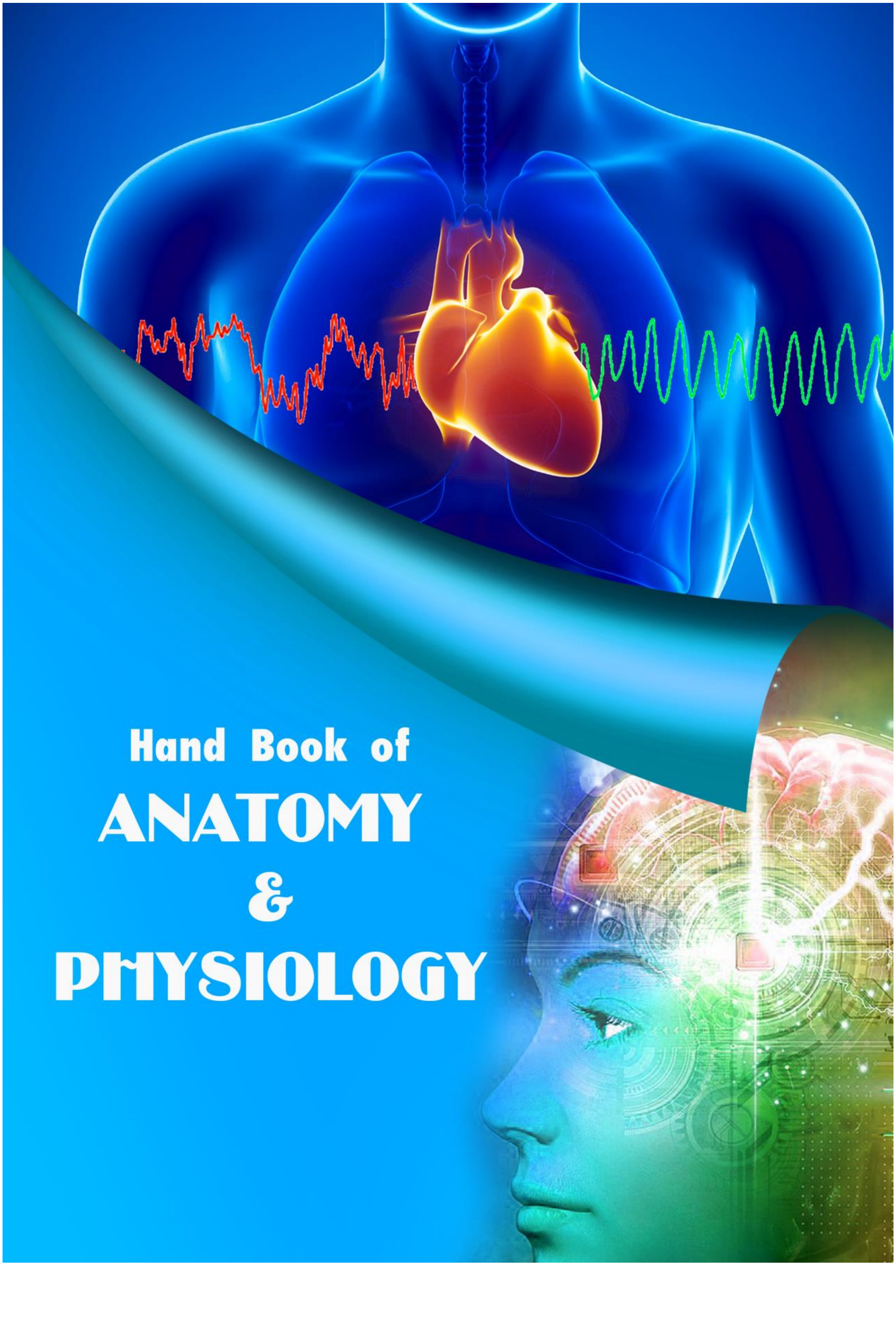

Hand Book of
ANATOMY
&
PHYSIOLOGY

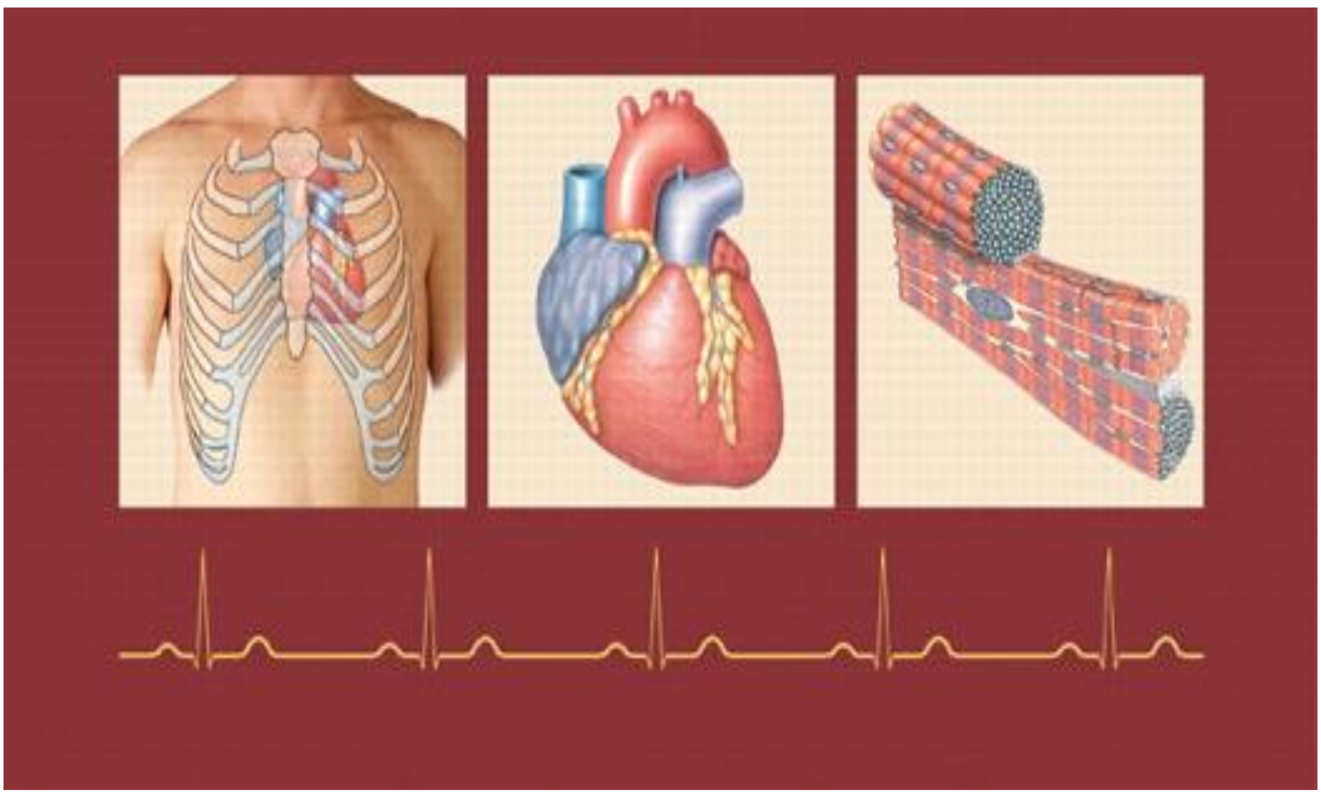
H.S.C (VOCATIONAL)

MEDICAL LABORATORY TECHNICIAN

STD: XI (PAPER-1)

ANATOMY AND PHYSIOLOGY

THEORY



INDEX

Lesson 1- Introduction to anatomy

Objective – At the end of the lesson the students will be able understand the different anatomical terms, to identify various body parts, the different organ systems and the different body cavities of human body.

1.1

Definition Anatomy – It is the study of structure and arrangement of different parts, organs, systems of body and relationship of its constituent parts to each other.

Definition Physiology – It is the study of functions of different parts, organs, systems of the human body.

1.2 Levels of Organization in the Human Body:

Chemical level- It is the simplest level which is composed of atoms and molecules. Atoms are the smallest units of matter. Two or more atoms combine to form a molecule, such as a protein, a water molecule, or a vitamin. In turn, molecules combine to form organelles, the internal organs of a cell.

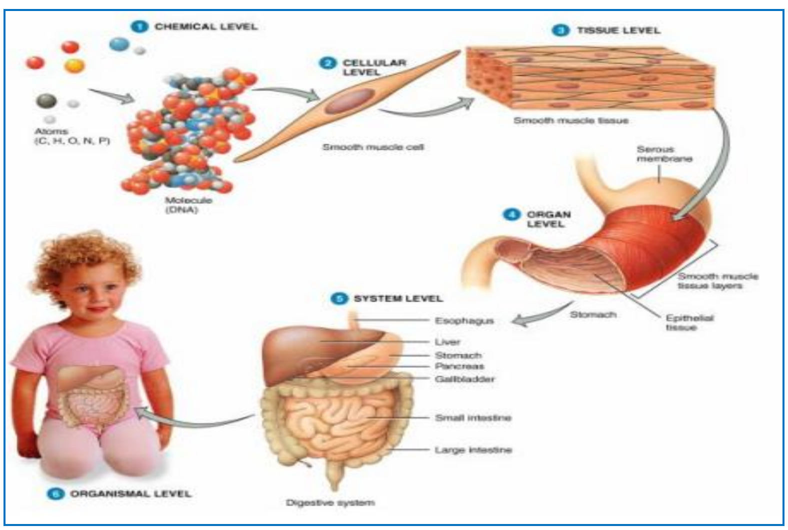


Figure 1.1 Levels of Organization of Human Body

- **Cellular level-** the cellular level is made up of the smallest unit of living matter, the cell.
- **Tissue level-** Tissues are groups of similar cells that have a common function. A tissue must contain two different types of cells. The four basic tissue types in humans include epithelium, connective, muscle, and nervous tissue.
- **Organ level-** an organ is a structure composed of at least two different tissue types that perform a specific function within the body. E.g. Brain, stomach, liver, etc.
- **Organ system level-** One or more organs work in unison to accomplish a common purpose. For instance, the heart and blood vessels work together and circulate blood throughout the body to provide oxygen and nutrients to cells.
- **Organismal level-** The organismal level is the highest level of organization. It is the sum total of all structural levels working together.

1.3 Different Systems of the body

The human body is made up of several organ systems that all work together as a unit to make sure the body keeps functioning. There are ten major organ systems in the body, each of which plays a different role in helping the body work.

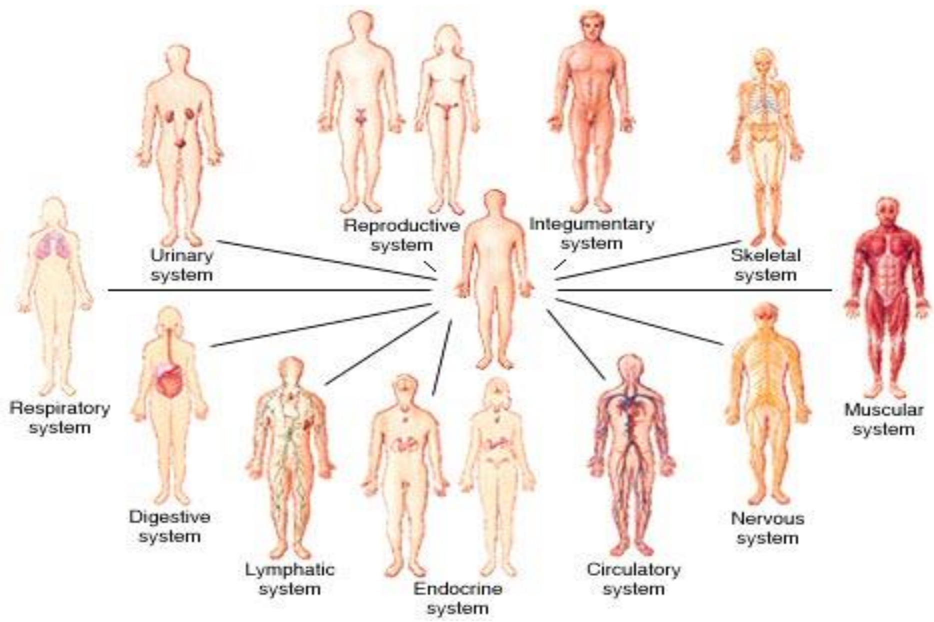


Figure 1.2 Different systems of Human Body

System	Major structures	Functions
Circulatory	Heart, blood vessels, blood (cardiovascular) lymph nodes and vessels, lymph (lymphatic)	Transports nutrients, wastes, hormones, and gases
Digestive	Mouth, throat, esophagus, stomach, liver, pancreas, small and large intestines	Extracts and absorbs nutrients from food; removes wastes; maintains water and chemical balances
Endocrine	Hypothalamus, pituitary, pancreas and many other endocrine glands	Regulates body temperature, metabolism, development, and reproduction; maintains homeostasis; regulates other organ systems
Excretory	Kidneys, urinary bladder, ureters, urethra, skin, lungs	Removes wastes from blood; regulates concentration of body fluids
Immune	White blood cells, lymph nodes and vessels, skin	Defends against pathogens and disease
Integumentary	Skin, nails, hair	Protects against injury, infection, and fluid loss; helps regulate body temperature
Muscular	Skeletal, smooth, and cardiac muscle tissues	Moves limbs and trunk; moves substances through body; provides structure and support
Nervous	Brain, spinal cord, nerves, sense organs	Regulates behavior; maintains homeostasis; regulates other organ systems; controls sensory and motor functions
Reproductive	Testes, penis (in males); ovaries, uterus, breasts (in females)	Produces gametes and offspring
Respiratory	Lungs, nose, mouth, trachea	Moves air into and out of lungs; controls gas exchange between blood and lungs
Skeletal	Bones and joints	Protects and supports the body and organs; interacts with skeletal muscles, produces red blood cells, white blood cells, and platelets

Figure 1.3 Chart showing the body systems and their functions

1.4 Anatomical Position

The anatomical position is an arbitrary position of the body used as a reference when describing different parts of the body in relation to each other. All the descriptions of the human body are based on the assumption that the person is standing erect, facing forward with feet together and upper limbs by the side of the body with the palms of the hand facing forwards. This is called as an ‘anatomical position.’

1.5 Anatomical Planes:

The various parts of the body are described in relation to certain imaginary planes, which are called as ‘Anatomical planes.’ The important anatomical planes are-

(a) Median Sagittal Plane t:-It is a vertical plane passing through the center of the body, dividing the body into right and left equal halves.

(b) Para median Planes: - Planes that are situated one or the other side of the median sagittal plane and parallel to it are called as “Para median planes.’ They divide the body in to right and left unequal parts.

(c) Coronal Plane: - It is a vertical plane passing through the center of the body and at right angles to the median sagittal plane which divides the body in to an anterior part and a posterior part.

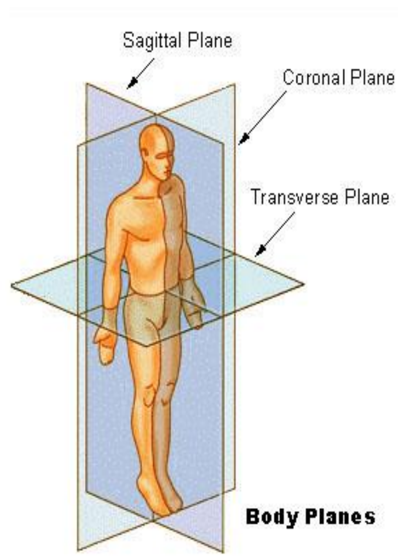


Figure 1.4 Anatomical Planes

(d) Transverse Plane:-It is a horizontal plane which lies parallel to the ground and at right angles to both median sagittal and coronal planes. It divides the body in to superior (upper) part and inferior (lower) part.

1.6 Anatomical Terms

In describing the relationship of one structure to another and to describe its position in the body certain specific terms are used called as 'Anatomical terms' or 'Directional terms.' The commonly used anatomical terms are-

(a) **Anterior or ventral –It** means towards or at the front of the body.
e.g. The sternum is anterior to the heart.

(b) **Posterior or dorsal** – it means towards or at the back of the body.
e.g. The oesophagus is posterior to trachea.

(c) **Superior or Cranial-** It means towards the head or upper part of the body or structure.
e.g. The head is superior to the heart.

(d) **Inferior or Caudal**– it means towards the feet or lower part of the body or structure.
e.g. The liver is inferior to Lung.

(e) **Superficial –** It means towards or at the surface of the body.
e.g. The skin is superficial to skeleton.

(f) **Deep –** It means away from the body surface towards the interior of the body.
e.g. The lungs are deep to the ribs.

(g) **Medial –** It means towards or at the midline of the body or structure.
e.g. The heart is medial to the lungs.

(h) **Lateral –** It means away from the midline of the body or structure.
e.g. The eyes are lateral to the bridge of the nose.

(i) **Proximal –** It means nearer to the root of the limb or a structure.
e.g. The knee is proximal to the ankle.

(j) **Distal –** It means away from the root of the limb or a structure.
e.g. The hand is distal to the forearm.

(k) **Ipsilateral** – It means on the same side of the body.

e.g. The left arm and left leg are ipsilateral.

(l) Contralateral – It means on the opposite side of the body.

e.g. The left arm and right leg are contralateral.

Figure 1.5 Anatomical Position

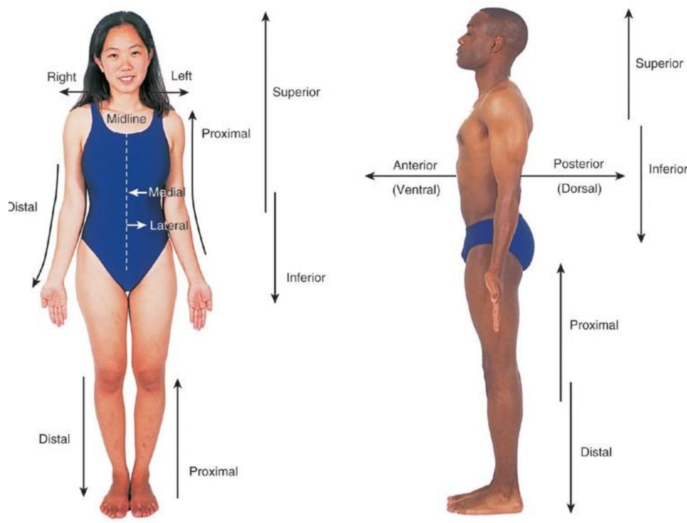


Figure 1.6 Anatomical terms

1.7 Body Cavities

There are two major cavities in the human body – Ventral and dorsal.

(a) **Ventral cavity: -** It is bigger in size and is divided in to two parts by the diaphragm namely thoracic cavity and abdominopelvic cavity.

i. **Thoracic Cavity**: It contains the heart, lungs, trachea, esophagus and the large blood vessels.

ii. **Abdomino-pelvic Cavity**: it is again divided in to two portions. The abdominal cavity, which contains most of the gastrointestinal tract and kidneys and adrenal glands and the pelvic cavity, which contains the reproductive organs, urinary bladder and rectum.

(b)- Dorsal Cavity: It is small in size and lies posteriorly. It has also two subdivisions. The upper portion called as **cranial cavity** contains brain and the lower portion called as **vertebral cavity** which contains the spinal cord.

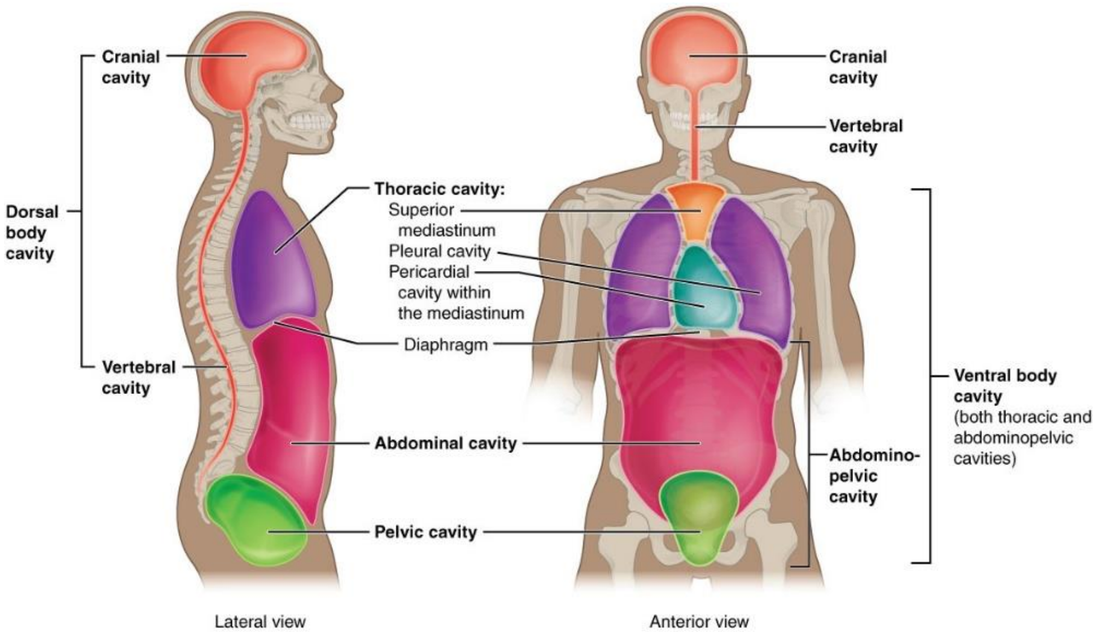


Figure 1.7 Body Cavities

Review Questions:

1. Define Anatomy and Physiology.

2. Describe the various levels of structural organization of human being.
3. Describe an anatomical position.
4. Describe the various anatomical planes.
5. Describe the meaning of the following anatomical terms with examples.
    a. Anterior and Posterior
    b. Superficial and Deep
    c. Superior and Inferior
    d. Medial and lateral
    e. Proximal and Distal

****

Lesson 2- Human cell

Objective:
At the end of the lesson the student will be able to understand the structure of a cell and identify different organelles and their functions.

2.1 The Cell

Cell is the structural and functional unit of all living organisms. Human body is made up of around 100 trillion or 10^{14} cells, divided in to about 200 different types. The word cell is derived from a Latin word 'cella' which means a 'store room'.

Definition of the cell

A cell may be defined as the basic structural and functional unit of a living matter and is capable of carrying out all the life processes independently.

Size of the cell

Most of the cells are microscopic, with average size ranging from 10 to 30 microns in diameter. The largest cell is the ovum, which is about 300 microns in diameter and is just visible to naked eyes. The erythrocyte is the smallest cell, being about 7.2 microns in diameter.

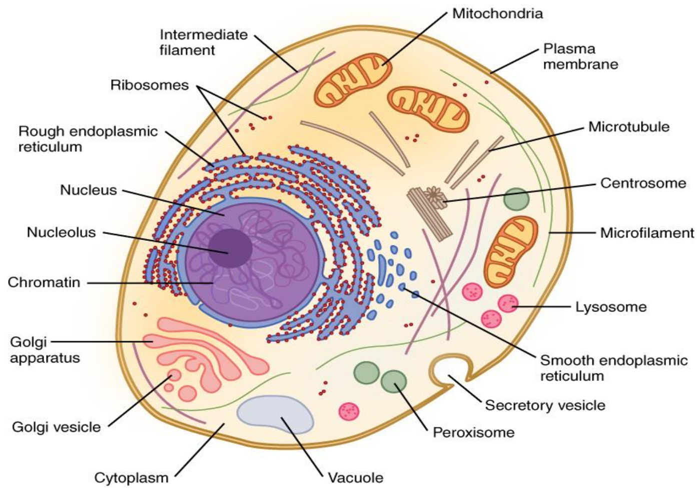


Figure 2.1 Structure of a Cell

2.2 Structure of the cell

A cell is a minute mass of protoplasm ('protos' meaning primitive or original and 'plasm' means a substance) which is highly opaque, jelly-like substance which consists of carbohydrates, proteins, fats, organic and inorganic salts. This mass of protoplasm is surrounded by a very, thin, delicate membrane called as 'cell membrane.' which regulates the exchange of substances between the cell and the external environment.

2.2.a Cell Membrane

It is also called as 'plasma membrane.' it is the outmost covering of the cell. It separates one cell from another as well as from the external environment. It is a very thin, delicate, semipermeable membrane. It is made up of proteins, lipids, water, carbohydrates and cholesterol.

Structure of a cell membrane

The cell membrane is mainly made up of proteins and lipids. The lipids are in the form of phospholipids. They are arranged in two parallel rows forming the phospholipid bilayer. The phospholipid molecules are polarized molecules having hydrophilic and hydrophobic ends. The phospholipid bilayer lies in between two protein layers. The outer protein layer is called as 'Peripheral proteins' whereas the inner protein layer is called as 'Integral proteins.'

In between the phospholipid and protein layers there are small openings or gaps called as membrane pores thorough which the substances pass in and out of the cell.

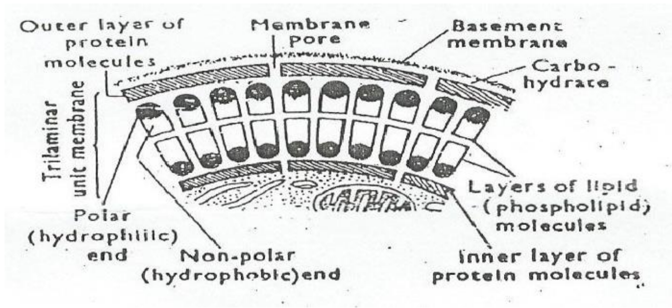


Figure 2.2 Structure of a cell membrane

Functions of cell membrane:

1. It forms a flexible boundary enclosing the cellular contents and separating them from the external environment.

2. It allows contact with the other body cells or foreign cells.

3. It provides receptor for chemicals such as enzymes, hormones, nutrients and antibodies.

4. It is selectively permeable and regulates entry and exit of substances between the cell and the external environment. This movement of substances across the cell membrane takes place either by passive process or by an active process.

(a) **Diffusion**: In passive process the substances move from the area of higher concentration the area of lower concentration by simple diffusion. e.g. movement of O_2 from the blood in to the cell and CO_2 from the cell in to the blood.

(b) **Active Transport**: Here the cell contributes energy in moving the substance across the cell membrane against the concentration gradient. e.g. movement of glucose.

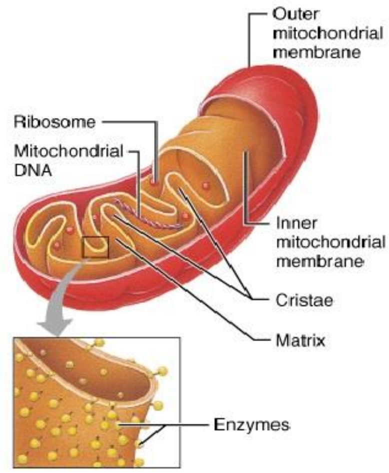
2.2.b Cytoplasm

Cytoplasm is the protoplasm lying inside the cell membrane and outside the nuclear membrane. It is ground substances in which many cellular elements are present. These are mainly divided in to cytoplasmic organelles and cytoplasmic inclusions.

2.2.c Cytoplasmic Organelles

Organelles (literally "little organs") are usually membrane-bound structures present inside the cytoplasm of cell that have specific functions. They include -

1. Mitochondria



Mitochondria are small, rod-shaped structures found throughout the cytoplasm. Each mitochondrion is covered with a double layered membrane. Both these membranes are similar in structure. The outer membrane is smooth whereas the inner membrane is folded to form incomplete partitions called as '**cristae**'. The interior of the mitochondrion is filled with a fluid called as '**matrix**'. The respiratory enzymes located on the cristae complete the cellular respiration by aerobic pathway producing high energy. Hence mitochondria are also called as 'powerhouse of the cell'.

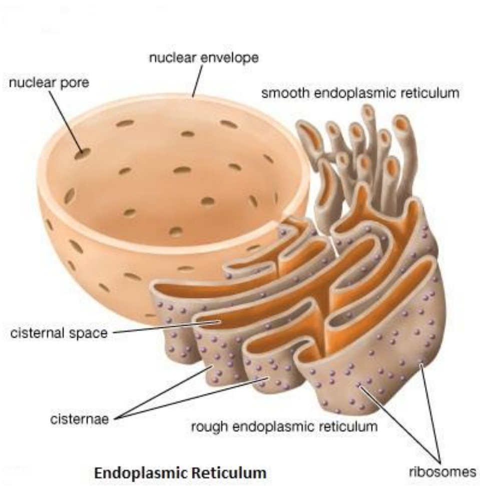
2. Endoplasmic Reticulum

It is a system of intercommunicating membranous tubules. It is made up of two layers or membranes which lie parallel to each other enclosing a small cavity. It is found throughout the cytoplasm forming a sort of a network or reticulum.

The ER is of two types.

(a) **Rough or Granular ER**: It has ribosomes attached on the outer surface of the ER. It helps in protein synthesis and its storage.

(b) **Smooth or Agranular ER**: It does not have ribosomes on its outer surface and hence appear smooth. It is mainly involved in lipid synthesis as well as synthesis of cholesterol and steroid hormones.



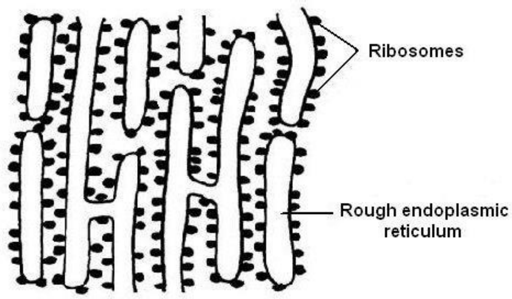


Figure 2.4 Endoplasmic Reticulum

Functions of ER:

1. ER acts as an intra-cellular supporting frame work that also maintains the form the cell.
2. The ER facilitates transport of materials from one part of the cell to another, thus forming the cells circulatory systems.
3. The ER provides space for temporary storage of synthetic products such as glycogen.
4. The rough ER carries ribosomes, which help in the synthesis of proteins.
5. The smooth ER helps in the synthesis of lipids and steroids.

3. Golgi apparatus (Golgi body or Golgi complex)

It was first described by a scientist Camillo Golgi. It is found in all animal cells except erythrocyte. It is usually found near the nucleus. It is made up of 3 different structures.

(a) **Flattened sacs** (Cisternae): These are 3-8 membranous sacs swollen at both ends.

Secretory vesicles: they are supposed to be the enlargements of the swollen ends of the cisternae, which breaks off due to increase in the size. The protein material synthesized by the ribosomes on rough ER is stored in the flattened sacs and secretory vesicles.

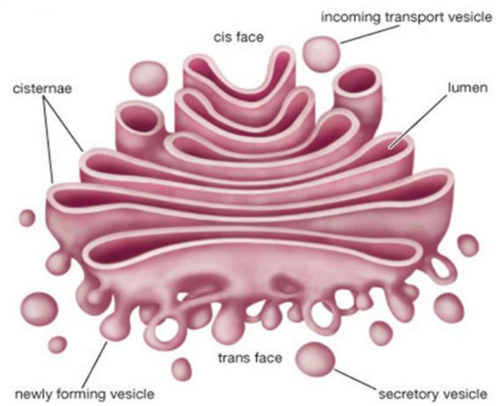


Fig 2.5 Golgi complex

(b) **Transport vesicles**: these are small in size and are considered as transport system that carries the protein material secreted by the ribosomes from the rough ER to the fattened sacs.

Functions of Golgi apparatus:

1. It is involved in the secretory activities of the cell. It is mainly concerned with the synthesis of hormones, enzymes, and other material required for building the cell membrane.
2. It stores proteins which are synthesized by the ribosomes and the rough ER.
3. It stores the lipids which are synthesized by the smooth ER.

4. Ribosomes

These are small granules about 100-150A^0 in diameter found scattered throughout the cytoplasm either singly or in groups. When present in groups they are called as 'polysomes.' They are composed of approximately 60% RNA and 40% protein.

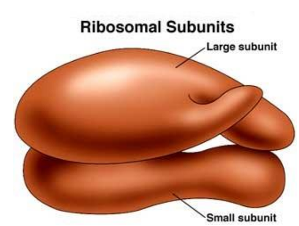


Fig.2.6 Ribosomes

A ribosome is not just one piece. There are two pieces or subunits. Scientists named them 60-S (large) and 40-S (small).

They are the main sites of protein synthesis and hence ribosomes are called as '**protein factories'** of the cell.

5. Lysosomes

These are membranous vesicles having a unit membrane. They are spherical in shape and are filled with hydrolytic enzymes which are capable of breaking down larger molecules like protein, carbohydrates and lipids in to smaller fragments, which can be easily digested. They are present in all animal cells except RBC.

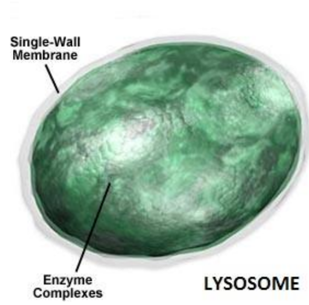


Fig. 2.7 Lysomes

They are present in large number in WBCs. The lysosomes helps in intracellular digestion. When the cell gets injured the lysosome release the digestive enzymes in to the cell which digest off the cellular elements, this process of self-destruction is called as 'autolysis." Hence lysosomes are called as '**suicidal bags'**

6. Centrosome

It is a dense spherical mass of protoplasm situated near the nucleus, usually below the nucleus. Each centrosome is made up of a pair of cylindrical structures called as "Centrioles." Each centriole is an empty cylinder about 3-5 microns in length. The wall of centriole is made up of ring of 9 thin, parallel tubular structures arranged longitudinally. Each of these 9 tubules is made up of 3 microtubules which are arranged radially. Usually both the cylinders lie perpendicular to each other.

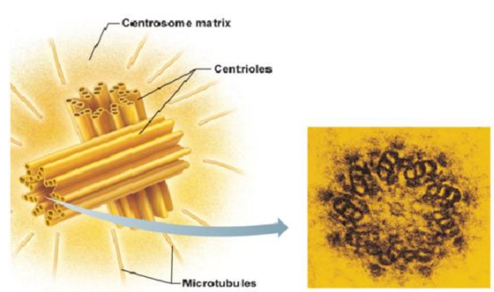


Figure 2.8 Centrosome

Functions: centrosome plays an important role in cell-division. The cell which does not have centrosome cannot reproduce.

2.3 The Nucleus

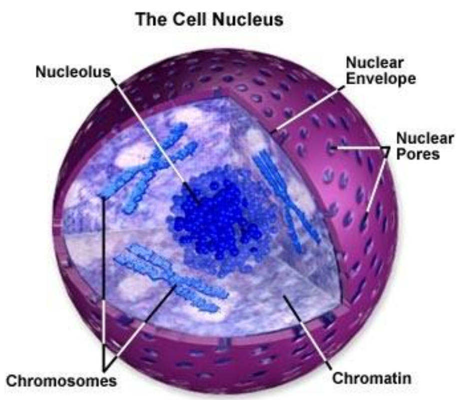


Figure 2.9 Nucleus

The nucleus is the central unit of cell. It is the largest cellular organelle which occupies about 10% of the total cell volume. The average diameter of the nucleus is approx. 6 micrometers (µm). It is dense spherical mass of protoplasm separated from the cytoplasm by a double-layered membrane, called '**nuclear membrane**.' In between the two layers of the membrane there is a minute space called as '**Perinuclear cisternae**.' The nuclear membrane has small pore through which the nucleus communicates with the ER and the cytoplasm. These pores are called as '**nuclear pores**.' Inside the nuclear membrane there is a jelly-like liquid called as '**nucleoplasm**.' The nucleus contains 1 or more spherical bodies called as 'nucleoli.' The nucleus contains many protein-rich threads called as **'chromatin'**. These chromatin threads form a network throughout the cytoplasm. Chromatin is responsible for deciding the hereditary characteristics of a person

Function of nucleus:

1. Nucleus is the controlling center of the cell metabolism.
2. It is the site of for synthesis of DNA, RNA, ribosomes.
3. It carries genetic information for growth and development.
4. It passes all genetic information to next generation.

<u>Review Questions:</u>

1. Draw a neat and labeled diagram of an animal cell.

2. Describe the structure and functions of the following cytoplasmic organelles. (a)Mitochondrion, (b) Endoplasmic Reticulum, (c) Golgi Apparatus, (d) Centrosome

Lesson 3- Tissues

Objective - At the end of the lesson the student will be able to define a tissue and classify the human tissues, know the structure and functions of various epithelial tissues and connective tissues, Classify muscular tissue and its function and identify nervous tissue and know its functions.

3.1 Definition

A tissue is a group of cells which are similar in structure and which perform common or related functions.

3.2 Classification of the tissues

Human body is made up of many different types of tissues having specialized functions. All the tissues, which form the body, are divided in two for types, which are called as elementary tissues of the body. They are –

A. Epithelial tissue - covers surfaces, lines cavities, forms glands.
B. Connective tissue - supports and protects other tissues.
C. Muscular tissue – causes movement.
D. Nervous tissue - receives and generates nerve impulse.

A-Epithelial tissues

This tissue forms the limiting and lining membranes of free surfaces of different structures and organs of the body. It also forms most of the glands of the body. The main characteristic features of epithelial tissue are –

1. It is made up of single or many layer of cells
2. The cells forming the epithelial tissues are closely packed with a very little or no intercellular substance.

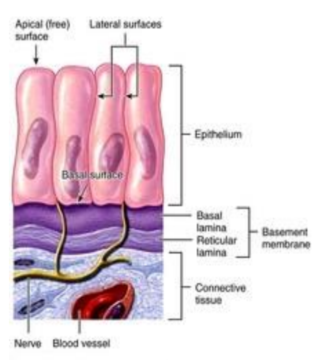


Fig 3.2.1 Epithelial tissue

3. The cementing substance is a mucoprotein which contains Hyaluronic acid and calcium salts.
4. There is generally a basement membrane on which the cells rest. The basement membrane is made up of two layers (i) Basement lamina and (ii) Reticular lamina.

Classification of Epithelial tissues

The epithelial tissues are classified in to two main groups.

1. Simple Epithelium
2. Compound Epithelium

1. Simple Epithelium

It is made up of single layer of cells arranged on a basement membrane. It is further divided in to 5 types.

1. Squamous epithelium
2. Cuboidal epithelium
3. Columnar epithelium
4. Ciliated epithelium
5. Glandular epithelium

1.1 Squamous Epithelium (Pavement epithelium)

It is made up of a single layer of flat cells arranged on a thin basement membrane. The cells are irregular in shape having a prominent oval or round nucleus. The cells are arranged edge to edge like stones in the pavement. Hence this epithelium is also called as 'pavement epithelium'.

Distribution:

a. It is found in the alveoli of lung.

b. It forms the inner lining of the heart and blood vessels (Called as endothelium).

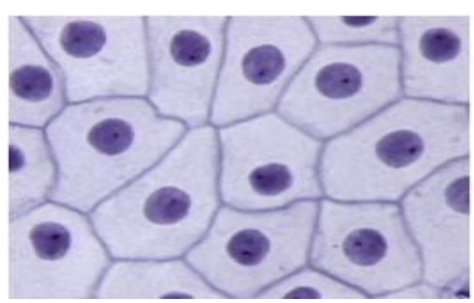


Fig ~~1~~.1 Squamous epithelium

c. It lines the inner surface of the serous cavities. (called as mesothelium)

d. It is present in the loop of Henley in the nephrons of the kidney.

Functions:

1. Passage of materials by passive diffusion and filtration.
2. Secretes lubricating substances in serosae

1.2 Cuboidal Epithelium

It is made up of a single layer of cube-shaped cells arranged on a basement membrane. The cells have prominent central nuclei.

Distribution:

a. It is found in walls of the kidney tubules.

b. The inner part of the digestive glands.

c. The thyroid gland

d. The salivary glands

e. The covering of the ovary.

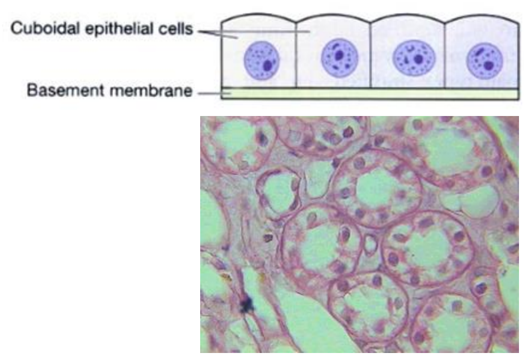


Figure 1.2 Cuboidal epithelium

Functions:

a. Secretion

b. Absorption

1.3 Columnar Epithelium

It is made up of a single layer of column-shaped cells arranged on a basement membrane. The height of the cell is more than the breadth. The nucleus is usually situated near the base.

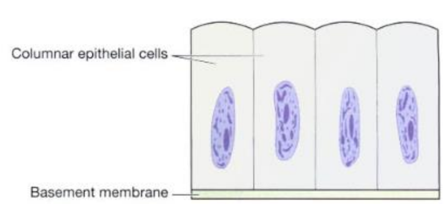


Figure 1.3.a Cuboidal epithelium

Distribution:

- It is found throughout the gastro-intestinal tract mainly the stomach, the whole length of small intestine and large intestine.
- It is found in the alveoli and ducts of many glands.
- It is found in the greater part of the male urethra.

Functions:

1. Secretion
2. Absorption

1.4 Ciliated Epithelium

In this epithelium the cells are mostly columnar in shape arranged on a basement membrane. The free surfaces of each cell shows presence of 20-30 hair-like structures called as ‘cilia.’

Distribution: It is found throughout the respiratory passage ,

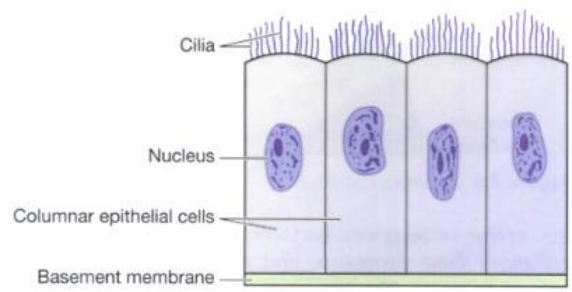


Figure 1.4 (b) Columnar epithelium

starting from trachea up to the terminal bronchiole.

In the fallopian tubes and greater part of the uterus

In the ventricular system of the brain

In the afferent tubule of the testes

Functions:

1. In trachea and the respiratory passage they eliminate any foreign particles or bacteria which are trapped in the sticky mucus.

2. In the fallopian tube, it carries the ovum from the ovary towards the uterus.

3. In the ventricles of brain it helps to maintain the circulation of CSF. (Cerebro-spinal Fluid)

4. In the afferent tubule of testes it carries the sperms from the testes during ejaculation.

1.5 Glandular Epithelium

This type of epithelium lines the alveoli and ducts of the glands. e.g. sebaceous gland, thyroid gland, salivary gland, etc. The cells forming this epithelium are mainly cuboidal or short columnar or polyhedral in shape arranged in a single layer.

Glands

The gland consists of a group of cells which secrete substances in to the duct or on the surface or directly in to the blood.

Classification of the glands

The glands are classified in to two groups:

1. Unicellular gland – Here the gland is made up of only one cell. e.g. Goblet cell

2. Multi-cellular gland – These are further divided as

i. Exocrine glands- these glands secrete their products into the duct. E.g. sebaceous gland, salivary gland, etc.

ii. Endocrine glands - These are ductless glands which pour their secretions directly in to the blood. These secretions are called as 'hormones'. e.g. Thyroid gland, Pituitary gland, Adrenal gland.

iii. Mixed glands – These glands perform both the functions i.e. Exocrine and Endocrine glands. e.g Pancreas, Ovaries.

Exocrine Glands – they are further classified

1. By structure (branching & shape) of duct as simple tubular, compound tubular, coiled tubular, simple saccular, compound saccular and tubulo-saccular.

2. By mode or type of secretion

a. Merocrine gland – secretory vesicles released via exocytosis (salivary glands)

b. Apocrine gland – apical portion of the cell is lost (mammary glands)

c. Holocrine gland – entire cell is destroyed during secretion (sebaceous gland)

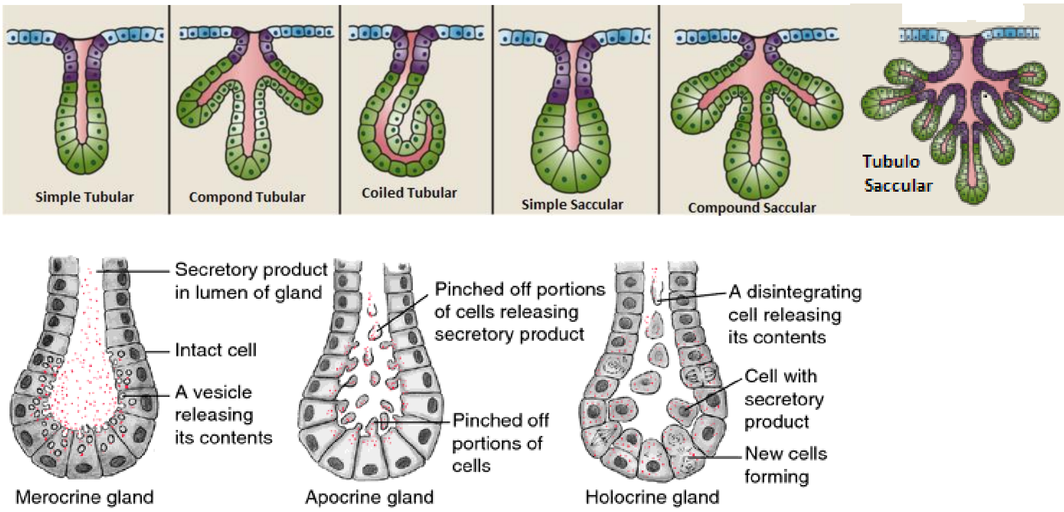


Figure 1.5 Classifications of Glands

Goblet Cell

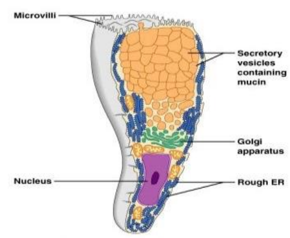


Figure 3.7 Goblet Cell

It is a mucus-secreting cell and found in between the cells forming the columnar or ciliated epithelium. The nucleus along with the cytoplasm is pushed towards the base of the cell, whereas the upper part contains a number of granules called as 'mucinogen granules.' Due to these granules the upper part of the cell bulges out and the cell appears like a goblet or wine glass. Hence this cell is called as 'goblet cell.' These mucinogen granules enlarge in size and finally burst open releasing the mucus or mucin outside. These cells are mainly found in stomach, the colon and the trachea.

Functions of goblet cell

a. Protection -The mucus secreted by the goblet cell forms a protective layer on the surface of the mucous membrane.
b. Lubrication - The mucus acts as a lubricant and prevents friction between the food and the wall of the intestine.
c. Dilution of irritant substances.
d. Neutralization of acids and alkalis.
e. The mucus being sticky in nature entangles bacteria or any foreign paticles

entering the body.

2. Compound Epithelium

They have more than one layer of cells. They include-

2.1 Transitional Epithelium

2.2 Stratified squamous epithelium – it is of two types-

a. keratinized

b. non-keratinized

2.1 Transitional Epithelium

It is made up of 3 to 4 layers of cells and occupies an intermediate position between single-layered simple epithelium and the multi-layered stratified epithelium. Hence, it is called as 'transitional epithelium.' The cells forming the superficial layer are large, irregularly quadrilateral, often containing two nuclei.

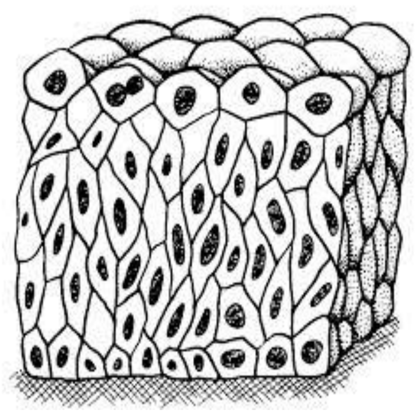


Fig.2.1 Transtitional epithelium

The next layer is of pear-shaped or pyriform cells with their rounded ends fitting in to the cup-shaped depressions on the lower border of the cells of the superficial layer. The next two layers are small quadrilateral cells, which remain packed in between the pointed ends of the cells of the second layer.

Distribution:

This type of epithelium is found throughout the urinary tract, where it lines the pelvis of the kidney, the ureters, the urinary bladder and the upper part of the urethra.

Functions:

- Protection
- Reabsorption
- It allows stretching.

2.2 Stratified Squamous Epithelium

It is made up of many layers of cells of different shapes. The cells in the deeper layers are mainly columnar in shape and as they grow towards the outer surface they become flattened. Stratified squamous epithelium is of 2 types: Keratinized & Non-keratinized

2.2.a Keratinized Stratified Squamous Epithelium

This type of epithelium is found on dry surfaces such as hairs, skin, nails, etc. The superficial layer is horny because of the deposition of keratin. The cells in the next layer are flattened down in the form of scales. Further down the cells are polyhedral and still deeper they are short columnar type. The cells in these layers are connected with each other by number. of fibrils and protoplasmic processes which look like thorns. Hence, these cells are called as ‘prickle cells.’ With the help of these prickles the cells in these layers are held together firmly.

Functions:

It protects the underlying structures from the effect of atmosphere, mechanical pressure, friction and injury.

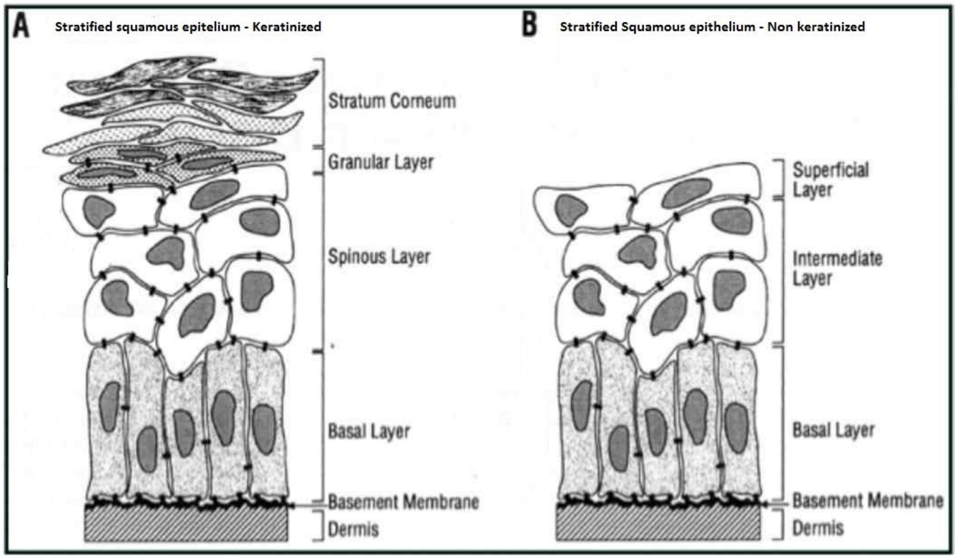


Figure 3.9 Stratified Squamous Epithelium (A) Keratinized (B) Non Keratinized

2.2 b. Non-keratinized Stratified Squamous Epithelium

In this type of epithelium the different layers of cells are similar to that of keratinized stratified squamous epithelium except that the horny layer of keratin is absent. This type of epithelium is found in the tongue, cornea of the eye, lower part of the anal canal, etc.

Functions:

It gives mechanical protection.

B. Connective tissues -

It is the most abundant and widespread tissue. It is the supporting tissue. It is usually highly vascular (richly supplied by blood vessels) except cartilage tissue which is avascular. The cells forming the connective tissue are more widely separated from each other as compared to the closely packed cells of epithelial tissues. There is a large amount of intercellular substance which may or may not contain fibers. The important connective tissues of the body are –

1. Areolar tissue

It is the most abundant connective tissue. It lies immediately below the skin forming the subcutaneous layer, below the mucosa forming the sub-mucous layer and in between the muscles, vessels and the nerves. The areolar tissue is composed of different types of cells and different types of fibers embedded in a semi-solid matrix. The fibers which are present in the areolar tissue are-

a. White fibers: They are made up of wavy strands or bundles of collagen fibers. They run in all directions forming a network. The fibers are tough and resistant to pulling force.

b. Yellow fibers: They are straight fibers and are branching. They are elastic in nature.

c. Reticular fibers: They are very thin fibers and branch freely. They are made up of collagen and glycoprotein.

The different types of cells which are present in areolar tissue are-

d. Fibroblasts: These are large, elongated cells with central, oval nucleus. The mature fibroblasts are called as fibrocytes. Fibroblast is an active cell whereas fibrocyte is an inactive cell. The fibroblasts

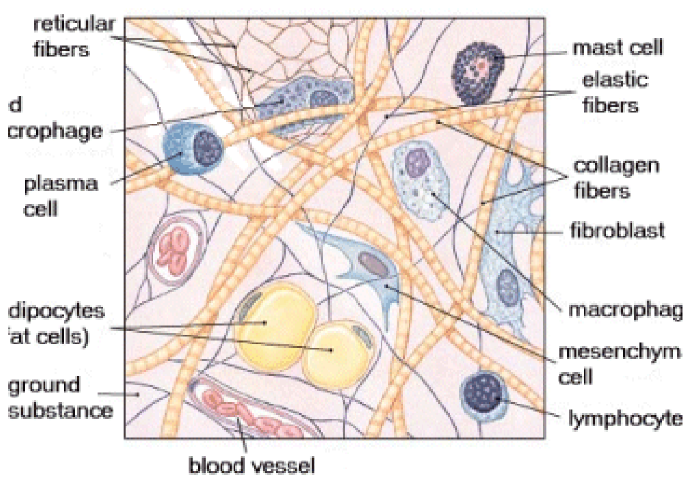


Fig 3.10 Areolar tissue

produce the white fibers.

b. Histiocyte: These are large, irregular cell with one or two nuclei and a basophilic cytoplasm.

c. Basophil: It is a large, round cell with a single nucleus and a granular basophilic cytoplasm.

d. Plasma cells: These are small, round or oval cells with a non-granular basophilic cytoplasm and a round eccentric nucleus.

e. Mast cell: It is a large round or oval cell with a coarse granular cytoplasm.

f. Pigment cells: Some of the connective tissue cells also contain pigmentary granules.

g. Fat cells(Adipocytes)

h. Leucocytes(White Blood Cells)

2. Adipose Tissue

It is compose of number. of fat cells containing free fat inside. These fat cells are also called as 'Adipocytes'. A group of adipocytes remain supported by a loose framework of areolar connective tissue. The fat cell is usually large, round or oval in shape with a big nucleus which is pushed along with the cytoplasm towards one side of the cell by a big fat tissue globule. The nucleus appears flat. This particular appearance of a fat cell is called as a "signet ring appearance".

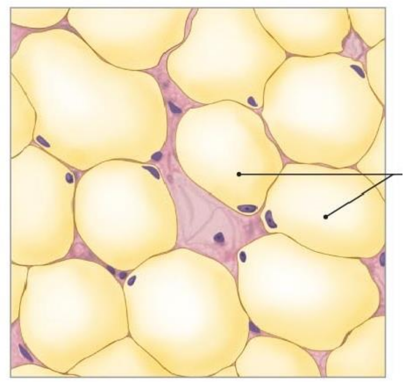


Fig B-2 Adipose tissue

Distribution:

It is found below the skin. It is also found supporting the important organs of the body like kidney, eyes and the heart. It is also present in the lactating mammary gland.

Functions:

1. It gives shape to the limbs and the body by running under the surface of the skin.
2. It is a poor conductor of heat and hence it prevents loss of heat from the body. Thus, it maintains the body temperature.
3. Fat is the main energy reserve of the body.
4. It protects the important organs of the body like heart, eyes and kidneys.

3. White Fibrous Tissue

It is a very strong connective tissue made up of closely packed white shining bundles of collagen fibers with a very small amount of intercellular substance (matrix). The bundles are wavy and run in different directions. They branch freely and the branches communicate with each other. The white fibers are made up of a protein known as collagen.

Distribution:

This is strong and tough connective tissue and it is found at places where greater strength is required such as-

1. The ligaments - which hold the bones together at joint.
2. The aponeurosis - the flat bands which connects the muscles to the bones.

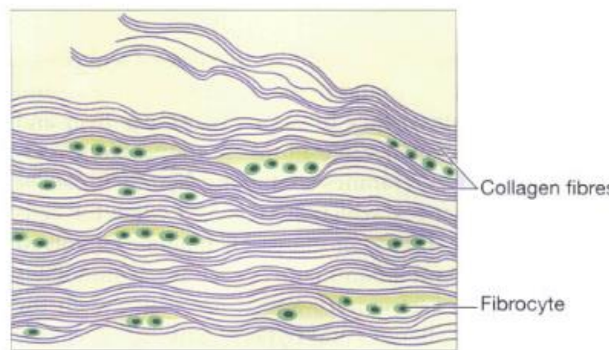


Figure B-3 White fibrous tissue

3. The tendons - which attaches the muscles to the bones.
4. The protective covering of the bone called as 'periosteum.'
5. The Duramater - the outermost layer of the meninges which covers the brain.
6. The fibrous layer of the pericardium.

Functions:

1. To connect the different tissues and the different parts of the body.
2. To afford mechanical protection against stretch and pressure.

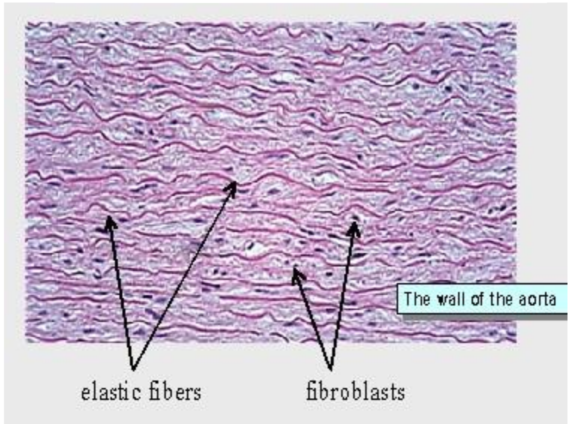


Figure B-4 Elastic Tissue

4. Yellow Elastic Tissue

This tissue contains a large amount of yellow elastic fibers which are thick and are made up of a protein called elastin. The individual fiber branches freely and the branches join together toform a network. The fibers run straight and singly. This tissue is capable of considerable extension and recoil.

Distribution: It is found in-

1. The ligamentum flavum of the vertebrae.
2. The walls of the trachea, bronchi and in the lungs.
3. The vocal cords.
4. The walls of the arteries.

Functions:

1. As a ligamentum flavum it holds the vertebrae together firmly still allowing a greater degree of movements.
2. In the lungs the elastic recoil helps expiration.
3. In vocal cords the extension and recoil helps phonation.
4. In the blood vessels it prevents excessive dilatation and by its recoil it helps in maintaining the circulation and the blood pressure.

5. Reticular Tissue

It is structurally similar to the areolar connective tissue. But it contains a large number of lymphocytes in a semi-solid matrix with a network of reticular fibers. The reticular fibers are produced by reticulate cells. They are thin, freely branching and selectively stained by silver oxide.

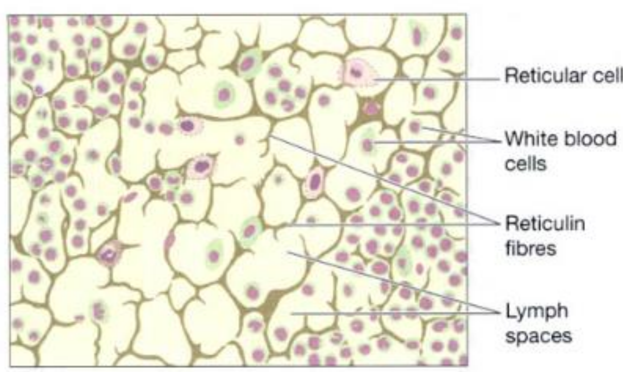


Figure B-5 Reticular Tissue

Hence, they are also called as 'agyrophil fibers'. The interspaces are small and are occupied by lymph and tissue fluid.

Distribution:

The reticular tissue helps to form the stroma of many organs including the liver, spleen and the lymph nodes. It forms the basement membrane of many epithelia.

6. Lymphoid Tissue

It is divided in to (a) Non-capsulated lymphatic nodules

(b)Capsulated lymphatic tissue

a. Non-capsulated lymphatic nodules

These nodules are a dense aggregation of lymphoid tissue. They appear and disappear frequently and new nodules are generated. These nodes are homogenous or sometimes show a darker periphery called cortex and a lighter central area called as the germinal center. Peyer's patches of the small intestine is the best example of solitary nodule.

Figure B- 6 Peyer's Patches

b. Capsulated lymphatic tissue

These are present in specific lymphoid organs. They are-

1. Lymph nodes
2. Spleen
3. Thymus
4. Tonsils

Functions:

1. To supply lymphocytes to the blood and the lymph stream.
2. To serve as a great defense against bacterial infection.

7. Cartilage Tissue

It is a dense, translucent connective tissue firm in consistency and somewhat elastic. In firmness and consistency it occupies an intermediate position between the fibrous tissue and the bone. It is made up of a large number of cartilage cells called as chondroblasts and a large amount of solid matrix. The matrix is made up of two types of proteins – chondromucoid and chondroalbumoid. The cartilage cells occur either singly or in groups within an empty space called as lacunae. The cells are large with rounded edge and a large nucleus. When in groups they are found either two or four together. Such cells form a cell nest. There are three types of cartilage tissues - Hyaline cartilage, Fibrocartilage and Elastic cartilage.

a. Hyaline Cartilage

It is made up of cartilage cells and a clear homogenous ground substance without any fibers. It appears bluish white, shining, translucent, homogenous mass which looks like a glass. (Hyaline means a glass). Hence, this cartilage is called as hyaline cartilage. The cartilage cells called as chondrocytes occupy small empty spaces called as lacunae. These cells form cell nests. The cell nest may have two or four cells. The ground substance is homogenous and is highly basophilic. The hyaline cartilage is

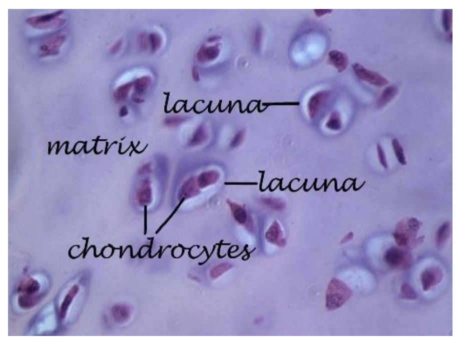


Figure B-7.a. Hyaline Cartilage

enclosed by a tough covering called as perichondrium.

The hyaline cartilage is found in-

(a) The ends of the long bones(articular cartilage)

(b) The anterior ends of the ribs.(costal cartilage)

(c) The epiphyseal cartilage.

d. The cartilages of nose, external auditory meatus the larynx, the tracheas and bronchi.

b. Fibro-cartilage

It is also called as white cartilage. It consists of dense masses of white collagen fibers in a solid matrix. The chondrocytes are widely dispersed in between the fibers. This type of cartilage is tough and hence it is found at places where greater strength is required such as-

1. Intervertebral discs
2. Menisci of knee joints

a. Public symphysis

b. The mandibular joint

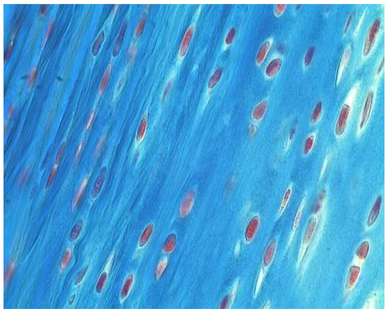


Figure B-7.b.Fibrocartilage

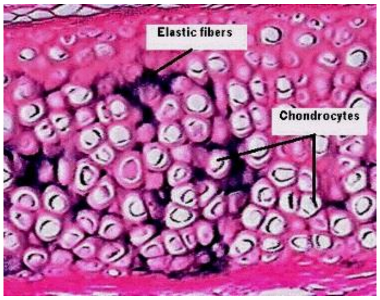


Figure B-7.c.Elastic Cartilage

c. Elastic cartilage

It is also called as yellow cartilage. It consists of number,of yellow elastic fibers which are straight fibers running through a solid matrix in all directions forming a network. The chondrocytes lie in between the fibers. This cartilage is present where both support and flexibility is required. It is found in –

a. The pinna of the ear

b. The epiglottis

c. The Eustachian tube

d. Laryngeal cartilages

8. Osseous Tissue (Bone)

It is the hardest connective tissue of the body and forms the skeleton. It consists of a large amount of intercellular substance surrounding widely separated bone cells. The intercellular substance consists of 40% organic part which is made up of collagen fibers and 60% inorganic part which consists of mineral salts namely phosphates and carbonates. The bone cells are of three types: Osteoblasts, osteocytes and Osteoclasts.

Osteoblasts-These are concerned with bone formation.

Osteocytes- These are entrapped osteoblasts.

Osteoclasts-These are giant bone cell with one or more darkly stained nuclei. They secrete a proteolytic enzyme which dissolves the bone tissue.

There are two types of bones:

a. Compact bone or cortical bone

b. Spongy bone or cancellous bone.

a. Compact Bone

It is typically found in the shaft of the long bones. When seen with the naked eyes it appears as a solid structure, but when seen under microscope it is seen to be made up of a large number, of circular units having similar structure. These units are called as the Haversian systems. The Haversian system is the structural and functional unit of a compact bone.

Each Haversian system shows the following characteristics:

3. In the center of the each Haversian

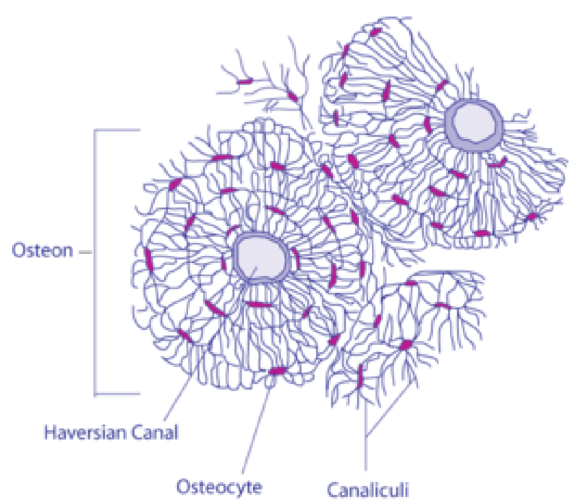


Figure B-8.a. Haversian system

system there is a “Haversian canal” which runs longitudinally and carries blood vessels, nerves and lymphatic.

4. Surrounding the central canal there are 8 to 15 concentric plates of bones called “lamellae”.

5. The space in between the two lamellae is called as ’lacunae’, which contains the bone cells called ‘osteocytes’.

6. Radiating between and linking the lacunae and the Haversian canal are fine wavy channels called as ‘canaliculi’.

7. The triangular space in between the Haversian system is occupied by the bone tissue and the osteophytes arranged irregularly and are called as ‘interstitial lamellae’.

b. Cancellous or Spongy bone

It is typically found in the rounded ends of the long bones and the body of the vertebrae. When seen with the naked eyes it looks like a sponge, hence it is called as a ‘spongy bone’. When seen under microscope the bone lamellae are arranged irregularly. There are no Haversian canals and the blood vessels ramify in the substance of the bone which is filled with bone marrow.

Periosteum

The periosteum is the vascular fibrous membrane covering bone, except at the articular surfaces. The periosteum consists of an outer "fibrous layer" and inner "cambium layer". The fibrous layer contains fibroblasts while the cambium layer contains progenitor cells which develop into osteoblasts that are responsible for increasing bone width. It is richly supplied with blood vessels and the blood vessels ramify in the substance of the bone and thus help to supply nutrition to the bone.

Functions of Periosteum:

1. It forms an outer tough protective covering of the bone.

2. It gives attachment to the muscles and to the tendons.

3. It gives attachment to the ligaments.

4. It carries nutritive vessels to the bone.

5. In a growing bone a layer of bone forming cells (Osteoblasts) lie below the periosteum which is responsible for formation of new bone and healing of fractures.

Blood

Blood is a fluid connective tissue. It contains intercellular substance plasma. Plasma is a straw colored liquid, consists of water and dissolved material. The formed elements of the blood are erythrocytes, leukocytes and thrombocytes. (Ref. Lesson No.5)

c. Muscular Tissue

Muscular tissue is a specialized tissue that enable the body and its parts to move. It forms about 40 to 50% of the total body weight. The word muscle is derived from a Latin word "muss" which means a mouse or a rat, and it is so called because some of the muscles have an end called 'tendon', which resembles the tail of rat.

Functions of Muscles:

Through contractions, muscles perform four functions.

1. Movement or motion **-** Skeletal muscles provide movements of the body by muscle contraction, such as walking, and running. Cardiac muscle contraction maintains the beating of the heart. Smooth muscle contraction in the intestines, urinary bladder, and blood vessels moves substances through the body.

2. Maintenance of posture - Skeletal muscles contract and make small adjustments almost continuously to hold the body in stationary positions, such as sitting or standing.

3. Stabilize joints - Skeletal muscles add stability to joints that have poor reinforcement and articular surfaces that do not fit well, such as in the shoulder and knee joints.

4. Heat production - Skeletal muscle constitutes 40% of body mass. Contractions produce heat and are important in maintaining normal body temperature.

Functional Characteristics of Muscles:

The most important characteristic properties of muscular tissue are -

1. Excitability – It is the ability of the muscular tissue to receive and respond the the stimulus.
2. Contractility – It is the ability of the muscular tissue to contract or to shorten (to become short and thick) when a sufficient amount of stimulus is received.
3. Extensibility – It is the ability of muscle to lengthen. or to stretch.
4. Elasticity – it is the ability of muscle to return to normal size and shape after contraction or extension.

Types of muscular tissue

There are 3 main types of Muscular tissue.

3.1 Striated Muscles or Voluntary Muscles

3.2 Smooth Muscle or Involuntary Muscles

3.3 Cardiac Muscles

3.1 Striated Muscles (Skeletal Muscles)

They are also called as skeletal or voluntary or stripped muscles. Because they show presence of alternate light and dark bands or strips or striations on them when seen under microscope. They are called skeletal muscles because they are attached to bones. They are called voluntary muscles because they are under the control of our will.

Structure of Skeletal Muscle

Muscles and groups of muscles are separated from one another by a sheet of dense connective tissue called fascia. Below the fascia lies the different layers which are –

1. Epimysium - a layer of dense fibrous connective tissue.
2. Perimysium – a collagenous tissue which separates the muscle tissue into small compartments.
3. Endomysium – This is the connective tissue wrapped around each individual muscle fiber

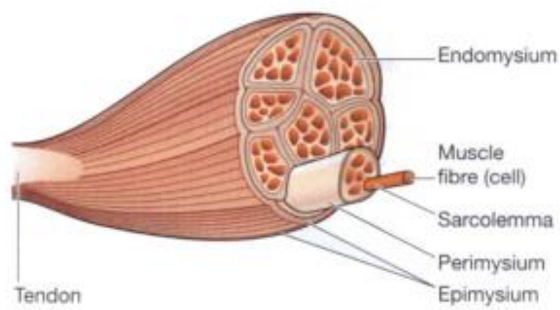


Figure 3.1.a Skeletal muscle Structure

4. Myofibrils – the thread like fibrils that make up the contractile part of a striated muscle fiber.

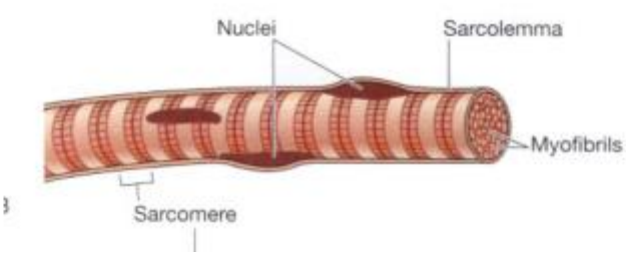


Figure 3.1.b Skeletal muscle fiber

A **muscle fiber** is a **muscle cell** which consists of a plasma membrane called the 'sarcolemma' which surrounds the fiber. Each muscle fiber is an elongated, cylindrical cell having many nuclei which are situated towards periphery. The length of the muscle fiber varies from 1 mm to 40 mm and the diameter varies from 10 microns to 100 microns. Each muscle fiber is made up of a number of thread like structures about 1 to 2 microns in diameter called as 'myofibrils'.

Structure of a myofibril

- The myofibril contain two types of myofilaments composed of contractile proteins:

○ Thick myofilaments - composed of the protein myosin. It is a rod-shaped molecule with two round heads at one end called cross bridges.

○ Thin myofilaments - composed of the protein actin. It consists of a double-stranded coil. The molecule also contains regulatory proteins called tropomyosin and troponin.

▪ The myofilaments do not extend the length of the muscle fiber.

▪ They are contained in small contractile compartments or units called sarcomeres.

▪ Sarcomeres are separated from each other by narrow zones of dense material called Z lines.

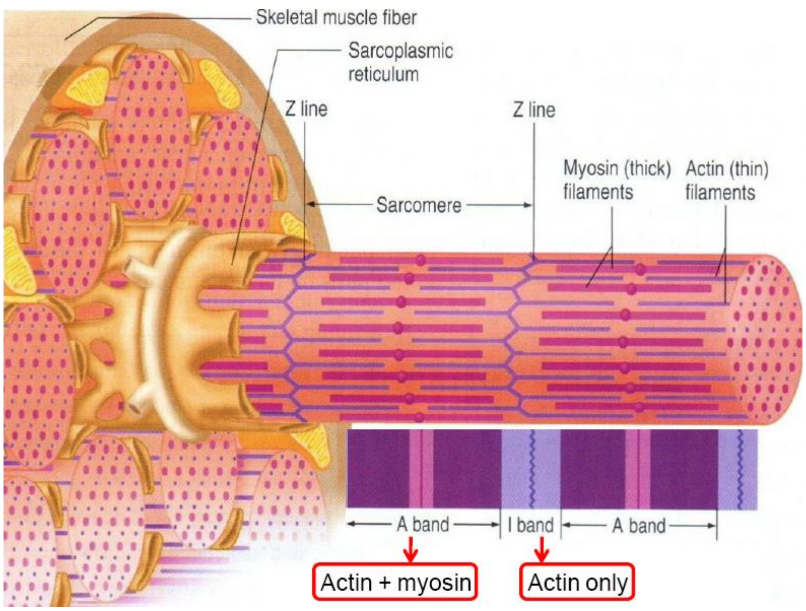


Figure 3.1.c Structure of a Myofibril

▪ The arrangement of thick and thin myofilaments produces the characteristic light and dark striations in the fiber.

▪ In a relaxed muscle, each sarcomere contains an area where thick and thin myofilaments overlap to form a dark, dense band called the A band. In the middle of the A band is a narrow area of thick myofilaments called the H zone. In the center of the H zone is the M line which is a series of fine threads that connect the middle of adjacent thick myofilaments.

▪ The light-colored, less dense area of the sarcomere is composed of only thin myofilaments and is called the I band. The Z line runs down the middle of the I band.

3.2 Smooth Muscle

The smooth muscles are also called as ‘Involuntary muscles’ or ‘Plain muscles’ or ‘visceral muscles’. They are called involuntary because they are not under control of our will. They are called as plain muscle as they do not show presence of alternate light and dark bands. They are called visceral because they are present in the hollow viscera of the body such as gastrointestinal tract, ducts of the glands and the blood vessels. They are also present in the iris and ciliary body of the eye and in the dermis of the skin.

Structure of a smooth muscle fiber

The smooth muscle fibers are elongated, spindle-shaped with a single, centrally-placed, round or oval nucleus. The central portion of the cell is wider with both ends tapering towards the periphery. The average length of the smooth muscle fiber is about 20-500 micron and the width is about 6 microns at the central widest portion. The smooth muscle cells are arranged in such a way that the central wider portion of the muscle cell lies in between the tapering ends of the adjacent muscle fibers. There is no distinct sarcolemma, but the muscle fiber is covered by a very thin membrane.

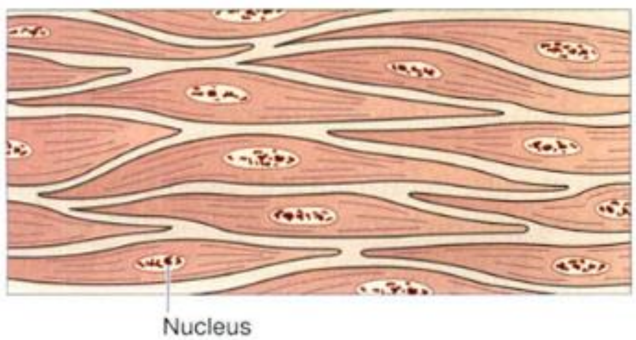


Figure 3.2 Smooth Muscle fibers

3.3 Cardiac Muscles

These are the muscles of the heart. They are also present in the roots the great vessels which are attached to the heart.

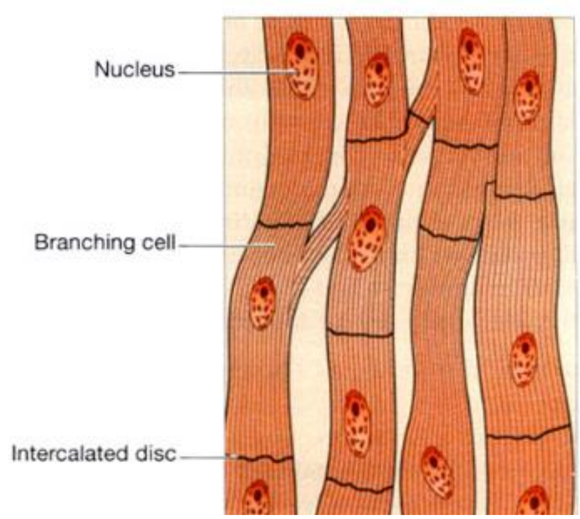


Figure 3.3 Cardiac Muscles

The characteristic property of cardiac muscle is that they contract automatically and rhythmically. They are striated i.e. they show presence of alternate light and dark band. However they are not voluntary like striated muscles. Each cardiac muscle cell shows presence of single nucleus, situated more or less in the center. The fibers branch freely, which connects with the branches of adjacent muscle fibers. The cardiac muscle cell also join with each other end to end. Thus they form a three-dimensional network which is called as ‘cardiac syncytium’. Because of this particular arrangement when the heart contracts it contracts as a whole. The joints between two cardiac muscle cells can be seen as lines which are thicker and darker than the ordinary cross stripes. These are called as’ intercalated discs’.

D. <u>Nervous tissue</u>

It is highly specialized tissue of the body. The nervous system of the body, which includes Central nervous system as well as Peripheral nervous system is totally made up of nervous tissue. The Central nervous system consist of brain and spinal cord whereas the Peripheral nervous system consist of the Cranial nerves, the spinal nerves and the autonomic nervous system.

The characteristic property of nervous tissue is irritability and conductivity. The irritability enables a cell to respond to a stimulus. The wave of excitation, which arises as a response to a stimulus, is called as a nerve impulse. This nerve impulse is conducted along the nerve to the effector organ where it evokes a response.

Structure of the nervous tissue

The nervous system consist of nerve cell and the supporting tissue. The nerve cells are called as “neurons” and are the basic structural and functional units of nervous system. There are about 10,000 million neurons in the human brain. The supporting tissue includes neuroglia in central nervous system and Schwan cells and capsular cells in peripheral nervous system.

NEURON

A neuron is the basic structural and functional unit of a nervous system. Each neuron consist of a cell body and the processes. The receptive processes are called as **Dendrites**, and the discharging process is called as an **Axon.**

Cell body

It is also called as soma or perikaryon. It is about 5 to 100 microns in diameter containing a single nucleus. The shape of the cell varies such as pyramidal, fusiform, stellate, flask shaped, polygonal etc. It forms the grey matter of the brain and spinal cord. The cell body shows the following structures.

- Cell membrane: It is about 75 A^{o} thick and made up of three layers – an outer and inner layer of proteins and the middle layer of lipids.
- Nucleus: It is large, round placed in the center of the cell. It may be eccentric when the cell gets injured.
- Cytoplasm: It shows presence of following structures.
  a. Centrosome
  b. Mitochondria - They are present throughout the cytoplasm and even in the processes of the neuron.
  c. Golgi Bodies: It is situated close to the nucleus.
  d. Lysosomes: These are thick walled membranous vesicles conducting hydrolytic enzymes.
  e. Neurofibrils: These are very fine fibers running throughout the cytoplasm and extend in all the processes. They act as an internal support of the neuron. They do not take part in the conduction of nerve impulse.

f. Nissl granules: These are deeply stained bodies present in the cytoplasm and extend into the dendrites. They are not seen near the axon because there is an overcrowding of the neuro fibrils at the axon. They are stained with the basic dyes. Histochemically, these bodies contain ribonucleoprotein and iron. The exact function of Nissl granules is not known. They are supposed to be helping in the synthesis of new proteins in the cell. When the nerve is injured the Nissl granules disappear and they reappear when the cell regenerates.

Review Questions:

1. Define a tissue. Which are the elementary tissues of the body?
2. What are epithelial tissues? What are their general functions?
3. Describe structure, distribution and functions of the following:
    1. Squamous epithelium
    2. Columnar epithelium
    3. Ciliated epithelium
    4. Transitional epithelium
    5. Stratified squamous epithelium
4. Define Gland. Classify glands in short.
5. Differentiate between Skeletal and smooth muscles.

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Lesson 4 -Skeletal system

Objective: After studying this chapter, you will be able to

- **List and describe the components of the skeletal system.**
- **Discuss the functions and organization of the skeletal system.**
- **Describe and classify the different types of bones.**
- **Describe the structure of a bone.**
- **List and describe the different bones forming the skull, vertebral column, the extremities, etc.**
- **List and describe the types of joints found in the skeletal system.**

4.1 Introduction

Human skeletal system is the system of bones as well as their associated connective tissues which includes cartilages, tendons and ligaments and joints of human body. The word comes from the Greek word "skeletos" meaning "dried up," from the verb that means "to dry." It was used to refer to a mummy. Skeleton is defined as the hard framework of human body around which the entire body is built. Almost all the hard parts of human body are components of human skeletal system. Joints are very important because they help the skeleton system to move at different locations.

4.2 Functions of Skeletal System

The skeleton system serves 6 major functions to human body -

1. **Support:** The skeleton provides the framework which supports the body and maintains its shape.

2. **Movement**: The joints between bones permit movement. Movement is powered by skeletal muscles, which are attached to the skeleton at various sites on bones.

3. **Protection**: The skeleton protects many vital organs of the body like, the skull protects the brain and eyes, the vertebrae protects the spinal cord, the rib cage protect the lungs and heart.

4. **Blood cell production**: The skeleton is the site of haematopoiesis, which takes place in red bone marrow.

5. **Storage of Minerals**: Bone matrix can store calcium and is involved in calcium metabolism. Bone also stores Phosphorus and to some extent iron.

6. **Endocrine regulation**: Bone cells release a hormone called osteocalcin, which contributes to the regulation of blood sugar (glucose) and fat deposition.

4.3 Components of Human Skeleton

Human skeleton is composed of three main components, namely, bones, associated cartilages and joints.

1. **Bones:** Bone is a tough and rigid form of connective tissue. It is the weight bearing organ of human body and it is responsible for almost all strength of human skeleton. As these are the main study area, it is discussed separately.

2. **Cartilages:** Cartilage is a type of connective tissue composed of special cells known as chondrocytes along with collagen or yellow elastic fibers. The fibers and the cells are embedded in a firm gel like matrix rich in mucopolysaccharides. Cartilage is not as hard and rigid as bone. It is much more flexible and elastic. There are three types of cartilage, namely, Hyaline cartilage, Fibrous cartilage and Elastic cartilage. (refer to lesson – 3- connective tissue section.)

3. **Joints:** Joints are important components of human skeleton because they make the human skeleton mobile. A joint occurs between “two or more bones”, “bone and cartilage” and “cartilage and cartilage”.

4.4 Divisions of Human Skeleton

Human skeleton can be divided into two divisions, namely, Axial and Appendicular skeleton.

(a) **Axial skeleton** forms the axis of human body.

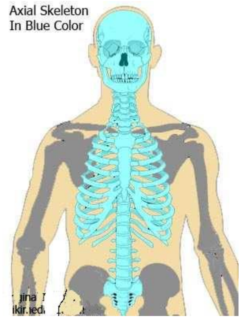


Figure 4.4.a.Axial Skeleton

It consists of –

- Skull
- Ossicles of the middle ear
- Hyoid bone
- Thorax or chest
- Vertebral column

(b) **Appendicular Skeleton** is the skeleton of appendages of human body. It consists of –

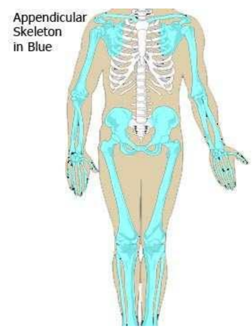


Figure 4.4.b. Appendicular Skeleton

- Shoulder Girdle
- Arms and Hands
- Pelvic Girdle
- Legs and Feet

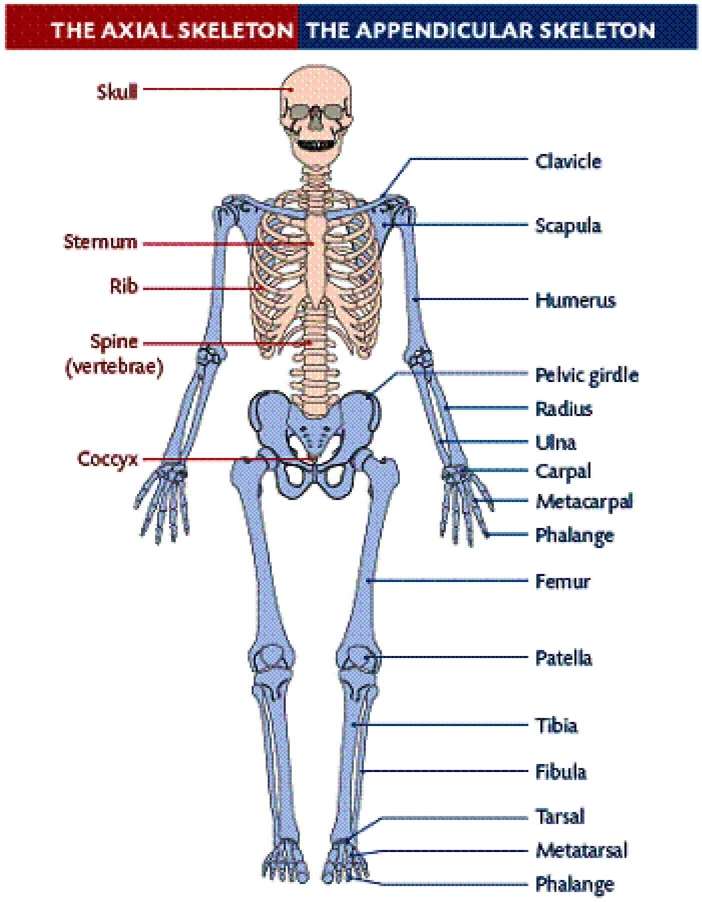


Figure 4.4.c. Axial and Appendicular Skeleton

4.5 Bones

Bone is a dense type of connective tissue impregnated with inorganic salts mainly the salts of calcium such as calcium phosphate, calcium carbonate etc. The organic portion of the bone constitutes one third (1/3) and the inorganic salt component constitutes two third (2/3). The inorganic salts are mainly responsible for rigidity and hardness, which make bone resist compression caused by the forces of weight and impact. The organic connective tissue portion of the bone makes it resilient and thus the bone can afford resistance to tensile forces.

The average adult skeleton has 206 bones. Bones can be categorized as paired or unpaired. A **paired bone** is two bones of the same type located on the right and left sides of the body, whereas an **unpaired bone** is a bone located on the midline of the body. For example, the bones of the upper and lower limbs are paired bones, whereas the bones of the vertebral column are unpaired bones.

4.6 Classification of Bones

Human bones are classified on different bases of classification. Generally four types of classifications are followed each dividing bones into different types.

4.6.1. On the basis of Shape

On the basis of shape, bones are classified into five different types.

i. **Long bones**: They are typically longer and wide. They have a shaft and two ends and are primarily made up of compact bones. Example - Humerus, Femur, Tibia, Radius, etc.

ii. **Short Bones**: They are generally cube-shaped and contain mostly spongy bone. Examples - Carpals, tarsals, etc.

iii. **Flat Bones**: They are thin, flat & often curved. Example -sternum, scapulae, ribs & most skull bones

iv. **Irregular Bones**: They have odd shapes and don't fit into other classes. Example - vertebrae

v. **Sesamoid Bones**: These are short bones with tendons. Example – Patella.’

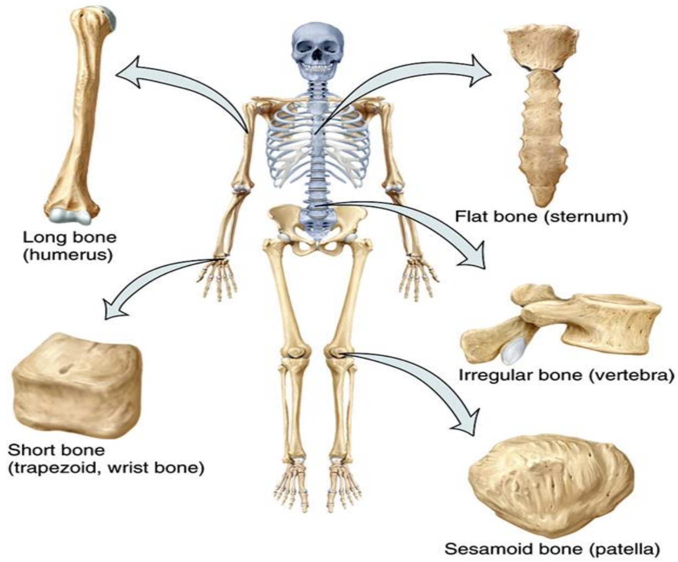


Figure 4.6.1. Types of Bones based on shapes

4.6.2. On the basis of bone development

On the basis of the pattern of development a bone follows, there are three categories.

(a) Membranous bones (skull and facial bones),

(b) Cartilaginous bones (bones of limbs, vertebral column and thoracic cage) and

(c) Membrano -cartilaginous bones (clavicle, mandible, occipital, temporal and sphenoid).

Membranous Bones   Cartilaginous Bones   Membrocartilaginous Bones

Figure 4.6.2. Classification According to Pattern of Development

4.6.3. On the Basis of bone region

On the basis of region, there are two types of bones, namely,

(a) Bones of axial skeleton and

(b) Bones of appendicular skeleton (Figure 4.4.c).

4.6.4. On the Basis of bone structure

The structural classification has two approaches that are macroscopic approach and microscopic approach.

(a) Macroscopic approach divides the bones into two categories that are;

Compact bone and Spongy Bone

(b) Microscopic approach divides the bones into following categories;

Lamellar bone and Fibrous bone

4.7 Structure of Bony Tissue

All bones consist of a dense, solid outer layer known as compact bone and an inner layer of spongy bone – a honeycomb of flat, needle-like projections called trabeculae.Bone tissue is a type of connective tissue,

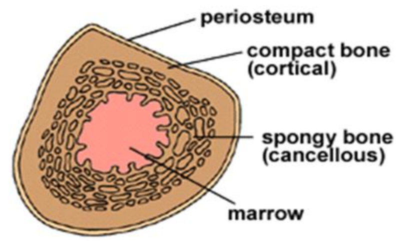


Figure 4.7.a. Structure of a bone

so it must consist of cells plus a significant amount of extracellular matrix.

Types of Bone Cells

The bone cells are mainly of three types:

1. <u>Osteoblasts</u> – These are Bone-building cells. They synthesize and secrete collagen fibers and other organic components of bone matrix. They are found in both the periosteum and the endosteum.

2. <u>Osteocytes</u> - – These are mature bone cells made from osteoblasts that have become trapped in the bone tissue around themselves. They maintain healthy bone tissue by secreting enzymes and controlling the bone mineral content.

3. Osteoclasts – These are bone absorbing cells. They are large cells that digest bone matrix. They are important in growth, healing, remodeling of bone.

Compact Bone

Compact bone consists of closely packed osteons or haversian systems. The osteon consists of a central canal called the haversian canal, which is surrounded by concentric rings (lamellae) of matrix. Between the rings of matrix, the bone cells (osteocytes) are located in spaces called lacunae. Small channels (canaliculi) radiate from the lacunae to the haversian canal to provide passageways through the hard matrix. In compact bone, the haversian systems are packed tightly together to form what appears to be a solid mass. The haversian canals contain blood vessels that are parallel to the long axis of the bone. These blood vessels interconnect, by way of perforating canals, with vessels on surface of the bone.

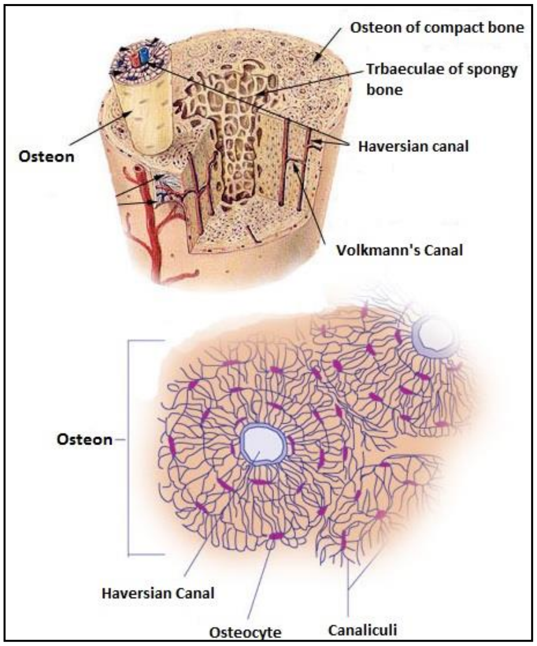


Figure 4.7.b. Structure of a Compact Bone

Spongy Bone

Spongy (cancellous) bone is lighter and less dense than compact bone. Spongy bone consists of plates (trabeculae) and bars of bone adjacent to small, irregular cavities that contain red bone marrow. The canaliculi connect to the adjacent cavities, instead of a central haversian canal, to receive their blood supply. It may appear that the trabeculae are arranged in a haphazard manner, but they are organized to provide maximum strength similar to braces that are used to support a building. The trabeculae of spongy bone follow the lines of stress and can realign if the direction of stress changes.

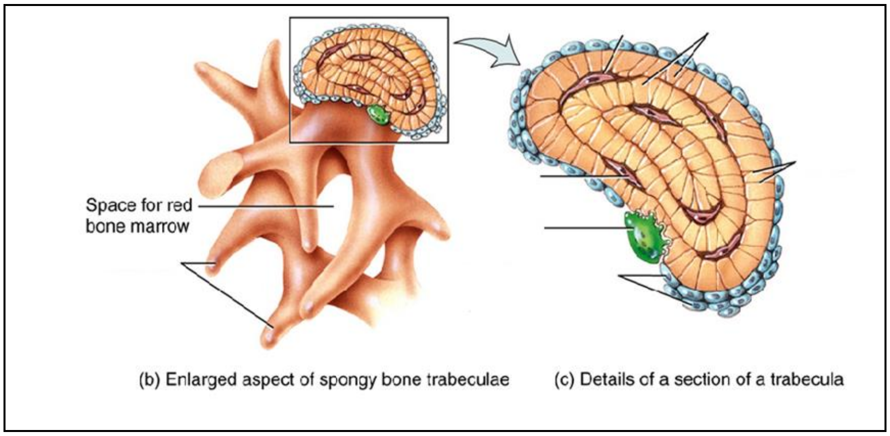


Figure 4.7.c. Structure of a Spongy Bone

4.8 Skull -

The skull consists of 22 cranial and facial bones, which, with the exception of the mandible, are tightly fused together.

Cranial bones (or cranium)

They are 8 in numbers and are joined together by sutures. They include 2 Temporal bones , 1 Occipital bone , 1 Frontal bone , 2 Parietal bones, , 1 Sphenoid bone and 1 Ethmoid bone . The important functions of cranial bones are -

• They enclose the cranial cavity, which supports and protects the brain

• They provide attachment sites for some head and neck muscles

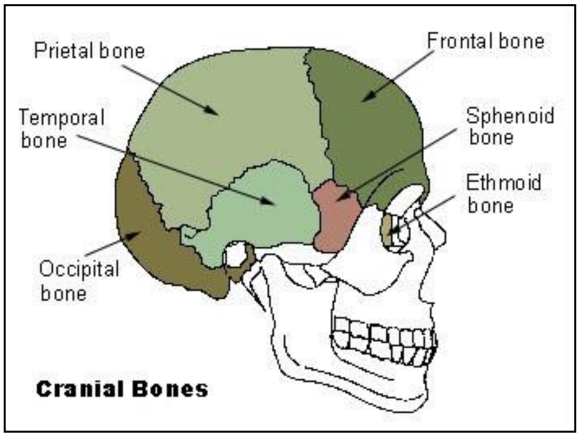
Facial bones (anterior aspect of skull)

They are 14 in number and they -

- Form framework of face
- Form cavities for sense organs of sight, taste and smell
- Provides openings for passage of air and food
- Hold the teeth
- Anchor the muscles of the face
- Allow for important movement like chewing, speech, and facial expressions.

Cranial Bones

1. The Frontal bone is one of the major cranial bones. It comprises of the forehead and the upper orbit of the eye. The front of the top of the head roughly covers the frontal lobes of the brain.
2. 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.
3. 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.
4. 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 ethmos meaning sieve and divides the nasal cavity from the brain.
5. There are 2 Sphenoid bones, each is situated behind the eyes at the base of the skull in front of the Temporals. Sphenoid bone has contact with all the other cranial bones. Because of it is shape and situation.
6. 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.



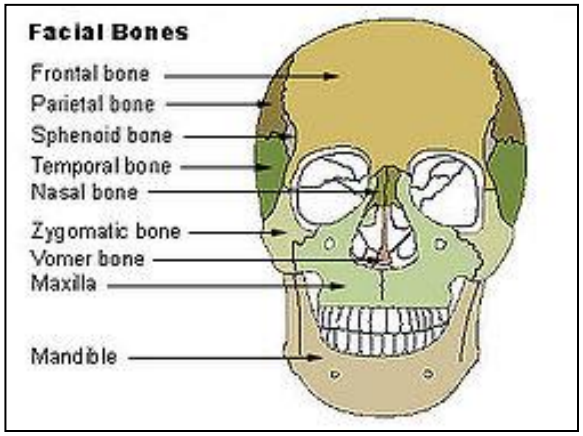


Figure 4.8 Cranial Bones and Facial bones

Facial Bones

1. Inferior Nasal Conchae (2): Shelf-like projections on the lateral wall of nasal cavity. They increase the surface area of the nasal cavity.
2. Lacrimal Bones (2): Smallest and most delicate bone of the skull. Present in the orbit.
3. Mandible: It is a U-shaped bone which forms the lower jaw. It consists of body (horizontal part) and ramus (vertical [part) with coronoid and condylar processes.
4. Maxillae bone (2): Paired, irregular shaped bones and together they form the upper jaw.
5. Nasal bones (2): Small, paired bones which forms the bridge of the nose.
6. Vomer bone: Plow-shaped bone present in the middle of the nasal cavity.
7. Zygomatic bone (2): Paired, irregular shaped bone also called as ‘cheek bone’.
8. Palatine bone(2): L-shaped bone which forms the posterior portion of the hard palate.

4.9 Vertebral column -

The vertebral column is made up of 33 bones, called **vertebrae**, which are stacked in a slightly curved formation from the base of the skull through the entire length of the back.

The vertebral column plays an extremely important role in our bodies as it supports the upper body's weight; provides posture while allowing for movement and flexibility; and protects the spinal cord.

The regions of the spine are named after the five categories of vertebrae. From top to bottom, the categories are the:

a. Cervical vertebrae
b. Thoracic vertebrae
c. Lumbar vertebrae
d. Sacrum
e. Coccyx

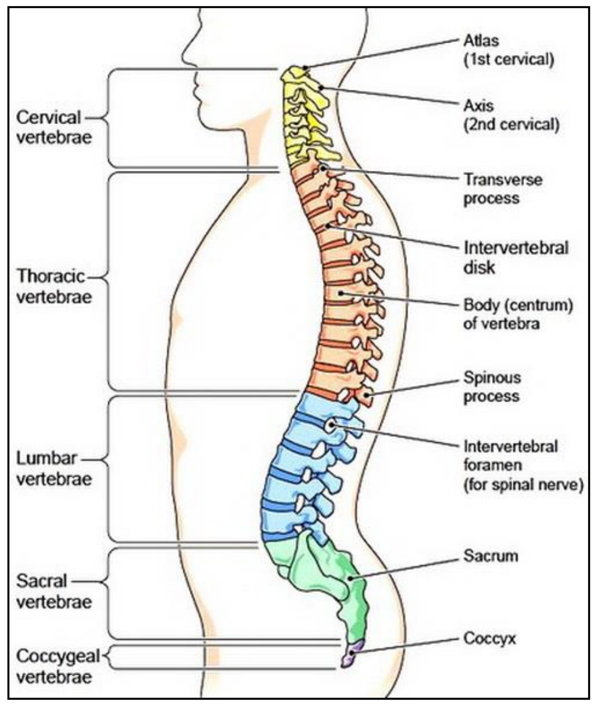


Figure 4.9 Vertebral column

While a normal, healthy spine appears to run in a straight line when viewed from the front or back, when viewed from the side, a distinctive "S" shape is seen. In fact, curvature occurs within each of the upper three regions, as well as within the bottom - most sacrococcygeal segment. Curvature allows for energy absorption throughout the spinal column during physical activities like walking or running.

The vertebrae grouped within the three upper regions of the vertebral column – the cervical vertebrae, the thoracic vertebrae and the lumbar vertebrae – are shaped differently from each other and serve different functions. A brief description of the vertebra of these regions is given below.

a. Cervical (neck) - The main function of the cervical spine is to support the weight of the head (about 10 pounds). The seven cervical vertebrae are numbered C1 to C7. The neck has the greatest range of motion because of two specialized vertebrae that connect to the skull. The first vertebra (C1) is the ring-shaped Atlas that connects directly to the skull. This joint allows for the nodding or “yes” motion of the head. The second vertebra (C2) is the peg-shaped Axis, which has a projection called the odontoid, that the atlas pivots around. This joint allows for the side-to-side or “no” motion of the head.

b. Thoracic (mid back) - The main function of the thoracic spine is to hold the rib cage and protect the heart and lungs. The twelve thoracic vertebrae are numbered T1 to T12. The range of motion in the thoracic spine is limited.

c. Lumbar (low back) - The main function of the lumbar spine is to bear the weight of the body. The five lumbar vertebrae are numbered L1 to L5. These vertebrae are much larger in size to absorb the stress of lifting and carrying heavy objects.

A typical vertebra has the following characteristics (see Figure 4.9.a):

- Body (Centrum) – It is disc-shaped, anterior portion that gives strength to the bone.
- Vertebral arch – It is a bony ring behind the vertebral body. The opening in the ring is the vertebral foramen, the passageway for the spinal cord.
- The pedicles and the laminae form the anterior and posterior sides, respectively, of the vertebral arch.
- Seven processes – 2 transverse. 1 spinous, 2 superior articular and 2 inferior articular.

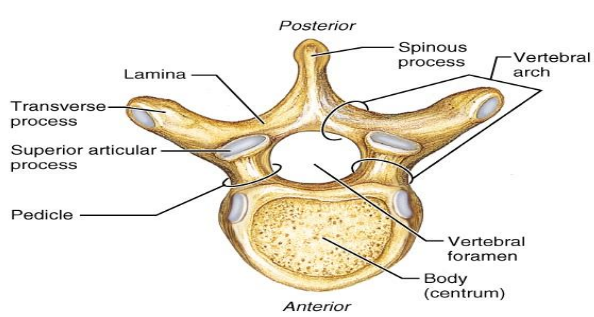


Figure 4.9.a. A typical vertebra

The intervertebral foramina are openings between the superior and inferior surfaces of each pedicle of the vertebral arch. Adjacent openings of successive vertebrae form a passage for nerves that leave the spinal cord and emerge outside the vertebral column.

Intervertebral discs separate adjacent vertebrae. Each disc consists of an outer ring of fibrocartilage (annulus fibrosus) surrounding a semi-fluid cushion (nucleus pulposus) that provides elasticity and compressibility.

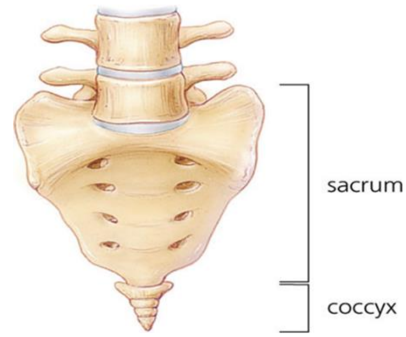


Figure 4.9.d and e Sacrum & coccyx

Sacrum - the main function of the sacrum is to connect the spine to the hip bones (iliac). There are five sacral vertebrae, which are fused together. Together with the iliac bones, they form a ring called the pelvic girdle.

Coccyx region - the four fused bones of the coccyx or tailbone provide attachment for ligaments and muscles of the pelvic floor.

4.10 Bony thorax -

The bony thorax forms the framework of the chest. It protects the vital organs like heart, lungs and major blood vessels, supports Shoulder girdle and upper limbs as well as provides attachment sites for muscles.

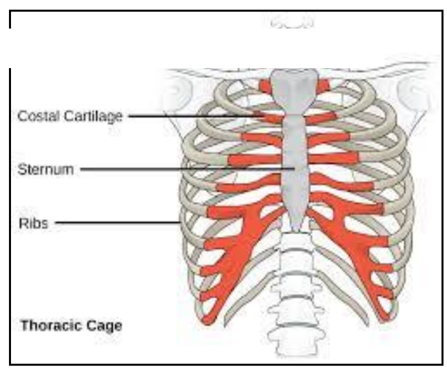


Figure 4.10 Bony Thorax

Components of the bony thorax

- 12 Thoracic vertebrae – posteriorly
- 12 Ribs – laterally
- Sternum and costal cartilage – anteriorly

Sternum

The sternum, commonly known as the breastbone, is a long, narrow flat bone about 6 inches long lies in the midline. It is formed from 3 parts:

- Manubrium – superior part which articulates with medial end of clavicles
- Body – bulk of sternum. Sides are articulate for costal cartilage of ribs 2–7
- Xiphoid process – inferior end of sternum. Ossifies around age 40

Ribs

Ribs (Latin: costae) are the long curved bones which form the thoracic cage. Human have 12 pairs of ribs which are divided in to 3 types.

- True ribs – The first 7pairs of ribs which are directly attached to the sternum through the costal cartilage.
- False ribs – The 8^{th} , 9^{th} , 10^{th} pairs of ribs which are not directly attached to sternum, they are attached indirectly.
- Floating ribs – The 11^{th} and 12^{th} pair of ribs are short and are free anteriorly.

4.11 Appendicular Skeleton

The appendicular skeleton includes the bones of the upper and lower extremities and the pectoral and pelvic girdles.

The appendicular skeleton functions primarily to facilitate movement.

A. The Pectoral Girdle

The pectoral Girdle also called shoulder girdle attaches the bones of the upper limbs to the axial skeleton. It also positions the shoulder and provides a base for arm movement.

It consists of two bones: Clavicle and scapula

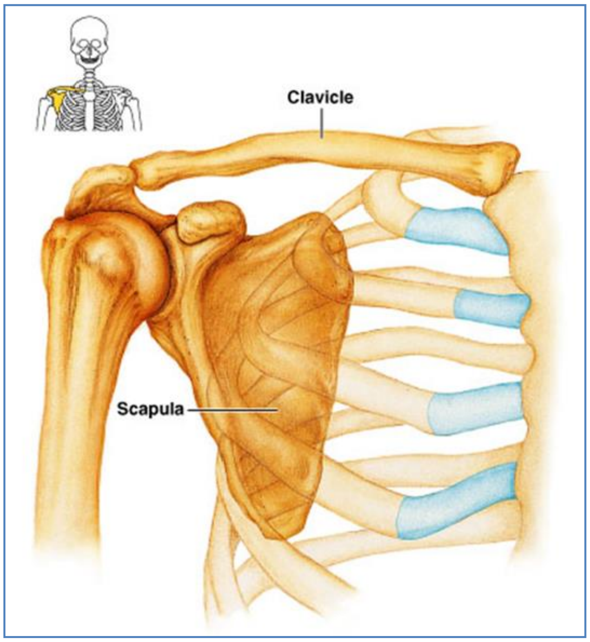
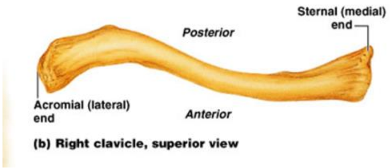


Figure 4.11.A Pectoral Girdle



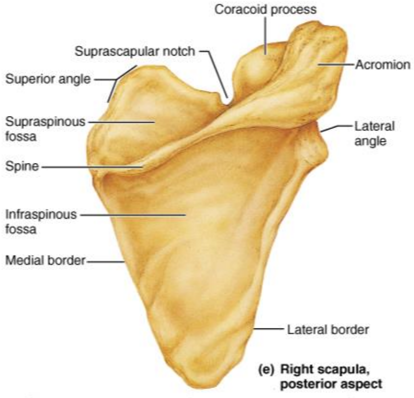


Figure 4.11 A.1 Clavicle and Scapula

4.11.A.1 .Clavicle: It is also called as 'collar bone'. It is a long, S-shaped bones having two curves -medial curve convex anteriorly and lateral one concave anteriorly. It originates at the manubrium (sternal end) and articulate with the scapulae (acromial end).

4.11.A.1 .Scapula: It is also called as 'shoulder blade.' It is a triangular flat bone found in upper back region. Scapular spine ends as acromion process. A sharp ridge widening to a flat process Glenoid cavity forms shoulder joint with head of humerus.

4.11.A.2 .<u>Upper Extremity</u>

The upper limb consists of 30 bones.

1. **The humerus** is the only bone of the upper arm. It is a long, large bone that extends from the scapula of the shoulder to the ulna and radius of the lower arm.

2. The forearm contains two long, parallel bones: the ulna and the radius.

a. **The ulna** is the longer and larger of the two bones, residing on the lateral side of the forearm

b. **The radius** is slightly shorter, thinner, and located on the medial side of the forearm.

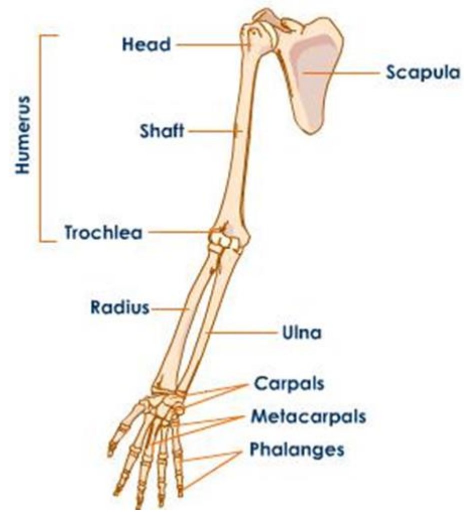


Figure 4.11 A.2 Upper extremity

3. **Hand**: the hand contains 27 tiny bones and many flexible joints.

a. **Carpals:** These are a group of 8 roughly cube-shaped bones in the proximal end of the hand.

b. **Metacarpals**: These are 5 long, cylindrical bones which form the supporting bones of the palm of the hand.

c. **The phalanges** (singular: phalanx) are a group of 14 bones that support and move the digits. Each digit contains three phalanges – proximal, middle, and distal – except for the thumb, which contains just a proximal phalanx and a distal phalanx.

<u>B. The Pelvic Girdle</u>

The pelvic girdle also called as hip girdle attaches the lower limbs to the axial skeleton. It as more stable than pectoral girdle. It is basin-like structure made up of 2 hip bones plus the axial sacrum and coccyx

4.11.B.1 .Hip Bone is actually made up of three bones which fuse together – Ileum, Ischium and Pubis. On its outer surface thee is a deep depression, 'acetabulum'. Which forms the hip joint with head of femur.

4.11.B.2. <u>Lower extremity</u>

The lower limb consists of 30 bones.

1. **The femur** is the longest, largest and strongest bone of the body. It has rounded head which attaches with acetabulum forming the hip joint. It has weak neck. It forms the thigh.

2. **Patella**: Also called as 'kneecap' – is a thick, circular-triangular bone which articulates with the femur.

3. The leg contains two long, parallel bones: the Tibia and the Fibula.

a. **The Tibia** also called as 'shin bone' is stronger and the main weight-bearing bone of the leg and resides on medial side of leg.

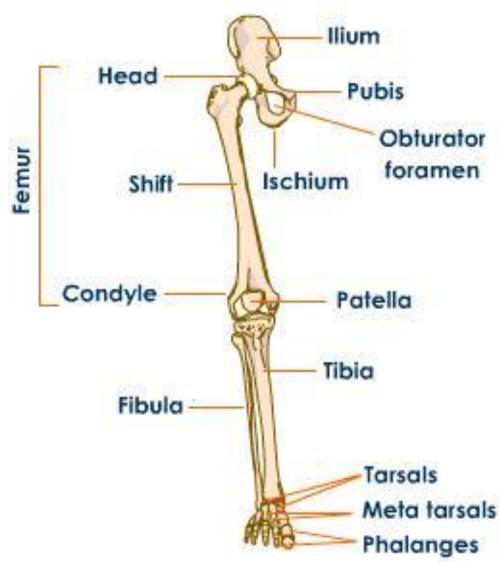


Figure 4.11.B.2 Lower Extremity

b. **The fibula** is thin bone and resides on lateral side of the leg.

4. **Foot:** The foot is a complex structure at the end of the leg that is made of 26 bones and 33 joints. the foot contains

a. **Tarsus**: There are 7 tarsal bones which includes the Calcaneus (Heel bone), Talus, Cuboid, Navicular and 3 Cuneiform, bones,

b. **Metatarsal:** These are 5 long, slender bones

c. **Phalanges:** These are 14 small bones of the digits, 2 for the great toe (Hallux) and 3 for remaining each finger.

4.12 Joints

Joints or articulations are the functional junctions between bones.

Functions of Joints:

- Hold the skeletal bones together.
- Allow the skeleton some flexibility so gross movement can occur
- Make bone growth possible

Classification of Joints:

1. Functional classification

(Focuses on amount of movement)

(a) Synarthroses (immovable joints)

(b) Amphiarthroses (slightly movable joints)

(c) Diarthroses (freely movable joints)

2. The structural classification

(a) Fibrous joints (bones held together by dense collagen fibers)

(b) Cartilaginous joints (bones held together by cartilage)

(c) Synovial joints (bones held together by ligaments)

4.12.1 Fibrous Joints

- Bones are connected by fibrous tissue
- Lack a synovial cavity
- Fibrous joints permit little or no movement
- Three types of fibrous joints

1. Sutures – Occur only between bones of the skull
2. Syndesmoses – Permits slight movement, tibio-fibular joint
3. Gomphoses - Immovable joint e.g. Joint between teeth and socket in the mandible.

4.12.2 Cartilaginous joints

- Lacks a synovial cavity
- Allows little or no movement
- Joint is tightly connected by either cartilage
- Two types of cartilaginous joints

1. Synchondroses – Sternocostal joint
2. Symphyses – Pubic Symphysis

4.12.3 Synovial Joints

They are characterized by the presence of a closed space or cavity between the bones: the joint cavity (= synovial cavity).

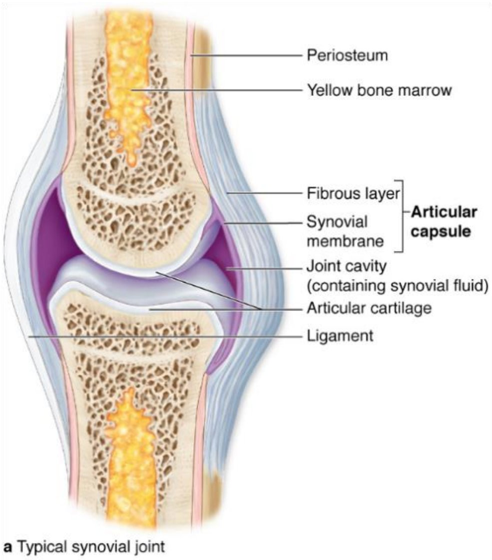


Figure 4.12.3.1 Synovial Joint

The articulating surfaces of the bones are covered by a thin layer of very smooth hyaline cartilage (articular cartilage) and lubricated by a special fluid, the synovial fluid secreted by the synovial membrane which lines the cavity. This fluid is composed of mucopolysaccharides, is highly viscous and slippery and reduces friction.

The joint cavity is enclosed by a double layered membrane: the articular capsule.

The outer layer is a tough membrane of collagen fibers (dense irregular connective tissue proper) which is firmly attached to the surface of the bones on either side of the joint. It is continuous with the periosteum. The internal layer is the synovial membrane (loose connective tissue proper) which covers all internal joint surfaces that are not hyaline cartilage.

Types of Synovial Joints:

Synovial joints are classified according to the shape of the articulating surfaces which, in turn, determines the range of movement permitted. They can be classified into six major categories:

1. Plane (= gliding)

- Opposite bone surfaces are flat or slightly curved.
- Only sliding motion in all directions are allowed. Since there is no bone movement around an axis, the joints are nonaxial.

2. Hinge

- Convex surface of one bone fits smoothly into concave surface of the second bone
- The movements allowed are similar to those allowed by a mechanical door hinge. Since the movements (flexion/extension) are all in one plane and around one axis, the joints are uniaxial.

3. Pivot

- A rounded, pointed or conical surface of one bone is inserted into a ring made partly of another bone and partly of a ligament.
- Since the only movement allowed is the rotation of one bone around its own axis, the Joints are uniaxial.

4. Ellipsoidal (= condyloid)

- Oval-shaped surface fits into an oval-shaped cavity (ellipse means oval).
- The movements allowed are flexion/extension, adduction/abduction and circumduction but NO ROTATION. Since bones can move in both planes: side to side and back and forth movements the joints are biaxial.

5. Saddle

- First bone's articular surface is concave in one direction and convex in the other while the second bone is just the opposite (or if you prefer, one bone is shaped like a saddle, and the other is shaped like its rider).
- The saddle joint is similar to the Ellipsoidal Joint but the movements are freer. The movements allowed are flexion/extension, adduction/abduction and circumduction but NO ROTATION. Since bones can move in both planes: side to side and back and forth movements the joints are biaxial.

6. Ball and socket

- Ball-shaped head fits into a cup-shaped depression
- These joints are the most freely moving of all synovial joints. The movements are allowed in all axes and planes: flexion/extension, adduction/abduction, circumduction and rotation. These joints are multiaxial.

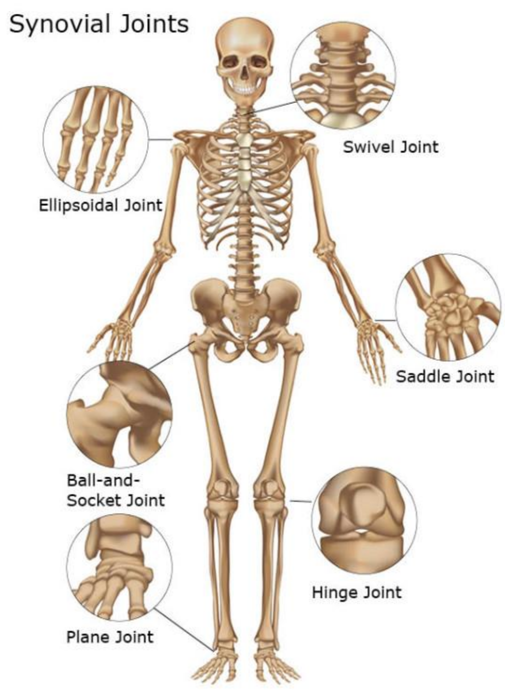


Figure 4.12.3.2 Types of Synovial Joints

Review Questions:

1. Describe the various functions of skeletal system.
2. Classify bones according to their shapes.
3. Enlist the bones forming the Axial and Appendicular skeleton.
4. Which are the different bones that form the skull?
5. Describe the structure of atypical vertebra.
6. Describe the Synovial Joint and its types.
7. Describe the Haversian system of a compact bone.

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Lesson 5- Blood

Objectives: At the end of the topic, the student will be able to:

1. Describe the primary functions of blood.
2. List the formed elements of blood and identify the most important function of each.
3. Explain the steps involved in blood clotting.
4. Describe ABO and Rh blood typing.

5.1 Introduction:

Blood is classified as a connective tissue, since nearly half of it is made up of cells. However, it differ from other connective tissues in that its cells are not fixed in position, instead they move freely in the liquid portion of the blood, the **plasma.**(See figure 5.1)

Blood is a viscous (thick) fluid that varies in colour from bright to dark red, depending on how much oxygen it is carrying. Its quantity differs with the size of the person; the average adult male, weighing 70 kg has about 5-6 litres of blood. This volume accounts for about 8% of the total body weight. It is carried through a closed system of vessels pumped by the heart. The circulating blood is of fundamental importance in maintaining the internal environment in a constant state (homeostasis).

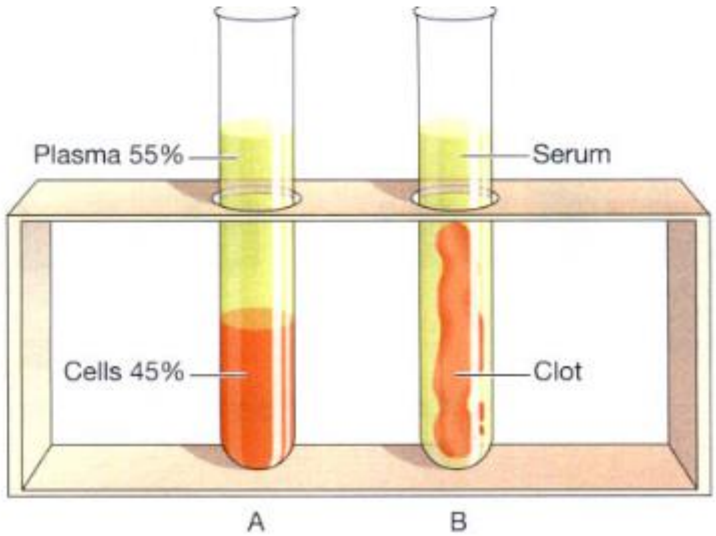

Figure: 5.1:

A. The proportions of blood cells and plasma in whole blood separated by gravity.

B. A blood clot in serum.

5.2 Functions of the Blood

1. **Transportation**

A. Oxygen- from inhaled air diffuses into the blood through the thin lung membranes and is carried to all the tissue of the body. Carbon dioxide, a waste product of cell metabolism, is carried from the tissues to the lungs, where it is breathed out.

B. The blood transports foods and other needed substances such as minerals and vitamins, to the cells. These materials may enter the blood from the digestive system or may be released into the blood from body stores.

C. The blood transports waste products from the cells to the sites from which they are released. The kidney removes excess water, minerals, and urea from protein metabolism and maintains the acid-base balance of the blood. The liver removes bile pigments and drugs.

D. The blood carries hormones from their sites of origin to the organs they affect.

2. Regulation

A. Buffers in the blood help keep the PH of body fluids at about 7.4

B. The blood serves to regulate the amount of fluid in the tissues by means of substances (mainly proteins) that maintain the proper osmotic pressure

C. The blood transports heat that is generated in the muscles to other parts of the body thus aiding in the regulation of body temperature.

3. Protection

A. The blood carries the cells that are among the body's defenders against pathogens. It also contains substances (antibodies) that are concerned with immunity to disease.

B. The blood contains factors that protect against blood loss.

5.3 Composition of Blood

The blood is composed of two prime elements: as already mentioned, the liquid element is called plasma; the cells and fragments of cells are called formed elements or corpuscles (See figure 5.2). The formed elements are classified as follows:

1. Erythrocytes, from erythro, meaning "red," are the red blood cells, which transport oxygen.

2. Leukocytes, from leuko, meaning "white," are the several types of white blood cells, which protect against infection.

3. Platelets, also called thrombocytes, are cell fragments that participate in blood clotting.

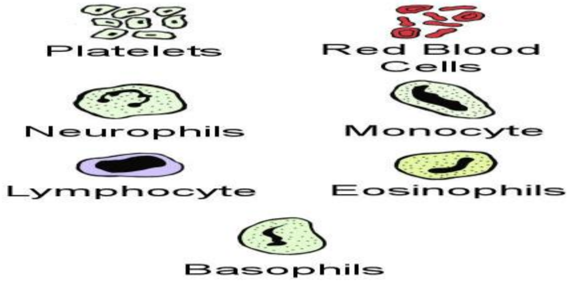

Figure 5.2: Blood cells

Blood Plasma

Over half of the total volume of blood is plasma. The plasma itself is 90% water. Many different substances dissolved or suspended in the water, make up the other 10%. The plasma content varies somewhat, since the substances carried by the blood to and from the organs get used and added to. However, the body tends to maintain a fairly constant level of these substances. For example, the level of glucose, a simple sugar, is maintained at a remarkably constant level of about on tenth of a 1% solution.

After water, the next largest percentage of material in the plasma is protein. Proteins are the principal constituents' of cytoplasm and are essential to the growth and the rebuilding of body tissues.

The plasma proteins include the following:

1. Albumin, the most abundant protein in plasma, is important for maintaining the osmotic pressure of the blood. This protein is manufactured in the liver.
2. The antibodies combat infection.
3. The blood clotting factors are also manufactured in the liver
4. A system of enzymes made of several proteins, collectively known as complement, helps antibodies in their fight against pathogens.

Nutrients are also found in the plasma. One group of nutrients is the **carbohydrates**. The principal form of carbohydrate found in the plasma is glucose, which is absorbed by the capillaries of the intestine following digestion. Glucose is stored mainly in the liver as glycogen and released as needed to supply energy.

Amino acids, the products of protein digestion, are also found in the plasma. These are also absorbed into the blood through the intestinal capillaries. **Lipids** constitute a small percentage of blood plasma. Lipids include fats. They may be stored as fat for reserve energy or carried to the cells as a source of energy. The mineral salts in the plasma appear primarily as chloride, carbonate, or phosphate salts of sodium, potassium, and magnesium. These salts have a variety of functions, including the formation of bone (calcium and phosphorus), the production of hormones by certain glands (iodine for the production of thyroid hormone), the transportation of the gases oxygen and carbon dioxide (iron), and the maintenance of the acid base balance (sodium and potassium carbonates and phosphates). Small amounts of other elements also help maintain homeostasis. Many other materials, such as waste products and hormones, are also transported in the plasma.

The Formed Elements

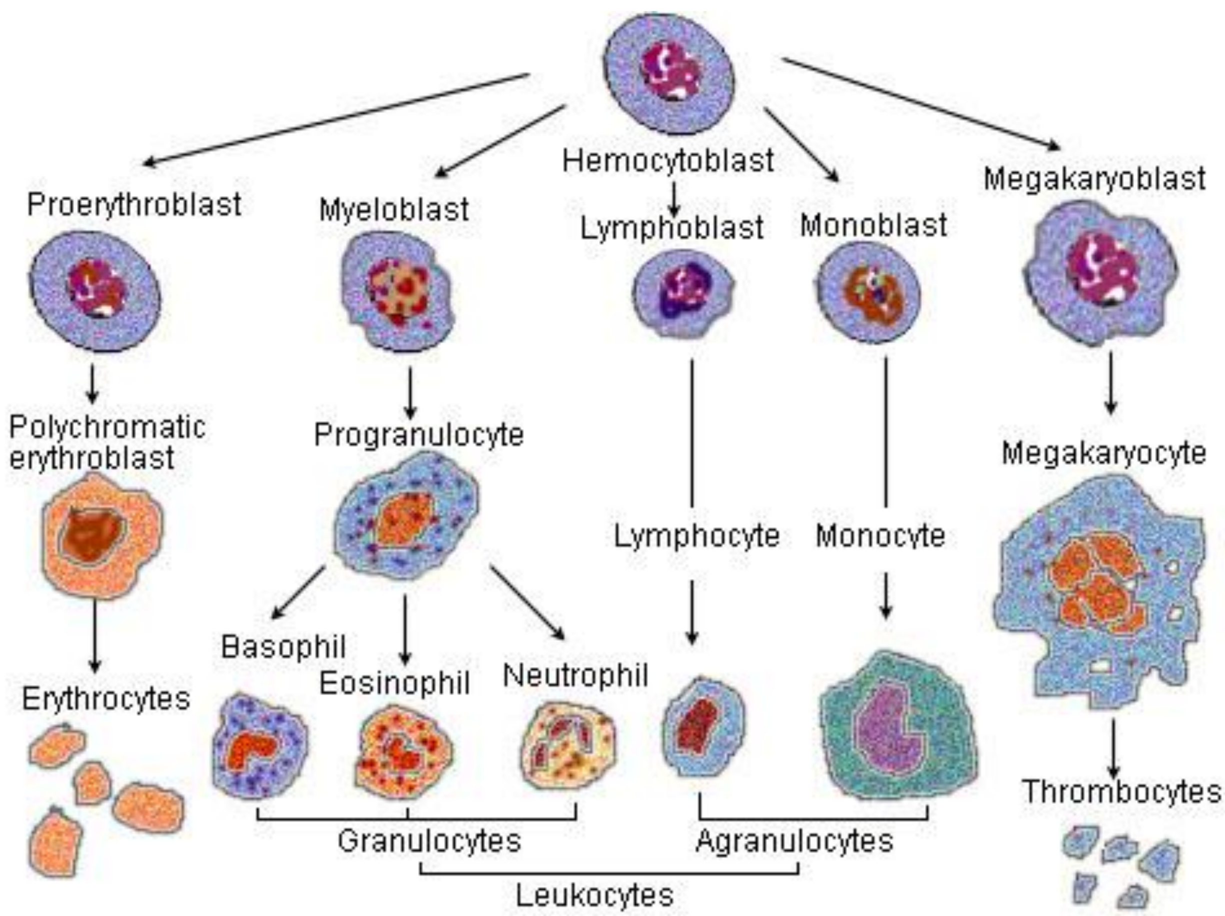

Fig.5.3

Erythrocytes

Fig 5.4

Erythrocytes, the red cells, are tiny, disk-shaped bodies with a central area that is thinner than the edges. They are different from other cells in that the mature form found in the circulating blood does not have a nucleus. These cells, have life spar of (120 days), some a One purpose of the red cells is to carry oxygen from the lungs to the tissues. The oxygen is bound in the red cells to **haemoglobin**, a protein that contains iron. Haemoglobin combined with oxygen gives the blood its characteristic red color. The more oxygen carried by the haemoglobin, the brighter is the red color of the blood. Therefore, the blood that goes from the lungs to the tissues is a bright red because it carries a great supply of oxygen; in contrast, the blood that returns to the lungs is a much darker red, since it has given up much of its oxygen to the tissues. Haemoglobin that has given up its oxygen is able to carry hydrogen ions; in this way, hemoglobin acts as a buffer and plays an important role in acid-base balance. The red cells also carry a small amount of carbon dioxide from the tissues to the lings for elimination in exhalation.

Carbon monoxide is a harmful gas that combines with haemoglobin to form a stable compound. It displaces the oxygen that is normally carried by the haemoglobin and reduces the oxygen-carrying ability of the blood. Carbon monoxide may be produced by the incomplete burning of various fuels, such as gasoline, coal, wood, and other carbon containing materials. It also occurs in automobile exhaust fumes and in cigarette smoke.

The erythrocytes are by far the most numerous of the corpuscles, averaging from 4.5 to 5 million per cubic millimeter of blood.

Leukocytes

Fig.5.5

The leukocytes, or white blood cells, are very different from the erythrocytes in appearance, quantity, and function. They contain nuclei of varying shapes and sizes; the cells themselves are round. Leukocytes are outnumbered by red cells by 700 to 1, numbering 5,000 to 10,000 per cubic millimetre of blood. Whereas the red cells have a definite color, the leukocytes tend to be colorless.

The different types of white blood cells are identified by their size, the shape of the nucleus, and the appearance of granules in the cytoplasm when the cells are stained, usually with Wright's blood stain. **Granulocytes** include **neutrophils**, which show lavender granules; **eosinophils**, which have beadlike, bright pink granules; and **basophils**, which have large, dark blue granules that often obscure the nucleus. The neutrophils are the most numerous of the white cells, constituting up to 60% of all leukocytes.

Because the nuclei of the nuclei of the neutrophils are of various shapes, they are also called **polymorphs** (meaning "many forms") or simply polys. The **agranulocytes**, so named because they lack easily visible granules, are the

lymphocytes and **monocytes**. The ratio of the different types of leukocytes is often a valuable clue in arriving at a diagnosis. The most important function of the leukocytes is to destroy pathogens. Whenever pathogens enter the tissues, as through a wound, certain white blood cells (neutrophils and monocytes) are attracted to that area. They leave the blood vessels and proceed by **a meboid** or ameba-like motion to the area of infection. There they engulf the invaders by a process called **phagocytosis**. If the pathogens are extremely strong or numerous, they may destroy the leukocytes. A collection of dead and living leukocytes, forms **pus**. A collection of pus localized in one area is known as **abscess.** The Lymphocytes destroy foreign invaders by attacking the cells directly or by producing antibodies that circulate in the blood and help to destroy the cells.

Platelets -

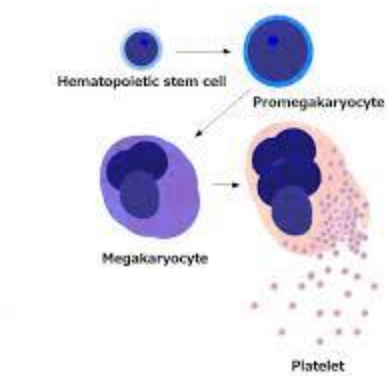

Fig.5.6

Of all the formed elements, the blood platelets (thrombocytes) are the smallest. These tiny structures are not cells in themselves, but fragments of cells. The number of platelets in the circulating blood has been estimated at 200,000 to 100,000 per cubic millimeter. Platelets are essential to blood coagulation (clotting). When, as a result of injury, blood comes in contact with any tissue other than the lining of the blood vessels, the platelets stick together and form a plug that seals the wound. They then release chemicals that take part in a series of reactions that eventually results in the formation of a clot. The last step in these reactions is the conversion ofa plasma protein called fibrinogen into solid threads of fibrin, which form the clot.

5.4 Blood Clotting

Blood clotting, or coagulation, is a protective device that prevents blood loss when a blood vessel is ruptured by an injury. The many substances necessary for clotting are normally inactive in the blood stream. A balance is maintained between compounds that promote clotting, known as procoagulants, and those that prevent clotting known as anticoagulants. In addition, there are also chemicals in the circulation that act to dissolve clots. Under normal conditions the substances that prevent clotting prevail. However, when an injury occurs, the procoagulants are activated and a clot is formed. Basically, the clotting process consists of the following essential steps

The injured tissues release thromboplastin, a substance that triggers the clotting mechanism.

1. Thromboplastin reacts with certain protein factors and calcium ions to form prothrombin activator, which in turn reacts with calcium ions to convert the prothrombin to thrombin.
2. Thrombin, in turn, converts soluble fibrinogen into insoluble fibrin. Fibrin forms a network of threads that entraps red blood cells and platelets to form clot.

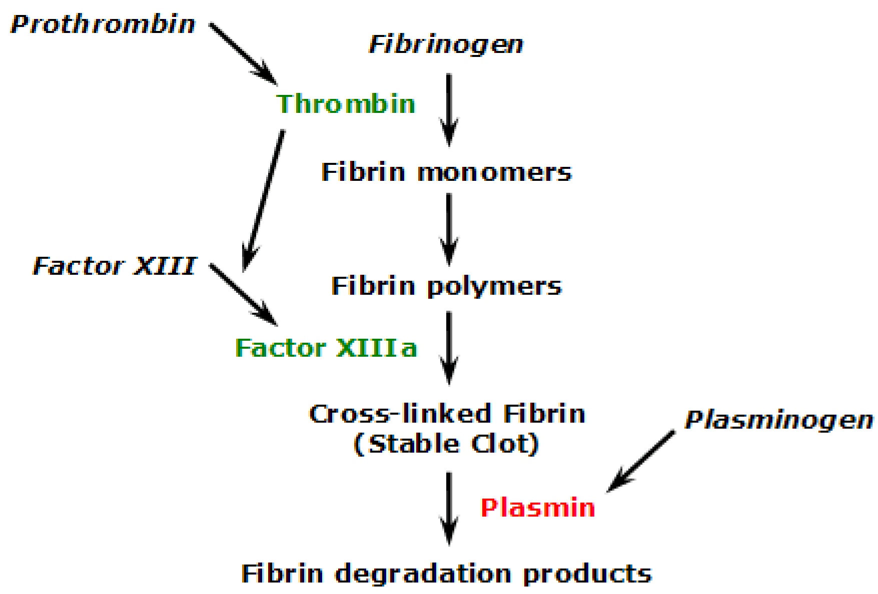

Figure: 5.7: Mechanism of Formation of clot

5.5 Blood Typing and Transfusions

5.5.a Blood Groups

If for some reason the amount of blood in the body is severely reduced, through **haemorrhage** or disease, the body cells suffer from lack of oxygen and food. The obvious measure to take in such an emergency is to inject blood from another person into the veins of the patient, a procedure called **transfusion**.

The various types of blood groups are-

1. ABO
2. RH
3. MNS
4. P
5. I
6. LUTHREN
7. KELL

8. LEWIS
9. Duffy
10. Kidd
11. Bombay
12. Diego

The patient's plasma may contain substances called antibodies that can cause the red cells of the donor's blood to become clumped, a process called **agglutination**. Alternatively, the donor's red blood cells may rupture and release their haemoglobin; such cells are said to be **haemolysed**, and the resulting condition can be very dangerous. These reactions are determined largely by certain proteins, called antigens, on the surface membrane of the red blood cells.

There are many types of these proteins but only two groups are particularly likely to cause a transfusion reaction, the so-called A and B antigens and the Rh factor. Four blood types involving the A and B antigens have been recognized: A, B, AB, and O. these letters indicate the types of antigen present on the red cells, with O indicating that neither A nor B antigen is present. It is these antigens on the donor's red cells that react with the antibodies in the patient's plasma and cause a transfusion reaction.

Blood serum containing antibodies that can agglutinate and destroy red cells that have A antigens on the surface is called **anti-A serum**; blood serum containing antibodies that can destroy red cells with B antigen on the surface is called **anti-B serum**. These sera are used to test for blood type.

Persons with type O blood are said to be **universal donors** because they lack the AB red cell antigens and in an emergency their blood can be given to anyone. Type AB individuals are called **universal recipients**, since their blood contains no antibodies to agglutinate red cells and they can therefore receive blood from most donors (Table 5-1).

Usually a person can safely give blood to any person with the same blood type. However, because of other factors that may be present in the blood, determination of blood type must be accompanied by additional tests (cross matching) for compatibility before a transfusion is given.

The Rh factor

Rh factor is another red cell antigen that determines the blood group. Those individuals who possess this antigen in their red cell surface are said to be **Rh positive**. Those who lack this antigen are said to be **Rh negative**. If Rh positive blood is given to an Rh negative person, he or she may become sensitized to the protein in the Rh positive blood. The sensitized person's blood cells may then produce antibodies to the "foreign" Rh antigens and destroy the transfused red cells.

RELATIONSHIPS BETWEEN BLOOD TYPES AND ANTIBODIES				
Blood Type	Antigens on Red Blood Cell	Can Donate Blood To	Antibodies in Cerum	Can Recieve Blood From
A	A	A, AB	Anti-B	A, O
B	B	B, AB	Anti-A	B, O
AB	A and B	AB	None	AB, O
O	None	A, B, AB, O	Anti-A and Anti-B	O

Table 5.1: ABO Blood group System

A pregnant woman who is Rh negative may become sensitized by proteins from her Rh positive fetus (this factor having been inherited from the father) if these proteins enter the mother's circulation before or during childbirth. During a subsequent pregnancy with an Rh positive fetus, some of the anti Rh antibodies may pass from the mother's blood in to the blood of her fetus and cause destruction of the fetus's red cells. This condition is called **erythroblastosis fetalis**, or

haemolytic disease of the newborn. Erythroblastosis fetalis may be prevented by administration of immune globulin Rho (D), or RhoGAM, to the mother shortly after delivery. This destroys the Rh positive fetal cells in the mother's blood and prevents her sensitization.

Questions-

1. What is blood ? Name its components.

2. Explain blood groups with special reference to ABO system.

3. Explain different types of WBC.

Assignments-

1. Prepare a chart showing developments of various cells.
2. Draw a flow chart of ABO system showings its various blood groups.

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Lesson-6 -Cardiovascular system (CVS)

Objectives-

At the end of the topic, the students will be able-

1 Identify heart and explain functions of heart

2. Describe various types of circulation
3. Describe cardiac cycle
4. Define cardiac output, pulse, blood pressure and ECG
5. Identify different types of blood vessels and describe their functions.

6.1 Introduction-

Commonly known as CVS . This system is made of up of hearts and blood vesssels. It deals with circulation of blood and lymph within the body.

The cardiovascular system is divided for study purpose into two main parts.

1. The circulatory system, consisting of the heart, which acts as a pump, and the blood vessels through which the blood circulates.

2. The lymphatic system, consisting of lymph nodes and lymph vessels, through which colourless lymph flows. The circulatory system ensures a continuous flow of blood to all body cells, and its function is subjected to continual physiological adjustments in order to maintain an adequate blood supply. When the supply of oxygen and nutrients to body cells become inadequate, tissue damage occurs and cell death may follow.

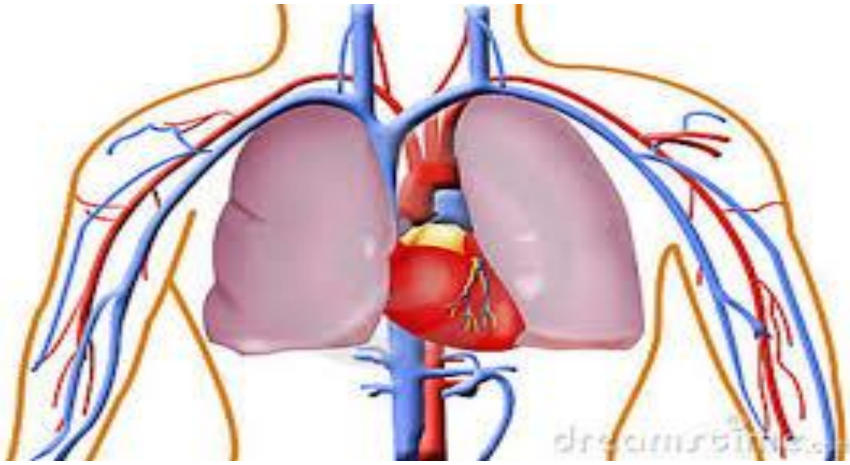


Fig.6.1

6.2 Heart-

Heart is a muscular organ present in thorax. The heart pumps blood into two anatomically separate systems of blood vessels -

- The pulmonary circulation
- The systemic circulation

Structure

The heart is composed of three layers of tissue - parietal pericardium

Pericardium- The pericardium is made up of two sacs. The outer sac consists of fibrous tissue (parietal pericardium) and the inner of a continuous double layer of serous membrane. (visceral pericardium).

Myocardium- The myocardium is composed of specialized cardiac muscle found only in the heart. It is not under voluntary control but, like skeletal muscle, cross-stripes are seen on microscopic examination. 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, can be seen as thicker, darker lines than the ordinary cross-stripes. This arrangement gives cardiac muscle the appearance of being a sheet of muscle rather than a very large number of individual cells.

<u>Endocardium</u>- This forms the lining of the myocardium and the heart valves. It is a thin, smooth, glistening membrane which permits smooth flow of blood inside the heart. It consists of flattened epithelial cells, continuous with the endothelium that lines the blood vessels. Ventricles are thicker than atria and left Ventricle is thicker than right Ventricle.

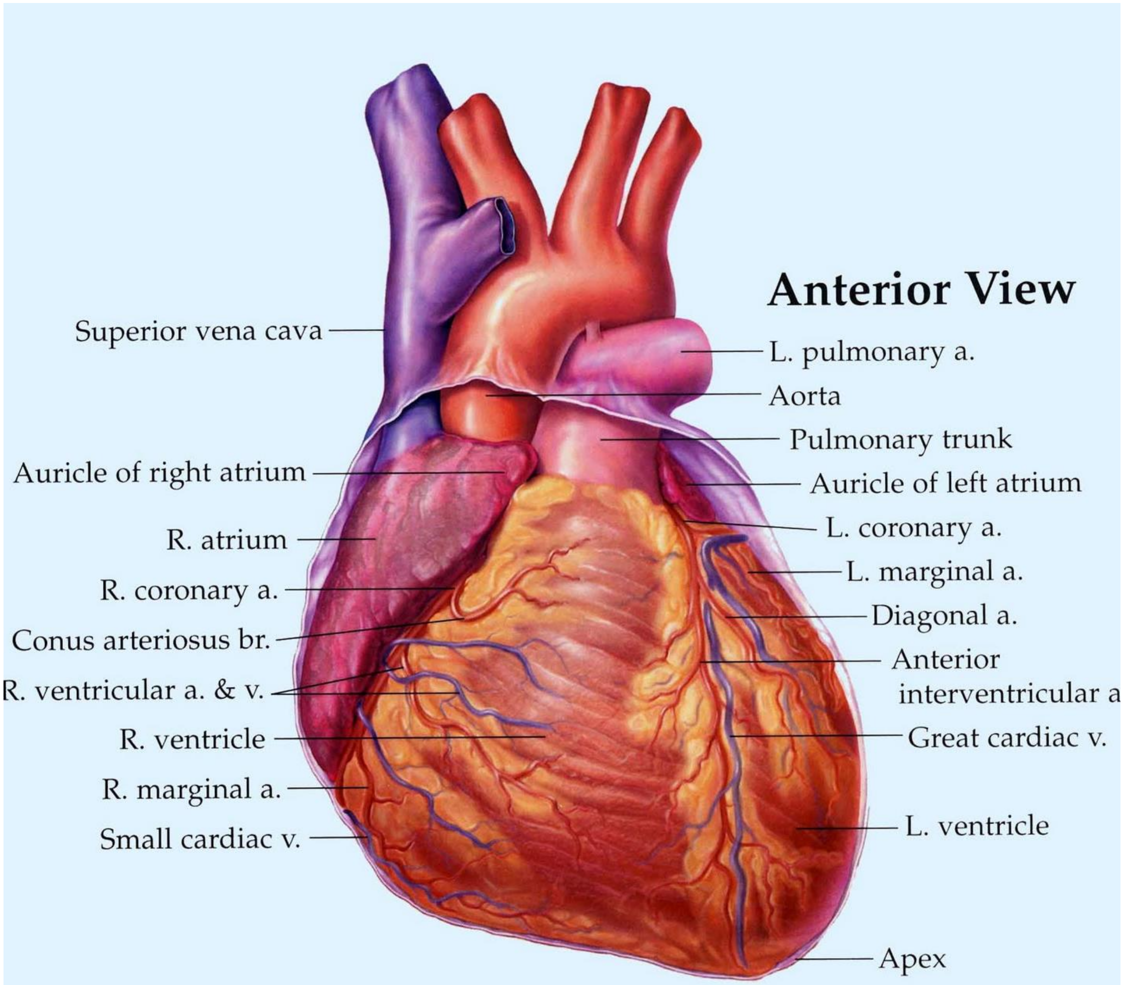


Fig 6.2

Interior of the heart- The heart is made up of four chambers, these are called atria and ventricles. Thus there are 2 atria (1left and 1right) and two ventricles(1 left and 1 right).The heart is divided into a right and left side by the Septum. The septum between atrias is called interatrial septum and the one between the ventricles is called interventricular septum. Due to this septal partition the blood does mix on the either side after birth. The atrial cavity on either side is separated by the leaf like structure called valve, namely atrioventricular. The vavles are formed by double folds of endocardium. The right atrioventricular valve (tricuspid valve) has three flaps or cusps and the left atrioventricular valve (mitral valve) has two cusps. The valves between the atria and ventricles open and

close passively according to changes in pressure in the chambers. The valves are prevented from opening upwards into the atria by tendinous cords, called chordae tendineae, which extend from the inferior surface of the cusps to little projections of myocardium covered with endothelium, called papillary muscles. The other valves of the heart are present between the ventricles and greater vessels called semilunar vavles. Valves between left ventricle and Aorta is called Aortic valve and that between right ventricle and pulmonary trunk is pulmonic valve. These valves open away from ventricles , thus valve maintain one way circulation.

Blood vessels related to heart –

1. Aorta – arises from left ventricle.
2. Pulmonary trunk – This trunk arises from right ventricle and divides as-
    a. Right pulmonary artery
    b. Left pulmonary artery
3. Left and right pulmonary veins- opens into left atrium.
4. Superior vena cava, inferior vena cava and coronary sinus- open into left atrium .

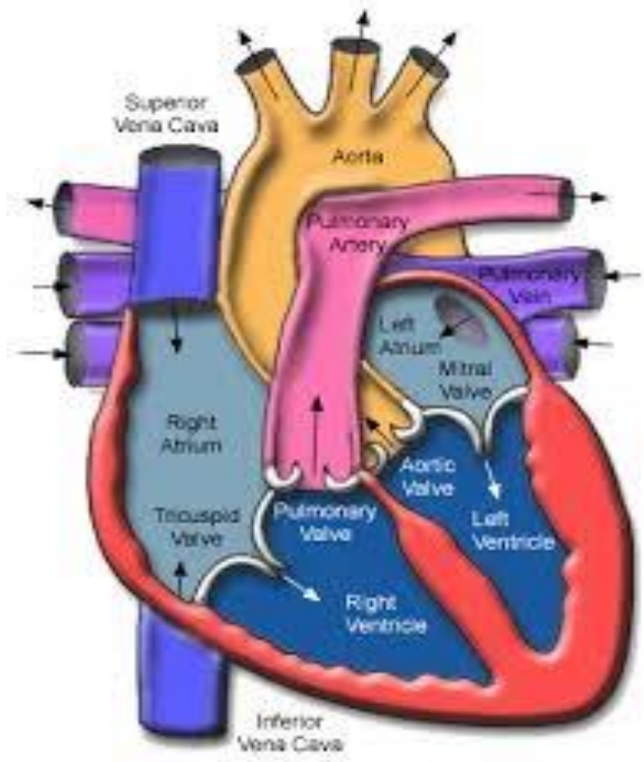


Fig 6.3

Blood supply to the heart-

Arterial supply- The heart is supplied with arterial blood by the right and left coronary arteries.

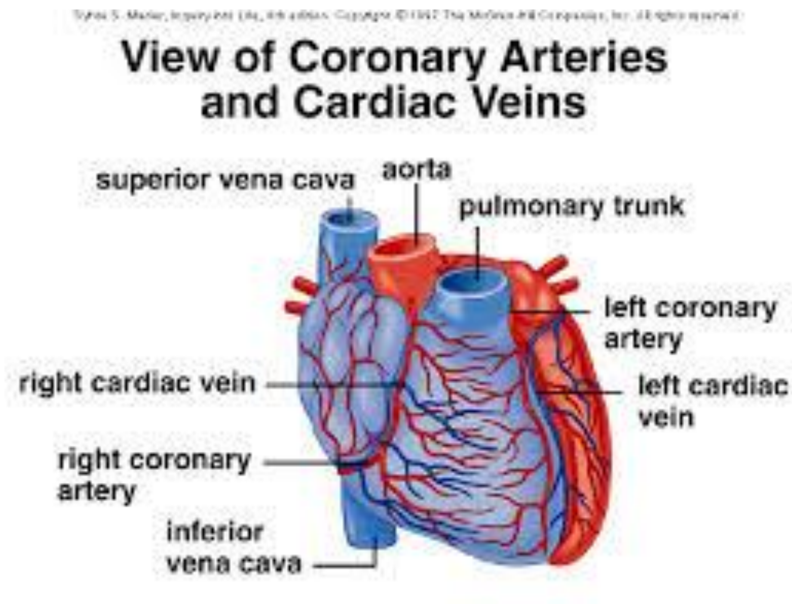


Fig 6.4

Venous drainage. Most of the venous blood is collected into several small veins that join to form the coronary sinus which opens into the right atrium.

Conducting system of the heart

The heart has an intrinsic system whereby the cardiac muscle is automatically stimulated to contract without the need for a nerve supply from the brain. There are small groups of specialised neuromuscular cells in the myocardium which initiate and conduct impulses causing coordinated and synchronised contraction
of the heart muscle.

The one present in the right atrium is called Sinoatrial node (SA node). It is also called as the pacemaker because it normally initiates the impulse.

Atrioventricular node (AV node) , this small mass of neuromuscular tissue is situated in the wall of the atrial septum near the atrioventricular valves.

Atrioventricular bundle (AV bundle or bundle of His) this is a mass of specialised fibres that originate 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.

Nerve supply to the heart-

In addition to the intrinsic impulses generated within the conducting system, the heart is influenced by autonomic nerves originating in the cardiovascular centre in the medulla oblongata.

6.3 Circulation –

Although circulation of blood round the body is continuous it is convenient to describe it in three parts:

6.3.a pulmonary circulation-

This consists of the circulation of blood from the right ventricle of the heart to the lungs and back to the left atrium. In the lungs, carbon dioxide is excreted and oxygen is absorbed. The pulmonary artery carrying deoxygenated blood, leaves the upper part of the right ventricle of the heart. It then divides in to left and right branches. Each branch then reaches the respective lungs and divide into further branches. Two pulmonary veins leave each lung, returning oxygenated blood to the left atrium of the heart, which is then passed to left ventricle during the contraction (systole) of left atrium. The blood is further moved to the aorta during ventricular contraction.

6.3.b systemic or general circulation-

The blood pumped out from the left ventricle is carried by the branches of the aorta around the body and is returned to the right atrium of the heart by the superior and inferior venae cavae. These various branches of the Aorta carries this oxygenated blood to different parts of the body as it divides and subdivides into smaller arteries, arterioles and capillaries. From these parts of the body the tributaries of the veins start and go on uniting to form the bigger when which carry the deoxygenated blood to the right atrium.The blood is then sent to right ventricle during the contraction (systole) of right atrium. From the right ventricle blood enters the pulmonary arteries during the contraction of right ventricles.

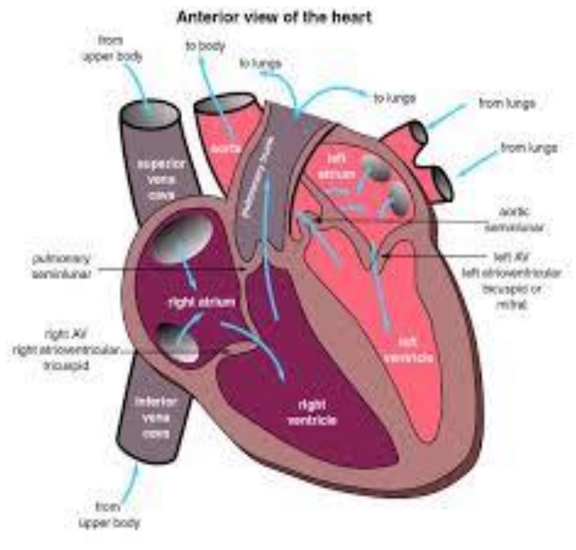


Fig 6.5

6.3.c Portal circulation- In the portal circulation the venous blood passes from the capillary beds of the abdominal part of the digestive system, the spleen and pancreas to the liver. It passes through a second capillary bed, the hepatic sinusoids, in the liver before entering the general circulation via the inferior vena cava. In this way blood with a high concentration of nutrients, absorbed from the stomach and intestines, goes to the liver first.

6.4 The cardiac cycle-

The heart acts as a pump and its action consists of a series of events known

as the cardiac cycle. During each cardiac cycle, the heart contracts and then relaxes. The period of contraction is called systole and that of relaxation, diastole.

Stages of the cardiac cycle- The normal number of cardiac cycles (also called as heart beats) per minute ranges from 60 to 80. Taking 74 as an example each cycle lasts about 0.8 of a second (0.3systole phase and 0.5 diastole phase) and consists of:

- Atrial systole — contraction of the atria
- Ventricular systole — contraction of the ventricles
- Complete cardiac diastole — relaxation of the atria and ventricles.

The superior vena cava and the inferior vena cava transport deoxygenated blood into the right atrium at the same time as the four pulmonary veins convey oxygenated blood into the left atrium. The SA node triggers a wave of contraction that spreads over the myocardium of both atria, emptying the atria (atrial systole). When the wave of contraction reaches the AV node it is stimulated to emit an impulse which quickly spreads to the ventricular muscle. This causes the contraction of ventricles both, pumping the blood into the pulmonary artery and the aorta (ventricular systole). The high pressure generated during ventricular contraction is greater than that in the aorta and forces the atrioventricular valves to close, preventing backflow of blood into the atria. After the phase of systole there is the phase of diastole (relaxation) which allows the heart muscle to relax and the atriums and ventricles to refill.The valves of the heart and of the great vessels open and close according to the pressure within the chambers of the heart.

Heart sounds- Two sounds, separated by a short pause, can be clearly distinguished. They are described in words as 'lub dup'. The first sound, 'lub', is fairly loud and is due to the closure of the atrioventricular valves. This corresponds with ventricular systole. The second sound, 'dup', is softer and is due to the closure of the aortic and pulmonary valves.

6.5. a Cardiac output- The cardiac output is the amount of blood ejected from the heart. The amount expelled by each contraction of the ventricles is the stroke volume. Cardiac output is expressed in litres per minute (1/min) and is calculated by multiplying the stroke volume by the heart rate (measured in beats per minute):

Cardiac output = Stroke volume x Heart rate.

b Pulse- The pulse is a wave of distension and elongation felt in an artery wall due to the contraction of the left ventricle. When the aorta is distended, a wave passes along the walls of the arteries and can be felt at any point where a superficial artery can be pressed gently against a bone (felt by fingers). The number of pulse beats per minute normally represents the heart rate and varies considerably in different people and in the same person at different times. An average of 60 to 80 is common at rest.

c Blood pressure –

Blood pressure is the force or pressure which the blood exerts on the walls of the blood vessels.

When the left ventricle contracts and pushes blood into the aorta the pressure produced within the arterial system is called the systolic blood pressure. In adults it is about 120 mmHg (millimetres of mercury) or 16 kPa (kilopascals). When complete cardiac diastole occurs and the heart is resting following the ejection of blood, the pressure within the arteries is called diastolic blood pressure. Arterial blood pressure is measured with a sphygmomanometer.

The normal range of blood pressure is –

Systolic pressure = 90 -120 mm of Hg.

Diastolic pressure = 60 -90 mm of Hg.

Normal bp in an adult ideally is = 120/80mm of Hg.

d ECG- As the body fluids and tissues are good conductors of electricity, the electrical activity within the heart can be detected by attaching electrodes to the surface of the body. The pattern of electrical activity may be displayed on an oscilloscope screen or traced on paper. The apparatus used is an electrocardiograph and the tracing is an electrocardiogram (ECG).

The normal ECG tracing shows five waves which, by convention, have been named P, Q, R, S and T.

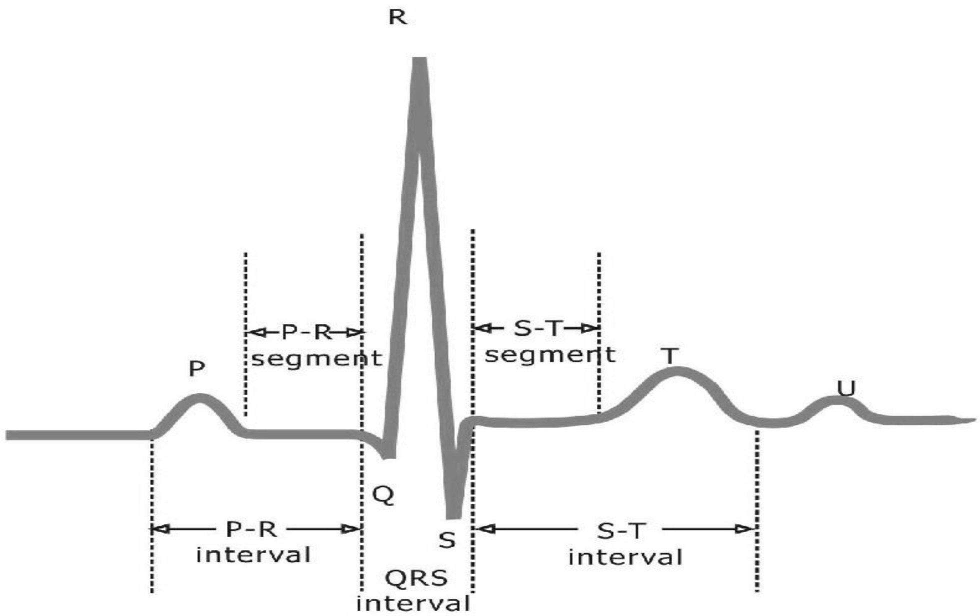


Fig 6.6

6.6 Types of blood vessels and their functions- The blood vessels are –

a Arteries – they usually carry oxygenated blood from heart to different parts of the body. They are thick walled. They appear red. They are of following types-

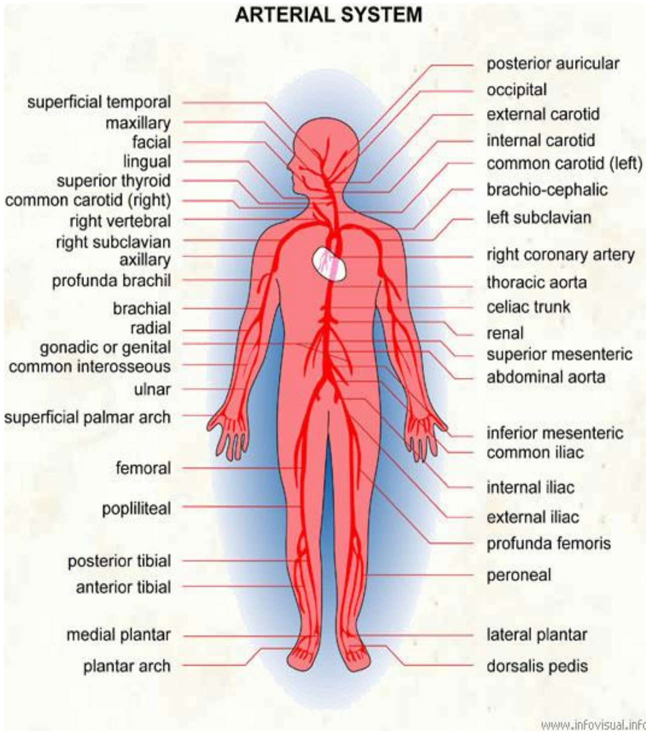


Fig 6.7

Aorta- The aorta begins at the upper part of the left Ventricle. It is the largest artery of the body and carries oxygenated blood. It further divides and subdivides to form other arteries of the body.

Carotid arteries- The right common carotid artery is a branch of the brachiocephalic artery. The left common carotid artery arises directly from the arch of the aorta. They pass upwards on either side of the neck and have the same distribution on each side. They supply blood to the head and the neck structures. They further divide to form external carotid artery and internal carotid artery.

The subclavian arteries- The right subclavian artery arises from the brachiocephalic artery; the left branches from the arch of the aorta. Each subclavian artery gives off two branches: the vertebral artery, which passes upwards to supply the brain, and the internal thoracic artery, which supplies the breast and a number of structures in the thoracic cavity.

The axillary artery- is a continuation of the subclavian artery and lies in the axilla. The first part lies deeply; then it runs more superficially to become the brachial artery.

The brachial artery- is a continuation of the axillary artery. It runs down the medial aspect of the upper arm, passes to the front of the elbow and extends to about 1 cm below the joint, where it divides into radial and ulnar arteries. It supplies structure of the arm.

The radial artery- passes down the radial or lateral side of the forearm to the wrist. It supplies structures of the forearm.

The ulnar artery- runs downwards on the ulnar or medial aspect of the forearm to cross the wrist and pass into the hand. It supplies structures of forearm. There are anastomoses between the radial and ulnar arteries, called the deep and superficial palmar arches, from which palmar metacarpal and palmar digital arteries arise to supply the structures in the hand and fingers.

Common iliac arteries - The right and left common iliac arteries are formed when the abdominal aorta divides at the level of the 4th lumbar vertebra . In front of the sacroiliac joint each divides into:

Internal iliac artery - The internal iliac artery runs medially to supply the organs within the pelvic cavity.

External iliac artery - The external iliac artery runs further towards the lower limb and becomes the Femoral artery.

Femoral artery- It is present in the thigh and supplies the structures of the thigh and some superficial pelvic and inguinal structures.

The popliteal artery- passes through the popliteal fossa behind the knee. It supplies the structures in this area, including the knee joint. At the lower border of the popliteal fossa it divides into the anterior and posterior tibial arteries.

The anterior tibial artery - passes forwards between the tibia and fibula and supplies the structures in the front of the leg.

The posterior tibial artery- runs downwards and medially on the back of the leg. Near its origin it gives off a large branch called the peroneal artery. In the lower part it becomes superficial and passes medial to the ankle joint to reach the sole of the foot where it continues as the plantar artery

The dorsalis pedis artery - is a continuation of the anterior tibial artery and passes over the dorsum of the foot, supplying arterial blood to the structures in this area.

The peroneal artery- it supplies the lateral aspect of the leg.

The plantar artery- supplies the structures in the sole of the foot. This artery, its branches and the dorsalis pedis artery form the plantar arch from which the digital branches arise to supply the toes.

b VEINS- They bring deoxygenated blood from various parts of the body to the heart. They are thin walled and appear blue. They bear vavles, which prevents back follow of blood.

They are as follows-

The external jugular veins - begins in the neck at the level of the angle of the jaw. It passes downwards in front of the sternocleidomastoid muscle, then behind Then behind the clavicle before entering the subclavian vein.It collects blood from head and neck ares.

The internal jugular veins - begin at the jugular foramina in the middle cranial fossa and each is the continuation of a sigmoid sinus. It collects blood from brain.

The subclavian veins- carrying blood from the upper limbs.

The brachiocephalic veins- It collects blood from neck area. The vein of either side unite together to form superior vena cava.

The superior vena cava- which drains all the venous blood from the head, neck and upper limbs.

The subclavian vein – collects blood from chest.

The axillary vein- collects blood from axillary area

The brachial vein- collects blood from arm

The ulnar vein- collects blood from forearm

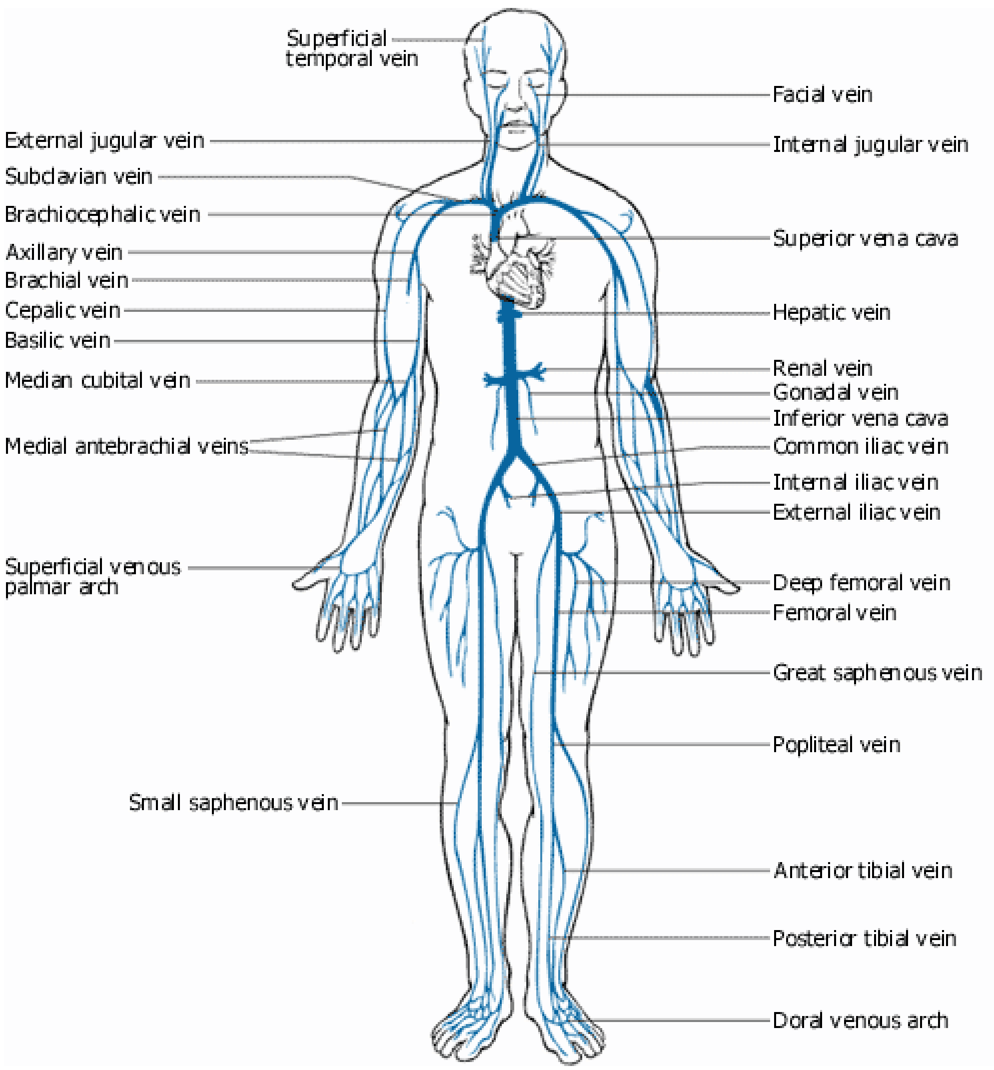


Fig 6.8

The radial veins- collects blood from forearm

The cephalic vein- collects blood from pectoral area

The median vein – collects blood from superdficial part of forearm.

The cubital vein.- collects blood from elbow.

The Portal vein- drains blood from its respective tributaries of the following organs-spleen, pancreas gall bladder, stomach, rectum, pelvis, descending colon of the large intestine ,the small intestine and the proximal parts of the large intestine, i.e. the caecum, ascending and transverse colon.

The small saphenous vein- They begin behind the ankle joint where many small veins which drain the dorsum of the foot.

The great saphenous vein- is the longest vein in the body. It drains the leg and the thigh.

The femoral vein- it drains the thigh.

The external iliac vein- it drains the pelvis

The internal iliac vein- receives tributaries from several veins which drain the organs of the pelvic cavity

The two common iliac veins- begin at the level of the sacroiliac joints. They ascend obliquely and end a little to the right of the body of the 5th lumbar vertebra by uniting to form the inferior vena cava.

The inferior vena cava- It opens into the right atrium and delivers the deoxygenated blood. It recievces blood from the two common iliac veins.

6.7 Lymphatic system-

Some part of the diffusible constituents of blood and waste materials from cells, diffuses through the more permeable walls of the lymph capillaries and becomes lymph. This lymph then passes through the lymph capillaries, lymph vessel , lymph nodes before returning to blood.

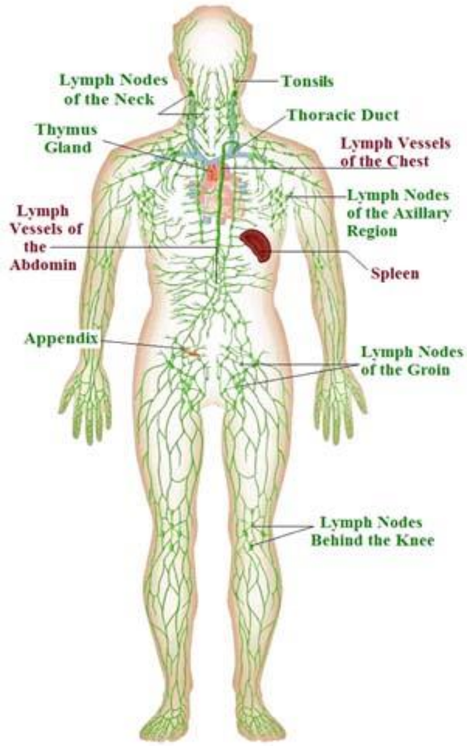


Fig 6.9

6.8 Parts of lymphatic system –

The lymphatic system consists of:

6.8.a Lymph:- Lymph is a clear watery fluid, similar in composition to plasma, with the important exception of plasma proteins, and identical in composition to interstitial fluid. Lymph transports the plasma proteins that seep out of the capillary beds back to the bloodstream. It also carries away larger particles, e.g. bacteria and cell debris from damaged tissues, which can then be filtered out and destroyed by the lymph nodes. Lymph contains lymphocytes, which circulate in the lymphatic system allowing them to patrol the different regions of the body. In the lacteals of the small intestine, fats absorbed into the lymphatics give the lymph (now called chyle), a milky appearance.

6.8.b.lymph vessels:- This includes- Lymph capillaries- These originate as blind-end tubes in the interstitial spaces.

6.8.c Lymph vessels:- The walls of lymph vessels are about the same thickness as those of small veins. Lymph vessels become larger as they join together, eventually forming two large ducts, the thoracic duct and right lymphatic duct, that empty lymph into the subclavian veins.

6.8.d lymph nodes:- Lymph nodes are oval or bean-shaped organs that lie, often in groups, along the length of lymph vessels.The lymph drains through a number of nodes, usually 8 to 10, before returning to the venous circulation. These nodes vary considerably in size: some are as small as a pin head and the largest are about the size of an almond.

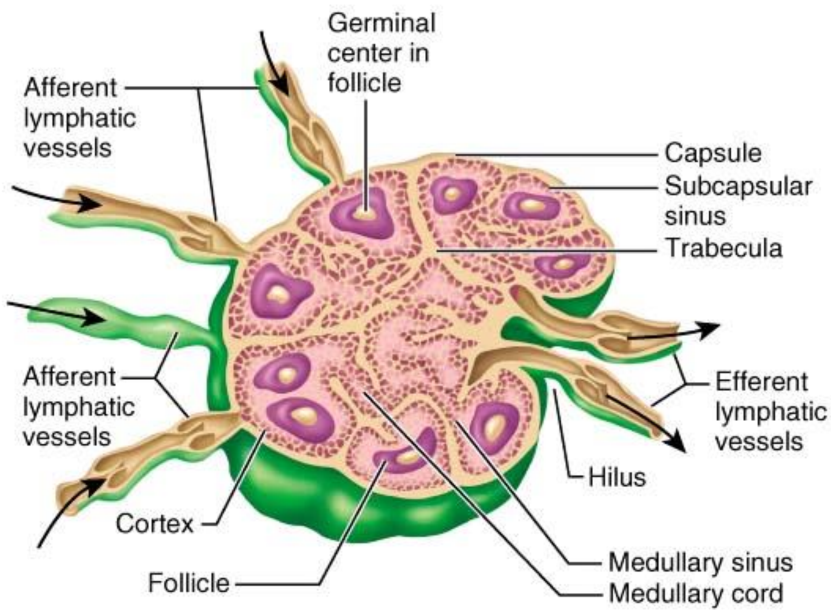


Fig 6.10

Functions of lymph nodes-

- **Filtering and phagocytes**
- **Proliferation of lymphocytes**

-Activated T- and B-lymphocytes multiply in lymph nodes. Antibodies produced by sensitised B-lymphocytes enter lymph and blood draining the node.

Lymph organs

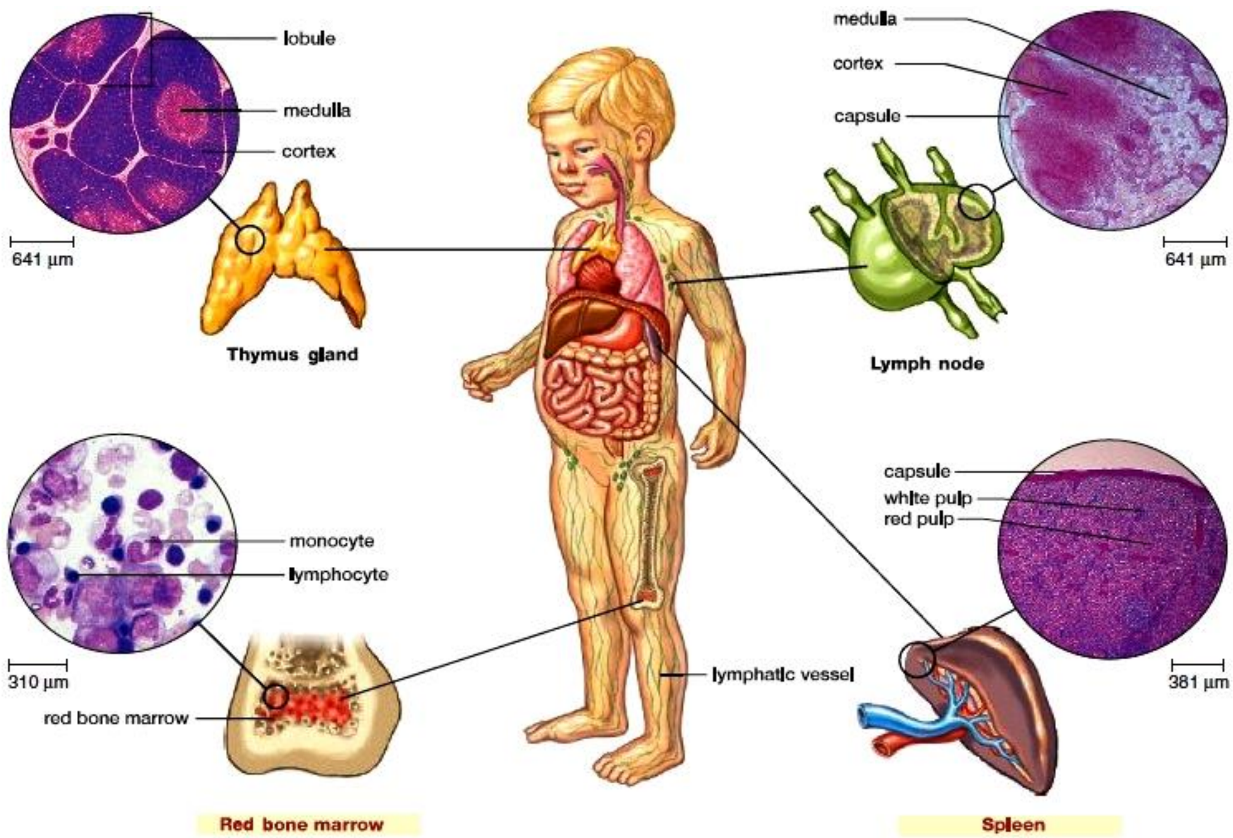


Fig 6.11

Spleen - The spleen is formed by reticular and lymphatic tissue and is the largest lymph organ. The spleen lies in the left hypochondriac region of the abdominal cavity between the fundus of the stomach and the diaphragm.

Thymus gland - lies in the upper part of the mediastinum behind the sternum and extends upwards into the root of the neck.. It weighs about 10 to 15 g at birth and grows until the individual reaches puberty, when it begins to atrophy

Questions:-

1. Explain structure of heart with diagram.

2. Define cardiac output, pulse & heart sounds.
3. Write a note on cardiac cycle.
4. Explain parts of lymphatic system.

Assignments:-

1. Draw a chart showing internal structure of heart.
2. Draw a chart of blood circulation in the body.
3. Prepare a chart showing labeled diagram of lymphatic system.

****

Lesson 7 -Respiratory System

Objectives: At the end of the topic, the student will be able to:

1) Identify all parts/ organs of Respiratory System
2) Will be able to define Respiration, with its mechanism, respiratory rate, tidal volume, vital capacity, hypoxia, Carbon dioxide.
3) Will be able to perform blood gas analysis

7.1 Introduction:

Our body needs oxygen to sustain itself. The Respiratory System consists of series of organs(see figure 7.1) responsible for taking in oxygen and expelling carbon dioxide, thus acting as a gas exchange system for our body.

The respiratory system is made of following parts:

7.2 Nose and Nasal Cavity

The nose is the main external opening and is the first section for the respiratory system through which air moves in. The nose is made up of cartilage, bone, muscle, and skin that supports and protects the anterior portion of the nasal cavity. The nasal cavity is a hollow space within the nose and skull that is lined with hairs and mucus membrane. (See figure 7.2).

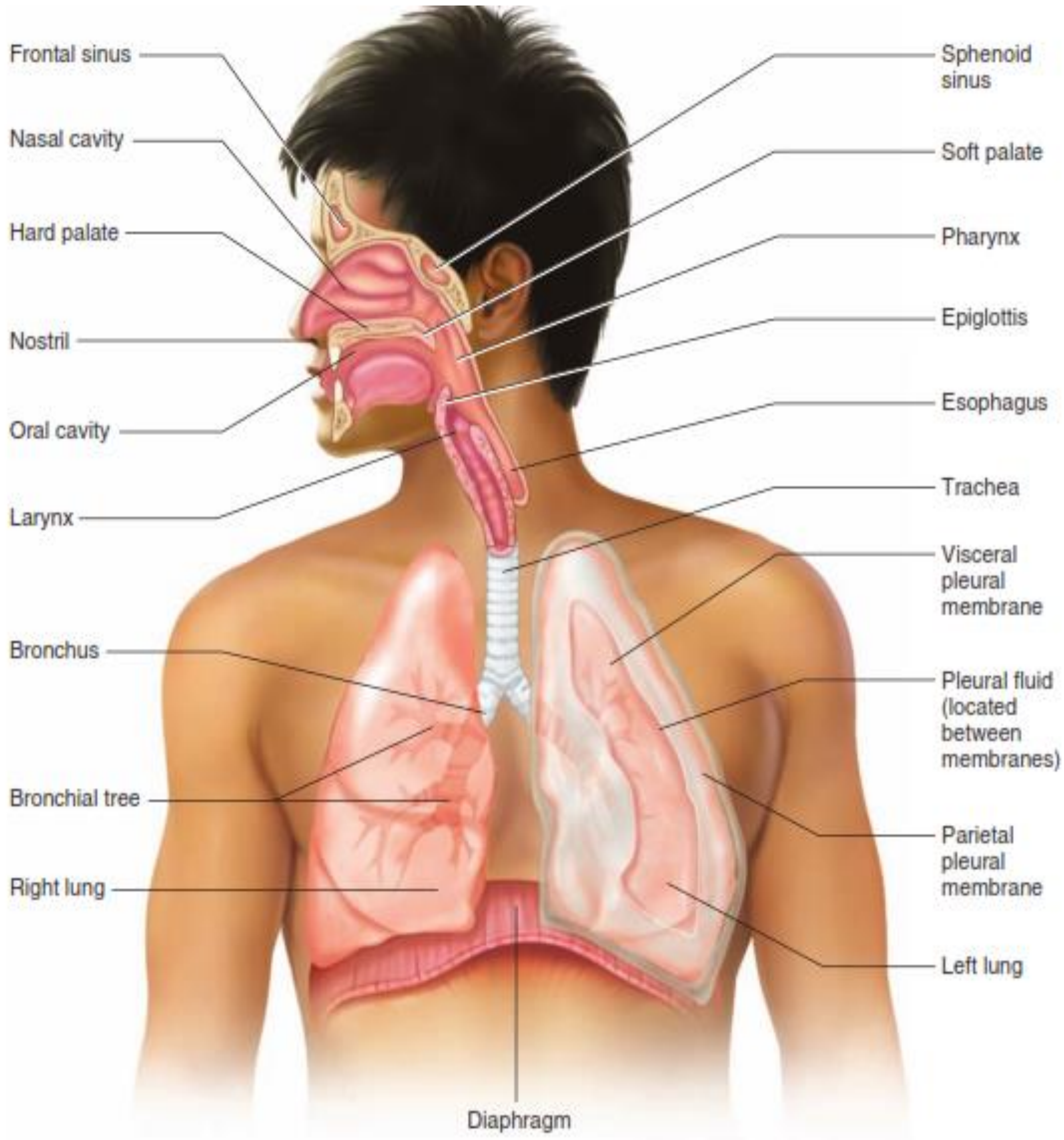


Figure: 7. 1: Organs of Respiratory System

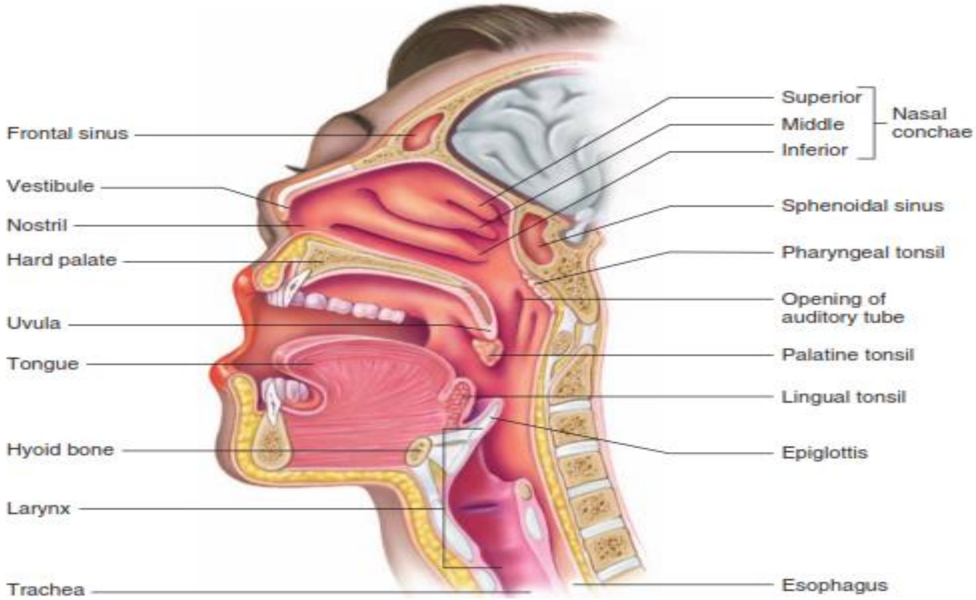


Figure: 7. 2: Nose and Nasal Cavity

Function of the Nose & Nasal cavity:

1. Humidification of air entering the body before it reaches the lungs.

2. Filtering the inhaled air by trapping the dust, mold, pollen and other environmental contaminants before they can reach the inner portions of the lungs.

3. To returns moisture and heat of the air exiting the body through the nose to the nasal cavity before being exhaled into the environment.

The mouth, also known as the oral cavity, can be used to supplement or replace the nasal cavity's functions when needed.

7.3. Pharynx

The pharynx or the throat is a muscular funnel that extends from the nasal cavity to the esophagus and larynx. The pharynx is divided into 3 regions: the nasopharynx, oropharynx, and laryngopharynx.(see figure 7.3) The nasopharynx is the superior region of the pharynx through which inhaled air from the nasal cavity passes and descends through the oropharynx, located in the posterior of the oral cavity. Air inhaled through the oral cavity enters the the oropharynx. The inhaled air then descends into the laryngopharynx, where it is diverted into the opening of the larynx by the epiglottis. The epiglottis is a flap that acts as a switch between the trachea and the esophagus. Because the pharynx is also used to swallow food, the epiglottis ensures that air passes into the trachea by covering the opening to the esophagus. During the process of swallowing, the epiglottis moves to cover the trachea to ensure that food enters the esophagus and to prevent choking.

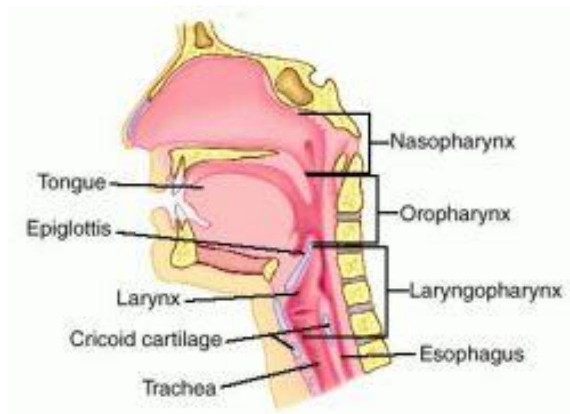


Figure: 7.3: Pharynx

Blood and Nerve supply:

Blood is supplied to the pharynx by several branches of the facial artery.

The venous return is into the facial and internal jugular veins.

The nerve supply is from the pharyngeal plexus, formed by parasympathetic and sympathetic nerves.

Parasympathetic supply is by the vagus and glossopharyngeal nerves.

Sympathetic supply is by nerves from the superiorcervical ganglia

Functions of Pharynx:

1. **Passageway for air and food.** The pharynx is an organ involved in both the respiratory and the digestive systems: air passes through the nasal and oral parts, and food through the oral and laryngeal parts.

2. **Warming and humidifying.** By the same methods as in the nose, the air is further warmed and moistened as it passes through the pharynx.

3. **Taste.** There are olfactory nerve endings of the sense of taste in the epithelium of the oral and pharyngeal parts.

4. **Hearing.** The auditory tube, extending from the nasal part to each middle ear, allows air to enter the middle ear. Satisfactory hearing depends on the presence of air at atmospheric pressure on each side of the tympanic membrane (ear drum).

5. **Protection.** The lymphatic tissue of the pharyngeal and laryngeal tonsils produces antibodies in response to antigens, e.g. microbes. The tonsils are larger in children and tend to atrophy in adults.

6. **Speech.** The pharynx functions in speech; by acting as a resonating chamber for the sound ascending from the larynx, it helps (together with the sinuses) to give the voice its individual characteristics.

7.4 Larynx

The larynx, or the voice box, connects the laryngopharynx and the trachea. The larynx is located in the anterior portion of the neck. Epiglottis, thyroid cartilage and the cricoid cartilage structures make up the larynx and give it its structure. In addition to cartilage, the larynx contains vocal folds of mucous membrane that vibrate to produce sounds required for talking and singing.

Blood and Nerve supply

Blood is supplied to the larynx by the superior and inferior Laryngeal arteries and drained by the thyroid veins, which join the internal jugular vein. The parasympathetic nerve supply is from the superior Laryngeal and Recurrent laryngeal nerves, which are branches of the vagus nerves, and the sympathetic nerves are from the superior cervical ganglia, one on each side. These provide the motor nerve supply to the muscles of the larynx and sensory fibers to the lining membrane.

Functions of larynx:

1. **Production of sound.** Sound has the properties of pitch, volume and resonance.

- **Pitch** of the voice depends upon the length and tightness of the cords. At puberty, the male vocal cords begin to grow longer, hence the lower pitch of the adult male voice.
- **Volume** of the voice depends upon the force with which the cords vibrate. The greater the force of expired air the more the cords vibrate and the louder the sound emitted.
- **Resonance**, or tone, is dependent upon the shape of the mouth, the position of the tongue and the lips, the facial muscles and the air in the paranasal sinuses.

2. **Speech.** This occurs during expiration when the sounds produced by the vocal cords are manipulated by the tongue, cheeks and lips.
3. **Protection of the lower respiratory tract.** During swallowing (deglutition) the larynx moves upwards, occluding the opening into it from the pharynx and the hinged epiglottis closes over the larynx. This ensures that food passes into the esophagus and not into the lower respiratory passages.
4. **Passage way for air.** This is between the pharynx and trachea.
5. **Humidifying, filtering and warming.** These continue as inspired air travels through the larynx.

7.5Trachea

The trachea, or windpipe, is a 5-inch long tube which connects the larynx to the bronchi and allows air to pass through the neck and into the thorax. The rings of cartilage making up the trachea allow it to remain open to air at all times.

Function of the trachea:

1. To provide a clear passage for entry and exit of air into the lungs.

2. The mucus produced by the epithelium lining the trachea, traps dust and other contaminants to prevents it from reaching the lungs. Cilia on the surface of the epithelial cells move the mucus upwards toward the pharynx where it can be swallowed and digested in the gastrointestinal tract.

7.6 Bronchi and Bronchioles

At the lower end of the trachea, the airway splits into left and right branches known as the primary bronchi. The left and right bronchi further branch off into smaller secondary bronchi which carry air into the lobes of the lungs—2 in the left lung and 3 in the right lung. (See figure 7.4) The secondary bronchi further split into many smaller tertiary bronchi which again split up into smaller bronchioles that spread throughout the lungs. Each bronchiole further splits into many smaller branches less than a millimeter in diameter called terminal bronchioles. Finally, the millions of tiny terminal bronchioles conduct air to the alveoli of the lungs.

Function of the bronchi and bronchioles:

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

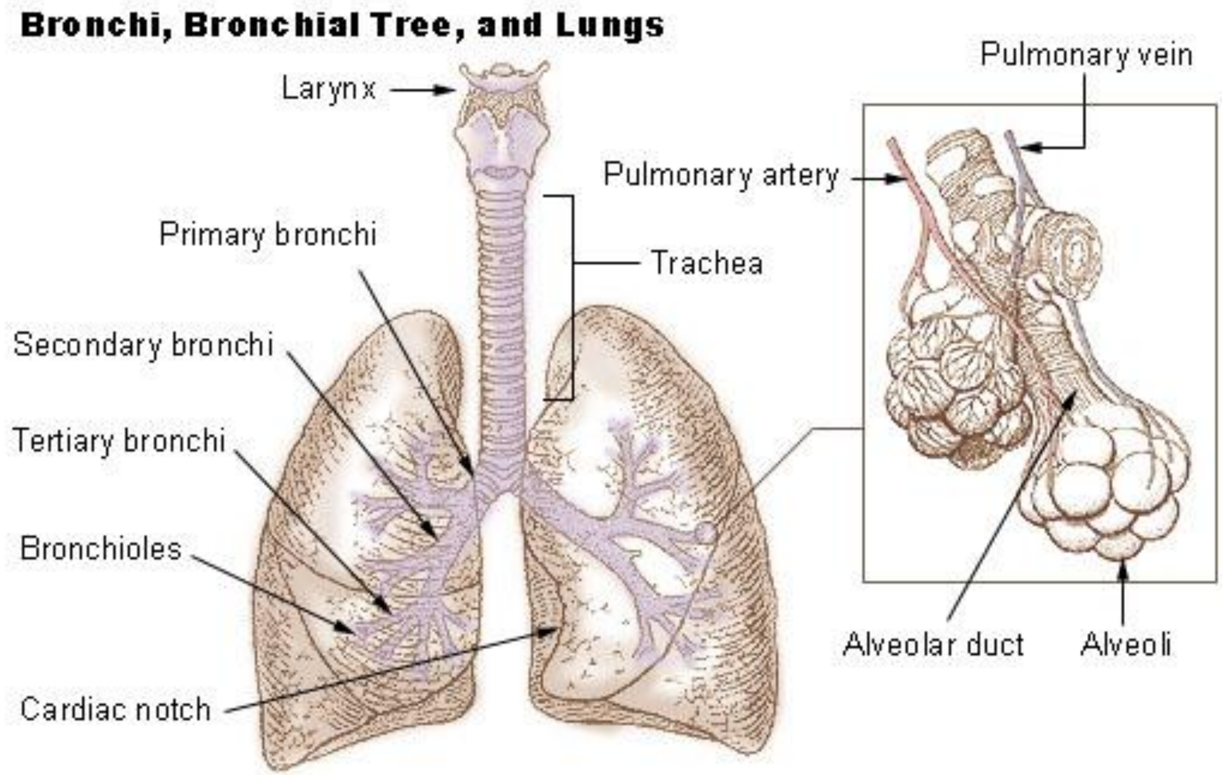


Figure: 7. 4: Bronchi, Bronchial tree and Lungs

7.7 Lungs

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

The lungs are made up of spongy tissues containing many capillaries and around 30 million tiny sacs known as alveoli. The alveoli are cup-shaped structures found at the end of the terminal bronchioles and surrounded by capillaries. The alveoli allow air entering into them to exchange its gases with the blood passing through the capillaries.

The lungs are surrounded by the pleural sac, which is a two-layered serous structure. (See figure 7.5) The thin space between the two pleural layers is known as the pleural cavity and normally contains a small amount of pleural fluid.

Function of Pleura and Pleural Cavity:

The pleural cavity, with its associated pleurae, aids optimal functioning of the lungs during breathing. The pleural cavity also contains pleural fluid, which allows the pleurae to slide effortlessly against each other during ventilation.

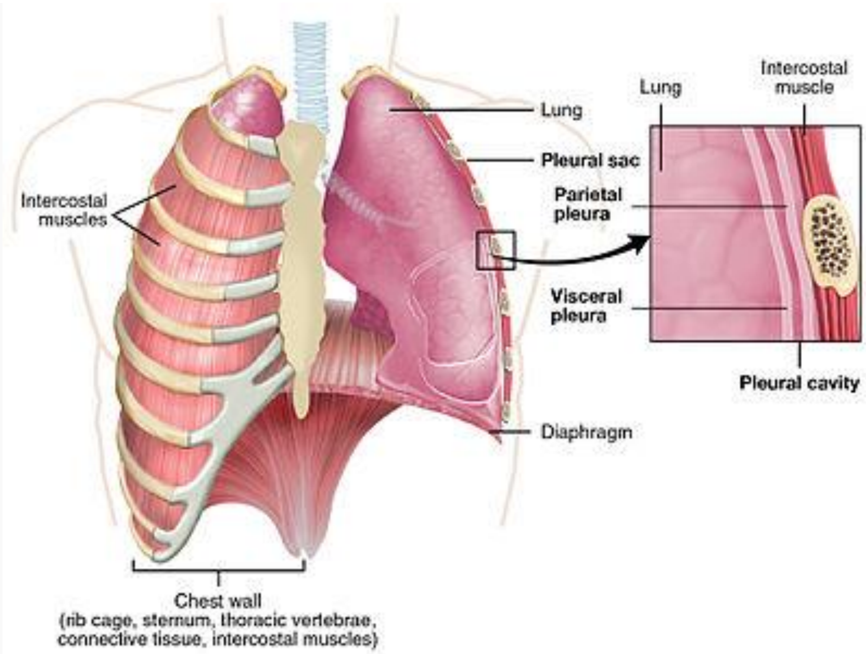


Figure: 7.5: Lungs with its Pleural Sac

Muscles of Respiration

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

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

7.8 Definitions of External and Internal Respiration

External Respiration: The gas exchange occurs between pulmonary capillaries and the alveolus.

Internal Respiration: The gas exchange occurs between the tissue and capillaries.

(See figure 7.6)

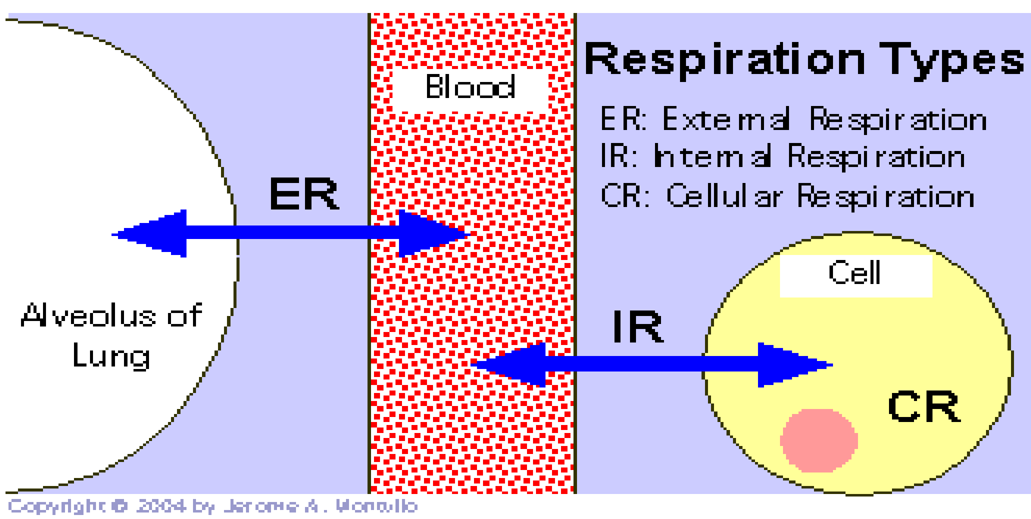


Figure 7.6: Types of Respiration

7.9 Mechanism of respiration

Inspiration:

It is a process by which air is brought into the lungs. (See figure 7.7)

First, the muscles between the ribs are contracted. The ribs are pulled out and the chest cavity expands. Following this, diaphragm contracts in such a way that it is brought down a little bit and also expands the chest cavity. Next, there is a contraction of muscles of the belly. All these events create a partial vacuum in the chest cavity and the atmospheric air rushes in the lung, as if the lungs were a suction pump.

Expiration

After the exchange of gases in the lungs, the air has to be expelled. Expulsion of the air from the lungs is called expiration. Reversal of the three events that had occurred in inspiration, results in expiration.

Breathing -

Breathing is a term which is applied to inhalation and exhalation. The act of intake of air into the lungs and expulsion of the air from the lungs is called breathing. Coming in and going out of the air ventilates the lung. Respiration is partly involuntary (automatic), and partly voluntary (by will). Respiration is controlled by a small centre located in the posterior part of the brain, called respiratory centre. (See Figure 7.8)

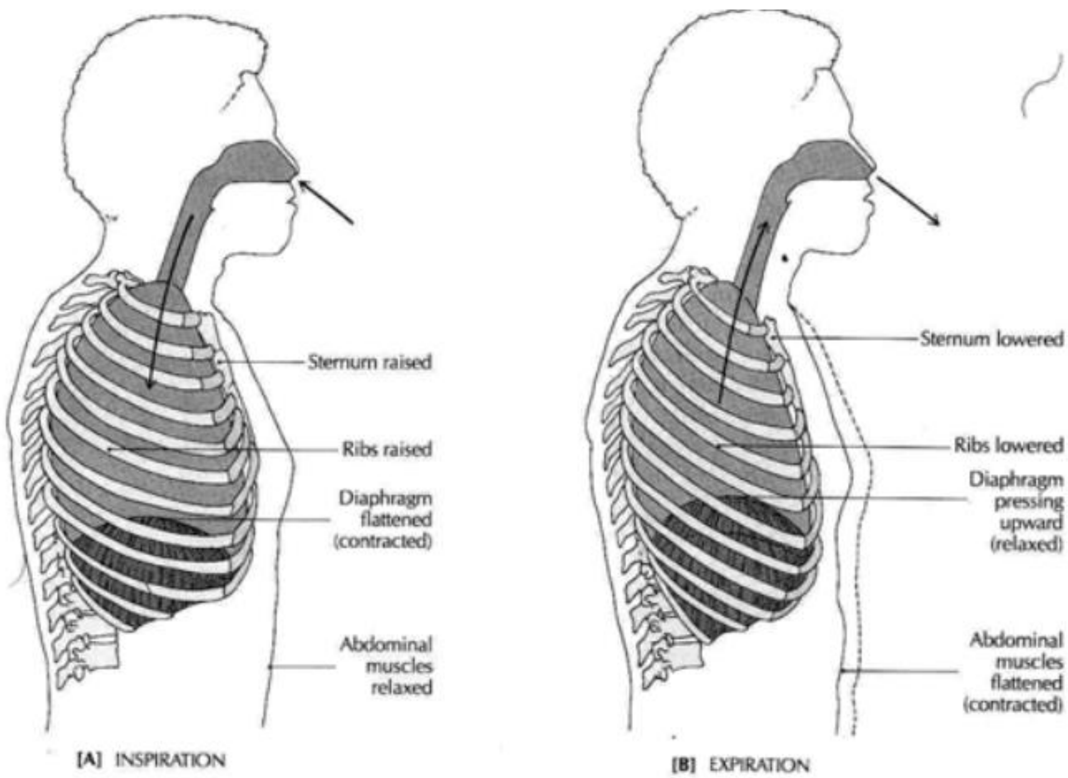


Figure: 7.7: Showing (A) Inspiration and (B) Expiration

Gas Exchange in Lungs:

Atmospheric air inhaled finally come to these alveoli. All around the alveoli there is a network of blood capillaries. These capillaries are extremely fine tubes with only one layered wall. The deoxygenated blood collected from different parts of the body is at first brought to the heart, and from here pumped out to the lungs. This blood which may also be called venous blood is sent to the lungs where it has to pass through the network of capillaries around the alveoli. In the alveoli, the inhaled air has about 21% oxygen. Percentage of oxygen in the alveolus is higher than in the venous blood. Therefore, oxygen from the alveolus diffuses out into the blood capillary and is picked up by the hemoglobin molecules present inside the red blood corpuscles. By the same principle, carbon dioxide, which is in greater amount in the venous blood, comes from the capillary into the alveolus.

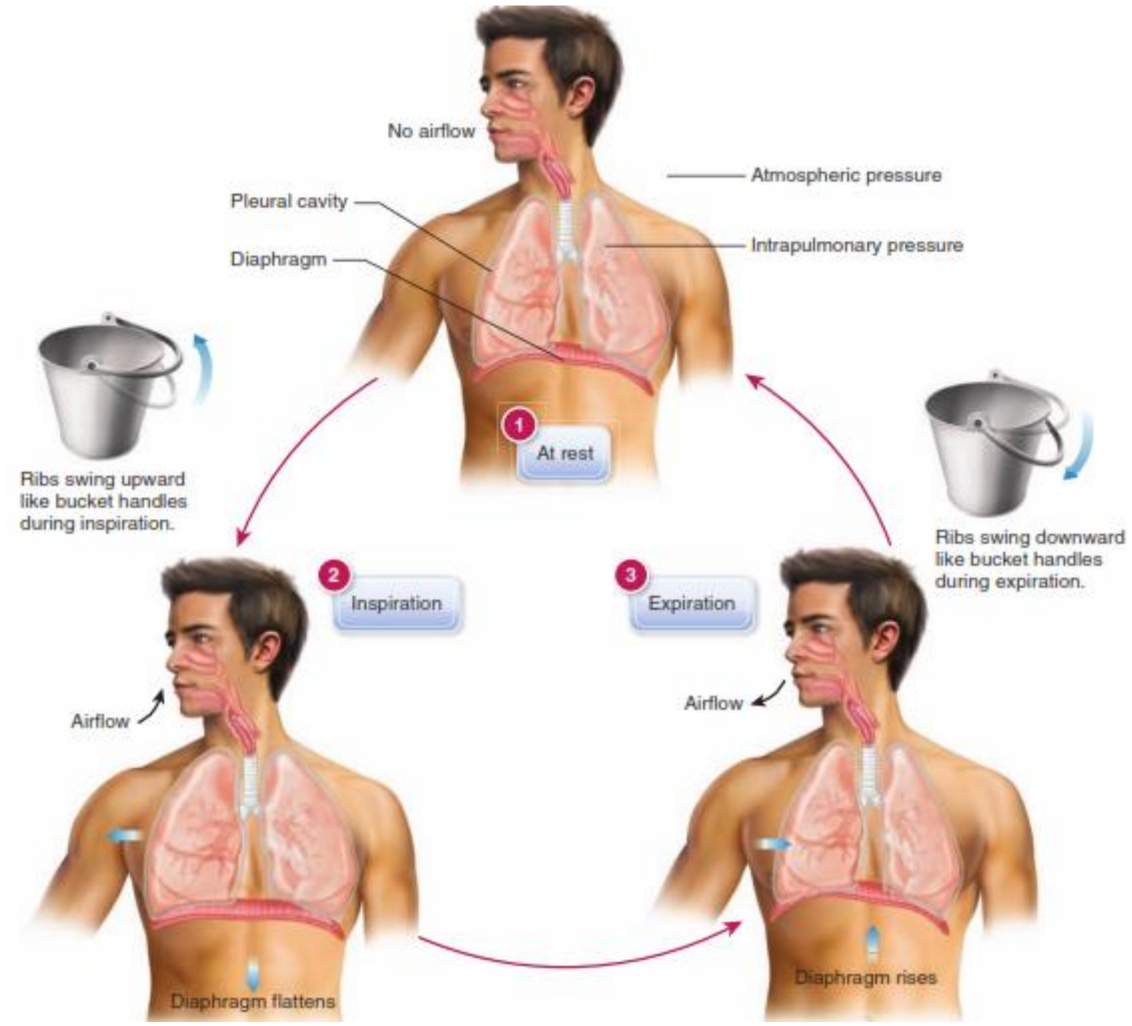


Figure 7.8: Mechanism of Respiration

7.10 Definition of Respiratory rate, tidal volume, Vital Capacity, cyanosis, Hypoxia, PCO2

- **Respiratory rate**: It is the number of breaths (inhalation-exhalation cycles) taken within a set amount of time (typically 60 seconds). Normal respiration rates for an adult person at rest range from 12 to 16 breaths per minute.
- **Tidal Volume:** The volume of air breathed in and out in a single quiet respiration is 500 milliliter, which is called the tidal volume. It is the lung volume representing the normal volume of air, when extra effort is not applied.

- **Vital capacity:** It is the maximum amount of air a person can expel from the lungs after a maximum inhalation. A normal adult has a vital capacity between 3 and 5 liters. A human's vital capacity depends on age, sex, height, mass, and ethnicity.
- **Cyanosis:** It is defined as a bluish discoloration, especially of the skin and mucous membranes, due to excessive concentration of deoxyhemoglobin in the blood caused by deoxygenation.
- **Hypoxia:** It is a pathological condition in which the body or a region of the body is deprived of an adequate oxygen supply
- **Partial pressure of carbon dioxide (PaCO2):** This measure the pressure of carbon dioxide dissolved in the blood and how well carbon dioxide is able to move out of the body.

7.11 Blood gas analysis -

Red blood cells transport oxygen and carbon dioxide — blood gases — throughout the body. The oxygen and carbon dioxide levels of the blood and the pH balance of the blood can indicate the presence of certain medical conditions, such as cardiac, lung or kidney disorders and the presence or status of other critical conditions such as uncontrolled diabetes, hemorrhage, drug overdose and shock. Arterial blood gas (ABG) is a test to determine these levels. This test requires collecting a small amount of blood from an artery and reading the results within 10 minutes.

Uses of a Blood Gas Test:

Knowing the blood's pH balance and oxygen and carbon dioxide reflects functioning of the lungs and kidneys. Identifying imbalances in the pH and blood gas levels can provide an early warning of an illness.

Blood Gas Test:

An ABG test requires obtaining a 2 ml sample of blood. This blood can be obtained from an artery in wrist, arm, or groin. First apply an alcohol or antiseptic swab to the skin, and then use a needle to draw blood.

The blood sample will be analyzed via a portable machine (See figure 7.9) or in an on-site laboratory. To get the best test result, the test must be analyzed within 10 minutes of drawing blood.

Figure 7.9: Arterial Blood Gas Analyzer

Interpreting the Results of a Blood Gas Test

Arterial blood gas test provides pH balance, bicarbonate, PCO_2.

While the normal values at sea level may vary based on the lab testing the sample, normal values:

- arterial blood pH: 7.38 to 7.42
- partial pressure of oxygen (PaO2): 75 to 100 mmHg
- partial pressure of carbon dioxide (PaCO2): 38 to 42 mmHg
- oxygen saturation (SaO2): 94 to 100 percent
- bicarbonate (HCO3): 22 to 28 mEq/L

If one gous higher than sea level, blood oxygen levels may be lower.

These results can indicate certain medical conditions such as the ones in the table below. If levels are off balance, doctor can recommend treatments, such as oxygen therapy, to get them back to normal.

Table 7.1: Interpreting the Results of a Blood Gas Test

Blood pH	**Bicarbonate**	**PCO_2**	**Condition**	**Common Causes**
Less than 7.4	Low	Low	Metabolic acidosis	Kidney failure, shock, Diabetic ketoacidosis
Greater than 7.4	High	High	Metabolic alkalosis	Chronic vomiting, low blood potassium
Less than 7.4	High	High	Respiratory acidosis	Lung diseases, including pneumonia or COPD
Greater than 7.4	Low	Low	Respiratory alkalosis	Breathing too fast, pain or anxiety.

Review Questions

1. Draw and explain lungs and its functions.
2. Describe mechanism of respiration.
3. Define tidal volume, hypoxia, cyanosis, respiratory rate.

Assignments

Prepare a chart showing different parts of respiratory system.

Lesson 8 - Digestive System

Objective: At the end of the topic the student will be able to-

1) Define digestion
2) Identify all parts of digestive system
3) Will be able to explain process of digestion

Introduction:

The digestive system is the collective name used to describe the alimentary canal, some accessory organs and a variety of digestive processes which take place at different levels in the canal to prepare food eaten in the diet for absorption. (See figure 8.1) The alimentary canal begins at the mouth, passes through the thorax, abdomen and pelvis and ends at the anus. Thus it is a system that deals with ingestion (taking food inside), propulsion(movement of food), digestion(breakdown of food to get required nutrients), absorption(uptake of these nutrients in blood) and excretion (passing out of waste material).

8.1: Definition of Digestion -

Digestion: This consists of:

- Mechanical breakdown of food by, e.g. mastication (chewing)
- Chemical digestion of food by enzymes present in secretions produced by glands and accessory organs of the digestive system.

8.2: Parts of digestive system:

8.2.a. Mouth - The mouth or oral cavity is bounded by muscles and bones: (See figure 8.2)

- Anteriorly —by the lips
- Posteriorly —it is continuous with the oropharynx

- Laterally —by the muscles of the cheeks
- Superiorly —by the bony hard palate and muscular soft palate
- Inferiorly —by the muscular tongue and the soft tissues of the floor of the mouth.

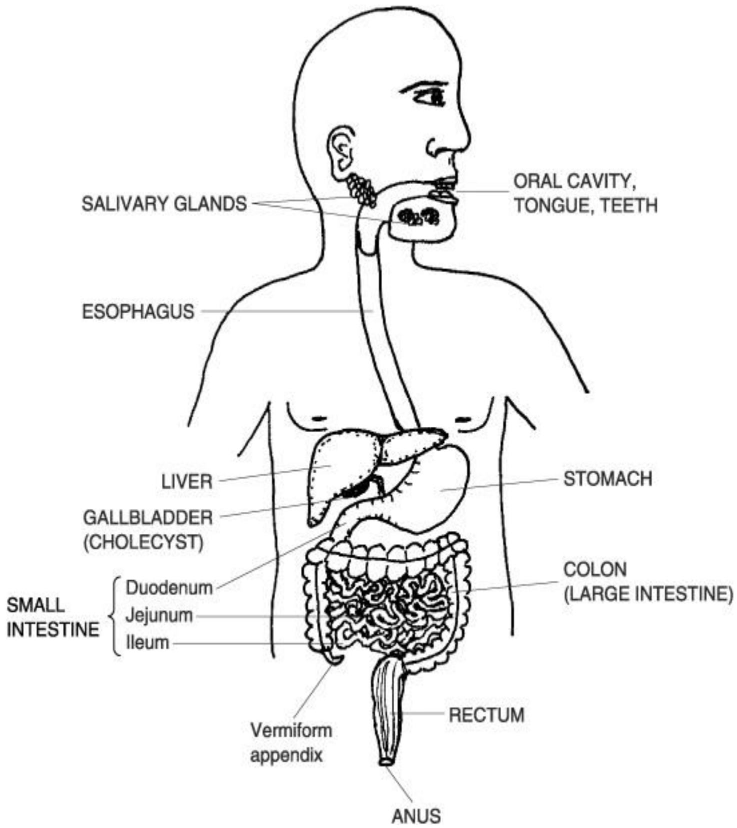


Figure 8.1: Alimentary canal

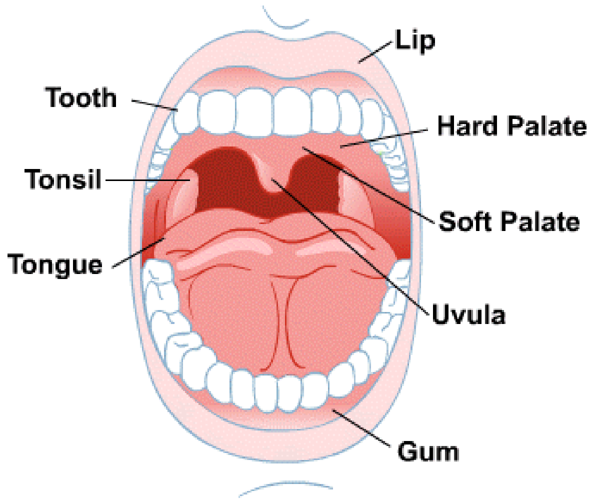


Figure 8.2: Parts of Mouth

8.2.b Salivary glands:

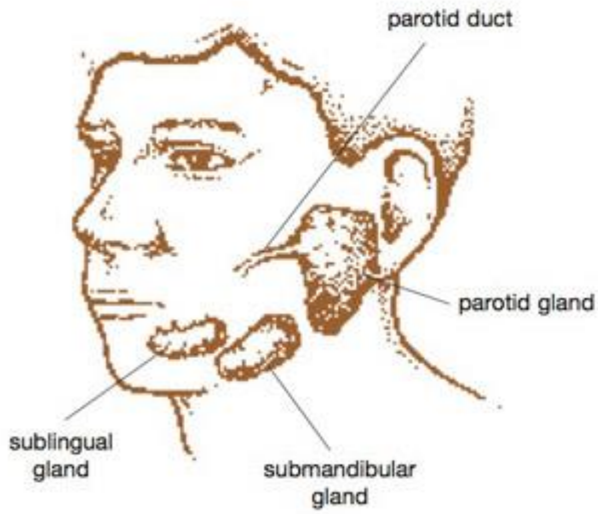
Salivary glands pour their secretions into the mouth. (See figure: 8.3)

There are three pairs:

- The parotid glands,

-The Submandibular glands

-The sublingual glands



Figures 8.3: Salivary Glands

Composition of Saliva- Saliva is the combined secretions from the salivary glands and the small mucus-secreting glands of the lining of the oral cavity. About 1.5 liters of saliva is produced daily and it consists of:

- Water
- Mineral Salts
- Enzyme: Salivary Amylase
- Mucus
- Lysozyme
- Immunoglobulins
- Blood-Clotting Factors etc.

Functions of saliva:

1. **Chemical digestion of polysaccharides.** Saliva contains the enzyme amylase that begins the breakdown of complex sugars, reducing them to the disaccharide maltose. The optimum pH for the action of salivary amylase is, slightly acid. Salivary pH ranges from 5.8 to 7.4 depending on the rate of flow; the higher the flow rate, the higher is the pH. Enzyme action continues during swallowing until

terminated by the strongly acidic pH (1.5 to 1.8) of the gastric juices, which degrades the amylase.

2. **Lubrication of food.** Dry food entering the mouth is moistened and lubricated by saliva before it can be made into a bolus ready for swallowing.

3. **Cleansing and lubricating.** An adequate flow of saliva is necessary to cleanse the mouth and keep its tissues soft, moist and pliable. It helps to prevent damage to the mucous membrane by rough or abrasive foodstuffs.

4. **Non-specific defence:** Lysozyme, Immunoglobulins and Clotting factors combat invading microbes.

5. **Taste.** The taste buds are stimulated only by chemical substances in solution. Dry foods stimulate the sense of taste only after thorough mixing with saliva. The senses of taste and smell are closely linked in the enjoyment,or otherwise, of food.

8.2. c. The Pharynx

It is divided for descriptive purpose into three parts:

- Nasopharynx-is important in respiration
- Oropharynx are passages common to both the respiratory and digestive system.
- Laryngopharynx respiratory

Food passes from the oral cavity into the pharynx and then to the oesophagus below, with which it is continuous. (See figure 8.4)

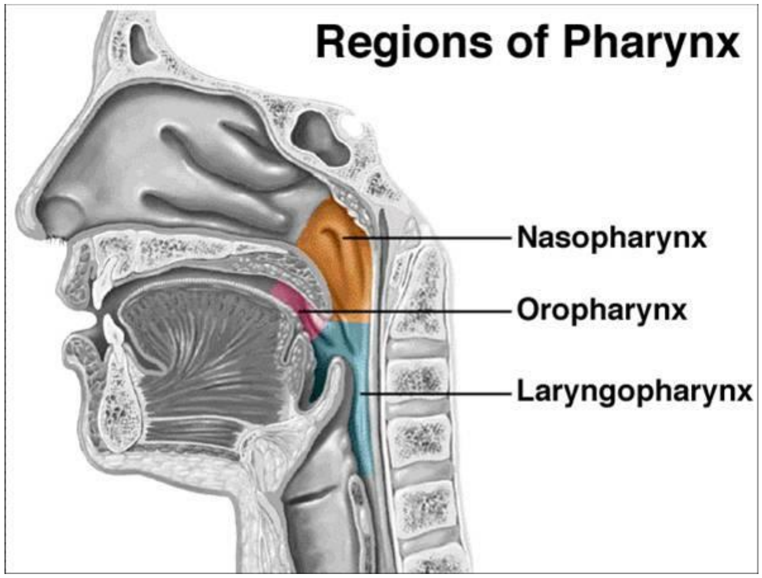


Figure: 8.4: Regions of Pharynx

- **Blood supply -**The blood supply to the pharynx is by several branches of the facial arteries. Venous drainage is into the facial veins and the internal jugular veins.
- **Nerve supply-**This is from the pharyngeal plexus and consists of parasympathetic and sympathetic nerves. Parasympathetic supply is mainly by the glossopharyngeal and vagus nerves and sympathetic from the cervical ganglia.

8.2.d. Oesophagus -

The oesophagus is about 25 cm long and about 2 cm in diameter and lies in the median plane in the thorax in front of the vertebral column behind the trachea and the heart. It is continuous with the pharynx above and just below the diaphragm it joins the stomach. (See figure 8.5) It passes between muscle fibers of the diaphragm behind the central tendon at the level of the 10th thoracic vertebra. Immediately the esophagus has passed through the diaphragm it curves upwards before opening into the stomach.

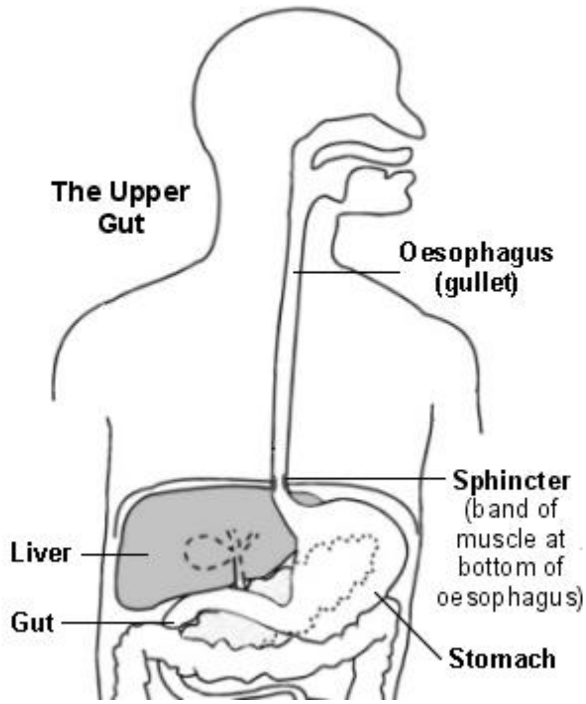


Figure 8.5: Oesophagus with other associated structures

Blood supply:

Arterial -The thoracic region of the oesophagus is supplied mainly by the oesophageal arteries, branches from the aorta. The abdominal region is supplied by branches from the inferior phrenic arteries and the left gastric branch of the coeliac artery.

Venous drainage - From the thoracic region venous drainage is into the azygos and hemiazygos veins. The abdominal part drains into the left gastric vein. There is avenues plexus at the distal end that links the upward and downward venous drainage, i.e. the general and portal circulations.

Nerve supply-Sympathetic and parasympathetic nerves terminate in them enteric and submucosal plexuses. Parasympathetic fibers are branches of the vagus nerve.

Functions of the Mouth, Pharynx and Oesophagus:

- **Formation of a bolus-**When food is taken into the mouth it is masticated or chewed by the teeth and moved round the mouth by the tongue and muscles of the cheeks. It is mixed with saliva and formed into a soft mass or bolus ready for deglutition or swallowing.

- **Deglutition or swallowing-** This occurs in three stages (a) Oral (b) Pharyngeal (c) Oesophageal after mastication the bolus is formed and then it is sallowed. It is initiated voluntarily but completed by a reflex (involuntary) action.

8.2.e. Stomach:

The stomach is a J-shaped dilated portion of the alimentary tract situated in the epigastric, umbilical and left hypochondriac regions of the abdominal cavity. The stomach is continuous with the oesophagus at the cardiac sphincter and with the duodenum at the pyloric sphincter. The stomach is divided into three regions: the fundus,the body and the pylorus. At the distal end of the pyloricantrum is the pyloric sphincter, guarding the opening between the stomach and the duodenum. When the stomach is inactive the pyloric sphincter is relaxed and open and when the stomach contains food the sphincteris closed. (See figure 8.6).

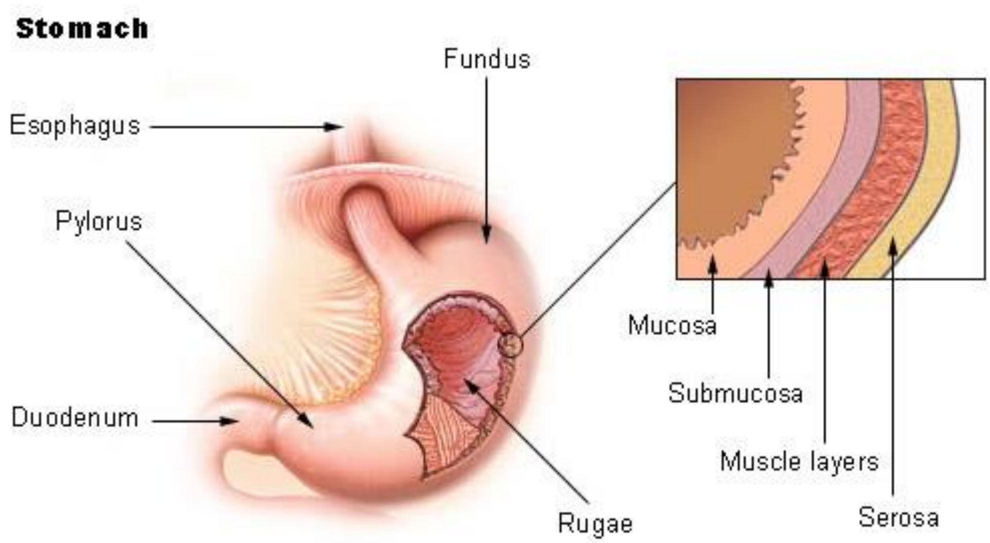


Figure 8.6: Anatomy of Stomach

Blood supply-

Arterial blood is supplied to the stomach by branches of the coeliac artery and venous drainage is into the portal vein.

Nerve supply-The sympathetic supply to the stomach is mainly from the coeliac plexus and the parasympathetic supply is from the vagus nerves. Sympathetic stimulation reduces the motility of the stomach and the secretion of gastric juice;vagal stimulation has the opposite effect **.**

Functions of the Stomach-

1. Storage of food- temporary storage allowing time for the digestive enzymes, pepsins, to act.
2. Chemical Digestion — pepsins convert proteins to polypeptides
3. Mechanical breakdown — the three smooth muscle layers enable the stomach to act as a churn, gastric juice is added and the contents are liquefied to chyme
4. Limited absorption of water, alcohol and some lipid soluble drugs
5. Non-specific defense against microbes — provided by hydrochloric acid in gastric juice. Vomiting may be are response to ingestion of gastric irritants, e.g. microbes or chemicals
6. Preparation of iron for absorption further along the tract — the acid environment of the stomach solubilises iron salts, which is required before iron can be absorbed
7. Production of intrinsic factor needed for absorption of vitamin B12 in the terminal ileum
8. Regulation of the passage of gastric contents into the duodenum. When the chyme is sufficiently acidified and liquefied, the pyloric antrum forces small jets of gastric contents through the pyloric sphincter into the duodenum.

1.2. f. Intestine -

Long tube -like structures that starts at the lower end of stomach are called intestines. They are of two types-

-**Small intestine**- The small intestine is continuous with the stomach at the pyloric sphincter and leads into the large intestine at the ileocaecal valve. It is a little over 5 meters long and lies in the abdominal cavity surrounded by the large intestine. In the small intestine the chemical digestion of food is completed and most of the absorption of nutrients takes place .The small intestine comprises three main sections continuous with each other.(See figure 8.7).

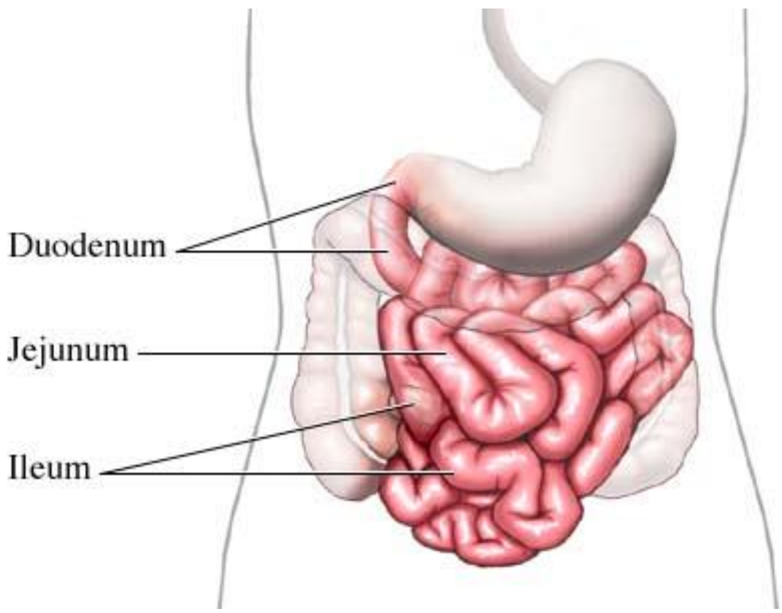


Figure 8.7: Small Intestine

The duodenum - is about 25 cm long and curves around the head of the pancreas. Secretions from the gall bladder and pancreas are released into the duodenum through a common structure, the hepatopancreatic ampulla, and the opening into the duodenum is guarded by the hepatopancreatic sphincter (of Oddi).

The jejunum- is the middle section of the small intestine and is about 2 metres long.The ileum - or terminal section, is about 3 metres long and ends at the ileocaecal valve, which controls the flow of material from the ileum to the caecum, the first part of the large intestine, and prevents regurgitation.

Blood supply-The superior mesenteric artery supplies the whole of the small intestine, and venous drainage is by the superior mesenteric vein which joins other veins to form the portal vein.

Nerve supply-Innervation of the small intestine is both sympathetic and parasympathetic .

Functions of the small intestine-

1. Onward movement of its contents which is produced by peristalsis
2. Secretion of intestinal juices
3. Completion of chemical digestion of carbohydrates, protein and fats in the enterocytes of the villi
4. Protection against infection by microbes that have survived the antimicrobial action of the hydrochloric acid in the stomach, by the solitary lymph follicles and aggregated lymph follicles
5. Secretion of the hormones cholecystokinin(CCK) and secretin
6. Absorption of nutrients.

The large intestine: It is also called colon it is about 1.5 metres long, beginningat the caecum in the right iliac fossa and terminating at the rectum and anal canal deep in the pelvis. Its lumen is larger than that of the small intestine. It forms an arch around the coiled-up small intestine.

The colon is divided into the--caecum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum and anal canal.(See figure 8.8).

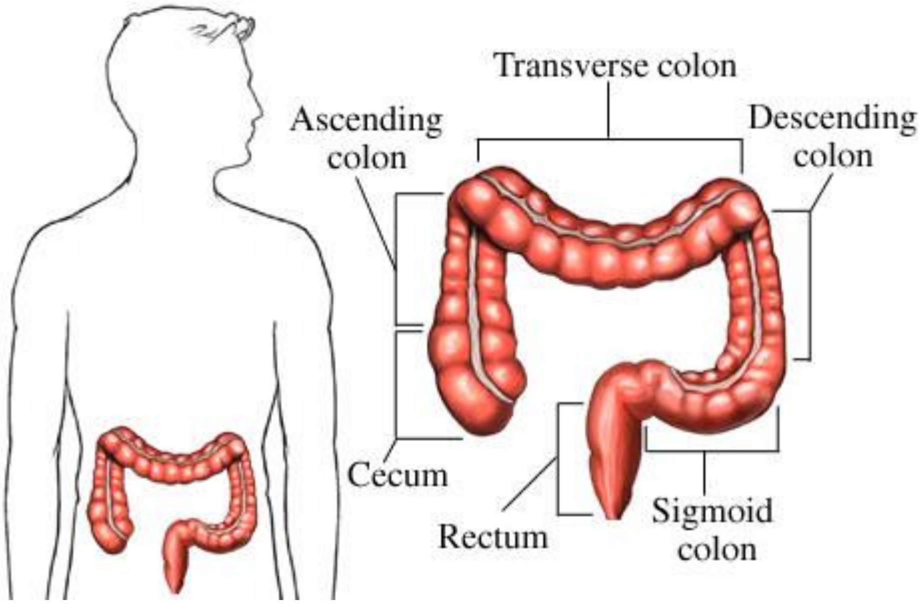


Figure 8.8: Large Intestine

-The caecum. This is the first part of the colon. It is adulated region which has a blind end inferiorly and is continuous with the ascending colon superiorly. Just below the junction of the two the ileocaecal valve opens from the ileum. The vermiform appendix is a fine tube, closed at one end, which leads from the caecum. It is usually about13 cm long and has the same structure as the walls of the colon but contains more lymphoid tissue

-The ascending colon. This passes upwards from the caecum to the level of the liver where it curves acutely to the left at the hepatic flexure to become the transverse colon.

-The transverse colon. This is a loop of colon which extends across the abdominal cavity in front of the duodenum and the stomach to the area of the spleen where it forms the splenic flexure and curves acutely downwards to become the descending colon.

-The descending colon. This passes down the left side of the abdominal cavity then curves towards the midline. After it enters the true pelvis it is known as the sigmoid colon.

-The sigmoid colon. This part describes an S-shaped curve in the pelvis then continues downwards to become the rectum.

The rectum: This is a slightly dilated section of the colon about 13 cm long. It leads from the sigmoid colon and terminates in the anal canal.

The anal canal: This is a short passage about 3.8 cm long in the adult and leads from the rectum to the exterior. Two sphincter muscles control the anus; the internal sphincter, consisting of smooth muscle fibers, is under the control of the autonomic nervous system and the external sphincter, formed by skeletal muscle, is under voluntary control.

Functions of the large intestine, rectum and anal canal-

1. Absorption--The contents of the ileum which pass through the ileocaecal valve into the caecum are fluid, even though some water has been absorbed in the small intestine. In the large intestine absorption of water continues until the familiar semisolid consistency of faeces is achieved. Mineral salts, vitamins and some drugs are also absorbed into the blood capillaries from the large intestine.

2. Microbial activity-The large intestine is heavily colonised by certain types ofbacteria, which synthesize vitamin K and folic acid. They include Escherichia coli, Enterobacter aerogenes, Streptococcus faecalis and Clostridium perfringens (welchii). These microbes are commensals in humans. They may become pathogenic if transferred to another part of the body, e.g. Escherichia coli may cause cystitis if it gains access to the urinary bladder.

3. Gases in the bowel consist of some of the constituents of air, mainly nitrogen, swallowed with food and drink and as a feature of some anxiety states. Hydrogen, carbon dioxide and methane are produced by bacterial fermentation of unabsorbed nutrients, especially carbohydrate. Gases pass out of the bowel as flatus.

4. Mass movement-The large intestine does not exhibit peristaltic movement as it is seen in other parts of the digestive tract. Only at fairly long intervals (about twice an hour) does a wave of strong peristalsis sweep along the transverse colon forcing its contents into the descending and sigmoid colons. This is known as mass movement and it is often precipitated by the entry of food into the stomach. This combination of stimulus and response is called the gastrocolic reflex.

5. **Defaecation-**Usually the rectum is empty, but when a mass movement forces the contents of the sigmoid colon into the rectum the nerve endings in its walls are stimulated by stretch. In the infant defecation occurs by reflex involuntary) action. However, sometime in the second or third year of life the ability to override the defecation reflex is developed. In practical terms this acquired voluntary control means that the brain can inhibit the reflex until such time as it is convenient to defecate. The external anal sphincteris under conscious control through the pudendal nerve.Thus defecation involves involuntary contraction of the muscle of the rectum and relaxation of the internal anal sphincter. Contraction of the abdominal muscles and lowering of the diaphragm increase the intra-abdominal pressure (Valsalva's manoeuvre) and so assist the process of defecation. When defecation is voluntarily postponed the feeling of fullness and need to defecate tends to fade until the next mass movement occurs and the reflex is initiated again. Repeated suppression of the reflex may lead to constipation.

8.2.g. Liver –

The liver is the largest gland in the body, weighing between 1 and 2.3 kg. It is situated in the upper part of the abdominal cavity occupying the greater part of the right hypochondriac region, part of the epigastric region and extending into the left hypochondriac region Its upper and anterior surfaces are smooth and curved to fit the under surface of the diaphragm; its posterior surface is irregular in outline. (See figure 8.9).

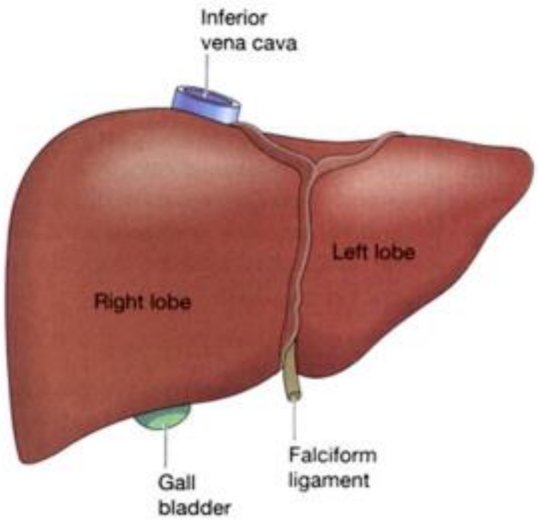


Figure 8.9: Liver

Organs associated with the liver-

Superiorly Anteriorly — Anterior abdominal wall.

Inferiorly —stomach, bile ducts, duodenum, hepatic flexure of the colon, right kidney and adrenal gland.

Posteriorly —oesophagus, inferior vena cava, aorta, gall bladder, vertebral column and diaphragm

Laterally — lower ribs and diaphragm.

The liver is enclosed in a thin inelastic capsule and incompletely covered by a layer of peritoneum. Folds of peritoneum form supporting ligaments attaching the liver to the inferior surface of the diaphragm. It is held in position partly by these ligaments and partly by the pressure of the organs in the abdominal cavity.The liver has four lobes. The two most obvious are the large right lobe and the smaller, wedge-shaped, left lobe.The other two, the caudate and quadrate lobes, are areas on the posterior surface.

Blood supply:

The hepatic artery and the portal vein take blood to the liver. Hepatic veins, varying in number, leave the posterior surface and immediately enter the inferior vena cava just below the diaphragm

Functions of the liver

The liver is an extremely active organ.

1. Carbohydrate metabolism: Conversion of glucose to glycogen in the presence of insulin, and converting liver glycogen back to glucose in the presence of glucagon.

These changes are important regulators of the blood glucose level. After a meal the blood in the portal vein has high glucose content and insulin converts some to glycogen for storage. Glucagon converts this glycogen back to glucose as required, to maintain the blood glucose level within relatively narrow limits

2. Fat metabolism. Desaturation of fat, i.e. converts stored fat to a form in which it can be used by the tissues to provide energy.

3. Protein metabolism. Deamination of amino acids• removes the nitrogenous portion from the amino acids not required for the formation of new proteinurea is formed from this nitrogenous portion which is excreted in urine.•

4. **Transamination** — removes the nitrogenous portion of amino acids and attaches it to other carbohydrate molecules forming new non-essential amino acids

5. **Synthesis of plasma proteins** and most of the blood clotting factors from the available amino acids occurs in the liver.

6. Breakdown of erythrocytes and defence against microbes. This is carried out by phagocytic Kupffer cells (hepatic macrophages) in the sinusoids.

7. Detoxification of drugs and noxious substances. These include ethanol (alcohol) and toxins produced by microbes.

8. Metabolism of ethanol. This follows consumption of alcoholic drinks.

9. Inactivation of hormones. These include insulin, glucagon, cortisol, aldoster one, thyroid and sex hormones.

10. Synthesis of vitamin A from carotene. Carotene is the provitamin found in some plants, e.g. carrots and green leaves of vegetables.

11. Production of heat. The liver uses a considerable amount of energy, has a high metabolic rate and produces a great deal of heat. It is the main heat-producing organ of the body.

12. Secretion of bile. The hepatocytes synthesis the constituents of bile from the mixed arterial and venous blood in the sinusoids. These include bile salts, bile pigments and cholesterol.

13. Storage. The substances include: • fat-soluble vitamins: A, D, E, K• iron, copper• some water-soluble vitamins, e.g. riboflavine, niacin, pyridoxine, folic acid and vitamin B12.

8.2.h. Gall bladder-

The gall bladder is a pear-shaped sac attached to the posterior surface of the liver by connective tissue. It has a fundus or expanded end, a body or main part and a neck which is continuous with the cystic duct.

Structure-The gall bladder has the same layers of tissue as those described in the basic structure of the alimentary canal, with some modifications. Peritoneum covers only the inferior surface. The gallbladder is in contact with the posterior surface of the right lobe of the liver and is held in place by the visceral peritoneum of the liver. There is an additional layer of oblique muscle fibres. Mucous membrane displays small rugae when the gallbladder is empty that disappear when it is distended with bile.

Blood supply-The cystic artery, a branch of the hepatic artery, supplies blood to the gall bladder. Blood is drained away by the cystic vein which joins the portal vein.

Nerve supply-Nerve impulses are conveyed by sympathetic and parasympathetic nerve fibres. There are the same autonomic plexuses as those described in the basic structure

Functions of the gall bladder-These include:

a. Reservoir for bile

b. Concentration of the bile by up to 10- or 15-fold, by absorption of water through the walls of the gallbladder

c. Release of stored bile -When the muscle wall of the gall bladder contracts bile passes through the bile ducts to the duodenum.

8.2.i. Pancrease-

The pancreas is a pale grey gland weighing about 60 grams. It is about 12 to 15 cm long and is situated in the epigastric and left hypochondriac regions of the abdominal cavity. It consists of a broad head, a body and a narrow tail. The head lies in the curve of the duodenum, the body behind the stomach and the tail lies in front of the left kidney and just reaches the spleen. The abdominal aorta and the inferior vena cava lie behind the gland.(See figure 8.10).

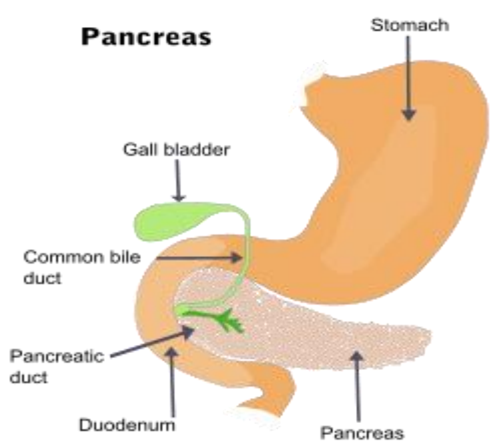


Figure: 8.10: Pancreas

Blood supply-The splenic and mesenteric arteries supply arterial blood to the pancreas and the venous drainage is by the veins of the same names that join other veins to form the portal vein .

Nerve supply-As in the alimentary tract, parasympathetic stimulation increases the secretion of pancreatic juice and sympathetic stimulation depresses it.

The pancreas is both an exocrine and endocrine gland.

Functions of pancrease -

The function of the exocrine pancreas is to produce pancreatic juice containing enzymes that digest carbohydrates proteins and fats. The function of the endocrine pancreas is to secrete the hormones insulin and glucagon, which are principally concerned with control of blood glucose levels.

8.3 Process of digestion:

BOLUS – soft, pliable ball – creating from chewing and addition of saliva – it slides down esophagus.(See figure 8.11).

PERISTALSIS – wavelike motions, moves food along esophagus, stomach and intestines.

- In the mouth-
    - saliva softens food to make it easier to swallow
    - PTYALIN in saliva converts starches into simple sugar under nervous control – just thinking of food can cause your mouth to water.
- In the stomach-
    - gastric (digestive) juices are released
    - stomach walls churn and mix (This mixture is chyme)
    - small amount of chyme enters duodenum at a time - controlled by pyloric sphincter
    - takes 2-4 hours for stomach to empty

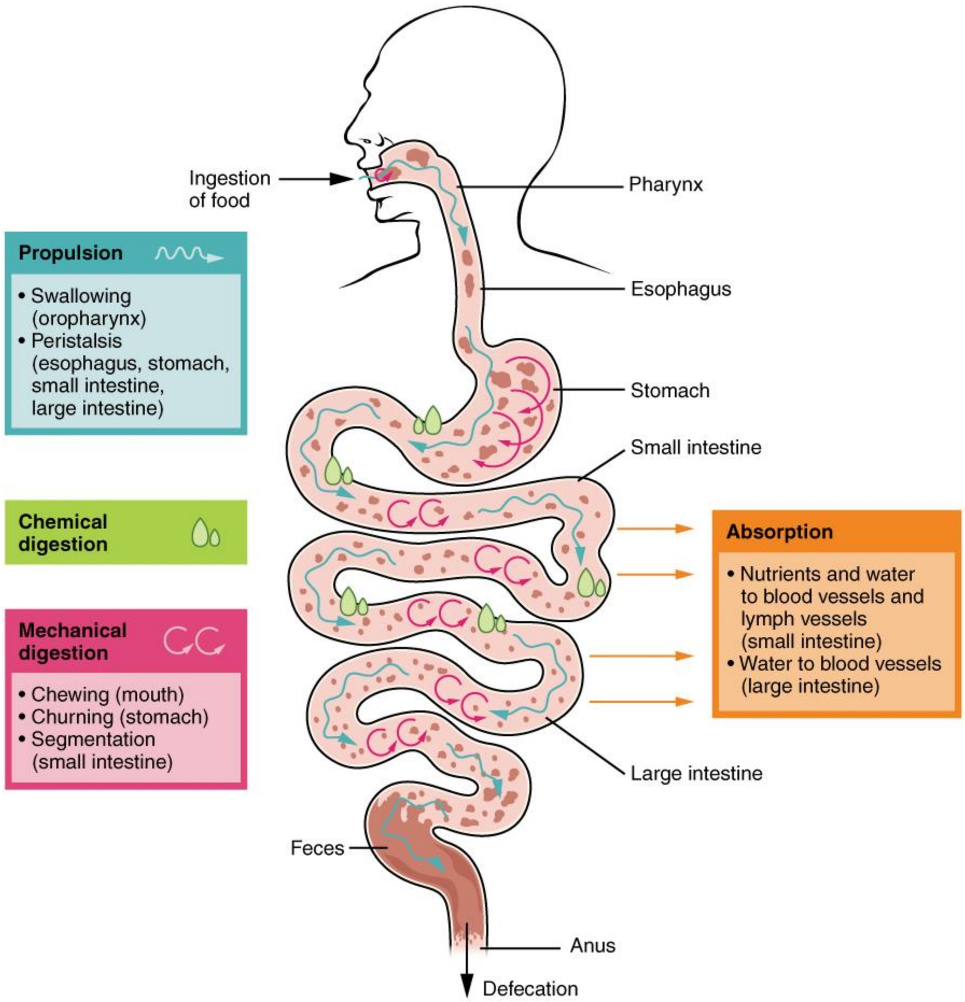


Figure 8.11: Process of Digestion

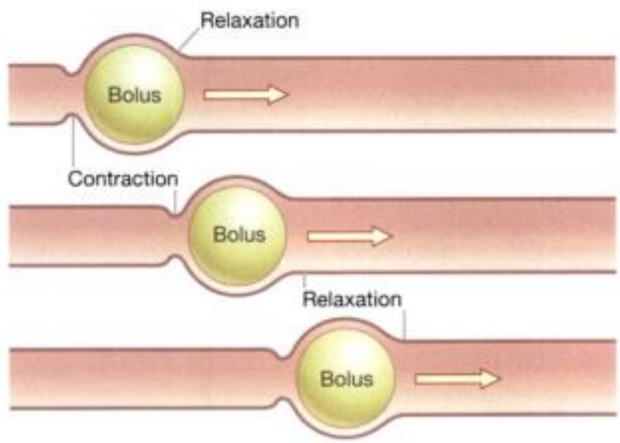


Figure 8:12 Movement of a bolus by peristalsis.

In the small intestine-

- where digestion is completed and absorption occurs
- addition of enzymes from pancreas and bile from liver/gallbladder

In the large intestine-

a. regulation of water balance by absorbing large quantities back into bloodstream

b. bacterial action on undigested food – decomposed products excreted through colon – bacteria form moderate amounts of B complex and Vitamin K

c. gas formation – 1-3 pints/day, pass it through rectum (flatulence) 14 times a day, bacteria produce the gas.

FECES – undigested semi-solid food material consisting of bacteria, waste products, mucous and cellulose

Questions

1. Draw the explain stomach.
2. Write a note Intestine.

3. Explain in brief process of Digestion.

Assignments

1. Prepare a chart of digestive system.
2. Prepare a chart showing liver, gall bladder, pancreas.

****

Lesson-9 Excretory System

Objective- At the end of the topic the students will be able to-

a. Identify all parts of urinary system

b. Explain their function

c. Identify layers of skin

d. Explain functions of the skin.

9.1 The Urinary system –

It is one of the excretory systems of the body. The urinary system plays a vital part in maintaining homeostasis of water and electrolyte concentrations within the body. The kidneys produce urine that contains metabolic waste products, including the nitrogenous compounds urea and uric acid, excess ions and some drugs. (See figure 9.1)

It consists of the following structures:

- 2 kidneys, which secrete urine
- 2 ureters, which convey the urine from the kidneys to the urinary bladder
- urinary bladder where urine collects and is temporarily stored
- 1 urethra through which the urine is discharged from the urinary bladder to the exterior.

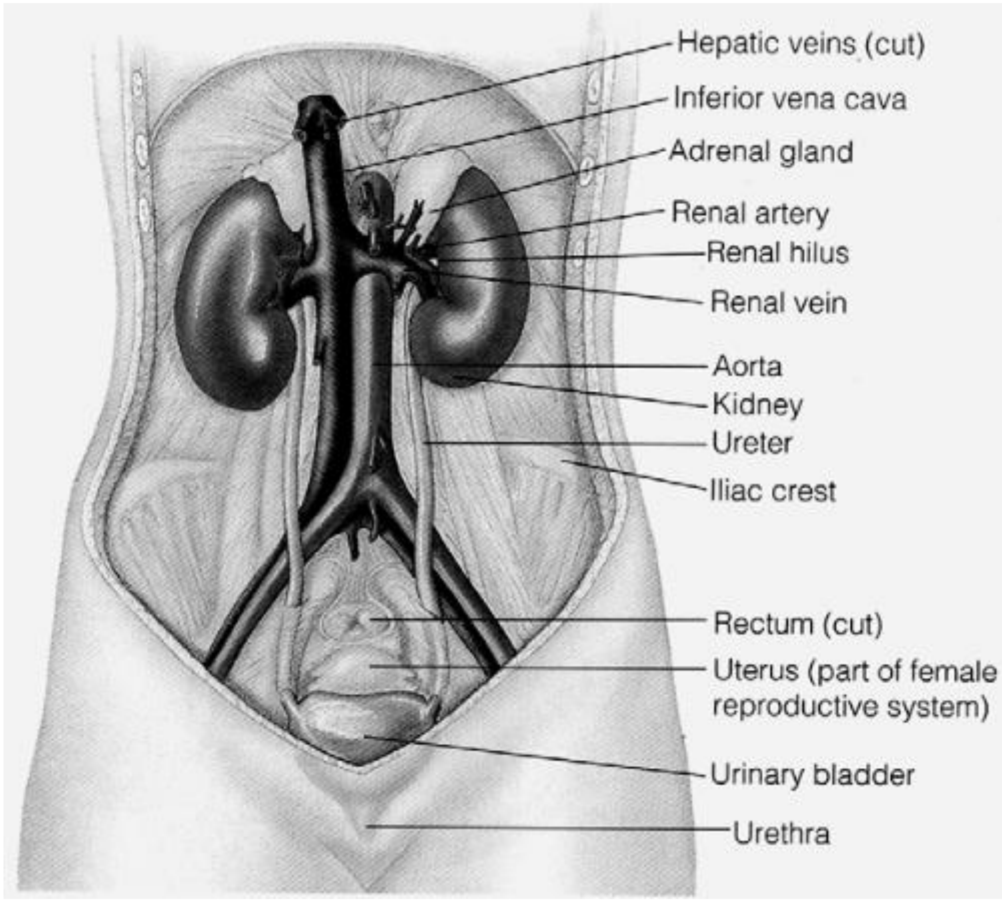


Figure: 9.1: The Urinary System

9.1.a Kidneys -

The kidneys, lie on the posterior abdominal wall, one on each side of the vertebral column, behind the peritoneum and below the diaphragm. They extend from the level of the 12th thoracic vertebra to the 3rd lumbar vertebra, receiving some protection from the lower rib cage. The right kidney is usually slightly lower than the left, probably because of the considerable space occupied by the liver .Kidneys are bean-shaped organs, about 11 cm long,6 cm wide, 3 cm thick and weigh 150 g. They are embedded in, and held in position by, a mass of fat. A sheath of fibro elastic renal fascia encloses the kidney and the renal fat.

Organs associated with the kidneys-

As the kidneys lie on either side of the vertebral column each is associated with a different group of structures.

Right kidney-

Superiorly — the right adrenal gland

Anteriorly —the right lobe of the liver, the duodenum and the hepatic flexure of the colon Posteriorly —the diaphragm, and muscles of the posterior abdominal wall

Left kidney-

Superiorly — the left adrenal gland

Anteriorly —the spleen, stomach, pancreas, jejunum and splenic flexure of the colon.

Posteriorly —the diaphragm and muscles

Gross structure of the kidney

There are three areas of tissue which can be distinguished when a longitudinal section of the kidney is viewed with the naked eye

- A fibrous capsule, surrounding the kidney
- The cortex, a reddish-brown layer of tissue immediately below the capsule and outside the pyramids
- the medulla, the innermost layer, consisting of pale conical-shaped striations, the renal pyramids.(See figure 9.2).

The hilum is the concave medial border of the kidney where the renal blood and lymph vessels, the ureter and nerves enter.

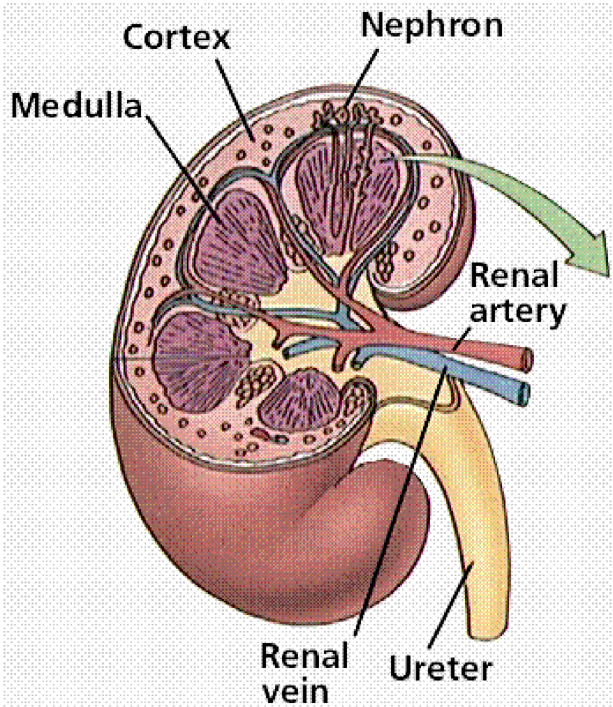


Figure: 9.2: Structure of kidney

The renal pelvis is the funnel-shaped structure which acts as a receptacle for the urine formed by the kidney.(See figure 9.3). It has a number of distal branches called calyces, each of which surrounds the apex of a renal pyramid. Urine formed in the kidney passes through a papilla at the apex of a pyramid into a minor calyx, then into a major calyx before passing through the pelvis into the ureter. The walls of the pelvis contain smooth muscle and are lined with transitional epithelium. Peristalsis of the smooth muscle originating in pacemaker cells in thewalls of the calyces propels urine through the pelvis and ureters to the bladder. This is an intrinsic property of the smooth muscle, and is not under nerve control.

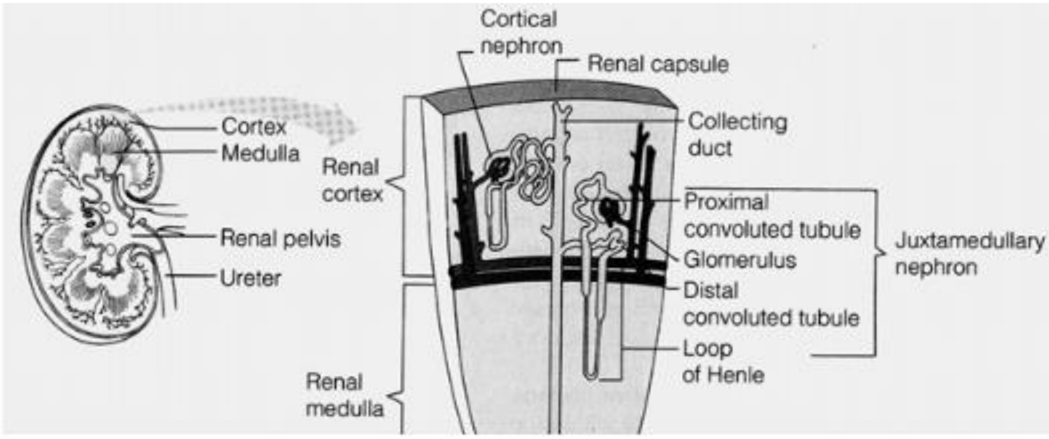


Figure 9.3: Internal Structure of Kidney

Microscopic structure of the kidney-

The kidney is composed of about 1 million functional units, the nephrons, and a smaller number of collecting tubules. The collecting tubules transport urine through the pyramids to the renal pelvis giving them their striped appearance. The tubules are supported by a small amount of connective tissue, containing blood vessels, nerves and lymph vessels.

The Nephron:

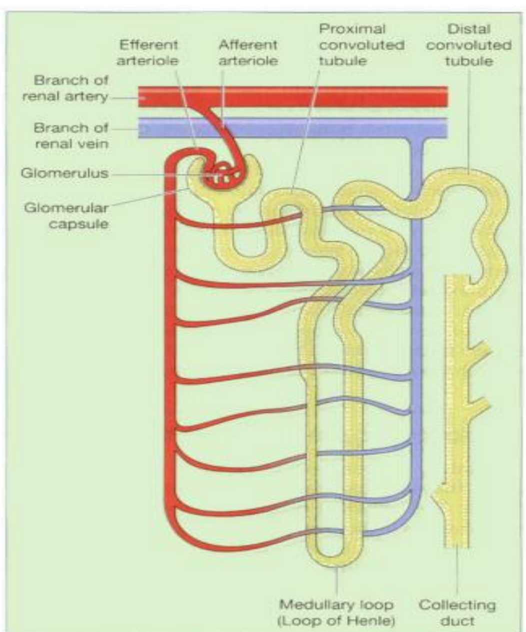


Figure: 9.4: Nephron and its associated structure

The nephron consists of a tubule closed at one end, the other end opening into a collecting tubule. (See figure 9.4). The closed or blind end is indented to form the cup-shaped glomerular capsule (Bowman's capsule) which almost completely encloses a network of arterial capillaries, the glomerulus. Continuing from the glomerular capsule the remainder of the nephron is about 3 cm long and is described in three parts:

- the proximal convoluted tubule
- the medullary loop (loop of Henle)
- the distal convoluted tubule, leading into a collecting duct.

Functions of the kidney

Formation of urine-The kidneys form urine which passes through the ureters to the bladder for storage prior to excretion. The composition of urine reflects the activities of the nephrons in the maintenance of homeostasis. Waste products of protein metabolism are excreted, electrolyte balance is maintained and the pH (acid-base balance) is maintained by the excretion of hydrogen ions. There are three processes involved in the formation of urine:

a. simple filtration
b. selective reabsorption
c. secretion.

9.1.b The Ureters-

Are the tubes that passes urine from the kidneys to the urinary bladder They are about 25 to 30 cm long with a diameter of about 3 mm .The ureter is continuous with the funnel-shaped renal pelvis. It passes downwards through the abdominal cavity ,behind the peritoneum in front of the psoas muscle into the pelvic cavity, and passes obliquely through the posterior wall of the bladder. Because of this arrangement, when urine accumulates and the pressure in the bladder rises, the ureters are compressed and the openings occluded. This prevents reflux of urine into the ureters (towards the kidneys) as the bladder fills and during micturition, when pressure increases as the muscular bladder wall contracts.

Structure

The ureters consist of three layers of tissue:

• an outer covering of fibrous tissue, continuous with the fibrous capsule of the kidney

• a middle muscular layer consisting of interlacing smooth muscle fibres that form a syncytium spiralling round the ureter, some in clockwise and some in anticlockwise directions and an additional outer longitudinal layer in the lower third area.

• an inner layer, the mucosa, lined with transitional epithelium.

Function of the ureters:

The ureters propel the urine from the kidneys into the bladder by peristaltic contraction of the smooth muscle layer. This is an intrinsic property of the smooth muscle and is not under autonomic nerve control. The waves of contraction originate in a pacemaker in the minor calyces. Peristaltic waves occur several times per minute, increasing in frequency with the volume of urine produced, and send little spurts of urine into the bladder.

9.1.c Urinary bladder -

The urinary bladder is a reservoir for urine. It lies in the pelvic cavity and its size and position vary, depending on the amount of urine it contains. When distended, the bladder rises into the abdominal cavity.

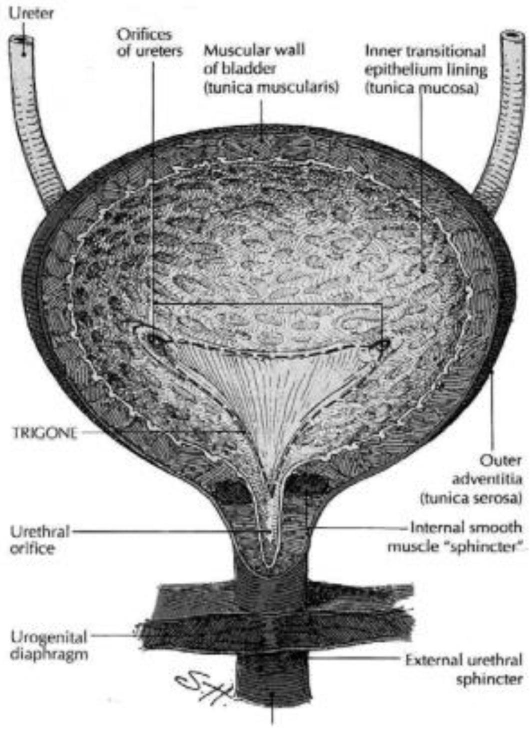


Figure: 9.5: Urinary Bladder and Urethra

Structure -

The bladder is roughly pear-shaped, but becomes more oval as it fills with urine. It has anterior, superior and posterior surfaces. The posterior surface is the base. The bladder opens into the urethra at its lowest point, the neck. The bladder wall is composed of three layers: the outer layer of loose connective tissue, containing blood and lymphatic vessels and nerves, covered on the upper surface by the peritoneum the middle layer, consisting of a mass of interlacing smooth muscle fibres and elastic tissue loosely arranged in three layers. This is called the detrusor muscle and it empties the bladder when it contracts the mucosa, lined with transitional epithelium. When the bladder is empty the inner lining is arranged in folds, or rugae, and these gradually disappear as the bladder fills.(See figure 9.5). The bladder is distensible but when it contains 300 to 400 ml the awareness of the desire to urinate is initiated. The total capacity is rarely more than about 600 ml.

The three orifices in the bladder wall form a triangle or trigone. The upper two orifices on the posterior wall are the openings of the ureters. The lower orifice is the point of origin of the urethra. Where the urethra commences is a thickening of the smooth muscle layer forming the internal urethra sphincter. This sphincter is not under voluntary control.

9.1.d.Urethra-

The urethra is a canal extending from the neck of the bladder to the exterior, at the external urethral orifice. Its length differs in the male and in the female. The male urethra is associated with the urinary and the reproductive systems,

The female urethra is approximately 4 cm long. It runs downwards and forwards behind the symphysis pubis and opens at the external urethral orifice just in front of the vagina. The external urethral orifice is guarded by the external urethral sphincter which is under voluntary control. Except during the passage of urine, the walls of the urethra are in close apposition.

The male urethra provides a common pathway for the flow of urine and semen, the combined secretions of the male reproductive organs. It is about 19 to 20 cm long and consists of three parts. The prostatic urethra originates at the urethral orifice of the bladder and passes through the prostate gland. The membranous urethra is the shortest and narrowest part and extends from the prostate gland to the bulb of the penis, after passing through the perineal membrane. The spongiose or penile urethra lies within the corpus spongiosum of the penis and terminates at the external urethral orifice in the glans penis.

9.2 Skin

Introduction-

The skin completely covers the body and is continuous with the membranes lining the body orifices. It:

- protects the underlying structures from injury and from invasion by microbes
- contains sensory (somatic) nerve endings of pain, temperature and touch
- is involved in the regulation of body temperature.
  - Structure - The skin has a surface area of about 1.5 to 2 M^2 in adults and it contains glands, hair and nails. There are two main layers:
    - epidermis
    - dermis.

Between the skin and underlying structures there is a layer of subcutaneous fat.

9.2. a Epidermis -

The epidermis is the most superficial layer of the skin and is composed of stratified keratinized squamous epithelium which varies in thickness in different parts of the body. It is thickest on the palms of the hands and soles of the feet. There are no blood vessels or nerve endings in the epidermis, but its deeper layers are bathed in interstitial fluid from the dermis, which provides oxygen and nutrients, and is drained away as lymph. There are several layers (strata) of cells in the epidermis which extend from the deepest germinative layer to the surface stratum corneum (a thick horny layer). The cells on the surface are flat, thin, non-nucleated, dead cells, or squames, in which the cytoplasm has been replaced by the fibrous protein keratin. These cells are constantly being rubbed off and replaced by cells which originated in the germinative layer and have undergone gradual change as they progressed towards the surface.Complete replacement of the epidermis takes about 40 days. Hairs, secretions from sebaceous glands and ducts of sweat glands pass through the epidermis to reach the surface.(See figure 9.6).

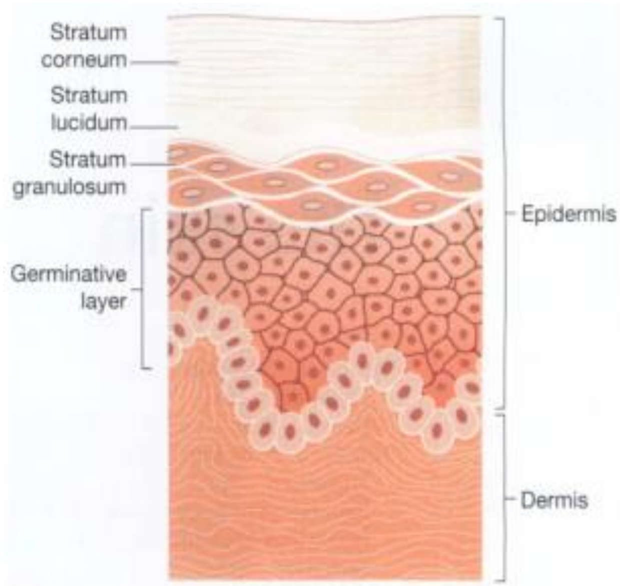


Figure: 9.6: Skin showing main layers of Epidermis

9.2.b. Dermis-

The dermis is tough and elastic. It is formed from connective tissue and the matrix contains collagen fibres interlaced with elastic fibres. Rupture of elastic fibres occurs when the skin is overstretched, resulting in permanent striae, or stretch marks, that may be found in pregnancy and obesity. Collagen fibres bind water and give the skin its tensile strength, but as this ability declines with age, wrinkles develop. Fibroblasts, macrophages and mast cells are the main cells found in the dermis. Underlying its deepest layer there is areolar tissue and varying amounts of adipose tissue (fat). (See figure 9.7).

The structures in the dermis are:

- blood vessels
- lymph vessels
- sensory (somatic) nerve endings
- sweat glands and their ducts
- hairs, arrector pili muscles and sebaceous glands.

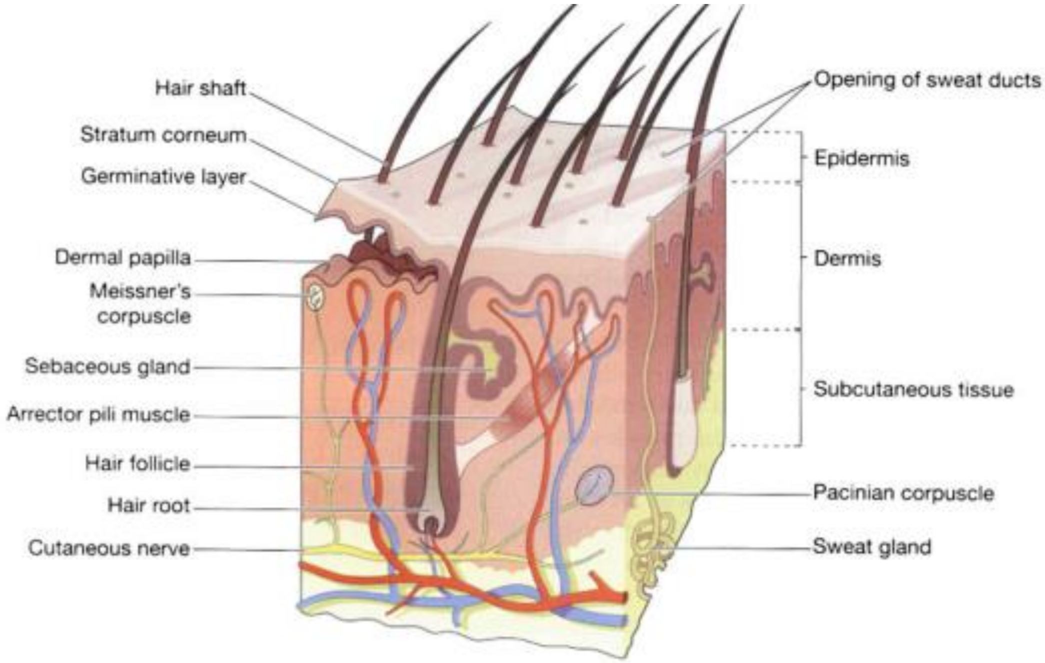


Figure: 9.7 Skin showing main structure of Dermis

Blood vessels.- Arterioles form a fine network with capillary branches supplying sweat glands, sebaceous glands, hair follicles and the dermis. The epidermis has no blood supply. It obtains nutrients and oxygen from interstitial fluid derived from blood vessels in the papillae of the dermis.

Lymph vessels-These form a network through out the dermis.

9.2.c.Function of the skin-

1. **Protection-**The skin forms a relatively waterproof layer that protects the deeper and more delicate structures. As an important on-specific defense mechanism it acts as a barrier against:

Invasion by microbes

- Chemicals
- Physical agents, e.g. mild trauma, ultraviolet light

- Dehydration.

2. **Regulation of body temperature-**Most of the heat loss from the body occurs through the skin. Only the heat lost through the skin can be regulated to maintain a constant body temperature. There is no control over heat lost by the other routes. Only the heat lost through the skin can be regulated to maintain a constant body temperature. There is no control over heat lost by the other route.

3. **Mechanisms of heat loss.**

o Evaporation: the body is cooled when heat is used to convert the water in sweat to water vapors.

o Radiation:exposed parts of the body radiate heat away from the body.

o Conduction:clothes and other objects in contact with the skin take up heat.

o Convection:, air passing over the exposed parts of the body is heated and rises, cool air replaces it and convection currents are set up. Heat is also lost from the clothes by convection.

4. **Activity of the sweat glands.** When the temperature of the body is increased by 0.25 to 0.5°C the sweat glands are stimulated to secrete sweat, which is conveyed to the surface of the body by ducts. When sweat droplets can be seen on the skin the rate of production is exceeding the rate of evaporation.

5. **Control of body temperature –when the** temperature rises the skin capillaries dilate and the extra blood near the surface increases heat loss by radiation, conduction and convection. The skin is warm and pink in color. When body temperature falls arteriolar constriction conserves heat and the skin is whiter and feels cool.

6. **Formation of vitamin D 7-dehydrocholesterol:** It is a lipid based substance in the skin and ultraviolet light from the sun converts it to vitaminD. This circulates in the blood and is used, with calcium and phosphate, in the formation and

maintenance of bone. Any vitamin D in excess of immediate requirements is stored in the liver.

7. **Sensation** -Sensory receptors consist of nerve endings in the dermis that are sensitive to touch, pressure, temperature or pain.Stimulation generates nerve impulses in sensory nerves that are transmitted to the cerebral cortex. Some areas have more sensory receptors than others causing them to be especially sensitive, e.g. the lips and fingertips.

8. **Absorption**-This property is limited but substances that can be absorbed include:

- some drugs, in transdermal patches, e.g. hormones used as replacement therapy in postmenopausal women, nicotine as an aid to stop smoking
- Some toxic chemicals, e.g. mercury.

9. **Excretion**-The skin is a minor excretory organ for some substances including:

- Sodium chloride in sweat and excess sweating may lead to abnormally low blood sodium levels
- Urea, especially when kidney function is impaired
- Aromatic substances, e.g. garlic and other spices.

Questions

1. Explain kidney with a wel-labelled diagram.
2. Write a note on urinary bladder.
3. Describe structure and functions of skin.

Assignments

1. Prepare a chart of urinary system.
2. Prepare a chart of layers of skin.
3. Prepare a chart of nephron.

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Lesson 10 Reproductive System

Objectives- At the end of the topic the students will –

a. Identify all parts of male and female reproductive system

b. **Explain all functions of the parts of male and female reproductive system**

Introduction-

This system deals with reproduction of a new human being. This system is divided into 2 parts.

10.1 FEMALE REPRODUCTIVE SYSTEM-

This system is made up of female reproductive organs.(See figure 10.1). The female reproductive organs, or genitalia, are divided into-

- .External organs(genitalia)
- .Internal organs.
- . Accessory organs

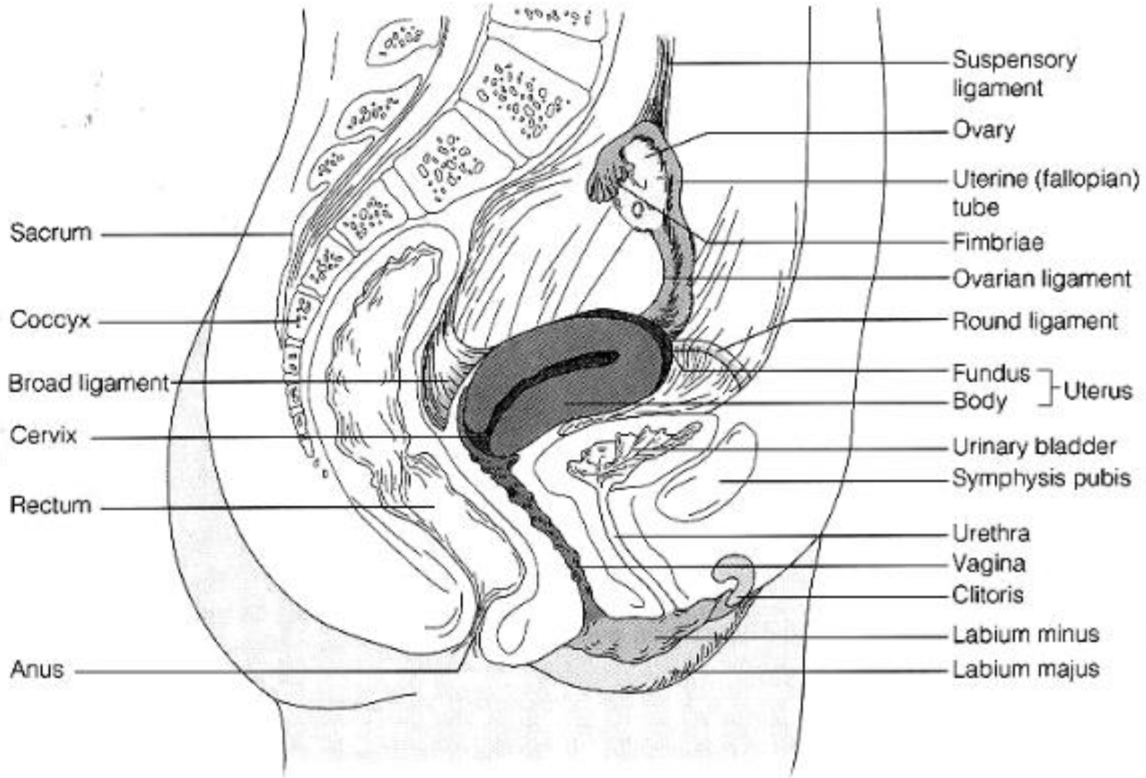

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Figure:10.1 Female Reproductive System

External genitalia-

The external genitalia,are known collectively as the vulva, and consist of the labia majora and labia minora, the clitoris, the vaginal orifice, the vestibule, the hymen and the vestibular glands (Bartholin's glands).(See figure 10.2).

10.1.a Labia Majora -

These are the two large folds which form the boundary of the vulva. They are composed of skin, fibrous tissue and fat and contain large numbers of sebaceous glands.

10.1.b Labia Minora-

These are two smaller folds of skin between the labia major a, containing numerous sebaceous glands.

10.1.c Clitoris-

The clitoris corresponds to the penis in the male and contains sensory nerve endings and erectile tissue but it has no reproductive significance

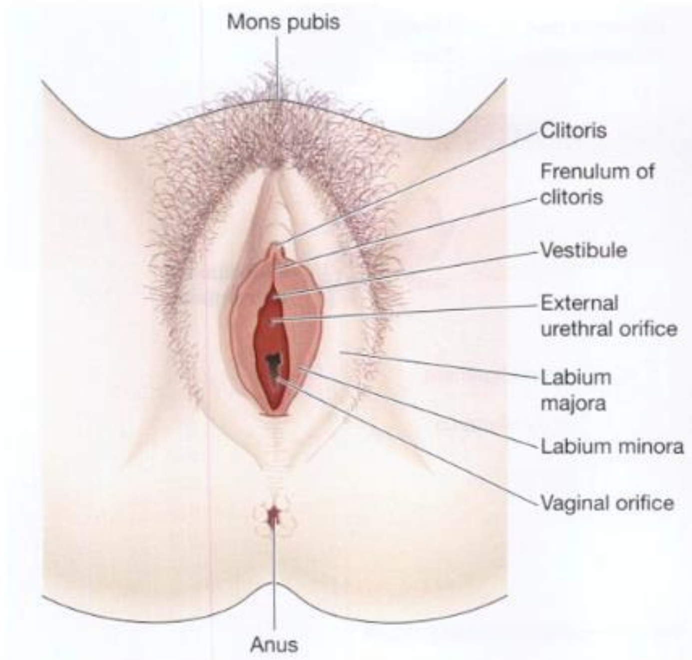

Figure: 10.2 Showing Female External Genitilia

.10.1.d Hymen-

The hymen is a thin layer of mucous membrane which partially occludes the opening of the vagina. It is normally incomplete to allow for passage of menstrual flow.

10.1.e Vestibular Glands -

The vestibular glands (Bartholin's glands) are situate done on each side near the vaginal opening. They are about the size of a small pea and have ducts, opening intothe vestibule immediately lateral to the attachment of the hymen.

Blood supply, lymph drainage and nerve supply-

The arterial supply- This is by branches from the internal pudendal arteries that branch from the internal iliac arteries and by external pudendal arteries that branch from the femoral arteries

The venous drainage- This forms a large plexus which eventually drains into the internal iliac veins.

Lymph drainage.-This is through the superficial inguinal nodes.

Nerve supply- This is by branches from pudendal nerves.

10.1.f Perineum -

The perineum is the area extending from the base of the labia minor a to the anal canal. It is roughly triangular and consists of connective tissue, muscle and fat. It gives attachment to the muscles of the pelvic floor.

Internal genitalia-

The internal organs of the female reproductive system lie in the pelvic cavity and consist of the vagina, uterus, two uterine tubes and two ovaries.(See figure 10.3).

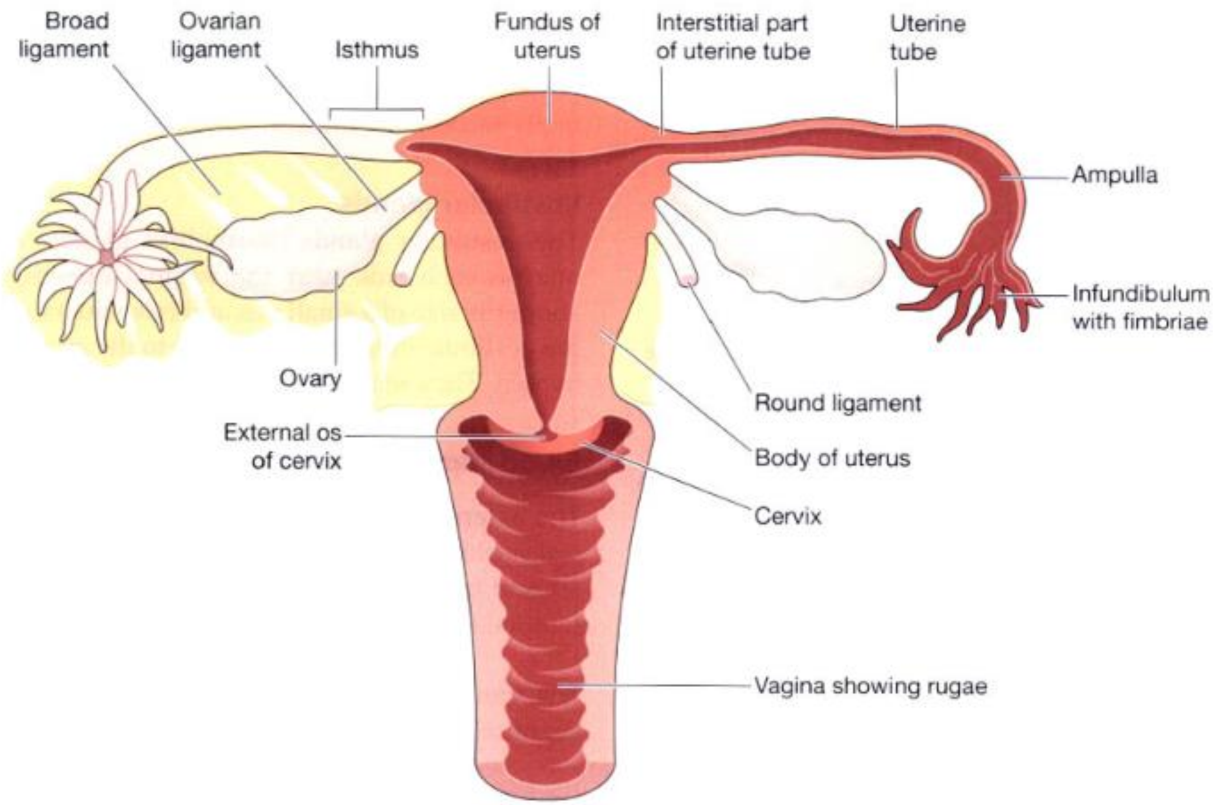

Figure:10.3: Showing the female reproductive organs in the pelvis

10.1.g Vagina-

The vagina is a fibromuscular tube lined with stratified squamous epithelium, connecting the external and internal organs of reproduction. It runs obliquely upwardsand backwards at an angle of about 45° between the bladder in front and rectum and anus behind. In the adult the anterior wall is about 7.5 cm (3 inches) long and the posteriorwall about 9 cm long. The difference is due to the angle of insertion of the cervix through the anterior wall.

Structure of the vagina:

It is moist by cervical secretions. Between puberty and the menopause, Lactobacillus acidophilus bacteria are normally present .The vagina has three layers: an outer covering of areolar tissue, which secrete lactic acid, maintaining the pH between 3.5-4.9, a middle layer of smooth muscle and an inner lining-tissue. The acidity inhibits the growth of microbes that may enter the vagina.

Blood supply, lymph drainage and nerve supply-

Arterial supply-

An arterial plexus is formed round the vagina, derived from the uterine and vaginal arteries which are branches of the internal iliac arteries.

Venous drainage –

A venous plexus, situated in the muscular wall, drains into the internal iliac veins.

Lymph drainage- This is through the deep and superficial iliac glands.

Nerve supply- This consists of parasympathetic fibres from the sacral outflow, sympathetic fibers from the lumbar out flow and somatic sensory fibres from the pudenda nerves.

Functions of the vagina-

The vagina acts as the receptacle for the penis during coitus, and provides an elastic passage way through which the baby passes during childbirth.

10.1.h Uterus -

The uterus is a hollow muscular pear-shaped organ, flattened antero posteriorly. It lies in the pelvic cavity between the urinary bladder and the rectum. It is about 7.5 cm long, 5 cm wide and its walls are about 2.5 cm thick. It weighs from 30 to 40 grams. (See figure 10.4).

The parts of the uterus are- .

The fundus- This is the dome-shaped part of the uterus above the openings of the uterine tubes.

The body- This is the main part. It is narrowest inferiorly at the internal os where it is continuous with the cervix.

The cervix ('neck' of the uterus)-This protrudes through the anterior wall of the vagina, opening into it at the external os.

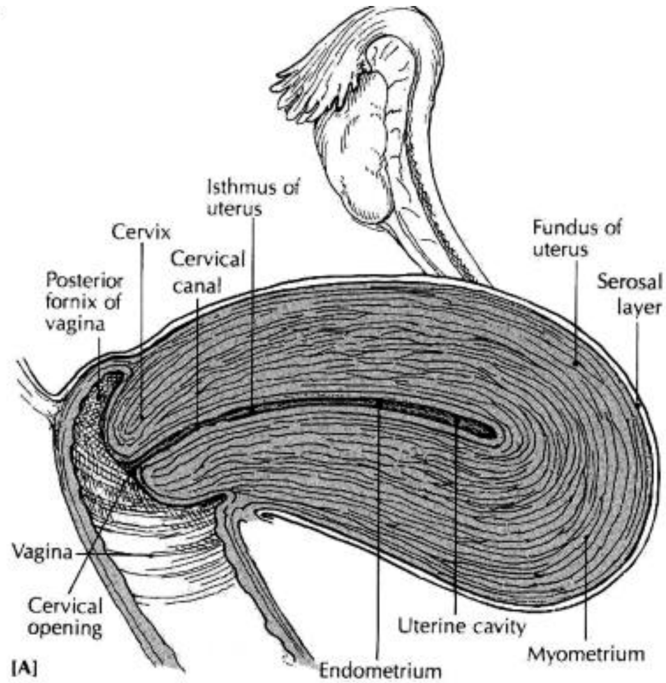

Figure:10.4 The Uterus

Structure of the uterus-

The walls of the uterus are composed of three layers of tissue:

Perimetrium-This is peritoneum, which is distributed differently on the various surfaces of the uterus.

Myometrium - This is the thickest layer of tissue in the uterine wall. It is a mass of smooth muscle fibers interlaced with areolar tissue, blood vessels and nerves.

Endometrium-This consists of columnar epithelium containing a large number of mucus-secreting tubular glands. It is divided functionally into two layers.

• The functional layer is the upper layer and it thickens and becomes rich in blood vessels in the first half of the menstrual cycle. If the ovum is not fertilised and does not implant, this layer is shed during menstruation.

• The basal layer lies next to the myometrium, and is not lost during menstruation. It is the layer from which the fresh functional layer is regenerated during each cycle.

Blood supply, lymph drainage and nerve supply-

The arterial supply- This is by the uterine arteries which are branches of the internal iliac arteries. They pass up the lateral aspects of the uterus between the two layers of the broad ligaments. They supply the uterus and uterine tubes and join with the ovarian arteries to supply the ovaries. Branches pass downwards to anastomose with the vaginal arteries to supply the vagina.

Venous drainage -The veins follow the same route as the arteries and eventually drain into the internal iliac veins.

Lymph drainage- There are deep and superficial lymphvessels which drain lymph from the uterus and the uterine tubes to the aortic lymph nodes and groups of nodes associated with the iliac blood vessels.

Nerve supply- The nerves supplying the uterus and the uterine tubes consist of parasympathetic fibres from the sacral outflow and sympathetic fibers from the lumbar outflow.

Functions of the uterus-After puberty, the endometrium of the uterus goes through a regular monthly cycle of changes, the menstrual cycle, which is under the control of hypothalamic and anterior pituitary hormones. The purpose of the cycle is to prepare the uterus to receive, nourish and protect a fertilized ovum. The cycle is usually regular, lasting between 26 and 30 days. If the ovum is not fertilized a new cycle begins with a short period of bleeding (menstruation).

If the ovum is fertilized the zygote embeds itself in the uterine wall. The uterine muscle grows to accommodate the developing baby, which is called an embryo during its first 8 weeks, and a fetus for the remainder of the pregnancy. Uterine secretions nourish the ovum before it implants in the endometrium, and after implantation the rapidly expanding ball of cells is nourished by the endometrial cells themselves. This is sufficient for only the first few weeks and the placenta is the organ that takes over thereafter. The placenta, which is attached to the fetus by the umbilical cord, is firmly attached to the wall of the uterus, and provides the means by which the growing baby receives oxygen and nutrients, and gets rid of its wastes. During pregnancy, which normally lasts about 40 weeks, the muscular walls of the uterus are prevented from contracting and expelling the baby early by high levels of the hormone progesterone secreted by the placenta. At the end of pregnancy (at term) the hormone oestrogen, which increases uterine contractility, becomes the predominant sex hormone in the blood. Additionally, oxytocin is released from the posterior pituitary, and also stimulates the uterine muscle. Control of oxytocin release is by positive feedback. During labour, the uterus forcefully expels the baby by means of powerful rhythmical contractions.

10.1.i Uterine tubes (Fallopion Tubes)

The uterine tubes are about 10 cm long and extend from the sides of the uterus between the body and the fundus. They lie in the upper free border of the broad ligament and their trumpet-shaped lateral ends penetrate the posterior wall, opening into the peritoneal cavity close to the ovaries. The end of each tube has finger-like projections called fimbriae. The longest of these is the ovarian fimbria which is in close association with the ovary.

Structure of the uterine tubes-The uterine tubes have an outer covering of peritoneum (broad ligament), middle layer of smooth muscle and are lined with ciliated epithelium.

Blood supply, lymph drainage and nerve supply-

It receives the same supply as the uterus.

Functions of the uterine tubes- The uterine tubes convey the ovum from the ovary to the uterus by peristalsis and ciliary movement. The mucus secreted by the lining membrane provides ideal conditions for movement of ova and spermatozoa.

Fertilization of the ovum usually takes place in the uterine tube, and the zygote is propelled into the uterus for implantation.

10.1.j Ovaries-

The ovaries are the female gonads, or glands, and they lie in a shallow fossa on the lateral walls of the pelvis. They are 2.5 to 3.5 cm long, 2 cm wide and 1cm thick. Each is attached to the upper part of the uterus by the ovarian ligament and to the back of the broad ligament by a broad band of tissue, the mesovarium. Blood vessels and nerves pass to the ovary through the mesovarium.

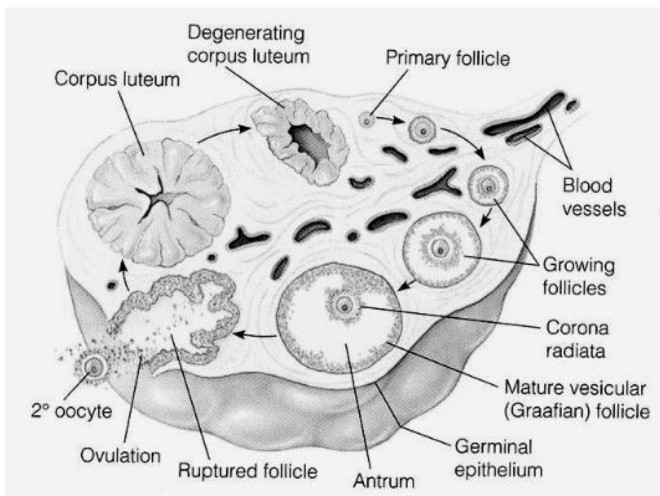

Figure: 10.5 The Ovary

Structure of the ovaries- The ovaries has two layers of tissue.

The medulla: This lies in the centre and consists of fibrous tissue, blood vessels and nerves.

The cortex: This surrounds the medulla. It has a framework of connective tissue, or stroma, covered by germinal epithelium. It contains ovarian follicles in various stages of maturity, each of which contains an ovum. Before puberty the ovaries are inactive but the stroma already contains immature (primordial) follicles, which the female has from birth. During the child bearing years, about every 28 days, one ovarian follicle (Grafian follicle) matures ruptures and releases its ovum into the peritoneal cavity. This is called ovulation and it occurs during most menstrual cycles.

Blood supply, lymph drainage and nerve supply-

Arterial supply-This is by the ovarian arteries, which branch from the abdominal aorta just below the renal arteries.

Venous drainage- This is into a plexus of veins behind the uterus from which the ovarian veins arise. The right ovarian vein opens into the inferior vena cava and the left into the left renal vein.

Lymph drainage. This is to the lateral aortic and preaortic lymph nodes. The lymph vessels follow the same route as the arteries.

Nerve supply. The ovaries are supplied by parasympathetic nerves from the sacral outflow and sympathetic nerves from the lumbar outflow. Their precise functions are not yet fully understood.

Functions of the ovaries- Maturation of the follicle is stimulated by follicle stimulating hormone (FSH) from the anterior pituitary, and estrogen secreted by the follicle lining cells. Ovulation is triggered by a surge of luteinising hormone (LH) from the anterior pituitary, which occurs a few hours before ovulation. After ovulation, the follicle lining cells develop into the corpus luteum (yellow body), under the influence of LH from the anterior pituitary. The corpus luteum produces the hormone progesterone and some oestrogen. If the ovum is fertilised it embeds itself in the wall of the uterus where it grows and develops and produces the hormone,human chorionic gonadotrophin (hCG), which stimulates the corpus luteum to continue secreting progesterone and oestrogen for the first 3 months of the pregnancy after which time this function is continued by the placenta. If the ovum is not fertilised the corpus luteum degenerates and a new cycle begins with menstruation. At the site of the degenerate corpus luteum an inactive mass of fibrous tissue forms, called the corpus albicans. Sometimes more than one follicle matures at a time, releasing two or more ova in the same cycle. When this happens and the ova are fertilized the result is a multiple pregnancy. These hormones control the development of female body characteristics, such as: development of sex organ and secondary sexual characters like, the menstrual cycle, development of breast , axillary and pubic hair, body shape, pregnancy,

Accessory glands –

10.1.k Breasts or Mammary glands –

The breasts or mammary glands are accessory glands of the female reproductive system. They exist also in the male but in only a rudimentary form.

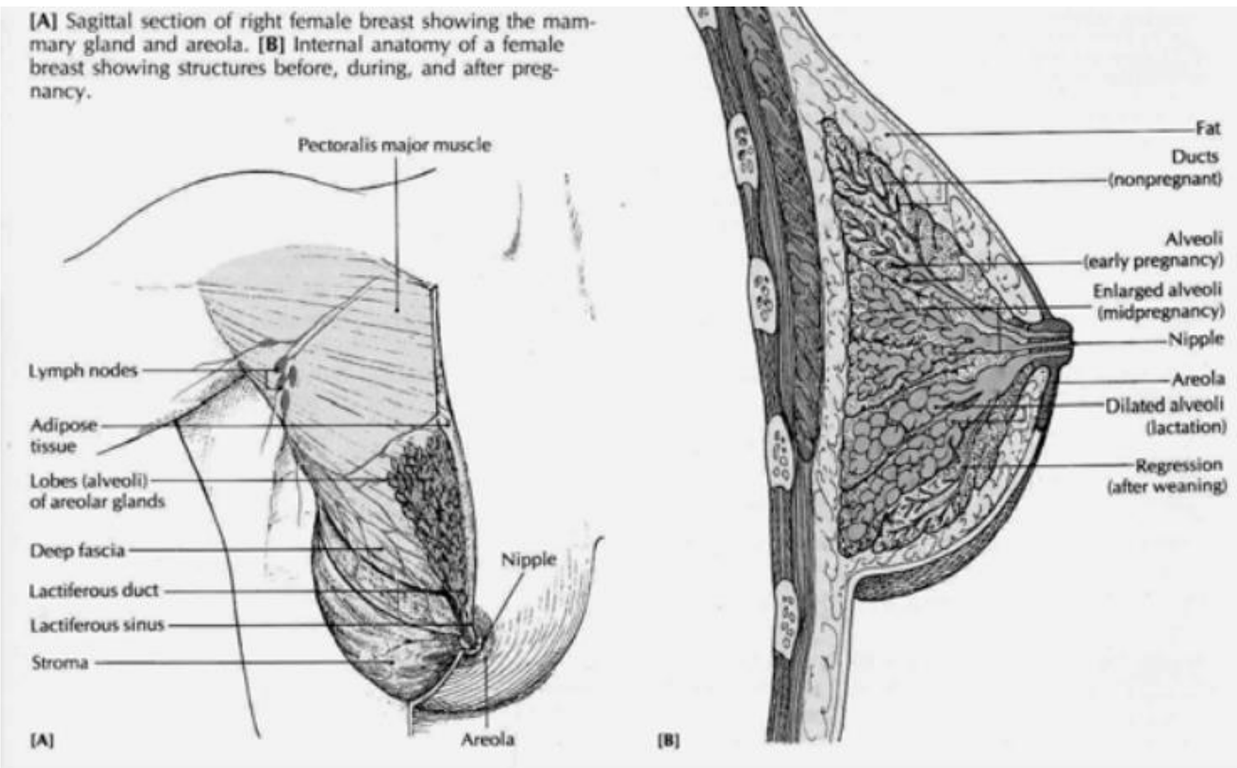

Figure: 10.6: Structure of the Breast

Structure of the breast-

The mammary glands consist of glandular tissue, fibrous tissue and fatty tissue. Each breast consists of about 20 lobes of glandular tissue, each lobe being made up of a number of lobules that radiate around the nipple. (See figure 10.6). The lobules consist of a cluster of alveoli which open into small ducts and these unite to form large excretory ducts, called lactiferous ducts. The lactiferous ducts converge towards the centre of the breast where they form dilatations or reservoirs for milk .Leading from each dilatation, or lactiferous sinus, is a narrow duct which opens on to the surface at the nipple. Fibrous tissue supports the glandular tissue and ducts, and fat covers the surface of the gland and is found between the lobes.

The nipple: This is a small conical eminence at the centre of the breast surrounded by a pigmented area, the areola. On the surface of the areola are numerous sebaceous glands (Montgomery's tubercles) which lubricate the nipple during lactation.

Blood supply, lymph drainage and nerve supply-

Arterial blood supply -The breasts are supplied with blood from the thoracic branches of the axillary arteries and from the internal mammary and intercostal arteries.

Venous drainage-This describes an anastomotic circle round the base of the nipple from which branches carry the venous blood to the circumference and end in the axillary and mammary veins.

Lymph drainage - This is mainly into the axillary lymph vessels and nodes. Lymph may drain through the internal mammary nodes if the superficial route is obstructed.

Nerve supply: The breasts are supplied by branches from the 4th, 5th and 6th thoracic nerves which contain sympathetic fibres. There are numerous somatic sensory nerve endings in the breast especially around the nipple. When these touch receptors are stimulated by sucking, impulses pass to the hypothalamus and the flow of the hormone oxytocin is increased, promoting the release of milk.

Function of the breast- The mammary glands are only active during late pregnancy and after the birth of a baby when they produce milk (lactation). Lactation is stimulated by the hormone prolactin.

10.2. MALE REPRODUCTIVE SYSTEM-

The male reproductive system consists of the following organs-(See figure 10.7).

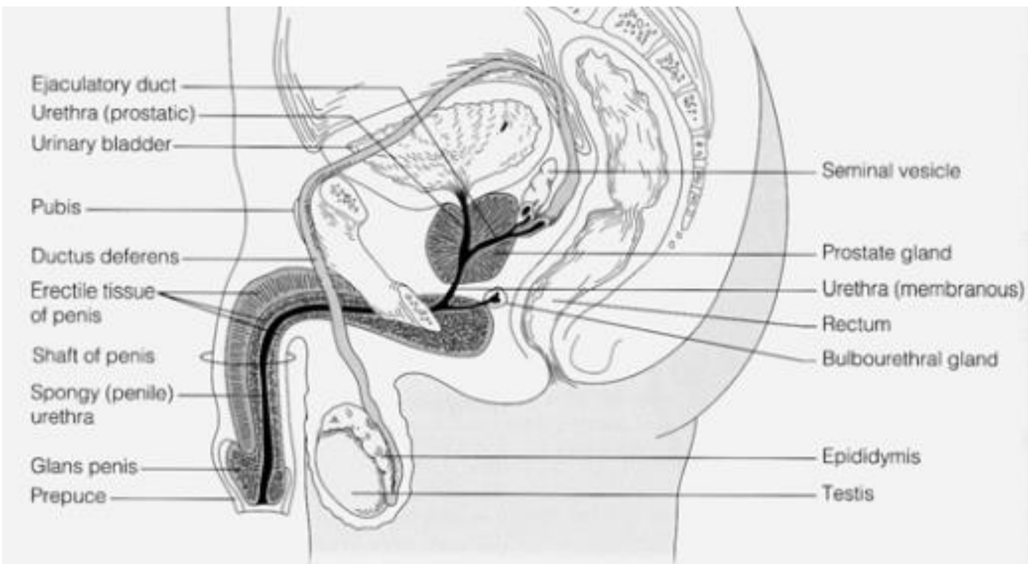

Figure: 10.7: Male Reproductive System

10.2.a Scrotum -

The scrotum is a pouch of deeply pigmented skin, fibrous and connective tissue and smooth muscle. It is divided into two compartments each of which contains one testis one epididymis and the testicular end of a spermatic cord. It lies below the symphysis pubis, in front of the upper parts of the thighs and behind the penis.

10.2.b Testes

The testes are the reproductive glands of the male and are the equivalent of the ovaries in the female. They are about 4.5 cm long, 2.5 cm wide and 3cm thick and are suspended in the scrotum by the spermatic cords. They are surrounded by three layers of tissue.(See figure 10.8).

The tunica vaginalis- This is a double membrane, forming the outer covering of the testes, and is a down growth of the abdominal and pelvic peritoneum.

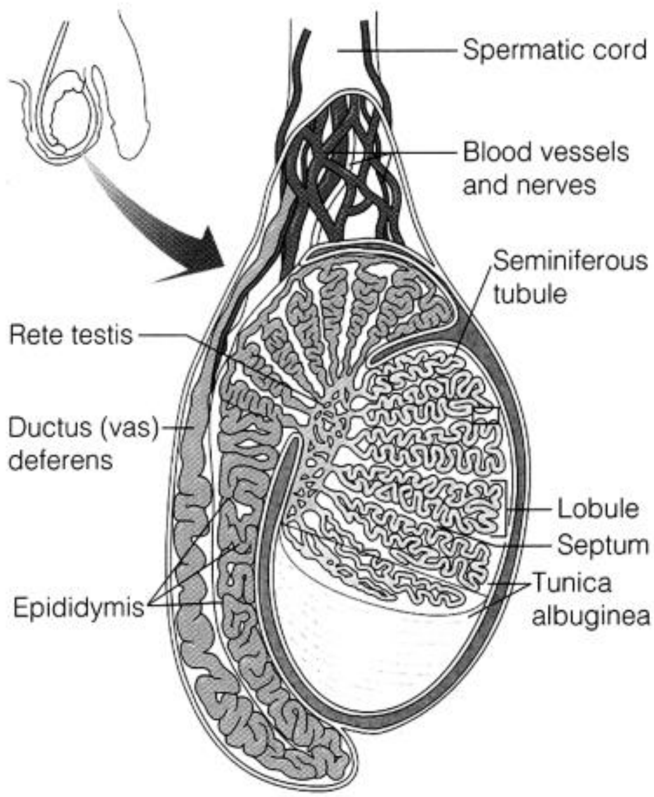

Figure:10.8: The Testes

The tunica albuginea- This is a fibrous covering beneath the tunica vaginalis that surrounds the testes. Ingrowths form septa dividing the glandular structure of the testes into lobules.

The tunica vasculosa- This consists of a network of capillaries supported by delicate connective tissue.

Structure of the testes-

In each testis are 200 to 300 lobules and within each lobule are 1 to 4 convoluted loops composed of germinal epithelial cells, called seminiferous tubules. Between the tubules there are groups of interstitial cells (of Ley dig) that secrete the hormone testosterone after puberty. At the upper pole of the testis the tubules combine to form a single tubule. This tubule, about 6 m in its full length, is repeatedly folded and tightly packed into a mass called the epididymis. It leaves the scrotum as the deferent duct(vas deferens) in the spermatic cord. Blood and lymph vessels pass to the testes in the spermatic cords.

Functions of the testes-

1. Spermatogenesis **-**

Spermatozoa (sperm) are produced in the seminiferous tubules of the testes, and mature as they pass through the long and convoluted epididymis, where they are stored. The hormone controlling sperm production is FSH from the anterior pituitary. A mature sperm has a head, a body, and a long whip-like tail that is used for motility. The head is almost completely filled by the nucleus, containing its DNA.(See figure 10.9).

2. Secretion of hormone – The testis secretes the hormone called testosterone , this hormone helps in development and maintenance of sex organs and secondary sexual characters like hoarseness of voice , beard and moustache, masculine features etc.

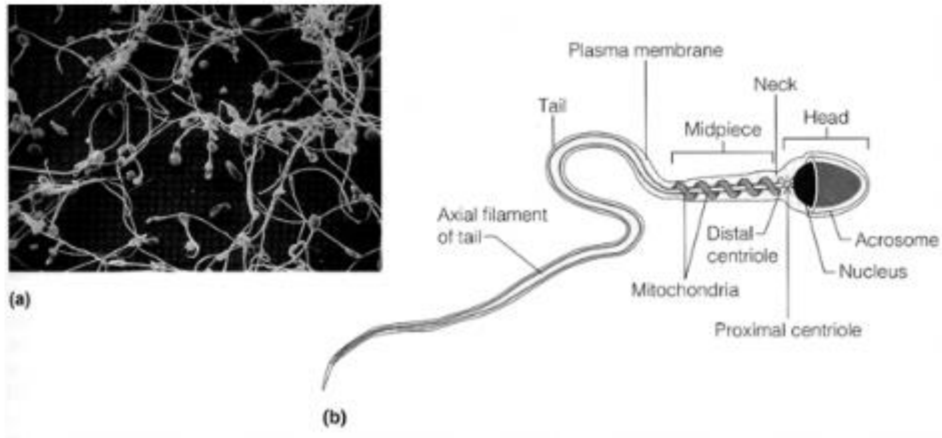

Figure: 10.9: Sperm

10.2.c Epididymis:

The epididymis is a long, coiled tube that rests on the backside of each testicle. It transports and stores sperm cells that are produced in the testes. It is the job of the epididymis to bring the sperm to maturity, since the sperm that emerge from the testes are immature and incapable of fertilization. During sexual arousal, contractions force the sperm into the vas deferens.

10.2.d Vas deferens:

The vas deferens is a long, muscular tube that travels from the epididymis into the pelvic cavity, to just behind the bladder. The vas deferens transports mature sperm to the urethra, the tube that carries urine or sperm to outside of the body, in preparation for ejaculation.

10.2.e The Spermatic cords -

The spermatic cords suspend the testes in the scrotum. Each cord contains a testicular artery, testicular veins, lymphatic, a deferent duct and testicular nerves, which come together to form the cord from their various origins in the abdomen. The cord, which is covered in a sheath of smooth muscle and connective and fibrous tissues, extends through the inguinal canal and is attached to the testis on the posterior wall.

The testicular artery: This branches from the abdominal aorta, just below the renal arteries.

The testicular vein: This passes into the abdominal cavity. The left vein opens into the left renal vein and the right into the inferior vena cava.

Lymph drainage: This is through lymph nodes around the aorta.

The deferent duct: This is some 45 cm long. It passes upwards from the testis through the inguinal canal and ascends medially towards the posterior wall of the bladder where it is joined by the duct from the seminal vesicle to form the ejaculatory duct.

The nerve supply: This is provided by branches from the 10^{th} and $l1^{th}$thoracic nerves.

10.2.f Seminal vesicles –

The seminal vesicles are two small fibromuscular pouches lined with columnar epithelium, lying on the posterior aspect of the bladder.At its lower end each seminal vesicle opens into a short duct which joins with the corresponding deferent duct to form an ejaculatory duct. (See figure 10.10)

Functions of the seminal vesicles-

The seminal vesicles contract and expel their stored contents, seminal fluid, during ejaculation. Seminal fluid, which forms 60% of the bulk of the fluid ejaculated at male orgasm, contains nutrients to support the sperm during their journey through the female reproductive tract.

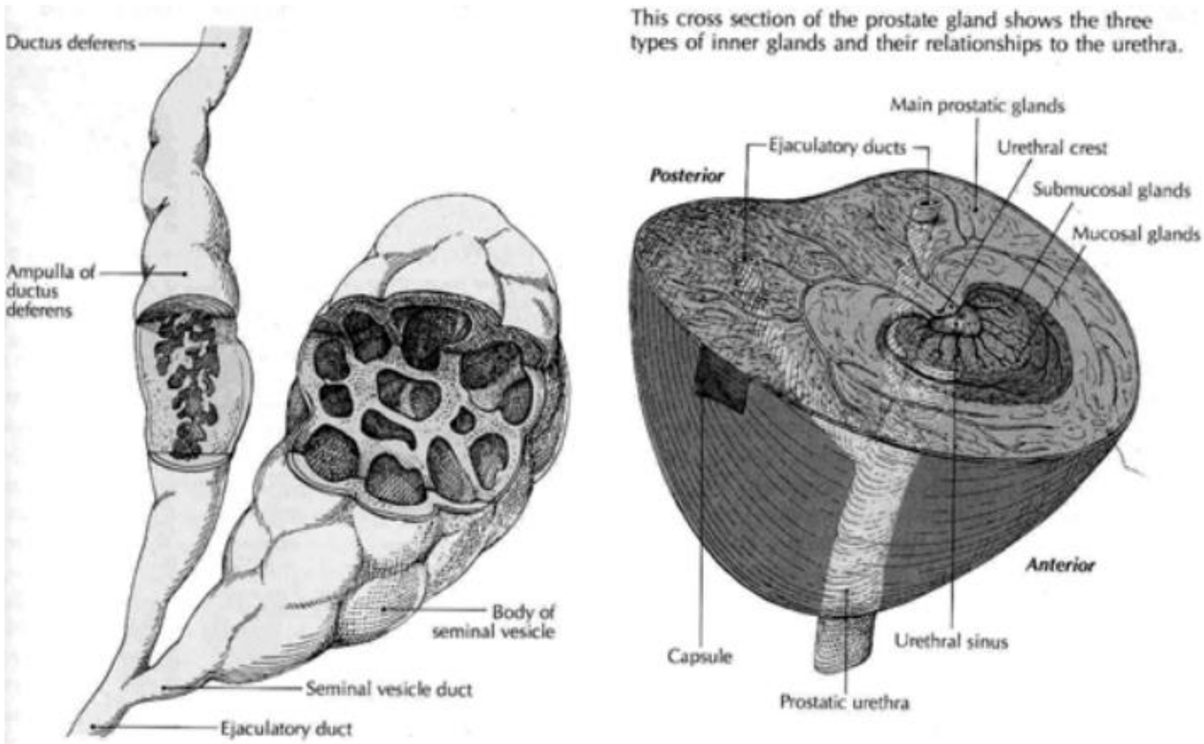

Figure: 10.10: Seminal vesicles and the prostate gland

10.2.g Ejaculatory ducts –

The ejaculatory ducts are two tubes about 2 cm long, each formed by the union of the duct from a seminal vesicle and a deferent duct. They pass through the prostate gland and join the prostatic urethra, carrying seminal fluid and spermatozoa to the urethra .The ejaculatory ducts are composed of the same layers of tissue as the seminal vesicles.

10.2.h Prostate gland –

The prostate gland lies in the pelvic cavity in front of the rectum and behind the symphysis pubis, surrounding the first part of the urethra. It consists of an outer fibrous covering, a layer of smooth muscle and glandular substance composed of columnar epithelial cells.(See figure 10.11)

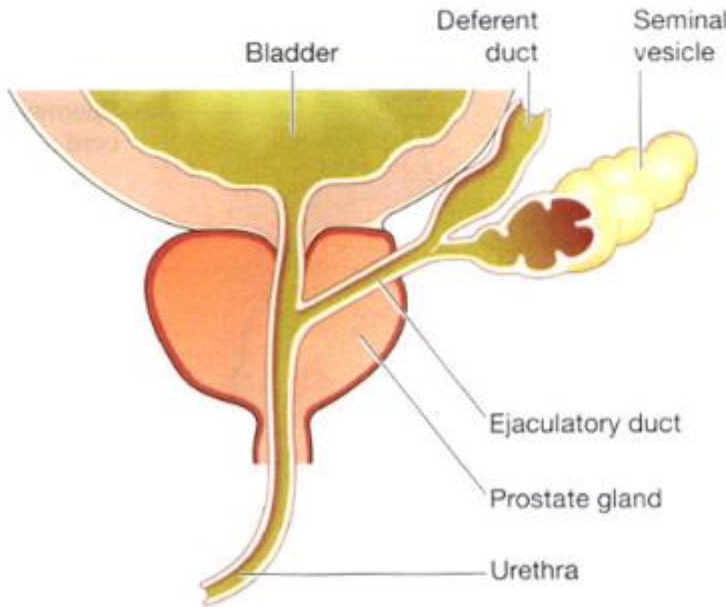

Figure: 10.11: Section of the prostate gland and associated reproductive structures on one side.

Functions of the prostate gland-

The prostate gland secretes a thin, milky fluid that makes up about 30% of semen, and gives it its milky appearance. It is slightly alkaline, which provides a protective local environment for sperm arriving in the acidic vagina. It also contains a clotting enzyme, which thickens the semen in the vagina, increasing the likelihood of semen being retained in the vicinity of the cervix.

10.2.i Urethra –

The male urethra provides a common pathway for the flow of urine and semen, the combined secretions of the male reproductive organs. It is about 19 to 20 cm long and consists of three parts. The prostatic urethra originates at the urethral orifice of the bladder and passes through the prostate gland. The membranous urethra is the shorter stand narrowest part and extends from the prostate gland to the bulb of the penis, after passing through the perineal membrane. The spongiose or penile urethra lies within the corpus spongiosum of the penis and terminates at the external urethral orifice in the glans penis.

There are two urethral sphincters. The internal sphincter consists of smooth muscle fibres at the neck of the bladder above the prostate gland. The external sphincter consists of skeletal muscle fibres surrounding the membranous part.

10.2.j Penis

The penis has a root and a body. The root lies in the perineum and the body surrounds the urethra. It is formed by three cylindrical masses of erectile tissue and involuntary muscle. The erectile tissue is supported by, (See figure 10.12),

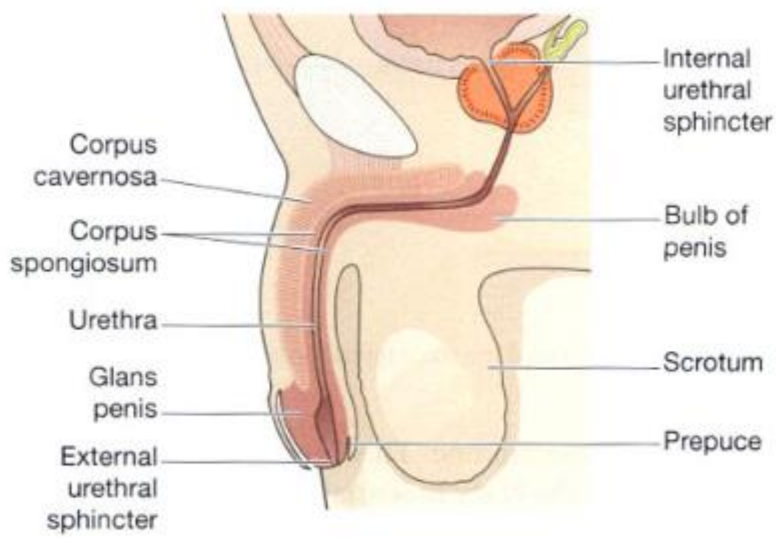

Figure: 10.12: The Penis

the two lateral columns are called the corpora cavernosa and the column between them, containing the urethra, is the corpus spongiosum. At its tip it is expanded into a triangular structure known as the glans penis. Just above the glans the skin is folded upon itself and forms a movable double layer, the foreskin or prepuce. Arterial blood is supplied by deep, dorsal and bulbar arteries of the penis which are branches from the internal pudendal arteries.A series of veins drain blood to the internal pudendal and internal iliac veins. The penis is supplied by autonomic and somatic nerves. Parasympathetic stimulation leads to filling of the spongy erectile tissue with blood, caused by arteriolar dilatation and venoconstriction, which increases blood flow into the penis and obstructs outflow. The penis therefore becomes engorged and erect, an essential prerequisite for coitus to occur. Fibrous tissue and covered with skin and has a rich blood supply.

1. Menstrual cycle
2. Puberty
3. Pregnancy
4. Fertilization

Questions

1. Name parts and functions of male reproductive system
2. Name parts and functions of female reproductive system
3. Explain structure of testis with cross section.
4. Explain structure of ovaries with cross section.

Assignments

1. Prepare a chart of male reproductive system.
2. Prepare a chart of female reproductive.

****

Lesson 11- Endocrine system

Objectives- At the end of the topic student will able to-

a. Define endocrine glands

b. Will know names of different endocrine glands and their hormones.

c. **Will explain function and significance of all these hormones.**

Introduction-

The endocrine system consists of glands widely separated from each other with no direct anatomical links. Homeostasis of the internal environment is maintained partly by the autonomic nervous system and partly by the endocrine system. They secrete chemical substances called hormones. A hormone is formed in one organ or gland and carried in the blood to another organ (target organ or tissue),probably quite distant, where it influences cellular activity, especially growth and metabolism. Most hormones are synthesized from amino acids (amines, polypeptides and proteins; see p. 23) or are cholesterol-based lipid (steroids). The ovaries and the testes secrete hormones associated with the reproductive system after puberty.

11.1 Endocrine glands-

Definition- Endocrine glands consist of groups of secretory cells surrounded by an extensive network of capillaries which facilitates diffusion of hormones (chemical messengers) from the secretory cells into the bloodstream. (See figure 11.1)

They are commonly referred to as the ductless glands because the hormones are secreted and diffuse directly into the bloodstream. The endocrine system consists of a number of distinct glands and some tissues in other organs. Although the hypothalamus is classified as a part of the brain and not as an endocrine gland it controls the pituitary gland and has an indirect effect on many others, in other words, the pituitary gland (hypophysis) and the hypothalamus act as a unit, regulating the activity of most of the other endocrine glands.

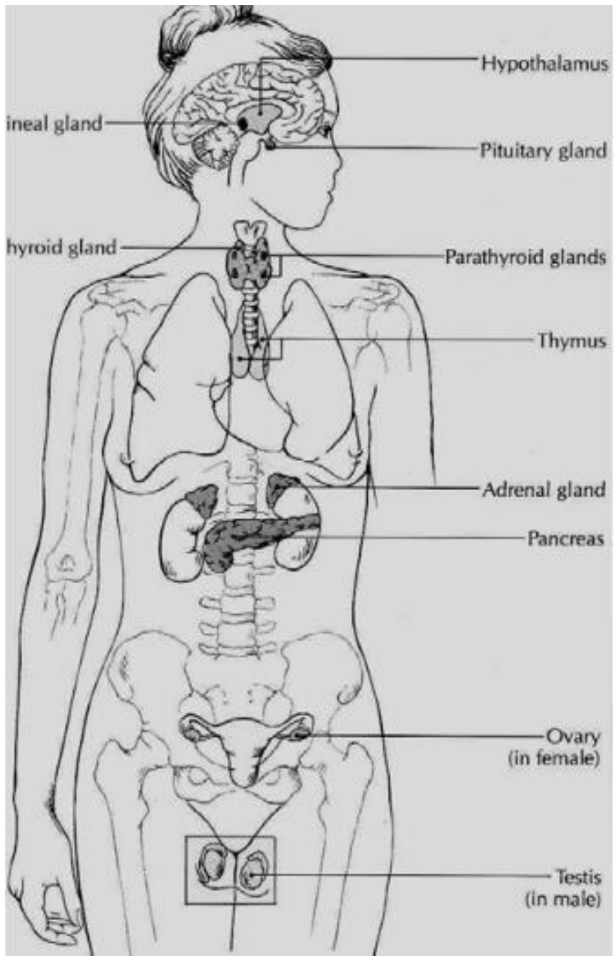

Figure: 11.1:Glands of Endocrine System

The endocrine glands are:

1. Pituitary gland- 1
2. Thyroid gland- 1
3. Parathyroid glands -2pairs
4. Adrenal (suprarenal) glands-2
5. The pancreas- 1(mixed gland)

6. Pineal gland or body-1
7. Thymus gland-1
8. Ovaries in the female-2
9. Testes in the male-2

11.1.a Pituitary gland–

The pituitary gland lies in the hypophyseal fossa of the sphenoid bone below the hypothalamus ,to which it is attached by a stalk. It is the size of a pea, weighs about 500 mg and consists of three distinct parts that originate from different types of cells. (See figure 11.2)

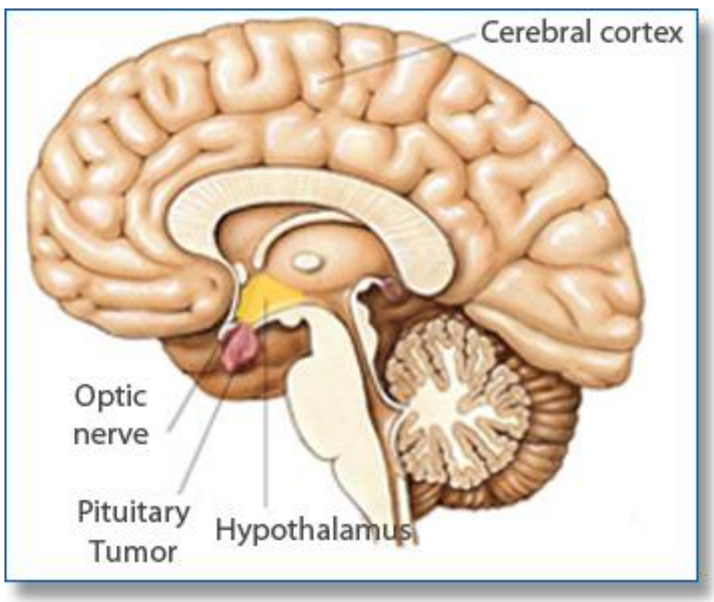

Figure:11.2:Pituitary Gland

The Anteriorpituitary – (adenohypophysis) is an up growth of glandular epithelium from the pharynx. This is supplied indirectly with arterial blood that has already passed through a capillary bed in the hypothalamus. This network of blood vessels forms part of the pituitary portal system, which transports blood from the hypothalamus to the anterior pituitary where it enters thin-walled vascular sinusoids and is in very close contact with the secretory cells. As well as providing oxygen and nutrients, this blood transports releasing and inhibiting hormones secreted by the hypothalamus. These hormones influence secretion and release of other hormones formed in the anteriorpituitary.

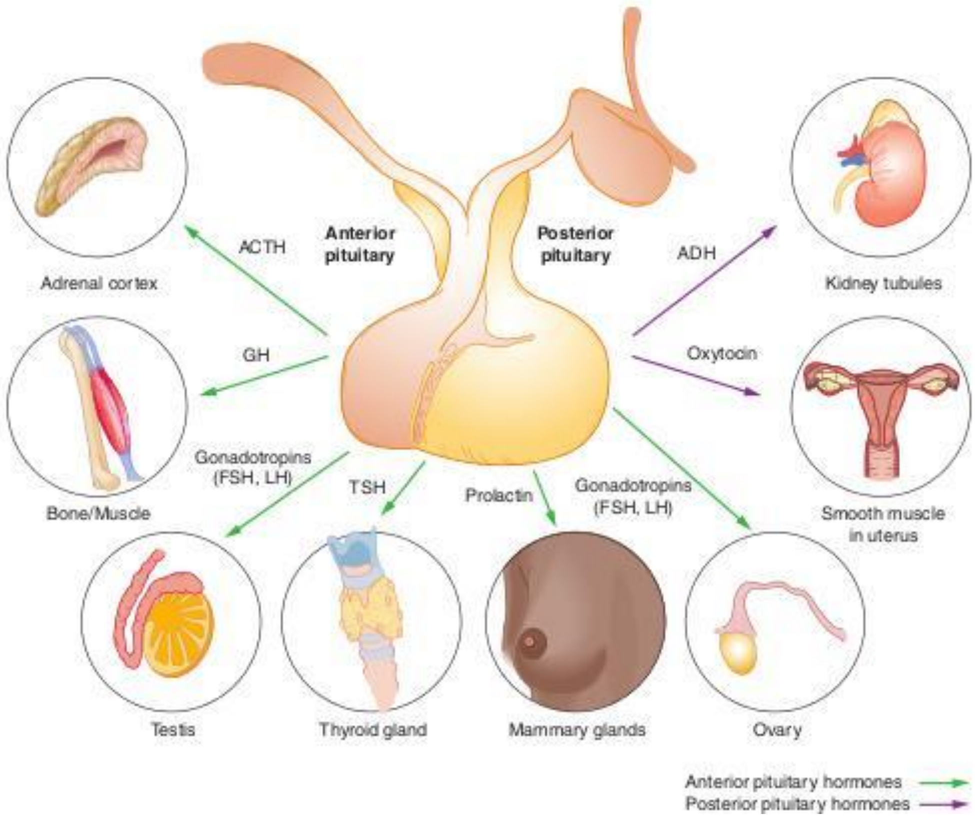

Figure: 11.3: Pituitary Gland secreting various hormones

Its hormones are as follows-(See figure 11.3)

Growth hormone (GH) –

This is the most abundant hormone synthesized by the anterior pituitary. It stimulates growth and division of most body cells but especially those in the bones and skeletal muscles. It also regulates aspects of metabolism in many organs, e.g. liver, intestines and pancreas; stimulates protein synthesis; promotes breakdown of fats; and increases blood glucose levels. Its release is stimulated by growth hormone releasing hormone (GHRH) and suppressed by growth hormone release inhibiting hormone (GHRIH) both of which are secreted by the hypothalamus. Secretion of GH is greater at night during sleep although hypoglycaemia, exercise and anxiety also stimulate release. The daily amount secreted peaks in adolescence and then declines with age.

Thyroid stimulating hormone (TSH)–

This hormone is synthesized by the anterior pituitary and its release is stimulated by TRH (Thyroid Releasing Hormone) from the hypothalamus. It stimulates growth and activity of the thyroid gland,which secretes the hormones thyroxine(T4) and triiodothyronine(T3). Release is lowest in the early evening and highest during the night.

Adrenocorticotrophic hormone (corticotrophin,ACTH)-

Corticotrophin releasing hormone (CRH) from the hypothalamus promotes the synthesis and release of ACTH by the anterior pituitary. This increases the concentration of cholesterol and steroids within the adrenal cortex and the output of steroid hormones, especially cortisol. ACTH levels are highest at about 8 a.m. and fall to their lowest about midnight, although high levels sometimes occur at midday and 6 p.m.

Prolactin-

This hormone stimulates lactation (milk production) and has a direct effect on the breasts immediately after parturition (childbirth). The blood level of prolactin is stimulated by prolactin releasing hormone (PRH) released from the hypothalamus and it is lowered by prolactin inhibiting hormone (PIH, dopamine) and by an increased blood level of prolactin.

Gonadotrophins–

After puberty two gonadotrophins (sex hormones) are secreted by the anterior pituitary in response to luteinizing hormone releasing hormone (LHRH), also known as gonadotrophin releasing hormone (GnRH). In both males and females these are:

• follicle stimulating hormone (FSH)

• luteinising hormone (LH).

In both sexes: FSH stimulates production of gametes(ova or spermatozoa).

In females: LH and FSH are involved in secretion of the hormones oestrogen and progesterone during the menstrual Cycle

In males: LH, also called interstitial cell stimulating hormone (ICSH) stimulates the interstitial cells of the testes to secrete the hormone testosterone

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11.1.b The Posterior pituitary (Neurohypophysis) -

It is a downward growth of nervous tissue from the brain. There is a network of nerve fibers between the hypothalamus and the posterior pituitary. This is formed from nervous tissue and consists of nerve cells surrounded by supporting cells called pituicytes. Posterior pituitary hormones are synthesized in the nerve cell bodies, transported along the axons and then stored in vesicles within the axon terminals. These hormones act directly on non-endocrine tissue and their release by exocytosis is stimulated by nerve impulses from the hypothalamus

The hormones of posterior pituitary are as follows-

- Oxytocin–

Oxytocin stimulates two target tissues during and after parturition (childbirth): uterine smooth muscle and the muscle cells of the lactating breast. During parturition increasing amounts of oxytocin are released by the posterior pituitary into the bloodstream in response to increasing distension of sensory stretch receptors in the uterine cervix by the baby's head. Sensory impulses are generated and travel to the control centre in the hypothalamus, stimulating the posterior pituitary to release more oxytocin. In turn this stimulates more forceful uterine contractions and greater stretching of the uterine cervix as the baby's head is forced further downwards.

Suckling generates sensory impulses that are transmitted from the breast to the hypothalamus. The impulses trigger the release of oxytocin from the posterior pituitary and oxytocin stimulates contraction of the myoepithelial cells around the glandular cells and ducts of the lactating breast to contract, ejecting milk.

-Antidiuretic hormone (ADH or vasopressin)

The main effect of antidiuretic hormone is to reduce urine output (diuresis is the production of a large volume of urine). ADH increases the permeability to water of the distal convoluted and collecting tubules of the nephrons of the kidneys. As a result the reabsorption of water from the glomerular filtrate is increased.

11.1.cIntermediate lobe-Between these Anterior & Posterior lobes there is a thin strip of tissue called the intermediate lobe and its function in humans is not known.

Blood supply-

Arterial blood: This is supplied by branches from the internal carotid artery. The anterior lobe is supplied indirectly by blood that has already passed through a capillary bed in the hypothalamus but the posterior lobe is supplied directly.

Venous blood:

This comes from both lobes, containing hormones, and leaves the gland in short veins that enter the venous sinuses between the layers of dura mater.

11.2. Thyroid gland-

The thyroid gland is situated in the neck in front of the larynx and trachea at the level of the 5th, 6th and 7th cervical and 1st thoracic vertebrae. It is a highly vascular gland that weighs about 25 g and is surrounded by a fibrous capsule. It resembles a butterfly in shape, consisting of two lobes, one on either side of the thyroid cartilage and upper cartilaginous rings of the trachea. The lobes are joined by a narrow isthmus, lying in front of the trachea.The lobes are roughly cone-shaped, about 5 cm long and 3 cm wide.

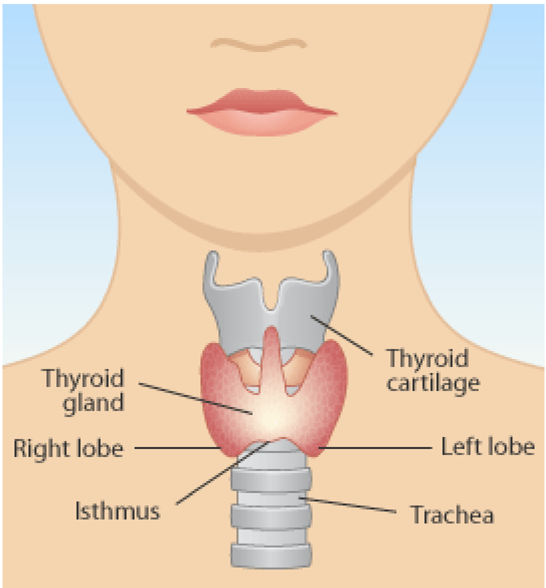


Figure: 11.4: Thyroid Gland

The thyroid secretes following hormones-

- Tri-iodothyronin (T3)
- Thyroxin(T4)
- Calcitonin

Blood supply-

Arterial supply-to the gland is through the superior and inferior thyroid arteries. The superior thyroid artery is a branch of the external carotid artery and the inferior thyroid artery is a branch of the subclavian artery.

Venous supply-is by the thyroid veins which drain into the internal jugular veins The thyroid hormones are synthesized as large precursor molecules called thyroglobulin, the major constituent of colloid. The release of T3 and T4 into the blood is regulated by thyroid stimulating hormone (TSH) from the anterior pituitary.

Functions-

Thyroid hormones enter the target cells and regulate the expression of genes in the nucleus, i.e. they increase or decrease the synthesis of some proteins including enzymes. They combine with specific receptor sites and enhance the effects of other hormones, e.g. adrenaline and noradrenalin.T3 and T4 affect most cells of the body by:

• increasing the basal metabolic rate and heat production

• regulating metabolism of carbohydrates, proteins and fats.

T3 and T4 are essential for normal growth and development especially of the skeleton and nervous system.

Most other organs and systems are also influenced by thyroid hormones — physiological effects of T3 and T4 on the heart, skeletal muscles, skin, digestive and reproductive systems

Calcitonin- This hormone is secreted by the parafollicular or C-cells in the thyroid gland. It acts on bone and the kidneys to reduce the blood calcium (Ca^{2+}) level when it is raised. It reduces the re absorption of calcium from bones and inhibits reabsorption of calcium by the renal tubules. This hormone is important during childhood when bones undergo considerable changes in size and shape.

11.3 Parathyroid glands-

There are four small parathyroid glands; two embedded in the posterior surface of each lobe of the thyroid gland .They are surrounded by fine connective tissue capsules. (See figure 11.5). The cells forming the glands are spherical in shape and are arranged in columns with channels containing blood between them.

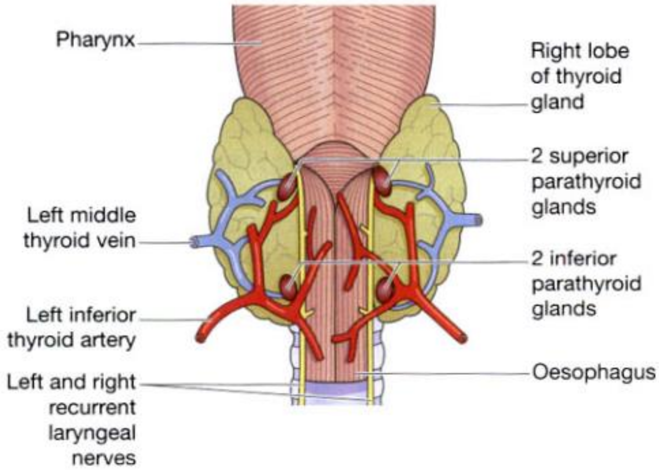


Figure:11.5 Parathyroid Gland and associated structures

Functions-The parathyroid glands secrete parathyroid hormone (PTH, parathormone). Secretion is regulated by the blood level of calcium. When this falls, secretion of PTH is increased and vice versa.

The main function of PTH is to increase the blood calcium level when it is low. This is achieved by indirectly increasing the amount of calcium absorbed from the small intestine and reabsorbed from the renal tubules. If these sources provide inadequate supplies then PTH stimulates osteoclasts (bone-destroying cells) and resorption of calcium from bones. Parathormone and calcitonin from the thyroid gland act in a complementary manner to maintain blood calcium levels within the normal range. This is needed for:

• Muscle contraction

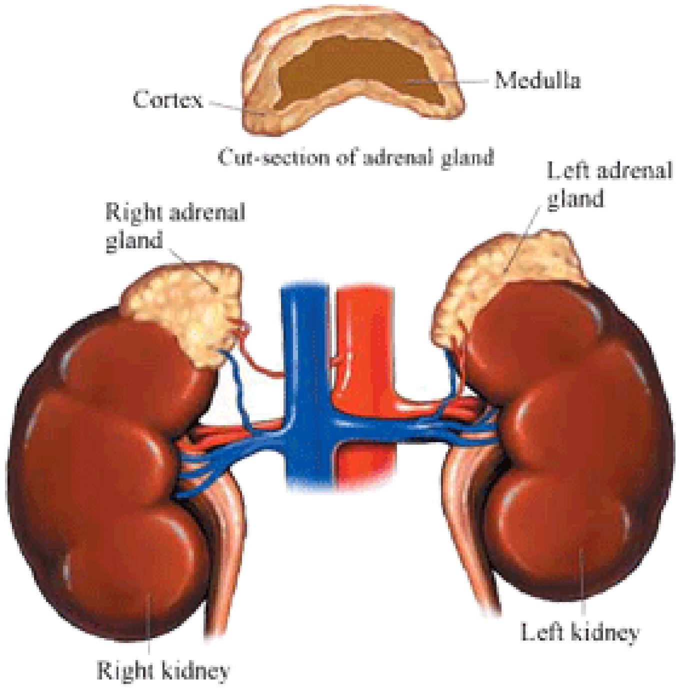
• blood clotting

• Nerve impulse transmission.

11.4. Adrenal glands-

There are two adrenal glands .They are also called as suprarenal gland because they, are situated on the upper pole of each kidney enclosed within the renal fascia.

They are about 4 cm long and 3 cm thick. The glands are composed of two parts which have different structures and functions. The outer part is the cortex and the inner part the medulla.(See figure 11.6)



<u>Figure:11.6: Adrenal gland</u>

Blood supply –

Arterial supply to the glands is by branches from the abdominal aorta and renal arteries.

Venous - is by suprarenal veins. The right gland drains into the inferior vena cava and the left in the left renal vein.

Hormones and Functions-

11.4.a The Adrenal cortex-

They produces three groups of steroid hormones from cholesterol. They are collectively called adrenocorticocoids(corticosteroids, corticoids). They are as follows:

•**Glucocorticoids-**

Cortisol (hydrocortisone), corticosterone and cortisone are the main glucocorticoids. They are essential for life, regulating metabolism and responses to stress. Secretion is stimulated by ACTH from the anterior pituitary and by stress.

Glucocorticoids have widespread effects and these include:

a. gluconeogenesis (formation of new sugar from, for example, protein) and hyperglycaemia (raised blood glucose level)

b. lipolysis (breakdown of triglycerides into fatty acids and glycerol for energy production)

c. stimulating breakdown of protein, releasing aminoacids, which can be used for synthesis of other proteins, e.g. enzymes, or for energy (ATP) production

d. promoting absorption of sodium and water from renal tubules

. Mineralocorticoids (aldosterone)-

Aldosterone is the main mineralocorticoid. Its functions are associated with the maintenance of water and electrolyte balance in the body. It stimulates the reabsorption of sodium (Na^+) by the renal tubules and excretion of potassium (K^+) in the urine.

•**Sex hormones-** Sex hormones secreted by the adrenal cortex are mainly androgens (male sex hormones) and the amounts produced are insignificant compared with those secreted by the testes and ovaries in late puberty and adulthood.

11.4.b The Adrenal medulla-

It is completely surrounded by the cortex. It develops from nervous tissue in the embryo and is part of the sympathetic division of the autonomic nervous system. It is stimulated by its extensive sympathetic nerve supply to produce the hormones adrenaline and noradrenaline.

Adrenaline and noradrenalin-

Noradrenaline is the postganglionic neurotransmitter of the sympathetic division of the autonomic nervous system. Adrenaline and some noradrenalinare released into the blood from the adrenal medulla during stimulation of the sympathetic nervous system. They are structurally very similar and this explains their similar effects. Adrenaline has a greater effect on the heart and metabolic processes whereas noradrenaline has more influence on blood vessels Together they potentiate the fight or flight response after initial sympathetic stimulation by:

- increasing heart rate
- increasing blood pressure
- diverting blood to essential organs including the heart, brain and skeletal muscles by dilating their blood vessels and constricting those of less essential organs, such as the skin
- increasing metabolic rate
- dilating the pupils.

Pancrease-

It is a mixed gland. The cells which make up the pancreatic islets (islets of Langerhans) are found in clusters irregularly distributed throughout the substance of the pancreas. Unlike the exocrine pancreas, which produces pancreatic juice, there are no ducts leading from the clusters of islet cells. Pancreatic hormones are secreted directly into the bloodstream and circulate throughout the body.

There are three main types of cells in the pancreatic islets:

- (alpha) cells that secrete glucagon
- (beta) cells that secrete insulin
- (delta) cells that secrete somatostatin.

Functions-

-Glucagon increases blood glucose levels

-Insulin reduces blood glucose levels.

11.5. The Pineal gland-

It is a small body attached to the roof of the third ventricle and is connected to it by a short stalk containing nerves, many of which terminate in the hypothalamus. The pineal gland is about 10 mm long, is reddish brown in color and is surrounded by a capsule.

Hormone and functions-

Melatonin-This is the hormone secreted by this gland. Although its functions are not fully understood, it is believed that is play following role-.

• Coordination of the circadian and diurnal rhythms of many tissues, possibly by influencing the hypothalamus

• Inhibition of growth and development of the sex organs before puberty, possibly by preventing synthesis or release of gonadotrophins.

11.6. Thymus gland-

Thymosin-

This is the hormone secreted by the thymus gland and is required for the development of T-lymphocytes for cell mediated immunity.

11.7. Ovaries-

They are mixed glands. They secrete female hormones-

- Oestrogen
- Progesterone

There hormones help in development of secondary sexual characters & organs e.g. Menarchy , Menstrual Cycle ,development of breast , pubic and axillary hairs body shape etc.

11.8. Testes-

They are mixed glands. They secrete hormones called testosterone.

Testosterone helps development of secondary sexual characters & organs .e.g. Hoaresness of voice ,growth of beard and moustache ,pubic and axillary hairs ,masculine features etc.

Questions

1. Name glands of endocrine system with their hormones.
2. Explains functions and significance of different hormones.
3. Describe structure of adrenal gland and its hormones.

Assignments

Prepare a chart showing different glands of endocrine system.

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Lesson: 12 - Nervous systems

Objective – At the end of the topic the students will be able to-

a. Identify brain, spinal cord and different nerves

b. Explain functions of brain, spinal cord and nerves.

c. Describe formation and function of CSF

Introduction-

The nervous system detects and responds to changes inside and outside the body. Nervous system stimulation provides an immediate response of the body to different kinds of stimulation. The nervous system consists of the brain, the spinal cord and peripheral nerves. Organization of nervous tissue within the body enables rapid communication between different parts of the body. Response to changes in the internal environment maintains homeostasis and regulates involuntary functions, e.g. blood pressure and digestive activity. Response to changes in the external environment maintains posture and other voluntary activities. Together with the endocrine system it controls important aspects of body function and maintains homeostasis.

The nervous system consists of a vast number of cells called neurones supported by a special type of connective tissue, neuroglia.

Each neuron consists of a –

- cell body and its processes,
- axon -1
- Dendrites –many.

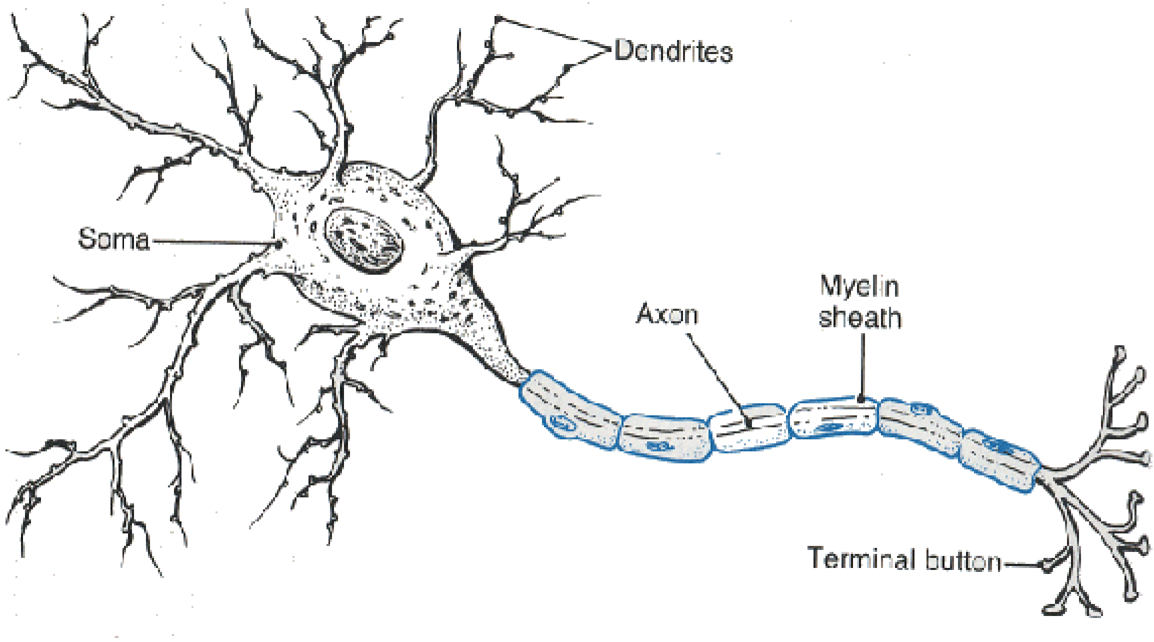


Figure: 12.1: Structure of Neuron

Neurons are commonly referred to as nerve cells. Bundles of axons bound together are called nerves. The physiological 'units' of the nervous system are nerve impulses, or action potentials, which are akin to tiny electrical charges.

The brain and spinal cord are completely surrounded by three membranes, the meninges, lying between the skull and the brain and between the vertebrae and the spinal cord. Named from outside inwards they are:

- dura mater
- arachnoid mater
- pia mater.

For descriptive purposes the parts of the nervous system are grouped as follows:

• **Central nervous system(CNS)**, consisting of the

- Brain
- Spinal cord

12.1.a Brain-

The brain constitutes about one-fiftieth of the body weight and lies within the cranial cavity. The parts are-

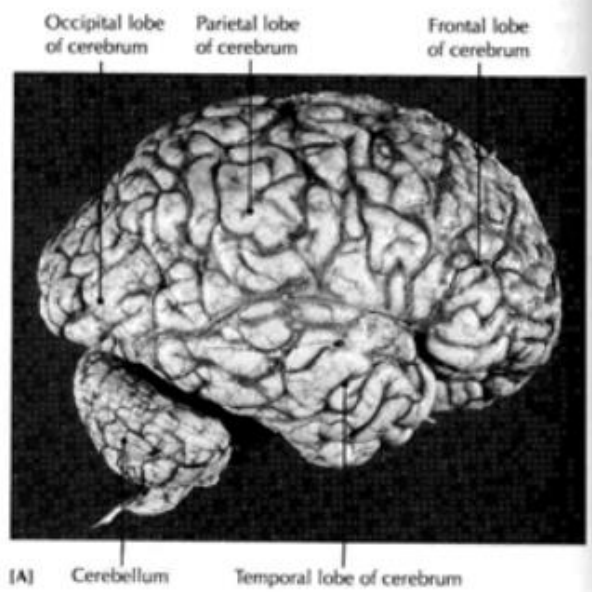
12.1.a.1 Cerebrum-

This is the largest part of the brain and it occupies the anterior and middle cranial fossae.. It is divided by a deep cleft, the longitudinal cerebral fissure, each containing one of the lateral ventricle into –

[A] Right lateral view of the external surface of the brain, showing the cerebellum and four of the six cerebral lobes. **[B]** Right sagittal section. **[C]** Right sagittal section showing the major subdivisions of the brain and its connection to the spinal cord.

THE FOUR MAJOR DIVISIONS OF THE BRAIN

BRAINSTEM	Midbrain Pons Medulla oblongata
CEREBELLUM	
CEREBRUM	
DIENCEPHALON	Thalamus Hypothalamus Epithalamus Ventral thalamus



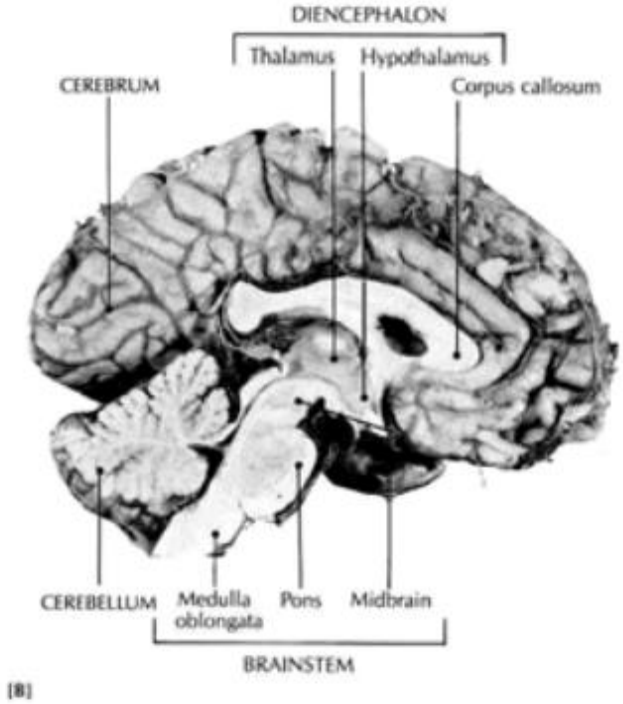


Figure:12.2:The Brain

-right cerebral hemispheres

-left cerebral hemispheres,

Deep within the brain the hemispheres are connected by a mass of white matter (nerve fibers) called the corpus callosum.. The superficial (peripheral) part of the cerebrum is composed of nerve cell bodies or grey matter, forming the cerebral cortex, and the deeper layers consist of nerve fibers or white matter. The cerebral cortex shows many in foldings or furrows of varying depth. The exposed areas of the folds are the gyri or convolutions and these are separated by sulci or fissures. These convolutions greatly increase the surface area of the cerebrum. For study purpose, each hemisphere of the cerebrum is divided into lobes which take the names of the bones of the cranium under which they lie:

- Frontal
- Parietal
- Temporal
- Occipital.

Functions of the cerebrum-

There are three main varieties of activity associated with the cerebral cortex:

1. mental activities involved in memory, intelligence, sense of responsibility, thinking, reasoning, moral sense and learning are attributed to the higher centres
2. Sensory perception, including the perception of pain, temperature, touch, sight, hearing, taste and smell.
3. Initiation and control of skeletal (voluntary) muscle contraction.

12.1.a.2 Brain stem-

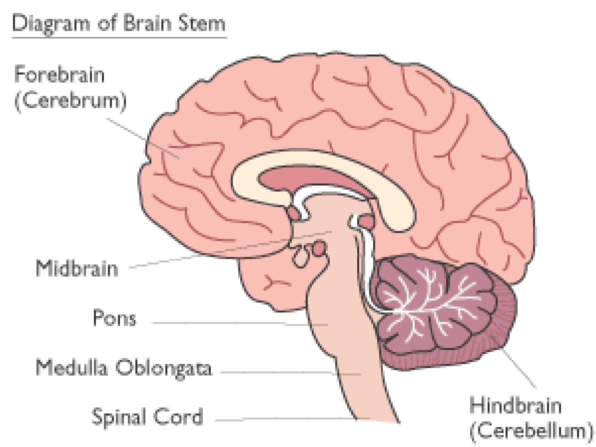


Figure: 12.3: The Brain Stem

The mid brain includes-

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 groups of cell bodies and nerve fibers (tracts) which connect the cerebrum with lower parts of the brain and with the spinal cord.

Pons-

The Pons is situated in front of the cerebellum, below the midbrain and above the medulla oblongata. It consists mainly of nerve fibres which form a bridge between the two hemispheres of the cerebellum, and of fibres passing between the higher levels of the brain and the spinal cord. There are groups of cells within the pons which act as relay stations and some of these are associated with the cranial nerves.

Medulla oblongata- The medulla oblongata extends from the pons above and is continuous with the spinal cord below. It is about 2.5 cm long and it lies just within the cranium above the foramen magnum. Its anterior and posterior surfaces are marked by central fissures.

Functions-

1. Coordination of skeletal muscle activity associated with voluntary motor movement and the maintenance of balance
2. Coordination of activity controlled by the autonomic nervous system, e.g. cardiovascular, respiratory and gastrointestinal activity
3. Selective awareness that functions through the reticular activating system (RAS) which selectively blocks or passes sensory information to the cerebral cortex, e.g. the slight sound made by a sick child moving in bed may arouse his mother but the noise of regularly passing trains may be suppressed.

12.1.a.3 Cerebellum-

The cerebellum is situated behind the Pons and immediately below the posterior portion of the cerebrum occupying the posterior cranial fossa. It is ovoid in shape and has two hemispheres, separated by a narrow median strip called the vermis. Grey matter forms the surface of the cerebellum, and the white matter lies deeply. brain stem**.**

Functions -

1. The cerebellum is concerned with the coordination of voluntary muscular movement, posture and balance.
2. The cerebellum controls and coordinates the movements of various groups of muscles ensuring smooth, even, precise actions.

3. It coordinates activities associated with the maintenance of the balance and equilibrium of the body.
4. The sensory input for these functions is derived from the muscles and joints, the eyes and the ears.
5. Proprioceptor impulses from the muscles and joints indicate their position in relation to the body as a whole and those impulses from the eyes and the semicircular canals in the ears provide information about the position of the head in space.
6. Impulses from the cerebellum influence the contraction of skeletal muscle so that balance and posture are maintained.

Blood supply to the brain-

The circulus arteriosus and its contributing arteries play a vital role in maintaining a constant supply of oxygen and glucose to the brain even when a contributing artery is narrowed or the head is moved. The brain receives about 15% of the cardiac output, approximately 750 ml of blood per minute. Auto regulation keeps blood flow to the brain constant by adjusting the diameter of the arterioles across a wide range of arterial blood pressure (about 65-140 mmHg) with changes occurring only outside these limits.

12.1.b Spinal cord-

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. It is starts at the lower end of the medulla oblongata. It is approximately 45 cm long in an adult, and is about the thickness of the little finger. When a specimen of cerebrospinal fluid is required it is taken from a point below the end of the cord, i.e. below the level of the 2nd lumbar vertebra. Nerves conveying impulses from the brain to the various organs and tissues descend through the spinal cord. At the appropriate level they leave then 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.

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. 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.

FUNCTIONS-

1. It contains various nerve tracts
2. Reflex action via reflex arc
3. It helps to send stimulus from Tissue to Brain.
4. It helps to bring response from Brain to Tissue

12.2 Peripheral nervous system(PNS)-

This part includes the spinal nerves-

12.2.a Spinal nerves

The nerves arise as roots from the spinal cord and then join to form the nerves called spinal nerves. These roots are of following types-

- The anterior nerve root consists of motor nerve fibres which are the axons of the nerve cells in 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.

There are 31 pairs of spinal nerves that 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.

- Cervical -8 pairs
- Thoracic -12 pairs
- Lumbar -5 pairs
- Sacral- 5 pairs
- Coccygeal. -1pair

Each nerve is formed by the union of a motor and a sensory nerve root and is, therefore, a mixed nerve. 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.

Each spinal nerve has a contribution from the sympathetic part of the autonomic nervous system in the form of a preganglionic fibre.

12.2.b Cranial nerves -

There are 12 pairs of cranial nerves originating from nuclei in the inferior surface of the brain. (See figure 12.4). These nerves are of three types-

-Sensory nerves- They carry stimulus from tissue to the brain.

- Motor nerves - They bring response from brain to the tissue

- Mixed nerves. - They function as both sensory and motor

Their names and numbers are:

I. Olfactory: sensory- These are the nerves of the sense of smell

II. Optic: sensory -These are the nerves of the sense of sight

III. Oculomotor: motor :

They supply:

A. Four extraocular muscles, which move the eyeball, i.e. the superior, medial and inferior recti and the inferior oblique muscle

B. **Intraocular muscles:**

- ciliary muscles which alter the shape of the lens, changing its refractive power
- circular muscles of the iris which constrict the pupil
- the levator palpebrae muscle which raises the upper eyelid

IV. Trochlear: motor : They supply the superior oblique muscles of the eyes.

V. Trigeminal: mixed : These nerves contain motor and sensory fibers and are among the largest of the cranial nerves. They are the chief sensory nerves for the face and head (including the oral and nasal cavities and teeth), receiving impulses of pain temperature and touch. The motor fibers stimulate the muscles of mastication.

VI. Abducent: motor: They supply the lateral rectus muscles of the eyeballs.

VII. Facial: mixed: The motor fibers supply the muscles of facial expression. The sensory fibers convey impulses from the taste buds in the anterior two-thirds of the tongue to the taste perception area in the cerebral cortex.

VIII. Vestibulocochlear (auditory): sensory: These nerves are composed of two distinct sets of fibres-

The vestibular nerve- They are associated with the maintenance of posture and balance.

The cochlear nerve -convey impulses to the hearing areas in the cerebral cortex where sound is perceived.

IX. Glossopharyngeal: mixed: The motor fibers stimulate the muscles of the tongue and pharynx and the secretary cells of the parotid (salivary) glands. The sensory fibers convey impulses to the cerebral cortex from the posterior third of the tongue, the tonsils and pharynx and from taste buds in the tongue and pharynx. These nerves are essential for the swallowing and gag reflexes.

X. Vagus: mixed: These nerves have a more extensive distribution than any other cranial nerves. These nerves form an important part of the parasympathetic nervous system. The motor fibers supply the smooth muscles and secretory glands of the pharynx, larynx, trachea, heart, esophagus, stomach, intestines, pancreas, gall bladder, bile ducts, spleen, kidneys, ureter and blood vessels in the thoracic and abdominal cavities. The sensory fibers convey impulses from the lining membranes of the same structures to the brain.

XI-Accessory: motor: The fibres supply the sternocliedomastoid and trapezius muscles. Branches join the vagus nerves and supply the pharyngeal and laryngeal muscles.

XII. Hypoglossal: motor. They supply the muscles of the tongue and muscles surrounding the hyoid bone and contribute to swallowing and speech.

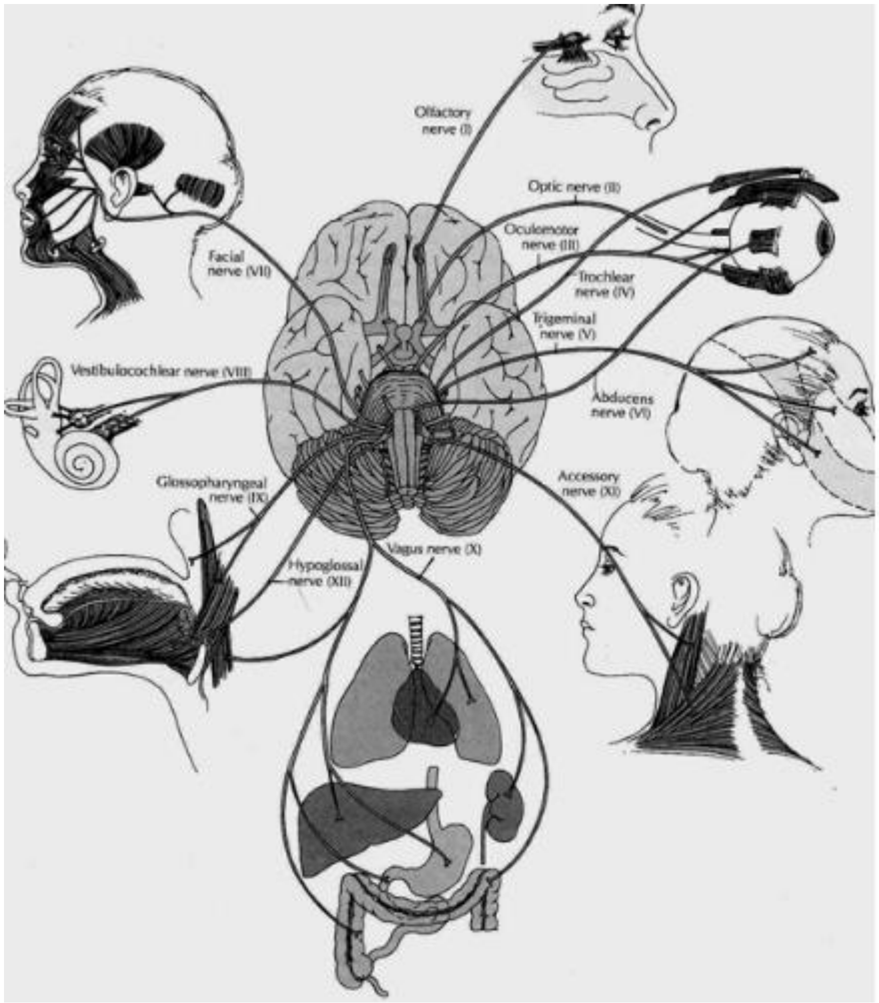


Figure:12.4: Base of the Brain Showing Cranial Nerves

12.3 Autonomous nervous system -

The autonomic or involuntary part of the nervous system controls the functions of the body carried out automatically', i.e. initiated in the brain below the level of the cerebrum. Although stimulation does not occur voluntarily the individual may be conscious of its effects, e.g. an increase in the heart rate. The effects of autonomic control are rapid and essential for homeostasis.

The effector organs are:

- Smooth muscle
- Cardiac muscle

• Glands

Effects of autonomic stimulation include:

- -changes in rate and force of the heartbeat stimulation or depression of secretion of glands vasoconstriction or vasodilatation
- bronchoconstriction or bronchodilation
- change in size of the pupils of the eyes.

12.5 The autonomic nervous system is divided into two divisions:

12•4[A]**Sympathetic** (thoracolumbar outflow)

12•4 [B]**Parasympathetic** (craniosacral outflow).

They normally work in an opposing manner, enabling or restoring balance of involuntary functions, maintaining homeostasis. Sympathetic activity tends to predominate in stressful situations and parasympathetic activity during rest.

Functions-

The autonomic nervous system is involved in a complex of reflex activities which, like the reflexes described previously, depend on sensory input to the brain or spinal cord, and on motor output. In this case the reflex action is rapid contraction, or inhibition of contraction, of involuntary (smooth and cardiac) muscle or glandular secretion. These reflexes are coordinated subconsciously in the brain, i.e. below the level of the cerebrum. Some sensory input does reach consciousness and may result in temporary inhibition of the reflex action, e.g. reflex micturition can be inhibited temporarily. The majority of the organs of the body are supplied by both sympathetic and parasympathetic nerves which have opposite effects that are finely balanced to ensure the optimum functioning of the organ.

12.3.a Sympathetic stimulation:

Prepares the body to deal with exciting and stressful situations, e.g. strengthening its defenses in danger and in extremes of environmental temperature. The adrenal glands are stimulated to secrete the hormones adrenaline and noradrenaline into the bloodstream. These hormones potentiate and sustain the effects of sympathetic stimulation. It is sometimes said that sympathetic stimulation mobilizes the body for 'fight or flight'.

12.3.b Parasympathetic stimulation:

Has a tendency to slow down body processes except digestion and absorption of food and the functions of the genitourinary systems. Its general effect is that of a 'peace maker' allowing restoration processes to occur quietly and peacefully. Normally the two systems function together maintaining a regular heartbeat, normal temperature and an internal environment compatible with the immediate external surroundings.

12.4 Cerebrospinal fluid-

It is commonly called as CSF. Cerebrospinal fluid is secreted into each ventricle of the brain by choroid plexuses. These are vascular areas where there is a proliferation of blood vessels surrounded by ependymal cells in the lining of ventricle walls. CSF passes back into the blood through tiny diverticula of arachnoid mater, called arachnoid villi (arachnoid granulations), that project into the venous sinuses. The movement of CSF from the subarachnoid space to venous sinuses depends upon the difference in pressure on each side of the walls of the arachnoid villi, which act as one-way valves. When CSF pressure is higher than venous pressure CSF passes into the blood and when the venous pressure is higher the arachnoid villi collapse, preventing the passage of blood constituents into the CSF. There may also be some reabsorption of CSF by cells in the walls of the ventricles. From the roof of the fourth ventricle CSF flows through foramina into the subarachnoid space and completely surrounds the brain and spinal cord. (See figure 12.5).

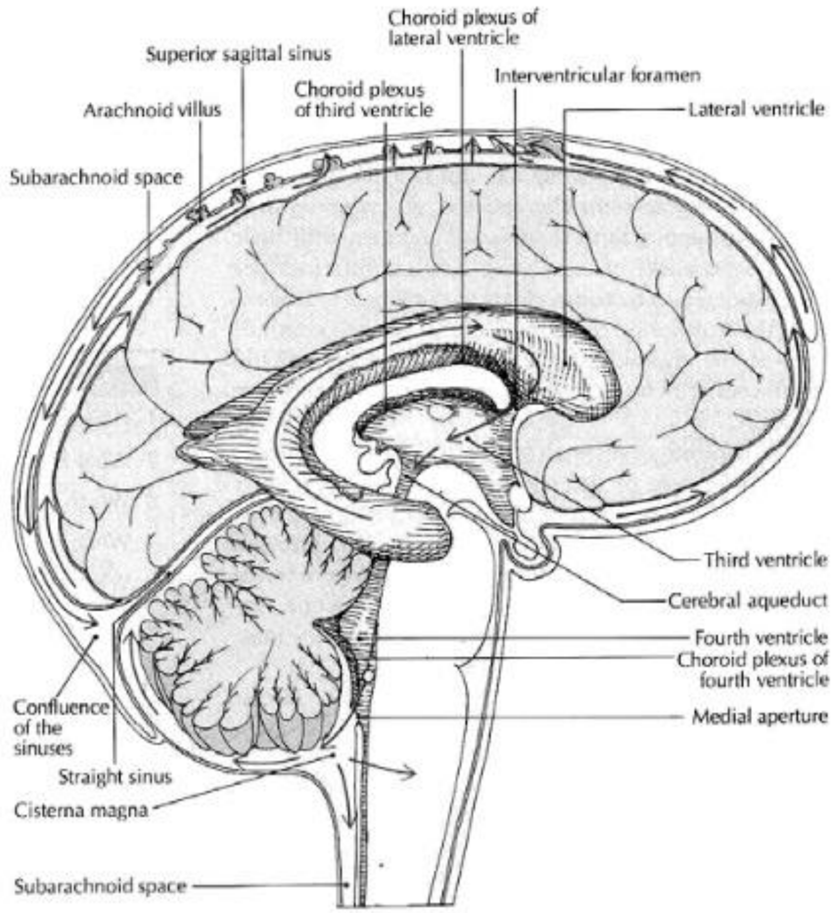


Figure:12.5Flow ofCerebrospinal Fluid

CSF is secreted continuously at a rate of about 0.5 ml per minute, i.e. 720 ml per day. The amount around the brain and spinal cord remains fairly constant at about 120 ml, which means that absorption, keeps pace with secretion. CSF is a clear, slightly alkaline fluid with a specific gravity of 1.005, consisting of:

- Water
- Glucose
- Plasma proteins: small amounts of albumin and globulin
- Mineral salts
- Creatinine- small amounts
- Urea - small
- A few leukocytes.

Functions

a. It supports and protects the brain and spinal cord.

b. It maintains a uniform pressure around these delicate structures.

c. It acts as a cushion and shock absorber between the brain and the cranial bones.

d. It keeps the brain and spinal cord moist and there may be interchange of substances between CSF and nerve cells, such as nutrients and waste products.

Questions

1. Draw and explain different parts of brain.
2. Explain functions of cerebrum and cerebellum.
3. Write a note on cerebrospinal fluid.
4. Name different cranial nerves and their functions.

Assignments

1. Prepare a chart of neuron.
2. Prepare a chart of cross section of spinal cord.

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