Dr. Preeti is Assistant Professor in kriya sharir department of BDM College of Ayurveda Science and hospital Chhuchhakwas, jhajjar, Haryana since past three years. The author has written many articles related to subject in reputed medical journals.

The book is primarily written for B.A.M.S, M.D. Kriya Sharir students.

The salient features of the book are

- The text is designed according to NCISM Syllabus for B.A.M.S 1ST Professional physiology students.
- Key term and important features are printed in bold face.
- Well labeled diagram are provided for proper understanding of text.
- Flow charts and tables are inserted wherever necessary for greater accuracy.

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MODERN TEXTBOOK OF KRIYA SHARIR VIGYAN

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First Edition

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Ayurveda (Kriya Sharir)

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At this moment I bow my head to god almighty, who directs me all along of my life. This world of word fails to provide me a word just capable of expressing my feeling of loyalty, respect and sincere gratitude for the lord Krishna who have enabled me to be what I am today.

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Author

Dr. Preeti

Chapter -1

HOMEOSTASIS

Defination - 'Homeostasis' refers to the maintenance of constant internal environment of the body, (eg. Body temp.)

- (Homeo = Same; Stasis = Standing)
- The word 'homeostasis' was introduced by **Harvard Professor**, Walter B Cannon in 1930.
- Internal environment in the body is the **extracellular fluid (ECF)** in which the cells live, which constantly moves throughout the body.
- ECF includes **blood** (circulates in the vascular system) and **interstitial Fluid** (fluid present in between the cells).
- ECF contains nutrients, ions and all other substances necessary for the **survival of the cells.**

✓ Normal healthy living of large organisms including human beings depends upon the constant maintenance of internal environment within the physiological limits. If the internal environment deviates beyond the **set limits,** body suffers from malfunction or dysfunction.

✓ The ultimate goal of an organism is to have a normal healthy living, which is achieved by the maintenance of internal environment within set limits.

ROLE OF VARIOUS SYSTEMS OF THE BODY IN HOMEOSTASIS –

✓ The respiratory system, blood and kidney help in the regulation of pH. Which is 7.4 (less ph - acidosis, High ph – alkosis), (If deviation – cell proper not work).

✓ The skin, respiratory system, digestive system, excretory system, skeletal muscles and nervous system are involved in maintaining the temperature within normal limits.(37.5°C)(In skin - vasodilation vessles presents).

✓ **Pancreas** regulate blood glucose levels with in the release of insulin or glucogen.

✓ Digestive system and circulatory system play major role in supply of nutrients to cell.

✓ Respiratory system **supply oxygen to body cells** and remove carbon dioxide from body.

✓ Kidney are involved in excretion of waste products.

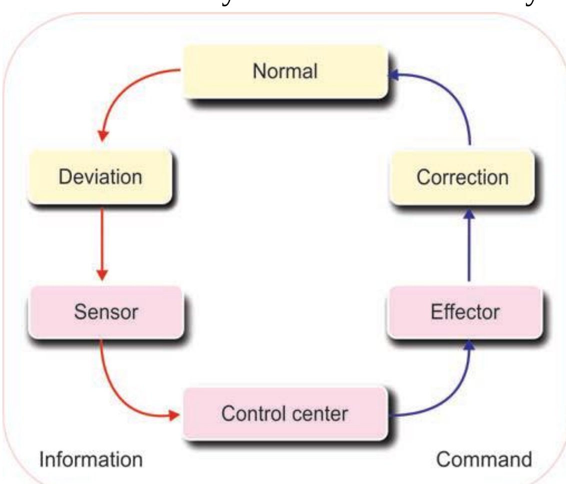
✓ Hormones are to be synthesized and released from endocrine glands in appropriate quantities.

- ✓ Kidney , skin , salivary gland and GIT tract regulate **water and electrolyte balance in the body.(** for osmolarity, deheydrated, over hydration)
- ✓ Blood - major part of internal environment must contain required number of normal red blood cells and plasma for transportation of nutritive substances, respiratory gases, metabolic and other waste products.
- ✓ Central nervous system(brain and spinal cord also) plays an important role in homeostasis. Sensory system detects (deviation) the state of the body or surroundings.
- ✓ Autonomic nervous system **regulates all the vegetative functions** of the body essential for homeostasis.

MECHANISM OF ACTION OF HOMEOSTATIC SYSTEM

Homeostatic mechanism in the body is responsible for maintaining the normalcy of various body systems.

- ➢ Whenever there is any change in the body , detectors or sensors detect (present –skin , nerve) the deviation and alert the control center (brain, CNS, ANS). The integrating center immediately sends information to the concerned effectors to either accelerate or inhibit the activity to restore the normalcy.



Components of homeostatic system

COMPONENTS OF HOMEOSTATIC SYSTEM

Homeostatic system in the body acts through self regulating devices, which operate in a cyclic manner.

This cycle includes four components:

1. Sensors or detectors and receptors -

which recognize the deviation and transmission of this message to a **control center.**

2. Control center or integrated center –

Control center receives from receptors and send commands to concerned effectors.

3. Effectors –
Effectors receive the commands from center and either accelerate or inhibit the activity so that normalcy is restored.
4. **Effectors -** which correct the deviation.

TWO TYPES OF FEEDBACK CONTROL SYSTEMS:-

1. Negative feedback
2. Positive feedback.

1. **Positive feedback -** Effectors(target gland,organ , area) sends positive feedback signals to the system in such a way as to increase the intensity. Positive feedback is less common than the negative feedback.

   - ✓ One of the positive feedbacks occurs during the blood clotting. Blood clotting is necessary to arrest bleeding during injury and it occurs in three stages.

Three stages are:
i. Formation of prothrombin activator
ii. Conversion of prothrombin into thrombin
iii. Conversion of fibrinogen into fibrin.

Eg.-

Injury to blood vessel and bledding

⬇

Formation of prothrombin activator

⬇

Conversion of prothrombin into thrombin

⬇

Conversion of fibrinogen into fibrin

⬇

Stoppage of bleeding

Figure :- Positive feedback mechanism – Coagulation of blood.

2ND EXAMPLE –

Other processes where positive feedback occurs are milk ejection reflex and parturition and both the processes involve oxytocin secretion.

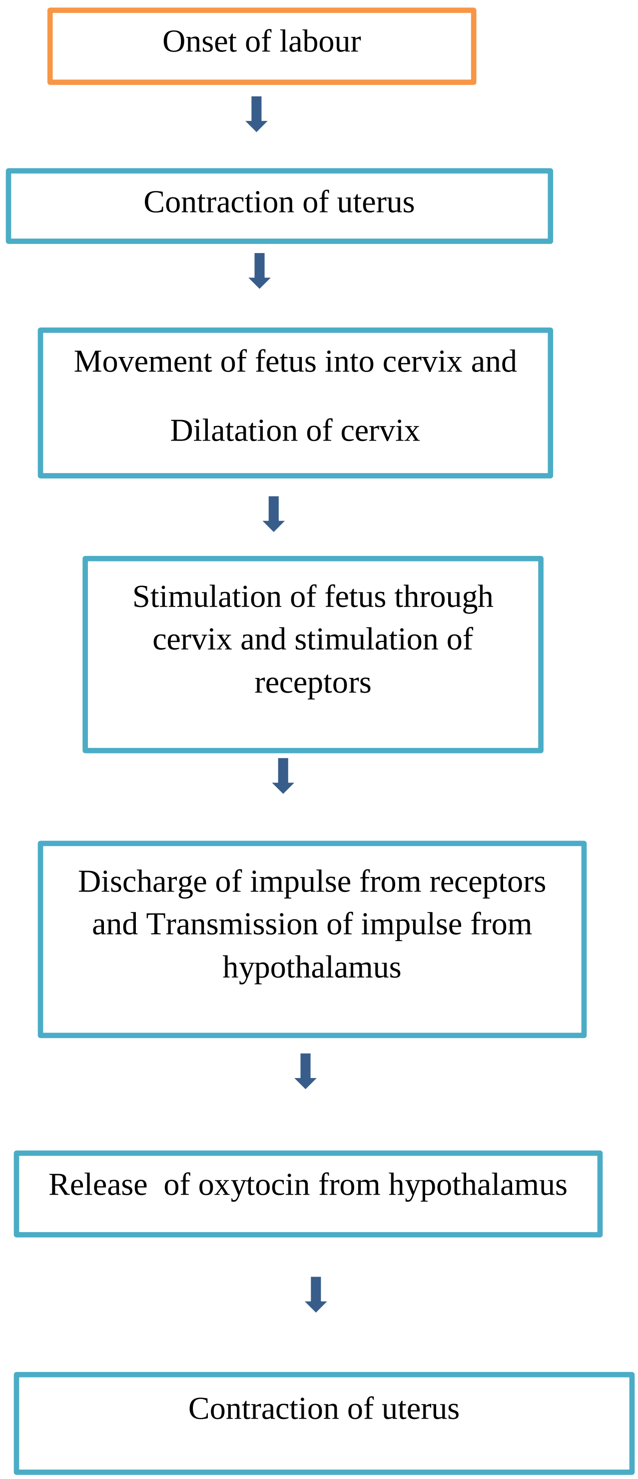


Figure:- Positive feedback mechanism – parturition.

- ❑ **Negative feedback** – Effectors sends negative feedback signals back to the system, in such a way as to arrest the change or slow or reverse the direction of change to stabilizer its own function.
- ✓ After receiving a message, effectors send negative feedback signals back to the system. Now, the system stabilizes its own function and makes an attempt to maintain homeostasis.

EXAMPLE 1-

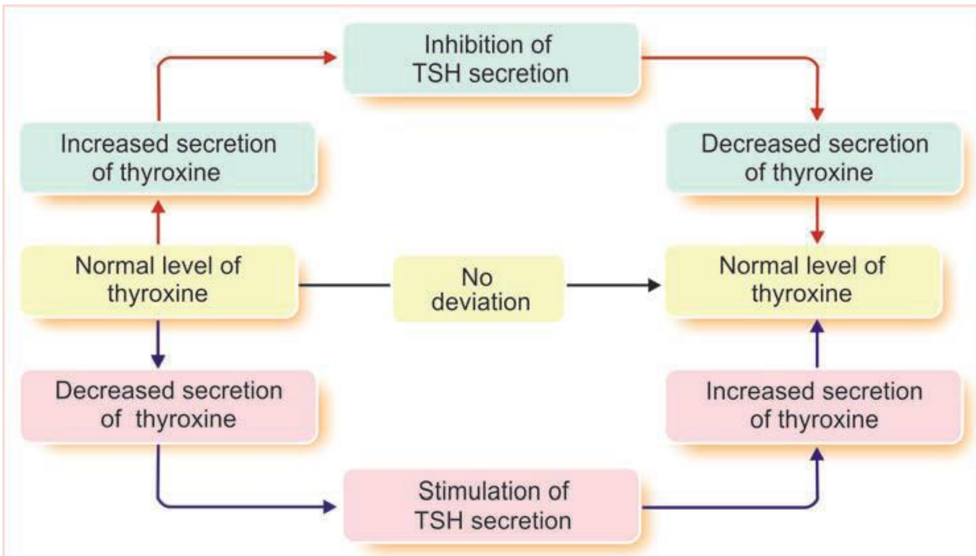


Figure :- Negative feedback mechanism – secretion of thyroxine.

MCQ –

Q.1. liver function are required for –

(a). Thermoregulation

(b).Osmoregulation

(c). Homeostasis

(d). both A and B

Q.2. Homeostasis is best described by which of the following statements.

a. Maintaining a stable and unaltered state of the body.

b. Stable equilibrium

c. Keeping the internal environment near constant.

d. Changing the external environment to meet the bodys requirements.

Q.3. What factors disturbs the homeostasis.

a. Social environment

b. Internal environment

c. external environment

d. All the above

Q.4. What is work of feedback system.

a. Monitor, change, evaluate.

b. change, evaluate, monitor

c. Monitor , evaluate , change

d. evaluate , Monitor, change

Q.5 **Which of the following is an example of positive feedback system.**

a. childbirth

b. control of BP

c. control of glucose level

d. All of the above

Q.6. In the homeostasis mechanism, the original stress reduced that is the room warms up and this show that these is operating by –

a. alpha feedback

b. negative feedback

c. gamma feedback

d. positive feedback

Q.7. The internal environment of the cell or body is formed by ECF then it is known as –

a. intracellular

b. ion conc.

c. solute

d. milieu interior

Q.8. When the body temperature increases, the blood vessels in the skin becomes wider and allows more blood to flow near the surface is called as –

a. vasoconstriction

b. vasodilation

c. islets of Langerhans

d. gain of control system.

Q.9. In humans, the temperature regulation control center is located in –

a. kidney

b. brain

c. lumgs

d. liver

Q.10. The homeostasis term was introduced by –

a. walter Sutton

b. walter cannon

c. james waston

d. fredick crick

Q. 11. The homeostasis is controlled by-

a. endocrine

b. nervous system

c. both a and b.

d. none of these

Q.12. Homeostasis was described as –

a. changing process

b. stable process

c. self regulating process

d. process of immunity

Answers – 1- C , 2 – a , 3 – b, 4 – c , 5 – a ,6 – b , 7 – d , 8 – b , 9 – b , 10 – b, 11 – c ,12 – c.

Chapter -2

CELL PHYSIOLOGY AND MEMBRANE PHYSIOLOGY

INTRODUCTION

All the living things are composed of cells. A single cell is the smallest unit that has all the characteristics of life.

Cell – Structural and functional unit of living body.

General Characteristics of Cell

Each cell in the body: -

1. Needs nutrition and oxygen.
2. Produces its own energy necessary for its growth, repair and other activities.
3. Eliminates carbon dioxide and other metabolic wastes.
4. Maintains the medium, i.e. the environment for its survival.
5. Shows immediate response to the entry of invaders like bacteria or toxic substances into the body.
6. Reproduces by division. There are some exceptions like neuron, which do not reproduce.

TISSUE

Tissue is defined as the group of cells having similar function. There are many types of tissues in the body.

STRUCTURE OF CELL MEMBRANE -

Each cell is formed by a cell body and a membrane covering the cell body called the cell membrane.

Two parts - Nucleus and cytoplasm

Structures of cell are of **three categories**: 1. Cell membrane
II. Cytoplasm
III. Nucleus

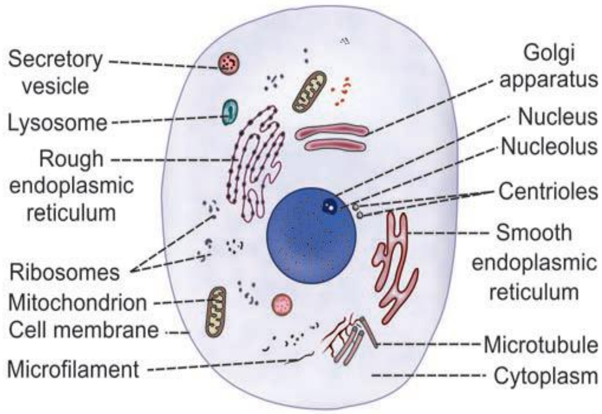


Figure:- Structure of the cell

1. **CELL MEMBRANE: -** Protective sheath, semipermeable membrane.

✓ **Also known – plasma membrane or plasmalemma**

✓ Cell membrane found in all cell that separates the interior of cell from the outside environment.

Thickness – 75 to 111 A

COMPOSITION – 3 substance, 1) Proteins (55%)
2) Lipids (40%)
3)Carbohydrates (5%)

STRUCTURE : 3 layered membrane, - One central electron- lucent layer (lipids layer) and Two electron - dense layers (2 Protein layer) .

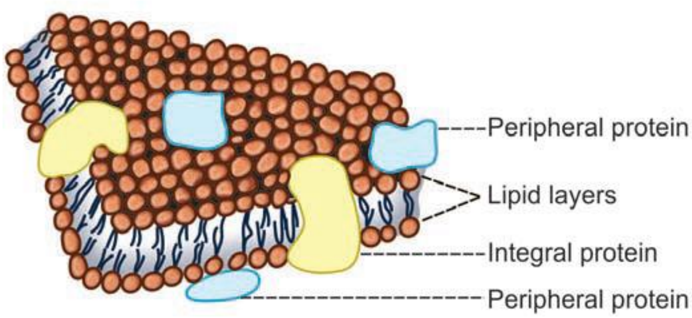


Figure: Diagram of the cell membrane

❑ **ARRANGEMENT OF MOLECULES IN CELL MEMBRANE**

1. ARRANGEMENTS OF LIPID BILAYERED –

✓ Consist of lipid molecule – 1. Phospholipids
2. Cholesterol

1. PHOSPHOLIPIDS -

Lipids molecule – Resemble pin shaped

Consist – head portion and tail portion

Head Portion – Outer part of phospholipids

- Globular, outside faces
- Water soluble
- Polar end (positive charge)
- Hydrophilic – strong affinity for water

Tail portion – Two chain of fatty acids
- Hydrophobic , Inner side faces

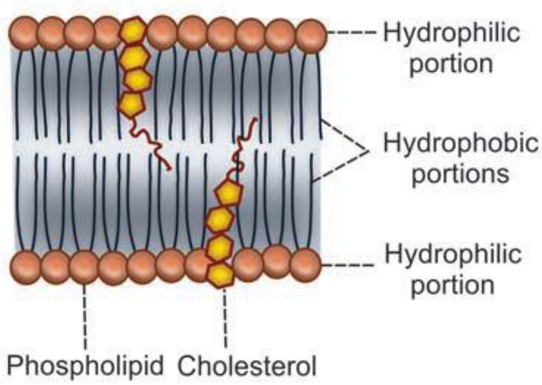


Figure: Lipids of the cell membrane

2. CHOLESTEROL -

- ✓ Cholesterol molecules are arranged in between the phospholipids molecules.
- ✓ Phospholipids are - soft and oily structures
- ✓ Cholesterol helps to 'pack' the phospholipids in the membrane.
- ✓ So, cholesterol is responsible for the structural integrity of lipid layer of the cell membrane.

Functions of Lipid Layer in Cell Membrane –

- ✓ Lipid layer of the cell membrane is a semipermeable membrane and allows only the fat-soluble substances to pass through it. (like oxygen, carbon dioxide and alcohol)
- ✓ The water-soluble substances cannot pass through this layer.(like. glucose, urea and electrolytes)

2. ARRANGMENTS OF PROTEINS IN CELL MEMBRANE

Most protein molecule flots about in the phospholipid bilayered forming fluid mosaic pattern.

It consists of **protein** – 1. lipoprotein - function – function of enzyme and channels (transport)

2. Glycoprotein - function – function of receptor.

TYPES OF PROTEIN – 2

1. Peripheral proteins
2. Integral proteins

1. **PERIPHERAL PROTEINS :-**

Present of peripheral to the lipid bilayered both side – inner side ,outer side

TYPES –

a) **Intracellular peripheral proteins:**

Located - Inner surface of cell membrane. eg. Receptors, transports proteins and some enzymes.

b) Extracellular peripheral proteins:

Located - Outer surface of cell membrane. Eg. Antigens , adhesion proteins and some enzymes.

2. INTEGRAL PROTEINS –

- ✓ Pass through entire thickness of cell membrane from one side to the other side.
- ✓ These proteins are tightly bound with the cell membrane.

Examples of integral protein: -

i. Cell adhesion proteins

ii. Cell junction proteins

iii. Some carrier (transport) proteins

iv. Channel proteins

v. Some hormone receptors

vi. Antigens

vii. Some enzymes.

On the basis of function serve as : -

1. Channel proteins
2. Carrier proteins

3. Receptor proteins
4. Antigen
5. Act as pump – eg. Sodium , potassium pump

3. ARRANGMENTS OF CARBOHYDRATES IN CELL MEMBRANE

- ✓ Carbohydrates attached to – protein (form glycoprotein) and some molecules attached to lipid and form glycolipids.
- ✓ Carbohydrates molecule form a thin loose covering called glycocalyx.

FUNCTIONS OF CARBOHYDRATES IN CELL MEMBRANCE -

1. Carbohydrate molecules are negatively charged and do not permit the negatively charged substances to move in and out of the cell.

2. Glycocalyx from the neighboring cells helps in the tight fixation of cells with one another.

3. Some carbohydrate molecules function as the receptors for some hormones.

FUNCTION OF CELL MEMBRANE –

1. Intergrity of the cell – Shape /size
2. Control transport – selectively permeable
3. Provide mechanical support for the protection of internal structure of the cell
4. Allow only useful substance to enter into cell
5. Does not allow harmful substance to enter into cell
6. Provide specificity to the cell
7. Exchange of gases

❑ CYTOPLASMIC ORGANELLES:

CYTOPLASM – jelly like materials formed by 80% of water and contains a clear liquid portion called cytosol.

TYPES – 2

1. **Ectoplasm** - outer part of cytoplasm

2. **Endoplasm** - inner part of cytoplasm

Contain – Many organelles with distinct structure and function.

- ✓ Mitochondria
- ✓ Endoplasmic reticulum
- ✓ Golgi apparatus
- ✓ Ribosomes
- ✓ Lysosomes
- ✓ Nucleus
- ✓ Cytoskeleton

❑ **MITOCONDRIA: -**

Shape - Spherical, oval or rod like bodies.

Diameter – 0.5 to 1 u.

STRUCTURE: Consist of **Membrane** : 2 layers –

1. **OUTER LAYER** –Smooth and contains various enzymes such as acetyl – CoA synthetase and glycerophosphate acetyltransferase.

    - ✓ **Inner layer** - Folded into incomplete septa called cristae.

- ✓ Matrix of mitochondria contains enzymes, required in kreb's cycle by which products of carbohydrates, fat and proteins metabolism are oxidised to produce energy, which is stored in the form of ATP
- ✓ Mitocondria contain ribosomes and DNA – Help in protein synthesis

2. INNER MEMBRANE - Contains enzymes of electron transport chain.(e.g. cytochrome oxidase).

- ✓ Fluid contains the enzymes of citric acid cycle, urea cycle etc.
- ✓ Mitochondria –power house of cell
- ✓ Erythrocytes (RBC) – do not contain mitochondria.

FUNCTION;-

- ✓ Production of energy , synthesis of ATP, Apoptosis.
- ✓ Storage of calcium , detoxification – in liver cells, cytochrome P450 system – involve in mitocondria and endoplasmic reticulum for detoxification.

❑ ENDOPLASMIC RETICULUM (ER)

- ✓ It is a tubular and microsomal vesicular structures which are interconnected with one another.
- ✓ It is covered by a limiting membrane which is formed by proteins and bilayered lipids.
- ✓ The lumen of endoplasmic reticulum contains a **endoplasmic matrix.**
- ✓ **Diameter of the lumen -** 400 to 700Å.

Classified into - 2 1. Rough ER
2. Smooth ER

1. **ROUGH ER** –

Appearance – Rough , bumpy or bead like.
Structure – vesicular or tubular

- ✓ Rough appearance is due to the attachment of granular ribosomes to its outer surface.

Function –

1. Synthesis of proteins
2. Degradation of wornout organelles like mitochondria.

2. SMOOTH ER –

Appearance – smooth and ribosomes are not attached to this.
Formed - by many interconnected tubules.

Function –

1. Synthesis of lipids and steroids .
2. Role in cellular metabolism – Smooth ER of outer surface contains many enzymes.
3. Storage and metabolism of calcium
4. Catabolism and detoxification of toxic substances like, some drugs and carcinogens in the liver.

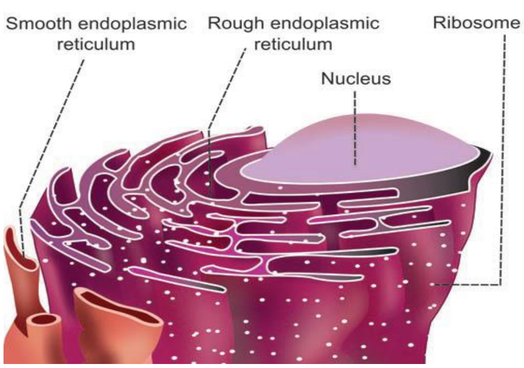


Figure: Endoplasmic reticulum.

❑ GOLGI APPARATUS: -

- ✓ discovered – Camillo golgi (1897)
- ✓ Also known as golgi complex, golgi body , simply golgi.
- ✓ Present in all cells except red blood cells.

Situated - Near the nucleus.

- ✓ Golgi apparatus consists of 5 to 8 flattened membranous sacs called the **cisternae.**

It has two ends or faces, namely **cis face and trans face.**

Cis face situated – Near the endoplasmic reticulum.

- ✓ Reticular vesicles from endoplasmic reticulum enter the Golgi apparatus through cis face.

Trans face situated – near the cell membrane.

- ✓ The processed substances make their exit from Golgi apparatus through trans face.

Function:-

1. Processing of materials

Vesicles containing glycoproteins and lipids are transported into Golgi apparatus and here, they are modified and processed.

2. Packaging of materials

All the processed materials are packed in the form of secretory granules, secretory vesicles and lysosomes, Because of this, Golgi apparatus is called the **'post office of the cell'.**

3. Labeling and delivery of materials

Golgi apparatus sorts out the processed and packed materials and labels them depending upon the chemical content for delivery (distribution) to their proper destinations.

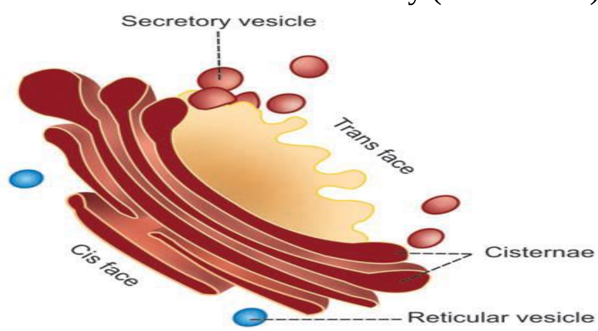


Figure:Golgi apparatus

❑ RIBOSOMES -

Ribosomes are the organelles without limiting membrane.

Structure - granular and small dot-like

Diameter - 15 nm.

- ✓ Ribosomes are made up of 35% of proteins and 65% of ribonucleic acid (RNA).
- ✓ RNA present in ribosomes is called ribosomal RNA (rRNA).

TYPES OF RIBOSOMES - 2

i. Ribosomes that are attached to rough endoplasmic reticulum

ii. Free ribosomes that are distributed in the cytoplasm.

FUNCTION –

a) Site of protein synthesis – all transmembrane proteins, secreted proteins.

b) Have a protective function

c) mRNA strand is protected from action of the enzymes.

d) Free ribosomes are responsible for the synthesis of proteins in haemoglobin.

❑ LYSOSOMES

Lysosome are the membrane – bound vesicular organelles found throughout the cytoplasm.

Formed – by golgi apparatus

✓ lysomomes is formed by a thickened covering membrane.

FUNCTION :

✓ Also called garbage system – due to degradation activity.

✓ Hydroxylase enzyme , eg. Proteases ➡ Proteins ➡ Amino acid .

lipases ➡ lipids ➡ fatty acids and glycerides.

Amylase ➡ Polysaccharides ➡ glucose.

❑ NUCLEUS

It is most prominent and largest cellular organelle.

Diameter – 10 to 22 u, present in all cells except the red blood cells.

Nucleus present - Eukaryotes

Without nucleus – Prokaryotes, most cell have one nucleus , few type cell – skeletal muscle have many nuclei.

Structure :- Covered – Nuclear membrane and contains many components (nucleoplasm, chromatin, nucleolus)

Function: -

1. Control of all the cell activites that include metabolism, protein synthesis, growth, reproduction.
2. Synthesis of RNA.
3. Control the cell division through genes.

4. Storage of hereditary information(in genes) and transformation from one generation of the species to the next.

❑ CYTOSKELETON

It is Cellular organ Organelle, Consists – 3 major protein components-

1- Microtubles,

2-Iintermediate filaments

3- Microfilaments

1. MICROTUBLES; - Straight , hollow, tubular structure of cytoskeleton .

Formed – bundles of globular proteins called tubulin.

Function –

- ✓ Determine the shape of the cell.
- ✓ Give structural strength to the cell.
- ✓ Responsible for the movement of centrioles and separate the chromosomes during mitosis.

2- INTERMEDIATE FILAMENTS :-

Formed – Rop like polymers, made up – fibrous proteins.

Function -

- ✓ Maintain the shape of the cell.
- ✓ Connect the adjacent cells through cells through desmosomes.

1. **MICROFILAMENTS** :- are long and fine thread- like structure.
   Made up – non- tubular contractile proteins called actin and myosin.

Function:

- ✓ Give structural strenght to the cell
- ✓ Are responsible for cellular movements like contraction, gliding and cytokines.

❑ TRANSPORT THROUGH CELL MEMBRANE

- ✓ Cell depend upon substances like nutrients, oxygen and water, which must be transported into the cell, and at the same time metabolic waste must be transported out of the cell.

BASIC MECHANISM OF TRANSPORT-

1. Passive transport mechanism
2. Active transport mechanism.

1. PASSIVE TRANSPORT

- ✓ Transport of substances along the **concentration gradient or electrical gradient or** both **(electrochemical gradient).**
- ✓ It is also known as **diffusion or downhill movement.**
- ✓ It does not need energy.
- ✓ The substance move from region of higher concentration to the region of lower concentration.

Depends upon the physical factors like –

A. Concentration gradient
B. Electrical gradient
C. Pressure gradient

A. Diffusion
B. Osmosis

A. DIFFUSION –

- ✓ Passive transport of molecules from higher concentration to lower concentration.

Diffusion is of two types -

1. Simple diffusion
2. Facilitated diffusion

1. SIMPLE DIFFUSION – transport of atoms or molecules occurs from one place to another due to their random movement.

- ✓ Simple diffusion of substances occurs either through lipid layer or protein layer of the cell membrane.
- ❑ Facilitated diffusion occurs with the help of the carrier proteins of the cell membrane.

Simple diffusion of substance occurs either through - 1. lipid layer
2. Protein layer
3. Facilitated or carrier – mediated diffusion

SIMPLE DIFFUSION THROUGH LIPID LAYER -

- ✓ Lipid layer of the cell membrane is permeable only to lipid-soluble substances like oxygen, carbon dioxide and alcohol.
- ✓ The diffusion through the lipid layer is directly proportional to the solubility of the substances in lipids.

SIMPLE DIFFUSION THROUGH PROTEIN LAYER -

- ✓ Protein layer of the cell membrane is permeable to water-soluble substances (like ion, glucose, urea etc). Mainly, electrolytes diffuse through the protein layer.
- ✓ The cell membrane has many channels. Some channels are continuously open, where as other are gated. They open up when they are properly stimulated. The stimulus can be electrical or chemical.

GATED CHANNELS –

Gated channels are divided into three categories:-

i. Voltage-gated channels
ii. Ligand-gated channels
iii. Mechanically gated channels.

- ✓ Channel which open when subjected to change in electrical potential called voltage gated channels e.g. Na+ channel, K+ channel, Ca++ channel.
- ✓ While the channels which open due to action of chemicals like neurotransmitter or hormones are called ligand gated channels.
- ✓ Some channels also open by mechanical stretch (mechano sensitive channel). eg. Cochlea – in stereocillia movement by mechanical activity.
- ✓

- ❑ **FACILITATED DIFFUSION**

- ✓ Water soluble substances having large molecules such as glucose cannot diffuse through Protein channels by simple diffusion.
- ✓ This substances transport through carrier proteins.
- ✓ Also called Carrier – mediated diffusion , due to glucose and amino acids are transported by facilitated diffusion because the diameter of these molecules is larger than the diameter of the channels.
- ✓ Concentrational charge occurs in carrier protein after molecule to be transported is bound at the receptor site.

TYPES OF CARRIER PROTEIN SYSTEM –

1. Uniport – only one type of molecules transport
2. Symport – one substance linked with another substance.
3. Antiport – exchange of one substance for another. Eg. (Na+ - K + exchange)

Symport & Antiport = co- transport

FACTORS AFFECTING RATE OF DIFFUSION-

1. Permeability of the Cell Membrane

- ✓ Is directly proportional to the permeability of cell membrane.
- ✓ Cell membrane is selectively permeable, only limited number of substances can diffuse through the membrane.

2. Temperature

- ✓ Is directly proportional to the body temperature.
- ✓ Increase in temperature increases the rate of diffusion.
- ✓ This is because of the thermal motion of molecules during increased temperature.

3. Concentration Gradient or Electrical Gradient of the Substance across the Cell Membrane

- ✓ Is directly proportional to the concentration gradient or electrical gradient of the diffusing substances across the cell membrane.

4. Solubility of the Substance

- ✓ Is directly proportional to the solubility of substances, particularly the lipid-soluble substances.
- ✓ Oxygen is highly soluble in lipids, it diffuses very rapidly through the lipid layer.

5. Thickness of the Cell Membrane

- ✓ Is inversely proportional to the thickness of the cell membrane.
- ✓ If the cell membrane is thick, diffusion of the substances is very slow.

6. Size of the Molecules

Is inversely proportional to the size of the molecules. Thus, the substances with smaller molecules diffuse rapidly than the substances with larger molecules.

7. Size of the Ions

Rate of diffusion is inversely proportional to the size of the ions. Smaller ions can pass through the membrane more easily than larger ions with the same charge.

❑ **OSMOSIS**

- ✓ Osmosis is the special type of diffusion.

- ✓ It is defined as the movement of water or any other solvent from an area of lower concentration to an area of higher concentration of a solute, through a semipermeable membrane .
- ✓ The semipermeable membrane permits the passage of only water or other solvents but not the solutes.
- ✓ Osmosis depends upon osmotic pressure.

Osmotic Pressure -

- ✓ It is the pressure created by the solutes in a fluid. During osmosis, when water or any other solvent moves from the area of lower concentration to the area of higher concentration, the solutes in the area of higher concentration get dissolved in the solvent. This creates a pressure which is known as osmotic pressure.

- ❑ **ACTIVE TRANSPORT**

- Movement of substances against the chemical , electrical or electrochemical gradient.
- Uphill transport (against water tide in river).
- Requires energy mainly by breakdown of ATP .

Carrier proteins -

TYPES of carrier protein system –

1. Uniport – only one type of molecules transport .
2. Symport – one substance linked with another substance.
3. Antiport – exchange of one substance for another. Eg. (Na+ - K + exchange)

Substance transported –

IONIC FORM – Na+, k+ Ca+2 , hydrogen, cl , I

NON – IONIC FORM - Glucose , amino acid, urea .

TYPES OF ACTIVE TRANSPORT

1. Primary AT
2. Secondary AT

1. PRIMARY ACTIVE TRANSPORT

Primary active transport is the type of transport mechanism in which the energy is liberated directly from the breakdown of ATP.

Example -

- ***Primary Active Transport of Sodium and Potassium:*** - Sodium-Potassium Pump

Na+ - k+ pump:- also called Na+ - K+ ATP ase pump.

- Helps in development of RMP (Resting membrane potential)

Structure of NA+ - K+ Pump :-

Two protein subunit molecules -

- ✓ Alpha – subunit (mw- 1,00, 000) – help in transport
- ✓ Beta – subunit (mw- 55,000)
- ✓ Transport of Na+ - k+ only by alpha subunit.

Alpha subunit has got 6 sites -

a. 3 receptor sites for Na+ ions on the intracellular face(inner surface).

b. 2 receptor sites for k+ ions on the extracellular face(outer surface).

c. One site for ATPase (near the site for Na+).

2. SECONDARY ACTIVE TRANSPORT –

- ✓ Transport of a substance with Na+ ion, by means of a common carrier protein.
- ✓ Transport of Na+ is coupled with transport of another substance.
- ✓ When sodium is transported by a carrier protein, another substance is also transported by the same protein simultaneously, either in the same direction or in the opposite direction.

TYPES –

a. Co – transport

b. Counter – transport

SODIUM COTRANSPORT –

Sodium cotransport is the process in which, along with sodium, another substance is transported by a carrier protein called symport.

Symport – e.g. – glucose , amino acid , Chloride, Iodine, Iron and urate.

- Carrier protein has 2 receptor site on outer surface – 1st for Na+ , 2nd for other substance.

SODIUM COUNTER TRANSPORT –

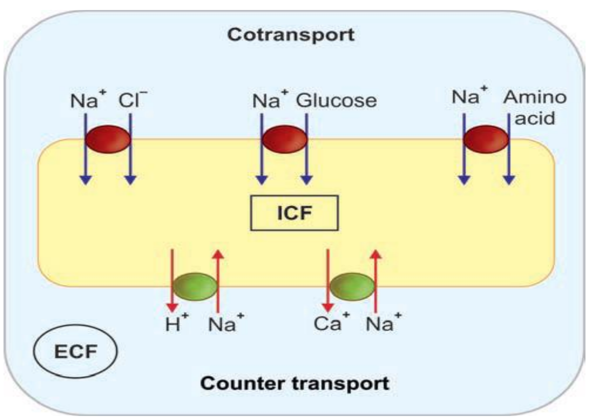
Sodium counter transport is the process by which the substances are transported across the cell membrane in exchange for sodium ions by carrier protein called antiport.

Example – Antiport – Na+ - Ca+ counter transport (in all cells).

- ✓ Na+ - H counter transport (in renal tubules)
- ✓ Other counter transport – Na+ - mg +2,

Na+ - k+ , Ca+2 – mg +2,

Ca+2 – k +



SPECIAL TYPES OF ACTIVE TRANSPORT –

- ✓ Also called the vesicular transport.

SPECIAL CATEGORIES OF ACTIVE TRANSPORT:

1. **ENDOCYTOSIS** – (**Macromolecules enter the cell)** Macromolecules (substances with larger molecules) cannot pass through the cell membrane.

Types -

1. Pinocytosis - like bacteria and antigens are taken into the cells. (**cell drinking.)**

2. Phagocytosis - particles larger than the macromolecules are engulfed into the cells. It is also called **cell eating.**

3. Receptor-mediated endocytosis - transport of macromolecules with the help of a receptor protein. Receptor-coated pits are involved in the receptor mediated endocytosis.

2**. EXOCYTOSIS** - Exocytosis is the process by which the substances are expelled from the cell. In this process, the substances are extruded from cell without passing through the cell membrane.

3. TRANSCYTOSIS -

In which an extracellular macromolecule enters through one side of a cell, migrates across cytoplasm of the cell and exits through the other side.

❑ PHAGOCYTOSIS

- ✓ Process by which particles larger than the macromolecules are engulfed into the cells.
- ✓ Cell eating and Neutrophils, monocytes and tissue macrophages(largest phagocytic cells) show phagocytosis.

MECHANISM –

Forigen body enters body

⬇

Phagocytic cell sends cytoplasmic extension

⬇

Particles engulfed and converted into vacuole

⬇

Vacuole is very large and called phagosome

⬇

Phagosome travels into interrior of cell

⬇

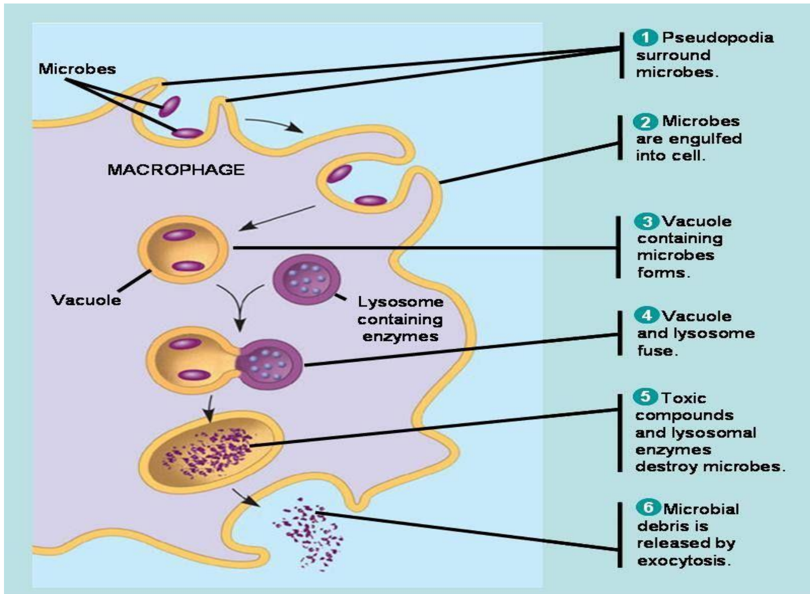
secondary lysosome (primary lysosome fuses with phagosome)

⬇

Hydrolytic enzymes activated

⬇

Degradation of phagosomall contents



MCQ –

Q.1 Which of the following cell organelles does not contain DNA .

a. nucleus

b. lysosomes

c. chloroplast

d. mitochondria

Q. 2. Which of the following cell organelles is called the powerhouse of the cell.

a. nucleus

b. lysosomes

c. chloroplast

d. mitochondria

Q. 3. Which of the following cell organelles regulates the entry and exit of molecules to and from the cell.

a. lysosomes

b. golgi bodies

c. cell membrane

d. mitochondria

Q.4. Which of the following cell organelles is called a suicidal bag.

a. lysosomes

b. golgi bodies

c. cell membrane

d. mitochondria

Q. 5. Which of the following is a single membrane – bound organelle.

a. vacuole

b. golgi apparatus

c. endoplasmic reticulum

d. all the above

Q.6. Which of the following statements is true about the nucleus.

a. it is absent in prokaryotes

b. it is called the brain of the cell

c. it contain DNA and other genetic materials.

d. all of the above.

Q.7. ………. Is a jelly like substance found floating inside the plasma membrane.

a. cell sap

b. cytoplasma

c. karyoplasma

d. mitochondria

Q.8. Which of the following cell organelles is called the powerhouse of the cell.

a. nucleus

b. lysosomes

c. chloroplast

d. mitochondria.

Q.9. Which of the following cell organelles regulates the entry and exit of molecules to and from the cell.

a. lysosomes

b. golgi bodies

c. cell membrane

d. mitochondria

Q.10. ……………..is the study of the cell, its types, structure, functions and its organelles.

a. biology

b. cell biology

c. microbiology

d. biotechnology

Answers - 1- b, 2 – d, 3- c , 4 –a , 5 –d , 6 – d , 7 – b , 8 – d, 9 – c , 10 – b.

Chapter – 3

RESTING MEMBRANE POTENTIAL

RESTING MEMBRANE POTENTIAL -

- ✓ Electrical potential difference (voltage) across the cell membrane (between inside and outside of the cell) under resting condition.
- ✓ **Also called** - membrane potential, transmembrane potential, transmembrane potential difference or transmembrane potential gradient.
- ✓ In human **skeletal muscle**, the resting membrane potential is --- –90 mV.

IONIC BASIS OF RESTING MEMBRANE POTENTIAL -

Development and maintenance of resting membrane potential in a muscle fiber or a neuron are carried out by movement of ions, which produce ionic imbalance across the cell membrane.

⬇

development of more positivity outside and more negativity inside the cell.

⬇

Ionic imbalance is produced by **two factors**.

1. Sodium - Potassium pump
2. Selective Permeability of cell membrane.

SELECTIVE PERMEABILITY OF CELL MEMBRANE –

Two types of channels are involved:-

i. Channels for major anions like proteins

ii. Leak channels

i. Channels for major anions (negatively charged substances) like proteins

Negatively charged large substances (proteins, organic phosphate and sulfate Compounds).

⬇

Channel are absent or closed in resting condition

⬇

Substances remain inside the cell (development and maintenance of negativity inside cell).

ii. Leak channels –

- The passive channels, which maintain the resting membrane potential by allowing movement of positive ions (Na+ and K+) across the cell membrane.
- 3 Ions **(Na+, Cl, K+)** unequally distributed - Na+ and Cl– more outside, K+ more inside.
- Cl– channels are **mostly closed** in resting conditions.
  - ✓ **Na+** is actively transported (against the concentration gradient) out of cell and **K+ is** actively transported (against the concentration gradient) into the cell.

⇩

because of concentration gradient, **Na+ diffuses back into the cell through** Na+ leak channels

⇩

K+ diffuses **out of the cell** through K+ leak channels.

- ✓ **In resting condition** - Almost all the K+ leak channels are opened. Most of the Na+ leak channels are closed.

⇩

Maintain the **concentration equilibrium.**

✓ After establishment of resting membrane potential, efflux of K+ stops :- concentration gradient.

It is because of two reasons: -

i. Positivity outside the cell repels positive K+ and prevents further efflux of these ions

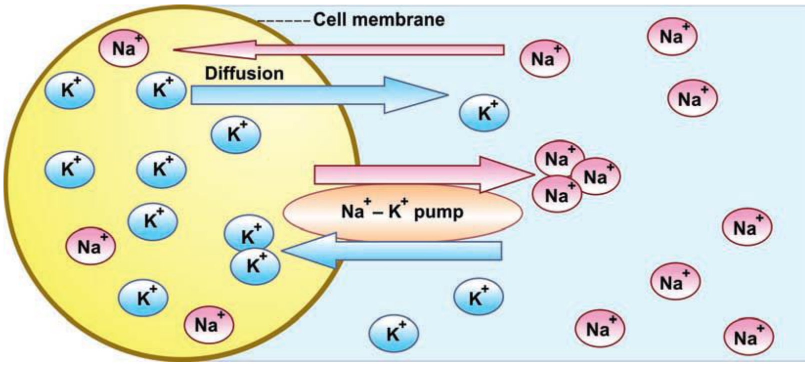
ii. Negativity inside the cell attracts positive K+ and prevents further leakage of these ions outside.

✓ Concentration of K+ inside the cell is about 140 mEq/L.

✓ Negativity inside the muscle fiber ----- –90 mV

Nerve fiber ------ –70 mV.

Hyperpolarization - If the K+ is not present or decreased, negativity increases beyond –120 Mv.



ACTION POTENTIAL

A series of **electrical changes** that occur in membrane potential when muscle/ nerve stimulated.

Occurs in 2 phase –

1. Depolarisation
2. Repolarisation

Depolarisation - Initial phase of action potential

⬇

Which inside become positive & outside become negative.

- ✓ Polarized state (RMP) Abolished resulting in depolarisation.

Repolarisation –

Phase of action potential

⬇

Which reverses back to RMP(inside become –ve & outside become +ve).

- ❑ Polarised state is Re - established.

Properties –

- Propagative
- Long – distance signal
- Both depolarization and repolarization

- Obeys all – or none law
- Summation is not possible
- Has refractory period

ACTION POTENTIAL CURVE

Graphical registration of electrical activity that occurs in an excitable tissue such as muscle after stimulation.

Types : -

1. Latent period
2. Depolarization
3. Repolarization

1. LATENT PERIOD

It is period when no change occurs in the electrical potential immediately after applying the stimulus.

Duration - 0.5 to 1 millisecond.

Stimulus artifact -

When a stimulus is applied, there is a slight irregular deflection of baseline for a very short period. This is called stimulus artifact.

because of the disturbance in the muscle due to leakage of current

from stimulating electrode to the recording electrode.

2. DEPOLARIZATION

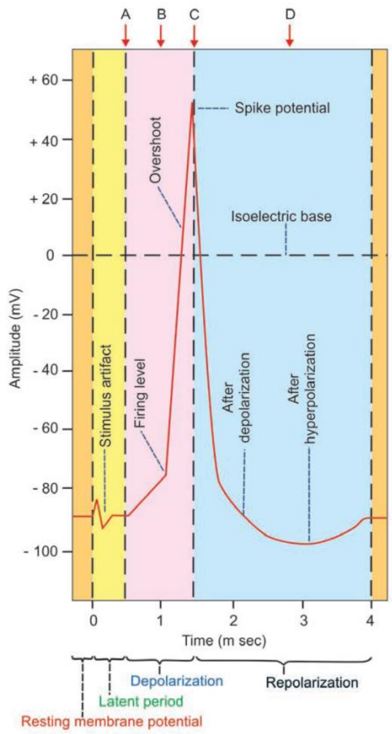
- Muscle is depolarized for about 15 mV.

Firing level and depolarization-

After the initial slow depolarization for 15 mV

Rate of depolarization increases suddenly.

Point at which, the depolarization increases suddenly is called firing level.



OVERSHOOT

From firing level, the curve reaches **isoelectric potential (zero potential) rapidly and then shoots up (overshoots)** beyond the zero potential **(isoelectric base) up to +55** mV.

3. REPOLARIZATION

Initially, Repolarization occurs rapidly and then it becomes slow.

Spike potential -

- Rapid rise in depolarization and the rapid fall in repolarization are together called spike potential.
- It lasts for 0.4 millisecond.

AFTER DEPOLARIZATION OR NEGATIVE AFTER POTENTIAL –

Rapid fall in repolarization is followed by a slow repolarization.

Duration - 2 to 4 milliseconds.

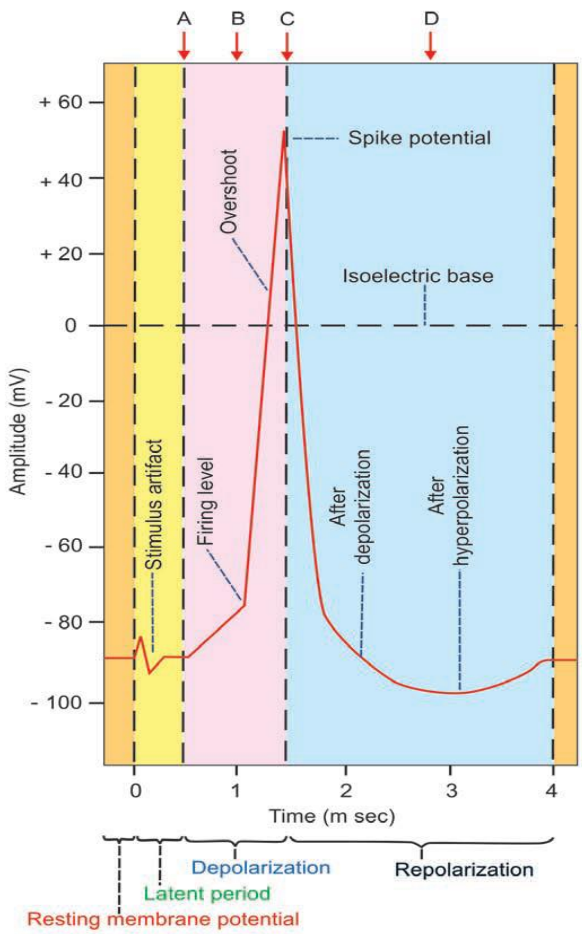
AFTER HYPERPOLARIZATION OR POSITIVE AFTER POTENTIAL –

After reaching the resting level (–90 mV)

Becomes more negative beyond resting level (duration - 50 milliseconds)

⬇

After this, resting membrane potential is restored slowly.



IONIC BASIS OF ACTION POTENTIAL

During the onset of depolarization,

⬇

voltage gated sodium channels open and there is slow influx of Na+.

⬇

Na+ channel activation(depolarization reaches 7 to 10 mV).

⬇

Na+ channels start opening at a faster rate (Na+ transport in short lived).

⬇

At the same time, K+ channels start opening (leads to efflux of K+ out of the cell).

⇓

causing repolarization (K+ channel open for longer time)

⇓

Causes efflux of more number of K+ producing

⇓

More negativity inside

⇓

Cause hyperpolarisation.

MCQ -

Q.1. The resting membrane potential is estasblished primarily due to -
a. sodium – potassium pump
b. efflux of potassium
c. influx of sodium
d. both b and c.

Q. 2. The resting membrane potential is maintained by –
a. ion leaks
b. neurotransmitters
c. ion pumps
d. both a and c

Q. 3. Resting membrane potential of neurons is maintained by –
a. hormones
b. neurotransmitter
c. ion channels
d. none of these

Q. 4. The resting potential is maintained largely by the sodium pump –
a. true
b. false

Q. 5. Membrane potential is present only in nerve cells.

A. true

b. false

Q.6.Which of the following has the highest permeability in a resting nerve cell.

a. Na+

b. Cl-

c.I-

d. K+

Q.7. Depolarization is when ……………… ions flow inside the neurons membrane.

a. potassium

b. sodium

c. chloride

d. magnesium

Q.8. A neuron fibers when ……………..

a. action potential ia achieved

b. apoptosis is induced

c. re – stimulation occurs

d. stimulation ceases

Q.9. Action potential can only in the forward direction.

a. true

b. false

Q. 10. Myelin sheath is composed mainly of ……………..

a. proteins

b. lipids

c. nucleic acid

d. cholesterol

Answers – 1 – b , 2 – c , 3- c , 4 – a , 5 – b, 6 – d , 7 – b , 8 – a , 9 – a , 10 – b.

Chapter- 4.

ACID – BASE BALANCE

The Normal PH of blood is maintained in narrow range of 7.35 – 7.45 (slightly alkaline)
eg. RBC – PH – 7.2
Skeletal muscle – 6.0 (slightly acidic)

- ✓ Change in blood ph will after the intracellular ph which, in iron, influence the metabolism.
  Eg. – distortion in protein structure – due to highly acidic, denaturation (loss of biological activity) – (due to enzyme activity – loss) .

PRODUCTION OF ACIDS BY THE BODY –

- ✓ The metabolism of body is accompanied by an overall production of acids.
- ✓ Carbonic acid formed from metabolic product of Co2.
- ✓ Lactic acid is produced in anaerobic metabolism.
- ✓ Sulfuric acid generated from proteins.
- ✓ A diet rich in animal protein results in more acid production by the body that leads to excretion of urine(acidic).

PRODUCTION OF BASES BY THE BODY –

- ✓ Some amount of bicarbonate generated from the organic acids such as lactate and citrate.
- ✓ Vegetarian diet produced salts of organic acids such as sodium lactate which can utilize H+ ions produced in the body.
- ✓ Vegetarian diet has an alkaline effect of the body.
- ✓ Excretion of neutral/ alkaline urine.

MCQ –

Q. 1. Excessive citrate in transfused blood can cause which of the following abnormalities.
a. metabolic alkalosis
b. metabolic acidosis
c. respiratory alkalosis
d. respiratory acidosis

Q. 2. All the true for renal handling of acids in metabolic acidosis except –
a. hydrogen ion secretion ins increased

b. bicarbonate reabsorption is decreased
c. urinary acidity is increased
d. urinary ammonia is increased.

Q. 3.Carbonic anhydrase is present at all places except –
a. gastric parietal cells
b. red blood cells
c. renal tubular cells
d. plasma.

Q. 4. Which out of the following conditions will not cause respiratory alkalosis.
a. fever
b. anxiety
c. laryngeal obstruction
d. salicylate toxicity

Q. 5 Causes of lactic acidosis include all except –
a. acute myocardial infarction
b. hypoxia
c. circulatory failure
d. infections

Q. 6. A student is nervous for a big exam and is breathing rapidly, what do you expect out of the followings.
a. metabolic acidosis
b. metabolic alkalosis
c. respiratory acidosis
d. respiratory alkalosis

Q. 7. What is the normal range of ph in the body.
a. 35- 45
b. 22 – 26
c. 7.35 – 7.45
d. both a and b

Q. 8. If bicarbonate caused the acidosis or the alkalosis, what type is it .
a. metabolic
b. respiratory
c. combined
d. none .

Q. 9. If Co2 causes acidosis or alkalosis, what type is it.
a. metabolic
b. respiratory
c. combined
d. none
Q.10. What is the normal range of bicarbonate ion in arterial blood.
a. 35 – 45 mEq/L
b. 22 – 26 m Eq/L
c.7. 35 – 7.45 m Eq/L
d. none.

Answers – 1- a, 2 – b , 3- d, 4- c, 5 –d ,6- d , 7 – c , 8 – a , 9 – b , 10 – b.

Chapter - 5

WATER AND ELECTROLYTE BALANCE

The term body fluid refers to body water and its dissolved solutes. Human beings are mostly water, ranging from about 75% of body mass in infants to about 50-60% in adult men and women, to as low as 45% in old age.

The percentage of body water changes with development, because the proportions of the body change from infancy to adult hood.

Our brain and kidneys have the highest proportions of water, which compose 80-85% of their masses. In contrast, teeth have the lower proportion of water, at 8-10%.

FLUID COMPARTMENTS -

The intracellular fluid (ICF) compartment includes all fluid enclosed in cells by their plasma membranes.

Extra Cellular fluid (ECF) surrounds all cells in the body. ECF has 2 primary constituents; the fluid component of blood (called plasma) and the interstitial fluid (IF) that surrounds all cells not in the blood.

The ICF makes up about 60% of the total water in the human body, and in an average-size adult male, the ICF accounts for about 25 liters of fluid. ICF volume tends to be very stable, because the amount of water in living cells in closely regulated.

The ECF accounts for the other one-third of body's water content. About 80% of ECF is interstitial fluid and 20% is blood plasma.

FLUID BALANCE -

When we say that the body is in fluid balance, we mean the required amount of water is present and is well proportioned among the various compartments.

The primary method of water movement into and out of body fluid compartments is osmosis. Thus, the solute concentration in the fluids determines the direction of water movement.

Most solutes in body fluids are electrolytes-'inorganic compounds that dissociate into ions'. Fluid balance hence means water and electrolyte balance.

BODY WATER -

Average adult takes in about 2500 ml of aqueous fluids. Most of the intake comes through digestive tract (through ingested liquids 1600 ml and moist foods 700 ml), about ml per day is generated metabolically, in the last steps of aerobic respiration. Additionally, each day same volume of water (2500 ml) leaves the body by different routes, most of it as urine and others via skin and as air expelled from lungs.

Regulation of water intake -

The water that leaves the body, as exhaled air, sweat or urine, is ultimately extracted from blood plasma.

- ✓ Thirst is a powerful regulator of fluid intake that operates in the **following manner** -

1. When water loss is more than water gain, it results in a condition called dehydration.

2. Dehydration stimulates thirst by decreasing saliva production, increasing blood osmotic pressure and decreasing blood volume.

3. Decreased saliva production causes dryness of mouth and pharynx. Increased blood osmotic pressure stimulates osmoreceptors in the hypothalamus and decreased blood volume stimulates release of renin and angiotensin II.

4. A dry mouth, stimulated osmoreceptors and increased angiotensin II in blood all stimulate the thirst center in hypothalamus.

5. Due to this thirst sensation is increased and it leads to increased fluid intake and dehydration is relieved.

Regulation of water output -

The hormones that regulate fluid loss are Anti diuretic hormone (ADH) and aldosterone.

1. A decrease in blood volume stimulates release of ADH and an increase in angiotensin II stimulates release of aldosterone.

2. ADH and aldosterone both slow fluid loss in urine.

Composition of body fluids -

The composition of plasma and interstitial fluid (IF) are more similar to each other than either is to intracellular fluid (ICF).

Blood plasma has high concentrations of sodium, chloride, bicarbonate and protein.

Interstitial fluid has high concentrations of sodium, chloride and bicarbonate, but a relatively lower concentration of protein.

Intracellular fluid has elevated amounts of potassium, phosphate, magnesium and protein.

Most body fluids are neutral in charge. The cations and anions are balanced in fluids,

Movement of Body fluids -

Exchange between plasma and interstitial fluid

The movement of substances between plasma and interstitial fluid occurs across capillary walls via three ways.

1. Vesicular transport

2. Diffusion

3. Bulk Flow (Filtration and Reabsorption)

1. In vesicular transport - first the substances in blood plasma cross the capillary wall and enter endothelial cell by endocytosis and then enter interstitial fluid by exocytosis. Only a small fraction of exchange occurs via this way.

2. Diffusion - Most substances cross the capillary wall by diffusion. Substances such as O_2, CO_2, glucose, amino acids, hormones and others diffuse through capillary walls down their concentration gradients.

3. Bulk flow - Consists of both filtration and reabsorption. Filtration predominates at the arteriolar ends of capillaries whereas reabsorption predominates at the venular ends of capillaries.

- ✓ At the arteriolar end of capillary, the "hydrostatic pressure" of blood (pressure exerted by blood against the walls of the blood vessels) is higher than the opposing colloid osmotic pressure in blood (a constant pressure primarily produced by circulating albumin). This pressure forces fluid and nutrients out of the capillaries into the surrounding tissues. At the venule, the hydrostatic pressure is less than the osmotic pressure in the vessel.

Exchange between interstitial and intracellular fluids -

Normally, intracellular fluid and interstitial fluid have the same osmotic pressures. So, the cells neither shrink nor swell. A change in their osmotic pressures can lead to fluid imbalance between these two compartments. In most of the cases, an osmotic pressure change is due to a change in the concentration of Na^+ (principal cation outside cells) or the concentration of K^+ (principal cation inside cells).

- ✓ ADH and aldosterone regulate Na^+ balance in body while aldosterone is the main regulator of K balance.

Electrolytes in body fluids -

- ✓ The body contains a large variety of ions, or electrolytes, which perform a variety of functions. Some ions assist in the transmission of electrical impulses along cell membranes in neurons and muscles.
- ✓ All of the ions in plasma contribute to the osmotic balance that controls the movement of water between cells and their environment.
- ✓ Electrolytes in living systems include sodium, potassium, chloride, bicarbonate, calcium, phosphate, magnesium, copper, zinc, iron, manganese, molybdenum, copper and chromium. In terms of body functioning six electrolytes are most important. These are sodium, potassium, chloride, bicarbonate, calcium and phosphate.

- ❑ **Sodium -**

- ✓ It is the major cation of the extracellular fluid. Excretion of sodium is accomplished primarily by the kidneys.

- ❑ **Potassium**

- ✓ It is the major intracellular cation. The low levels of potassium in blood and CSF are due to sodium-potassium pumps in cell membranes, which maintain the normal potassium concentration gradients between ICF and ECF. It is excreted, both actively and passively by renal tubules, especially DCT and collecting ducts. Functions are mentioned in chapter of minerals.

- ❑ **Chloride**

- ✓ Bicarbonates, calcium and phosphate are mentioned in detail in chapter of minerals

MCQ –
Q. 1. Which is not a cause of hypokalemia.
a. insulin administration
b. adrenaline infusion
c. alkalosis

d. digoxin

Q. 2. What is not a cause of hypercalcemia .
a. post prandial measurement
b. tuberculosis
c. renal failure
d. hypomagnasemia

Q. 3.Which does not cause a high osmolar gap, increased anion gap metabolic acidosis.
a. methanol
b. ethanol
c. acetone
d. chloral hydrate

Q. 4. Which condition can be fully compensated for with regards to ph .
a. respiratory acidosis
b. respiratory alkalosis
c. metabolic acidosis.
d. none.

Q. 5 . Which does not cause a metabolic alkalosis .
a. vomiting
b. diarrohea
c.loop diuretics
d. none.

Q. 6. Which condition needs extra assessment when considering hypertonic solutions.
a. respiratory
b. renal
c. heart
d. liver

Q. 7 . K is important for what functions.
a. muscle function
b. insulin
c. protein regulation
d. all the above.

Q. 8. A patient is hyperkalemic , which foods are best for thiss patients.
a. whole grain bread

b. low Na
c. beans and chicken
d. pudding

Q. 9. How much Ca is stored in thew bones.
a. 1%
b.2%
c.95%
d.99%

Q.10. Calcitonin is released when C++ level are at –
a. low
b. average
c. high
d. none of the above.

Answers- 1 – d, 2- d , 3- d, 4- b , 5- b, 6- c, 7 – d, 8 – c , 9 – d , 10 –d.

Chapter - 6

BASIC COMPONENTS OF FOOD

The basic components of food are as follows-

1. PROTEINS -

- ✓ Proteins are required to make up the loss due to daily wear and tear of the body tissues. They promote growth of children and convalescents by laying down new body tissues. They are also essential for synthesis of enzymes, protein hormones and plasma proteins.

- ✓ Our body synthesizes its own proteins from 20 different amino acids. Of these 20 amino acids, 10 are essential and the other 10 can be synthesized by the body from intermediaries of carbohydrate and fat metabolism.

- ✓ Proteins which contain all the 10 essential amino acids and called 1" class proteins. Animal proteins (meat, fish, egg and milk) are usually 1 class proteins. Gelatin is an exception.
- ✓ Vegetable proteins are often 2nd class proteins i.e. they do not contain all essential amino acids. Hence a combination of different vegetables should be taken to achieve full value of proteins.

- ✓ An average adult needs 50 gms of protein daily.

2. CARBOHYDRATES -

- ✓ Carbohydrates are necessary to supply our body with glucose, which is the primary source of energy. They are generally divided into **3 categories viz.**

1. SIMPLE SUGARS -

These are again divided into 2 sub groups. Monosaccharides like glucose and fructose and disaccharides like sucrose, lactose and maltose.

Sources of simple sugars include fruits, processed grains like wheat, rice, sugarcane, milk.

Complex sugars or polysaccharides -

They digest slowly and the best example is starch. Starch is found in rice, wheat, potato, starchy vegetables.

2. FIBERS -

Fibers are carbohydrates which cannot be digested. Cellulose, lignin and pectin are examples. They do not supply calories but increase the bulk of stool. Legumes, whole grains and berries are good sources of dietary fiber,

- ✓ Daily recommendation of carbohydrates for healthy adults is 225 gm.

3. FATS -

Food fat supplies calories. I gm of fat supplies 9kcal. Fat contains the essential fatty acids which cannot be synthesized by the body. Fat also is the vehicle for fat soluble vitamins (A, D, E and K).

- ✓ Essential fatty acids are- linoleic acid, linolenic acids and arachidonic acid
- ✓ Most food fats are triglycerides. Depending upon the nature of fatty acids in the triglycerides, they can be divided into **three groups**. -

1. Saturated fats.
2. Monounsaturated fats
3. Polyunsaturated fats.

   - ❑ Healthy fats include monounsaturated and polyunsaturated e.g. nuts, olives and avocados are sources of monounsaturated fats and fish and sea food are primary sources of polyunsaturated fats.
   - ❑ On the other hand, foods like mutton fat, beef fat, pork fat, coconut oil are examples of saturated fat and are bad for health. They increase the risk of heart diseases.

- ✓ Daily intake of fat for healthy adults is 44 grams.

4. VITAMINS -

Many vitamins are essential for health and thus considered primary component of nutrition. They are discussed in detail in chapter of vitamin and minerals.

5. MINERALS -

Minerals are vital for proper human health. They are discussed in detail in chapter of vitamin and minerals.

6. WATER -

Water is necessary to maintain proper bodily function. It is discussed in detail in chapter of water and electrolyte balance.

Chapter - 7

VITAMINS AND MINERALS

VITAMINS -

Vitamins are organic molecules that are needed in small quantities for normal metabolism throughout the body. Most vitamin molecules attach to enzymes or coenzymes and help them work properly. Vitamin cannot be synthesized in the body.

They must be supplied from outside eg. Through foods. Some vitamins like Biotin, some members of vitamin B complex are synthesized by the bacteria of intestine. One exception is vitamin D.

- ✓ Dehydrocholesterol which is normally present in our on exposure to sunlight is converted into vitamin D.
- ✓ The body can store fat soluble vitamins-A, D, E and K in the liver for later use. But it cannot store significant amounts of water soluble vitamins such as vitamin B and vitamin C. So, they must be continually supplied in the diet.

FAT SOLUBLE VITAMINS -

- ❑ **VITAMIN A (RETINOL) -**

Sources -

(i) Naturally occurring vitamin A is called Retinol. It is obtained from animal tissues only. The richest source of vitamin A is sea fish liver oil. Cod liver oil, shark liver oil, butter, egg, yolk are other good sources.

(ii) The pro vitamin, beta carotene is present in plant tissues. Yellow and green part of the plant contains maximum à carotene. Carrots are rich in à carotene. Papaya, mango, pumpkin, spinach are other good sources.

Daily requirement -

The recommended daily allowance for

(1) Children = 400-600 mcg/day

(ii) Men = 750-1000 mcg/day

(iii) Women = 750 meg/day

(iv) Pregnancy = 1000 mcg/day

Functions -

1. It maintains the normal epithelial tissue of the body and prevents keratinization of epithelia.

2. Produces visual pigments. The form of vitamin A called Retinol.

3. Retinol is required for normal reproduction. It acts like a steroid hormone in controlling the expression of certain genes.

4.Antioxidant property – Play an important role in cancers and vitamin A deficiency.

Manifestation of hypovitaminosis A

1. **Eye signs -**
   It results in thickening of corneal epithelium and eyes become dry. The condition is called Xerophthalmia.

Bitot's spots -

On the cornea are seen as an early sign of vitamin A deficiency. It results in night blindness.

2. Skin changes -

It causes hyper keratinization of the skin and atrophy of the sweat glands.

3. Respiratory tract -

The epithelial cells of the respiratory tract become keratinized and lose the power to secrete mucus leading to repeated respiratory tract infections.

4. GI Tract -

Vitamin A deficiency results in changes in epithelial cells and disappearance of goblet cells leading to diarrhea.

4. **Urinary tract -**

   The dead epithelial cells form debris in the urinary tract, helping the bacteria to grow over them This leads to urinary tract infections,

Hyper vitaminosis A

Excessive intake can lead to toxicity since the vitamin is stored. It is seen in children whose parents are overzealous in vitamin A supplementation.

Symptoms of toxicity include anorexia, irritability, headache, peeling of skin, drowsiness and vomiting.

❑ Vitamin D (Cholecalciferol)

Sources -

Fish liver oil, fish, egg, yolk are good sources of the vitamin. Milk contains moderate quantity of the vitamin. Epidermis of our skin contains 7dehydrocholesterol which is a precursor of vitamin D in the human body.

Daily Requirement -

(i) Children 10 mcg/day

(ii) Adults=5 mcg/day

(iii) Pregnancy, lactation= 10 mcg/day

Functions - The active form of vitamin D has profound influence on calcium and phosphorus metabolism mediated through its actions on intestine, bone and kidneys.

Deficiency -

1. Deficiency of vitamin D manifests as rickets in children. Also the ribs are deformed. A characteristic swelling is seen at costochondral joints called **rachitic rosary.**

2. In adults deficiency of vitamin D manifests as osteomalacia. It results in poorly calcified bones with fracture with even mild trauma.

❑ Vitamin E (Tocopherol)

Sources

Vegetable oils are rich sources of vitamin E e.g. wheat germ oil, sunflower oil, safflower oil, cotton seed oil etc.

Daily requirement -

Males - 10 mg/day

Female - 8 mg/day

Functions -

1. It is the most powerful natural antioxidant. Vitamin E protects the plasma membrane from the attack of free radicals.
2. Vitamin E protects RBC from hemolysis. It prevents peroxidation, thus keeping the structural and functional integrity of all cells.
3. Vitamin E boosts immune response.
4. It reduces the risk of atherosclerosis.

Deficiency Manifestations -

Animal studies show disorders of -

(i) Skeletal muscles (Myopathy)

(ii) Cardiac muscles

(iii) Reproductive system

(iv) Nervous system

Human deficiency has not been reported. But volunteers have shown increased fragility of RBCs, muscular weakness and creatinuria.

Hypervitaminosis E -

At doses above 1000 IU/day, it may cause tendency to hemorrhage, as it is a mild anticoagulant.

❑ Vitamin K

Sources -

Vitamin K is present in two naturally occuring substances.

(i) Vitamin K, Present in the plant foods specially green leafy vegetables and used medicinally.

(ii) Vitamin K, synthesized by the bacteria of the human intestinal flora.

Daily Requirement - 50-100 mg/day

Functions -

- ✓ Vitamin K is necessary for coagulation.
- ✓ Factors dependent on vitamin-K are Factor II (Prothrombin), Factor-VII (Stable factor.) Factor- IX (Christmas factor), Factor X (Stuart Prowers Factor).

Clinical manifestations of deficiency

Vitamin K deficiency causes delayed coagulation as seen in clinical features of hemophilia.

❑ WATER SOLUBLE VITAMINS

- ✓ Vitamin B complex consists of a group of vitamins, all of which are water soluble.
- ✓ The important members of vitamin B complex group are enumerated as under:-

(i) Thiamine (Vitamin B_1)

(ii) Riboflavin (Vitamin B_2)

(iii) Niacin

(iv) Pyridoxine

(v) Pantothenic acid and co-enzyme A

vi) Biotin

(vii) Folic acid

(viii) Vitamin B_{12}

❑ Vitamin B_1

Sources - It is present widely in plant foods; particularly rich sources are polishings of rice and husks of wheat. Yeast is also an excellent source. Which is a rich source of thiamine.

Daily Requirement -

Requirement is 1-1.5 mg/day.

Functions - 1. It acts as coenzyme for many different enzymes that break carbon to carbon bonds and are involved in carbohydrate metabolism of pyruvic acid to CO_2 and H_2O.
2. It is essential for synthesis of acetylcholine.

Deficiency - 1. Beri Beri

Vitamin B_1 deficiency causes two forms of beri beri.

(i)Dry -
In this condition, CNS manifestations are major feature. Peripheral neuritis with sensory disturbance leads to complete paralysis.

(ii) Wet –
Here cardiovascular manifestations are prominent. Edema of legs, face and trunk are main feature. Palpitation, breathlessness and distended neck veins are observed. Death occurs due to heart failure.

(iii) Polyneuritis –
It is common in chronic alcoholics. Alcohol utilization requires large doses of thiamine. Also it inhibits intestinal absorption of thiamine leading to thiamine deficiency

❑ Vitamin B_2 (Riboflavin)

Sources - Rich sources are liver, yeast, egg and whole milk. Other good sources are fish, whole cereals, germinating seeds, legumes, green leafy vegetables.

Daily Requirement – Adults: 1.5 mg/day.

Functions - It acts as component of certain coenzymes for example FAD and FMN in carbohydrate and protein metabolism especially in cells of eye, skin, intestinal mucosa and blood.

Deficiency signs –

1. **Oral –**

Cheilosis- It is the fissuring of the red parts of the lips.

Angular stomatitis - It is the inflammation at the corners of mouth.

Glossits - Inflammation of the tongue.

II. Ocular -

- ✓ Circumcorneal vascularization occurs.
- ✓ Proliferation of the bulbar conjunctival capillaries is the earliest sign of riboflavin deficiency.

III. Skin –

Dermatitis of the face is common. Dermatitis of the trunk and extremities also occur.

IV. Anemia

Normocytic anemia is common.

❑ NIACIN

Sources - The richest natural sources are dried yeast, rice polishing, liver, peanut, whole cereals, legumes, meat and fish.

Daily Requirement - 20 mg/day.

Functions –

1. It is an essential component of NAD and NADP, coenzymes in oxidation - reduction reactions.

2. In lipid metabolism it inhibits production of cholesterol and assists in triglyceride breakdown.

Deficiency -

Clinically it results in Pellagra (meaning rough skin) Features of Pellagra –

1. Dermatitis

2. Diarrhea

3. Dementia and if not treated eventually death occurs.

❑ Vitamin B_6 –Pyridoxine

It is synthesized by bacteria of GIT and stored in liver, muscle and brain.

Sources - Rich sources are yeast, rice polishing, wheat germs, cereals, legumes, oil seeds, egg, milk, meat, fish and green leafy vegetables.

Daily Requirement - Adults-1-2 mg/day

Functions -

1. It acts as an essential co-enzyme for normal amino acid metabolism.
2. It assists production of circulating antibodies.

Deficiency signs -

1. Neurological Manifestation

Neurological symptoms like convulsion and peripheral neuritis are seen.

2. **Dermatological Manifestations** -

Dermatitis of eye, nose and mouth.

❑ Pantothenic Acid

This vitamin is needed for the synthesis of co-enzyme A.

Sources - It is widely distributed in plants and animals. It is also synthesized by the normal bacterial flora in intestines. Yeast, liver and eggs are good sources.

Daily requirement - 10 mg/day

Functions - Co-enzyme A is an important component of fatty acid synthase complex, cell respiration etc.

Deficiency symptoms -

Fatigue, muscle spasm and neuromuscular degeneration.

❑ Biotin

Sources – Normal bacterial flora of gut, liver, yeast, soybean, milk, egg yolk.

Requirement - 200-300 mg

Function - Biotin acts as co- enzyme for conversion of pyruvic acid to oxaloacetic acid and synthesis of fatty acids and purine

Deficiency - Mental depression, muscular pain, dermatitis, fatigue and nausea.

❑ Folic Acid

Sources - Yeast, green leafy vegetables, cereals, pulses, oil seeds and egg.

Daily Requirement - 200 mcg/day , Pregnancy - 400 mcg/day

Function -

- ✓ It is a component of enzyme systems synthesizing purines and pyrimidines built into DNA and RNA.
- ✓ It is essential for normal production of red and white blood cells.

Deficiency - 1. Reduced DNA synthesis.

2. Macrocytic Anemia.

3. Birth defects-Folic acid deficiency during pregnancy may lead to neural tube defects in the fetus.

4. Cancer-Folic acid is beneficial in prevention of bronchial carcinoma and cervical carcinoma.

❑ Vitamin B12

It is the only vitamin containing cobalt.

Sources - Rich sources of vitamin B_{12} are all animal products like liver, muscle, egg and milk. Vegetables do not contain vitamin B_{12}

Daily Requirement - 3 to 5 mg

Functions - It acts as coenzyme necessary for red cell production, formation of amino acid methionine and manufacture of choline (used to synthesize acetylcholine)

Deficiency symptoms -

- ✓ Macrocytic anemia, neurological disorders like memory loss, ataxia.
- ✓ Demyelination and death of neurons occur in spinal cord and brain.

❑ Vitamin C (Ascorbic Acid)

Sources - It is found only in plant foods. Richest source is amla, lime, lemon, oranges. Small amounts are also present in potato and fresh green vegetables.

Requirement: - 40 mg/day

Larger intake is required after major surgery or injury to facilitate formation of connective tissue during healing.

Functions -

1. Vitamin C is essential for hydroxylation in connective tissue during collagen synthesis.

2. It is involved in the formation of dentin in the teeth.

3. It functions as antioxidant in the body.

4.It is involved in formation of Neurotransmitter norepinephrine and serotonin in Central Nervous System.

Deficiency - Severe deficiency of vitamin C is called Scurvy.

1. Vitamin C deficiency affects connective tissue formation particularly blood vessels, leading to abnormal petechial hemorrhages under the skin.

2. Bleeding of guns is a common symptom.

3. Joint pain can occur due to bleeding in joints.

4.Generalized weakness and flaccidity of muscles.

❑ MINERAL

Minerals are required in trace amount and usually work as cofactors and enzymes. Minerals present in body can be classified as:-

1. Macro minerals - Macro minerals are calcium, magnesium, sodium, potassium, phosphorus, and chloride. They constitute 60-80% of all inorganic material in the body.

2.Micro minerals - These are required in very small amounts. They are iron, iodine, manganese, copper, chromium, zinc, selenium and fluoride.

MACRO MINERALS -

❑ Calcium

Calcium content of body and blood -

- ✓ Calcium (Ca) is the major inorganic element comprising nearly 2% of body weight.
- ✓ Human body has 1200 gm of calcium.
- ✓ Major amount is present in bone and teeth (99%). Only 1% is in blood and soft tissues.
- ✓ Serum calcium level in human adult is 9-11 mg/100 ml.

Blood calcium is present in three different forms -

i Ionized calcium which is the physiologically active form (4.5-5.5 mg%).

ii. Albumin bound calcium (4-4.5 mg%).

iii. Calcium complexes with citrate, phosphate and bicarbonate (0.5 mg%).

- ✓ Blood calcium level is controlled by calcitonin and parathyroid hormones. Absorption occurs only in the presence of vitamin-D

Sources - Milk, egg yolk, shellfish, green leafy vegetables.

Daily Requirement - Children-1.2gm/da , Adult-0.8 gm/day**,**

Pregnancy and lactation- 1.2gm/ day

Functions - 1. Formation of bones and teeth.

2. Required for blood clotting.

3. Required for normal muscle and nerve activity,

4. Calcium is the mineral and cation of the extracellular fluid.

5. It is required for contraction of heart.

6. It controls the permeability of the cell membranes.

7. Releases hormones like insulin from storage granules.

❑ Phosphorus

- ✓ Phosphorus content of body and blood
- ✓ About 80% of phosphorus is found in bones and teeth as phosphate salts.
- ✓ Remainder is distributed in muscle, brain cells and blood as phosphate ions (HPO_4).
- ✓ Blood phosphate level is controlled by calcitonin and parathyroid hormone

Sources - Milk, meat, cereals, nuts.

Daily Requirement - Adult 800 mg/day.

Functions -1. Formation of bones and teeth.

2. Phosphates constitute a major buffer system of blood

3. It plays important role in muscle contraction and nerve activity.

4. It is component of many enzymes.

5. It is involved in energy transfer (ATP).

6. It is component of DNA and RNA.

❑ Magnesium

Magnesium is an important cation (Mg^2) in intracellular fluid. About 70% of total magnesium is in skeletal tissues. The remainder is in muscle, brain and other tissues.

Sources - Green leafy vegetables, whole grains, nuts, sea food.

Daily Requirement - Adult-300 mg/day, Children-250 mg/day

Functions - 1. It is required for normal functioning of muscle and nervous tissue.

2. It participates in bone formation.

3.It is a constituent of many coenzymes.

4. Its deficiency is linked to hypertension, high blood levels of cholesterol and spasm in blood vessels.

❑ Sodium

- ✓ Sodium (Na^+) is the major cation of the extracellular fluid. Most of the body's sodium is located in the blood and in the fluid in the space surrounding the cells.
- ✓ Sodium is required by all cells in the body to maintain a normal fluid balance.

Sources - Table salt, cereals, legumes, egg, carrot, tomato, milk.
Daily Requirement - 5 gm/day

Average daily intake from table salt is 5-10 gm/day.

Functions - 1. It maintains osmotic pressure, ie, it maintains the volume of blood and blood pressure. Sodium loss causes blood volume to decrease.

2. It regulates the electrolyte and pH balance of extracellular compartment.

3. It controls the electronic potentials of excitable tissues such as nerve and muscle

4. It helps in the active transport of glucose, galactose and amino acids across intestinal mucosa and for Na/K-ATPase.

Average serum sodium level: - 142 mEq/L

❑ Potassium

- ✓ Potassium is the most important cation of intra cellular fluid (ICF).
- ✓ Its average concentration in ICF is 150 mEq/L.
- ✓ Extra cellular concentration of potassium is 3.5-5 mEq/L.

Extra cellular potassium is important for its controlling influence upon neuromuscular irritability, cardiac muscle and the orientation of Na/K-ATPase (Na pump) against the concentration gradient.

Sources - Milk, banana, melon, potato, spinach, raisins, peas, beans.

Daily Requirement - 4 gm/day

Functions 1. It is the principal cation of ICF.

2. It is required for the functioning of nerves, skeletal muscle and cardiac muscles.

3. Potassium is required as a co-factor in several enzymatic reactions in the body.

4. Potassium is involved in the acid-base balance.

- **Chloride**

It is the major extracellular anion. Its serum concentration is 105 mEq/L.

Normal intake of NaCl supplies required amounts.

Functions - 1. It plays role in acid-base balance of blood.

2. It plays role in water balance.

3. It helps in formation of HCI in stomach.

MICRO MINERALS -

- **Iron**

✓ It is a trace element. Total body iron is about 5gm.

Sources - Liver, meat, egg yolk, vegetables, whole wheat, legumes, dates.

Functions -

Iron is necessary for synthesis of certain proteins, eg. Heme proteins , non heme proteins.

Daily Requirement -

Adult male-12 mg/day , Female- 20 mg/day

Pregnancy and lactation- 40 mg/day

- **Copper**

Sources - Fish, liver, nuts, green vegetables.

Daily Requirement - Adult-3mg/day

Functions -1. It is required with iron for synthesis of hemoglobin.

2. It is a component of coenzymes in electron transport chain.

3. It is necessary for enzymes needed for melanin pigment formation.

- **Zinc**

Sources - Meat, egg, fish, spinach, lettuce.

Daily Requirement -

Adult- 10-15 mg/day

Children-3-15 mg/day

Pregnancy and lactation -20-25 mg/day

Functions - 1. As a component of carbonic anhydrase, important in carbon dioxide metabolism.

2. It is necessary for normal growth and wound healing, normal taste sensations and appetite, and normal sperm counts in males.

3. It is a component of peptidases, involved in protein digestion.

4. Its deficiency leads to impaired immunity and slow learning.

❑ Manganese

Sources - Wheat germ seeds, nuts, leafy vegetables, meat.

Daily Requirement - Adult-3.5 mg/day , Children 0.2 mg/day

Functions - 1. It activates several enzymes.

2. It is needed for hemoglobin synthesis, urea formation, growth, reproduction, lactation, bone formation and inhibiting cell damage.

❑ Selenium

Sources - Fish, meat, egg yolk, whole grain

Daily Requirement - Adult-0.2 mg/day

Functions - 1. Acts as an antioxidant.

2. It prevents chromosome breakage and may play a role in preventing certain birth defects and esophageal cancer.

❑ Fluoride

Sources - Fish, tea, drinking water.

Daily Requirement - Adult 1-2 mg/day

Functions - It is needed for bone and teeth formation. The surface layer of enamel contains a higher content of fluoride than deeper layers.

❑ Chromium

Sources – Brewer's yeast, wine, beer, molasses.

Daily Requirement - Adult - 0.05-20 mg/day.

Functions -

1. It functions in the control of glucose and lipid metabolism.
2. Helps in increasing blood levels of HDL, while decreasing levels of LDL.

❑ Iodine

The adult human body contains about 50 mg of iodine.

Sources - Sea food, drinking water, iodized table salt, onions etc.

Daily Requirement - 150 µg/day

Function - Most important role of iodine is in the synthesis of thyroid hormones, T, and T, which regulate metabolic rate.

MCQ –

Q.1. Which of the following components are major nutrients in our food.

a. carbohydrates

b. lipids and proteins

c. vitamins and minerals

d. all the above

Q. 2. Which of the following food components give energy to our body.

a. proteins

b. vitamins

c. minerals

d. carbohydrates

Q. 3.Which of the following minerals functions by building strong bones and teeth.

a. iodine

b. calcium

c.iron

d. sodium

Q.4. Egg is a rich source of …………

a. proteins

b. vitamins

c. minerals

d. all the above

Q. 5. Which of the following food components is rich in fat .

a. rice and maize

b. milk , egg and beans

c. butter, cheese and oil

d. none

Q. 6.Which of the following food items is best source of plant proteins.

a. milk

b.egg

c.legumes

d. cheese

Q.7. Which vitamin helps in keeping our skin and eyes healthy.

a. vitamin A

b. vitamin C

C. vitamin D

d. vitamin E

Q. 8. Which nutrients is primarily responsible for providing roughage in our diet.

a. carbohydrates

b. fats

c. proteins

d. dietary fibers

Q. 9. Which group of vitamins includes vitamin –B complex.

a. vitamin A

b. vitamin C

c. vitamin D

d. vitamin B – Complex

Q. 10. Which nutrients category primarily aids in the growth and repair of our body.

a. carbohydrates

b. fats

c. proteins

d. vitamins

Answers – 1- d, 2- d, 3- b, 4- d, 5 – c, 6 – c, 7- a , 8 – d, 9- d, 10 – c

Chapter - 8

FUNCTIONAL ANATOMY OF RESPIRATORY TRACT

FUNCTIONAL ANATOMY OF RESPIRATORY TRACT -

- ✓ Respiration is the process by which oxygen is taken in and carbon dioxide is given out.
- ✓ The first breath takes place only after birth.
- ✓ Fetal lungs are non-functional**.**

Normal Respiratory Rate at Different Age

Newborn : 30 to 60/minute
Early childhood : 20 to 40/minute
Late childhood : 15 to 25/minute
Adult : 12 to 16/minute.

TYPES OF RESPIRATION

Two types: -

1. **EXTERNAL RESPIRATION -** That involves exchange of respiratory gases, i.e. oxygen and carbon dioxide between lungs and blood.

2. **INTERNAL RESPIRATION -** Which involves exchange of gases between blood and tissues.

PHASES OF RESPIRATION

Two phases: -

1. **Inspiration** during which air enters the lungs from atmosphere.
2. **Expiration** during which air leaves the lungs.

- ❑ During normal breathing --- Inspiration is active process and Expiration is a passive process.

- ❑ Respiratory tract is the anatomical structure through which air moves in and out. It includes nose, pharynx, larynx, trachea, bronchi and lungs.

- ❑ ***Pleura***

  Each lung is enclosed by a bilayered serous membrane called pleura or **pleural sac.**

  Pleura has two layers --- inner **visceral and outer parietal layers.**

Visceral layer - Attached firmly to the surface of the lungs.
Parietal layer - Attached to the wall of thoracic cavity.

Intrapleural Space or pleural cavity - --
Narrow space in between the two layers of pleura.

INTRAPLEURAL FLUID -
Thin film of serous fluid called intrapleural fluid - secreted by the visceral layer of the pleura.

FUNCTIONS OF INTRAPLEURAL FLUID -
1. It functions as the lubricant to prevent friction between two layers of pleura.
2. It is involved in creating the negative pressure called **intrapleural pressure within intrapleural space.**

Pleural Cavity in Abnormal Conditions -
In some pathological conditions, the pleural cavity expands with accumulation of air **(pneumothorax), water (hydrothorax), blood (hemothorax) or pus (pyothorax).**

TRACHEOBRONCHIAL TREE

- ✓ Trachea and bronchi are together called tracheobronchial tree.
- ✓ It forms a part of air passage.

COMPONENTS OF TRACHEOBRONCHIAL TREE -
1. **Trachea bifurcates into two main or primary bronchi** called right and left bronchi.
2. Each primary bronchus enters the lungs and divides into **secondary bronchi.**
3. Secondary bronchi divide into **tertiary bronchi. In** right lung - 10 tertiary bronchi and in left lung - eight tertiary bronchi
4. Tertiary bronchi divide several times with reduction in length and diameter into many generations of **bronchioles**
5. When the diameter of bronchiole becomes 1 mm or less, it is called **terminal bronchiole**
6. Terminal bronchiole continues or divides into **respiratory bronchioles, which have a diameter of** 0.5 mm.

UPPER AND LOWER RESPIRATORY TRACTS -
Generally, respiratory tract is divided into two parts:
1. Upper respiratory tract - All the structures from nose up to vocal cords; vocal cords are the folds of mucous membrane within larynx that vibrates to produce the voice.

2. Lower respiratory tract - Trachea, bronchi and lungs.

Respiratory unit -

Respiratory unit is defined as the structural and functional unit of lung. Exchange of gases occurs only in this part of the respiratory tract.

STRUCTURE OF RESPIRATORY UNIT -

Respiratory unit starts from the respiratory bronchioles. Thus, respiratory unit includes:

1. Respiratory bronchioles
2. Alveolar ducts
3. Alveolar sacs
4. Antrum
5. Alveoli.

ALVEOLAR CELLS OR PNEUMOCYTES -

- Alveolar epithelium consists of alveolar cells or pneumocytes,
- Two types - type I alveolar cells and type II alveolar cells.

Type I alveolar cells -

- ✓ Squamous epithelial cells forming about 95% of the total number of cells.
- ✓ These cells form the site of gaseous exchange between the alveolus and blood.

Type II alveolar cells -

- ✓ Cuboidal in nature and form about 5% of alveolar cells.
- ✓ These cells are also called **granular pneumocytes.**
- ✓ **Type II alveolar cells secrete alveolar fluid and surfactant.**

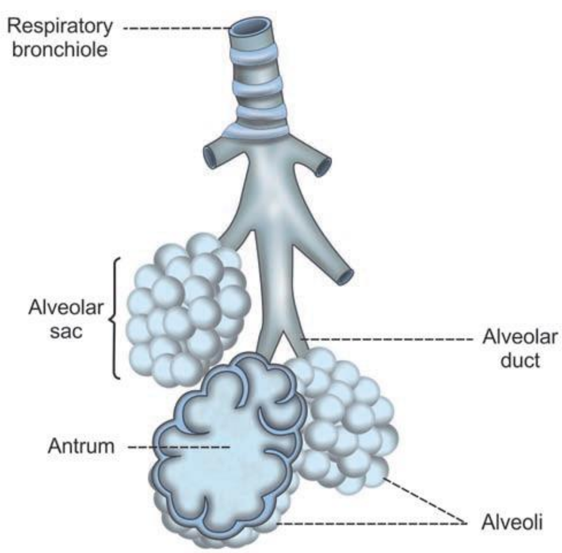


Figure: - Respiratory unit

❑ PULMONARY CIRCULATION -

PULMONARY CIRCULATION - system of blood vessels that forms a closed circuit between heart and lungs, as distinguished from the systemic circulation between the heart and all other body tissues.

PULMONARY BLOOD VESSELS -
Include **pulmonary artery ----** Carries **deoxygenated blood to alveoli of lungs.**
Bronchial artery ---- **Supply oxygenated blood** to other structures of lungs.

PULMONARY ARTERY

✓ Pulmonary artery supplies deoxygenated blood pumped from right ventricle to alveoli of lungs.

✓ After leaving the right ventricle, this artery

⬇

divides into **right and left branches.**

⬇

Each branch enters the corresponding lung along with primary bronchus.

⬇

After entering the lung, pulmonary artery divides into small vessels and finally forms the **capillary plexus.**

⬇

⬇

Capillary plexus is concerned with alveolar gas exchange.

⬇

Oxygenated blood from the alveoli is carried to left atrium by one pulmonary vein from each side.

BRONCHIAL ARTERY -

✓ Bronchial artery arises from descending thoracic aorta.

✓ It supplies arterial blood to bronchi, connective tissue and other structures of lung stroma, visceral pleura and pulmonary lymph nodes.

⬇

Venous blood from these structures is drained by two **bronchial veins from each** side.

⬇

Bronchial veins from right side drain into **azygos vein and left bronchial veins drain into superior hemiazygos**

⬇

However, blood from distal portion of bronchial circulation is drained directly into the tributaries of **pulmonary veins.**

PHYSIOLOGICAL SHUNT

Definition

Physiological shunt is defined as a diversion through which the venous blood is mixed with arterial blood.

PULMONARY BLOOD FLOW

- ✓ Lungs receive the whole amount of blood that is pumped out from right ventricle.
- ✓ Output of blood per minute is same in both right and left ventricle.
- ✓ It is about 5 liter.

Pulmonary Arterial Pressure -

Systolic pressure : 25 mm Hg

Diastolic pressure : 10 mm Hg

Mean arterial pressure : 15 mm Hg.

Pulmonary Capillary Pressure -

Pulmonary capillary pressure is about 7 mm Hg.

This pressure is sufficient for exchange of gases between alveoli and blood.

REGULATION OF PULMONARY BLOOD FLOW

Regulated by the following factors: -

1. Cardiac output

2. Vascular resistance

3. Nervous factors

4. Chemical factors

5. Gravity and hydrostatic pressure

1. CARDIAC OUTPUT

- ✓ Pulmonary blood flow is **directly proportional to** cardiac output.
- ✓ So, any factor that alters the cardiac output, also affects pulmonary blood flow.

Cardiac output is in turn regulated by four factors:

i. Venous return

ii. Force of contraction

iii. Rate of contraction

iv. Peripheral resistance.

2. VASCULAR RESISTANCE

- ✓ Pulmonary blood flow is **inversely proportional to the** pulmonary vascular resistance.
- ✓ Pulmonary vascular resistance is altered in different phases of respiration.
- ✓ During Inspiration - decreased intrathoracic pressure and causes decrease in vascular resistance resulting in increased pulmonary blood flow.
- ✓ During Expiration - the pulmonary vascular resistance increases resulting in decreased blood flow.

3. NERVOUS FACTORS

- ✓ Stimulation of sympathetic nerves under experimental conditions increases the pulmonary vascular resistance by vasoconstriction.
- ✓ And the stimulation of parasympathetic, i.e. vagus nerve decreases the vascular resistance by vasodilatation.

4. CHEMICAL FACTORS

- ✓ Excess of carbon dioxide or lack of oxygen causes vasoconstriction.
- ✓ The cause for pulmonary vasoconstriction by hypoxia.
- ✓ If some part of lungs is affected by hypoxia, there is constriction of capillaries in that area.Thus, blood is directed to the alveoli of neighboring area where gaseous exchange occurs.

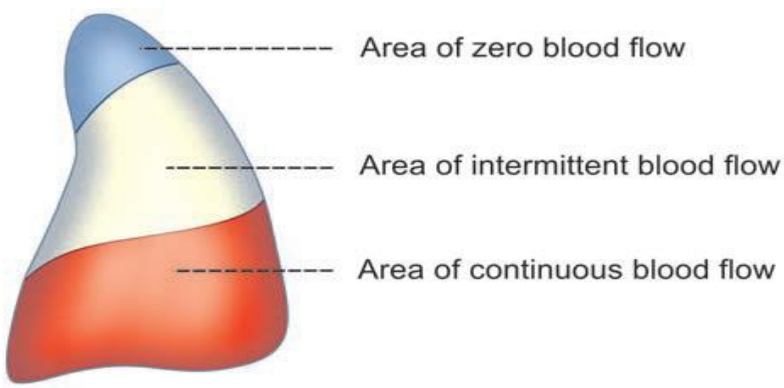
5. GRAVITY AND HYDROSTATIC PRESSURE

- ✓ Normally in standing position, blood pressure in lower extremity of the body is very high and in upper parts above the level of heart, the pressure is low.
- ✓ This is because of the effect of gravitational force.
- ✓ Pulmonary vascular pressure varies in different parts of the lungs:

i. ***Apical Portion – Zone 1***

Normally, in the apical portion of lungs, pulmonary capillary pressure is almost same as alveolar pressure.

- ✓ If pulmonary arterial pressure decreases or if alveolar pressure increases, the capillaries are collapsed.
- ✓ This prevents flow of blood to alveoli. So, this zone of lung is called **area of zero blood flow.**



ii. Midportion – Zone 2

- ✓ In the midportion of lungs, the pressure in alveoli is less than pulmonary systolic pressure and more than the pulmonary diastolic pressure due to blood flow to the alveoli increases during systole and decreases during diastole. So, this zone of the lung is called **area of intermittent flow.**

iii. Lower Portion – Zone 3

- ✓ In the lower portion of lungs, the pulmonary arterial pressure is high and it is more than alveolar pressure both during systole and diastole due to blood flows continuously. So this part of lungs is called **area of continuous blood flow.**

MCQ-

Q.1. In which part of the respiratory system , gaseous exchange takes place.

a. alveoli

b. pharynx

c. larynx

d.trachea

Q.2……. Is located between two pleural sacs and is the central compartments of thoracic cavity.

a. hilum

b. pleura

c. mediastinum

d. thoracic cage

Q.3. Which of the following are parts of the human respiratory system.

a. trachea

b. diaphragm

c. lungs

d. all the above.

Q. 4.The tiny air sacs present in human lungs is called……

a. alveoli

b. bronchioies

c. lungs

d. pleura

Q. 5. The exchange of gases between the external environment and the lungs…..

a. Respiration
b. External respiration
c. Cellular respiration
d. None

Q. 6. In aves, the exchange of gases occurs within the ……

a. lungs

b. air sacs

c. air sacs and lungs

d. none

Q. 7. The wind pipe is also called the …..
a. larynx
b. lungs
c. trachea
d. oesophagus

Q.8. Which of the following gas is released out during the process of respiration.
a. oxygen
b. hydrogen
c. carbon dioxide
d. none.

Q.9. Which of the following is correct for the partial pressure of oxygen in alveoli.
a. less than CO2
b. less than blood
c. more than blood
d. none

Q.10. Most of the carbon dioxide produced in the tissues is transported to the lungs as-
a. carbonates
b. bicarbonates
c. dissolved in the blood
d. attached to haemoglobin

Answers – 1- a, 2- c, 3- d, 4- a, 5- b, 6-a, 7-c, 8- c,9- c, 10 - b

Chapter – 9

MECHANISM OF RESPIRATION

MECHANISM OF RESPIRATION

Mechanism of respiration involve the breathing mechanism and exchange of gases.

✓ Respiratory / breathing mechanism and exchange of gases – components are :

1. Respiratory movements
2. Respiratory pressure
3. lungs compliance
4. Work of breathing

1. Respiratory movements –

- Respiration occurs in two phages – 1. Inspiration , 2. Expiration
- During normal quiet breathing, Inspiration – Active process & Expiration – Passive

Muscles of Respiration : - 2 types

1. **Inspiratory muscle ---- 1. Primary Inspiratory** – 1. Diaphragm (phernic nerve- C3- C5)

2. External Intercostal nerve (intercostal nerve –T1 – T11**.**

2. Accessory Inspiratory muscle – Sternocleidomestroid , scalene, anterior serrati elevator of scapula, Pectorals.

2. Expiratory muscle – 1. **Primary Expiratory Muscle** – Internal intercostal nerve.

2. Accessory Expiratory Muscle – Abdominal muscle

❑ **MOVEMENT OF THORACIC CAGE**

✓ Inspiration - enlargement of thoracic cage.

✓ Increase **all diameters –** viz. Anteroposterior, Transverse and Vertical diameters.

- ✓ Anteroposterior and transverse diameters of thoracic cage are increased by the elevation of ribs.
- ✓ Vertical diameter is increased by the descent of diaphragm.

CHANGE OF THORACIC CAGE BY MOVEMENT OF SOME STRUCTURES -

1. **Thoracic lid -** formed by – manubrium sterni , 1st pair of ribs

Movement of thoracic lid : - increase anterio posterior diameter - Due to the contraction of scalene muscles.

2. Upper Costal Series – Formed by - 2nd – upper 6 pairs of ribs

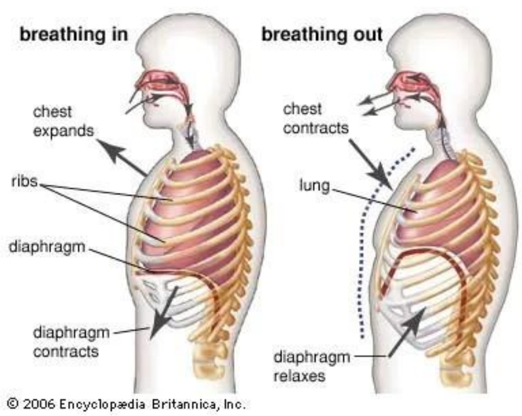
Movement – increase **anteroposterior and transverse diameter**

TYPES – Two

1. BUCKET HANDLE - Central portions ribs - move upwards and outwards to a more horizonta position. It increases the **transverse diameter of** thoracic cage.

2. PUMP HANDLE MOVEMENT - Contraction of external intercostal muscles.

- ✓ Cage - elevation of ribs.
  - ✓ Movement - upward and forward movement of sternum
  - ✓ It increases **Anteroposterior diameter of** the thoracic cage.



3. Lower Costal Series – Formed by - lower – 7th – 10th pairs of ribs.

- ✓ Movement – increase transverse diameter.
- ✓ Bucket handle movement – ribs swinging outward and upward.

4. Diaphragm – Normally before inspiration – dome shape diaphragm.

During inspiration – diaphragm central portion downwards - diaphragm is flattened.

- Flattening of diaphragm increases the **vertical diameter of the thoracic cage.**

❑ MOVEMENT OF LUNGS

During Inspiration – Increase negative pressure in thoracic cage

- Due to the enlargement of thoracic Cage.

During Expiration – dec. negative pressure

- Lungs comes to the **preinspiratory position.**
- The air is expelled out of lungs.

Collapsing Tendency of Lungs –

Factors Causing Collapsing Tendency –

1. Elastic property of lung tissues - Show constant recoiling tendency and try to collapse the lungs

2. ***Surface tension*** – It is a tension exerted by the fluid secreted from alveolar epithelium on the surface of alveolar membrane.

Factors Preventing Collapsing tendency –

1. Intrapleural pressure - Pleural cavity - Always Negative (Because of negativity, it keeps the lungs expanded and prevents the collapsing tendency of lungs produced by the elastic tissues).

2. Surfactant - It is a substance secreted in alveolar epithelium.

It reduces surface tension and prevents the collapsing tendency produced by surface tension.

Surfactant -

- ✓ Surfactant is a **surface acting material or agent**
- ✓ **That is** responsible for lowering the surface tension of a fluid.

  - ❑ ***Source of secretion of pulmonary surfactant*** **by two types of cells:**

1. Type II alveolar epithelial cells in the lungs, - Presence of microvilli on their alveolar surface.

2. **Clara cells -** Situated in the bronchioles.

Chemistry of surfactant -

Surfactant is a **lipoprotein complex formed by lipids** especially phospholipids, proteins and ions.

FUNCTIONS OF SURFACTANT

1. Surfactant reduces the **surface tension in the** alveoli of lungs and prevents **collapsing tendency** of lungs.

2. Surfactant is responsible for stabilization of the alveoli, which is necessary to withstand the collapsing tendency.

3. It plays an important role in the inflation of lungs after birth. In fetus, the secretion of surfactant begins after the 3rd month.

4.Another important function of surfactant is its role in defense within the lungs against infection and inflammation.

❑ RESPIRATORY PRESSURE

Two types of pressure are exerted in the thoracic cage / cavity of lungs during respiration.

1. Intrapleural pressure / intra thoracic pressure
2. Intra – Alveolar pressure/ intrapulmonary pressure

1. Intrapleural pressure / intra thoracic pressure – (- ve pressure)

Pressure exerting in pleural cavity - due to suction of the fluid b/w pleural cavity , b/w visceral and parital layer of pleura.

Normal value – Intra Pleural pressure is always negative

CAUSE FOR NEGATIVE OF INTRAPLEURAL PRESSURE –

- Pleural cavity is always lined by a thin layer of fluid - Secreted by the visceral layer of pleura.
- This fluid pumped from the pleural cavity into the lymphatic vessels.
- Pumping of fluid creates the negative pressure in the pleural cavity.

Condition when pressure become +ve -

- ✓ Pneumothorax , hydrothorax, hemothorax , pyothorax.

Measurement of intrapleural pressure –

1. Direct method :- Introduce needle into pleural cavity and connecting the needle to a mercury manometer.

1. **Indirect method :** - Introducing the esophageal balloon, which is connected to a manometer.

Significance of Intrapleural Pressure-

1. It prevents the collapsing tendency of lungs.
2. Responsible for venous return (respiratory pump for venous return).

2. INTRA-ALVEOLAR PRESSURE –

- ✓ Intra alveolar pressure existing in the alveoli of the lungs.
- ✓ It is also known as **intrapulmonary pressure.**

Normal value –

Normally intra – Alveolar pressure = atmospheric pressure (760 mm Hg)

Inspiration – becomes –ve

Expiration – becomes +ve

Measurement : - by using plethysmograph.

SIGNIFICANCE OF INTRA-ALVEOLAR PRESSURE –

1. flow of air in and out of alveoli : -

- During inspiration – Intraalveolar (Negative) - air enters the alveoli.
- During expiration - Intraalveolar (Positive) - air is expelled out of alveoli.

2. Intraalveolar pressure also helps in exchange of gases between the alveolar air and the blood.

TRANSPULMONARY PRESSURE –

- ✓ Pressure difference b/w Intraalveolar pressure and Intrapleural pressure.
- ✓ It measure of elastic forces in lungs - Responsible for collapsing tendency of lungs.

❑ COMPLIANCE

- ✓ Ability of the lungs and thorax to expand or it is the **expansibility of lungs and thorax.**
- ✓ **It** is defined as the change in volume per unit change in the pressure.

Significance of Determining Compliance -

Useful - measure of stiffness of lungs.

NORMAL VALUES
Compliance is expressed by two ways:
1. In relation to intraalveolar pressure
2. In relation to intrapleural pressure

Compliance in Relation to Intra-alveolar Pressure
Compliance is the volume increase in lungs per unit increase in the intraalveolar pressure.

Compliance in Relation to Intrapleural Pressure
Compliance is the volume increase in lungs per unit decrease in the intrapleural pressure.

TYPES OF COMPLIANCE
Compliance is of two types:
1. Static compliance
2. Dynamic compliance.

1. *Static Compliance*
- ✓ Static compliance is the compliance measured under **static conditions, i.e. by measuring pressure and** volume when breathing does not take place.
- ✓ Static compliance is the pressure required to overcome the elastic resistance of respiratory system for a given tidal volume under zero flow (static) condition.

2. *Dynamic Compliance*
Dynamic compliance is the compliance measured during **dynamic conditions, i.e. during breathing.**

❑ **WORK OF BREATHING**

Work of breathing is the work done by respiratory muscles during breathing to overcome the resistance in thorax and respiratory tract.

WORK DONE BY RESPIRATORY MUSCLES
- ✓ During respiratory processes, inspiration is active process and the expiration is a passive process.
- ✓ So, during quiet breathing, respiratory muscles perform the work only during inspiration and not during expiration.

MCQ –

Q.1. The gaseous exchange in alveoli is a type of –
a. simple diffusion
b. osmosis
c. active transport
d. passive transport

Q.2. Which of the following organs only receives oxygenated blood.
a. lungs
b. liver
c. heart
d. spleen

Q.3. Which of the following membranes encloses lungs.
a. pleural membrane
b. pericardium
c. perichondrium
d. none

Q. 4. The alveolar epithelium of lungs is –
a. cillated squamous
b. noncilliated squamous
c. noncillated columnar
d. none

Q. 5Which of the following is a chronic respiratory disorder caused by smoking.
a. asthma
b. emphysema
c. respiratory alkalosis
d. respiratory acidosis

Q.6. RBCs present in the blood of a person residing at higher altitudes –
a. decrease in size
b. increase in size
c. decreased in the number
d. increase in the number

Q. 7. Which of the following parts of the brain regulates the respiratory process.
a. vagus nerve
b. cerebral peduncle
c. medulla oblongata

d. cerebellum

Q.8………… acts as air conditioners.
a. nasal chambers
b. larynx
c. pharynx
d. lungs

Q. 9. Hyaline cartilage has a primary function of –
a. protect thyroid
b. increase surface area
c. support trachea
d. none

Q. 10. The trachea leads to the –
a. pulmonary vessels
b. esophagus
c. bronchi
d. bronchioles

Answers – 1-a, 2- d, 3- a, 4- b, 5-b, 6- b, 7- c, 8- a, 9- a, 10 –c.

Chapter – 10

TRANSPORT OF GASES

TRANSPORT OF OXYGEN -

- ✓ Oxygen, which is essential for the cells is transported from alveoli of lungs to the cells. Carbon dioxide, which is the waste product in cells is transported from cells to lungs.
- ✓ **Oxygen is transported from alveoli to the tissue by blood in two forms:-**

1. As simple physical solution

2. In combination with hemoglobin

1. AS SIMPLE SOLUTION –

- Oxygen dissolves in water of plasma and is transported in this physical form.
- It is only 0.3 mL/100 mL of plasma.
- Because of poor solubility of oxygen in water content of plasma.
- Important during the conditions like muscular exercise to meet the excess demand of oxygen by the tissues.

1. IN COMBINATION WITH HEMOGLOBIN –

Oxygen combines with hemoglobin in blood and is transported as Oxyhemoglobin.

Maximum amount (97%) of oxygen is transported.

Oxygenation of Hemoglobin –

Oxygen combines with h emoglobin only as a physical combination

⬇

Oxygenation and not oxidation.

⬇

Oxygen can be readily released from hemoglobin when it is needed.

- ➢ Oxygen combines with the iron in heme part of hemoglobin

⬇

Each molecule of hemoglobin contains 4 atoms of iron.

⬇

Iron present in ferrous form

⬇

Each iron atom combines with one molecule of oxygen.

⬇

After combination, iron remains in ferrous form only.

⬇

This called oxygenation and not oxidation.

Oxygen Carrying Capacity of Hemoglobin -

Amount of oxygen transported by 1 gram of hemoglobin. It is 1.34 mL/g.

OXYGEN-HEMOGLOBIN DISSOCIATION CURVE

- ✓ Curve that demonstrates the relationship between partial pressure of oxygen and the percentage saturation of hemoglobin with oxygen.
- ✓ It explains hemoglobin's affinity for oxygen.
- ✓ When the partial pressure of oxygen is more, hemoglobin accepts oxygen and when the partial pressure of oxygen is less, hemoglobin releases oxygen.

Normal Oxygen-hemoglobin Dissociation Curve –

- ✓ Curve is 'S' shaped or **sigmoid shaped .**
- ✓ Lower part indicates dissociation of oxygen from hemoglobin.
- ✓ Upper part indicates the uptake of oxygen by hemoglobin depending upon partial pressure of oxygen.

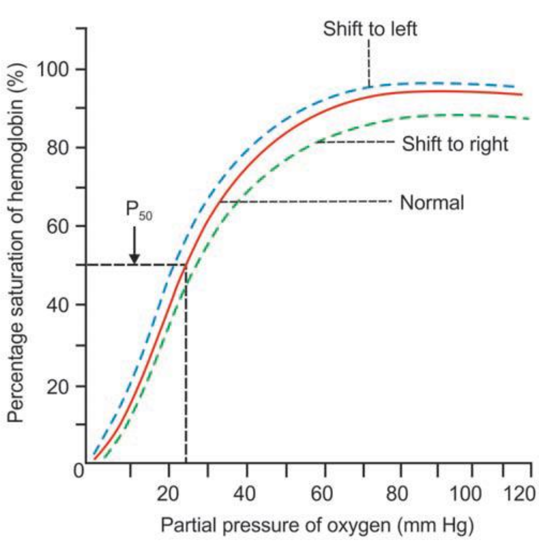


Figure : - Oxygen-hemoglobin dissociation curve.

P50

P50 is the partial pressure of oxygen at which hemoglobin saturation with oxygen is 50%.

1. Partial pressure of oxygen is 25 to 27 mm Hg – Hb is Saturated to about 50%.
2. At 40 mm Hg of oxygen - 75%.
3. 100 mm Hg of oxygen – saturation 95%

Factors Affecting Curve –

Curve is shifted to left or right by various factors: -

1. Shift to left - acceptance **(association) of** oxygen by hemoglobin

2. Shift to right - **dissociation of oxygen from** hemoglobin.

1. **Shift to right** –

Conditions: -

i. Decrease in partial pressure of oxygen

ii. Increase in partial pressure of carbon dioxide (Bohr effect)

iii. Increase in hydrogen ion concentration and decrease in pH (acidity)

iv. Increased body temperature

v. Excess of 2,3-diphosphoglycerate (DPG) in RBC.

↓

called 2,3-biphosphoglycerate (BPG)

↓

byproduct in Embden-Meyerhof pathway

↓

combines with β-chains of hemoglobin

↓

DPG increases in RBC (muscular exercise and in high attitude)

↓

Oxygen hemoglobin dissociation curve shifts to right.

2. **Shift to left –**

Conditions: -

i. Fetal blood because, fetal hemoglobin has got more affinity for oxygen than the adult hemoglobin

ii. Decrease in hydrogen ion concentration and increase in pH (alkalinity).

Bohr Effect –

- ✓ Effect by which presence of carbon dioxide decreases the affinity of hemoglobin for oxygen.
- ✓ Postulated by **Christian Bohr in 1904.**

❑ In the tissues, due to continuous metabolic activities,

⬇

Partial pressure of carbon dioxide is very high and the partial pressure of oxygen is low

⬇

Due to this pressure gradient,

⬇

CO^2 enters blood and O3 is released from the blood to the tissues

⬇

Enhances release of O2 to tissue

❑ All the factors, which shift curve to right enhance the Bohr effect.

❑ TRANSPORT OF CARBON DIOXIDE

Carbon dioxide is transported by the blood from cells to the alveoli.

In 4 ways :- 1. As dissolved form (7%)

2. As carbonic acid (negligible)

3. As bicarbonate (63%)

4. As carbamino compounds (30%).

1. AS DISSOLVED FORM

- ✓ Co2 diffuses into blood and dissolves in the fluid of plasma forming a simple solution.
- ✓ Only about 3 mL/100 mL of plasma of co2 is transported.

2. **AS CARBONIC ACID**

- ✓ dissolved CO^2 in plasma combines with the water to form carbonic acid.

✓ Transport of carbon dioxide in this form is negligible

3. **AS BICARBONATE**

From plasma, carbon dioxide enters the RBCs

⬇

In RBCs, co2 combines with water - form carbonic acid

⬇

Rapid due of the presence of carbonic anhydrase

⬇

Only inside the RBCs and not in plasma.

⬇

Carbonic acid unstable

⬇

Dissociates into bicarbonate and hydrogen ions

⬇

Due to high concentration

⬇

it diffuse through the cell membrane into plasma.

CHLORIDE SHIFT OR HAMBURGER PHENOMENON –

✓ Exchange of a chloride ion for a bicarbonate ion across RBC membrane.

✓ Discovered by **Hartog Jakob Hamburger in 1892**

✓ Occurs when Co2 enters the blood from tissues.

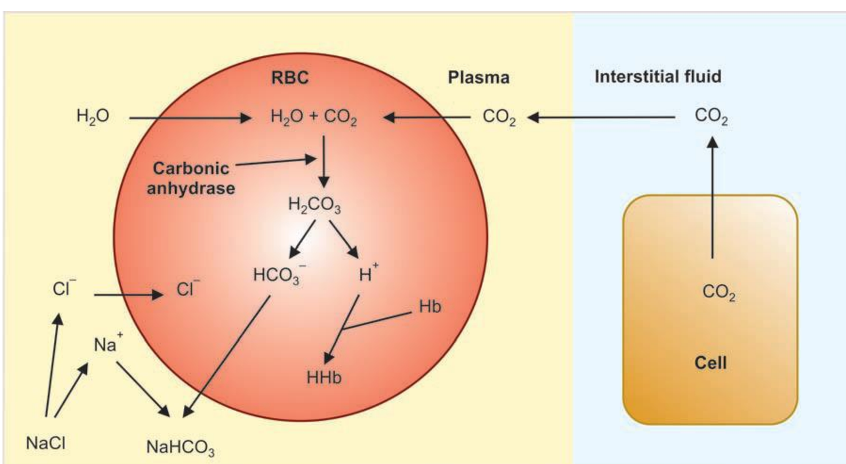


Figure : - Transport of carbon dioxide in blood in the form of bicarbonate and chloride shift.

IN THIS FIGURE -

- ✓ Anion exchanger 1 (band 3 protein) – act like antiport pump in RBC membrane.
- ✓ Responsible for exchange of bicarbonate ions and chloride .

✓ $NaHCO_3$ (sodium bicarbonate) – transported in blood

✓ H + ion dissociate from carbonic acid – buffered by Hb inside cell.

Reverse Chloride Shift: -

✓ Process by which chloride ions are moved back into plasma from RBC shift.

✓ Occurs in lungs

✓ Helps in elimination of Co_2 from the blood.

✓ When blood reaches alveoli , $NaHCO_3$

Na^+ HCO3 (move into RBC)

Nacl (plasma) And Cl move out of RBC into plasma

- $HCO_3 + H^+$ (inside RBC) = H_2CO_3 – ----- $H_2O + CO_2$ (Expelled out).

AS CARBAMINO COMPOUNDS

✓ Carbon dioxide is transported in blood in combination with hemoglobin and plasma proteins.

✓ CO^2 + Hb – $HbCo_2$ (Carbamino Hb / Carbhemoglobin)

✓ It combines with plasma proteins - Carbamino proteins.

✓ Carbamino hb + Carbamino proteins – Called Carbamino compound.

✓ Amount of carbon dioxide transported in combination with plasma proteins is very less compared to the amount transported in combination with hemoglobin.

↓

because the quantity of proteins in plasma is only half of the quantity of hemoglobin.

HALDANE EFFECT -

- ✓ Effect by which combination of oxygen with hemoglobin displaces carbon dioxide from hemoglobin.
- ✓ Described by **John Scott Haldane** in 1860.
- ✓ Excess of oxygen content ----- causes shift of the carbon dioxide dissociation curve to right.

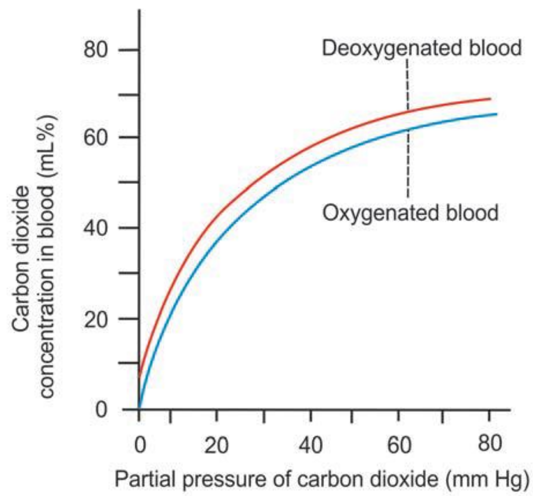


Figure : - Carbon dioxide dissociation curve

Causes for Haldane effect –

Due to the combination with oxygen, hemoglobin becomes strongly acidic.

a) Highly acidic Hb

↓

Low tendency to combine with Co2

↓

CO2 displaced from blood.

b) because of acidity, H+ ion released in excess.

↓

From carbonic acid

↙ ↘

CO_2 H_2O

↓

Released from blood into alveoli.

SIGNIFICANCE : - Release of Co2 from blood into alveoli of lungs and Uptake of O2 by the blood.

MCQ –

Q.1. Each Hb can carry a maximum of ….. oxygen molecules.

a. 2

b. 4.

c.8

d. 6

Q. 2. The binding of Hb with carbon dioxide forms –

a. methamoglobin

b. carbamino– haemoglobin

c. oxyhaemoglobin

d. none

Q. 3. Carbonic anhydrase plays as important role in the transport of carbon dioxide in –

a. leukocytes

b. thrombocytes

c. erythrocytes

d. platlets

Q.4. The formation of caronic acid from carbon dioxide and water has catalyzed the enzyme –

a. carbonic anhydrase

b.carbonic anhydrade

c. carbonic hydrase

d. both a and c

Q. 5 Binding of oxygen with Hb is primarily related to –

a. partial pressure of O_2

b. partial pressure of CO_2

c. hydrogen ion concentration

d. temperature

Q. 6. Factors which can cause right shift in oxyhaemoglobin curve include all except –

a. increase in P_{co2}

b. decrease in P_{co2}

c. increase in ph

d. increase in H^+ Concentration

Q.7. The partial pressure of oxygen is equal in –

a. atmospheric air and alveoli

b. alveoli and oxygenated blood

c. alveoli and deoxygenated blood

d. deoxygenated blood and tissue

Q. 8. In the human body, CO_2 is primarily carried in blood as –

a. dissolved in plasma

b. carbaminohaemoglobin

c. sodium bicarbonate

d. potassium carbonate

Q.9. What % of carbon dioxide transport in the form of carbamino haemoglobin.

a.. 20 – 25%

b.5- 7%

c. 3%

d. 97%

Q.10. Oxygen dissociation curve will shift to right on decrease of –

a. temperature

b. acidity

c.ph

d. carbon dioxide concentration

Answers – 1- b, 2- b, 3- c, 4- a, 5-a, 6 – c, 7- a, 8-c, 9- a, 10 - a

Chapter – 11

PULMONARY FUNCTION TESTS

PULMONARY FUNCTION TESTS

- ✓ Are Useful - Assessing the **functional status of the respiratory** system both in physiological and pathological conditions.
- ✓ It based on the measurement of volume of air breathed in and out in quiet breathing and forced breathing.
- ✓ These tests are by using spirometer.

TYPES OF LUNG FUNCTION TESTS

Two types: -

1. Static lung function tests

2. Dynamic lung function tests.

1. STATIC LUNG FUNCTION tests are based on - **volume of air that flows into or out of lungs.**

- ✓ Tests include - Static lung volumes and static lung capacities.

2.DYNAMIC LUNG FUNCTION tests are based on time, i.e. the **rate at which air flows into or out of lungs.**

- ✓ **Tests** include - forced vital capacity, forced expiratory volume, maximum ventilation volume and peak expiratory flow.
- ✓ Dynamic lung function **tests are useful** in determining the severity of obstructive and restrictive lung diseases.

LUNG VOLUMES

- ✓ Are the volumes of air breathed by an individual.
- ✓ These volumes represents the volume of air present in the lung under a specified static condition (specific position of thorax).

4 Types:

1. Tidal volume

2. Inspiratory reserve volume

3. Expiratory reserve volume

4. Residual volume.

1.TIDAL VOLUME -

- Volume of air breathed in and out of lungs in a single normal quiet respiration.
- Signifies the normal depth of breathing.

Normal Value - 500 mL (0.5 L).

2.INSPIRATORY RESERVE VOLUME

An additional volume of air that can be inspired forcefully after the end of normal inspiration.

Normal Value - 3,300 mL (3.3 L).

3.EXPIRATORY RESERVE VOLUME

An additional volume of air that can be expired out forcefully, after normal expiration.

Normal Value - 1,000 mL (1 L).

4.RESIDUAL VOLUME

Volume of air remaining in lungs even after forced expiration.

- Significance - 1. It helps to aerate the blood in between breathing and during expiration.

2. It maintains the contour of the lungs.

Normal Value - 1,200 mL (1.2 L)

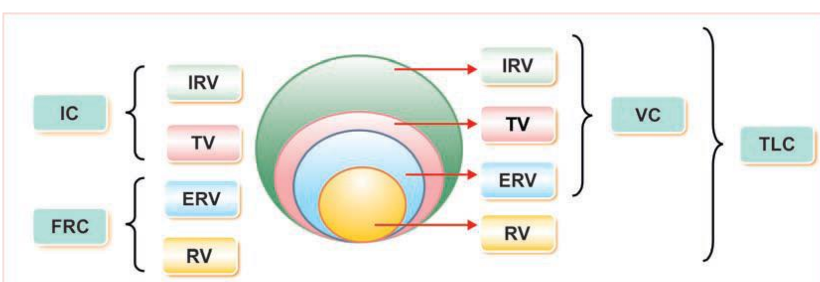


Figure : - Lung volumes and capacities.

LUNG CAPACITIES

Static lung capacities are the combination of two or more lung volumes.

4 Types:-

1. Inspiratory capacity

2. Vital capacity

3. Functional residual capacity

4. Total lung capacity

1.INSPIRATORY CAPACITY

Maximum volume of air that is inspired after normal expiration (end expiratory position).

IC = TV + IRV = 500 + 3,300 = 3,800 mL

2.VITAL CAPACITY (VC)

Maximum volume of air that can be expelled out forcefully after a deep (maximal) inspiration.

VC = IRV + TV + ERV = 3,300 + 500 + 1,000 = 4,800 mL

Significance - Its determination is useful in clinical diagnosis.

1. **FUNCTIONAL RESIDUAL CAPACITY**

Volume of air remaining in lungs after normal expiration (after normal tidal expiration).

FRC = ERV + RV = 1,000 + 1,200 = 2,200 mL

2. **TOTAL LUNG CAPACITY**

- Volume of air present in lungs after a deep (maximal) inspiration.
- It includes all the volumes.

TLC = IRV + TV + ERV + RV = 3,300 + 500 + 1,000 + 1,200 = 6,000 Ml

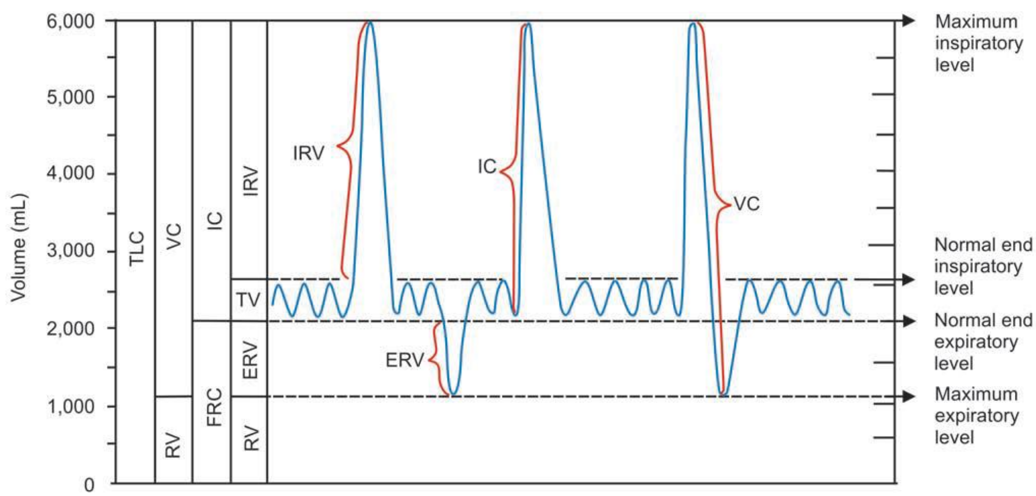


Figure: - TV = Tidal volume, IRV = Inspiratory reserve volume, ERV = Expiratory reserve volume, RV = Residual volume, IC = Inspiratory capacity, FRC = Functional residual capacity, VC = Vital capacity, TLC = Total lung capacity.

MCQ -

Q.1. Which instrument is used to measure the amount of air inhaled and exhaled during each breath.

a. lactometer

b. spirometer

c.hygrometer

d. none

Q.2.Which of the following quantitative measure of inspiratory and expiratory flow is especially useful in diagnosing chronic obstructive pulmonary disease (COPD).

a. forced expiratory volume in one second.

b. forced vital capacity

c. functional residual capacity

d. peak expiratory flow

Q.3Which of the following would produce a restrictive pattern on spirometry.

a. chronic bronchitis

b. cystic fibrosis

c. serve anaemia

d. serve kyphosis

Q.4. As respiration through the lungs is called pulmonary respiration , which type of respiration is done through skin.

a. pulmonary

b. bronchial

c.cutaneous

4. more than one of the above.

Answers – 1. B, 2 – a, 3- d, 4- c.

Chapter –12

INTRODUCTION TO DIGESTIVE SYSTEM

Digestion is defined as the process by which food is broken down into simple chemical substances that can be absorbed and used as nutrients by the body.

FUNCTIONS : -

1. Ingestion or consumption of food substances.

2. Breaking them into small particles.

3. Transport of small particles to different areas of the digestive tract.

4. Secretion of necessary enzymes and other substances for digestion.

5. Digestion of the food particles.

6. Absorption of the digestive products (nutrients).

7. Removal of unwanted substances from the body.

FUNCTIONAL ANATOMY OF DIGESTIVE SYSTEM

Digestive system is made up of **gastrointestinal tract** (GI tract) or alimentary canal and accessory organs, which help in the process of digestion and absorption.

- ✓ GI tract is a tubular structure, length Mouth up to Anus - About 30 feet.

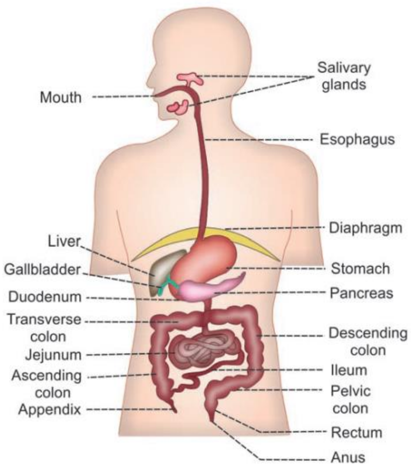
GI tract is formed by **two types of organs**:

1. Primary digestive organs.

2. Accessory digestive organs.

1. *Primary Digestive Organs*

Primary digestive organs are : - Mouth , Pharynx , Esophagus , Stomach , Small intestine , Large intestine.



2. ***Accessory Digestive Organs***

Accessory digestive organs are those which help primary digestive organs in the process of digestion. Eg. Teeth , Tongue , Salivary glands , Exocrine part of pancreas , Liver , Gallbladder.

WALL OF GASTROINTESTINAL TRACT

1. Mucus layer

2. Submucus layer

3. Muscular layer

4. Serous or fibrous layer.

1. MUCUS LAYER

- Mucus layer is the innermost layer of the wall of GI tract.
- It is also called gastrointestinal mucosa or mucus membrane.

Mucosa has three layer of structures: -

i. Epithelial lining

ii. Lamina propria

iii. Muscularis mucosa.

2. SUBMUCUS LAYER

- Submucus layer is also present in all parts of GI tract, except the mouth and pharynx. It contains loose collagen fibers, elastic fibers, reticular fibers and few cells of connective tissue. Blood vessels, lymphatic vessels and nerve plexus are present in this layer

3. MUSCULAR LAYER

- Muscular layer in lips, cheeks and wall of pharynx contains skeletal muscle fibers.
- The esophagus has both skeletal and smooth muscle fibers.
- Wall of the stomach and intestine is formed by smooth muscle fibers.

Smooth muscle fibers in stomach are arranged in three layers: -

i. Inner oblique layer

ii. Middle circular layer

iii. Outer longitudinal layer.

Smooth muscle fibers in the intestine are arranged in two layers: -

i. Inner circular layer

ii. Outer longitudinal layer.

- **Auerbach nerve plexus is present in between the** circular and longitudinal muscle fibers.

4. SEROUS OR FIBROUS LAYER

- Outermost layer of the wall of GI tract is either serous or fibrous in nature.
- The serous layer is also called **serosa** or **serous membrane and it is formed by connective** tissue and mesoepithelial cells.
- It covers stomach, small intestine and large intestine.

NERVE SUPPLY TO GASTROINTESTINAL TRACT

GI tract has two types of nerve supply: -

I. Intrinsic nerve supply

II. Extrinsic nerve supply.

ENTERIC NERVOUS SYSTEM -

- Also called - Little brain of gut.

- ❑ Intrinsic nerves to GI tract form the enteric nervous system that controls all the secretions and movements of GI tract.

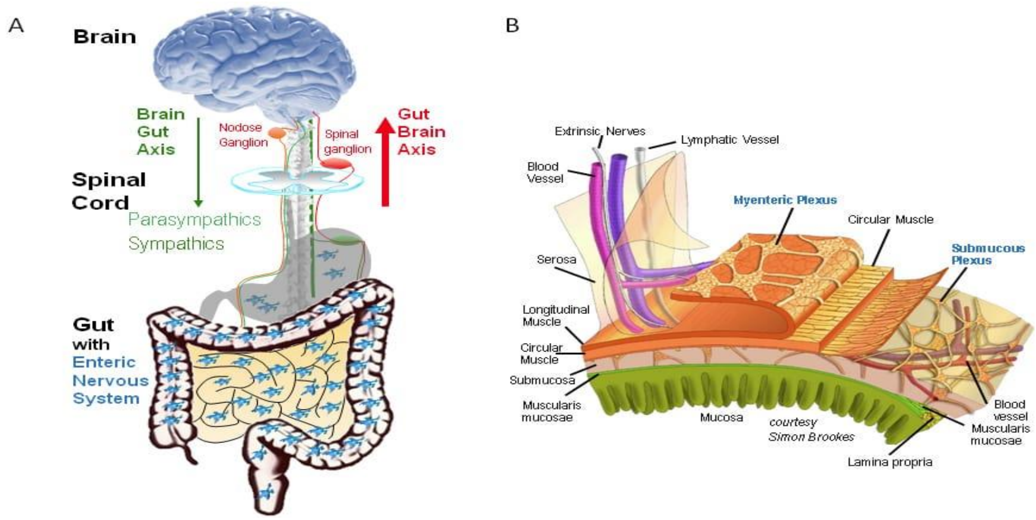
- ✓ Present within the wall of GI tract from esophagus to anus.

Nerve fibers of this system are interconnected and form two major networks called –

1. Auerbach plexus

2. Meissner plexus.

- ❑ These nerve plexus contain nerve cell bodies, processes of nerve cells and the receptors. The receptors in the GI tract are stretch receptors and chemoreceptors.
- ❑ Enteric nervous system is controlled by extrinsic nerves.



1. **AUERBACH PLEXUS -**

- ✓ Also known as **myenteric nerve plexus.**

- ✓ **Present - between inner circular muscle** layer and the outer longitudinal muscle layer.

Functions of Auerbach plexus -

- ➢ Major function - Regulate the movements of GI tract.

- ➢ Some nerve fibers of this plexus accelerate the movements by secreting the excitatory Neurotransmitter substances like acetylcholine, serotonin and substance P.

- ➢ Other fibers of this plexus inhibit the GI motility by secreting the inhibitory neurotransmitters such as vasoactive intestinal polypeptide (VIP), Neurotensin and Enkephalin.

2. MEISSNER NERVE PLEXUS -

- ✓ Also Called Submucus nerve plexus.
- ✓ It is situated in between the muscular layer and submucosal layer of GI tract.

Functions of Meissner plexus -

- ✓ Function of Meissner plexus is the regulation of secretory functions of GI tract.
- ✓ These nerve fibers cause constriction of blood vessels of GI tract.

EXTRINSIC NERVE SUPPLY

- ➢ Extrinsic nerves that control the enteric nervous system are from autonomic nervous system.
- ➢ Both **sympathetic and parasympathetic** divisions of autonomic nervous system innervate the GI tract.

❑ **Sympathetic Nerve Fibers –**

Preganglionic sympathetic nerve fibers to GI tract arise

⬇

from lateral horns of spinal cord between fifth thoracic and second lumbar segments (T5 to L2).

⬇

from here, fibers leave the spinal cord,

⬇

terminate in the **celiac and mesenteric ganglia.**

⬇

postganglionic fibers from these ganglia are distributed throughout the GI tract.

Functions of sympathetic nerve fibers –

- ✓ Inhibit the movements and **decrease the secretions of GI tract** by secreting neurotransmitter noradrenaline.

❑ **Parasympathetic Nerve Fibers -**

- ➢ Parasympathetic nerve fibers to GI tract pass through some of the **Cranial Nerves and Sacral Nerves.**
- ➢ **The preganglionic** and postganglionic parasympathetic nerve fibers to mouth and salivary glands pass through facial and glossopharyngeal nerves.
- ➢ Preganglionic nerve arise from (S2, S3 and S4) of spinal cord and pass through pelvic nerve.

Functions of parasympathetic nerve fibers -

- Accelerate the movements and increase the secretions of GI tract.
- The neurotransmitter secreted by the parasympathetic nerve fibers is acetylcholine (Ach).

MCQ -

Q.1.Fat is digest by –

a. proteinase

b. amylase

c. lipase

d. saliva

Q.2.Where does the process of digestion of food begin in humans.

a. mouth

b. food pipe

c. stomach

d. small intestine

Q.3. Which of the following vitamins is stored in the liver.

a. vita.K

B.vita.D

c.vita.E

D.All of these

Q. 4. Which is the first enzyme to mix with food in digestive tract of human.

a. pepsin

b. cellulose

c. amylase

d. trypsin

Q.5. Bile juice is formed in the –

a. kidney

b. salivary gland

c. liver

d. lung

Q.6. Saliva helps in digestion of-

a. starch

b. fiber

c.proteins

d. fats

Q.7.In the buccal cavity of human being, digestion of which one of the following get started.

a.protein

b.fat

c. carbohydrates

d. none

Q.8. Name the layer in the wall of the stomach that contains nerve and blood vessels.

a. lamina propria

b. mucosa

c. muscularies mucosa

d. sub mucosa

Q. 9. In human body, the digestion of proteins begins in which of the following organs.

a. liver

b. mouth

c. small intestine

d. stomach

Q.10. After digestion, protein is converted into……….

a. glucose

b. sucrose

c. fat

d. amino acid

Answers – 1- c, 2- a, 3- d, 4- c, 5- c, 6- a, 7- c, 8- d, 9-d, 10-d.

Chapter – 13

SALIVARY GLANDS

In humans, the saliva is secreted by three pairs of major (larger) salivary glands and some minor (small) salivary glands.

MAJOR SALIVARY GLANDS -

1. Parotid glands

2. Submaxillary or Submandibular glands

3. Sublingual glands.

1. Parotid Glands -

- ✓ largest of all salivary glands,
- ✓ **Situated** - at the side of the face just below and in front of the ear.
- ✓ Each gland weighs about 20 to 30 g in adults.
- ✓ Secretions from- by Stensen duct.
- ✓ This duct is about 35 mm to 40 mm long.

2. Submaxillary Glands -

- ✓ Submaxillary glands or submandibular glands are located in submaxillary triangle, medial to mandible.
- ✓ Each gland weighs – 8 to 10 g.
- ✓ Duct present - Wharton duct,about 40 mm long.

3. Sublingual Glands -

- ✓ Smallest salivary glands
- ✓ **Situated** - in the mucosa at the floor of the mouth.
- ✓ Each gland weights - about 2 to 3 g.
- ✓ Duct present - ducts of Rivinus , Bartholin duct.

MINOR SALIVARY GLANDS –

1. Lingual Serous Glands
2. Lingual Mucus Glands
3. Buccal Glands
4. Labial Glands
5. 5. Palatal Glands

PROPERTIES OF SALIVA -

1. **Volume:** 1000 mL to 1500 mL of saliva is secreted per day.

2. Reaction: - slightly acidic with pH of 6.35 to 6.85

3. Specific gravity: It ranges between 1.002 and 1.012

4. Tonicity: Saliva is hypotonic to plasma.

COMPOSITION OF SALIVA -

Mixed saliva contains 99.5% water and 0.5% solids.

FUNCTIONS OF SALIVA

Saliva is a very essential digestive juice.

1. **PREPARATION OF FOOD FOR SWALLOWING -**

When food is taken into the mouth, it is moistened and dissolved by saliva.

⬇

Mucus membrane of mouth is also moistened by saliva.

⬇

By movement of tongue, the moistened and masticated food is rolled into a bolus.

⬇

Mucin of saliva lubricates the bolus and facilitates swallowing.

2. APPRECIATION OF TASTE -

- ✓ Taste is a chemical sensation. So that dissolved substances can stimulate the taste buds.
- ✓ The stimulated taste buds recognize the taste.

3. DIGESTIVE FUNCTION -

Saliva has three digestive enzymes, namely salivary amylase, maltase and lingual lipase.

Enzyme	Source of secretion	Activator	Action
Salivary amylase	All salivary glands	Acid medium	Converts starch into maltose
Maltase	Major salivary glands	Acid medium	Converts maltose into glucose
Lingual lipase	Lingual glands	Acid medium	Converts triglycerides of milk fat into fatty acids and diacylglycerol

4. CLEANSING AND PROTECTIVE FUNCTIONS

i. Due to the constant secretion of saliva, the mouth and teeth are rinsed and kept free off food debris, shed epithelial cells and foreign particles.

ii. Enzyme lysozyme of saliva kills some bacteria such as *staphylococcus, streptococcus and Brucella*

iii. **Proline-rich proteins present in saliva posses** antimicrobial property and neutralize the toxic substances such as tannins.

iv. Proline-rich proteins and lactoferrin protect the teeth by stimulating enamel formation.

vi. Mucin present in the saliva protects the mouth by lubricating the mucus membrane of mouth.

5.ROLE IN SPEECH -

By moistening and lubricating soft parts of mouth and lips, saliva helps in speech.

6. **EXCRETORY FUNCTION**

- ✓ Many substances are excreted in saliva.
- ✓ It excretes substances like mercury, potassium iodide, lead, and thiocyanate.
- ✓ Saliva also excretes some viruses such as those causing rabies and mumps.

7. **REGULATION OF BODY TEMPERATURE**

In dogs and cattle, excessive dripping of saliva during panting helps in the loss of heat and regulation of body temperature.

8. **REGULATION OF WATER BALANCE**

When the body water content decreases, salivary secretion also decreases. This causes dryness of the mouth and induces thirst.

- **REGULATION OF SALIVARY SECRETION**

Only by nervous mechanism (Autonomic nervous system)

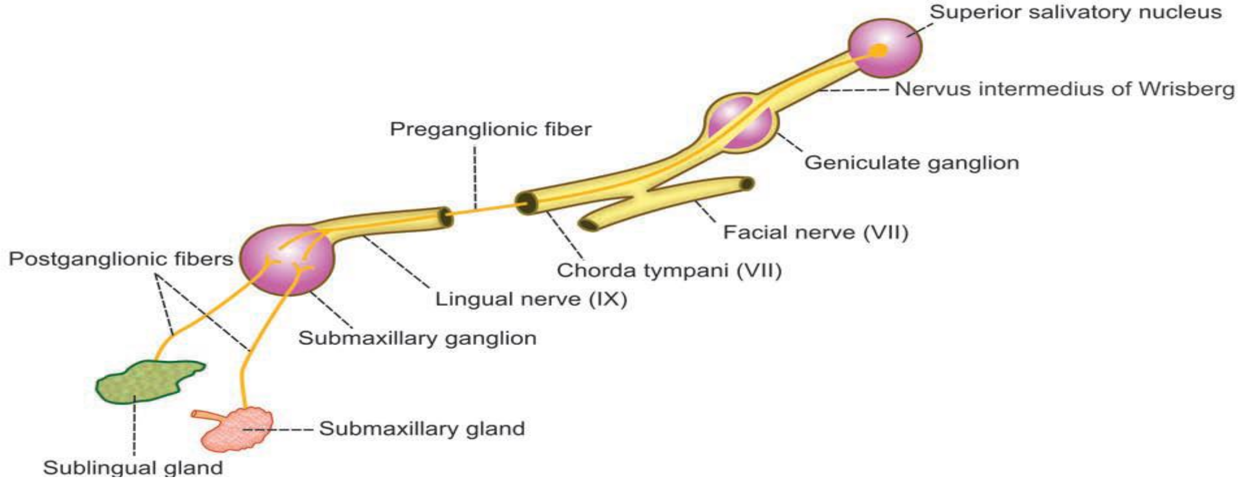
NERVE SUPPLY TO SALIVARY GLANDS -

Supplied by both Parasympathetic and Sympathetic divisions of autonomic nervous system

PARASYMPATHETIC FIBERS -

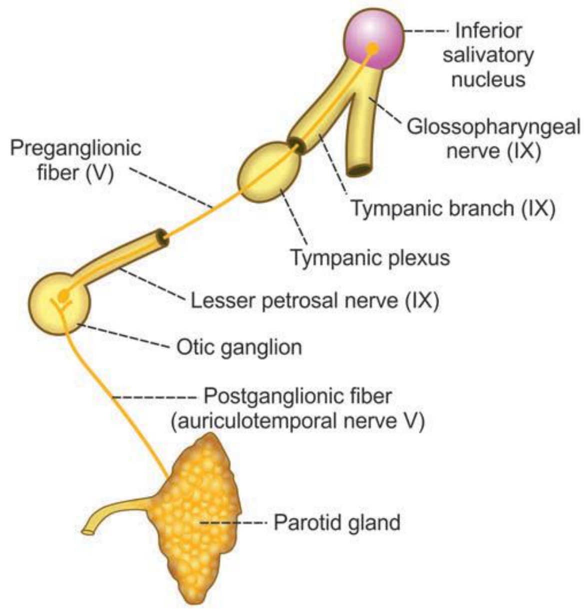
Parasympathetic Fibers to Submandibular and Sublingual Glands

- ✓ Superior Salivatory nucleus, situated in pons.



Parasympathetic Fibers to Parotid Gland

Inferior salivatory nucleus situated in the upper part of medulla oblongata.



FUNCTION OF PARASYMPATHETIC FIBERS –

Stimulation of parasympathetic fibers of salivary glands

⬇

Causes secretion of Saliva with large quantity of water.

⬇

Because the parasympathetic fibers activate Acinar cells and dilate blood vessels of salivary glands.

⬇

Neurotransmitter is acetylcholine.

SYMPATHETIC FIBERS -

- ✓ Sympathetic preganglionic fibers arise from

⬇

lateral horns of T1 – T2 of spinal cord.

- ✓ Fibers leave cord through the anterior nerve roots and end in superior cervical ganglion of the sympathetic chain.

⬇

Postganglionic fibers arise from this ganglion and are distributed to the salivary glands.

FUNCTION OF SYMPATHETIC FIBERS -

Stimulation of sympathetic fibers causes secretion of saliva (thick and rich in organic constituents)

⬇

because, these fibers activate the acinar cells and cause vasoconstriction.

⬇

Neurotransmitter is noradrenaline.

❑ REFLEX REGULATION OF SALIVARY SECRETION -

Regulated by Nervous mechanism through reflex action.

Salivary reflexes are of two types: -

1. Unconditioned reflex.
2. Conditioned reflex.

1. Unconditioned Reflex -

- ✓ Inborn reflex that is present since birth.
- ✓ It does not need any previous experience
- ✓ This reflex induces salivary secretion when any substance is placed in the mouth due to the stimulation of nerve endings in the mucus membrane of the oral cavity.

2. Conditioned Reflex -

- ✓ It is acquired by experience and it needs previous experience.
- ✓ Presence of food in the mouth is not necessary to elicit this reflex.
- ✓ The stimuli for this reflex are the sight, smell, hearing or thought of food.

MCQ –

Q. 1. The duct of bartholin is linked with –

a. sublingual gland

b. maxillary

c. parotid gland

d. infraorbital glands

Q.2. Largest salivary gland is –

a. sublingual gland

b. maxillary

c. parotid gland

Q.3. Tongue is attached to the floor of buccal cavity by –

a. falciform ligament

b. frenulum

c. lingual papilla

d. none

Q.4.Nuhns glands are present on –

a. stomach

b. tongue

c. skin

d. intestine

Q.5. Stensons duct drains –

a. submandibular gland

b. sublingual gland

c. parotid gland

d. minor salivary gland

Answers – 1.- a, 2- c, 3- b, 4- b, 5- c

Chapter – 14

GASTRIC SECRETION

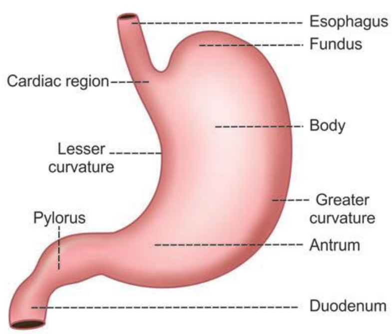
FUNCTIONAL ANATOMY OF STOMACH

- ✓ Stomach is a hollow organ situated just below the diaphragm on the left side in the abdominal cavity.
- ✓ Volume of empty stomach is 50 mL.

PARTS OF STOMACH

Four parts: -

1. Cardiac region
2. Fundus



3. Body or corpus
4. Pyloric region

1. **Cardiac Region**

- ➢ Upper part of the stomach where esophagus opens.
- ➢ The opening is guarded by a sphincter called **cardiac sphincter,**
- ➢ **Which opens only towards** stomach.
- ➢ This portion is also known as **cardiac end.**

2. Fundus -

- ✓ Small dome shaped structure.
- ✓ It is elevated above the level of esophageal opening.

3. Body or Corpus -

Body is the largest part of stomach forming about 75% to 80% of the whole stomach.

4. Pyloric Region -

- Two parts, Antrum and Pyloric canal.
- The body of stomach ends in **Antrum.**
- **Junction between** body and Antrum is marked by an angular notch called **incisura angularis.**

STRUCTURE OF STOMACH WALL -

Four layers of structures:

1. Outer serous layer: *Formed by **peritoneum***

2. Muscular layer: *Made up of three layers of smooth* muscle fibers, namely inner oblique, middle circular and outer longitudinal layers.

3. Submucus layer: *Formed by areolar tissue, blood* vessels, lymph vessels and **Meissner nerve plexus.**

4. Inner mucus layer: *Lined by mucus secreting* columnar epithelial cells. The gastric glands and **gastric pits are present** in this layer.

FUNCTIONS OF GASTRIC GLANDS -

- ✓ Function of the gastric gland is to secrete gastric juice.
- ✓ Secretory activities of different cells of gastric glands and enteroendocrine cells.

Cell	Secretory products
Chief cells	Pepsinogen Rennin Lipase Gelatinase Urase
Parietal cells	Hydrochloric acid Intrinsic factor of Castle
Mucus neck cells	Mucin
G cells	Gastrin
Enterochromaffin (EC) cells	Serotonin
Enterochromaffin-like (ECL) cells	Histamine

FUNCTIONS OF STOMACH -

1. MECHANICAL FUNCTION

i. Storage Function -

Food is stored in the stomach for a long period, i.e. for 3 to 4 hours and emptied into the intestine slowly.

ii. Formation of Chyme -

Peristaltic movements of stomach mix the bolus with gastric juice and convert it into the semisolid material known as chyme.

2. DIGESTIVE FUNCTION

3. PROTECTIVE FUNCTION

4. HEMOPOIETIC FUNCTION

5. EXCRETORY FUNCTION

Many substances like toxins, alkaloids and metals are excreted through gastric juice.

- **PROPERTIES OF GASTRIC JUICE -**

Volume : 1200 mL/day to 1500 mL/day.

Reaction : Gastric juice is highly acidic with a pH of 0.9 to 1.2.

Specific gravity : 1.002 to 1.004

- **COMPOSITION OF GASTRIC JUICE -**

Gastric juice contains 99.5% of water and 0.5% solids. Solids are organic and inorganic substances.

FUNCTIONS OF GASTRIC JUICE

1. DIGESTIVE FUNCTION -

- Gastric juice acts mainly on proteins.
- Proteolytic enzymes of the gastric juice are pepsin and rennin.
- Gastric juice also contains some other enzymes like gastric lipase, gelatinase, urase and gastric amylase.

PEPSIN -

- Pepsin is secreted as inactive pepsinogen.

- Pepsinogen is converted into pepsin by hydrochloric acid.

Action of pepsin -

- Pepsin converts proteins into proteoses, peptones and polypeptides.
- Pepsin also causes curdling and digestion of milk (casein).

GASTRIC LIPASE -

Gastric lipase is a weak lipolytic enzyme.

Actions of Other Enzymes of Gastric Juice

i. Gelatinase: Degrades type I and type V gelatin and type IV and V collagen into peptides.

ii. Urase: Acts on urea and produces ammonia

iii. Gastric amylase: Degrades starch

iv. Rennin: Curdles milk (present in animals only).

2. HEMOPOIETIC FUNCTION

- Intrinsic factor of **Castle, secreted by parietal cells of** gastric glands plays an important role in erythropoiesis.
- It is necessary for the absorption of vitamin B12 from GI tract into the blood.
- Vitamin B12 is an important maturation factor during erythropoiesis.
- Absence of **intrinsic factor in gastric** juice causes deficiency of vitamin B12, leading to **pernicious anemia.**

3. PROTECTIVE FUNCTION – FUNCTION OF MUCUS

Mucus is a mucoprotein, secreted by mucus neck cells of the gastric glands and surface mucus cells in fundus, body and other parts of stomach.

4. FUNCTIONS OF HYDROCHLORIC ACID

Hydrochloric acid is present in the gastric juice:

i. Activates pepsinogen into pepsin

ii. Kills some of the bacteria entering the stomach along with food substances.

iii. Provides acid medium, which is necessary for the action of hormones.

SECRETION OF GASTRIC JUICE - SECRETION OF PEPSINOGEN

Pepsinogen is synthesized from amino acids in the ribosomes attached to **endoplasmic reticulum in chief** cells.

- Pepsinogen molecules are packed into **zymogen granules by Golgi apparatus.**
- When zymogen granule is secreted into stomach from chief cells, the granule is dissolved and pepsinogen is released into gastric juice.
- Pepsinogen is activated into pepsin by hydrochloric acid.

SECRETION OF HYDROCHLORIC ACID

According to **Davenport theory,**

⬇

hydrochloric acid secretion is an active process

⬇

that takes place in the Canaliculi of parietal cells in gastric glands.

⬇

Energy from oxidation of glucose.

- Carbon dioxide is derived from metabolic activities of parietal cell.

⬇

presence of **carbonic anhydrase.**

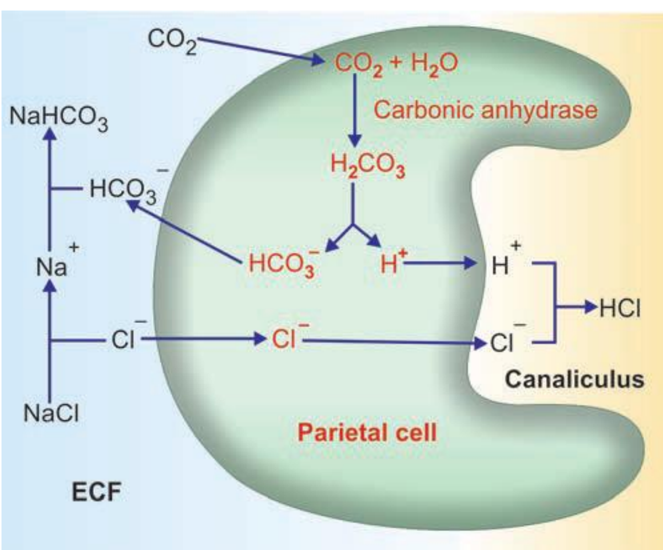


Figure : - Secretion of hydrochloric acid in the parietal cell of gastric gland.

Factors stimulating the secretion of hydrochloric acid –

Such as – Gastrin , Histamine , Vagal stimulation.

Factors inhibiting the secretion of hydrochloric acid -

Such as - Secretin , Gastric inhibitory polypeptide , Peptide YY.

❑ REGULATION OF GASTRIC SECRETION -

Regulation of gastric secretion and intestinal secretion is studied by some experimental procedures.

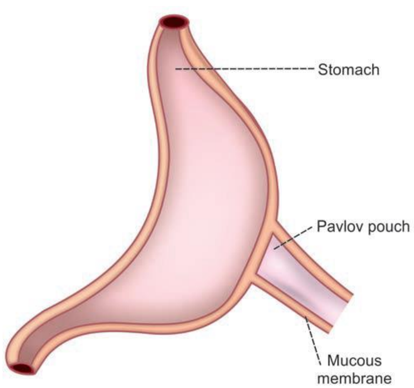
METHODS OF STUDY -

1. **PAVLOV POUCH**

Pavlov pouch is a small part of the stomach that is incompletely separated from the main portion and made into a small bag like pouch.

Use of Pavlov pouch

Used to demonstrate the different phases of gastric secretion, particularly cephalic phase and used to demonstrate the role of vagus in cephalic phase.



2. HEIDENHAIN POUCH -

Heidenhain pouch is the modified Pavlov pouch.

USE - Useful to demonstrate the role of sympathetic nerve and the hormonal regulation of gastric secretion after vagotomy .

3. BICKEL POUCH –

Used to demonstrate the role of hormones in gastric secretion.

4. FARREL AND IVY POUCH

Useful to study the role of hormones during gastric and intestinal phases of gastric secretion.

5. SHAM FEEDING –

Useful to demonstrate the secretion of gastric juice during cephalic phase.

PHASES OF GASTRIC SECRETION -

Secretion of gastric juice is a continuous process.

Gastric secretion occurs in three different phases: -

I. Cephalic phase

II. Gastric phase

III. Intestinal phase.

In human beings, a fourth phase called **interdigestive phase.**

CEPHALIC PHASE

- ➢ Secretion of gastric juice by the stimuli arising from head region (cephalus) is called cephalic phase.

This phase regulated by nervous mechanism.

- ➢ Gastric juice secreted during this phase is called appetite juice.
- ➢ Quantity is less but it is rich in enzymes and hydrochloric acid.
- ✓ Nervous mechanism Regulates Cephalic phase through reflex action.

Two types of reflexes occur: -

1. Unconditioned reflex

2. Conditioned reflex.

1. *Unconditioned Reflex*

- ✓ Unconditioned reflex is the inborn reflex.
- ✓ When food is placed in the mouth, salivary secretion is induced. Simultaneously, gastric secretion also occurs.

Stages of reflex action:-

i. Presence of food in the mouth stimulates the taste buds and other receptors.

↓

ii. Sensory (afferent) impulses from mouth pass via afferent nerve fibers of glossopharyngeal and facial nerves to **amygdala and appetite center** present in hypothalamus.

↓

iii. Efferent impulses pass through dorsal nucleus of vagus and vagal efferent nerve fibers to the wall of the stomach.

↓

iv. Vagal efferent nerve endings secrete acetylcholine, which stimulates gastric secretion.

2. *Conditioned Reflex*

- ✓ Conditioned reflex is the reflex response acquired by previous experience.
- ✓ The sight, smell, hearing or thought of food, which induce salivary secretion induce gastric secretion also.

Stages of reflex action:

i. Thinking of food stimulates the cerebral cortex directly, Impulses from the special sensory organs.

↓

through afferent fibers of neural circuits to the cerebral cortex.

↓

ii. Impulses pass through dorsal nucleus of vagus and vagal efferents

↓

to reach the stomach wall.

↓

iii. Vagal nerve endings secrete acetylcholine,

↓

which stimulates the gastric secretion.

GASTRIC PHASE –

- ✓ Secretion of gastric juice when food enters the stomach is called gastric phase.
- ✓ Phase is regulated by both nervous and hormonal control.
- ✓ Gastric juice rich in pepsinogen and hydrochloric acid.

Mechanisms involved in gastric phase are:-

1. Nervous mechanism - Through local myenteric reflex and vagovagal reflex

2. Hormonal mechanism - Gastrin

- ✓ Stimuli, which initiate these two mechanisms are:-

1. Distention of stomach
2. Mechanical stimulation of gastric mucosa - by bulk of food
3. Chemical stimulation of gastric mucosa - by the food contents.

1. *Nervous Mechanism*

Local myenteric reflex –

- Reflex elicited by stimulation of myenteric nerve plexus in stomach wall.
- Food particles stimulate the local nerve plexus present in the wall of the stomach.

⬇

nerve fibers release acetylcholine,

⬇

which stimulates the gastric glands to secrete a large quantity of gastric juice.

- Simultaneously, acetylcholine stimulates G cells to secrete gastrin.

Vagovagal reflex –

- Reflex which involves both afferent and efferent vagal fibers.
- Entrance of bolus into stomach stimulates

⬇

Sensory (afferent) nerve endings of vagus

⬇

Sensory impulses are transmitted by sensory fibers of vagus to

⬇

Dorsal nucleus of vagus, (located medulla of brainstem)

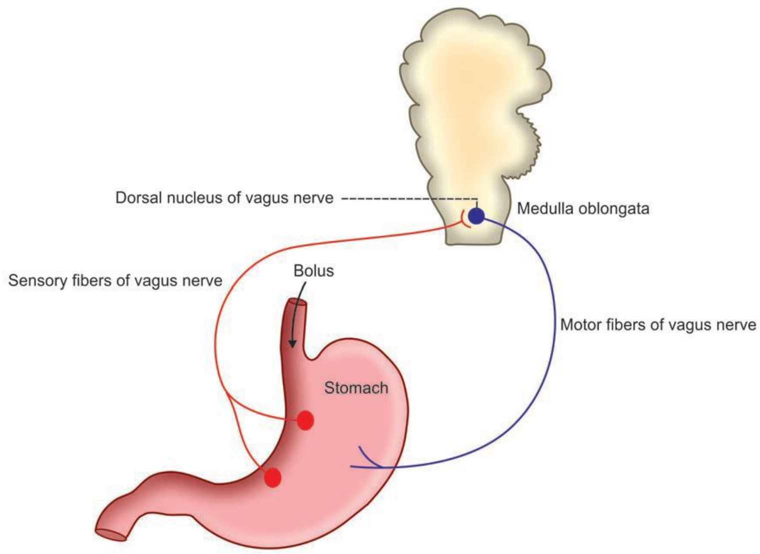
⬇

Efferent impulses through the motor (efferent) fibers of vagus, back to

⬇

Stomach (cause secretion of gastric juice).

- Both afferent and efferent impulses pass through Vagus, this reflex is called Vagovagal reflex.



2. ***Hormonal Mechanism – Gastrin -***

- Gastrointestinal hormone secreted by the G cells (in the pyloric glands of stomach).
- Small amount of gastrin is also secreted in mucosa of upper small intestine.
- In fetus - also secreted by islets of Langerhans in pancreas.
- Gastrin – polypeptide (G14, G17 or G34 amino acids).
- Mechanism involved in the release of gastrin - local nervous reflex or vagovagal reflex.
- Nerve endings release neurotransmitter called gastrin releasing peptide,(stimulates the G cells to secrete gastrin).

Actions of gastrin on gastric secretion -

Stimulates secretion of pepsinogen and hydrochloric acid by gastric glands.

INTESTINAL PHASE

- Secretion of gastric juice when Chyme enters the intestine.
- Initially, the gastric secretion increases but later it stops.
- Regulated by nervous and hormonal control.

INITIAL STAGE OF INTESTINAL PHASE -

Chyme that enters intestine stimulates

⬇

duodenal mucosa to release gastrin,

⬇

transported to stomach by blood

⬇

increases gastric secretion.

LATER STAGE OF INTESTINAL PHASE –

After the initial increase, there is a decrease or complete stoppage of gastric secretion.

Gastric secretion is inhibited by two factors:

1. Enterogastric reflex

2. Gastrointestinal (GI) hormones.

1**. ENTEROGASTRIC REFLEX -**

Enterogastric reflex inhibits the gastric secretion and motility.

⬇

due to the distention of intestinal mucosa by chyme

⬇

or chemical or osmotic irritation of intestinal mucosa by chemical substances in the chyme.

- Mediated by Myenteric nerve (Auerbach) plexus and vagus.

2. GASTROINTESTINAL HORMONES –

Presence of chyme in the intestine stimulates

⬇

secretion of many GI hormones from intestinal mucosa

⬇

All these hormones inhibit gastric secretion.

GI HORMONES WHICH INHIBIT GASTRIC SECRETION:-

i. ***Secretin****: Secreted by the presence of acid* chyme in the intestine

ii. ***Cholecystokinin****: Secreted by the presence* of chyme containing fats and amino acids in intestine

iii. ***Gastric inhibitory peptide (GIP****): Secreted by the* presence of chyme containing glucose and fats in the intestine

iv. ***Vasoactive intestinal polypeptide (VIP):*** *Secreted* by the presence of acidic chyme in intestine

v. ***Peptide YY****: Secreted by the presence of fatty* Chyme in intestine.

- ✓ **Somatostatin** also inhibits gastric secretion
  ⬇
  Secreted by pancreas during intestinal phase.

INTERDIGESTIVE PHASE

- ✓ Secretion of gastric juice in between meals (or during period of fasting) is called interdigestive phase.
- ✓ Gastric secretion mainly due to the hormones like gastrin.
- ❑ Alcohol and caffine increase gastric secretion by
  ⬇
  Stimulating gastric mucosa.

MCQ -

Q.1. Stimulation of gastrointestinal secretion include –

A. Chemical stimuli

b. tactile stimulation

c. distension

d. all

Q. 2. The GIT is controlled by –

a. intrinsic nervous system

b. sympathetic N.S.

C. Para sympathetic N.S.

D. all

Q. 3. Inhibition of myenteric plexus leads to which of the following.

a. diarrhea

b. decreased gut motility

c. hyperactivity in the stomach

d. none

Q. 4. Stimulation of sub mucosal plexus result in an increase in which of the following.

a. motility of the gut

b. secretion of the gut

c. sphincter tone

d. stomach ph

Q. 5. All the following are correct about gastrin except –

a. it is stimulated by distension of antrum

b. it is stimulated by insulin induced hypoglycaemia

c. it secretion is increased by secretin.

Q.6. Mastication –

a. is entirely a voluntary act.

b. includes both voluntary and reflex components.

c. both a and b

d. none

Q. 7. Man is unable to digest dietary.

a. glycogen

b. dextrin

c. glucose

d. cellulose

Q. 8. The salivary secretion –

a. has a serous component.

b. has a mucous component.

c. both

d. none

Q. 9. Saliva is necessary for –

a. digestion of food

b. swallowing of food

c. both a and b

d. antisepsis in mouth

Q. 10. During which stage of swallowing is respiration inhibited.

a. voluntary stage

b. pharyngeal stage

c. esophageal stage

d. postprandial stage.

Answers – 1. D, 2 – d, 3- b, 4- b, 5- c, 6- b, 7- d, 8- c, 9- d, 10 - b

Chapter – 15

PANCREATIC SECRETION

PANCREAS -

- ✓ Pancreas is a dual organ having two functions, namely **endocrine function and exocrine function.**
- ✓ **Endocrine** function is concerned - Production of hormones
- ✓ Exocrine function is concerned - Secretion of digestive juice called pancreatic juice.
- ➢ Exocrine part of pancreas resembles salivary gland in structure.

It is made up of **acini or alveoli.**

PROPERTIES OF PANCREATIC JUICE

Volume : 500 to 800 mL/day

Reaction : Highly alkaline with a pH of 8 to 8.3

Specific gravity : 1.010 to 1.018

COMPOSITION OF PANCREATIC JUICE -

Pancreatic juice contains 99.5% of water and 0.5% of solids.

- ➢ Bicarbonate content is very high in pancreatic juice.
- ➢ It is about 110 to 150 mEq/ L

High bicarbonate content of pancreatic juice is important because of **two reasons**: -

i. High bicarbonate content makes the pancreatic juice **highly alkaline - protects the intestinal** mucosa from acid chyme by neutralizing it.

ii. Bicarbonate ions provide the required pH (7 to 9) for the activation of pancreatic enzymes.

FUNCTIONS OF PANCREATIC JUICE -

Pancreatic juice has - digestive functions and neutralizing action.

DIGESTIVE FUNCTIONS OF PANCREATIC JUICE

Pancreatic juice plays an important role in the digestion of proteins and lipids. It also has mild digestive action on carbohydrates.

DIGESTION OF PROTEINS -

Major proteolytic enzymes of pancreatic juice - **1. *Trypsin***

2. Chymotrypsin **3. Carboxypeptidases**

4. Nucleases **5. Elastase**

6. Collagenase

1. **Trypsin** - Single polypeptide (mw- 25,000).

- Contains - 229 amino acids.
- Secreted as inactive trypsinogen
- Which is converted into active trypsin by **enterokinase.**

Trypsin inhibitor –

If trypsin is activated when it is in pancreas

⬇

hydrolyze the pancreatic tissue proteins

⬇

pancreatic damage

- But its activation in secretory cells, acini and ducts of pancreas is prevented by an inhibitor protein called trypsin inhibitor.

ACTIONS OF TRYPSIN -

i. Digestion of proteins: (**endopeptidase) -** breaks the interior bonds of the protein Molecules.

Converts proteins ------ Proteoses and Polypeptides

ii. Curdling of milk: (Converts **caseinogen** - **casein**

iii. Blood clotting: It accelerates blood clotting

iv. It activates the other enzymes of pancreatic juice, viz. -

a. Chymotrypsinogen into chymotrypsin

b. Procarboxypeptidases into carboxypeptidases

c. Proelastase into elastase

d. Procolipase into colipase

v. Trypsin also activates collagenase, phospholipase A and phospholipase B

vi. **Autocatalytic action**: Once formed, trypsin itself converts trypsinogen into trypsin.

2. CHYMOTRYPSIN –

Which is activated into chymotrypsin by trypsin.

Actions of chymotrypsin –

i. **Digestion of proteins:** (endopeptidase) - converts proteins into polypeptides

ii. Digestion of milk: (digests caseinogen faster than trypsin.

iii. On blood clotting: No action.

3. CARBOXYPEPTIDASES -

- ✓ Carboxypeptidases are carboxypeptidase A and carboxyp eptidase B.
- ✓ Carboxypeptidase A is derived from the precursor procarboxypeptidase A.

4. NUCLEASES -

- ✓ Ribonuclease and deoxyribonuclease - digestion of nucleic acids.
- ✓ These enzymes convert the ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) into mononucleotides.

5. ELASTASE -

- ✓ Secreted as inactive proelastase, which is activated into elastase by trypsin.
- ✓ Elastase digests the elastic fibers.

6. COLLAGENASE -

- ✓ Secreted as inactive Procollagenase, which is activated into collagenase by trypsin.
- ✓ It digests collagen.

DIGESTION OF LIPIDS -

Lipolytic enzymes present in Pancreatic juice – - Pancreatic lipase,
- Cholesterol ester hydrolase,
- Phospholipase A, phospholipase B,

- Colipase

- Bile – Saltactivated lipase.

1. PANCREATIC LIPASE -

- ✓ PH required for enzyme is 7 to 9. - powerful lipolytic enzyme.
- ✓ Digests - triglycerides into monoglycerides and fatty.

Digestion of fat by pancreatic lipase requires **two factors**: -

i. Bile salts - (emulsification of fat, prior to their digestion)

ii. Colipase - (coenzyme necessary for pancreatic lipase to digest the dietary lipids). About 80% of the fat is digested by pancreatic lipase.

Steatorrhea - Deficiency or absence of this enzyme leads to excretion of undigested fat in feces.

2. CHOLESTEROL ESTER HYDROLASE -

Cholesterol esterase converts cholesterol ester into free cholesterol and fatty acid by hydrolysis.

3. PHOSPHOLIPASE A -

- Activated by trypsin.
- Phospholipase A digests phospholipids, namely **lecithin and cephalin** and converts them into **lysophospholipids.**

4. PHOSPHOLIPASE B -

- Activated by trypsin.
- Converts lysophospholipids (lysolecithin and lysocephalin) to **phosphoryl choline and free fatty acids.**

5. COLIPASE -

- ✓ Secreted as inactive procolipase.
- ✓ Procolipase is activated into colipase by trypsin.
- ✓ **Function** - digestive action of pancreatic lipase on fats.

6. BILE-SALT-ACTIVATED LIPASE -

- ✓ lipolytic enzyme activated by bile salt.
- ✓ Also called **carboxyl ester lipase or cholesterol esterase.**
- ✓ Hydrolyses a variety of lipids (phospholipids, cholesterol esters and triglycerides).

❑ DIGESTION OF CARBOHYDRATES

- ✓ Pancreatic amylase (Amylolytic enzyme) present in pancreatic juice.
- ✓ Like salivary amylase, the pancreatic amylase also converts **starch** into **dextrin** and **maltose.**

NEUTRALIZING ACTION –

- ✓ Alkaline pancreatic juice (Presence of bicarbonate ions) neutralizes acidity of chyme in the intestine.
- ✓ Important function - Protects the intestine from destructive action of acid in the chyme.

Enzyme	Activator	Acts on (substrate)	End products
Trypsin	Enterokinase Trypsin	Proteins	Proteoses and polypeptides
Chymotrypsin	Trypsin	Proteins	Polypeptides
Carboxypeptidases	Trypsin	Polypeptides	Amino acids
Nucleases	Trypsin	RNA and DNA	Mononucleotides
Elastase	Trypsin	Elastin	Amino acids
Collagenase	Trypsin	Collagen	Amino acids
Pancreatic lipase	Alkaline medium	Triglycerides	Monoglycerides and fatty acids
Cholesterol ester hydrolase	Alkaline medium	Cholesterol ester	Cholesterol and fatty acids
Phospholipase A	Trypsin	Phospholipids	Lysophospholipids
Phospholipase B	Trypsin	Lysophospholipids	Phosphoryl choline and free fatty acids
Colipase	Trypsin	Facilitates action of pancreatic lipase	–
Bile-salt-activated lipase	Trypsin	Phospholipids	Lysophospholipids
		Cholesterol esters	Cholesterol and fatty acids
		Triglycerides	Monoglycerides and fatty acids
Pancreatic amylase	–	Starch	Dextrin and maltose

Figure: Digestive enzymes of pancreatic juice

REGULATION OF PANCREATIC SECRETION -

Regulated by both Nervous and Hormonal factors.

STAGES OF PANCREATIC SECRETION -

Three stages - 1. Cephalic phase

1. Cephalic

2. Gastric phase

3. Intestinal phase.

These three phases of pancreatic secretion correspond with three phases of gastric secretion.

1. CEPHALIC PHASE

Cephalic phase is regulated by **nervous mechanism** through reflex action.

Two types of reflexes occur: -

1. Unconditioned reflex

2. Conditioned reflex.

Unconditioned Reflex

- ✓ Inborn reflex.

STAGES OF REFLEX ACTION:-

Presence of food in mouth stimulates **taste buds and other receptors in the mouth**

⬇

Sensory (afferent) impulses from mouth reach dorsal nucleus of vagus

⬇

efferent impulses reach pancreatic acini via vagal efferent nerve fibers

⬇

Vagal efferent nerve endings secrete acetylcholine - stimulates pancreatic secretion

Conditioned Reflex

- ✓ Reflex response acquired by previous experience .
- ✓ The sight, smell, hearing or thought of food, which induce salivary secretion and gastric secretion induce pancreatic secretion also.

STAGES OF REFLEX ACTION: -

i. Impulses from special sensory organs (eye, ear and nose) pass through

⬇

Afferent fibers of neural circuits to the cerebral cortex.

⬇

Impulses pass through dorsal nucleus of vagus and vagal efferents

⬇

Reach pancreatic acini (Vagal nerve endings secrete) - acetylcholine,

⬇

Stimulates pancreatic secretion.

2. GASTRIC PHASE

- Secretion of pancreatic juice when food enters the stomach is known as gastric phase.
- This phase is under hormonal control.
- When food enters the stomach, gastrin is secreted from stomach.

⬇

Gastrin is transported to pancreas through blood,

⬇

it stimulates pancreatic secretion.

3. INTESTINAL PHASE

- Secretion of pancreatic juice when chyme enters the intestine.
- This phase is also under hormonal control.
- Some hormones stimulate the pancreatic secretion and some hormones inhibit the pancreatic secretion.

Hormones Stimulating Pancreatic Secretion - Secretin , Cholecystokinin.

Action of secretin -

1. Stimulates the secretion of watery juice (rich in of bicarbonate ion and high in volume).

2. It increases pancreactic secretion (by acting on pancreatic ductules via cyclic AMP(messenger).

Action of cholecystokinin -

Secretion of pancreatic juice (rich in enzyme and low in volume),

⬇

Acting on pancreatic acinar cells via **inosine triphosphate** (second messenger).

✓ **Hormones Inhibiting Pancreatic Secretion -** Pancreatic polypeptide (PP) , Somatostatin , Peptide YY , Peptides like ghrelin and leptin.

MCQ –

Q.1. Gastric secretion inhibition is brought about by –

a. enterogastrone

b. gastrin

c. cholecystokinin

d. none

Q.2. When pancreatic juice is pumped into the duodenum in humans, one of the consitutents is –

a. trypsin

b. trypsionogen

c. cholecystokinin

d. none

Q. 3. Major product of the chief cell is –

a. mucus

b. pepsinogen

c. vit. B12

d. none

Q.4. The islets of the Langerhans are found in which of the following.

a. stomach

b. pancreas

c. alimentary canal

d. liver

Q. 5. Pancreatic juice secretion is caused by –

a. gastrin

b. secretin

c. enterogastrone

d. none

Q. 6. The common passage for pancreatic juice and bile is –

a. stomach

b. ampulla

c. duct of wirsung

d. none

Q. 7. Most diagnostic investigation for the acute pancreatitis.

a. serum LDH

b. serum lipase

c. serum amylase

d. serum p – lsoamylase

Q. 8. Pancreas in relation to the duodenum and stomach .

a. posterior

b. posterior and superior

c. anterior

d. none

Q. 9. Pancreas is the ………. Gland.

a. heterocrine

b. exocrine

c. endocrine

d. hormone

Q. 10 It is possible to live without a pancreas.

a. true

b. false

Answers – 1- a, 2- b, 3- b, 4- b, 5- a, 6- a, 7-b, 8- a, 9 – a, 10- a

Chapter – 16

LIVER

LIVER

- Liver is a dual organ having both secretory and excretory functions.
- It is the largest gland in the body,
- Weighing about 1.5 kg in man.
- located in the upper and right side of the abdominal cavity.

PROPERTIES OF BILE

Volume : 800 to 1,200 mL/day

Reaction : Alkaline

pH : 8 to 8.6

Specific gravity : 1.010 to 1.011

Color : Golden yellow or green.

COMPOSITION OF BILE

Bile contains 97.6% of water and 2.4% of solids.

SECRETION OF BILE

- Bile is secreted by hepatocytes.
- Bile secreted by hepatocytes contains large quantity of bile acids, bile pigments, cholesterol, lecithin and fatty acids.
- From hepatocytes, bile is released into canaliculi.
- From here, it passes through small ducts and hepatic ducts and reaches the common hepatic duct.
- From common hepatic duct, bile is diverted either directly into the intestine or into the gallbladder.

STORAGE OF BILE

- Most of the bile from liver enters the gallbladder, where it is stored.

- It is released from gallbladder into the intestine whenever it is required.

BILE SALTS

Bile salts are the sodium and potassium salts of bile acids, which are conjugated with **glycine** or **taurine.**

FORMATION OF BILE SALTS

Bile salts are formed from **bile acids.**

There are two **primary bile acids in human, namely cholic acid and chenodeoxycholic acid,**

⬇

which are formed in liver and enter the intestine through bile.

⬇

Due to the bacterial action in the intestine, the primary bile acids are converted into

Secondary bile acids: -

Cholic acid → **deoxycholic acid**

Chenodeoxycholic acid → **lithocholic acid**

FUNCTIONS OF BILE SALTS

Bile salts are required for digestion and absorption of fats in the intestine.

1. **Emulsification of Fats -**

Emulsification (fat globules are broken down into minute droplets)

⬇

in the form of a milky fluid called **emulsion**

- ✓ Lipolytic enzymes of GI tract cannot digest the fats

⬇

fats are insoluble in water due to surface tension.

⬇

Bile salts emulsify fats by reducing surface tension

⬇

due to their **detergent action.**

- ❑ Unemulsified fat usually passes through intestine - It is eliminated in feces.
- ❑ Emulsification of fats by bile salts (needs the presence of lecithin from bile).

2. Absorption of Fats -

- ✓ Absorption of digested fats from intestine into blood.
- ✓ Bile salts combine with fats and make complexes of fats called **micelles.**

3. Choleretic Action -

Bile salts stimulate the secretion of bile from liver. This action is called choleretic action.

4. Cholagogue Action -

Cholagogue is an agent which causes contraction of gallbladder and release of bile into the intestine.

5. Laxative Action -

- ✓ Laxative is an agent which induces defecation.
- ✓ Bile salts act as laxatives by stimulating peristaltic movements of intestine.

6. Prevention of Gallstone Formation -

- ✓ Bile salts prevent the formation of gallstone by keeping cholesterol and lecithin in solution.
- ✓ In the absence of bile salts, cholesterol precipitates along with lecithin and forms gallstone.

❑ **BILE PIGMENTS**

- ✓ Bile pigments are the excretory products in bile.
- ✓ **Bilirubin** and **biliverdin are the two bile pigments and bilirubin is** major bile pigment.
- ✓ Bile pigments are formed during the breakdown of hemoglobin, which is released from the destroyed RBCs in the reticuloendothelial system.

NORMAL PLASMA LEVELS OF BILIRUBIN

- ✓ Normal bilirubin (Total bilirubin) content in plasma is 0.5 to 1.5 mg/dL.
- ✓ When it exceeds 1mg/dL, the condition is called **hyperbilirubinemia.**
- ✓ **When it exceeds 2 mg/dL, jaundice occurs.**

FUNCTIONS OF BILE

Most of the functions of bile are due to the bile salts.

1. DIGESTIVE FUNCTION

Same as bile salts.

2. ABSORPTIVE FUNCTIONS

Same as bile salts.

3. EXCRETORY FUNCTIONS

Bile pigments are the major excretory products of the bile. Other substances excreted in bile are:- Heavy metals like copper and iron , Some bacteria like typhoid bacteria,
Cholesterol, Lecithin , Alkaline phosphatase.

4. LAXATIVE ACTION

Same as bile salts.

5. ANTISEPTIC ACTION

Bile inhibits the growth of certain bacteria in the lumen of intestine by its **natural detergent action.**

6. CHOLERETIC ACTION

Same as bile salts.

7. MAINTENANCE OF pH IN GASTROINTESTINAL TRACT

As bile is highly alkaline, it neutralizes the acid chyme which enters the intestine from stomach.

8. PREVENTION OF GALLSTONE FORMATION

Same as bile salts.

9. LUBRICATION FUNCTION

Mucin in bile - Acts as a lubricant for the chyme in intestine.

10. CHOLAGOGUE ACTION

Same as bile salts.

❑ FUNCTIONS OF LIVER

- ✓ Liver is the largest gland and one of the vital organs of the body.
- ✓ It performs many vital metabolic and homeostatic functions.

1. METABOLIC FUNCTION

Liver is the organ where maximum metabolic reactions such as metabolism of carbohydrates, proteins, fats, vitamins and many hormones are carried out.

2. STORAGE FUNCTION

Many substances like glycogen, amino acids, iron, folic acid and vitamins A, B12 and D are stored in liver.

3. SYNTHETIC FUNCTION

- Liver produces glucose by gluconeogenesis.
- It synthesizes all the plasma proteins and other proteins (except immunoglobulins) such as clotting factors, and hormone binding proteins.
- It also synthesizes steroids, Somatomedin and heparin.

4. SECRETION OF BILE

- Liver secretes bile which contains bile salts, bile pigments, cholesterol, fatty acids and lecithin.
- Bile salts are required for digestion and absorption of fats in the intestine.
- Bile helps to carry away waste products and breakdown fats, which are excreted through feces or urine.

5. EXCRETORY FUNCTION

Liver excretes cholesterol, bile pigments, heavy metals (like lead, arsenic and bismuth), toxins, bacteria and virus (like that of yellow fever) through bile.

6. HEAT PRODUCTION

Heat is produced in the liver because of metabolic reactions. Liver is the organ where maximum heat is produced.

7. HEMOPOIETIC FUNCTION

- ✓ In fetus (hepatic stage), liver produces the blood cells .
- ✓ It stores vitamin B12 necessary for erythropoiesis and iron necessary for synthesis of hemoglobin.

8. HEMOLYTIC FUNCTION

The senile RBCs after a lifespan of 120 days are destroyed by reticuloendothelial cells (Kupffer cells) of liver.

9. INACTIVATION OF HORMONES AND DRUGS

The fat soluble drugs are converted into water soluble substances, which are excreted through bile or urine.

10. DEFENSIVE AND DETOXIFICATION FUNCTIONS

- ✓ **Reticuloendothelial cells** (Kupffer cells) of the liver play an important role in the defense of the body.
- ✓ Liver is also involved in the detoxification of the foreign bodies.

MCQ –

Q.1. What are the functions of the human liver .

a. bile production

b. fats metabolism

c. carbohydrate

d. all the above

Q.2. Which organ is responsible for the production of Albumin.

a. heart

b. kidneys

c. liver

d. none

Q. 3. Where is the liver situated in the human body.

a. next to pancreas

b. next to heart

c. nex to kidney

d. above the abdominal cavity.

Q. 4. Which vitamins does the liver store.

a. vit. A

b. vit. B12

c. vit. C

d. all the above

Q. 5. Bile salts acts as activator of which enzyme.

a. lipase

b. pepsinogen

c. pancreatic lipase

d. trypsin

Q. 6. Bile salts help in emulsification of proteins.

a. true

b. false

Q. 7. What enzyme does liver secretes.

a. bile juice

b. thyroxin

c. insulin

d. all the above

Q. 8. Which vitamin is stored in liver.

a. vit. E

B. vit. K

c. vit. C

D. Only a and b

Q. 9. Which of following is a liver disease.

a. appendicitis

b. cirrhosis

c. conjunctivitis

d. diabetes

Q.10. Which of the following cells are found in liver.

a. kupffer cells

b. neurons

c. sperm cells

d. none

Answers- 1.- d, 2- c, 3- d, 4- d, 5- a, 6- b, 7- a, 8- d, 9- b, 10 – a.

Chapter – 17

SMALL INTESTINE

SMALL INTESTINE

- ✓ Small intestine is the part of gastrointestinal (GI) tract, extending between the **pyloric sphincter of stomach** and **ileocecal valve, which opens into large intestine.**
- ✓ **It** is called small intestine because of its small diameter, compared to that of the large intestine.
- ✓ But it is longer than large intestine.
- ✓ Its length is about 6 meter.

IMPORTANT FUNCTION OF SMALL INTESTINE IS ABSORPTION.

Maximum absorption of digested food products takes place in small intestine.

Small intestine consists of three portions: -

1. Proximal part known as duodenum

2. Middle part known as jejunum

3. Distal part known as ileum.

PROPERTIES OF SUCCUS ENTERICUS

Volume : 1800 mL/day

Reaction : Alkaline

pH : 8.3

COMPOSITION OF SUCCUS ENTERICUS

Succus Entericus contains water (99.5%) and solids (0.5%).

FUNCTIONS OF SUCCUS ENTERICUS

1. DIGESTIVE FUNCTION

- ✓ Enzymes of Succus Entericus act on digested food and convert them into final digestive products.

- ✓ Enzymes are produced and released into Succus Entericus by enterocytes of the villi.

Enzyme	Substrate	End products
Peptidases	Peptides	Amino acids
Sucrase	Sucrose	Fructose and glucose
Maltase	Maltose and maltriose	Glucose
Lactase	Lactose	Galactose and glucose
Dextrinase	Dextrin, maltose and maltriose	Glucose
Trehalase	Trehalose	Glucose
Intestinal lipase	Triglycerides	Fatty acids

2. PROTECTIVE FUNCTION

i. Mucus present in the succus entericus protects the intestinal wall from the acid chyme, which enters the intestine from stomach; thereby it prevents the **intestinal ulcer.**

ii. **Defensins secreted by paneth cells of intestinal** glands are the **antimicrobial peptides.**

3. ACTIVATOR FUNCTION

- Enterokinase present in intestinal juice activates trypsinogen into trypsin.
- Trypsin, in turn activates other enzymes.

4. HEMOPOIETIC FUNCTION

- **Intrinsic factor of Castle present in the intestine plays** an important role in erythropoiesis .
- It is necessary for the absorption of vitamin B12.

5. HYDROLYTIC PROCESS

Intestinal juice helps in all the enzymatic reactions of digestion.

FUNCTIONS OF SMALL INTESTINE

1. MECHANICAL FUNCTION

Mixing movements of small intestine help in the thorough mixing of chyme with the digestive juices like succus entericus, pancreatic juice and bile.

2. SECRETORY FUNCTION

Small intestine secretes Succus Entericus, Enterokinase and the GI hormones.

3. HORMONAL FUNCTION

Small intestine secretes many GI hormones such as secretin, cholecystokinin, etc.

These hormones regulate the movement of GI tract and secretory activities of small intestine and pancreas.

4. DIGESTIVE FUNCTION

Refer functions of Succus Entericus.

5. ACTIVATOR FUNCTION

Refer functions of succus entericus.

6. HEMOPOIETIC FUNCTION

Refer functions of succus entericus.

7. HYDROLYTIC FUNCTION

Refer functions of succus entericus.

8. ABSORPTIVE FUNCTIONS

- ✓ Presence of villi and microvilli in small intestinal mucosa increases the surface area of mucosa.
- ✓ This facilitates the absorptive function of intestine.
- ✓ Digested products of foodstuffs, proteins, car bohydrates, fats and other nutritive substances such as vitamins, minerals and water are absorbed mostly in small intestine.

REGULATION OF SECRETION OF SUCCUS ENTERICUS

Regulated by both Nervous and Hormonal mechanisms.

NERVOUS REGULATION

- ✓ The local nervous reflexes play an important role in increasing the secretion of intestinal juice.

- ✓ When chyme enters the small intestine, the mucosa is stimulated by tactile stimuli or irritation.
- ✓ It causes the development of local nervous reflexes, which stimulate the glands of intestine.

HORMONAL REGULATION

- ✓ When Chyme enters the small intestine, intestinal mucosa secretes enterocrinin, secretin and cholecystokinin, which promote the secretion of Succus Entericus by stimulating the intestinal glands.

LARGE INTESTINE

LARGE INTESTINE

Large intestine or colon extends from ileocecal valve up to anus.

PARTS OF LARGE INTESTINE

Large intestine is made up of the following parts: -

1. Cecum with appendix
2. Ascending colon
3. Transverse colon
4. Descending colon
5. Sigmoid colon or pelvic colon
6. Rectum
7. Anal canal.

SECRETIONS OF LARGE INTESTINE

Large intestinal juice is a watery fluid with pH of 8.0.

COMPOSITION OF LARGE INTESTINAL JUICE

Large intestinal juice contains 99.5% of water and 0.5% of solids.

FUNCTIONS OF LARGE INTESTINAL JUICE

Neutralization of Acids -

- ✓ Strong acids formed by bacterial action in large intestine are neutralized by the alkaline nature of large intestinal juice.
- ✓ The alkalinity of this juice is mainly due to the presence of large quantity of bicarbonate.

Lubrication Activity

- ✓ Mucin present in the secretion of large intestine lubricates mucosa of large intestine.
- ✓ Mucin also protects large intestine by preventing the damage caused by mechanical injury or chemical substances.

2. FORMATION OF FECES

After the absorption of nutrients, water and other substances, the unwanted substances in the large intestine form feces. This is excreted out.

3. EXCRETORY FUNCTION

Large intestine excretes heavy metals like mercury, lead, bismuth and arsenic through feces.

4. SECRETORY FUNCTION

Large intestine secretes mucin and inorganic substances like chlorides and bicarbonates.

5. SYNTHETIC FUNCTION

- ✓ Bacterial flora of large intestine synthesizes folic acid, vitamin B12 and vitamin K.
- ✓ Large intestine contributes in **erythropoietic activity and blood** clotting mechanism.

MCQ -

Q.1. Small intestine is divided into ……. Parts.

a. 1

b. 2

c.4

d.3

Q. 2. Crypts of lieberkuhn are found in …….

a. gall bladder

b. intestine

c. liver

d. kidney

Q.3. The food that enters the intestine from stomach is called….

a. chime

b. fundus

c. chyle

d. bolus

Q. 4. In which of the following putrefying bacteria are present.

a. colon

b. intestine

c. liver

d. kidney

Q.5. …….Stores the temporary faeces.

a. colon

b. caecum

c. rectum

d. kidney

Q.6. Large intestine is divided into ……parts.

a. 3

b. 2

c.1

d.4

Q.7 Which among the following is the longest.

a. stomach

b. esophagus

c. small intestine

d. large intestine

Q. 8. The opening of ileum is guarded by …….

a. ileo caecal valve

b. mitral valve

c. sphincter

d. villi

Q. 9. Secretin and cholecystokinin are secreted by ----

a. esophagus

b. stomach

c. ileum

d. duodenum

Q.10. Which among the following is vestigial in function.

a. duodenum

b. vermiform apprndix

c. a and b

d. none

Answers- 1-d, 2-b, 3- a, 4- a, 5- c, 6- a, 7- c, 8- a, 9- d, 10 - b

Chapter – 18

MOVEMENTS OF GASTROINTESTINAL TRACT

MASTICATION

- ✓ **Chewing is the first mechanical process** in the gastrointestinal (GI) tract, by which the food substances are torn or cut into small particles and crushed or ground into a soft **bolus.**

Significances of mastication -

1. Breakdown of foodstuffs into smaller particles

2. Mixing of saliva with food substances thoroughly

3. Lubrication and moistening of dry food by saliva, so that the bolus can be easily swallowed

4. Appreciation of taste of the food.

DEGLUTITION

Definition

Deglutition or swallowing is the process by which food moves from mouth into stomach.

Stages of Deglutition

Deglutition occurs in three stages: -

I. Oral stage (food moves from mouth - pharynx)

II. Pharyngeal stage (food moves from pharynx - esophagus)

III. Esophageal stage (food moves from esophagus - stomach).

ORAL STAGE OR FIRST STAGE

Voluntary stage (bolus from mouth passes into pharynx)

Sequence of Events during Oral Stage

1. Preparatory position - Bolus is placed over postero - dorsal surface of the tongue.

2. Anterior part of tongue - Retracted and depressed.

3. Posterior part of tongue - elevated and retracted against the hard palate.

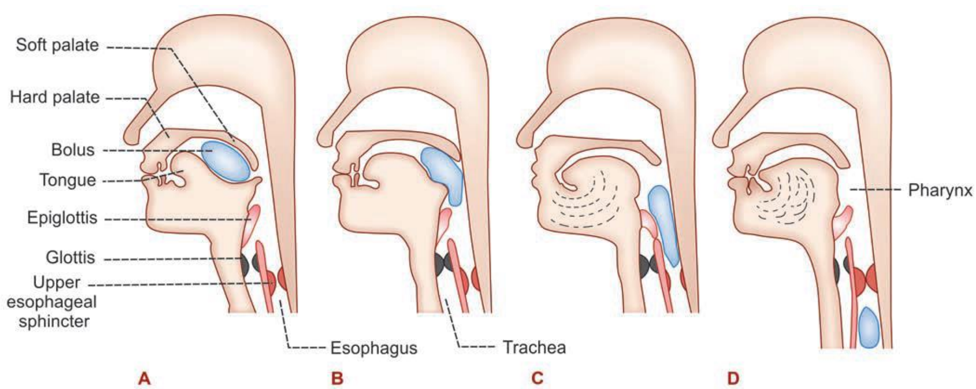
4. Forceful contraction of tongue against palate produces a positive pressure in the posterior part of oral cavity.

PHARYNGEAL STAGE OR SECOND STAGE

- ✓ Involuntary stage (bolus is pushed from pharynx into the esophagus).
- ✓ Pharynx is a common passage for food and air.
- ✓ It divides into larynx and esophagus.
- ✓ Larynx - lies anteriorly and continues as respiratory passage.
- ✓ Esophagus – lies behind larynx and continues as GI tract.
- ✓ pharynx communicates with - mouth , nose, larynx , esophagus.

Pharynx can enter into four paths:

1. Back into mouth
2. Upward into naso pharynx
3. Forward into larynx
4. Downward into esophagus.



Stages of deglutition. - A. Preparatory stage; B. Oral stage; C. Pharyngeal stage; D. Esophageal stage.

- ✓ Entrance of bolus through other paths is prevented as follows: -

1. Back into Mouth

Prevented by: -

i. Position of tongue against the soft palate (roof of the mouth)

ii. High intraoral pressure, developed by the movement of tongue.

2. Upward into Nasopharynx

Prevented by - elevation of soft palate along with its extension called uvula.

3. Forward into Larynx

Prevented by - i. Approximation of the vocal cords

ii. Forward and upward movement of larynx

iii. Backward movement of epiglottis to seal the opening of the larynx (glottis).

iv. All these movements arrest respiration for a few seconds. It is called deglutition apnea.

Deglutition apnea -

- ✓ Apnea refers to temporary arrest of breathing.
- ✓ Deglutition apnea or **swallowing apnea is the arrest of breathing** during pharyngeal stage of deglutition.

4.Entrance of Bolus into Esophagus -

As the other three paths are closed, the bolus has to pass only through the esophagus.

i. Upward movement of larynx stretches the opening of esophagus

ii. Simultaneously, upper 3 to 4 cm of esophagus relaxes.

This part of esophagus is formed by the crico pharyngeal muscle, called **upper esophageal sphincter or pharyngo esophageal sphincter.**

⬇

Peristaltic contractions start in the pharynx due to the contraction of pharyngeal muscles

⬇

Elevation of larynx also lifts the glottis away from the food passage.

- ❑ The whole process takes place within 1 to 2 seconds and this process is purely involuntary.

ESOPHAGEAL STAGE OR THIRD STAGE

- ➢ Also an involuntary stage.
- ➢ In this stage, food from esophagus enters the stomach.

- Esophagus forms the passage for movement of bolus from pharynx to the stomach.
- Movements of esophagus are called peristaltic waves.

⬇

Means a wave of contraction, followed by the wave of relaxation of muscle fibers of GI tract,

⬇

Travel in aboral direction (away from mouth).

⬇

Contents are propelled down along the GI tract.

- Two types of peristaltic contractions are produced in esophagus.

1. Primary peristaltic contractions
2. Secondary peristaltic contractions.

1. Primary Peristaltic Contractions -

When bolus reaches the upper part of esophagus,

⬇

peristalsis starts (known as primary peristalsis).

⬇

the peristaltic contractions pass down through the rest of the esophagus,

⬇

Propelling the bolus towards stomach.

- Initially, pressure becomes negative in the upper part of esophagus. (due to the stretching of the closed esophagus by the elevation of larynx)
- But immediately, pressure becomes positive and increases up to 10 - to 15 cm of H_2O.

2. Secondary Peristaltic Contractions -

If the primary peristaltic contractions are unable to propel the bolus into the stomach,

⬇

Secondary peristaltic contractions appear

⬇

induced by distention of upper esophagus by the bolus.

⬇

After origin, these contractions pass down , producing a positive pressure.

Role of Lower Esophageal Sphincter -

Distal 2 to 5 cm of esophagus acts like a sphincter (called lower esophageal sphincter).

⬇

It is constricted always.

- When bolus enters this part of the esophagus,

⬇

this sphincter relaxes so that the contents enter the stomach.

- The relaxation and constriction of sphincter occur in sequence

⬇

with the arrival of peristaltic contractions of esophagus.

❑ MOVEMENTS OF SMALL INTESTINE

Movements of small intestine are essential for mixing the chyme with digestive juices, propulsion of food and absorption.

Types of Movements of Small Intestine

Four types: -

1. Mixing movements: - i. Segmentation movements

ii. Pendular movements.

2. Propulsive movements: - i. Peristaltic movements

ii. Peristaltic rush.

3. Peristalsis in fasting – migrating motor complex

4. Movements of villi.

1. MIXING MOVEMENTS

Responsible for proper **mixing of chyme** with digestive juices such **as pancreatic juice, bile and intestinal juice.**

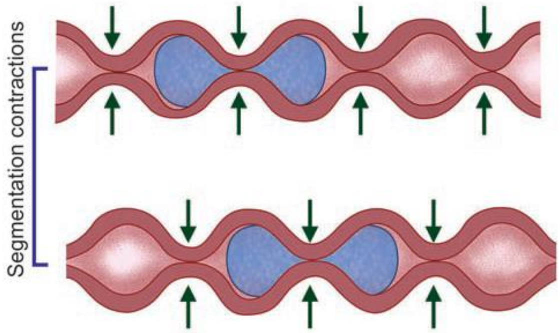
i. Segmentation Contractions -

- ✓ Common type of movements of small intestine
- ✓ Which occur regularly or irregularly, but in a rhythmic fashion.
- ✓ So, these movements are also called rhythmic segmentation contractions.

- The contractions occur at regularly spaced intervals along a section of intestine

⬇

Segments of intestine in between the contracted segments are relaxed.



- Alternate segments of contraction and relaxation give appearance of rings, resembling the chain of sausages.
- After sometime, the contracted segments are relaxed and the relaxed segments are contracted.
- Segmentation contractions **chop** chyme many times. This helps in mixing of chyme with digestive juices.

ii. Pendular Movement

✓ This is sweeping movement of small intestine, resembling the movements of **pendulum of** clock. Small portions of intestine (loops) sweep forward and backward or upward and downward.

✓ It helps in mixing of chyme with digestive juices.

2. PROPULSIVE MOVEMENTS

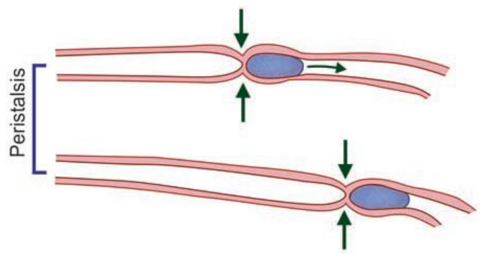
Movements of small intestine which push the chyme in the aboral direction through intestine.

i. *Peristaltic Movements*

✓ Peristalsis is defined as the wave of contraction followed by wave of relaxation of muscle fibers.

It always travels in aboral direction.

✓ Stimulation of smooth muscles of intestine initiates the peristalsis.



- ✓ Travels from point of stimulation in both directions.

  ⬇

  But under normal conditions, the progress of contraction

  ⬇

  In an oral direction is inhibited quickly

  ⬇

  Contractions disappear

  ⬇

  Only the contraction that travels in an aboral direction persists.

ii. *Peristaltic Rush*

- Sometimes, the small intestine shows a powerful peristaltic contraction.

  ⬇

  Caused by excessive irritation of intestinal mucosa

- Begins in duodenum and passes through entire length of small intestine and reaches the ileocecal valve within few minutes.
- Peristaltic rush sweeps the contents of intestine into the colon.
- It relieves the small intestine off either irritants or excessive distention.

3. PERISTALSIS IN FASTING – MIGRATING MOTOR COMPLEX

Type of peristaltic contraction, (occurs in stomach and small intestine) during the periods of fasting for several hours.

- In this, a large portion of stomach or intestine is involved in contraction.
- Occurs once in every 1½ to 2 hours (20 to 30 cm extends) contraction.
- It starts as a moderately active peristalsis in the body of stomach.
- It takes about 10 minutes to reach the colon after taking origin from the stomach.

Significance - This sweeps excess digestive secretions into colon and prevents accumulation of the secretions in stomach and intestine.

- It also sweeps residual indigested materials into colon.

4. MOVEMENTS OF VILLI

- Intestinal villi show movements simultaneously along with intestinal movements.

because of extension of smooth muscle fibers of the intestinal wall into the villi.

- Movements of villi shortening and elongation,

Occur alternatively and help in emptying lymph from central lacteal into lymphatic system.

- Increased surface area of villi - helps absorption of digested food particles from lumen of intestine.
- Movements of villi are caused by local nervous reflexes.
- Hormone secreted from the small intestinal mucosa called **villikinin (**increasing movements of villi).

- **MOVEMENTS OF LARGE INTESTINE**

large intestine shows sluggish movements.

These movements are important for mixing, propulsive and absorptive functions.

Types of Movements of Large Intestine

Two types: -

1. Mixing movements: - Segmentation contractions

2. Propulsive movements: - Mass peristalsis.

1. MIXING MOVEMENTS – SEGMENTATION CONTRACTIONS

- Large circular constrictions, which appear in the colon, are called mixing segmentation contractions.
- These contractions occur at regular distance in colon.
- Length of the portion of colon involved in each contraction is nearly about 2.5 cm.

2. PROPULSIVE MOVEMENTS – MASS PERISTALSIS

- Mass peristalsis or mass movement propels the feces from colon towards anus.
- This movement occurs only a few times every day.
- Duration of mass movement is about 10 minutes in the morning before or after breakfast.
- This is because of neurogenic factors like **gastrocolic reflex (see below) and parasympathetic** stimulation.

DEFECATION

- ✓ Voiding of feces is known as defecation.
- ✓ Feces is formed in the large intestine and stored in sigmoid colon. By the influence of an appropriate stimulus, it is expelled out through the anus.
- ✓ This is prevented by tonic constriction of anal sphincters, in the absence of the stimulus through the anus.

DEFECATION REFLEX

Mass movement drives the feces into sigmoid or pelvic colon. In the sigmoid colon, the feces is stored.

⬇

desire for defecation occurs

⬇

when some feces enters rectum due to the mass movement.

- ✓ When desire for defecation is elicited by an increase in the Intrarectal pressure to about 20 to 25 cm H2O.
- ✓ Usual stimulus for defecation is intake of liquid like coffee or tea or water.
- ✓ But it differs from person to person.

ACT OF DEFECATION -

When , the rectum is empty.

⬇

During the development of mass movement, the feces is pushed into rectum and the defecation reflex is initiated.

⬇

It ia a process of defecation involves the contraction of rectum and relaxation of internal and external anal sphincters.

⬇

Internal anal sphincter is made up of smooth muscle and it is innervated by parasympathetic nerve fibers via pelvic nerve.

⬇

External anal sphincter is composed of skeletal muscle and controlled by somatic nerve fibers

⬇

which pass through **pudendal nerve.**

⬇

Pudendal nerve always keeps the external sphincter constricted and

⬇

sphincter can relax only when the pudendal nerve is inhibited.

- **GASTROCOLIC REFLEX -**

Gastrocolic reflex is the contraction of rectum, followed by the desire for defecation caused by distention of stomach by food.

✓ This reflex causes only a weak contraction of rectum. But, it initiates defecation reflex.

PATHWAY FOR DEFECATION REFLEX -

When rectum is distended due to the entry of feces by mass movement, sensory nerve endings are stimulated.

⬇

Impulses from the nerve endings are transmitted via afferent fibers of pelvic nerve

⬇

to the defecation center (situated - sacral segments(center) of spinal cord).

⬇

Center in turn, sends motor impulses to the descending colon, sigmoid colon and rectum via efferent nerve fibers of pelvic nerve.

⬇

Motor impulses cause strong contraction of descending colon, sigmoid colon and rectum and relaxation of internal sphincter.

⬇

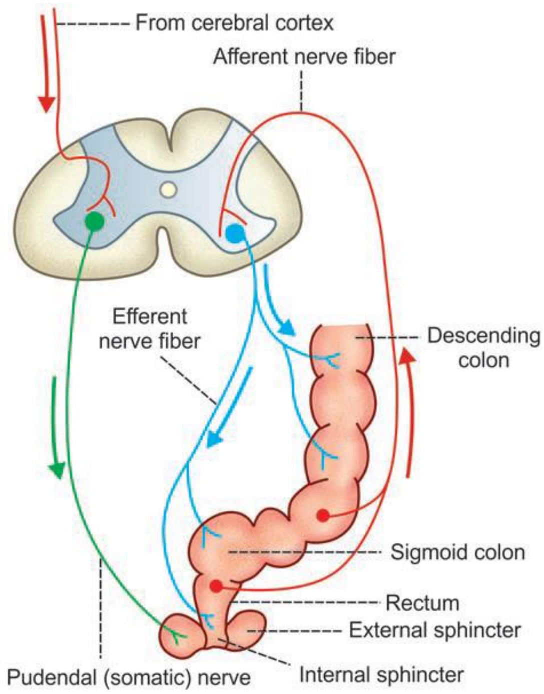
Simultaneously, voluntary relaxation of external sphincter occurs.

⬇

due to the inhibition of Pudendal nerve,

⬇

by impulses arising from cerebral cortex.



❑ GASTROESOPHAGEAL REFLUX DISEASE (GERD)

- ✓ It is characterized by regurgitation of acidic gastric content through esophagus.
- ✓ The regurgitated gastric content flows into pharynx or mouth.

Cause - due to the weakness or **incompetence** (failure to constrict) of **lower esophageal sphincter.**

Features of GERD -

i. Heart burn or pyrosis (painful burning sensation in chest due to regurgitation of acidic gastric content into esophagus)

ii. Esophagitis (inflammation of esophagus)

iii. Dysphagia

iv. Cough and change of voice

v. Esophageal ulcers or cancer (in chronic cases).

❑ DIARRHEA

- ✓ Diarrhea is the frequent and profuse discharge of intestinal contents in loose and fluid form.
- ✓ It occurs due to the increased movement of intestine. It may be acute or chronic.

Cause -

1. *Dietary abuse*: - *intake of* contaminated water or food, artificial sweeteners found in food, spicy food, etc.

2. *Food intolerance*: - by indigestion of food substances, particularly lactose, a sugar present in milk and milk products may not be digested easily

3. *Infections by:*-

i. Bacteria such as *Escherichia coli, Salmonella, Shigella, etc.*

ii. Viruses like rotavirus, hepatitis virus, etc.

4. *Reaction to medicines such as:*-

i. Antibiotics

ii. Antihypertensive drugs

iii. Antacids containing magnesium

iv. Laxatives

5. *Intestinal diseases: Chronic diarrhea occurs during* inflammation of intestine, irritable bowel syndrome and abnormal motility of the intestine.

FEATURES

- ✓ Severe diarrhea results in loss of excess water and electrolytes. This leads to **dehydration and electrolyte** imbalance.
- ✓ Chronic diarrhea results in **hypokalemia** and **metabolic acidosis.**

Other features - abdominal pain, nausea and **bloating (a condition in** which the subject feels the abdomen full and tight due to excess intestinal gas).

❑ CONSTIPATION -

Failure of voiding of feces, which produces discomfort is known as constipation.

Due to - lack of movements necessary for defecation , due to the absence of mass movement in colon, feces remain in the large intestine for a long time, resulting in absorption of fluid. So the feces become hard and dry.

Causes

1. *Dietary causes* -

Lack of fiber or lack of liquids in diet causes constipation.

2. *Irregular bowel habit*

Irregular bowel habit is most common cause for constipation.

3. *Spasm of sigmoid colon*

Spasm in the sigmoid colon **(spastic colon) prevents its** motility, resulting in constipation.

4. *Diseases*

Constipation is common in many types of diseases.

5. *Dysfunction of myenteric plexus in large intestine – megacolon*

6. *Drugs*

Many drugs are cause for constipation . E.g. diuretics, pain relievers, antihypertensive drugs.

Chapter – 19

DIGESTION, ABSORPTION AND METABOLISM Of

CARBOHYDRATES

CARBOHYDRATES IN DIET -

Human diet contains three types of carbohydrates: -

- ✓ **1. POLYSACCHARIDES : -** Large polysaccharides are glycogen, amylose, Amylopectin the form of starch.
- ✓ Glycogen is available in nonvegetarian diet.
- ✓ Amylose and amylopectin are available in vegetarian diet (plant origin.)

2. **DISACCHARIDES –**
   Two types - Available in the diet.
   Sucrose (Glucose + Fructose), which is called **table sugar** or cane sugar.
   Lactose (Glucose + Galactose), which is the sugar available in milk.

3. **MONOSACCHARIDES –**
   Monosaccharides consumed in human diet are mostly glucose and fructose.

DIGESTION OF CARBOHYDRATES –

Area	Juice	Enzyme	Substrate	End product
Mouth	Saliva	Salivary amylase	Polysaccharides – cooked starch	Disaccharides – dextrin and maltose
Stomach	Gastric juice	Gastric amylase	Weak amylase	The action is negligible
Small intestine	Pancreatic juice	Pancreatic amylase	Polysaccharides	Disaccharides – Dextrin, maltose and maltriose
	Succus entericus	Sucrase	Sucrose	Glucose and fructose
		Maltase	Maltose and maltriose	Glucose
		Lactase	Lactose	Glucose and galactose
		Dextrinase	Dextrin, maltose and maltriose	Glucose
		Trehalase	Trehalose	Glucose

FINAL PRODUCTS OF CARBOHYDRATE DIGESTION –

- ✓ Monosaccharides, which are **glucose, fructose and galactose**.

- ✓ **Glucose represents 80%** of the final product of carbohydrate digestion.
- ✓ Galactose and fructose represent the remaining 20%.

ABSORPTION OF CARBOHYDRATES –

Carbohydrates are absorbed from the small intestine mainly as monosaccharides, viz. glucose, galactose and fructose.

ABSORPTION OF GLUCOSE

Glucose is transported from the lumen of small intestine

⬇

into the epithelial cells in the mucus membrane of small intestine,

⬇

by of sodium Cotransport.

⬇

Energy for this is obtained by the binding process of sodium ion and glucose molecule to carrier protein

⬇

From the epithelial cell, glucose is absorbed

⬇

into the portal vein by **facilitated diffusion.**

⬇

From here, it is transported into blood by active transport, utilizing the energy liberated by breakdown of ATP.

ABSORPTION OF GALACTOSE -

Galactose is also absorbed from the small intestine in the same mechanism as that of glucose.

ABSORPTION OF FRUCTOSE -

- ✓ Fructose is absorbed into blood by means of **facilitated diffusion.**
- ✓ **Some molecules of fructose are converted** into glucose.

METABOLISM OF CARBOHYDRATES -

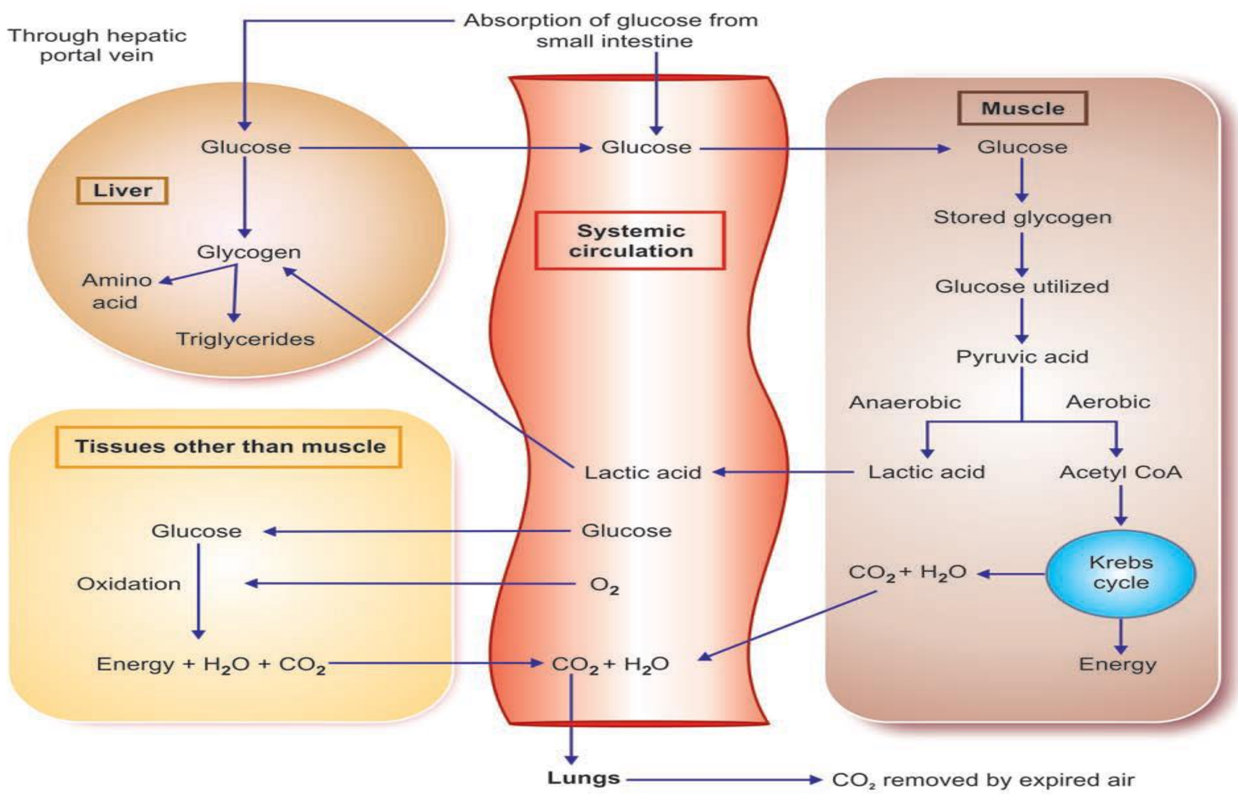


FIGURE : diagram of carbohydrate metabolism

❑ DIGESTION, ABSORPTION AND METABOLISM OF PROTEINS

PROTEINS IN DIET -

- ✓ Containing high protein - Meat, fish, egg and milk.
- ✓ Proteins are also available in wheat, soybeans, oats and various types of pulses.

Proteins present in : -

1. Wheat: Glutenin and gliadin, which constitute gluten
2. Milk: Casein, lactalbumin, albumin and myosin
3. Egg: Albumin and vitellin

4. Meat: Collagen, albumin and myosin.

- Dietary proteins are formed by long chains of amino acids, bound together by peptide linkages.

DIGESTION OF PROTEINS -

Enzymes responsible for the digestion of proteins are called **Proteolytic enzymes.**

Area	Juice	Enzyme	Substrate	End product
Mouth	Saliva	No proteolytic enzyme	Polysaccharides – cooked starch	Disaccharides – dextrin and maltose
Stomach	Gastric juice	Pepsin	Proteins	Proteoses, peptones, large polypeptides
Small intestine	Pancreatic juice	Trypsin Chymotrypsin	Proteoses Peptones	Dipeptides Tripeptides Polypeptides
		Carboxypeptidases A and B	Dipeptides Tripeptides Polypeptides	Amino acids
	Succus entericus	Dipeptidases	Dipeptides	Amino acids
		Tripeptidases	Tripeptides	
		Amino peptidases	Large polypeptides	

FINAL PRODUCTS OF PROTEIN DIGESTION -

Are the amino acids, which are absorbed into blood from Intestine.

ABSORPTION OF PROTEINS -

✓ Proteins are absorbed in the form of amino acids from small intestine.

METABOLISM OF PROTEINS -

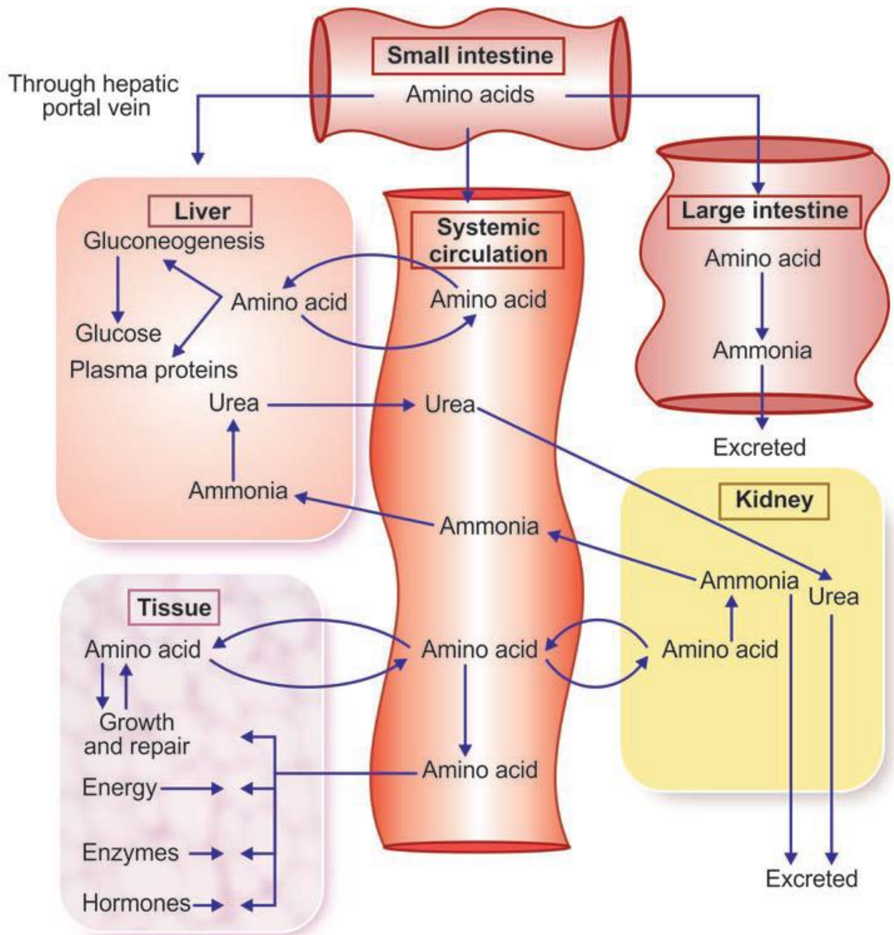


FIGURE : diagram of protein metabolism.

❑ DIGESTION, ABSORPTION AND METABOLISM OF LIPIDS

- ✓ Lipids are mostly consumed in the form of **neutral fats,**
- ✓ Which are also known as **triglycerides.**
- ✓ **Triglycerides** are made - glycerol nucleus and free fatty acids.

- ✓ Triglycerides form the major constituent in foods of animal origin and much less in foods of plant origin.
- ✓ Apart from triglycerides, usual diet also contains small quantities of **cholesterol and cholesterol esters.**

Dietary fats are classified into two types:
1. Saturated fats
2. Unsaturated fats.

❑ SATURATED FATS

- ✓ Which contain triglycerides formed from only saturated fatty acids.
- ✓ The fatty acids having maximum amount of hydrogen ions without any double bonds between carbon atoms are called saturated fatty acids.

❑ UNSATURATED FATS

- ✓ Fats containing unsaturated fatty acids are known as unsaturated fats.
- ✓ Unsaturated fatty acids are fatty acids formed by dehydrogenation of saturated fatty acids.

Three types: -
1. Monounsaturated fats
2. Polyunsaturated fats
3. Trans fats.

1. **Monounsaturated Fats -**

Unsaturated fats which contain one double bond between the carbon atoms are called monounsaturated fats.

2. Polyunsaturated Fats

- ✓ Unsaturated fats with more than one double bond between the carbon atoms are called polyunsaturated fats.
- ✓ Polyunsaturated fats belong to the family of essential fatty acids (fatty acids required in diet).

Polyunsaturated fats are of two types: -

1. **Omega-3 fats or omega3**

Fatty acids having double bond in the third space from the end of the carbon chain.

2. **Omega-6 fats or omega6**

Fatty acids having double bond in the sixth space from the end of the carbon chain.

- ❑ Both **Omega-3 and Omega-6 fatty acids** are beneficial to the body.
- ✓ However, consuming too much of omega6 fatty acids results in hazards than benefits.
- ✓ So, the diet containing 3 : 1 ratio of omega-6 to omega-3 fatty acids is often recommended by experts.

3. ***Trans Fats -***

Trans fats or trans fatty acids are unsaturated fatty acids, with molecules containing trans (across or opposite side) double bonds between carbon atoms.

Type of fat	Sources	Functions
Saturated fats	Full fat milk, cheese, cream, butter. Commercially baked biscuits and pastries Deep-fried fast food Coconut oil and palm oil Fatty meat	Increase blood cholesterol and thereby increase the risk of atherosclerosis and coronary heart diseases
Monounsaturated fats	Oils (canola, olive and peanut oils) Nuts (cashews, almonds, hazelnuts and peanuts) Margarine	Decrease blood cholesterol and thereby decrease the risk of coronary heart diseases
Polyunsaturated fats	*Fruits and vegetables* Vegetable oils (sunflower, safflower, corn or soy oils) Nuts (walnuts) Flax seeds Polyunsaturated margarines Lean meat Fish and sea foods Egg	*Decrease* Blood cholesterol and triglycerides and thereby reduces blood pressure Risk of coronary heart diseases Risk of obesity Platelet aggregation and prevents excess blood clotting Inflammation throughout body *Increase* Disease-countering actions in the body
Trans fats	Milk Cheese and table margarines Lamb and beef	Increase low density lipoproteins and thereby increase the risk of atherosclerosis and coronary heart diseases

DIGESTION OF LIPIDS

Lipids are digested by **lipolytic enzyme.**

Figure : Digestion of lipids -

Area	Juice	Enzyme	Substrate	End product
Mouth	Saliva	Lingual lipase	Triglycerides	Fatty acid 1, 2-diacylglycerol
Stomach	Gastric juice	Gastric lipase (weak lipase)	Triglycerides	Fatty acids Glycerol
Small intestine	Pancreatic juice	Pancreatic lipase	Triglycerides	Monoglycerides Fatty acid
		Cholesterol ester hydrolase	Cholesterol ester	Free cholesterol Fatty acid
		Phospholipase A	Phospholipids	Lysophospholipids
		Phospholipase B	Lysophospholipids	Phosphoryl choline Free fatty acids
		Colipase	Facilitates action of pancreatic lipase	–
		Bile-salt-activated lipase	Phospholipids	Lysophospholipids
			Cholesterol esters	Cholesterol and fatty acids
	Succus entericus	Intestinal lipase	Triglycerides	Fatty acids Glycerol (weak action)

FINAL PRODUCTS OF FAT DIGESTION -

Fatty acids, cholesterol and Monoglycerides are the final products of lipid digestion.

ABSORPTION OF LIPIDS -

1. Monoglycerides, Cholesterol and fatty acids from the micelles enter the cells of intestinal mucosa by simple diffusion.

↓

In the mucosal cells, most of the monoglycerides are converted into triglycerides.

↓

Triglycerides are also formed by **re-esterification of fatty acids with** more than 10 to 12 carbon atoms.

- Some of the cholesterol is also esterified.
- Triglycerides and cholesterol esters are coated with a layer of protein, cholesterol and phospholipids to form **chylomicrons.**

↓

Chylomicrons cannot pass through the membrane of the blood capillaries because of the larger size.

↓

So, these lipid particles enter the lymph vessels and then are transferred into blood from lymph.

2. Fatty acids containing less than 10 to 12 carbon atoms enter the portal blood

⬇

From **Mucosal cells** and are transported as free fatty acids or unesterified fatty acids.

⬇

Most of the fats are absorbed in the upper part of small intestine.

⬇

Presence of bile is essential for fat absorption.

STORAGE OF LIPIDS

- ✓ Lipids are stored in adipose tissue and liver.
- ✓ Fat stored in adipose tissue is called **neutral fat or tissue fat.**

METABOLISM OF LIPIDS -

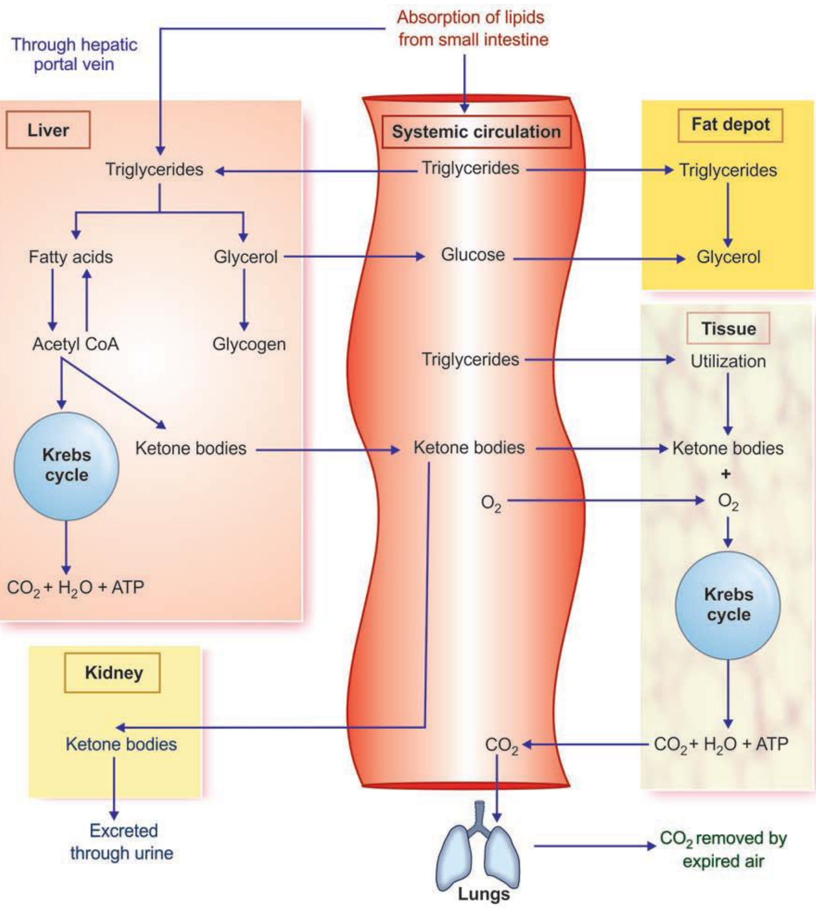


FIGURE : diagram of lipid metabolism.

MCQ –

Q.1. Where does the majority of nutrient absorption occur in the digestive system.

a. mouth

b. stomach

c. small intestine

d. large intestine

Q. 2. What is the role of HCL in the stomach.

a. break down carbohydrates

b. break down proteins

c. emulsify fats

d. none

Q. 3. What is the primary function of the enzyme amylase in digestion.

a. breakdown of proteins

b. break down of carbohydrates

c. breakdown of fats

d. absorption of water

Q. 4. What is the function of bile in digestion.

a. emulsify fats

b. neutralize stomach acid

c. breakdown proteins

d. none

Q. 5. What is the final product of carbohydrates digestion in the small intestine.

a. fatty acid

b.amino acid

c. glucose

d. none

Q. 6. Which of following are included in the simple carbohydrates.

a. monosaccharides

b. polysaccharides

c. glycogen

d. fiber

Q.7. Which of the following is a form of table sugar.

a. maltose

b. glucose

c. sucrose

d. fructose

Q. 8. Maltose is a disaccharides of –

a. fructose and lactose

b. glucose and glucose

c. glucose and lactose

d. none

Q. 9. Name the major storage form of carbohydrates in animals.

a. starch

b. chitin

c. glycogen

d. cellulose

Q. 10.Final product of protein –

a. amino acid

b. glucose

c. glycogen

d. none

Answers – 1. – c, 2- b, 3- b, 4- a, 5- c, 6- a, 7- c, 8- b, 9- c, 10 - a 7.

Chapter – 20

INTRODUCTION OF ENDOCRINOLOGY

All the physiological activities of the body are regulated by two major systems:

1. Nervous system

2. Endocrine system.

- ✓ These two systems interact with one another and regulate the body functions.
- ✓ Endocrine system functions by secreting some chemical substances called hormones.

CELL-TO-CELL SIGNALING

- ✓ Cell to cell signaling refers to the transfer of information from one cell to another.
- ✓ It is also called cell signaling or intercellular communication.

CHEMICAL MESSENGERS

- ✓ Chemical messengers are the substances involved in cell signaling.
- ✓ These messengers are mainly secreted from endocrine glands.
- ✓ Some chemical messengers are secreted by nerve endings and tissues also.
- ✓ All these chemical messengers carry the message (signal) from the signaling cells (controlling cells) to the target cells.
- ✓ The messenger substances may be the hormones or hormone like substances.

Classification of Chemical Messengers

Two types: -

1. Classical hormones secreted by endocrine glands

2. Local hormones secreted from other tissues.

Chemical messengers are classified into four types:

1. Endocrine messengers

2. Paracrine messengers

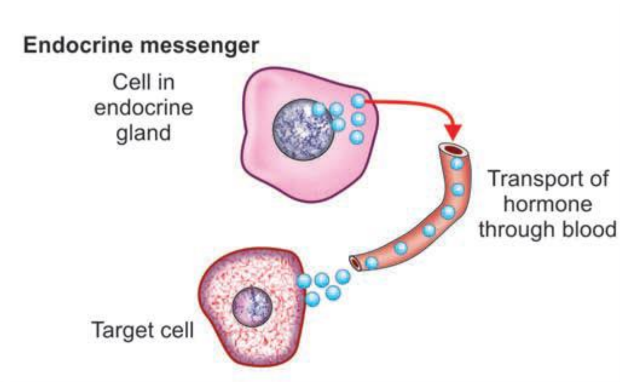
3. Autocrine messengers

4. Neurocrine messengers.

1. **Endocrine Messengers**

A hormone is defined as a chemical messenger, synthesized by endocrine glands and transported by blood to the target organs or tissues (site of action).

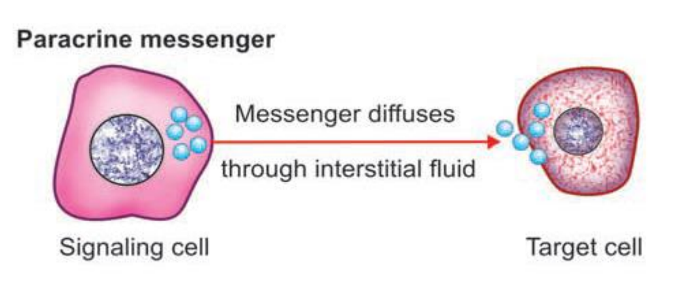
Examples - growth hormone and insulin.



2. *Paracrine Messengers*

- ✓ These are chemical messengers, which diffuse from the control cells to the target cells through the interstitial fluid.
- ✓ Some of these substances directly enter the neighboring target cells through gap junctions.
- ✓ Such substances are also called **juxtacrine messengers or local hormones.**

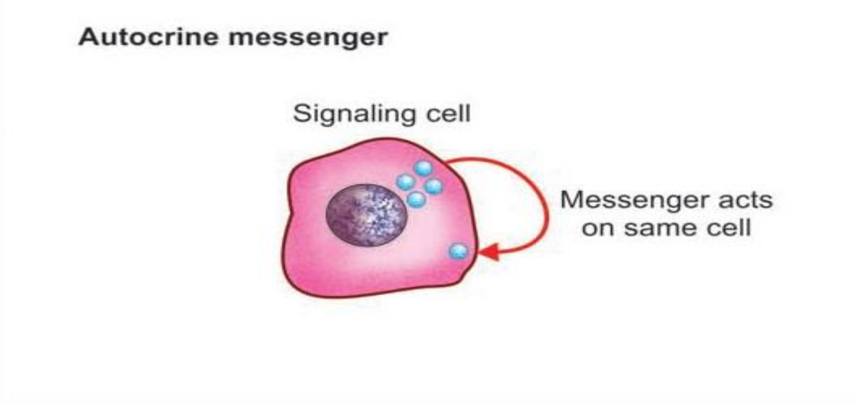
Examples - prostaglandins and histamine.



3. Autocrine Messengers -

- ✓ These are chemical messengers that control the source cells which secrete them.
- ✓ So, these messengers are also called **intracellular chemical mediators.**

Examples - leukotrienes.



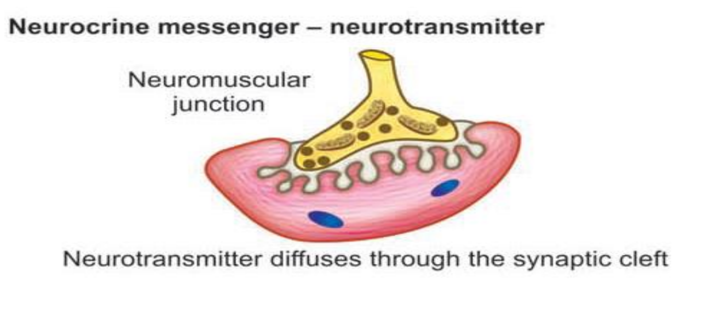
4. Neurocrine or Neural Messengers

Neurocrine or neural messengers are neurotransmitters and neurohormones .

Neurotransmitter -

That carries information form one nerve cell to another nerve cell or muscle or another tissue.

Examples - acetylcholine and dopamine.



ENDOCRINE GLANDS

- ✓ These are glands which synthesize and release the classical hormones into the blood.
- ✓ Endocrine glands are also called **ductless glands because the** hormones secreted by them are released directly into blood without any duct.

✓ Endocrine glands play an important role in homeostasis and control of various other activities in the body through their hormones.

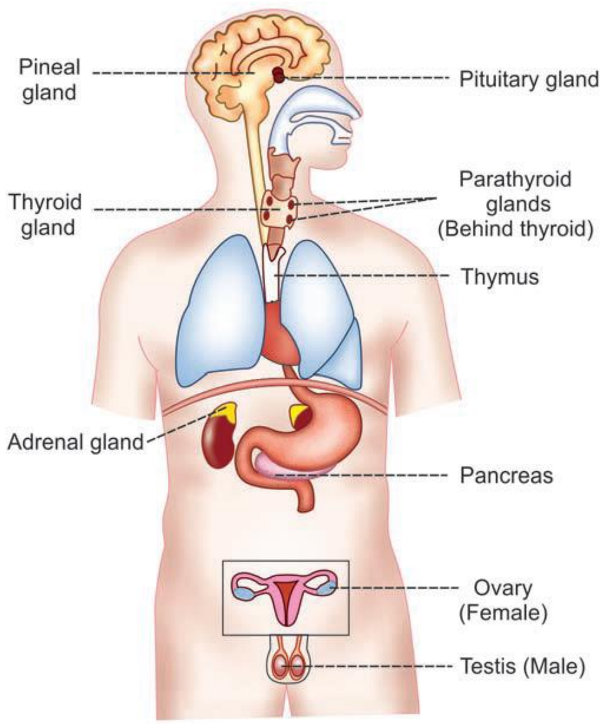


Diagram showing major endocrine glands.

Anterior pituitary	1. Growth hormone (GH) 2. Thyroid-stimulating hormone (TSH) 3. Adrenocorticotropic hormone (ACTH) 4. Follicle stimulating hormone (FSH) 5. Luteinizing hormone (LH) 6. Prolactin	Adrenal cortex	*Mineralocorticoids* 1. Aldosterone 2. 11-deoxycorticosterone
			Glucocorticoids 1. Cortisol 2. Corticosterone
Posterior pituitary	1. Antidiuretic hormone (ADH) 2. Oxytocin		*Sex hormones* 1. Androgens 2. Estrogen 3. Progesterone
Thyroid gland	1. Thyroxine (T_4) 2. Triiodothyronine (T_3) 3. Calcitonin		
Parathyroid gland	Parathormone	Adrenal medulla	1. Catecholamines 2. Adrenaline (Epinephrine) 3. Noradrenaline (Norepinephrine) 4. Dopamine
Pancreas – Islets of Langerhans	1. Insulin 2. Glucagon 3. Somatostatin 4. Pancreatic polypeptide		

Figure - Hormones secreted by major endocrine glands.

- **HORMONES**

CHEMISTRY OF HORMONES

Hormones are **chemical messengers, synthesized by** endocrine glands.

Based on chemical nature, hormones are classified into three types : -

1. Steroid hormones

2. Protein hormones

3. Derivatives of the amino acid called tyrosine.

STEROID HORMONES

- ✓ Steroid hormones are the hormones synthesized from cholesterol or its derivatives.
- ✓ Secreted by - adrenal cortex, gonads and placenta.

PROTEIN HORMONES

Protein hormones are secreted by pituitary gland, parathyroid glands, pancreas and placenta .

TYROSINE DERIVATIVES

Two types of hormones, namely thyroid hormones and adrenal medullary hormones are derived from the amino acid tyrosine.

HORMONAL ACTION

- ✓ Hormone does not act directly on target cells.
- ✓ First it combines with receptor present on the target cells and forms a **hormone-receptor complex.**
- ✓ **This hormone receptor** complex induces various changes or reactions in the target cells.

HORMONE RECEPTORS

- ✓ Hormone receptors are the large proteins present in the target cells.

- ✓ Each cell has thousands of receptors.
- ✓ Important characteristic feature of the receptors - each receptor is specific for one single hormone, i.e. each receptor can combine with only one hormone.

MECHANISM OF HORMONAL ACTION

Hormone does not act on the target cell directly.

⇩

Combines with receptor to form hormone-receptor complex.

- ✓ This complex executes the hormonal action by any one of the following mechanisms:

1. By altering permeability of cell membrane
2. By activating intracellular enzyme
3. By acting on genes.

1. BY ALTERING PERMEABILITY OF CELL MEMBRANE -

Neurotransmitters in synapse or neuromuscular junction act by changing the permeability of postsynaptic membrane

2. BY ACTIVATING INTRACELLULAR ENZYME-

Protein hormones and the catecholamines act by activating the intracellular enzymes.

First Messenger

The hormone which acts on a target cell, is called first messenger or **chemical mediator.**

It combines with the receptor and forms hormone-receptor complex.

Second Messenger -

Hormone-receptor complex activates the enzymes of the cell and causes the formation of another substance called the second messenger or **intracellular hormonal mediator.**

Second messenger example –

Cyclic AMP, cAMP or cyclic adenosine 3'5'- Monophosphate.

3. BY ACTING ON GENES

Thyroid and steroid hormones execute their function by acting on genes in the target cells.

Sequence of Events during Activation of Genes

i. Hormone enters the interior of cell

⬇

and binds with receptor in cytoplasm (steroid hormone) or in nucleus (thyroid hormone)

⬇

and forms hormone receptor complex.

⬇

ii. Hormone-receptor complex moves towards the DNA

⬇

and binds with DNA

⬇

iii. This increases transcription of mRNA

⬇

iv. mRNA moves out of nucleus

⬇

v. Mode of action of steroid hormones

⬇

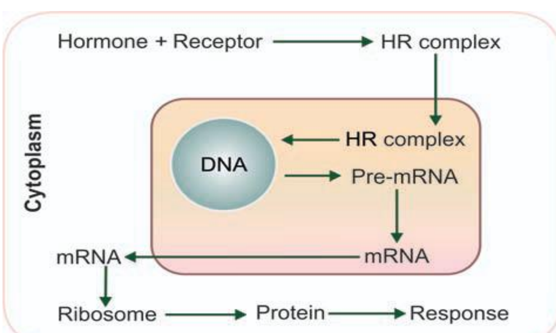
and reaches ribosomes and activates them

⬇

v. Activated ribosomes produce large quantities of proteins

⬇

vi. These proteins produce physiological responses in the target cells.



Chapter - 21

PITUITARY GLAND

- ✓ Pituitary gland or **hypophysis is a small endocrine** gland with a diameter of 1 cm.
- ✓ Weight - 0.5 to 1 g.
- ✓ Present in the sphenoid bone ('s**ella turcica')**
- ✓ It is connected with the hypothalamus by the **pituitary stalk** or **hypophyseal stalk.**

Parts of pituitary gland

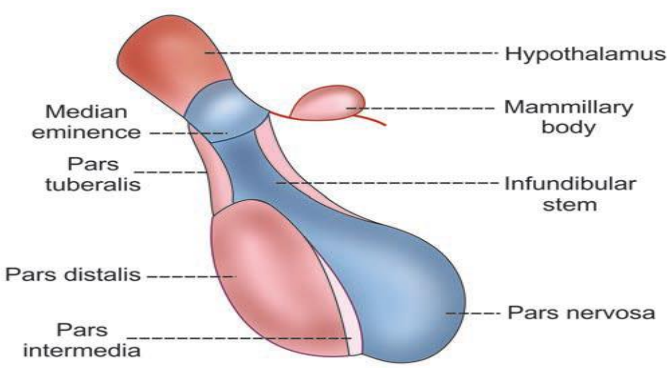
DIVISIONS OF PITUITARY GLAND

Two divisions:

1. Anterior pituitary or adenohypophysis

2. Posterior pituitary or neurohypophysis.

- ✓ Between the two divisions, there is a small and relatively avascular structure called **pars intermedia.**



Parts of pituitary gland.

HORMONES SECRETED BY ANTERIOR PITUITARY

Six hormones are secreted by the anterior pituitary:

1. Growth hormone (GH) or somatotropic hormone (STH)

2. Thyroid-stimulating hormone (TSH) or thyrotropic hormone -

- ✓ TSH necessary for the - Growth and Secretory activity of thyroid gland

3. Adrenocorticotropic hormone (ACTH) -

  - ✓ ACTH is necessary for - Structural integrity , Secretory activity of adrenal cortex.

4. Follicle-stimulating hormone (FSH) -

- ✓ In males - FSH + testosterone accelerates the process of **spermeogenesis**

In females FSH: -

1. Development of **graafian follicle**
2. Secretion of estrogen
3. Promotes the **aromatase activity in granulosa cells**

Androgens convert → **Estrogen**

5. Luteinizing Hormone (LH)

Actions of LH –

- ✓ Secretion of testosterone from Leydig cells

LH also called - **interstitial cell-stimulating hormone (ICSH)**

In females, LH: -

1. Responsible for **ovulation**
2. Necessary for the formation of corpus luteum
3. Activates the secretory functions of corpus luteum.

6. Prolactin

Actions -

- ✓ Final preparation of mammary glands for the production and secretion of milk.

HORMONES OF POSTERIOR PITUITARY

Posterior pituitary hormones are:

1. Antidiuretic hormone (ADH) or vasopressin

2. Oxytocin.

Note : - Posterior pituitary does not secrete any hormone.

- ✓ ADH and oxytocin are synthesized in the hypothalamus.

GROWTH HORMONE -

Source of Secretion

GH is secreted by somatotropes (acidophilic cells) of anterior pituitary.

Transport –

Growth hormone is transported in blood by GH-binding proteins (GHBPs).

Metabolism –

Degraded in liver and kidney.

Actions of Growth Hormone –

- ✓ GH is responsible for the general growth of the body.
- ✓ GH increases the size and number of cells by mitotic division.
- ✓ GH causes specific differentiation of certain types of cells like bone cells and muscle cells.

1. **On metabolism** –

GH increases the synthesis of proteins, mobilization of lipids and conservation of carbohydrates.

a. **On protein metabolism –**

GH accelerates the synthesis of proteins by: -

i. Increasing amino acid transport through cell Membrane.

ii. Increasing ribonucleic acid (RNA) translation.

iii. Increasing transcription of DNA to RNA.

iv. Decreasing catabolism of protein.

v. Promoting anabolism of proteins indirectly.

b. On fat metabolism –

GH mobilizes fats from adipose tissue

(Leads) ↓

increases concentration of fatty acids in the body fluids.

(use) ↓

for production of energy by the cells.

- ✓ Due to fats mobilization – production of Acetoacetic acid leading to ketosis.
- ✓ **Also cause fatty liver due to** causes accumulation of fat in liver.

c. *On carbohydrate metabolism -*

Major action of GH on carbohydrates is the conservation of glucose.

EFFECTS –

i. Decrease in the **peripheral utilization of glucose** for energy production.

(because Acetyl-CoA inhibits the glycolytic pathway).

ii. Increase in the deposition of glycogen in the cells.

iii. Decrease in the uptake of glucose by the cells.

iv**. Diabetogenic effect of GH-**

Hypersecretion of GH increases blood glucose level

(cause) ↓

increase insulin secretion from β-cells

↓ (due to excess secretion /activity)

β-cells are burnt out at one stage

(cause) ↓

deficiency of insulin

(Cause) ↓

true diabetes mellitus or full-blown diabetes mellitus.

2. ON BONES –

GH action on bone - Embryonic stage (differentiation and development of bone cells).

Later stage – Growth of skeleton (increases length + thickness).

IN BONES, GH INCREASES:

i. Increases Synthesis and deposition of proteins by chondrocytes and osteogenic cells

ii. Increases Multiplication of **chondrocytes and osteogenic cells.**

iii. Formation of new bones by converting chondrocytes into osteogenic cells

iv. Availability of calcium for mineralization of bone matrix.

- GH increases the length of the bones, until epiphysis fuses with shaft (at puberty).
- It stimulates the **osteoblasts** strongly. So, the bone continues to grow in thickness throughout the life(jaw bone and the skull bones).

- **MODE OF ACTION OF GH – SOMATOMEDIN**

- ✓ GH acts on bones, growth and protein metabolism through somatomedin secreted by liver.
- ✓ It is a polypeptide, molecular weight - about 7,500

Types of somatomedin – Two types

i. Insulin-like growth factor-I (IGF-I), which is also called somatomedin C

ii. Insulin-like growth factor-II.

- ✓ Somatomedin C (IGF-I) acts on the bones and protein metabolism.
- ✓ Insulin-like growth factor-II plays an important role in the growth of fetus.
- ✓ The action of somatomedin C lasts for about 20 hours.
- ✓ Mode of action of somatomedin C acts through the second messenger called cyclic AMP.

Growth hormone receptor -

- ✓ GH receptor is called growth hormone secretagogue (GHS) receptor.
- ✓ It is a transmembrane receptor, belonging to cytokine receptor family.
- ✓ Receptor situated mainly in liver cells.

REGULATION OF GH SECRETION –

- ✓ Hypothalamus and feedback mechanism play an important role in the regulation of GH secretion
- ✓ GH secretion is **stimulated** by: - Hypoglycemia , Fasting , Starvation , Exercise , Stress and trauma , Initial stages of sleep.
- ❑ GH secretion **inhibited** by – Hyperglycemia , increase free F .A in blood , later stage of sleep.

- ❑ **REGULATION OF GH SECRETIO**
  Hypothalamus and Feedback control (GH- secretion under –ve feedback control)

- ❑ GHRELIN – promotes secretion of GH.

ACTIVITY OF ANTERIOR PITUITARY -

HYPER-ACTIVITY	**HYPO- ACTIVITY**
⬇	⬇
1. Gigantism	1. Pituitary dwarfism
2. Acromegaly	
3. Acromegalic gigantism	

HYPER-ACTIVITY ANTERIOR PITUITARY -

1. **GIGANTISM -** Gigantism is the pituitary disorder characterized by excess growth of the body.

Causes –

- ✓ Hypersecretion of GH in childhood or in pre-adult life.
- ✓ Hypersecretion of GH is because of tumor of anterior pituitary.

Signs and symptoms –

i. General overgrowth of the body (high more than 7 or 8 feet)

ii. The limbs are disproportionately long.

iii. Giants are hyperglycemic and they develop glycosuria and pituitary diabetes.

iv. Visual disturbances leading to bitemporal hemianopia.

v. Tumor of the pituitary gland itself causes constant headache .

2. ACROMEGALY -

Acromegaly is the disorder characterized by the enlargement, thickening and broadening of bones, particularly in the extremities of the body.

CAUSES –

- ✓ Due to hypersecretion of GH in adults after the fusion of epiphysis with shaft of the bone.
- ✓ Hypersecretion of GH is because of tumor of acidophil cells in the anterior pituitary.

SIGNS AND SYMPTOMS –

1. **GORILLA FACE**: Face with rough features such as -
    - Protrusion of supraorbital ridges,
    - Broadening of nose,
    - Thickening of lips,
    - Thickening and wrinkles formation on forehead
    - Prognathism (protrusion of lower jaw)

ii. Enlargement of hands and feet.

iii. Kyphosis (extreme curvature of upper back – thoracic spine)

iv. Thickening of scalp, like bulldog scalp

v. Overgrowth of body hair

vi. Enlargement of visceral organs such as lungs, thymus, heart, liver and spleen

vii. Hyperactivity of thyroid, parathyroid and adrenal glands

viii. Hyperglycemia and glucosuria, resulting in diabetes mellitus

ix. Hypertension , Headache , Visual disturbance.

3. ACROMEGALIC GIGANTISM -

Acromegalic gigantism is a rare disorder with symptoms of both gigantism and acromegaly.

Hypersecretion of GH in children, before the fusion of epiphysis with shaft of the bones

⬇

causes gigantism

- Hypersecretion of GH is continued even after the fusion of epiphysis,

⬇

symptoms of acromegaly also appear

- **HYPOACTIVITY OF ANTERIOR PITUITARY**

1. **Dwarfism -**

Dwarfism is a pituitary disorder in children, characterized by the stunted growth.

CAUSES –

Reduction in GH secretion in infancy or early childhood causes dwarfism.

i. Tumor of chromophobes

ii. Deficiency of GH-releasing hormone secreted by hypothalamus

iii. Deficiency of somatomedin C

iv. Atrophy or degeneration of acidophilic cells in the anterior pituitary

SIGNS AND SYMPTOMS –

- ✓ Stunted skeletal growth (Height about 3 feet)
- ✓ head becomes slightly larger in relation to the body
- ✓ mental activity is normal with no mental retardation

Reproductive function is not affected, if there is only GH deficiency

❑ POSTERIOR PITUITARY -

Posterior pituitary hormones are:

1. Antidiuretic hormone (ADH) or vasopressin
2. Oxytocin.

NOTE – Posterior pituitary does not secrete any hormones.

- ❑ Oxytocin and ADH synthesized from hypothalamus.

ANTIDIURETIC HORMONE

Source of Secretion - by supraoptic nucleus of hypothalamus.

- ✓ Also secreted by paraventricular nucleus in small quantity.
- ✓ Transported to posterior pituitary through the nerve fibers of hypothalamo-hypophyseal tract, by means of axonic flow.

Actions -

Antidiuretic hormone has two actions: 1. Retention of water

2. Vasopressor action.

1.RETENTION OF WATER -

It increases the reabsorption of water from distal convoluted tubule and collecting duct in the kidneys .

⬇

In the absence of ADH, the distal convoluted tubule and collecting duct are totally impermeable to water.

⬇

Reabsorption of water does not occur in the renal tubules

⬇

dilute urine is excreted.

⬇

loss of large amount of water through urine.

⬇

This condition is called **diabetes insipidus**

⬇

and the excretion of large amount of water is called **diuresis**.

Mode of action on renal tubules -

ADH increases water reabsorption in tubular epithelial membrane

⬇

by regulating the water channel proteins (aquaporins)

⬇

through V2 receptors

2. VASOPRESSOR ACTION

ADH shows vasoconstrictor action.

⬇

Causes Constriction of the arteries in all parts of the body.

- ✓ Due to vasoconstriction, the blood pressure increases.
- ✓ ADH acts on blood vessels through V1A receptors.
- ✓ Amount of ADH required to cause the vasopressor effect greater than the amount required to cause the antidiuretic effect.

REGULATION OF SECRETION -

ADH secretion depends upon the volume of body fluid and the osmolarity of the body fluids.

Stimulants for ADH secretion are:

1. Decrease in the extracellular fluid (ECF) volume
2. Increase in osmolar concentration in the ECF

ROLE OF OSMORECEPTORS

- ❑ Osmoreceptors are the receptors which give response to change in the osmolar concentration of the blood.
- ❑ These receptors are situated in the hypothalamus near supraoptic and paraventricular nuclei.

When osmolar concentration of blood increases,

⬇

Osmoreceptors are activated.

⬇

Stimulate the Supraoptic and Paraventricular nuclei

⬇

Send motor impulses to posterior pituitary through

↓

cause release of ADH

↓

ADH causes reabsorption of water from the renal tubules.

↓

This increases ECF volume and restores the normal osmolarity

2. OXYTOCIN -

- ✓ Secreted by paraventricular nucleus of hypothalamus.
- ✓ Also secreted by supraoptic nucleus in small quantity
- ✓ It is transported from **hypothalamus** to posterior pituitary

  ↓

  through the nerve fibers of hypothalamo-hypophyseal tract.
- ✓ In the posterior pituitary, the oxytocin is stored in the nerve endings of hypothalamo-hypophyseal tract.
- ✓ When suitable stimuli reach the posterior pituitary from hypothalamus, oxytocin is released into the blood.
- ✓ Oxytocin is secreted in both males and females.
- ✓ **Actions in Females** - Oxytocin acts on mammary glands and uterus.

ACTION OF OXYTOCIN ON MAMMARY GLANDS

- ✓ Oxytocin causes ejection of milk from the mammary glands.
- ✓ Ducts of the mammary glands are lined by myoepithelial cells.

  ↓

  Oxytocin causes contraction of the myoepithelial cells

  ↓

  flow of milk from alveoli to exterior through duct system and nipple.

MILK EJECTION REFLEX -

- ✓ Plenty of touch receptors are present on the mammary glands(around the nipple).
- ✓ Reflex is initiated by the nervous factors and completed by the hormonal action,

  ↓

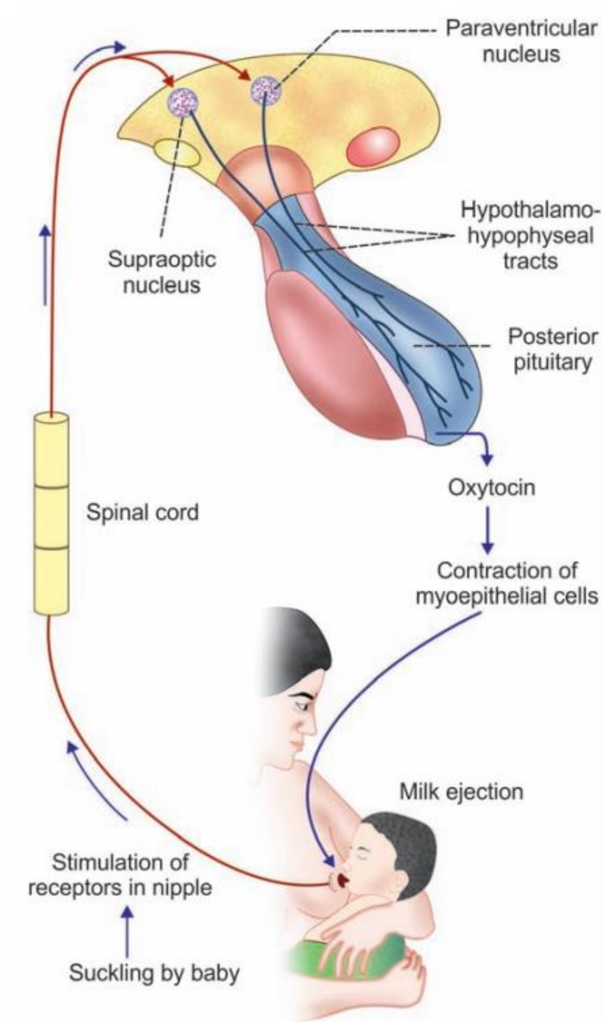
Called a **Neuroendocrine reflex**.

⬇

large amount of oxytocin is released by

⬇

Positive feedback mechanism.



ACTION ON UTERUS

Oxytocin acts on pregnant uterus and also non-pregnant uterus.

On pregnant uterus – Throughout the period of pregnancy, oxytocin secretion is inhibited by estrogen and progesterone.

At the end of pregnancy, (secretion of two hormones decreases and secretion of oxytocin increases).

⬇

Oxytocin causes contraction of uterus and helps in the expulsion of fetus

On non-pregnant uterus

The action of oxytocin on non-pregnant uterus is to facilitate the transport of sperms through female genital tract up to the fallopian tube,

⬇

by producing the uterine contraction during sexual intercourse.

- Sensitivity of uterus to oxytocin is accelerated by estrogen and decreased by progesterone.

ACTION IN MALES -

In males, the release of oxytocin increases during ejaculation.

⬇

facilitates release of sperm into urethra

⬇

by causing contraction of smooth muscle fibers

⬇

in reproductive tract, particularly vas deferens.

- **HYPOACTIVITY OF POSTERIOR PITUITARY**

DIABETES INSIPIDUS

Diabetes insipidus is a posterior pituitary disorder characterized by excess excretion of water through urine.

Causes - deficiency of ADH

Which occurs in the following conditions: -

i. Lesion (injury) or degeneration of supraoptic and paraventricular nuclei of hypothalamus

ii. Lesion in hypothalamo-hypophyseal tract

iii. Atrophy of posterior pituitary

iv. Inability of renal tubules to give response to ADH hormone.

SIGNS AND SYMPTOMS

i. **Polyuria:** - Excretion of large quantity of dilute urine, with increased frequency of voiding is called polyuria.

Daily output of urine - between 4 to 12 liter

ii. Polydipsia: - Intake of excess water is called polydipsia.

Because of polyuria, lot of water is lost from the body, resulting in intake of large quantity of water.

iii. Dehydration: In some cases, the thirst center in the hypothalamus is also affected by the lesion.

⬇

Water intake decreases and loss of water through urine is not compensated.

⬇

So, dehydration develops which may lead to death.

MCQ –

Q.1. FSH is produced by –

a. thyroid gland

b. anterior pituitary gland

c. posterior pituitary gland

d. none

Q. 2. Which of the following is an accumulation and releasing centre of neurohormone.

a. hypothalamus

b. anterior pituitary gland

c. posterior pituitary gland

d. all the above

Q. 3. Sertoli cells are regulated by pituitary hormone known as –

a. FSH

B. LH

C. GH

D. none

Q.4. Gigantism and acromegaly are due to –

a.hyperthyrodiasm

b. hyperpituitarism

c. hypothyrodiasm

d. none

Q.5.Which of the following gland is regarded as a master gland.

a. adrenal gland

b. hypothalamus

c. pituitary gland

d. thyroid

Q. 6. Which hormone causes the contraction of labour.

a. prolactin

b. estrogen

c. progesterone

d. oxytocin

Q. 7. The thyroid gland in the human body is located.

a. armpit

b. spleen

c. abdomen

d. neck

Q.8. Which among the following is an endocrine gland in the human body.

a. salivary gland

b. digestive gland

c. pituitary gland

d. sweat gland

Q. 9. Growth hormone is secreted by which gland.

a. pineal gland

b. pituitary gland

c. hypothalamus

d. none

Q. 10. Tropic hormone are formed –

a. anterior pituitary

b. posterior pituitary gland

c. thyroid

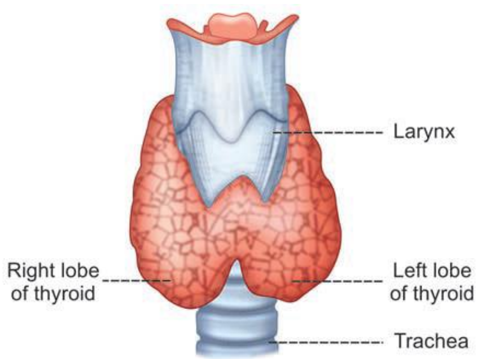
d. none

Answers – 1- b, 2- c, 3- a,4-b, 5- c, 6- d, 7- d, 8- c, 9- b, 10 – a.

Chapter - 22

THYROID GLAND

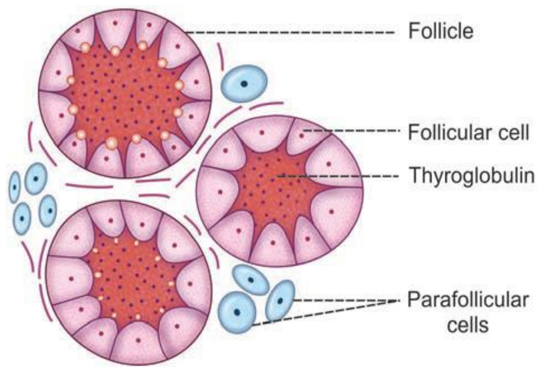
- ✓ Thyroid is an endocrine gland
- ✓ **Situated** - Root of the neck on either side of the trachea.
- ✓ It has two lobes, which are connected in the middle by an isthmus .
- ✓ It weighs about 20 to 40 g in adults.
- ✓ Thyroid is larger in females than in males.
- ✓ The structure and the function of the thyroid gland change in different stages of the sexual cycle in females.
- ✓ Its function increases slightly during pregnancy and lactation



- ✓ Decreases during menopause.

HISTOLOGY OF THYROID GLAND

- ✓ Thyroid gland is composed of large number of closed follicles.
- ✓ These follicles are lined with cuboidal epithelial cells, which are called the follicular cells.
- ✓ Follicular cavity is filled with a colloidal substance known as thyroglobulin, which is secreted by the follicular cells.
- ✓ Follicular cells secrete tetraiodothyronine (T4 or thyroxine) and tri-iodothyronine (T3).
- ✓ In between the follicles, the parafollicular cells are present . These cells secrete calcitonin.



HORMONES OF THYROID GLAND

Thyroid gland secretes three hormones:

1. Tetraiodothyronine or T4 (thyroxine)
2. Tri-iodothyronine or T3
3. Calcitonin.

SYNTHESIS OF THYROID HORMONES

- ✓ Takes place in thyroglobulin, present in follicular cavity.
- ✓ Essential components – Iodine +Tyrosine (absorbed from GI Tract)

⬇

Converted into iodide

⬇

Absorbed from GI tract.

STAGES OF SYNTHESIS OF THYROID HORMONES

Five stages: -

1. Thyroglobulin synthesis
2. Iodide trapping
3. Oxidation of iodide
4. Transport of iodine into follicular cavity
5. Iodination of tyrosine
6. Coupling reactions.

1. **THYROGLOBULIN SYNTHESIS**

Endoplasmic reticulum and Golgi apparatus in the follicular cells

⬇

of thyroid gland synthesize and secrete thyroglobulin continuously.

2. IODIDE TRAPPING

Iodide is actively transported from blood into follicular cell, against electrochemical gradient.

Iodide pump : -

- ✓ Iodide is transported into the follicular cell along with sodium by sodium-iodide symport pump, which is also called iodide pump.
- ✓ Normally, iodide is 30 times more concentrated in the thyroid gland than in the blood.
- ✓ During hyperactivity of the thyroid gland, the concentration it increases 200 times more.

3. OXIDATION OF IODIDE

Iodide must be oxidized to iodine,

⬇

because only iodine is capable of combining with tyrosine to form thyroid hormones.

- ✓ Occurs inside the follicular cells in the presence of thyroid peroxidase.
- ✓ Absence or inactivity of this enzyme stops the synthesis of thyroid hormones.

4. TRANSPORT OF IODINE INTO FOLLICULAR CAVITY

From the follicular cells, iodine is transported into the follicular cavity by an iodide-chloride pump called pendrin.

5. IODINATION OF TYROSINE

- ✓ Combination of iodine with tyrosine is known as iodination.
- ✓ It takes place in thyroglobulin.
- ✓ Iodine binds with thyroglobulin (process is called organification of thyroglobulin).

⬇

Then, iodine (I) combines with tyrosine, (present in thyroglobulin).

⬇

Accelerated by the enzyme iodinase,(secreted by follicular cells).

6. COUPLING REACTIONS : -

Iodotyrosine residues (MIT & DIT) get coupled with one another.

Tyrosine + I = Monoiodotyrosine (MIT)

MIT + I = Di-iodotyrosine (DIT)

DIT + MIT = Tri-iodothyronine (T3)

MIT + DIT = Reverse T3

DIT + DIT = Tetraiodothyronine or Thyroxine (T4)

❑ STORAGE OF THYROID HORMONES

- ✓ After synthesis, thyroid hormones remain in the form of vesicles within thyroglobulin and are stored for long period.
- ✓ Thyroid gland is store its hormones for a long period of about 4 months.
- ✓ when the synthesis of thyroid hormone stops, the signs and symptoms of deficiency do not appear for about 4 months.

❑ FUNCTIONS OF THYROID HORMONES

Thyroid hormones have two major effects on the body:

I. To increase basal metabolic rate

II. To stimulate growth in children.

Actions of thyroid hormones are: -

1. ACTION ON BASAL METABOLIC RATE (BMR)

Thyroxine increases the metabolic activities in most of the body tissues, except brain, retina, spleen, testes and lungs.

2. ACTION ON PROTEIN METABOLISM

Thyroid hormone increases the synthesis of proteins in the cells. The protein synthesis is accelerated by the following ways:„ -

1. i. By Increasing the Translation of RNA
2. ii. By Increasing the Transcription of DNA to RNA
3. iii. By Increasing the Activity of Mitochondria
4. iv. By Increasing the Activity of Cellular Enzymes

3. ACTION ON CARBOHYDRATE METABOLISM

i. Thyroxine Increases the absorption of glucose from GI tract

ii. Enhances the glucose uptake by the cells (accelerating transport of glucose through the cell membrane).

iii. Increases the breakdown of glycogen into glucose

iv. Accelerates gluconeogenesis.

4. ACTION ON FAT METABOLISM

- ✓ Thyroxine decreases the fat storage by mobilizing it from adipose tissues and fat depots.
- ✓ Thyroxine increases the free fatty acid level in blood.

5. ACTION ON PLASMA AND LIVER FATS

- ✓ Thyroxine decrease cholestrol, phospholipids and triglyceride levels in plasma.
- ✓ Atherosclerosis (hyposecretion of thyroxine).
- ✓ Fatty liver (thyroxine increase , deposition of fats in liver)

6. ACTION ON VITAMIN METABOLISM

- ✓ Thyroxine increases the formation of many enzymes.
- ✓ Vitamins form essential parts of the enzymes, vitamins may be utilized during the formation of the enzymes.

7. ACTION ON BODY TEMPERATURE

Thyroid hormone increases the heat production in the body,

⬇

by accelerating various cellular metabolic processes and increasing BMR.

- ✓ During hypersecretion of thyroxine, the body temperature increases greatly, resulting in excess sweating.

8. ACTION ON GROWTH

Thyroxine is more important to promote growth and development of brain during fetal life and first few years of postnatal life.

Deficiency of thyroid hormones during this period leads to **mental retardation.**

9. ACTION ON BODY WEIGHT

- ✓ Thyroxine is essential for maintaining the body weight.
- ✓ Increase in thyroxine secretion decreases the body weight and fat storage.
- ✓ Decrease in thyroxine secretion increases the body weight because of fat deposition.

10. ACTION ON CARDIOVASCULAR SYSTEM

Thyroxine increases the overall activity of cardiovascular system. Eg. ***Heart Rate , Force of Contraction of the Heart , Blood Vessels , Arterial Blood Pressure.***

11. ACTION ON RESPIRATION

Thyroxine increases the rate and force of respiration indirectly.

12. ACTION ON GASTROINTESTINAL TRACT

- ✓ Thyroxine increases the appetite and food intake.
- ✓ It also increases the secretions and movements of GI tract.
- ✓ Hypersecretion of thyroxine causes diarrhea and the lack of thyroxine causes constipation.

13. ACTION ON CENTRAL NERVOUS SYSTEM

Thyroxine is very essential for the development and maintenance of normal functioning of central nervous system (CNS).

❑ REGULATION OF SECRETION OF THYROID HORMONES

Secretion of thyroid hormones is controlled by anterior pituitary and hypothalamus through feedback mechanism.

ROLE OF PITUITARY GLAND

Thyroid-stimulating Hormone –

TSH secreted by anterior pituitary is the major factor regulating the synthesis and release of thyroid hormones.

It is also necessary for the growth and the secretory activity of the thyroid gland.

ACTIONS OF THYROID-STIMULATING HORMONE

Thyroid-stimulating hormone increases*:*

1. The number of follicular cells of thyroid

2. Conversion of cuboidal cells into columnar cells and it causes the development of thyroid follicles

3. Size and secretory activity of follicular cells

4. Iodide pump and iodide trapping in follicular cells

5. Thyroglobulin secretion into follicles

6. Iodination of tyrosine and coupling to form the hormones

7. Proteolysis of the thyroglobulin.

❑ Mode of Action of TSH

TSH acts through cyclic AMP mechanism.

❑ ROLE OF HYPOTHALAMUS

- ✓ Hypothalamus regulates thyroid secretion through thyrotropic-releasing hormone (TRH).
- ✓ TRH is transported through hypothalamo-hypophyseal portal vessels

to the anterior pituitary , TRH causes the release of TSH.

FEEDBACK CONTROL

Thyroid hormones regulate their own secretion through negative feedback control, by inhibiting the release of TRH from hypothalamus and TSH from anterior pituitary.

APPLIED PHYSIOLOGY – DISORDERS OF THYROID GLAND

❑ HYPERTHYROIDISM

Increased secretion of thyroid hormones is called hyperthyroidism.

Causes of Hyperthyroidism

Hyperthyroidism is caused by:

1. Graves' disease

2. Thyroid adenoma.

1. *Graves' disease* -

Graves' disease is an autoimmune disease and it is the most common cause of hyperthyroidism

2. *Thyroid adenoma* -

Sometimes, a localized tumor develops in the thyroid tissue. It is known as thyroid adenoma and it secretes large quantities of thyroid hormones.

⬇

hormone secreted from adenoma depresses the production of TSH.

SIGNS AND SYMPTOMS OF HYPERTHYROIDISM

1. Intolerance to heat as the body produces lot of heat due to increased basal metabolic rate caused by excess of thyroxine.

2. Increased sweating due to vasodilatation

3. Decreased body weight due to fat mobilization

4. Diarrhea due to increased motility of GI tract

5. Muscular weakness because of excess protein catabolism

6. Nervousness, extreme fatigue, inability to sleep, mild tremor in the hands .

7. Toxic goiter , Oligomenorrhea or Amenorrhea etc.

❑ HYPOTHYROIDISM

- ✓ Decreased secretion of thyroid hormones is called hypothyroidism.
- ✓ Hypothyroidism leads to myxedema in adults and cretinism in children.

***Myxedema* -**

Myxedema is the hypothyroidism in adults, characterized by generalized edematous appearance.

Causes for myxedema -

Common cause of myxedema is the autoimmune disease called **Hashimoto's thyroiditis,** which is common in late middle-aged women.

Signs and symptoms of myxedema -

1. Swelling of the face

2. Bagginess under the eyes

3. Non-pitting type of edema,

4. Atherosclerosis: - It is the hardening of the walls of arteries because of accumulation of fat deposits and other substances.

- ✓ Other general features of hypothyroidism in adults .eg. Anemia , Fatigue and muscular sluggishness , Menorrhagia and polymenorrhea , Increase in body weight, Constipation etc.

❑ CRETINISM

Cretinism is the hypothyroidism in children, characterized by stunted growth.

Causes for cretinism -

Cretinism occurs due to congenital absence of thyroid gland, genetic disorder or lack of iodine in the diet.

SYMPTOMS -

- ✓ Sluggish movements and **croaking sound** while crying.
- ✓ Stunted growth with bloated body.
- ✓ The tongue becomes so big that it hangs down with dripping of saliva.
- ✓ The big tongue obstructs swallowing and breathing.

❑ GOITER

Goiter means enlargement of the thyroid gland. It occurs both in hypothyroidism and hyperthyroidism.

Goiter in Hyperthyroidism – Toxic Goiter

Toxic goiter is the enlargement of thyroid gland with increased secretion of thyroid hormones, caused by thyroid tumor.

Goiter in Hypothyroidism – Non-toxic Goiter

- ✓ Non-toxic goiter is the enlargement of thyroid gland without increase in hormone secretion. It is also called **hypothyroid goiter.**
- ✓ The goitrogens become active only during low iodine intake.

MCQ –

Q. 1. Which of the following are the hormone secreted by thyroid gland.

a. T3

B. T4

C. None

d. both a and b.

Q.2. Excess release of thyroid hormone in body causes the –

a. hyperthyroidism

b. goiter

c. hypertyroidism

d. none

Q. 3. Which of the following the symptoms of release of excess of T3 and T4 hormones.

a. anxiety

b. hair loss

c. nervousness

d. all of the above

Q. 4. Which of the following disease is caused due to the deficiency of the iodine.

a. thyroid nodules

b. thyroid cancer

c. goiter

d. none

Q. 5.Which of the following are the symptoms of hypothyroidism

a. dry skin and dry hair

b. joint and muscle pain

c. depression

d. al the above

Q. 6. Which of the following conditions marked by the low TSH.

a. hypothyroidism

b. goiter

c. hyperthyroidism

d. none

Q. 7. Which of the following hormone regulates BMR of the body.

a. thyroxine

b. adrenaline

c. all the above

d. none

Q. 8. The thyroid gland influences the function of which of the following organs.

a. brain

b. skin

c.heart

d. all of the above.

Q. 9. Which type of epithelium is present in tyroid follicles.

a. squamous

b. cuboidal

c. columnar

d. none

Q. 10. How many lobes are present in the tyroid.

a. 1

b.3

c.2

d. 4

Answers- 1- d, 2-a, 3- d, 4-c, 5- d, 6-a, 7-a, 8- d, 9-b, 10 –c.

Chapter – 23

ENDOCRINE FUNCTIONS OF PANCREAS

- ✓ Endocrine function of pancreas is performed by the islets of Langerhans.
- ✓ Human pancreas contains about 1 to 2 million islets.
- ✓ Islets of Langerhans consist of four types of cells:

1. A cells or α-cells, which secrete glucagon
2. B cells or β-cells, which secrete insulin
3. D cells or δ-cells, which secrete Somatostatin
4. F cells or PP cells, which secrete pancreatic polypeptide.

1. INSULIN

„ **Source of secretion -**

Insulin is secreted by B cells or β-cells in the islets of Langerhans of pancreas.

SYNTHESIS -

Synthesis of insulin occurs in the rough endoplasmic reticulum of β-cells in islets of Langerhans.

Preproinsulin → Proinsulin

Peptic cleavage ↓

Insulin

METABOLISM -

Insulin is degraded in liver and kidney.

ACTIONS OF INSULIN -

- ✓ Insulin is the important hormone that is concerned with the regulation of carbohydrate metabolism and blood glucose level.
- ✓ It is also concerned with the metabolism of proteins and fats.

1. On Carbohydrate Metabolism

Only Antidiabetic hormone secreted in the body,

⬇

reduces blood glucose level.

By - following actions on carbohydrate metabolism

i. Increases transport and uptake of glucose by the cells

ii. Promotes peripheral utilization of glucose

iii. Promotes storage of glucose – glycogenesis

iv. Inhibits glycogenolysis and gluconeogenesis

2. On Protein Metabolism

Insulin facilitates the synthesis and storage of proteins and inhibits the cellular utilization of proteins by –

i. Facilitating transport of amino acids into the cell from blood, by increasing permeability of cell membrane for amino acids.

ii. Accelerating protein synthesis by influencing transcription of DNA and by increasing the

translation of mRNA.

iii. Preventing protein catabolism by decreasing activity of cellular enzymes.

iv. Preventing conversion of proteins into glucose.

3. *On Fat Metabolism*

- ✓ Insulin stimulates the synthesis of fat.
- ✓ It also increases the storage of fat in the adipose tissue.

Actions of insulin on fat metabolism are:

i. Synthesis of fatty acids and triglycerides -

a. Glucose into fatty acids

b. Fatty acids into triglycerides.

ii. Transport of fatty acids into adipose tissue

iii. Storage of fat - Insulin promotes the storage of fat in adipose tissue.

4. On Growth

Insulin promotes growth of body by its anabolic action on proteins.

REGULATION OF INSULIN SECRETION -

Insulin secretion is mainly regulated by blood glucose level.

Role of Blood Glucose Level

NORMAL BLOOD GLUCOSE LEVEL

- ✓ In normal persons, blood glucose level is controlled within a narrow range.
- ✓ In the early morning after overnight **fasting,** the blood glucose level is low ranging between 70 and 110 mg/dL of blood.
- ✓ Between first and second hour after meals **(postprandial),** the blood glucose level rises to 100 to 140 mg/dL.
- ✓ Glucose level in blood is brought back to normal at the end of second hour after the meals.
- ✓ Blood glucose regulating mechanism is operated through liver and muscle by the influence of the pancreatic hormones – insulin and glucagon.
- ✓ Many other hormones are also involved in the regulation of blood glucose level.
- ✓ Insulin is the only hormone that reduces the blood glucose level and it is called the **antidiabetogenic hormone.**
- ✓ The hormones which increase blood glucose level are called **diabetogenic hormones** or **anti-insulin hormones.**

2. **GLUCAGON –**
   SOURCE OF SECRETION

- ✓ Glucagon is secreted from **A cells** or **α-cells** in the islets of Langerhans of pancreas.
- ✓ It is also secreted from **A cells** of stomach and **L cells** of intestine.

„

„ **SYNTHESIS**

- ✓ Glucagon is synthesized from **preproglucagon** in the α-cells of islets.
- ✓ Preproglucagon is converted into **proglucagon,** which gives rise to glucagon.

METABOLISM

- ✓ About 30% of glucagon is degraded in liver and 20% in kidney.
- ✓ 50% of the circulating glucagon is degraded in blood itself by enzymes such as **serine** and **cysteine proteases.**

❑ ACTIONS OF GLUCAGON

Actions of glucagon are antagonistic to those of insulin.

⬇

It increases the blood glucose level,

⬇

peripheral utilization of lipids and the conversion of proteins into glucose.

1. On Carbohydrate Metabolism –

Increases blood glucose level by:

1. Facilitating glucose transport into liver cells

2. Increasing glycogenolysis

3. Increasing gluconeogenesis

2. On Protein Metabolism –

1. Increases transport of amino acids into liver cells

2. Increases utilization of amino acids for gluconeogenesis

3. On Fat Metabolism –

1. Increases lipolysis

2. Promotes ketogenesis

4. Other Actions

Glucagon: -

i. Inhibits the secretion of gastric juice

ii. Increases the secretion of bile from liver.

❑ REGULATION OF GLUCAGON SECRETION

Secretion of glucagon is controlled mainly by glucose and amino acid levels in the blood.

1. *Role of Blood Glucose Level*

When blood glucose level decreases below 80 mg/dL of blood,

⬇

α-cells of islets of Langerhans are stimulated

⬇

more glucagon is released.

⬇

Glucagon, in turn increases the blood glucose level.

- ✓ When blood glucose level increases, α-cells are inhibited and the secretion of glucagon decreases.

2. *Role of Amino Acid Level in Blood*

- ✓ Increase in amino acid level in blood stimulates the secretion of glucagon.
- ✓ Glucagon, in turn converts the amino acids into glucose.

3. *Role of Other Factors*

Factors which increase glucagon secretion,such as- Exercise , Stress , Gastrin.

3. SOMATOSTATIN -

SOURCE OF SECRETION

Somatostatin is secreted from: -

1. Hypothalamus

2. D cells (δ-cells) in islets of Langerhans of pancreas

3. D cells in stomach and upper part of small intestine.

SYNTHESIS

- ✓ Somatostatin is synthesized from the precursor prosomatostatin.
- ✓ Prosomatostatin is converted into somatostatin.

METABOLISM - Somatostatin is degraded in liver and kidney.

4. PANCREATIC POLYPEPTIDE

SOURCE OF SECRETION

- ✓ Pancreatic polypeptide is secreted by F cells or PP cells in the islets of Langerhans of pancreas.
- ✓ It is also found in small intestine.

SYNTHESIS

Pancreatic polypeptide is synthesized from preprohormone in the PP cells of islets.

METABOLISM

Pancreatic polypeptide is degraded from in kidney.

ACTIONS OF PANCREATIC POLYPEPTIDE

- ✓ Physiological action of pancreatic polypeptide is not known.
- ✓ It is believed to increase the secretion of glucagon from α-cells in islets of Langerhans.

MCQ –

Q. 1. Gastric secretion inhibition is brought about by –

a. enterogastrone

b.gastrin

c. cholecystokinin

d. none

Q. 2. The major product of the chief cell is –

a. mucus

b. pepsinogen

c. vit. B12

d. none

Q.3. Pancreatic juice secretion is caused by –

a. secretin

b. gastrin

c. enterogastrone

d. none

Q.4. It is possible to live without a pancreas.

a. true

b. false

Q. 5. Which pancreatic cells produce insulin.

a. germ cells

b. epithelial cells

c. islet cells

d. none

Q. 6.Principal fat digesting enzyme is in pancreatic juice.

a. true

b. false.

Q. 7. A person can survive without pancreas.

a. true

b. false.

Q.8. Which cells produce insulin.

a. alpha

b. beta cells

c. delta cells

d. none

Q. 9.When pancreatic juice is pumped into duodenum in humans, one of the constituents is –

a. trypsin

b. trypsinogen

c. enterokinase

d. chymotrypsin

Q.10. The common passage for pancreatic juice and bile is –

a. stomach

b. ampulla

c. duct of wirsung

d. duct of oddi

Answers – 1.- a, , 2- b, 3-a, 4- a, 5- c, 6-a, 7- a, 8- a, 9- b, 10 – b.

Chapter – 24

ADRENAL CORTEX

- ✓ Adrenal glands are called the **'life-saving glands'** or **'essential endocrine glands'.**
- ✓ It is because the absence of adrenocortical hormones causes death within 3 to 15 days and absence of adrenomedullary hormones decreases the resistance to mental and physical stress.

FUNCTIONAL ANATOMY OF ADRENAL GLANDS

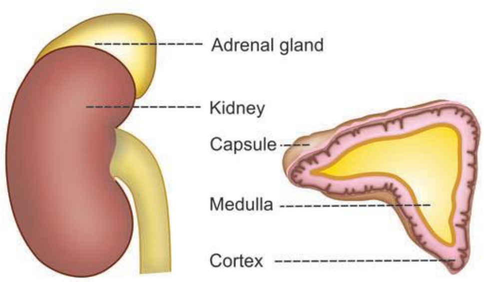
- ✓ There are two adrenal glands.
- ✓ Each gland is situated on the upper pole of each kidney.
- ✓ Each gland weighs about 4 g.

PARTS OF ADRENAL GLAND

Two parts: -

1. **Adrenal cortex:** Outer portion, constituting 80% of the gland.

2.Adrenal medulla: Central portion, constituting 20% of the gland.



HISTOLOGY OF ADRENAL CORTEX

Adrenal cortex is formed by three layers of structure.

1. Outer zona glomerulosa

2. Middle zona fasciculata

3. Inner zona reticularis.

HORMONES OF ADRENAL CORTEX -

Adrenocortical hormones are steroids in nature, hence the name **‘corticosteroids’.**

Corticosteroids are classified into three groups:

1. Mineralocorticoids
2. Glucocorticoids
3. Sex hormones.

1. MINERALOCORTICOIDS

Mineralocorticoids are the corticosteroids that act on the minerals (electrolytes), particularly sodium and potassium.

Mineralocorticoids are: -

1. Aldosterone
2. 11-deoxycorticosterone.

SOURCE OF SECRETION

Mineralocorticoids are secreted by Zona glomerulosa of adrenal cortex.

FUNCTIONS OF MINERALOCORTICOIDS

Ninety percent of mineralocorticoid activity is provided by aldosterone.

Life-saving Hormone

- ✓ Aldosterone is very essential for life and it maintains the osmolarity and volume of ECF.
- ✓ It is usually called life-saving hormone because, its absence causes death within 3 days to 2 weeks.
- ✓ Aldosterone has three important functions.

  It increases: -

  1. Reabsorption of sodium from renal tubules
  2. Excretion of potassium through renal tubules
  3. Secretion of hydrogen into renal tubules.

REGULATION OF SECRETION -

Aldosterone secretion is regulated by four important factors .

1. Increase in potassium ion (K+) concentration in ECF

2. Decrease in sodium ion (Na+) concentration in ECF

3. Decrease in ECF volume

4. Adrenocorticotropic hormone (ACTH).

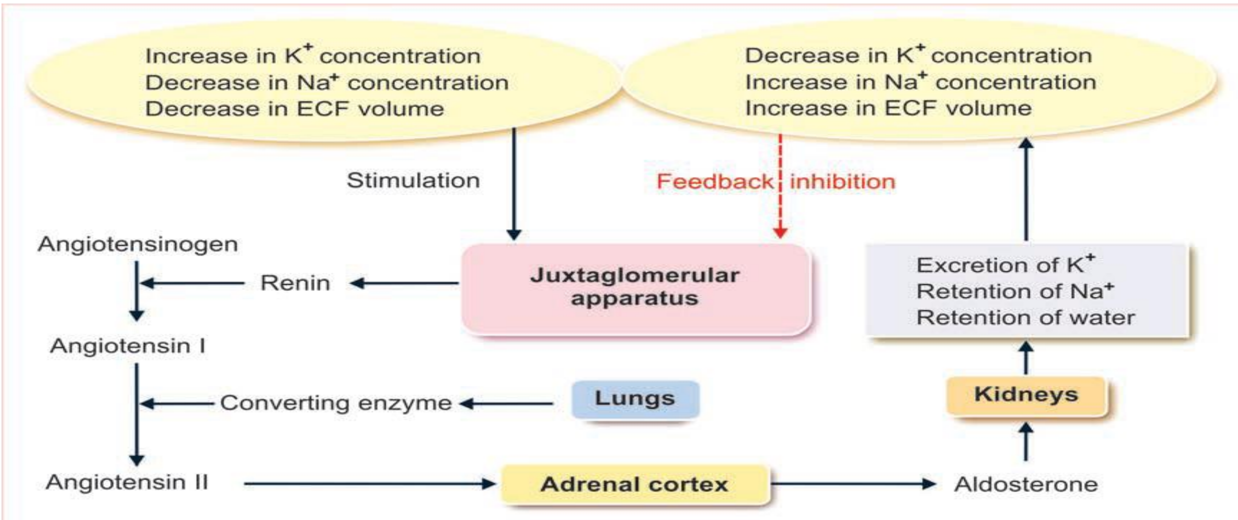


Figure: REGULATION OF SECRETION

2. GLUCOCORTICOIDS

Glucocorticoids act mainly on glucose metabolism.

Glucocorticoids are: -

1. Cortisol

2. Corticosterone

3. Cortisone.

SOURCE OF SECRETION

Glucocorticoids are secreted mainly by zona fasciculata of adrenal cortex.

A small quantity of glucocorticoids is also secreted by zona reticularis.

FUNCTIONS OF GLUCOCORTICOIDS -

Glucocorticoids have metabolic effects on carbohydrates, proteins, fats and water.

1. *On Carbohydrate Metabolism*

Glucocorticoids increase the blood glucose level by two ways: -

i. By promoting gluconeogenesis in liver from amino acids.

ii. By inhibiting the uptake and utilization of glucose by peripheral cells.

2. *On Protein Metabolism*

Glucocorticoids promote the catabolism of proteins, leading to: -

i. Decrease in cellular proteins

ii. Increase in plasma level of amino acids

iii. Increase in protein content in liver.

Glucocorticoids cause **catabolism of proteins** by the following methods: -

i. By releasing amino acids from body cells (except liver cells), into the blood

ii. By increasing the uptake of amino acids by hepatic cells from blood.

3. *On Fat Metabolism*

Glucocorticoids cause mobilization and redistribution of fats. Actions on fats are: -

i. Mobilization of fatty acids from adipose tissue

ii. Increasing the concentration of fatty acids in blood

iii. Increasing the utilization of fat for energy.

4. *On Mineral Metabolism*

- ✓ Glucocorticoids enhance the retention of sodium and to lesser extent, increase the excretion of potassium.
- ✓ Hypersecretion of glucocorticoids causes edema, hypertension, hypokalemia and muscular weakness.

6. *On Bone*

- ✓ Glucocorticoids stimulate the bone resorption **(osteoclastic activity)** and inhibit bone formation and mineralization **(osteoblastic activity).**
- ✓ Hypersecretion of glucocorticoids - **Osteoporosis** occurs.

7. *On Muscles -*

Glucocorticoids increase the catabolism of proteins in muscle. Hypersecretion causes muscular weakness due to loss of protein.

8. *On Blood Cells*

These hormones also decrease the number of basophils and lymphocytes and increase the number of circulating neutrophils, RBCs and platelets.

9. *On Central Nervous System*

Glucocorticoids are essential for normal functioning of nervous system.

Insufficiency of these hormones causes personality changes like irritability and lack of concentration.

❑ REGULATION OF SECRETION

- ✓ Anterior pituitary regulates glucocorticoid secretion by secreting adrenocorticotropic hormone (ACTH).
- ✓ ACTH secretion is regulated by hypothalamus through corticotropin-releasing factor (CRF).

3. ADRENAL SEX HORMONES

- ✓ Adrenal sex hormones are secreted mainly by zona reticularis.
- ✓ Zona fasciculata secretes small quantities of sex hormones.
- ✓ Adrenal cortex secretes male sex hormones, which are called **androgens.**
- ✓ But small quantity of **estrogen** and **progesterone** are also secreted by adrenal cortex.

Androgens secreted by adrenal cortex: -

1. Dehydroepiandrosterone
2. Androstenedione

3. Testosterone.

APPLIED PHYSIOLOGY

❑ HYPERACTIVITY OF ADRENAL CORTEX

Following conditions: -

1. Cushing syndrome
2. Adrenogenital syndrome

CUSHING SYNDROME

Cushing syndrome is a disorder characterized by obesity.

Causes -

- ✓ Cushing syndrome is due to the hypersecretion of glucocorticoids, particularly cortisol.
- ✓ If it is due to pituitary origin, it is known as **Cushing disease.**
- ✓ If it is due to adrenal origin it is called **Cushing syndrome.**

Pituitary Origin –

Hypersecretion of glucocorticoid -

i. Tumor in pituitary cells

ii. Malignant tumor of non-endocrine origin like cancer of lungs or abdominal viscera

Adrenal Origin

Cortisol secretion is increased by:

i. Tumor in zona fasciculata of adrenal cortex

ii. Carcinoma of adrenal cortex

iii. Prolonged treatment of chronic inflammatory diseases

Signs and Symptoms

a. *Moon face:* The edematous facial appearance due to fat accumulation and retention of water and salt

b. *Torso:* Fat accumulation in the chest and abdomen.

c. *Buffalo hump:* Due to fat deposit on the back of neck and shoulder

d. *Pot belly:* Due to fat accumulation in upper abdomen

ii. *Purple striae:* Reddish purple stripes on abdomen

iii. Thinning of extremities

Iv. Poor wound healing.

v. Facial plethora: Facial redness

2. ADRENOGENITAL SYNDROME

Causes

Adrenogenital syndrome is due to the tumor of zona reticularis in adrenal cortex.

Symptoms –

Symptoms in females –

i. Masculinization due to increased muscular growth

ii. Deepening of voice

iii. Amenorrhea

iv. Enlargement of clitoris and Male type of hair growth.

Symptoms in males –

i. Gynecomastia (enlargement of breast)

ii. Atrophy of testis

iii. Loss of interest in women.

- **HYPOACTIVITY OF ADRENAL CORTEX**

Hyposecretion of adrenocortical hormones leads to -

1. Addison disease or chronic adrenal insufficiency

2. Congenital adrenal hyperplasia.

1. ADDISON DISEASE OR CHRONIC ADRENAL INSUFFICIENCY

Addison disease is the failure of adrenal cortex to secrete corticosteroids.

Signs and Symptoms –

i. Pigmentation of skin and mucous membrane due to excess ACTH secretion

ii. Muscular weakness

iii. Dehydration with loss of sodium

iv. Hypotension

v. Hypoglycemia

ADRENAL MEDULLA -

- ✓ Medulla is the inner part of adrenal gland and it forms 20% of the mass of adrenal gland.
- ✓ It is made up of **chromaffin cells.**

Types of chromaffin cells -

Adrenal medulla is formed by two types of chromaffin cells:

1. Adrenaline-secreting cells (90%)

2. Noradrenaline-secreting cells (10%).

HORMONES OF ADRENAL MEDULLA

Catecholamines secreted by adrenal medulla -

1. Adrenaline or epinephrine

2. Noradrenaline or norepinephrine

3. Dopamine.

ACTIONS OF ADRENALINE AND NORADRENALINE

- ✓ Adrenaline and noradrenaline stimulate the nervous system.

- ✓ Adrenaline has significant effects on metabolic functions and both adrenaline and noradrenaline have significant effects on cardiovascular system.
- ✓ Circulating adrenaline and noradrenaline have similar effect of sympathetic stimulation.
- ✓ Adrenaline acts through both alpha and beta receptors equally. Noradrenaline acts mainly through alpha receptors and occasionally through beta receptors.

DOPAMINE -

- ✓ Dopamine is secreted by adrenal medulla.
- ✓ Dopamine is also secreted by dopaminergic neurons in some areas of brain, particularly basal ganglia. In brain, this hormone acts as a neurotransmitter.
- ✓ Deficiency of dopamine in basal ganglia produces nervous disorder called **parkinsonism.**

MCQ –

Q. 1. Adrenaline and non adrenaline are hormones and act as –

a. neurotransmitters

b. energy storing substance

c. food storage material

d. none

Q. 2. Glomerular area of adrenal cortex is responsible for –

a. water and electrolyte balance

b. steroid hormone secretion

c. blood pressure

d. none

Q.3. Which of the following hormone is known as flight and fight hormone.

a. thyroxin

b. adrenaline

c. ADH

d. oxytocin

Q. 4.ADH acts on –

a. loop of henle

b. collecting ducts of testes

c. collecting tubules of kidneys

d. PCT

Q. 5. Adrenal gland is derived from –

a. endoderm

b. mesoderm

c. ectoderm

d. ectoderm and mesoderm

Q. 6. Adrenaline hormone increases –

a. blood pressure

b. blood glucose level

c. arteriosclerosis

d. none

Q. 7. ADH deficiency shows –

a. polydipsia

b. polyuria

c. none

d. both a and b.

Q.8. The adrenal gland is located –

a. peritoneal cavity

b. kidney

c. liver

d. all the above

Q. 9. What is the name of the cells producing the hormone in adrenal medulla.

a. f cells

b. p cells

c. both

d. chromaffin

Q. 10. The adrenal …….. secretes small amount of both sex hormone.

a. medulla

b. cortex

c. accessory gland

d cells

Answers – 1- a, 2- a, 3- b, 4- c, 5- d, 6- a, 7- d, 8-b, 9 – d, 10 - b

Chapter - 25

ENDOCRINE FUNCTIONS OF OTHER ORGANS

PINEAL GLAND –

SITUATION AND STRUCTURE

- ✓ Pineal gland or **epiphysis** is located in the diencephalic area of brain above the hypothalamus.
- ✓ It is a small Coneshaped structure with a length of about 10 mm.

Pineal gland has two types of cells:

1. Large epithelial cells called parenchymal cells

2. Neuroglial cells.

FUNCTIONS

Pineal gland has two functions: -

1. It controls the sexual activities in animals by regulating the seasonal fertility.

2. It secretes the hormonal substance called melatonin.

Melatonin

Source of secretion

Melatonin is secreted by the parenchymal cells of pineal gland.

Actions of melatonin

- ✓ Melatonin acts mainly on gonads. Its action differs from species to species.
- ✓ In humans, it inhibits the onset of puberty by inhibiting the gonads.

- ❑ **THYMUS**

SITUATION

Thymus is situated in front of trachea, below the thyroid gland.

FUNCTIONS

- ✓ Thymus has lymphoid function and endocrine function.
- ✓ It plays an important role in development of immunity in the body.

Thymus has two functions: -

1. Processing the T lymphocytes

2. Endocrine function.

1. *Processing the T Lymphocytes*

- ✓ Thymus plays an essential role in the development of immunity by processing the T lymphocytes.
- ✓ The lymphocytes which are produced in bone marrow are processed in thymus into T lymphocytes.

2. *Endocrine Function of Thymus -*

Thymus secretes two hormones:

i. Thymosin

ii. Thymin.

❑ KIDNEYS

Kidneys secrete five hormonal substances:

1. Erythropoietin

2. Thrombopoietin

3. Renin

4. 1,25-dihydroxycholecalciferol (calcitriol)

5. Prostaglandins.

1. ERYTHROPOIETIN –

Action of Erythropoietin

Erythropoietin stimulates the bone marrow and causes erythropoiesis.

2. THROMBOPOIETIN –

Action of Thrombopoietin

Thrombopoietin stimulates the production of platelets.

3. RENIN –

Actions of Renin

Renin converts angiotensinogen into angiotensin I, which is converted into angiotensin II by a converting enzyme.

4. 1,25-DIHYDROXYCHOLECALCIFEROL – CALCITRIOL

The activated vitamin D plays an important role in the maintenance of blood calcium level.

5. PROSTAGLANDINS –

Action of Prostaglandins

Prostaglandins decrease the blood pressure by systemic vasodilatation, diuresis and natriuresis.

- **HEART**

Heart secretes the hormones atrial natriuretic peptide and brain natriuretic peptide.

Recently, another peptide called C-type natriuretic peptide is found in heart.

LOCAL HORMONES

Local hormones are the substances which act on the same area of their secretion or in immediate neighborhood.

Classification of Local Hormones

Two types: -

I. Hormones synthesized in tissues

II. Hormones synthesized in blood.

LOCAL HORMONES SYNTHESIZED IN TISSUES

Local hormones synthesized in the tissues are: -

1. Prostaglandins and related substances

2. Other local hormones synthesized in tissues.

PROSTAGLANDINS AND ITS RELATED HORMONES

Prostaglandins and other hormones which are derived from **arachidonic acid** are collectively called **eicosanoids.** The eicosanoids are:

1. Prostaglandins

2. Thromboxanes

3. Prostacyclin

OTHER LOCAL HORMONES SYNTHESIZED IN TISSUES –

Such as - Acetylcholine , Serotonin , Histamine, Substance P , Heparin , Leptin Gastrointestinal hormones etc.

LOCAL HORMONES PRODUCED IN BLOOD

Local hormones produced in the blood are:- Serotonin , Angiotensinogen, Kinins.

Chapter – 26

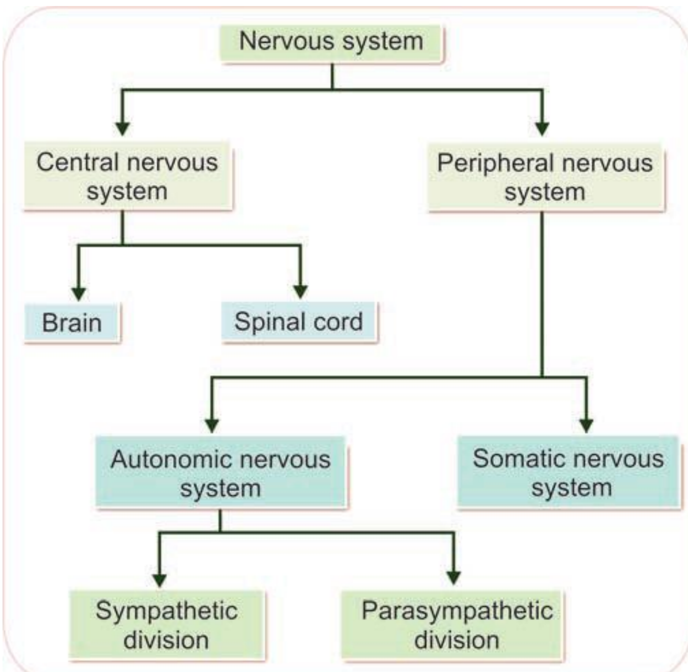
INTRODUCTION TO NERVOUS SYSTEM

- ✓ Nervous system controls all the activities of the body.
- ✓ It is quicker than other control system in the body, namely endocrine system.

Divided into two parts:-

1. Central nervous system

2. Peripheral nervous system.



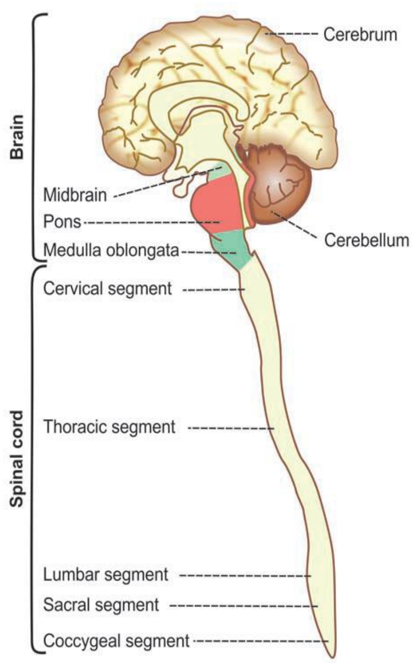
1. CENTRAL NERVOUS SYSTEM

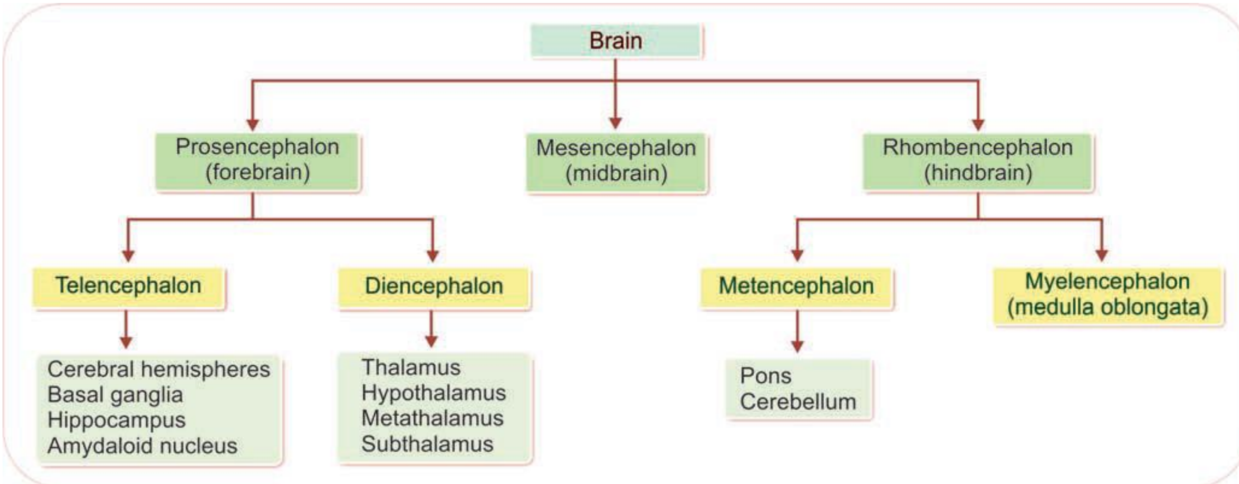
- ✓ Central nervous system (CNS) includes **brain and spinal cord.**
- ✓ **Formed by neurons and supporting cells** called **neuroglia.**
- ✓ **Structures of brain and spinal cord are** arranged in two layers - **gray matter and white matter.**
- ✓ **Gray matter formed - nerve cell bodies and** proximal parts of nerve fibers, arising from nerve cell body.
- ✓ White matter formed - remaining parts of nerve fibers.

- ✓ In brain, white matter is placed - inner part
- ✓ gray matter is placed - outer part.
- ✓ In spinal cord, white matter is in the outer part
- ✓ gray matter - inner part.

BRAIN -

- ✓ It is situated in the **skull.**
- ✓ **It is continued as spinal** cord in the **vertebral canal through the foramen magnum** of the skull bone.
- ✓ Brain and spinal cord are surrounded by three layers of **meninges called the outer dura mater,** middle **arachnoid mater and inner pia mater.**
- ✓ The space between arachnoid mater and pia mater is known as **subarachnoid space. This space is filled** with a fluid called cerebrospinal fluid.





Parts of Brain

Brain consists of three major divisions -

1. *Prosencephalon*

- ✓ Otherwise known as **forebrain.**
- ✓ Divided into two parts:

i. Telencephalon - includes cerebral hemispheres, basal ganglia, hippocampus and amygdaloid nucleus

ii. Diencephalon - consisting of thalamus, hypo thalamus, metathalamus and subthalamus.

2. *Mesencephalon*

Also known as **midbrain.**

3. *Rhombencephalon*

Rhombencephalon or **hindbrain is subdivided into two** portions:

i. Metencephalon, formed by pons and cerebellum

ii. Myelencephalon or medulla oblongata

- ❑ Midbrain, pons and medulla oblongata are together called the brainstem.

2. **PERIPHERAL NERVOUS SYSTEM**

- ✓ Formed by neurons and their processes present in all regions of the body.
- ✓ It consists of cranial nerves - arising from brain and spinal nerves - arising from spinal cord.
- ✓ It is again divided into two subdivisions:

1. Somatic nervous system

2. Autonomic nervous system.

1. ***Somatic Nervous System***

- ✓ Concerned with **somatic functions.**
- ✓ **It includes the nerves supplying the skeletal** muscles.
- ✓ Somatic nervous system is responsible for muscular activities and movements of the body.

2. ***Autonomic Nervous System***

- ✓ Concerned with regulation of **visceral or vegetative functions.**
- ✓ **So, it is otherwise** called **vegetative or involuntary nervous system.**
- ❑ Autonomic nervous system consists of two divisions - sympathetic division and parasympathetic division.

❑ **NEURON**

- ✓ **Neuron** or **nerve cell** is defined as the structural and functional unit of nervous system.
- ✓ Neuron is similar to any other cell in the body, having nucleus and all the organelles in cytoplasm.
- ✓ It is different from other cells by two ways: -

1. Neuron has branches or processes called **axon** and **dendrites**

2. Neuron does not have centrosome. So, it cannot undergo division.

CLASSIFICATION OF NEURON

Three different methods -

A. Depending upon the number of poles

B. Depending upon the function

C. Depending upon the length of axon.

A. DEPENDING UPON THE NUMBER OF POLES

Three types: -

1. Unipolar neurons

2. Bipolar neurons

3. Multipolar neurons.

1. *Unipolar Neurons*

- ✓ Unipolar neurons are the neurons that have only **one pole.**
- ✓ From a single pole, both axon and dendrite arise
- ✓ This type of nerve cells is present only in embryonic stage in human beings.

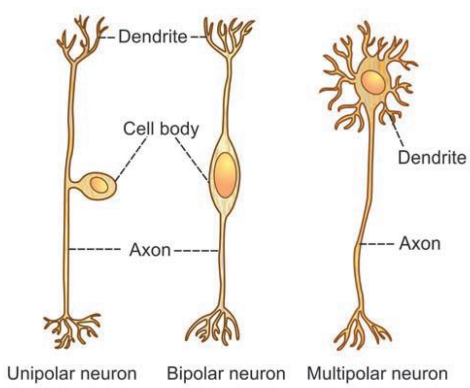


Fig. : Types of neuron

2. *Bipolar Neurons*

- ✓ Neurons with **two poles** are known as bipolar neurons.
- ✓ Axon arises from one pole and dendrites arise from the other pole.

3. ***Multipolar Neurons***

- ✓ Multipolar neurons are the neurons which have **many poles.**
- ✓ One of the poles gives rise to axon and all other poles give rise to dendrites.

B. DEPENDING UPON THE FUNCTION

Two types:

1. Motor or efferent neurons

2. Sensory or afferent neurons.

1. ***Motor or Efferent Neurons***

- ✓ Motor or efferent neurons are the neurons which carry the **motor impulses** from central nervous system to peripheral effector organs like muscles, glands, blood vessels, etc.
- ✓ Each motor neuron has a long axon and short dendrites.

2. ***Sensory or Afferent Neurons***

Sensory or afferent neurons are the neurons which carry the **sensory impulses** from periphery to central nervous system.

Each sensory neuron has a short axon and long dendrites.

C. DEPENDING UPON THE LENGTH OF AXON

Two types:

1. Golgi type I neurons

2. Golgi type II neurons.

1. ***Golgi Type I Neurons***

- ✓ Golgi type I neurons have **long axons.**
- ✓ Cell body of these neurons is in different parts of central nervous system and their axons reach the remote peripheral organs.

2. ***Golgi Type II Neurons***

- ✓ Neurons of this type have **short axons.**

- ✓ These neurons are present in cerebral cortex and spinal cord.

STRUCTURE OF NEURON

Neuron is made up of three parts:

1. Nerve cell body

2. Dendrite

3. Axon.

- ✓ Dendrite and axon form the **processes** of neuron
- ✓ Dendrites are **short processes** and the axons are **long processes.**
- ✓ Dendrites and axons are usually called **nerve fibers.**

NERVE CELL BODY

- ✓ Nerve cell body is also known as **soma** or **perikaryon.**
- ✓ It is irregular in shape.
- ✓ It is constituted by a mass of cytoplasm called neuroplasm, and is covered by a cell membrane.
- ✓ The cytoplasm contains a large nucleus, Nissl bodies, neurofibrils, mitochondria and Golgi apparatus.
- ❑ Nissl bodies and neurofibrils are found only in nerve cell and not in other cells.

DENDRITE

- ✓ Dendrite is the **branched process** of neuron and it is branched repeatedly.
- ✓ Dendrite may be present or absent.
- ✓ If present, it may be one or many in number.
- ✓ Dendrite has Nissl granules and neurofibrils.
- ✓ Dendrite transmits impulses towards the nerve cell body.
- ✓ Usually, the dendrite is shorter than axon.

AXON -

- ✓ Axon is the **longer process** of nerve cell.
- ✓ Each neuron has only one axon.
- ✓ Axon extends for a long distance away from the nerve cell body.
- ✓ Length of longest axon is about 1 meter.
- ✓ Axon transmits impulses away from the nerve cell body.

CLASSIFICATION OF NERVE FIBERS

BASIS OF CLASSIFICATION

Nerve fibers are classified by six different methods.

1. DEPENDING UPON STRUCTURE

Two types:

i. ***Myelinated Nerve Fibers***

Myelinated nerve fibers are the nerve fibers that are covered by **myelin sheath.**

ii. ***Non-myelinated Nerve Fibers***

Nonmyelinated nerve fibers are the nerve fibers which are not covered by myelin sheath.

2. DEPENDING UPON DISTRIBUTION

Two types:

i. ***Somatic Nerve Fibers***

Somatic nerve fibers supply the **skeletal muscles** of the body.

ii. ***Visceral or Autonomic Nerve Fibers***

Autonomic nerve fibers supply the various **internal organs** of the body.

3. DEPENDING UPON ORIGIN

Two types:

i. ***Cranial Nerve Fibers***

Nerve fibers arising from **brain** are called cranial nerve fibers.

ii. ***Spinal Nerve Fibers***

Nerve fibers arising from **spinal cord** are called spinal nerve fibers.

4. DEPENDING UPON FUNCTION

Two types: -

i. ***Sensory Nerve Fibers***

Sensory nerve fibers carry sensory impulses from different parts of the body to the central nervous system.

- ✓ Also known as **afferent nerve fibers.**

ii. ***Motor Nerve Fibers***

Motor nerve fibers carry motor impulses from central nervous system to different parts of the body.

- ✓ Also called **efferent nerve fibers.**

5. DEPENDING UPON SECRETION OF NEUROTRANSMITTER

Two types:

i. ***Adrenergic Nerve Fibers***

Adrenergic nerve fibers secrete **noradrenaline.**

ii. ***Cholinergic Nerve Fibers***

Cholinergic nerve fibers secrete **acetylcholine.**

6. DEPENDING UPON DIAMETER AND CONDUCTION OF IMPULSE

i. Type A nerve fibers

ii. Type B nerve fibers

iii. Type C nerve fibers.

- ✓ Type A nerve fibers are the thickest fibers and type C nerve fibers are the thinnest fibers.
- ✓ Type C fibers are also known as Type IV fibers.
- ✓ Except type C fibers, all the nerve fibers are myelinated.

❑ PROPERTIES OF NERVE FIBERS

There are properties –

- ✓ EXCITABILITY
- ✓ CONDUCTIVITY
- ✓ REFRACTORY PERIOD
- ✓ SUMMATION
- ✓ ALL-OR-NONE LAW

❑ EXCITABILITY -

- ✓ Excitability is defined as the **physiochemical change** that occurs in a tissue when stimulus is applied.
- ✓ Nerve fibers have a low threshold for excitation than the other cells.

Response Due to Stimulation of Nerve Fiber

Based on the strength of stimulus -

1. ***Action potential or nerve impulse***

- ✓ Action potential develops in a nerve fiber when it is stimulated by a stimulus with adequate strength.
- ✓ Adequate strength of stimulus, necessary for producing the action potential in a nerve fiber is known as **threshold** or **minimal stimulus.**

2. ***Electrotonic potential or local potential***

When the stimulus with **subliminal strength** is applied, only electrotonic potential develops and the action potential does not develop.

ACTION POTENTIAL OR NERVE IMPULSE

Action potential in a nerve fiber is similar to that in a muscle, except for some minor differences.

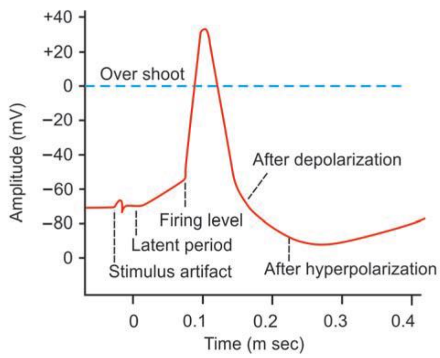


FIGURE : Action potential in nerve fiber

Event	Nerve fiber	Skeletal muscle fiber
Resting membrane potential	–70 mV	–90 mV
Firing level	–55 mV	–75 mV
End of depolarization	+35 mV	+55 mV

Figure : Differences between electrical potential in nerve fiber and muscle fiber.

Properties of Action Potential -

1. Propagative
2. long distance signal
3. Both depolarisation + repolarisation
4. Obeys ALL – or – none law
5. Summation not possible
6. Has refractory period

ELECTROTONIC POTENTIAL OR LOCAL POTENTIAL

- ✓ local potential is a non-propagated **local response** that develops in the nerve fiber when a subliminal stimulus is applied.

- ✓ Subliminal or subthreshold stimulus does not produce action potential.

Properties of Electrotonic Potential

1. Electrotonic potential is **non-propagated**

2. It does not obey **all-or-none law.**

3. Only depolarisation or hyperpolarization

4. Short – distance signal

5. Summation is possible

6. No refractory period

- ❑ **CONDUCTIVITY -**

- ✓ Conductivity is the ability of nerve fibers to transmit the impulse from the area of stimulation to the other areas.
- ✓ Action potential is transmitted through the nerve fiber in only one direction.
- ✓ Depolarization occurs first at the site of stimulation in the nerve fiber. It causes depolarization of the neighboring areas.
- ✓ Depolarization is followed by repolarization.

CONDUCTION THROUGH MYELINATED

NERVE FIBER – SALTATORY CONDUCTION

- ✓ Saltatory conduction is the form of conduction of nerve impulse in which, the impulse jumps from **one node to another.**
- ✓ Conduction of impulse through a myelinated nerve fiber is about 50 times faster than through a nonmyelinated fiber.

Mechanism of Saltatory Conduction

- ✓ Myelin sheath is not permeable to ions.
- ✓ So, the entry of sodium from extracellular fluid into nerve fiber occurs only in the node of Ranvier.
- ✓ Where the myelin sheath is absent.
- ✓ It causes depolarization in the node and not in the internode.

- **REFRACTORY PERIOD**

  Refractory period is the period at which the nerve does not give any response to a stimulus.

TYPES OF REFRACTORY PERIOD

Refractory period is of two types:

1. ***Absolute Refractory Period -***

Absolute refractory period is the period during which the nerve does not show any response at all, whatever may be the strength of stimulus.

2. ***Relative Refractory Period -***

It is the period, during which the nerve fiber shows response, if the strength of stimulus is increased to maximum.

- **SUMMATION**

- ✓ When one subliminal stimulus is applied, it does not produce any response in the nerve fiber because, the subliminal stimulus is very weak.
- ✓ However, if two or more subliminal stimuli are applied within a short interval of about 0.5 millisecond, the response is produced.
- ✓ It is because the subliminal stimuli are summed up together to become strong enough to produce the response.
- ✓ This phenomenon is known as summation.

- **ALL-OR-NONE LAW**

All-or-none law states that when a nerve is stimulated by a stimulus it gives maximum response or does not give response at all.

MCQ –

Q. 1. Human neural system has –

a. CNS

b.PNS

c. both a and b

d. none

Q. 2. Myelinated nerve fibers are found in –

a. cranial nerves

b. spinal nerves

c. both a and b

d. none

Q.3. Number of spinal nerves in human are –

a. 11 pairs

b. 27 pairs

c. 32 pairs

d. 31 pairs.

Q. 4. The gape between two neuron is called as –

a. synapse

b. axon

c. dendrite

d. none

Q. 5 Which of the following is the main thinking part of the human brain.

a. hind brain

b. cerebrum

c. mid brain

d.. none

Q. 6. Dendrites and axon are parts of which cell.

a. red blood cells

b. neuron

c. nephron

d. none

Q. 7. …….controls involuntary activities like coughing and sneezing.

a. medulla

b. cerebrum

c. pons

d. cerebellum

Q.8. The part of the brain from which spinal cord originates is –

a. pons

b. medulla oblongata

c. cerebrum

d. none

Q.9. Which part of the brain controls the heart.

a. spinal cord

b. medulla oblongata

c. neuron

d. none

Q.10. Centre for heat, touch, cold and pressure are in –

a. frontal lobe

b. occipital lobe

c. parietal lobe

d. none

Answers- 1- c, 2-c, 3- d,4-a, 5-b, 6-b, 7-a, 8-b, 9-b, 10 –c.

Chapter---27

RECEPTORS

Receptors are sensory (afferent) nerve endings that terminate in periphery as bare **unmyelinated endings** or in the form of specialized **capsulated structures.**

- Actually receptors function like

↓

Transducer

↓

Converts one form of energy - another.

↓

Action potentials in nerve fiber.

CLASSIFICATION OF RECEPTORS

Two types: -

A. Exteroceptors

B. Interoceptors.

A. EXTEROCEPTORS

Which give response to stimuli arising from **outside the body.**

It is divided into three groups: -

1. *Cutaneous Receptors or Mechanoreceptors*

- Receptors situated in the skin are called the cutaneous receptors.
- Response to **mechanical stimuli such as touch, pressure and pain.**
- **Touch and** pressure receptors give response to **vibration also.**

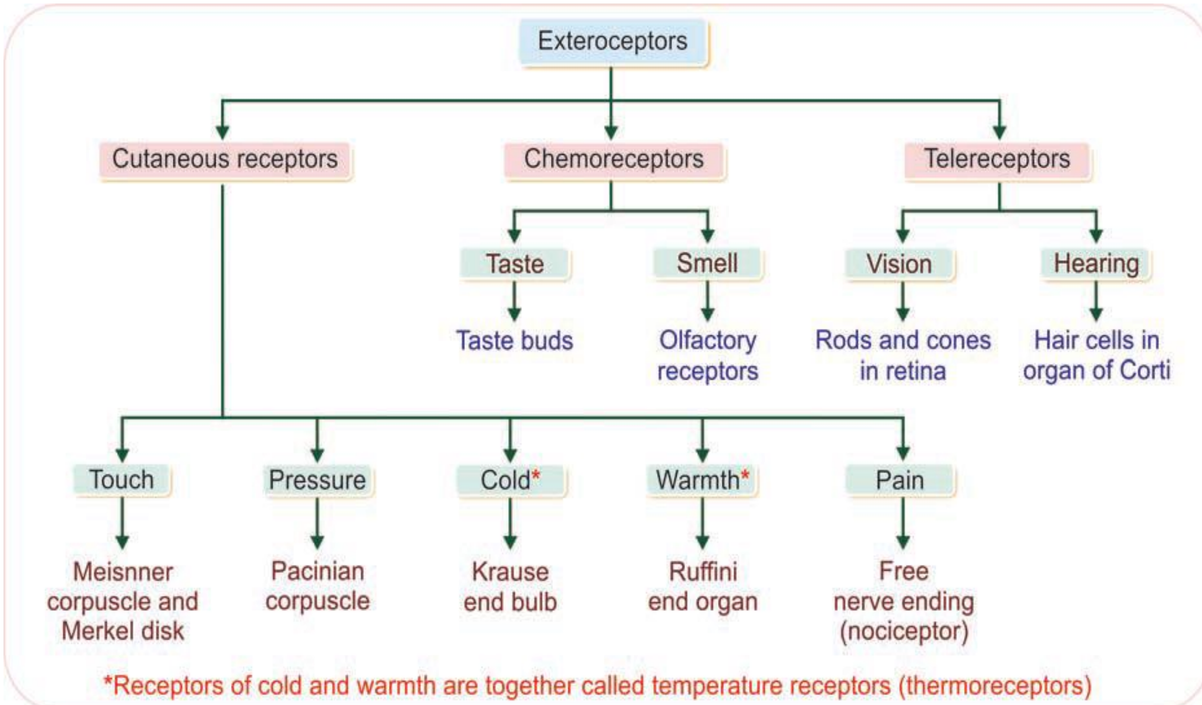
2. *Chemoreceptors*

Which give response to **chemical stimuli,** are called the chemoreceptors.

3. *Telereceptors*

✓ Give response to stimuli arising **away from the body.**

✓ Also called the **distance receptors.**



B. INTEROCEPTORS

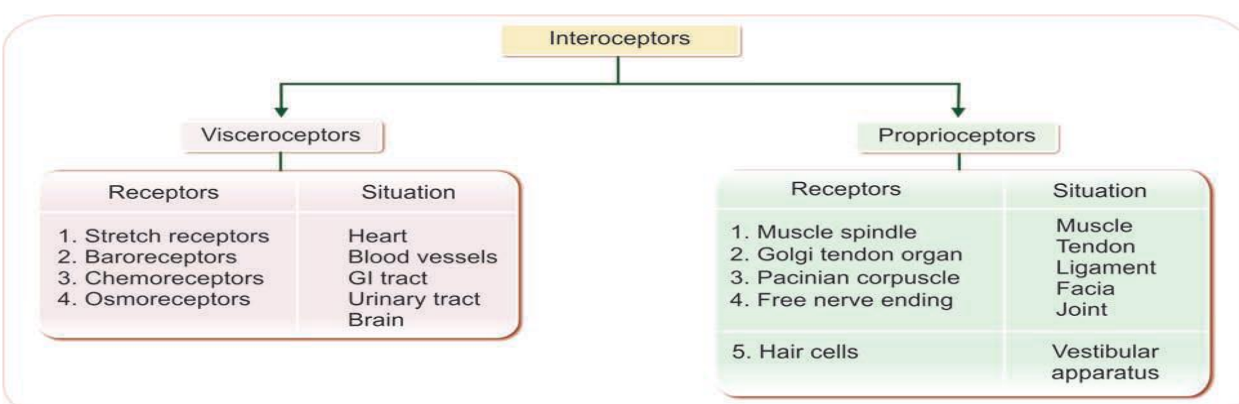
Which give response to stimuli arising from **within the body.**

1. ***Visceroceptors***

Situated in the viscera are called visceroceptors.

2. ***Proprioceptors***

Which give response to **change in the position of different parts of the body.**



- **PROPERTIES OF RECEPTORS -**

1. SPECIFICITY OF RESPONSE – MÜLLER LAW

- Müller law refers to the response given by a particular type of receptor to a specific sensation.
- Pain receptors give response only to pain sensation.
- Each type of sensation depends upon the part of the brain in which its fibers terminate.

2. ADAPTATION – SENSORY ADAPTATION

Adaptation is the decline in discharge of sensory impulses when a receptor is stimulated continuously with constant strength.

Depending upon adaptation time, receptors are divided into two types:

i. **Phasic receptors - adapted rapidly.**

Touch and pressure receptors are the phasic receptors

ii. **Tonic receptors - adapt slowly.**

Muscle spindle, pain receptors and cold receptors are the tonic receptors.

3. RESPONSE TO INCREASE IN STRENGTH OF STIMULUS – WEBERFECHNER LAW

If the response given by the receptor is to be doubled,

⬇

Strength of stimulus must be increased 100 times.

⬇

This phenomenon is called WeberFechner law.

4. SENSORY TRANSDUCTION

Process by which the energy (stimulus) in the environment

⬇

Converted into electrical impulses (action potentials) in nerve fiber

⬇

For example, Chemoreceptor converts - Chemical energy - into action potential in sensory nerve fiber.

- ✓ Touch receptor converts - Mechanical energy - into action potential

5. RECEPTOR POTENTIAL

Definition

- ✓ It is a **nonpropagated** transmembrane potential difference that develops when a receptor is stimulated.

6. LAW OF PROJECTION

When a sensory pathway from receptor to cerebral cortex is stimulated on any particular site along its course, the sensation caused by stimulus is always felt (referred) at the location of receptor

Examples of Law of Projection

i. Sensation complained by amputated patients in the missing limb **(phantom limb) is the best example** of law of projection.

For example -

leg has been amputated,

⬇

Cut end heals with scar formation.

⬇

If cut end of sensory fibers are stimulated (during movement of thigh),

⬇

Sensation feels from **non – existent leg.**

❑ REFLEX ACTIVITY

- ✓ Reflex activity is the response to a peripheral nervous stimulation that occurs without our consciousness.
- ✓ It is a type of **protective mechanism and it protects the body** from irreparable damages.

For example - When hand is placed on a hot object, it is withdrawn immediately.

- ✓ When a bright light is thrown into the eyes, eyelids are closed and pupil is constricted to prevent the damage of retina by entrance of excessive light into the eyes.

REFLEX ARC -

Reflex arc is the anatomical nervous pathway for a reflex action.

A simple reflex arc includes five components

1. *Receptor*

Receptor is the **end organ, which receives the stimulus.**

When receptor is stimulated, impulses are generated in afferent nerve.

2. *Afferent Nerve*

Afferent or **sensory nerve transmits sensory impulses** from the receptor to center.

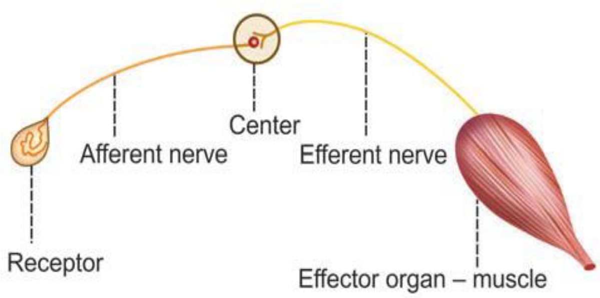
3. *Center*

Center receives the sensory impulses via afferent nerve fibers and in turn, it generates appropriate motor impulses.

- ✓ Center is located in the brain or spinal cord.

4. *Efferent Nerve*

Efferent or **motor nerve transmits motor impulses from** the center to the effector organ.



5. *Effector Organ*

Effector organ is the structure such as muscle or gland where the activity occurs in response to stimulus.

- ✓ Afferent and efferent nerve fibers may be connected directly to the center.

CLASSIFICATION OF REFLEXES -

Reflexes are classified by six different methods de pending upon various factors.

1. DEPENDING UPON WHETHER INBORN OR ACQUIRED REFLEXES

i. *Inborn Reflexes or Unconditioned Reflexes*

- ✓ Unconditioned reflexes are the **natural reflexes,** which are present since the time of birth, hence the name inborn reflexes.
- ✓ Such reflexes do not require previous learning, training or conditioning.

ii. ***Acquired Reflexes or Conditioned Reflexes***

- ✓ Conditioned or acquired reflexes are the reflexes that are developed **after conditioning** or **training.**
- ✓ These reflexes are not inborn but, acquired after birth.
- ✓ Example is the secretion of saliva by sight, smell, thought or hearing of a known edible substance.

2. DEPENDING UPON SITUATION – ANATOMICAL CLASSIFICATION

Reflexes are classified depending upon the situation of the center.

i. ***Cerebellar Reflexes***

Cerebellar reflexes are the reflexes which have their center in **cerebellum.**

ii. ***Cortical Reflexes***

Cortical reflexes are the reflexes that have their center in **cerebral cortex.**

iii. ***Midbrain Reflexes***

Midbrain reflexes are the reflexes which have their center in **midbrain.**

iv. ***Bulbar or Medullary Reflexes***

Bulbar or medullary reflexes are the reflexes which have their center in **medulla oblongata.**

v. ***Spinal Reflexes***

Reflexes having their center in the spinal cord are called spinal reflexes.

Depending upon the segments involved, spinal reflexes are divided into three groups:

a. Segmental spinal reflexes

b. Intrasegmental spinal reflexes

c. Suprasegmental spinal reflexes

3. DEPENDING UPON PURPOSE – PHYSIOLOGICAL CLASSIFICATION

Reflexes are classified depending upon the purpose **(functional significance).**

i. ***Protective Reflexes or Flexor Reflexes***

- ✓ Protective reflexes are the reflexes which protect the body from **nociceptic (harmful) stimuli.**
- ✓ These reflexes are also called **withdrawal reflexes** or flexor reflexes.
- ✓ Protective reflexes involve flexion at different joints hence the name flexor reflexes.

ii. ***Antigravity Reflexes or Extensor Reflexes***

Antigravity reflexes are the reflexes that protect the body against **gravitational force.**

These reflexes are also called the extensor reflexes because, the extensor muscles contract during these reflexes resulting in extension at joints.

4. DEPENDING UPON THE NUMBER OF SYNAPSE

Depending upon the number of synapse in reflex arc, reflexes are classified into two types:

i. ***Monosynaptic Reflexes***

Reflexes having only **one synapse** in the reflex arc are called monosynaptic reflexes. Stretch reflex is the best example for monosynaptic reflex.

ii. ***Polysynaptic Reflexes***

Reflexes having **more than one** synapse in the reflex arc are called polysynaptic reflexes. Flexor reflexes (withdrawal reflexes) are the polysynaptic reflexes.

5. DEPENDING UPON WHETHER SOMATIC OR VISCERAL REFLEXES

i. ***Somatic Reflexes***

Somatic reflexes are the reflexes, for which the reflex arc is formed by **somatic nerve fibers.**

ii. ***Visceral or Autonomic Reflexes***

Visceral or autonomic reflexes are the reflexes, for which at least a part of reflex arc is formed by **autonomic nerve fibers.**

6. DEPENDING UPON CLINICAL BASIS

Depending upon the clinical basis, reflexes are classified into four types:

i. Superficial reflexes

ii. Deep reflexes

iii. Visceral reflexes

iv. Pathological reflexes.

i. SUPERFICIAL REFLEXES

- ✓ Superficial reflexes are the reflexes, which are elicited from the surface of the body.
- ✓ Superficial reflexes are of two types:- mucus membrane reflexes and skin reflexes.

1. MUCOUS MEMBRANE REFLEXES

Mucous membrane reflexes arise from the mucus membrane.

2. CUTANEOUS REFLEXES OR SKIN REFLEXES

Cutaneous reflexes are elicited from skin by the stimulation of cutaneous receptors.

ii. DEEP REFLEXES

Deep reflexes are elicited from deeper structures beneath the skin like tendon.

iii. VISCERAL REFLEXES

Visceral reflexes are the reflexes arising from **pupil** and **visceral organs.**

iv. PATHOLOGICAL REFLEXES

Pathological reflexes are the reflexes that are elicited only in pathological conditions.

Eg. Babinski sign, Clonus, Pendular movements.

❑ SYNAPSE

Synapse is the junction between two neurons.

CLASSIFICATION OF SYNAPSE

Two methods:-

A. Anatomical classification

B. Functional classification.

ANATOMICAL CLASSIFICATION

Depending upon **ending of axon, synapse is** classified into three types:

1. **Axoaxonic synapse - One neuron** terminates on axon of another neuron

2. **Axodendritic synapse – One** neuron terminates on dendrite of another neuron

3. **Axosomatic synapse - One neuron** ends on soma (cell body) of another neuron

FUNCTIONAL CLASSIFICATION

On the basis of **mode of impulse transmission.**

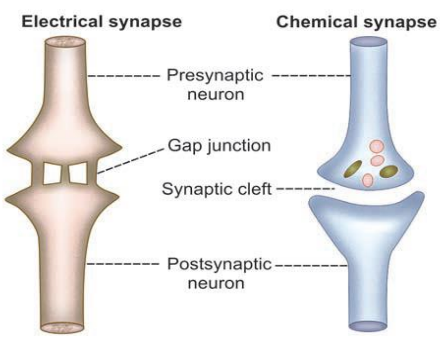
Classified into two categories:

1. Electrical synapse

2. Chemical synapse

1. *Electrical Synapse*

- Electrical synapse is the synapse in which the physiological continuity between the presynaptic and post synaptic neurons is provided by **gap junction between** the two neurons.
- There is **direct exchange** of ions between the two neurons through the gap junction.
- Because of this reason, the action potential reaching the terminal portion of presynaptic neuron directly enters the postsynaptic neuron.



2. Chemical Synapse

- ✓ Junction between a nerve fiber and a muscle fiber or between two nerve fibers, through which the signals are transmitted by the release of chemical transmitter(neurotransmitter substance).

- ✓ In the chemical synapse, there is no continuity between the two neurons because of the presence of a space called **synaptic cleft between the** two neurons.

FUNCTIONS OF SYNAPSE

Main function of the synapse is to transmit the impulses, i.e. action potential from one neuron to another.

Synapses are divided into two types:

1. Excitatory synapses, which transmit the impulses (excitatory function)

2. Inhibitory synapses, which inhibit the transmission of impulses (inhibitory function).

PROPERTIES OF SYNAPSE

1. ONE WAY CONDUCTION – BELL-MAGENDIE LAW

Impulses are transmitted only in **one direction in synapse, i.e. from** presynaptic neuron to postsynaptic neuron.

2. SYNAPTIC DELAY

Short delay that occurs during the transmission of impulses through the synapse.

It is due to the time taken for:-

i. Release of neurotransmitter

ii. Passage of neurotransmitter from axon terminal to postsynaptic membrane

iii. Action of the neurotransmitter to open the ionic channels in postsynaptic membrane.

Normal duration of synaptic delay is 0.3 to 0.5 millisecond.

3. FATIGUE

During continuous muscular activity,

⬇

Synapse becomes the seat of fatigue along with **Betz cells**

⬇

present in motor area of frontal lobe of cerebral cortex

- ❑ Fatigue at synapse is due to the **depletion of neurotransmitter substance, acetylcholine.**

4. SUMMATION

Fusion of effects or progressive increase in the excitatory postsynaptic potential in post synaptic neuron when many presynaptic excitatory terminals are stimulated.

Summation is of two types:

i. ***Spatial Summation -***

Many presynaptic terminals are stimulated.

ii. ***Temporal Summation -***

One presynaptic terminal is stimulated repeatedly.

MCQ –

Q.1. The gap between two neuron is called as-

a. synapse

b. axon

c. dendrite

d. none

Q. 2. Part of the brain that helps in regulation and maintenance of muscular activities.

a. medulla oblongata

b. midbrain

c. cerebrum

d. cerebellum

Q.3. The outer covering of human brain is……

a. coracoid

b. piamater

c. duramater

d. arachnoid

Q.4. Our brain mainly depends on which of the following food.

a. only fat

b. glucose and amino acid

c. fat and proteins

d. only glucose

Q. 5. The parasympathetic nervous system does not –

a. slow heart beat

b. accelerate heart rate

c. stimulate salivary secretion

d. none

Q. 6. Nerve which carry impulses from receptor organs such as skin, eyes, nose, muscles, to the brain and spinal cord are –

a. somatic sensory

b. somatic motor

c. visceral sensory

d. none

Answers – 1- a, 2-d, 3- c, 4- b,5- b, 6-a.

Chapter --28

BASAL GANGLIA

Basal ganglia form the part of **extrapyramidal system,**

↓

Which is concerned with integration and regulation motor activities.

FUNCTIONS OF BASAL GANGLIA

1. CONTROL OF MUSCLE TONE

- ✓ Basal ganglia control the muscle tone.
- ✓ Gamma motor neurons of spinal cord are responsible for development of tone in the muscles.
- ✓ Basal ganglia **decrease** the **muscle tone**

↓

by inhibiting gamma motor neurons

↓

through descending inhibitory reticular system in brainstem

↓

During the lesion of basal ganglia, muscle tone increases.

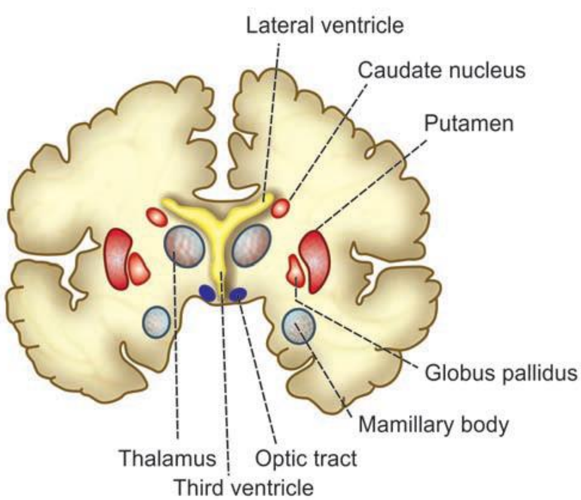


Figure : Basal ganglia

2. CONTROL OF MOTOR ACTIVITY

i. *Regulation of Voluntary Movements -*

Movements during voluntary motor activity are initiated by cerebral cortex.

During lesions of basal ganglia, the control mechanism is lost and so the movements become inaccurate and awkward.

Neuronal circuits arise from three areas of the cerebral cortex: -

a. Premotor area

b. Primary motor area

c. Supplementary motor area

ii. *Regulation of Conscious Movements*

Fibers between cerebral cortex and caudate nucleus are

⬇

Concerned with regulation of conscious movements.

⬇

This function called **cognitive control** of activity

iii. *Regulation of Subconscious Movements*

Cortical fibers reaching putamen are directly

⬇

Concerned with regulation of some subconscious movements,

⬇

skilled activities such as writing the learnt alphabet, paper cutting, nail hammering, etc.

3. CONTROL OF REFLEX MUSCULAR ACTIVITY

Some reflex muscular activities, particularly **visual** and **labyrinthine reflexes** are important in maintaining the posture.

- ✓ Basal ganglia are responsible for the coordination and integration of impulses for these reflex activities.
- ✓ During lesion of basal ganglia, the postural movements, especially the visual and labyrinthine reflexes become abnormal.

4. CONTROL OF AUTOMATIC ASSOCIATED MOVEMENTS

Automatic associated movements are the movements in the body,

⬇

which take place along with some motor activities.

⬇

Examples - Swing of the arms while walking, appropriate facial expressions.

5. ROLE IN AROUSAL MECHANISM

Globus pallidus and red nucleus are

↓

involved in arousal mechanism

↓

because of their connections with reticular formation.

6. ROLE OF NEUROTRANSMITTERS IN THE FUNCTIONS OF BASAL GANGLIA

Functions of basal ganglia on motor activities

↓

are executed by some neurotransmitters

↓

released by nerve endings within basal ganglia.

↓

Examples - dopamine, acetylcholine, noradrenaline etc.

CHAPTER - 29

PHYSIOLOGY OF PAIN

- ✓ Pain is defined as an unpleasant and emotional experience associated with or without actual tissue damage.
- ✓ Pain sensation is described in many ways like sharp, pricking, electrical, dull ache, shooting, cutting, stabbing, etc.

COMPONENTS OF PAIN SENSATION

Pain sensation has two components:

1. Fast pain

2. Slow pain.

- ✓ Fast pain is the first sensation whenever a pain stimulus is applied.
- ✓ Fast pain is followed by the slow pain, which is experienced as a dull, diffused and unpleasant pain.
- ✓ Receptors for both the components of pain are same, i.e. the free nerve endings.
- ✓ But, afferent nerve fibers are different.
- ✓ Fast pain sensation is carried by Aδ fibers and slow pain sensation is carried by C type of nerve fibers.

PATHWAYS OF PAIN SENSATION

Pain sensation from various parts of body is carried to brain by different pathways which are:

1. Pathway from skin and deeper structures

2. Pathway from face

3. Pathway from viscera

4. Pathway from pelvic region.

1. FROM SKIN AND DEEPER STRUCTURES

Receptors

Free nerve endings (throughout the body).

First Order Neurons

First order neurons are the cells in posterior nerve root ganglia .

Fast pain fibers - Fast pain sensation is carried by Aδ type afferent fibers

⬇

Which synapse with neurons of **marginal nucleus** in the posterior gray horn.

Slow pain fibers - Slow pain sensation is carried by C type afferent fibers,

⬇

which synapse with neurons of **substantia gelatinosa**

⬇

in the posterior gray horn .

Second Order Neurons

- ✓ Neurons of marginal nucleus and substantia gelatinosa of Rolando form the second order neurons.
- ✓ Fibers from these neurons ascend in the form of the lateral spinothalamic tract.

Fast pain fibers - After taking origin,

⬇

fibers cross reach the lateral white column

⬇

form the neospinothalamic fibers in lateral spinothalamic tract.

⬇

These nerve fibers terminate in **ventral posterolateral nucleus** of thalamus.

Slow pain fibers - which arise from neurons of substantia gelatinosa,

⬇

cross the midline and run along fast pain fibers

⬇

as **paleospinothalamic fibers** in lateral spinothalamic tract.

⬇

terminate in ventral posterolateral nucleus of thalamus.

- ✓ **Remaining fibers terminate in areas: -** Nuclei of reticular formation in brainstem, Tectum of midbrain , Gray matter surrounding aqueduct of Sylvius.

Third Order Neurons

Third order neurons of pain pathway are the neurons in:

i. Thalamic nucleus

ii. Reticular formation

iii. Tectum

iv. Gray matter around aqueduct of Sylvius.

- ✓ Axons from these neurons reach the sensory area of cerebral cortex .
- ✓ Some fibers from reticular formation reach hypothalamus.

CENTER FOR PAIN SENSATION -

Post central gyrus of parietal cortex.

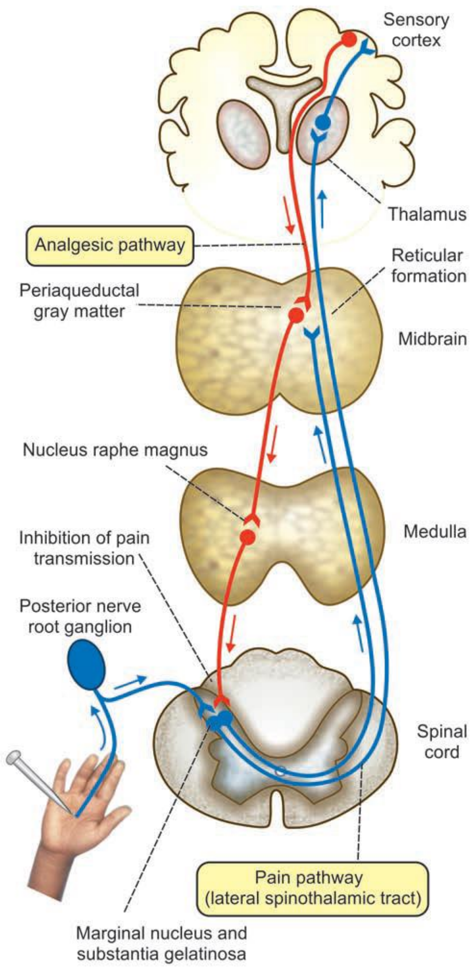
Fibers reaching hypothalamus are concerned with arousal mechanism (due to pain stimulus).

2. FROM FACE

Pain sensation from face is carried by trigeminal nerve.

3. FROM VISCERA

- ✓ Pain sensation from thoracic and abdominal viscera is transmitted by sympathetic (thoracolumbar) nerves.
- ✓ Pain from esophagus, trachea and pharynx is carried by vagus and glossopharyngeal nerves.



4. FROM PELVIC REGION -

Pain sensation from deeper structures of pelvic region is conveyed by sacral parasympathetic nerves.

❑ REFERRED PAIN

Referred pain is the pain that is perceived at a site adjacent to or away from the site of origin.

- ✓ Deep pain and some visceral pain are referred to other areas.
- ✓ But, superficial pain is not referred.

EXAMPLES - 1. Cardiac pain is felt at inner part of left arm and left shoulder.

2. Pain in ovary is referred to umbilicus and Pain in diaphragm is referred to shoulder

4. Pain in gallbladder is referred to epigastric region

CHAPTER - 30

HYPOTHALAMUS

- ✓ Hypothalamus is a diencephalic structure.
- ✓ It is situated just below thalamus in the ventral part of **diencephalon.**
- ✓ It is formed by groups of nuclei, scattered in the walls and floor of third ventricle.

FUNCTIONS OF HYPOTHALAMUS

- ✓ Hypothalamus is the important part of brain, concerned with **homeostasis of the body.**
- ✓ **It regulates many vital** functions of the body like endocrine functions, visceral

functions, metabolic activities, hunger, thirst, sleep, wakefulness, emotion, sexual functions, etc.

1. SECRETION OF POSTERIOR PITUITARY HORMONES

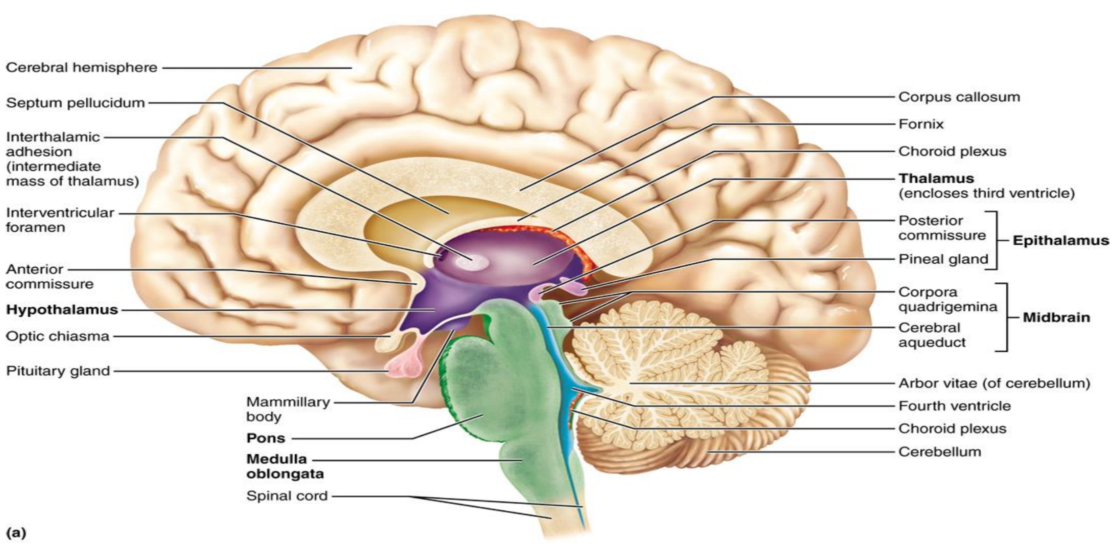
- ✓ Hypothalamus is the site of secretion for the posterior pituitary hormones.
- ✓ **Antidiuretic hormone (ADH) and oxytocin are secreted by supraoptic and paraventricular** nuclei.

↓

two hormones are transported by means of axonic or axoplasmic flow

↓

through the fibers of hypothalamohypophyseal tracts to posterior pituitary.



2. CONTROL OF ANTERIOR PITUITARY

Hypothalamus controls the secretions of anterior pituitary gland by secreting **releasing hormones and inhibitory hormones.**

- **It secretes seven hormones -**

i. Growth hormone-releasing hormone (GHRH)

ii. Growth hormone-releasing polypeptide (GHRP)

iii. Growth hormone-inhibiting hormone (GHIH) or somatostatin

iv. Thyrotropin-releasing hormone (TRH)

v. Corticotropin-releasing hormone (CRH)

vi. Gonadotropin-releasing hormone (GnRH)

vii. Prolactin-inhibiting hormone (PIH).

- ✓ These hormones are secreted by discrete areas of hypothalamus and transported to anterior pituitary by the **hypothalamohypophyseal portal blood vessels.**

3. CONTROL OF ADRENAL CORTEX

Anterior pituitary regulates adrenal cortex

⬇

by secreting **adrenocorticotropic hormone (ACTH).**

⬇

regulated by corticotropin-releasing hormone (CRH),

⬇

secreted by the paraventricular nucleus of hypothalamus

4. CONTROL OF ADRENAL MEDULLA

Dorsomedial and posterior hypothamic nuclei

⬇

excited by emotional stimuli.

- ✓ These hypothalamic nuclei, in turn, send impulses to adrenal medulla

⬇

through sympathetic fibers

⬇

cause release of **catecholamines,(essential)**

⬇

to cope up with emotional stress

5. REGULATION OF AUTONOMIC NERVOUS SYSTEM

- ✓ Hypothalamus controls autonomic nervous system (ANS).
- ✓ ANS divided – 1. Sympathetic division (regulated by posterior and lateral nuclei of hypothalamus).

  2. Parasympathetic division of ANS is controlled by anterior group of nuclei.

6. REGULATION OF HEART RATE

Hypothalamus regulates heart rate

⬇

through **vasomotor center (medulla oblongata).**

Posterior and lateral nuclei of hypothalamus on stimulation

⬇

increases heart rate.

- ❑ Stimulation of preoptic and anterior nuclei - decreases heart rate

7. REGULATION OF BLOOD PRESSURE

- ✓ Hypothalamus regulates the blood pressure by acting on the **vasomotor center.**
- ✓ **Stimulation of posterior and** lateral hypothalamic nuclei - increases arterial blood pressure.
- ✓ Stimulation of Preoptic area - decreases the blood pressure.

8. REGULATION OF BODY TEMPERATURE

Normal temp. - 37°C.

Two Centers which regulate the body temperature:

i. **Heat loss center that is present in preoptic** nucleus of anterior hypothalamus.

ii. **Heat gain center that is situated in posterior** hypothalamic nucleus.

9. REGULATION OF HUNGER AND FOOD INTAKE

Two centers present in hypothalamus: -

i. Feeding center - Situated - lateral hypothalamic nucleus.

ii. Satiety center - ventromedial nucleus of the hypothalamus.

10. REGULATION OF WATER BALANCE

Hypothalamus regulates water content of the body by two mechanisms:

i. Thirst mechanism – situated lateral nucleus of hypothalamus.

ii. Antidiuretic hormone (ADH) mechanism - supraoptic nucleus

11. REGULATION OF SLEEP AND WAKEFULNESS

- ✓ Mamillary body in the posterior hypothalamus is considered as the **wakefulness center.**
- ✓ Stimulation of anterior hypothalamus also leads to sleep.

12. ROLE IN BEHAVIOR AND EMOTIONAL CHANGES

Hypothalamus and limbic system act opposite to one another.

- ✓ Hypothalamus has two centers for behaviorial and emotional changes.

i. Reward center

ii. Punishment center.

Reward Center

- ✓ Situated in medial forebrain bundle and ventromedial nucleus of hypothalamus.
- ✓ Stimulation of these areas pleases or satisfies the animals.

Punishment Center

Situated in posterior and lateral nuclei of hypothalamus.

13. REGULATION OF SEXUAL FUNCTION

Hypothalamus plays an important role in maintaining the sexual functions, especially in females.

⬇

by secreting gonadotropin releasing hormones.

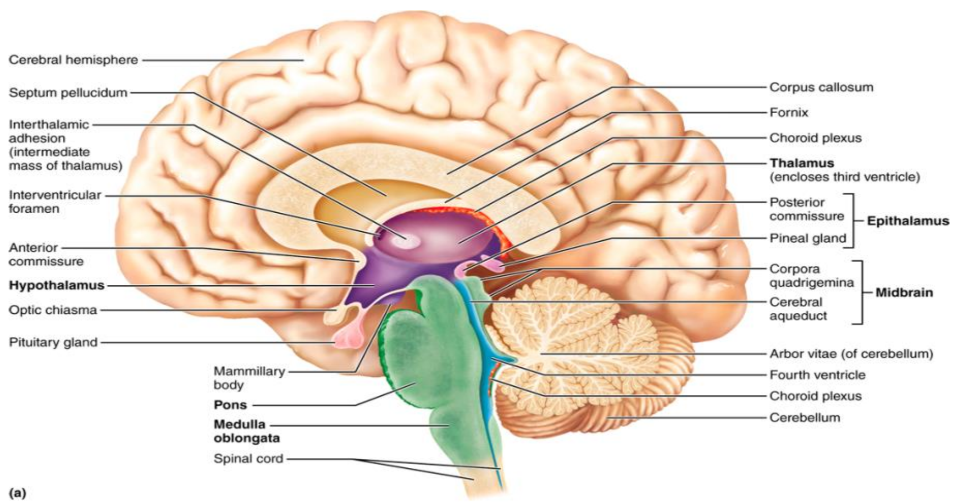
- ❑ Arcuate and posterior hypothalamic nuclei - regulation of sexual functions.

14. ROLE IN RESPONSE TO SMELL

- ✓ Posterior hypothalamus along with other structures like hippocampus and brainstem nuclei are responsible for the autonomic responses of body to olfactory stimuli.
- ✓ The responses include feeding activities and emotional responses like fear, excitement and pleasure.

❑ THALAMUS

- ✓ Thalamus is a large ovoid mass of gray matter
- ✓ Situated - bilaterally in **diencephalon.**
- ✓ **Both thalami form 80% of** diencephalon.
- ✓ Thalami on both sides are connected in their rostral portions by means of an **intermediate mass.**
- ✓ Caudal portions are more widely separated by corpora quadrigemina.



FUNCTIONS OF THALAMUS

- ❑ Thalamus is primarily concerned with **somatic functions**
- ❑ It plays little role in the visceral functions.
- ❑ 6Following are the various functions of thalamus:

1. RELAY CENTER

- ✓ Thalamus forms the relay center for the sensations.
- ✓ Impulses of almost all the sensations reach the thalamic nuclei, particularly in the ventral posterolateral nucleus.

↓ through thalamocortical fibers.

cerebral cortex

2. CENTER FOR PROCESSING OF SENSORY INFORMATION

- ✓ Major center for processing the sensory information.
- ✓ All the peripheral sensory impulses reaching thalamus are integrated and modified before being sent to specific areas of cerebral cortex. This process called of sensory information.

3. CENTER FOR DETERMINING QUALITY OF SENSATIONS

To determine the affective nature of sensations. Usually the sensations have two qualities:

i. Discriminative nature

ii. Affective nature.

i. **Discriminative Nature -**

Ability to recognize the type, location and other details of the sensations.

It is the function of cerebral cortex.

ii. Affective Nature -

Capacity to determine whether a sensation is pleasant or unpleasant and agreeable or disagreeable.

It is the function of thalamus.

4. CENTER FOR SEXUAL SENSATIONS

Thalamus forms the center for perception of sexual sensations.

5. ROLE IN AROUSAL AND ALERTNESS REACTIONS

Because of its connections with nuclei of reticular formation, thalamus plays an important role in arousal and alertness reactions.

6. CENTER FOR REFLEX ACTIVITY

The sensory fibers relay here, thalamus forms the center for many reflex activities.

7. CENTER FOR INTEGRATION OF MOTOR ACTIVITY

- ✓ Through the connections with cerebellum and basal ganglia.
- ✓ Thalamus serves as a center for integration of motor functions.

❑ CEREBELLUM

- ✓ Cerebellum consists of a narrow, worm-like central body called **vermis** and two lateral lobes, the right and left **cerebellar hemispheres.**
- ✓ The name cerebellum means " little brain".
- ✓ Most of the nerve cells in the brain are in the cerebellum.

PHYSIOLOGICAL OR FUNCTIONAL DIVISIONS

Cerebellum is divided into three divisions:

1. Vestibulocerebellum

2. Spinocerebellum

3. Corticocerebellum.

- ❑ **FUNCTION** –

1. **Control of body posture and equilibrium** –

The flocculonodular lobe is concerned with control of body posture and equilibrium.

2. Control of muscle tone and stretch reflexes –

The medial part of anterior lobe of cerebellum inhibits the muscle tone , where as the lateral parts of the anterior lobe facilitates the muscle tone.

3. Control of movements –

The cerebellum does not initiate movement , rather it coordinates movement that are initiated in the motor system.

4. Vision –

Cerebellum coordinates eye movements.

5. Other function –

Cerebellum has some role in thinking , including processing language and mood.

❑ CEREBRAL CORTEX

- ✓ **Cerebral cortex** is also called **pallidum** and it consists of two hemispheres.
- ✓ Both the **cerebral hemispheres** are separated by a deep **vertical fissure** (deep furrow or groove).

- ✓ The separation is complete anteriorly and posteriorly.

LOBES OF CEREBRAL CORTEX -

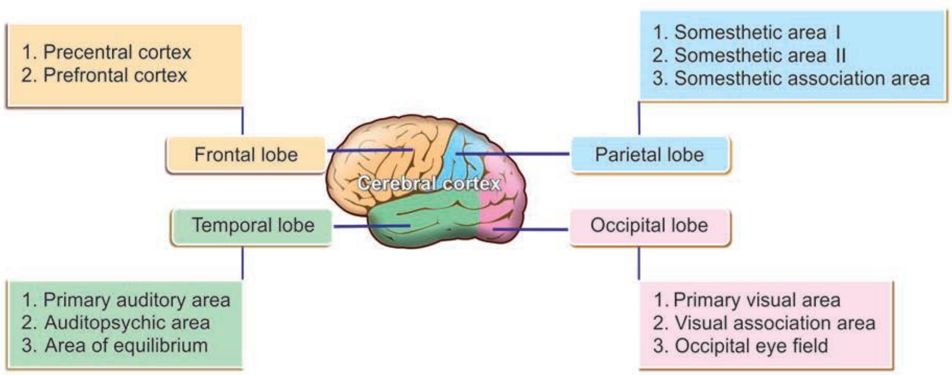
Four lobes :-

1. Frontal lobe

2. Parietal lobe

3. Occipital lobe

4. Temporal lobe.



FUNCTION :-

1. **Memory –** Cerebral cortex is involved in memory, including forming new memories and semantic memory.
2. **Thinking –** Cerebral cortex is responsible for thinking , learning, reasoning and problem sloving.
3. **Sensation –** Cerebral cortex processes sensory information, including pain, touch, pressure and temperature.
4. **Language –** Cerebral cortex is responsible for producing and understanding language.
5. **Movement –** Cerebral cortex controls voluntary movements.
6. **Emotions –** cerebral cortex is involved in regulating emotions.
7. **Consciousness –** It is responsible for consciousness.

❑ MID BRAIN

✓ Mid brain, also called mesencephalon, is a part of the central nervous system.
✓ It is located below cerebral cortex and at the top of brainstem.

There are 2 crainal nerves present in the midbrain.

1. Oculomotor nerve (cranial nerves III)
2. Trochlear nerve (cranial nerve IV)

FUNCTION –

✓ It is transmitting information necessary for vision and hearing.
✓ It also play an important role in motor movement, pain, and sleep /wake cycle.

❑ PONS

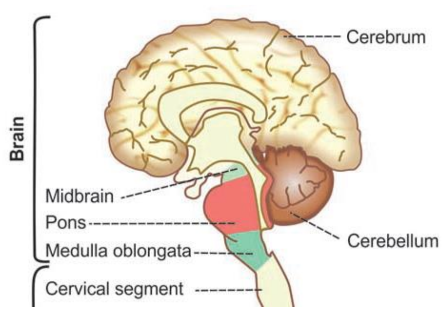
Pons is a part of brainstem, a structure that links the lowermost structures in brain, just above medulla oblongata.

FUNCTION –

1. It influnences sleep cycle – pons set your body level of alterness when you wake up.
2. It manage pain signals from anywhere in your body below your neck.
3. It also works coperatively with other parts of brainstem that manage your breathing.
4. Many cranial nerve involed in this –
   i. Trigeminal nerve (v) – provide the sense of touch an pain for face and control the muscle during chewing.
   ii. Abducens nerve (vi) – Control the eye movement.
   iii. Facial nerve (vii) – Control the facial expression and taste sensation of tongue.

   iv. Vestibulocochlear nerve (viii) – Cholear nerve gives sense of hearing.

5. It also contains several junction points for nerves that control muscles and carry information from sense in head and face.



❑ MEDULLA OBLONGATA

Medulla oblongata is a part of brainstem, which connects brain to spinal cord through the foramen magnum.

FUNCTION –

1. It Control the heart rate, breathing, blood pressure etc.
2. It manage other automatic processes. Eg. Coughing, sneezing , swallowing, vomiting.
3. In this involed many cranial nerve –

    Glossopharyngeal (IX) – control swallowing, taste, saliva production.
    Vagus nerve (X) – role in breathing , heart function, digestion.
    Accessory nerve (XI) – control the upper back and neck muscles.
    Hypoglossal nerve (XII) – control the tongue movement, speech and swallowing.

Chapter --31
SPEECH

- ✓ Speech is defined as the expression of thoughts by production of articulate sound, bearing a definite meaning.
- ✓ It is one of the highest functions of brain.
- ✓ When a sound is produced verbally, it is called the speech.
- ✓ If it is expressed by visual symbols, it is known as writing.
- ✓ If visual symbols or written words are expressed verbally, that becomes reading.

MECHANISM OF SPEECH

Speech depends upon coordinated activities of central speech apparatus and peripheral speech apparatus.

- ✓ **Central speech apparatus** - Consists of higher centers,
  i.e. the Cortical and subcortical centers.
- ✓ **Peripheral speech apparatus** - includes larynx or sound box, pharynx, mouth, nasal cavities, tongue and lips.

Peripheral speech apparatus function - in Coordination with respiratory system,

⬇

with the influences of motor impulses

⬇

from respective motor areas of cerebral cortex.

DEVELOPMENT OF SPEECH -

First Stage **-** The development of speech is the association of certain words with visual, tactile, auditory and other sensations.

⬇

aroused by objects in the external world.

⬇

Association of words with other sensations is stored as memory.

Second Stage –

- ✓ New neuronal circuits are established during the development of speech.

When a definite meaning has been attached to certain words,

⬇

pathway between the auditory area (Heschl area; area 41) and motor area

⬇

for the muscles of articulation,

⬇

which helps in speech (Broca area 44) is established.

Role of Cortical Areas in the Development of Speech

Development of speech involves integration of three important areas of cerebral cortex:

1. Wernicke area
2. Broca area
3. Motor area.

1. Role of Wernicke area – *(Speech understanding)*

Speech understanding of speech begins in Wernicke area

⬇

Situated in upper part of temporal lobe.

⬇

It sends fibers to Broca area

⬇

through a tract called arcuate fasciculus.

- ✓ Wernicke area is responsible for understanding the visual and auditory information

⬇

required for the production of words.

- ❑ After understanding the words, it sends the information to Broca area.

2. Role of Broca area – *(Speech synthesis)*

Speech is synthesized in the Broca area.

⬇

Situated adjacent to the motor area,

⬇

responsible for the movements of tongue, lips and larynx,

⬇

which are necessary for speech.

- ❑ Broca area develops the pattern of motor activities required to verbalize the words.
- ❑ The pattern of motor activities is sent to motor area.

3. Role of motor area – *Activation of peripheral speech apparatus.*

- ✓ By receiving the pattern of activities from Broca area,

⬇

Motor area activates peripheral speech apparatus.

⬇

Results in initiation of movements of tongue, lips and larynx required for speech.

NERVOUS CONTROL OF SPEECH

Speech is an integrated and a well-coordinated motor phenomenon.

⬇

Many parts of cortical and subcortical areas are involved in the mechanism of speech.

✓ Subcortical areas concerned with speech are controlled by cortical areas of dominant hemisphere. In about 95% of human beings, the left cerebral hemisphere is functionally dominant and those persons are right handed.

A. *Motor Areas*

1. ***Broca area*** – It is also called **speech center,** motor speech area or lower frontal area.

✓ It includes areas 44 and 45 (situated in lower part of lateral surface of prefrontal cortex).

✓ Broca area controls the movements of structures (tongue, lips and larynx) involved in vocalization.

2. Upper frontal motor area -

✓ It is situated in Paracentral gyrus over the medial surface of cerebral hemisphere.

✓ It controls the coordinated movements involved in writing.

B. *Sensory Areas*

1. *Secondary auditory area*

✓ Secondary auditory area includes area 22.

✓ It is situated in the superior temporal gyrus.

✓ It is concerned with the **interpretation of auditory sensation** and storage of memories of spoken words.

2. *Secondary visual area*

✓ Secondary visual area includes area 18.

✓ It is present in angular gyrus of the parietal cortex.

✓ This area is concerned with the **interpretation of visual sensation** and storage of memories of the visual symbols.

C. *Wernicke Area*

✓ Wernicke area is situated in the upper part of temporal lobe.

✓ This area is responsible for the **interpretation of auditory sensation.**

✓ It also plays an important role in speech.

- ✓ It is responsible for understanding the auditory information about any word and sending the information to Broca area.

Chapter - 32

HIGHER INTELLECTUAL FUNCTIONS

- ✓ Higher intellectual functions are very essential to make up the human mind.
- ✓ These functions are also called **higher brain functions** or **higher cortical functions.**

LEARNING -

Learning is defined as the process by which new information is acquired.

It alters the behavior of a person on the basis of past experience.

CLASSIFICATION OF LEARNING

Two types: -
1. Non-associative learning
2. Associative learning.

1. *Non-associative Learning*

Non-associative learning involves response of a person to only one type of stimulus.
It is based on two factors: -
i. Habituation
ii. Sensitization.

i. Habituation

Habituation means getting used to something, to which a person is constantly exposed. When a person is exposed to a stimulus repeatedly, he starts ignoring the stimulus slowly. Finally, the person is habituated to the event (stimulus) and ignores it.

ii. *Sensitization*

- ✓ Sensitization is a process by which the body is made to become more sensitive to a stimulus. It is called **amplification of response.**
- ✓ If the same stimulus is combined with another type of stimulus, which may be pleasant or unpleasant, the person becomes more sensitive to original stimulus.
- ✓ Sensitization increases the response to an innocuous stimulus when that stimulus is applied after another type of stimulus.

For example, a woman is sensitized to crying sound of her baby.

⬇

She get habituated to different sounds around her

⬇

Sleep is not disturbed by these sounds.

2. *Associative Learning*

- ✓ It is a complex process.
- ✓ It involves learning about relations between two or more stimuli at a time.

Example - Conditioned reflex.

❑ MEMORY

Memory is defined as the ability to recall past experience or information.

It is also defined as retention of learned materials.

There are various degrees of memory - for few seconds, last for hours, days, months or even years together.

ANATOMICAL BASIS OF MEMORY

- ✓ Anatomical basis of memory is the **synapse** in brain.
- ✓ Synapse for memory coding is slightly different from other synapses.

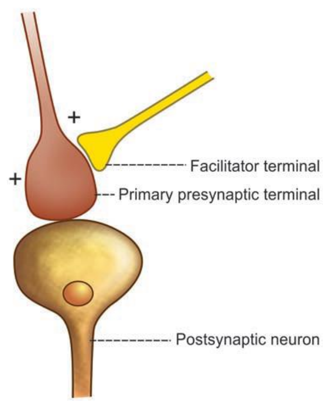


FIGURE : Synaptic terminal for memory encoding.

1st Case - When sensory terminal is stimulated alone without facilitator terminal,

⬇

firing from sensory terminal leads to habituation,

⬇

firing decreases slowly.

2nd Case -

If both the terminals are stimulated,

↓

facilitation occurs

↓

the signals remain strong for long period,

↓

for few months to few years.

PHYSIOLOGICAL BASIS OF MEMORY

- ✓ Memory is stored in brain by the alteration of synaptic transmission between the neurons involved in memory.
- ✓ Storage of memory may be facilitated or habituated depending upon many factors, such as neurotransmitter, synaptic transmission, functional status of brain, etc.

Facilitation -

- ✓ It is the process by which memory storage is enhanced.
- ✓ It involves increase in synaptic transmission and increased postsynaptic activity.
- ✓ It is referred as positive memory.
- ✓ Facilitation of memory is called **memory sensitization.**

Habituation -

- ✓ It is the process by which memory storage is **attenuated** (attenuation = decrease in strength, effect or value).
- ✓ It involves reduction in synaptic transmission and slow stoppage of postsynaptic activity.
- ✓ It is referred as **negative memory.**

Basis for Short-term Memory

- ✓ Basic mechanism of memory is the development of new neuronal circuits by the formation of new synapses and facilitation of synaptic transmission.
- ✓ Number of presynaptic terminals and size of the terminals are also increased.

Basis for Long-term Memory

- ✓ When neuronal circuit is reinforced by constant activity, memory is consolidated and encoded into different areas of the brain.
- ✓ This encoding makes memory a permanent or a long-term memory.

CONSOLIDATION OF MEMORY

The process by which a short-term memory is crystallized into a long-term memory is called memory consolidation.

- ✓ Consolidation causes permanent facilitation of synapses.

⬇

It is possible by rehearsal mechanism, i.e. rehearsal of same information again and again accelerates and potentiates the degree of transfer of short-term memory into long-term memory, Like - poem and phrase.

CLASSIFICATION OF MEMORY

1. Short-term Memories
2. Long-term Memories

1. *Short-term memory*

- ✓ It is the recalling events that happened very recently (within hours or days).
- ✓ It is also known as recent memory.

For example, telephone number that is known today may be remembered till tomorrow. But if it is not recalled repeatedly, it may be forgotten on the third day.

- ✓ Short-term memory may be interrupted by many factors such as- stress, trauma, drug abuse, etc.
- ✓ There is another form of short-term memory called **working memory.**

⬇

Recollection of past experience for a very short period, on the basis of which an action is executed.

2. *Long-term memory*

- ✓ Long-term memory is the recalling of events of weeks, months, years or sometimes lifetime.
- ✓ It is otherwise called the **remote memory.**

Examples are, recalling first day of schooling, birthday celebration of previous year etc. Physiologically, memory is classified into two types -

1. Explicit memory
2. Implicit memory

1. *Explicit memory*

- ✓ Explicit memory is defined as the memory that involves conscious recollection of past experience.
- ✓ It consists of memories regarding events, which occurred in external world around us.
- ✓ Explicit memory is otherwise known as **declarative memory** or **recognition memory.**

Examples - birthday party celebrated three days ago, breakfast, etc.

- Explicit memory involves hippocampus and medial part of temporal lobe.

2. ***Implicit memory***

- ✓ It is defined as the memory in which past experience is utilized without conscious awareness.
- ✓ It helps to perform various skilled activities properly.
- ✓ Implicit memory is otherwise known as **non-declarative memory** or **skilled memory.**

Examples - Cycling, driving, playing tennis, dancing, typing, etc.

- Implicit memory involves the sensory and motor pathways.

Memories Depending upon Durationt

Three types: -

1. Sensory memory
2. Primary memory
3. Secondary memory

1**.** ***Sensory memory***

- ➢ Sensory memory is the ability to retain sensory signals in sensory areas of brain, for a very short period of few seconds after the actual sensory experience, i.e. few hundred milliseconds.
- ➢ But, Signals are replaced by new sensory signals in less than 1 second.
- ➢ It is the initial stage of memory.
- ➢ It resembles working memory.

2. ***Primary memory***

- ✓ Primary memory is the memory of facts, words, numbers, letters or other information retained for few minutes at a time.
- ✓ The information is available for recall easily from memory store itself.
- ✓ This memory is easily replaced by new bits of memory.

3. ***Secondary memory***

- ✓ It is the storage of information in brain for a longer period.
- ✓ The information could be recalled after hours, days, months or years.
- ✓ It is also called **fixed memory** or **permanent memory.**
- ✓ It resembles long-term memory.

❑ CONDITIONED REFLEXES

Conditioned reflex is the acquired reflex that requires learning, memory and recall of previous experience.

- ✓ It is acquired after birth and it forms the basis of learning.
- ✓ Conditioned reflex is different from unconditioned reflex.

Unconditioned reflex is the inborn reflex, which does not need previous experience.

CLASSIFICATION OF CONDITIONED REFLEXES

Two types: -

A. Classical conditioned reflexes

B. Instrumental conditioned reflexes.

A. **CLASSICAL CONDITIONED REFLEXES**

Classical conditioned reflexes are those reflexes, which are established by a **conditioned stimulus,** followed by an **unconditioned stimulus.**

Method of Study – *Pavlov's Bell-Dog Experiments.*

TYPES AND PROPERTIES OF CLASSICAL CONDITIONED REFLEXES –

Into two groups according to the properties of reflexes -

I. Positive or excitatory conditioned reflexes

II. Negative conditioned reflexes

I. POSITIVE CONDITIONED REFLEXES (EXCITATION OF CONDITIONED REFLEXES)

3 TYPES -

1. Primary conditioned reflex
2. Secondary conditioned reflex
3. Tertiary conditioned reflex.

1. *Primary Conditioned Reflex*

- ✓ It is the reflex developed with one unconditioned stimulus and one conditioned stimulus.
- ✓ The animal is fed with food (unconditioned stimulus).
- ✓ Both the stimuli are repeated for some days.
- ✓ After the development of reflex, the flash of light (conditioned stimulus) alone causes salivary secretion without food (unconditioned stimulus).

2. *Secondary Conditioned Reflex*

The reflex is developed with one unconditioned stimulus and two conditioned stimuli.

For example - Animal is fed with food (unconditioned reflex) and simultaneously a flash of light **(first conditioned stimulus)** and a bell sound **(second conditioned stimulus)** are applied.

- After development of the reflex, bell sound (second conditioned stimulus) alone can cause salivary secretion.

3. *Tertiary Conditioned Reflex*

In this reflex, a **third conditioned stimulus** is added and the reflex is established.
The reflex with more than three conditioned stimuli is not possible.
Many types of conditioned stimuli associated with sight and hearing were employed by Pavlov.

II. NEGATIVE CONDITIONED REFLEXES (INHIBITION OF CONDITIONED REFLEXES)

Two types:-
1. External or indirect inhibition
2. Internal or direct inhibition.

1. *External or Indirect Inhibition*

- ✓ Established conditioned reflex is inhibited by some form of stimulus, which is quite different from the conditioned stimulus.
- ✓ It is not related to conditioned stimulus.

For example - Some disturbing factors like sudden entrance of a stranger, sudden noise or a strong smell can abolish the conditioned reflex and inhibit salivary secretion.

- ✓ If the extra (inhibitory) stimulus is repeated for some time, its inhibitory effect gets weakened or abolished.

2. *Internal or Direct Inhibition*

Four ways in which the established conditioned reflex is abolished by direct or internal factors, which are related to the conditioned stimulus.

i. Extinction of conditioned reflex
ii. Conditioned inhibition
iii. Inhibition by delay or delayed conditioned reflex
iv. Differential inhibition

i***. Extinction of conditioned reflex -***

- ✓ Extinction is the failure of conditioned reflex.
- ✓ It occurs if an established conditioned reflex is not reinforced by unconditioned stimulus.
- ❑ If a Conditioned stimulus is given repeatedly several times, without reinforcing it by unconditioned stimulus, there is failure of conditioned reflex.

ii. ***Conditioned inhibition***

- ✓ Conditioned inhibition is the failure of conditioned reflex due to introduction of an unknown (new) conditioned stimulus.
- ✓ Two conditioned stimuli are given with unconditioned stimulus (food) repeatedly, the secondary conditioned reflex is developed.

iii. ***Inhibition by delay or delayed conditioned reflex -***

The absence of response or delayed response that occurs while eliciting a conditioned reflex by
delaying the unconditioned stimulus.

- ✓ Conditioned stimulus (light or sound) must be followed by unconditioned stimulus (food) immediately.

⬇

If unconditioned stimulus is applied after a long period, response may be absent or delayed. The reflex is called delayed conditioned reflex.

iv. ***Differential inhibition -***

- ✓ The failure of conditioned reflex that occurs when the conditioned stimulus is altered.
- ✓ The alteration in frequency of sound or intensity of light abolishes the conditioned reflex.

- ❑ **INSTRUMENTAL OR OPERANT CONDITIONED REFLEXES**
- ✓ Those reflexes in which the behavior of the person is instrumental.
- ✓ This type of reflexes is developed by the conditioned stimulus, followed by a reward or punishment. Also called **operant conditioned reflexes** or **Skinner conditioning.**

Several types such as:-

1. Conditioned avoidance reflex
2. Food avoidance reflex
3. Conditioned reward reflex.

Chapter - 33

AUTONOMIC NERVOUS SYSTEM (ANS)

- ✓ Primarily concerned with regulation of visceral or vegetative functions of the body.
- ✓ It is also called **vegetative** or **involuntary nervous system.**

DIVISIONS OF ANS

ANS is divided into two divisions:

1. Sympathetic division
2. Parasympathetic division.

1. SYMPATHETIC DIVISION

- ✓ Also called **thoraco lumbar outflow because, preganglionic neurons are** situated in lateral gray horns of 12 thoracic and first two lumbar segments of spinal cord.
- ✓ Fibers arising from here are known as preganglionic fibers.
- ✓ Preganglionic terminate in postganglionic neurons - situated in the sympathetic ganglia.
- ✓ Sympathetic division supplies smooth muscle fibers of all the visceral organs.

SYMPATHETIC GANGLIA

Ganglia of sympathetic division are classified into three groups:

A. Paravertebral or sympathetic chain ganglia

B. Prevertebral or collateral ganglia

C. Terminal or peripheral ganglia

A. *Paravertebral or Sympathetic Chain Ganglia*

- ✓ Arranged in a segmental fashion along the anterolateral surface of vertebral column.
- ✓ Ganglia on either side of the spinal cord are connected with each other by longitudinal fibers, to form the **sympathetic chains.**
- ✓ Ganglia of the sympathetic chain (trunk) on each side are divided into four groups:

1. Cervical ganglia : 8 in number
2. Thoracic ganglia : 12 in number
3. Lumbar ganglia : 5 in number
4. Sacral ganglia : 5 in number.

1. *Cervical ganglia*

Eight cervical ganglia are arranged in three groups:

i. ***Superior cervical ganglion:*** *It is formed by* fusion of upper four cervical ganglia. It is the largest ganglion of ANS.

ii. *Middle cervical ganglion:* *It is formed by fifth* and sixth cervical ganglia

iii. *Inferior cervical ganglion* *: This ganglion is* formed by the fusion of seventh and eighth cervical ganglia.

2. *Thoracic ganglia*

- ✓ There are 12 thoracic ganglia on each side and these ganglia are evenly spaced.
- ✓ Thoracic ganglia receive preganglionic fibers from the thoracic segments of spinal cord.
- ✓ Postganglionic fibers from thoracic ganglia are distributed to **visceral organs in the thorax and abdomen.**

3. *Lumbar ganglia*

- ✓ There are 5 lumbar ganglia.
- ✓ Preganglionic fibers for these ganglia arise from first and second lumbar spinal segments (L1 and L2) and reach the lumbar ganglia.
- ✓ From here, the fibers extend down to sacral ganglia.
- ✓ Postganglionic fibers from these ganglia supply the abdominal and **pelvic organs.**

4. *Sacral ganglia*

- ✓ There are 5 sacral ganglia, which receive the preganglionic fibers from L1 and L2 segments.
- ✓ Postganglionic fibers from sacral ganglia innervate the **blood vessels** and **sweat glands in the lower limb.**

B. *Prevertebral or Collateral Ganglia*

Situated in thorax, abdomen and pelvis, in relation to aorta and its branches.

Prevertebral ganglia are: -

1. Celiac ganglion
2. Superior mesenteric ganglion
3. Inferior mesenteric ganglion.

- ✓ Prevertebral ganglia receive preganglionic fibers from T5 to L2 segments.
- ✓ Postganglionic fibers from these ganglia supply visceral organs of thorax, abdomen and pelvis.

C. *Terminal or Peripheral Ganglia*

- ✓ Situated within or close to structures innervated by them.
- ✓ Heart, bronchi, pancreas and urinary bladder are innervated by the terminal ganglia.

2. PARASYMPATHETIC DIVISION

Parasympathetic division of ANS is otherwise called the **craniosacral outflow because, the fibers of this division** arise from brain and sacral segments of spinal cord.

CRANIAL OUTFLOW OR CRANIAL PORTION OF PARASYMPATHETIC DIVISION

It arises from brainstem.

Cranial outflow includes the following cranial nerves:

1. Oculomotor (III) nerve
2. Facial (VII) nerve
3. Glossopharyngeal (IX) nerve
4. Vagus (X) nerve.

Preganglionic fibers of these cranial nerves arise from neurons situated at two different levels:

1. Tectal or midbrain outflow (III cranial nerve)
2. Bulbar level or bulbar outflow (VII, IX and X cranial nerves).

- ✓ Preganglionic fibers are longer and reach the postganglionic neurons - Situated within the organs
- ✓ Preganglionic fibers are myelinated, but the postganglionic fibers are non-myelinated.

1. *Tectal or Midbrain Outflow*

Group of cells forming **Edinger-Westphal nucleus of** III cranial nerve gives rise to tectal fibers.

Fibers from this nucleus end in Ciliary ganglion.

Postganglionic fibers from here supply the sphincter pupillae and Ciliary muscle.

2. *Bulbar Level or Bulbar Outflow*

- ✓ Preganglionic fibers are the fibers of VII, IX and X cranial nerves,
- ✓ Which arise from the nuclei present in the medulla oblongata.
- ❑ Fibers of VII cranial nerve supply the lacrimal, nasal, submaxillary and sublingual glands.
- ❑ Fibers of IX cranial nerve supply the parotid gland
- ❑ Fibers of X cranial nerve supply visceral organs of the body.

SACRAL OUTFLOW OR SACRAL PORTION OF PARASYMPATHETIC DIVISION

- ✓ Sacral outflow or sacral portion of parasympathetic division arises from the sacral segments of spinal cord.
- ✓ Preganglionic fibers arise from anterior gray horn cells of 2nd, 3rd and 4th (from 1st also in some cases) sacral segments of spinal cord and form the pelvic nerve.
- ✓ Fibers end on postganglionic neurons, which are situated on or near the visceral organs.
- ✓ Sacral parasympathetic fibers supply those visceral organs which are not supplied by vagus.

FUNCTIONS OF ANS

- ✓ Autonomic nervous system is concerned with the regulation of functions, which are beyond voluntary control.
- ✓ By controlling the various vegetative functions,
- ✓ ANS plays an important role in maintaining constant internal environment (homeostasis).
- ✓ Almost all the visceral organs are supplied by both sympathetic and parasympathetic divisions of ANS.

NEUROTRANSMITTERS OF ANS SYMPATHETIC FIBERS

1. *Preganglionic fibers: Acetylcholine (Ach)*
2. *Postganglionic noradrenergic fibers: Noradrenaline*
3. *Postganglionic cholinergic fibers: Acetylcholine (Ach)*

PARASYMPATHETIC FIBERS

1. Preganglionic fibers: *Acetylcholine (Ach)*
2. Postganglionic fibers: *Acetylcholine (Ach)*

Chapter – 34

CRANIAL NERVES

- ✓ Cranial nerves are 12 pairs of nerves that arise directly from the brain(including brain stem).
- ✓ Numbering of cranial nerve is based on the order in which they emerge from the brain, from front to back.
- ✓ First two cranial nerves arise from cerebrum, remaining 10 arise from brainstem.
- ✓ Cranial nerves connect muscles and sense organs of head, neck, thorax and abdomen region directly to brain.

Cranial Nerve	Mnemonic
I – Olfactory Nerve	Oh
II – Optic Nerve	Oh
III – Oculomotor Nerve	Oh
IV – Trochlear Nerve	To
V – Trigeminal Nerve	Touch
VI – Abducens Nerve	And
VII – Facial Nerve	Feel
VIII – Vestibulocochlear Nerve	Very
IX – Glossopharyngeal Nerve	Good
X – Vagus Nerve	Velvet
XI - Accessory Nerve	Ah
XII – Hypoglossal Nerve	Heaven

Types of cranial nerve –

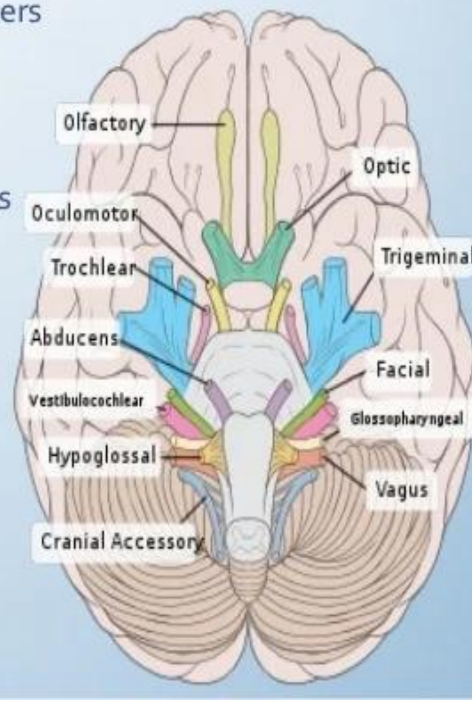
1. Sensory (Afferent) nerve – carry information from periphery to brain.
2. Motor (Afferent) nerve – carry information from brain to pheriphery.
3. Mixed nerves – they do both

Classification of cranial nerves

SENSORY CRANIAL NERVES: Afferent fibers
IOlfactory nerve
IIOptic nerve
VIII Vestibulocochlear nerve

MOTOR CRANIAL NERVES: Efferent fibers
III Oculomotor nerve
IV Trochlear nerve
VIAbducent nerve
XI Accessory nerv
XII Hypoglossal nerve

MIXED NERVES: Both fibers
VTrigeminal nerve,
VII Facial nerve,
IXGlossopharyngeal nerve
XVagus nerve



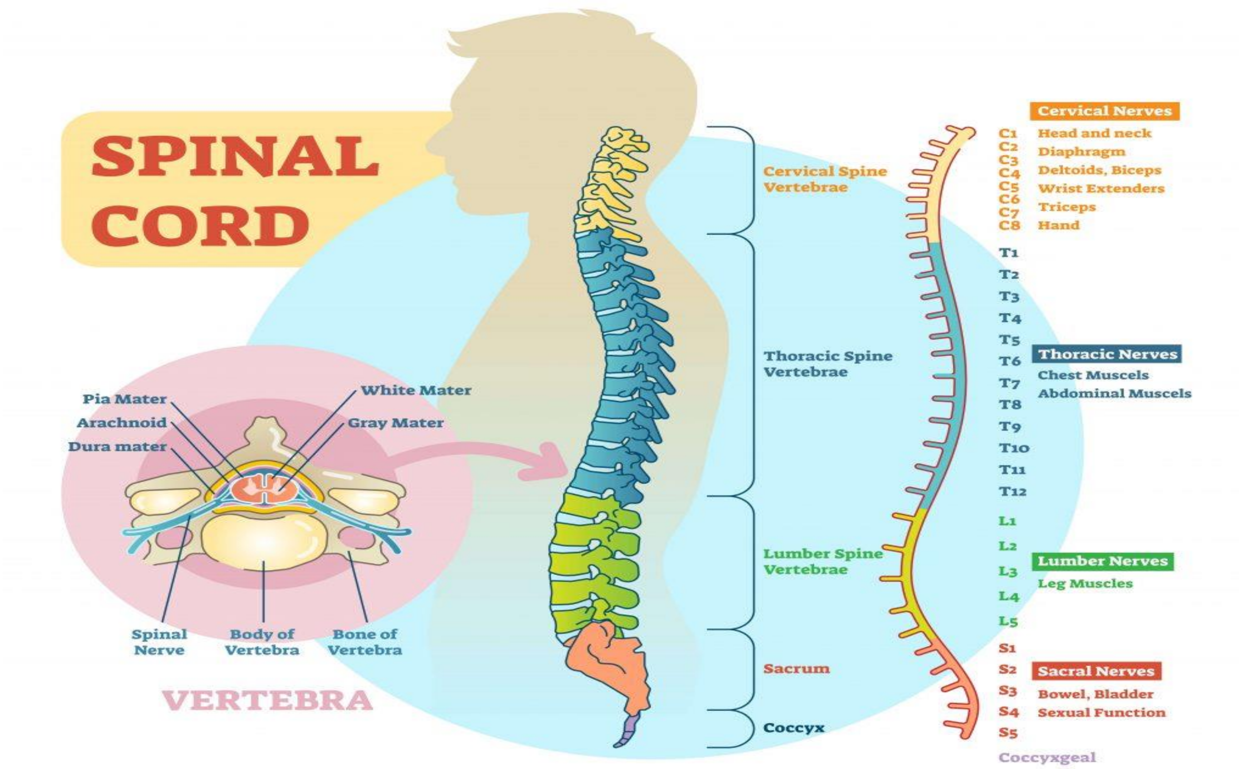
Cranial nerves	Nerve type	Functions
I. Olfactory nerve	Sensory	Sense of Smell
II. Optic nerve	Sensory	Vision
III. Oculomotor nerve	motor	Control muscles of the eye except superior oblique muscles and lateral rectus muscles
IV. Trochlear nerve	motor	Control superior oblique muscles so ability of eye to look down and inwards
V. Trigeminal nerve	Both	Provides sensation to face and controls the muscles for chewing
VI. Abducens nerve	motor	Controls lateral rectus muscles so ability to look outwards
VII. Facial nerve	Both	Controls muscles of facial expressions (except chewing muscles), taste, lacrimal glands and salivary glands
VIII. Vestibulocochlear nerve	Sensory	Hearing and balance

IX. Glossopharyngeal nerve	Both	Serves pharynx for swallowing (gag reflex), (taste)posterior third of tongue, tonsils, middle ear.
X. Vagus nerve	Both	Sensation to outer part of ear, throat, heart, abdominal organs, taste sensation Control movement of the throat and soft palate. Regulates heart rhythm, smooth muscles of airways, lungs and GIT.
XI. Accessory nerve	motor	Control muscles that move head, neck and shoulder
XII. Hypoglossal nerve	motor	Control tongue muscles

Chapter – 35
SPINAL CORD

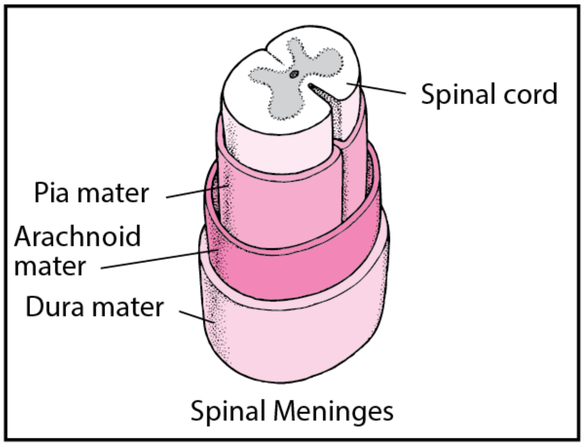
Situation –

- ✓ Spinal cord lies loosely in the **vertebral canal.**
- ✓ It extends from **foramen magnum** where it is continuous with medulla oblongata, above and up to the lower border of first lumbar vertebra below.



COVERINGS -

- ✓ Spinal cord is covered by sheaths called **meninges,** Meninges are **dura mater, pia mater** and **arachnoid mater.**
- ✓ These coverings continue as coverings of brain.
- ✓ Meninges are responsible for protection and nourishment of the nervous tissues.



Enlargements –

Spinal cord has two spindle-shaped swellings, namely **cervical** and **lumbar enlargements.**

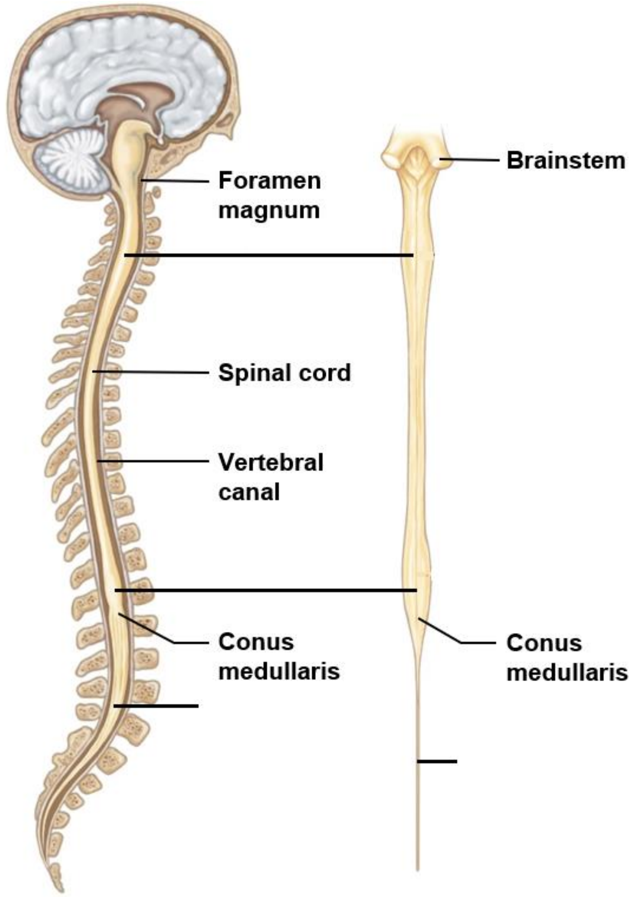
Conus Medullaris and Filum Terminale –

- ✓ Below the lumbar enlargement, spinal cord rapidly narrows to a cone-shaped termination called **conus medullaris.**
- ✓ A slender non-nervous filament called **filum Terminale.**

Segments –

- ✓ Spinal cord is made up of 31 segments.

Appearance of the segment is by nerves arising from spinal cord, which are called spinal nerve.



Spinal Nerves

Segments of spinal cord correspond to 31 pairs of spinal nerves in a symmetrical manner.

Spinal segments/Spinal nerves			
1.	Cervical segments/Cervical spinal nerves	=	8
2.	Thoracic segments/Thoracic spinal nerves	=	12
3.	Lumbar segments/Lumbar spinal nerves	=	5
4.	Sacral segments/Sacral spinal nerves	=	5
5.	Coccygeal segment/Coccygeal spinal nerves	=	1
	Total	=	31

GRAY MATTER OF SPINAL CORD

- ✓ It is the collection of nerve cell bodies, dendrites and parts of axons.
- ✓ It is placed centrally in the form of **wings of the butterfly** and it resembles the letter ‘H’.
- ✓ Exactly in the center of gray matter, there is a canal called the **spinal canal.**
- ❑ Ventral and the dorsal portions of each lateral half of gray matter are called ventral (anterior) and dorsal (posterior) gray horns respectively.
- ❑ Part of the gray matter anterior to central canal is called the **anterior gray commissure**
- ❑ Part of gray matter posterior to the central canal is called **posterior gray commissure.**

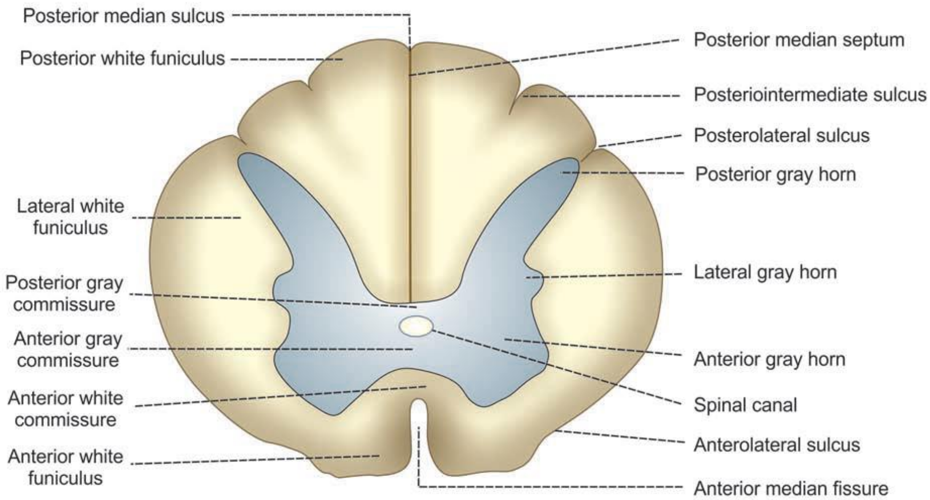


FIGURE : Section of spinal cord: thoracic segment

Neurons in Gray Matter of Spinal Cord

Gray matter contains two types of multipolar neurons:

1. *Golgi type I neurons*

- Golgi type I neurons have **long axons** and are usually found in anterior horns.
- Axons of these neurons form the long tracts of spinal cord.

2. Golgi type II neurons

- Golgi type II neurons have **short axons,** found in posterior horns.
- Axons of these neurons pass towards the anterior horn of same side or opposite side.

Nuclei in Anterior Gray Horn –Organization of Neurons in Gray Matter

Organization of neurons in the gray matter of spinal cord is described in two methods: -

1. Nuclei or columns
2. Laminae or layers

NUCLEI

Clusters of neurons are present in the form of nuclei or cell columns in gray matter.

Nuclei in Posterior Gray Horn –

1. *Marginal nucleus*
2. *Substantia gelatinosa of Rolando*
3. *Chief sensory nucleus or nucleus proprius*
4. 4. *Dorsal nucleus of Clarke*

Nuclei in Lateral Gray Horn –

1. *Alpha motor neurons*
2. *Gamma motor neurons*
3. *Renshaw cells*

LAMINAE

- Neurons of gray matter are distributed in laminae or layers.
- Each lamina consists of neurons of different size and shape.

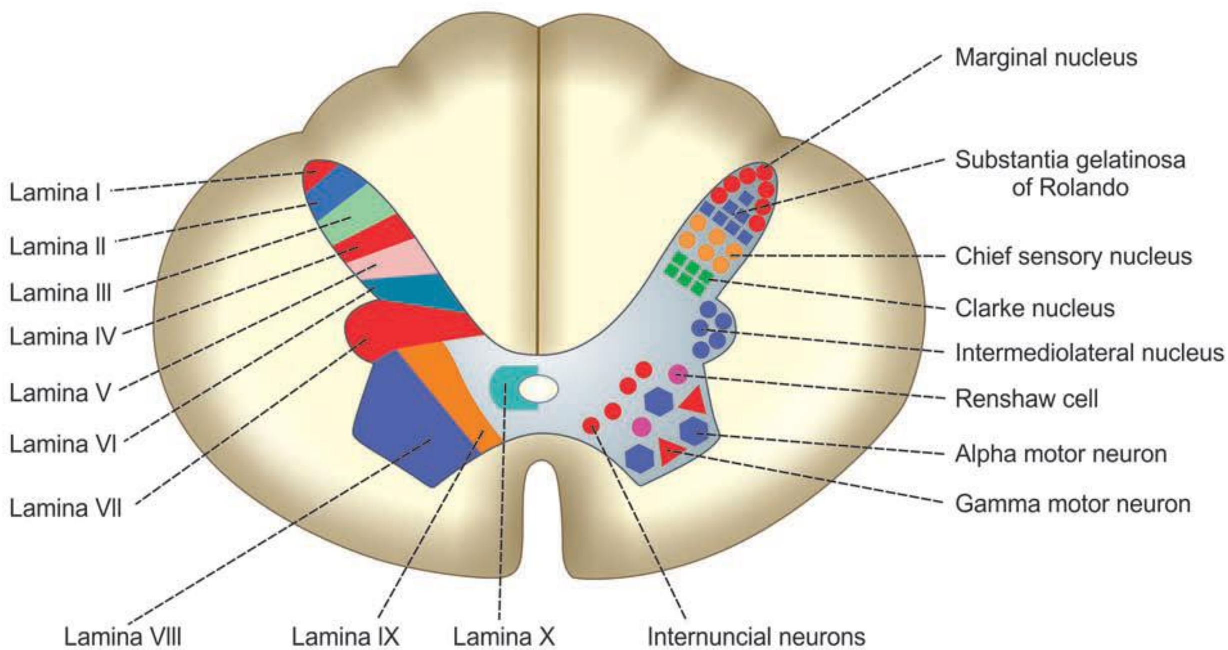


FIGURE : Neurons in gray horn of spinal cord : thoracic segment

WHITE MATTER OF SPINAL CORD

- White matter of spinal cord surrounds the gray matter.
- It is formed by the bundles of both **myelinated and nonmyelinated fibers**.
- Anterior median fissure and posterior median septum divide the entire mass of white matter into two lateral halves.

I. The band of white matter lying in front of anterior gray commissure is called **anterior white commissure.**

II. Each half of the white matter is divided by the fibers of anterior and posterior nerve roots into three white columns or funiculi: - I. *Anterior or Ventral White Column*
II. *Lateral White Column*
III. *Posterior or Dorsal White Column*

TRACTS IN SPINAL CORD

Groups of nerve fibers passing through spinal cord are known as tracts of the spinal cord. The spinal tracts are divided into two main groups.

1. Short tracts
2. Long tracts.

1. *Short Tracts*

Fibers of the short tracts connect different parts of spinal cord itself.

Short tracts are of two types: -

i. **Association or intrinsic tracts -** which connect adjacent segments of spinal cord on the same side

ii. **Commissural tracts -** which connect opposite halves of same segment of spinal cord.

2. *Long Tracts*

Long tracts of spinal cord, which are also called **projection tracts,** connect the spinal cord with other parts of central nervous system.

Long tracts are of two types: -

i. Ascending tracts - Which carry sensory impulses from the spinal cord to brain

ii. Descending tracts - Which carry motor impulses from brain to the spinal cord.

ASCENDING TRACTS OF SPINAL CORD

It is carry the impulses of various sensations to the brain.

Three groups of neurons -

1. First order neurons
2. Second order neurons
3. Third order neurons.

1. First Order Neurons

- ✓ It receive sensory impulses from the receptors and send them to sensory neurons present in the posterior gray horn of spinal cord through their fibers.
- ✓ Nerve cell bodies of these neurons are located in **posterior nerve root ganglion.**

2. Second Order Neurons

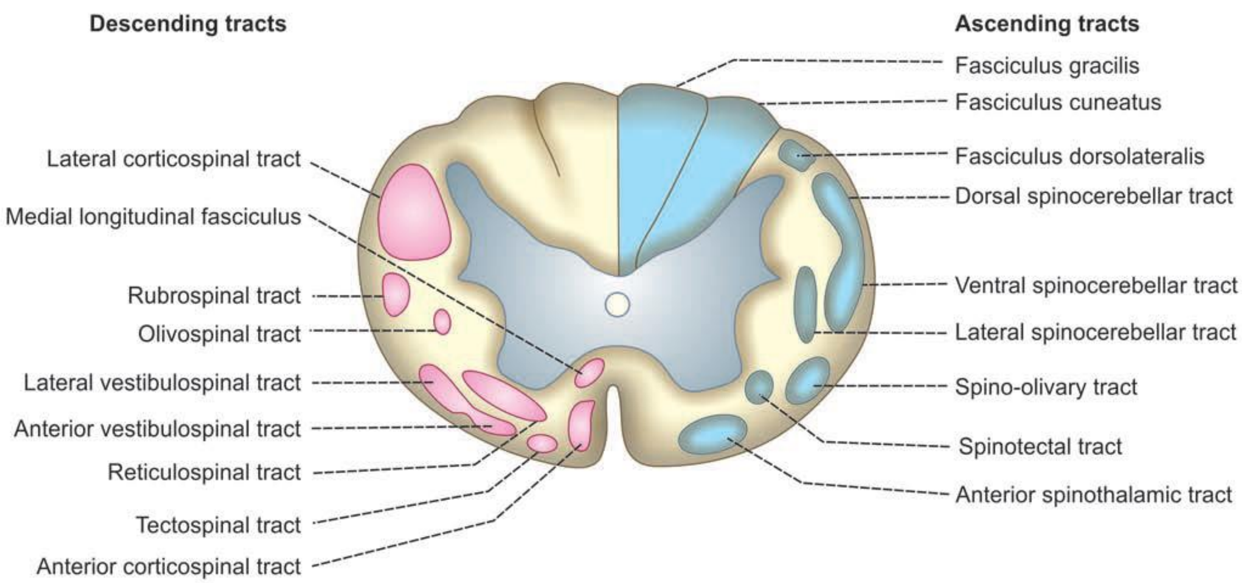
- ✓ Sensory neurons present in the posterior gray horn.
- ✓ These fibers carry sensory impulses from spinal cord to different brain areas below cerebral cortex **(subcortical areas)** such as thalamus.
- ✓ Ascending tracts in the posterior white funiculus, Formed by the fibers of first order neurons.

3. Third Order Neurons

- ✓ Third order neurons are in the **subcortical areas.**
- ✓ Fibers of these neurons carry the sensory impulses from subcortical areas to cerebral cortex.

ASCENDING TRACTS OF SPINAL CORD -

White column	Tract
Anterior white column	1. Anterior spinothalamic tract
Lateral white column	1. Lateral spinothalamic tract 2. Ventral spinocerebellar tract 3. Dorsal spinocerebellar tract 4. Spinotectal tract 5. Fasiculus dorsolateralis 6. Spinoreticular tract 7. Spino-olivary tract 8. Spinovestibular tract
Posterior white column	1. Fasciculus gracilis 2. Fasciculus cuneatus 3. Comma tract of Schultze



DESCENDING TRACTS OF SPINAL CORD

Descending tracts of the spinal cord are formed by motor nerve fibers arising from brain and descend into spinal cord.

These tracts carry motor impulses from brain to spinal cord.

Two types: -

A. Pyramidal tracts

B. Extrapyramidal tracts.

Descending tracts of spinal cord

Type	Tract
Pyramidal tracts	1. Anterior corticospinal tract 2. Lateral corticospinal tract
Extrapyramidal tracts	1. Medial longitudinal fasciculus 2. Anterior vestibulospinal tract 3. Lateral vestibulospinal tract 4. Reticulospinal tract 5. Tectospinal tract 6. Rubrospinal tract 7. Olivospinal tract

PYRAMIDAL TRACTS

- ✓ Pyramidal tracts were the first tracts to be found in man.
- ✓ It concerned with voluntary motor activities of the body.
- ✓ Also known as **Corticospinal tracts.**

EXTRAPYRAMIDAL TRACTS

Descending tracts of spinal cord other than pyramidal tracts are called extrapyramidal tracts.

FUNCTION OF SPINAL CORD –

- ✓ Forms a connecting link between the brain and and PNS.
- ✓ Provides structural supports and builds a body posture.
- ✓ Facilitates flexible movements.
- ✓ Myelin present in the white matter acts as a electrical insulation.
- ✓ Communicates message from the brain to different parts of the body.
- ✓ Coordinates reflexes
- ✓ Receives sensory information from receptors and approaches towards the brain for processing.