the systemic blood circulation system.

ix) Interlobular artery:

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

x) Interlobular vein:

The interlobular vein receives deoxygenated blood (at lower pressure) that it drains away from the glomerular filtration units and from the Loops of Henle.

xi) 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.

xii) Collecting Duct (Kidney):

The collecting duct labeled in the diagram above is part of the kidney nephron (shown much enlarged). The distal convoluted tubules of many nephrons empty into a single collecting duct.

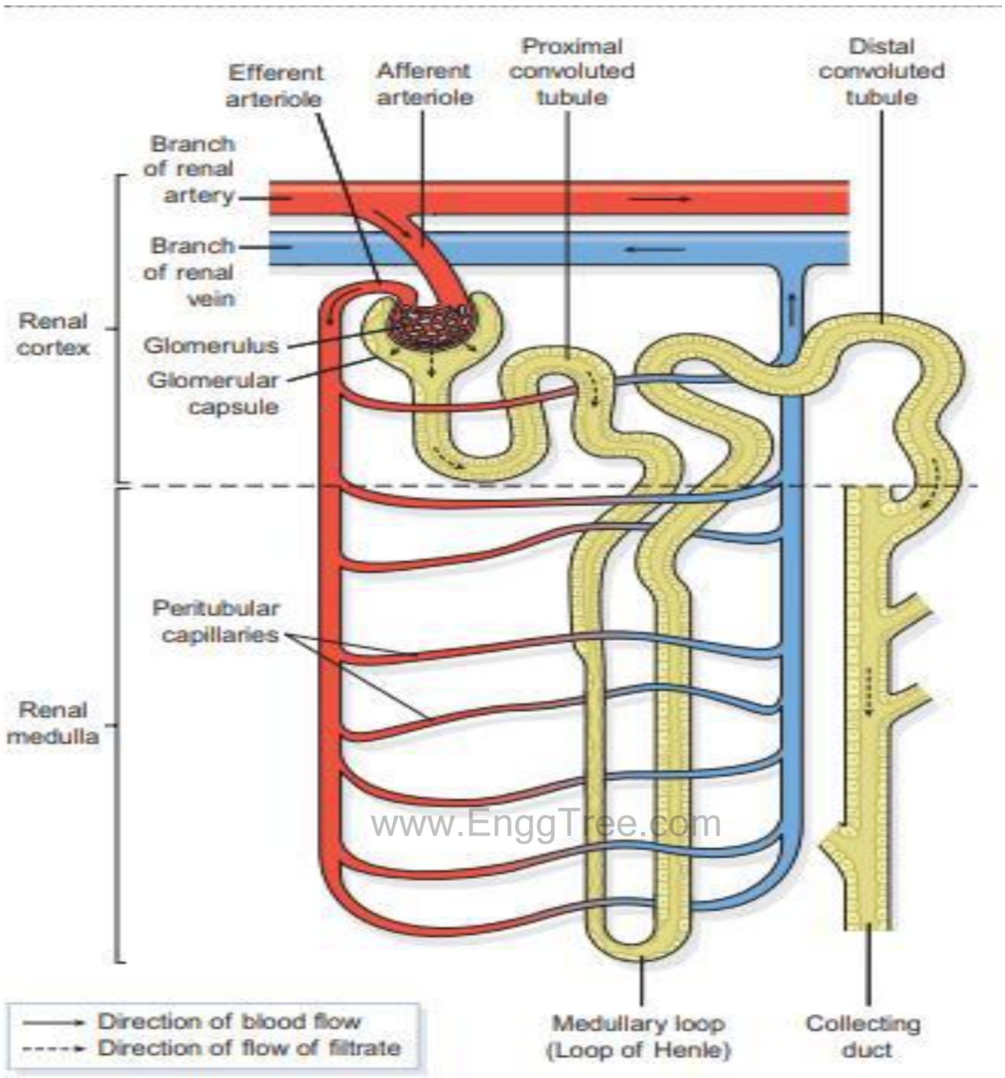
Many such collecting ducts unite to drain urine extracted by the kidney into papillary ducts, then into a minor calyx, then the major calyx (at the centre of the kidney), and finally into the ureter through which the urine leaves the kidney en-route to the urinary bladder.

xiii) Ureter:

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

4. Describe the structure of Nephron.

Structure of Nephron:



- ✓ Nephron is the functional unit of the Kidney. The kidney contains about 1–2 million functional units, the Nephrons, and a much smaller number of collecting ducts. The collecting ducts transport urine through the pyramids to the calyces, giving the pyramids their striped appearance.
- ✓ The collecting ducts are supported by connective tissue, containing blood vessels, nerves and lymph vessels. The nephron is essentially a tubule closed at one end that joins a collecting duct at the other end. The closed or blind end is indented to form the cup-shaped glomerular capsule (Bowman's capsule).
- ✓ Continuing from the glomerular capsule, the remainder of the nephron is about 3 cm long and described in three parts:

- The proximal convoluted tubule.
- The medullary loop (loop of henle).
- The distal convoluted tubule, leading into a collecting duct.

✓ The collecting ducts unite, forming larger ducts that empty into the minor calyces. The kidneys receive about 20% of the cardiac output. After entering the kidney at the hilum, the renal artery divides into smaller arteries and arterioles.

✓ In the cortex an arteriole, the afferent arteriole, enters each glomerular capsule and then subdivides into a cluster of tiny arterial capillaries, forming the glomerulus. Between these capillary loops are connective tissue phagocytic mesangial cells, which are part of the monocyte–macrophage defence system.

✓ The blood vessel leading away from the glomerulus is the efferent arteriole. The afferent arteriole has a larger diameter than the efferent arteriole, which increases pressure inside the glomerulus and drives filtration across the glomerular capillary walls.

✓ The efferent arteriole divides into a second peritubular (meaning 'around tubules') capillary network, which wraps around the remainder of the tubule, allowing exchange between the fluid in the tubule and the blood stream .

✓ This maintains the local supply of oxygen and nutrients and removes waste products. Venous blood drained from this capillary bed eventually leaves the kidney in the renal vein, which empties into the inferior vena cava.

✓ The walls of the glomerulus and the glomerular capsule consist of a single layer of flattened epithelial cells. The glomerular walls are more permeable than those of other capillaries.

✓ The remainder of the nephron and the collecting duct are formed by a single layer of simple squamous epithelium . Renal blood vessels are supplied by both sympathetic and parasympathetic nerves.

✓ The presence of both divisions of the autonomic nervous system controls renal blood vessel diameter and renal blood flow independently of auto regulation.

5. Describe the functions Of Kidney (or) Urine formation.

Different parts of the nephron are responsible for various functions of Kidney. Fluid filtered from the blood enters the Bowman's capsule then flows into the proximal tubule, down the descending limb of the loop of Henle, then up the ascending limb, into the distal tubule and then the connecting and finally the collecting tubule.

There are three stages to urine formation :

- Glomerular filtration
- Tubular reabsorption
- Tubular secretion.

- **Glomerular Filtration**

This occurs when fluid from the glomerular capillaries pass into the Bowman's capsule. This is fairly non-selective meaning that almost all of the substances in the the blood except cells and plasma proteins as well as the substances bound to these proteins enter the nephron.

- **Tubular Reabsorption**

During this phase, all parts of the tubule act to return essential substances out of the nephron so that it is not lost in the urine. It is a highly selective process in that the tubules carefully "choose" what will be returned to the body and what will be passed out with the urine. This transfer of substances is known as **Tubular Reabsorption** and may involve both active and passive mechanisms.

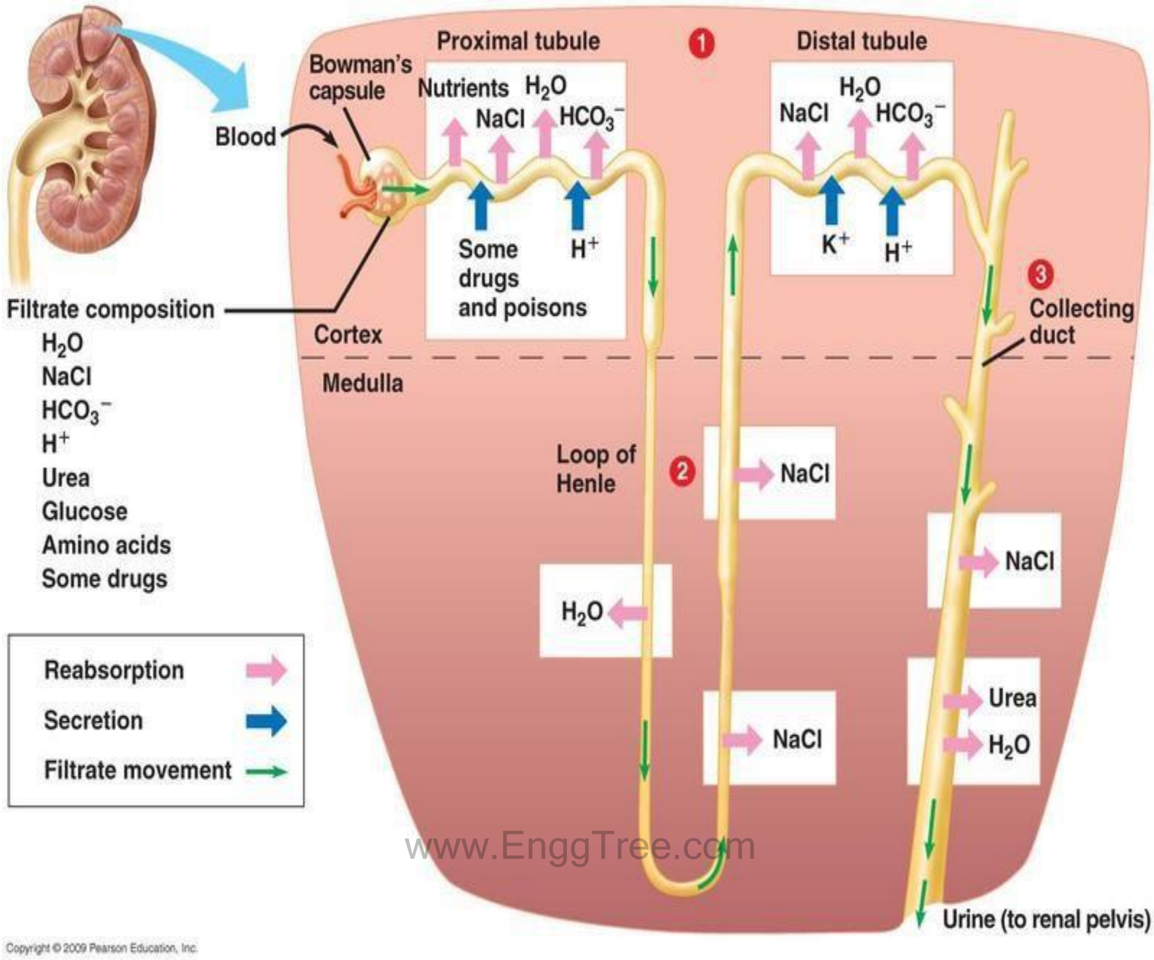
Some of the substances pass through the space between the epithelial cells while others through the cells itself. In this way, the substances are returned back to the body either by being "dumped" into the tissue of the kidney outside of the nephron or returned directly into the bloodstream.

- **Tubular Secretion**

Just as substances that enter through the glomerulus are removed from the nephron and returned to the body, many substances are drawn from the body and "dumped" into the tubules. Acids, alkalines, certain ions, toxins and drugs are secreted into the tubules and this process is known as tubular secretion.

In this manner it can be rapidly passed out with the urine independent of glomerular filtration and in a more selective manner.

Mechanism of urine formation:



The basic function of the nephron is to filter blood and remove waste substances while retaining essential substances for various biochemical processes. In the process, the nephron can also influence the pH (acid-base balance) of the blood, regulate blood pressure, maintain the blood volume and control the level of electrolytes in the body fluids.

The functions of the nephron can be discussed with regards to each part :

Bowman's capsule

- Collects the incoming fluid from the glomerular capillaries.

Proximal tubule

- Sodium, chloride, water, glucose and amino acids are reabsorbed (removed from the tubules).

- Organic acids and bases like bile salts, oxalate and urate are secreted into the proximal tubule.

Loop of Henle

- Water is reabsorbed mainly in the descending limb and thin segment of the ascending limb.
- Sodium, calcium, chloride, magnesium and potassium are actively reabsorbed in the thick segment of the ascending limb.

Distal tubule

- Controls the blood flow through the glomerular capillaries and glomerular filtration of the nephron to which it belongs.
- Sodium, potassium and chloride reabsorption.

Collecting tubule

- Sodium, potassium and chloride reabsorption.
- Hydrogen ion secretion.

6. Discuss about the Regulation Of Blood Pressure By Urimary System and urinary reflex.

Regulation Of Blood Pressure

- ✓ Kidneys are to maintain blood pressure is through the regulation of the volume of blood in the body. The kidneys are able to reduce **blood** volume by reducing the reabsorption of water into the **blood** and producing watery, dilute **urine**.
- ✓ When **blood pressure** becomes too low, the kidneys can produce the enzyme renin to constrict **blood** vessels and produce concentrated **urine**, which allows more water to remain in the **blood**.
- ✓ The renin-angiotensin system or RAS regulates blood pressure and fluid balance in the body. When blood volume or sodium levels in the body are low, or blood potassium is high, cells in the kidney release the enzyme, renin.
- ✓ Renin converts angiotensinogen, which is produced in the liver, to the hormone angiotensin I.
- ✓ An enzyme known as ACE or angiotensin-converting enzyme found in the lungs metabolizes angiotensin I into angiotensin II. Angiotensin II causes blood vessels to constrict and blood pressure to increase. Angiotensin II stimulates the release

of the hormone aldosterone in the adrenal glands, which causes the renal tubules to retain sodium and water and excrete potassium.

- ✓ Together, angiotensin II and aldosterone work to raise blood volume, blood pressure and sodium levels in the blood to restore the balance of sodium, potassium, and fluids. If the renin-angiotensin system becomes overactive, consistently high blood pressure results.

Urinary reflex (or) Micturition Reflex

- ➢ **Micturition** is the physiological term for urination or voiding. It results from an interplay of involuntary and voluntary actions by the internal and external urethral sphincters.
- ➢ When bladder volume reaches about 150 mL, an urge to void is sensed but is easily over ridden. Voluntary control of urination relies on consciously preventing relaxation of the external urethral sphincter to maintain urinary continence.
- ➢ As the bladder fills, subsequent urges become harder to ignore. **Micturition** is a result of stretch receptors in the bladder wall that transmit nerve impulses to the sacral region of the spinal cord to generate a spinal reflex.

- ➢ The resulting parasympathetic neural outflow causes contraction of the detrusor muscle and relaxation of the involuntary internal urethral sphincter. At the same time, the spinal cord inhibits somatic motor neurons, resulting in the relaxation of the skeletal muscle of the external urethral sphincter.
- ➢ The micturition reflex is active in infants but with maturity, children learn to override the reflex by asserting external sphincter control, thereby delaying voiding (potty training).
- ➢ Nerves involved in the control of urination include the hypogastric, pelvic, and pudendal . Voluntary micturition requires an intact spinal cord and functional pudendal nerve arising from the **sacral micturition center**.
- ➢ Since the external urinary sphincter is voluntary skeletal muscle, actions by cholinergic neurons maintain contraction (and thereby continence) during filling of the bladder.
- ➢ At the same time, sympathetic nervous activity via the hypogastric nerves suppresses contraction of the detrusor muscle. With further bladder stretch,

afferent signals traveling over sacral pelvic nerves activate parasympathetic neurons.

- This activates efferent neurons to release acetylcholine at the neuromuscular junctions, producing detrusor contraction and bladder emptying.