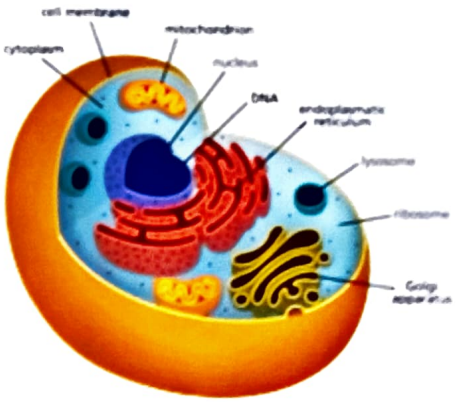
CELLULAR LEVEL OF ORGANIZATION

Points to be covered in this topic

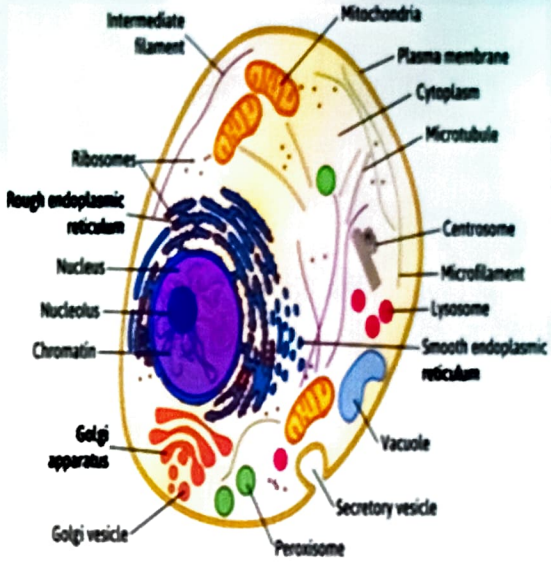
1. STRUCTURE AND FUNCTIONS OF CELL
2. TRANSPORT ACROSS CELL MEMBRANE
3. CELL DIVISION
4. CELL JUNCTION



5. GENERAL PRINCIPLES OF CELL COMMUNICATION
   - (a) Contact-dependent
   - (b) Paracrine
   - (c) Synaptic
   - (d) Endocrine

STRUCTURE AND FUNCTIONS OF CELL

❑ INTRODUCTION



- All the **living things** are composed of **cells**.
- A single cell is the **smallest** unit that has all the characteristics of life.
- Cell is defined as the **structural** and **functional** unit of the 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 bacteria or **toxic** substances into the body
6. Reproduces by **division**. There are some exceptions like neuron, which do not reproduce

Cells
↓
Tissues
↓
Organs
↓
Organ systems
↓
Living organism

❖ Structure and their Functions of Cell

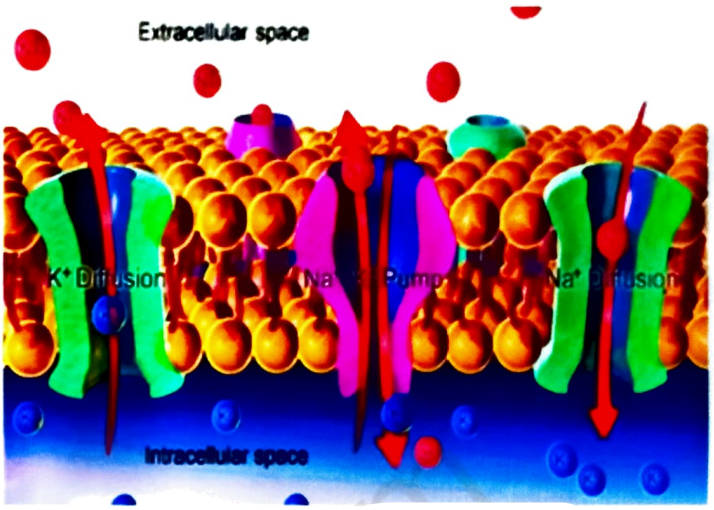
S. NO.	Organelles	Functions
1.	Rough endoplasmic reticulum	1. Synthesis of proteins 2. Degradation of worn out organelles
2.	Smooth endoplasmic reticulum	1. Synthesis of lipids and steroids 2. Role in cellular metabolism 3. Storage and metabolism of calcium 4. Catabolism and detoxification of toxic substances

S. NO.	Organelles	Functions
3.	Golgi apparatus	1. Processing, packaging, labeling and delivery of proteins and lipids
4.	Lysosomes	1. Degradation of macromolecules 2. Degradation of worn out organelles 3. Removal of excess of secretory products 4. Secretion of perforin, granzymes, melanin and serotonin
5.	Peroxisomes	1. Breakdown of excess fatty acids 2. Detoxification of hydrogen peroxide and other metabolic products 3. Oxygen utilization 4. Acceleration of gluconeogenesis 5. Degradation of purine to uric acid 6. Role in the formation of myelin 7. Role in the formation of bile acids
6.	Centrosome	1. Movement of chromosomes during cell division
7.	Mitochondria	1. Production of energy 2. Synthesis of ATP 3. Initiation of apoptosis
8.	Ribosomes	1. Synthesis of proteins
9.	Cytoskeleton	1. Determination of shape of the cell 2. Stability of cell shape 3. Cellular movements
10.	Nucleus	1. Control of all activities of the cell 2. Synthesis of RNA 3. Sending genetic instruction to cytoplasm for protein synthesis 4. Formation of subunits of ribosomes 5. Control of cell division 6. Storage of hereditary information in genes

TRANSPORT ACROSS CELL MEMBRANE

❑ INTRODUCTION

- All the cells in the body must be supplied with **essential substances** like nutrients, water, electrolytes, etc.
- Cells also transport many **unwanted substances** like waste materials, carbon dioxide, etc.
- The cells achieve these by means of **transport mechanisms** across the cell membrane.



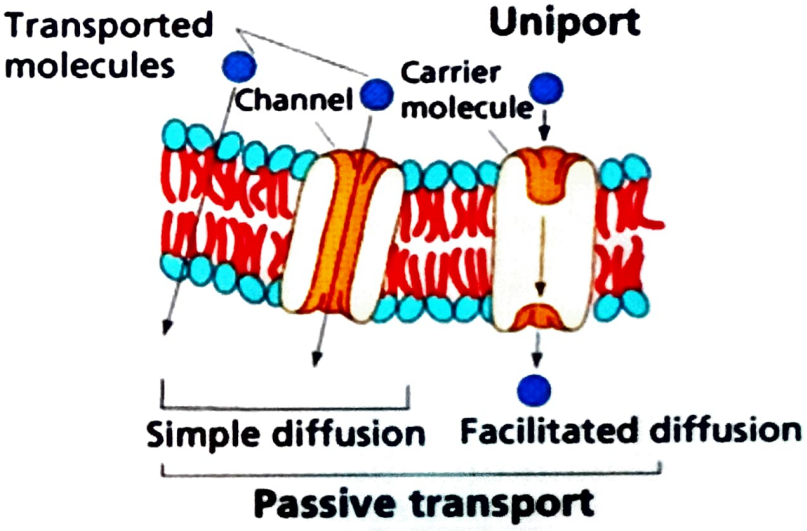
❖ Basic Mechanism of Transport

Two types of basic mechanisms are involved in the transport of substances across the cell membrane:

- ✓ **Passive transport mechanism**
- ✓ **Active transport mechanism**

✓ Passive transport mechanism

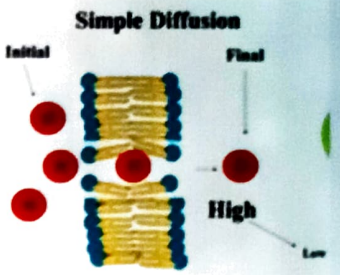
- Passive transport is the transport of substances along the **concentration gradient** or **electrical gradient** or both (electrochemical gradient).
- It is also known as **diffusion** or **downhill movement**. It does not need **energy**.
- The substances move from region of **higher** concentration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

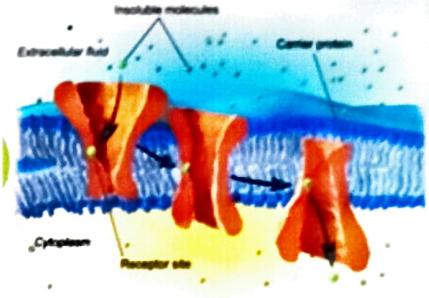


Types of Passive transport mechanism

Diffusion is of **two** types,

Simple diffusion	Facilitated diffusion
It occurs either through lipid layer or protein layer of the cell membrane.	It occurs with the help of the carrier proteins of the cell membrane.





Facilitated Diffusion

SPECIAL TYPES OF PASSIVE TRANSPORT

1. Bulk flow 2. Filtration 3. Osmosis

1. Bulk flow

- It is the **diffusion** of large quantity of substances from a region of high pressure to the region of low pressure.
- It is due to the pressure gradient of the substance across the cell membrane.

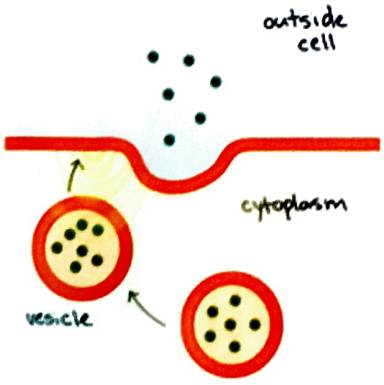
2. Filtration

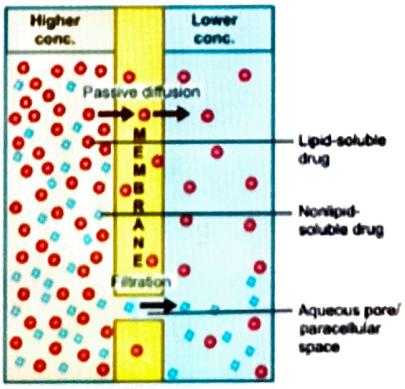
- Movement of water and solutes from an area of high hydrostatic pressure to an area of low hydrostatic pressure is called filtration.

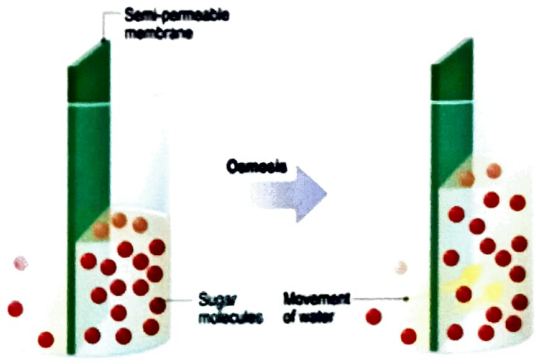
3. Osmosis

- 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.**

OSMOSIS



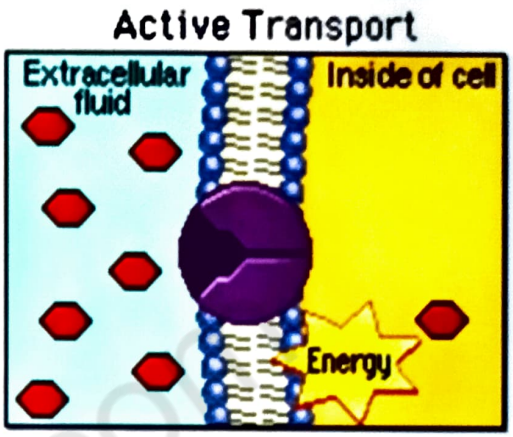




✓ Active transport mechanism

- It is the movement of substances against the **chemical** or requires **energy**, which is obtained mainly by breakdown **electrical** or **electrochemical gradient.**
- It requires **energy**, which is obtained mainly by breakdown of high energy compounds like adenosine triphosphate **(ATP).**

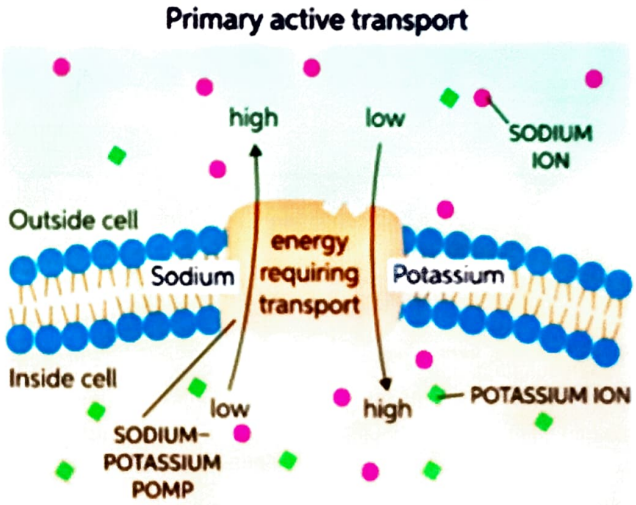
➢ MECHANISM OF ACTIVE TRANSPORT



- When a **substance** to be transported across the cell membrane comes near the **cell**, it combines with the **carrier protein** of the cell membrane and forms **substance-protein complex.**
- This **complex** moves towards the **inner surface** of the cell membrane. Now, the substance is released from the **carrier proteins.**
- The **same carrier protein** moves back to the outer surface of the cell membrane to transport another molecule of the substance

➢ TYPES OF ACTIVE TRANSPORT two types

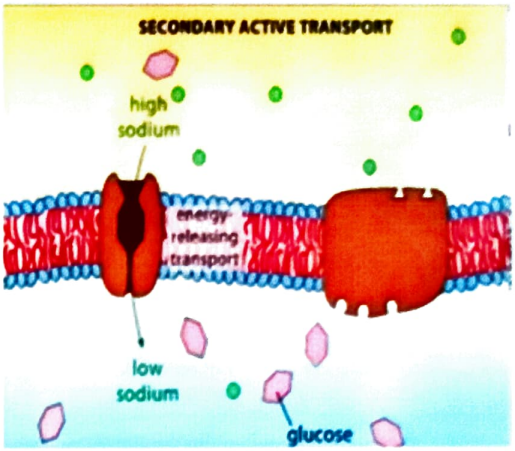
1. Primary active transport
2. Secondary active transport



1. Primary active transport

- It is the type of **transport mechanism** in which the energy is liberated directly from the breakdown of **ATP.**
- The substances like **sodium, potassium, calcium, hydrogen** and **chloride** are transported across the cell membrane.

2. Secondary active transport

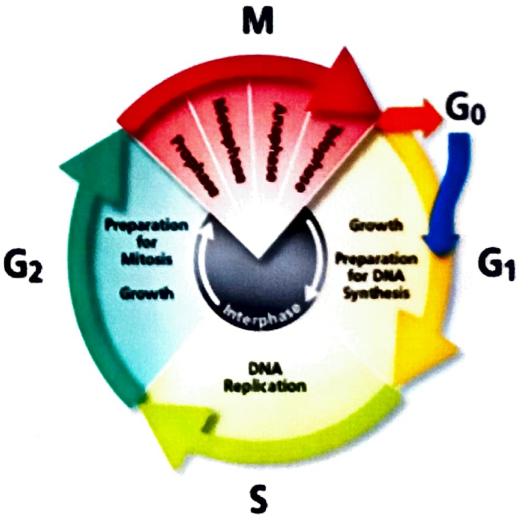


- Secondary active transport is the **transport** of a substance with **sodium ion**, by means of a **common** carrier protein.
- When **sodium** is transported by a carrier protein, another substance is also transported by the same protein simultaneously, either in the same direction or in the **opposite direction**

CELL DEVISION

❑ INTRODUCTION

- A **sequence** of events by which a cell **duplicates** its **genome**, synthesizes other **cell contents** and eventually **divides** into two daughter cell is termed as **cell cycle.**
- It occurs in a **coordinated** manner under **genetic control.**
- A typical eukaryotic somatic cell has two mainstages: a long undividing stage **interphase** (I-phase)and a shorter nucleus dividing stage mitotic phase(**M-phase**). These two are followed by a still shorter phase of cytoplasmic division called **cytokinesis(C-phase).**



- Interphase is the metabolically **active stage** and is a period of **intense synthesis** and **growth.**
- This phase is divided into three periods - first gap phase **(G_1 phase),** synthesis phase **(S-phase)** and second gap/ growth phase **(G_2-phase).**
- M phase may occur by **mitosis** or **meiosis** . It separates the products chromosomes replication and distributes the same to daughter cells.

❖ MITOSIS

- Mitosis occurs during formation of body cells therefore, called **somatic cell division.**
- As the daughter cells resemble their mother cell genetically, it is also called **duplication division** or **equational division.**
- Mitosis leads to production of **diploid daughter** cells with **identical genetic compliment** and helps to restore **nucleo-cytoplasmic ratio.**
- It also replaces **old cells** and helps to **increase** number of cells within an organism.

➢ Phases of Mitosis

a. Interphase:

- It is the **first** stage of the cell cycle and the period **before** cell division
- During this phase, the cell **matures**, **copies** its **DNA** and prepares to **divide**.

b. Prophase:

- The **chromatin** condenses and **spindle** fibers form at each side of the cell. The nuclear membrane **breaks** apart

c. Metaphase:

- The **chromosomes** line up along the **center** of the cell and the **spindle fibers** attach to each **chromosome** at the **centromere**.
- **Best phase** to count and study the number and morphology of chromosomes.

d. Anaphase:

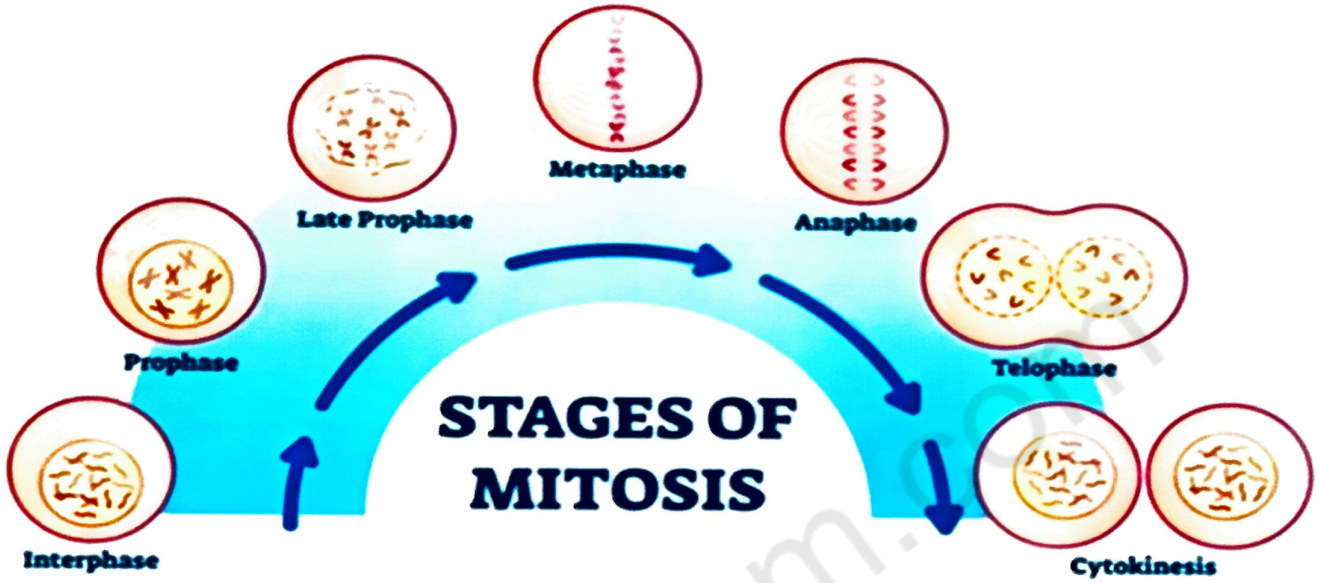
- The **spindle fiber** splits the **centromere** and the **chromatids** move to **opposite sides** of the cell.

e. Telophase:

- The chromosomes **loosen** on each side and the **nuclear membrane** begins to form around the **chromatin** (strands of DNA).

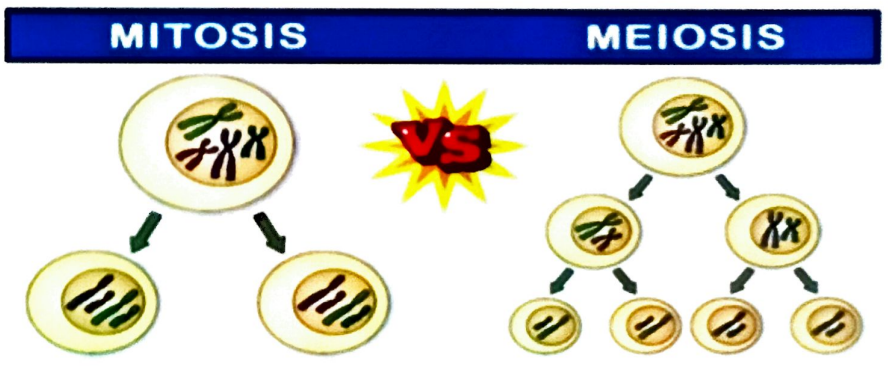
f. Cytokinesis:

- During this stage the cell membrane pinches in (in animal cells) or a cell plate is formed (in plant cells) at the middle of the cell dividing the cell into two separate daughter cells
- Each daughter cell gets half of the cell organelles and an identical set of chromosomes.



❖ MEIOSIS

- Meiosis is a specialized kind of cell division that reduces the chromosome number by half which results in the production of haploid daughter cells.
- It ensures the production of **haploid phase** in the life cycle of sexually reproducing organisms whereas fertilization restores the diploid phase.
- Meiosis involves two sequential cycles of nuclear and cell division called meiosis I and meiosis II but only a/single cycle of DNA replication.



- **Meiosis** – It includes **2 sets of division**

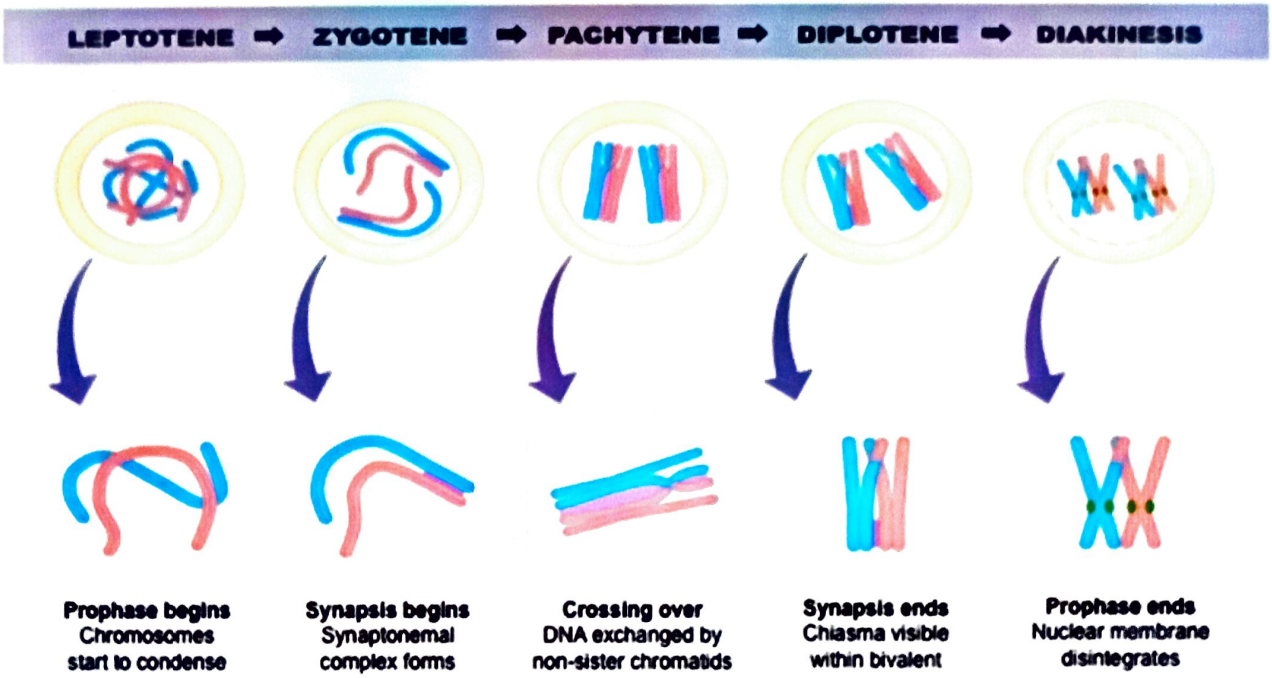
Meiosis I	Meiosis II
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

I. **Meiosis I-** Also called as **reductional division** or **heterotypic division** because it brings about change from **diploid** to **haploidstate.**

➢ **Subdivided into 4 phases-**

1. **Prophase I**
   - long and complex
   - Divided into 5 stages

Stages	Characteristics
Leptotene	• Beaded , long chromosomes • chromosomes shows bouquent arrangements
Zygotene	• Chromosomes become shorter and thicker • bivalents or tetrad (paired homologous chromosomes)are seen • Synapsis occurs
Pachytene	• Longest stage • Tetrad clearly appears as spirally arranged chromosomes of homologous pair • Crossing over occurs • This stage is characterized by the appearance of recombination nodule
Diplotene	• Bivalents repel each other • Chiasmata points strongly appeared
Diakinesis	Terminalization occurs Nuclear membrane disappears, centrioles migrate to poles and spindle fibers begin to form



2. Metaphase I

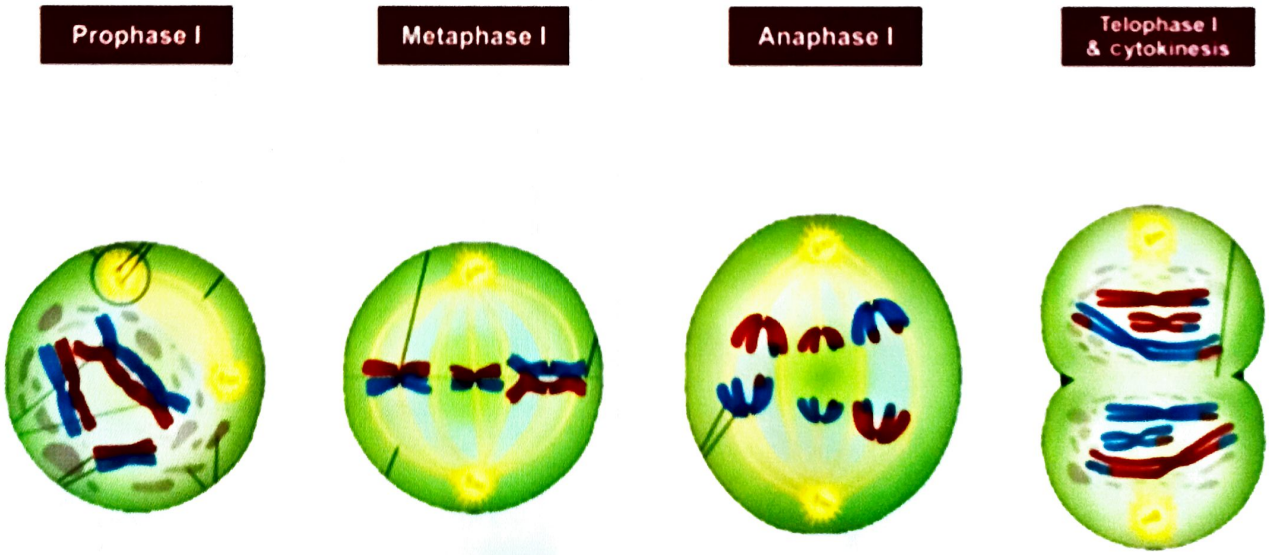
- **Arrangement** of chromosomes at **equator**
- **Maximum** condensation of **chromosomes**

3. Anaphase I

- Movement of **homologous** without **centromere** breakage , nuclei form

4. Telophase I

- Chromosomes **elongate**
- Formation of two **haploid cells**



II. MEIOSIS II- Also called as Equational division , or Homotypic division which maintains haploid number

➢ Subdivided into 4 phases

1. Prophase II

- Meiosis II is initiated immediately after cytokinesis, usually before the chromosomes have fully elongated.
- It resembles a normal mitosis.
- The nuclear membrane disappears by the end of prophase II. The chromosomes again become compact.

2. Metaphase II:

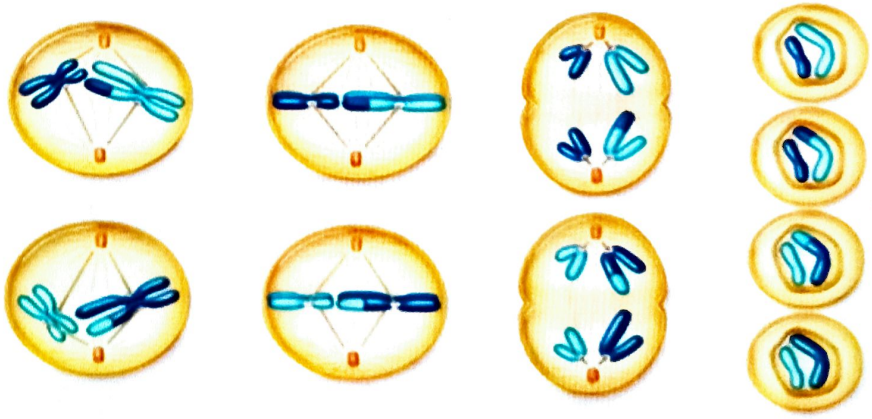
- The chromosomes align at the equator at this stage
- The microtubules from opposite poles of the spindle get attached to the kinetochores of sister chromatids.

3. Anaphase II:

- It begins with the simultaneous splitting of the centromere of each chromosome
- Allowing them to move toward opposite poles of the cell by shortening of microtubules attached to kinetochores.

4. Telophase II:

- It is the last stage , in which the two groups of chromosomes once again get enclosed by a nuclear envelope
- Cytokinesis follows resulting in the formation of tetrad of cells i.e., four haploid daughter cells

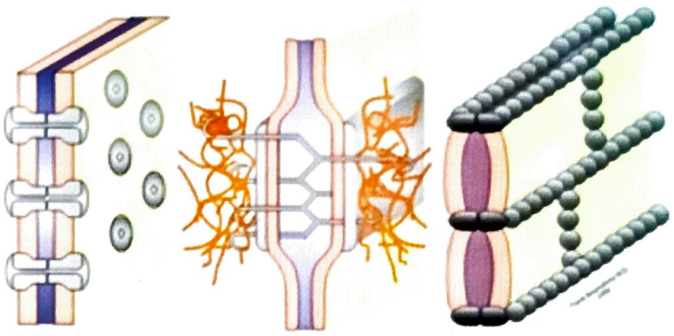


Prophase II Metaphase II Anaphase II Telophase II

CELL JUNCTION

❑ INTRODUCTION

- Cell junction is the **connection** between the **neighboring cells** or the contact between the **cell** and **extracellular matrix**. It is also called **membrane junction.**

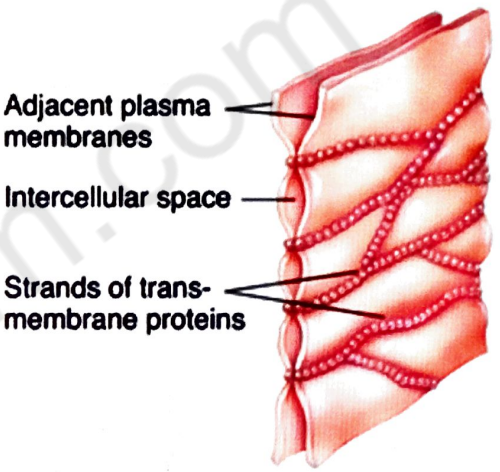


❖ **CLASSIFICATION-** three types

1. **Occluding junctions**
2. **Communicating junctions**
3. **Anchoring junctions.**

1. Occluding junctions

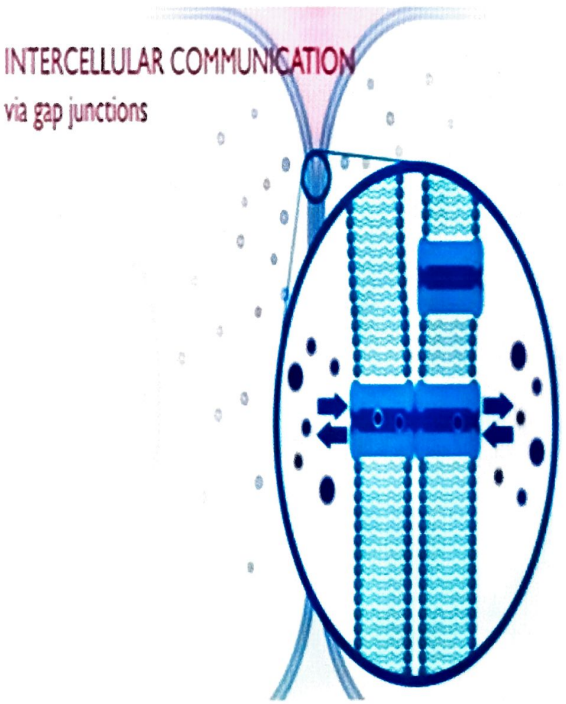
- Cell junctions which prevent **intercellular exchange** of substances are called **occluding junctions,**
- These junctions **prevent** the **movement** of ions and molecules from one cell to another cell.
- **Tight junctions** belong to this category.



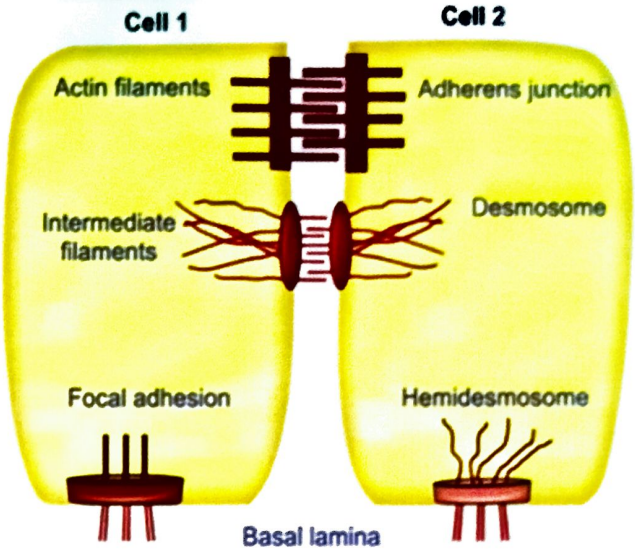
(a) Tight junctions

2. Communicating junctions

- Cell junctions which permit the **intercellular exchange** of substances are called **communicating junctions,**
- These **junctions** permit the **movement** of ions and molecules from one cell to another cell.
- **Gap junction** and **chemical synapse** are the **communicating junctions.**



3. Anchoring junctions



- Anchoring junctions are the junctions, which provide **strength** to the cells by acting like **mechanical attachments**
- These junctions provide firm **structural attachment** between two cells or between a cell and the **extracellular matrix .**
- They are responsible for the **structural integrity** of the tissues
- **Heart muscle** and **Epidermis of skin** contains this type of tissues.

❖ SUMMARY

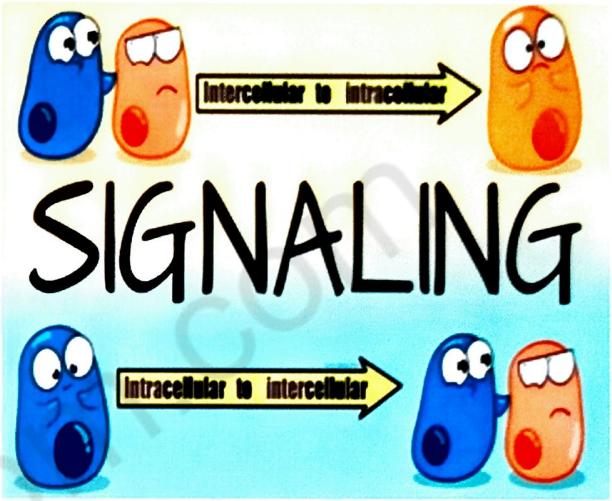
Junction type	Proteins involved	Function	Example
Tight junction	Occludin Claudin JAMs Cingulin Symplekin	• Strength and stability to tissues • Selective permeability • Fencing function • Maintenance of cell polarity • Formation of blood brain barrier	Epithelial lining of intestinal mucosa and renal tubule Endothelium in capillary wall and choroid plexus
Gap junction	Connexins	• Allows passage of small molecules, • ions and chemical messengers • Propagation of action potential	Epithelial lining Heart Intestine
Adherens junction	Cadherins	• Cell to cell attachment	Epithelial lining Heart Intestine
Focal adhesions	Integrins	Cell attachment to • Basal lamina • Extracellular matrix	Epithelial lining

Desmosome	Cadherins	Cell to cell attachment	Epithelial lining Skin
Hemidesmosome	Integrins	Cell attachment to • Basal lamina • Extracellular matrix	Epithelial lining

GENERAL PRINCIPLES OF CELL COMMUNICATION

❑ INTRODUCTION

- **Cell signaling** (signal transduction) is the ability of cells to respond to **stimuli** from their environment.
- Examples are wound healing after injury, activation of the immune system in response to pathogens, and changes in gene expression during different developmental stages.



- Communication between cells is called **intercellular signaling**
- communication within a cell is called **intracellular signaling.**

❖ Importance of cell communication

- During development , **cells differentiate** to adopt specialized roles.
- It helps in **determination** of cell fate i.e. live, die or divide.
- Help in **neurotransmission.**
- Regulation of **metabolism.**
- **Contraction** and **expansion** of muscle.
- Regulation of development of **secondary sexual characteristics.**

❖ Signaling Molecules and Receptors

✓ **Signaling molecules(Ligands)** are the initiator of the cell signaling process.

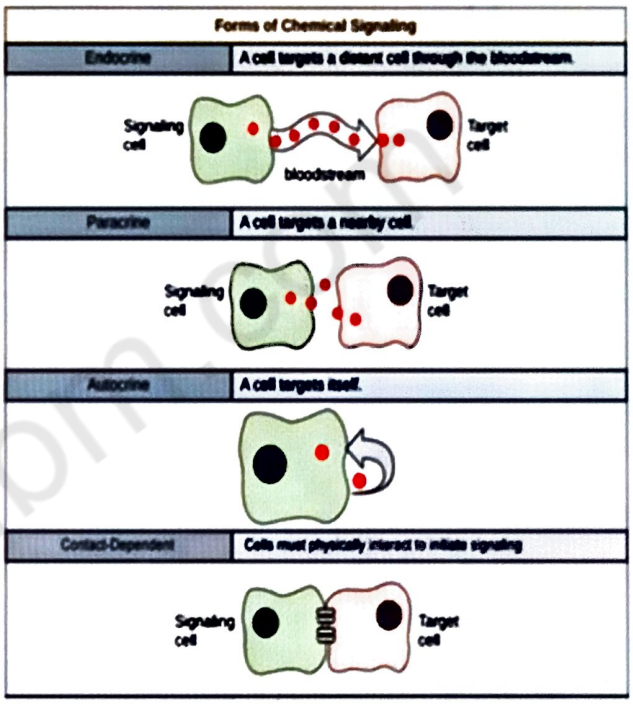
- **Different** types of **molecules** can serve as **signaling molecules.** examples are proteins, lipids, amino acid metabolites ,gases and many others.

✓ The proteins that respond to ligands are also called **Receptors**.

- When a **ligand** binds to its **receptor**, the receptor can change **conformation**, transmitting a **signal** into the cell.
- A **signaling molecule** will bind to a **specific receptor** that typically binds only one type of signaling molecule.
- This specificity occurs because **signaling molecules** have a unique charge, shape, size, and hydrophobicity that only **permit** them to bind to specific, **complementary regions** on receptors.

❖ **Types of Cell Signaling** Four major categories-

1. Long-range signaling **(endocrine)**
2. Short-range signaling **(paracrine)**
3. Self-activation **(autocrine)**
4. Direct activation **(contact-dependent,** also called **juxtracrine)**

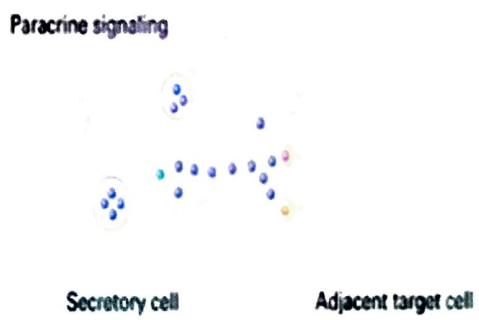


1. Endocrine Signaling

- Signals from distant cells are called **endocrine signals**
- They originate from **endocrine cells.**
- In the body, many endocrine cells are located in endocrine glands
- These types of signals usually produce a **slower response** but have a **longer-lasting effect**
- The ligands released in endocrine signaling are called **Hormones**

2. Paracrine signaling

- Signaling cells secrete **signal molecules** into the extracellular fluid.
- The secreted molecules are **local mediators,** which act only on cells in the **local environment** of the signaling cell. This is called paracrine signaling



3. Synaptic signaling,

- It is the example of **paracrine signaling** in which nerve cells **transmit signals**. This process is named for the **synapse**, the junction between two nerve cells where **signal transmission** occurs.
- When the sending **neuron fires**, an **electrical impulse** moves rapidly through the cell, traveling down a long, fiber-like extension called an **axon**.
- When the impulse reaches the **synapse**, it triggers the release of **ligands** called **neurotransmitters**, which quickly cross the **small gap** between the **nerve cells**. When the **neurotransmitters** arrive at the receiving cell, they bind to **receptors** and cause a **chemical change** inside of the cell

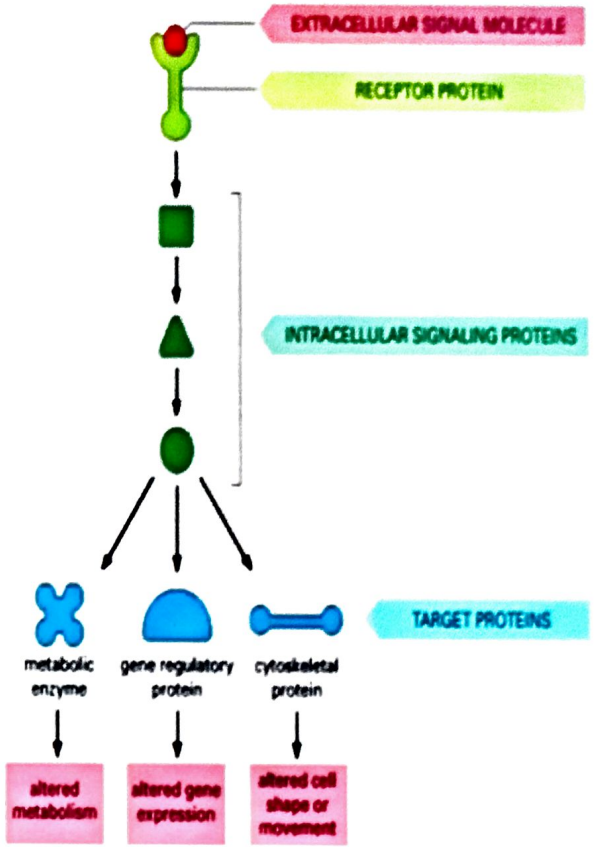
4. Contact-Dependent Signaling (juxtracrine signaling)

- In **contact-dependent signaling** cells must **physically** interact to initiate **cell signaling.**
- This can be through **gap junctions** and/or through interactions of **transmembrane proteins.**
- In this case, the **signaling molecule**/ligand is generally bound to the **membrane** of one cell, so that cell needs to come in direct **contact** with the receptor on the target cell to deliver the signal.

❖ Intracellular signaling pathway activation by extracellular signal molecule

- These communication mechanisms depend heavily on **extracellular signal molecules**, which are produced by **cells** to **signal** to their neighbors or to cells further away.
- These proteins include cell-surface **receptor proteins**, which bind the **signal molecule**, plus a variety of intracellular signaling proteins that distribute the signal to appropriate **parts** of the cell.

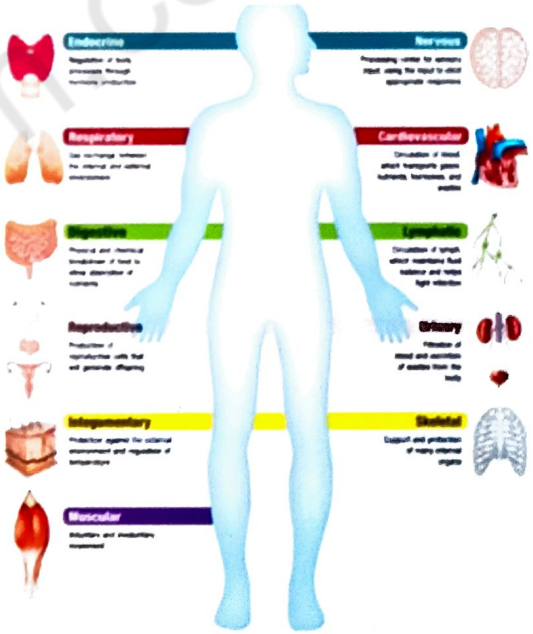
- The intracellular signaling proteins are **kinases, phosphatases, GTP-binding proteins**, and many other proteins with which they interact.
- At the end of each **intracellular signaling** pathway are target proteins, which are altered when the pathway is active and change the **behavior** of the cell.
- Depending on the signal's effect, these target proteins can be **gene regulatory proteins**, **ion channels**, components of a **metabolic pathway**, parts of the cytoskeleton, etc.



LEVELS OF STRUCTURAL ORGANIZATION AND BODY SYSTEM

Points to be covered in this topic

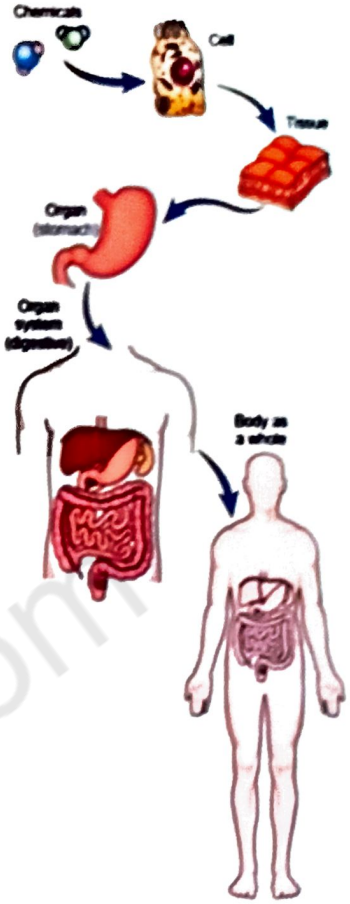
1. LEVELS OF STRUCTURAL ORGANISATIONS
   - (a) Chemical level
   - (b) Cellular level
   - (c) Tissue level
   - (d) Organ level
   - (e) System level
   - (f) Organism level



2. BODY SYSTEMS
3. BASIC LIFE PROCESSES
4. HOMEOSTATIS
5. BASIC ANATOMICAL TERMINOLOGIES

LEVELS OF STRUCTURAL ORGANIZATION AND BODY SYSTEM

❑ LEVELS OF STRUCTURAL ORGANISATIONS



- The vital processes of human body are controlled and maintained by **different levels** of structural organization.
- These levels of structural organization show an **increase** in **structural complexity** and **function**.
- There are **six** fundamental levels of organizations
  1. **Chemical level**
  2. **Cellular level**
  3. **Tissue level**
  4. **Organ level**
  5. **System level**
  6. **Organism level**

1. Chemical Level

- It is the most **basic level** of organization.
- It includes **atoms**, the smallest unit of matter that participate **in chemical reactions.**
- Two or more **atoms** join together to form molecules.
- Certain **atoms** like, carbon (C), hydrogen (H), oxygen (0), nitrogen (N), phosphorus (P), calcium (Ca), and sulfur (S) are crucial for **maintaining** life

2. Cellular Level

- Cell **constitutes** the most **basic** structural and **functional** unit of human body.
- Different **molecules** combine together to form **cells**
- Human body contains **muscle cells, nerve cells** and **epithelial cells.**
- Each cell varies greatly in **structure** and **function**.
- Each type of **cell** performs a **specific task**

3. Tissue Level

- Tissue is a **group** of **cells** that work together to perform a **particular function.**
- Human body contains four basic types of tissue **epithelial tissue, connective tissue, muscular tissue and nervous tissue**

4. Organ Level

- Different types of **tissue** combine together to form an **organ.**
- Organs are composed of two or more different types of tissues having **specific functions** and **recognizable shapes**
- Examples of organs are the stomach, skin, bones, heart, liver, lungs and brain.

5. System Level

- A group of **organs** combine together to form **a system**
- The organs of a system work together to perform a **major physiological function** of the body
- The human body comprises of **eleven organ system** such as Integumentary system, Skeletal system, Lymphatic system, Digestive system, Respiratory system, Muscular system, Nervous system, Endocrine system, Cardiovascular system, Urinary system, Reproductive system (Male and Female), and Special sensory organs

6. Organism Level

- It is the highest level of **structural organization**
- All parts of the human body functioning **together** constitute the **total organism** i.e. human body
- An organism is capable of independently performing **vital functions necessary for life**

❑ BODY SYSTEMS

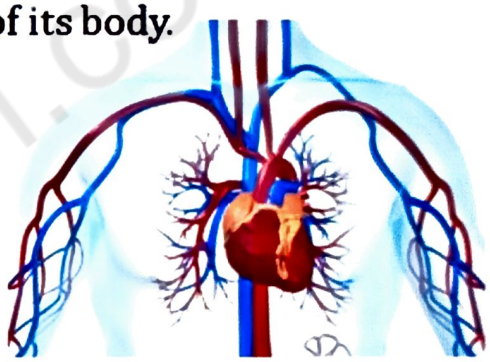
- Human beings are **contiguous** living systems.
- The different systems are **interconnected** and **dependent** on each other.
- They cannot function **separately**
- An organ system is composed of **groups** of **structures** that work together to **perform** a **common task** or specific function.

❖ Nervous System

✓ **Organs:** Brain, spinal cord and nerves.

✓ **Functions**

- It coordinates **voluntary** and **involuntary actions** and transmits signals between different parts of its body.
- It maintains **homeostasis.**

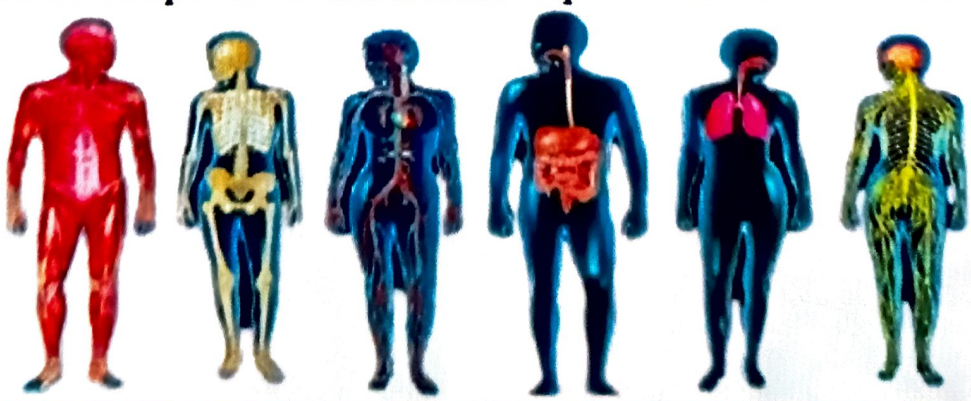


❖ Cardiovascular System

✓ **Organs**: Blood, heart and blood vessels.

✓ **Functions**

- Heart **pumps** blood through blood vessels
- Blood carries **oxygen** and nutrients to cells and carries **carbon dioxide** and wastes away from cells
- Helps regulate acid-base balance, temperature and water content of body fluids.
- Blood components help defend against **disease**
- Blood transports biochemicals required for metabolism



❖ Digestive System

✓ **Organs**: Mouth, pharynx, oesophagus, stomach, small and large intestine and anus, accessory organs such as salivary glands, liver, gallbladder and pancreas.

✓ **Functions**

- **Mechanical** and **chemical** breakdown of food
- Absorption of nutrients
- **Elimination** of solid wastes

❖ Urinary System

✓ **Organ**: Kidneys, ureters, urinary bladder and urethra

✓ **Functions**

- Produces **stores** and **eliminates** urine.
- **Eliminates** wastes and regulates volume and chemical composition of blood
- Helps maintain the acid-base balance of body fluids
- Maintains mineral balance of body

❖ Respiratory System

✓ **Organs**: Nose, Lungs, pharynx, larynx, traches and bronchial tubes

✓ **Functions** .

- Transfers oxygen from inhaled air to blood and carbon dioxide from blood to exhaled air.
- Helps regulate **acid-base balance** of body fluids
- Production of sound by vocal cord

❖ Lymphatic System

✓ **Organs**: Lymph, lymph vessels, spleen, thymus, lymph nodes and tonsils

✓ **Functions**

- Returns **proteins** and fluid to **blood**.
- Carries lipids from gastrointestinal tract to blood.
- Lymphatic cells protect against disease-causing **microbes**

❖ Endocrine system

✓ **Organs** pineal gland , hypothalamus , pituitary gland, thymus, thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries and testes

✓ **Functions**

- Regulates body activities by releasing **hormones**.
- Hormones affect specific **target cells** and alter their metabolism
- Hormones have a relatively longer effect on target cells..

❖ Male Reproductive System

✓ **Organs** Testes, epididymis, ductus deferens and penis

✓ **Functions**

- Produce and release **sex hormones.**
- **Produce**, store and transport sperm
- Discharge sperm in the **female reproductive tract**

❖ Female Reproductive System

✓ **Organs:** Ovaries, uterine tubes, uterus and vagina.

✓ **Functions**.

- Produce ova necessary for **fertilization.**
- **Transport** ova to the site of fertilization.
- Enable sperm to **enter** the body.
- Provide favorable environment for the developing **embryo.**

❖ Muscular System

✓ **Organs**: Skeletal muscle and tendons.

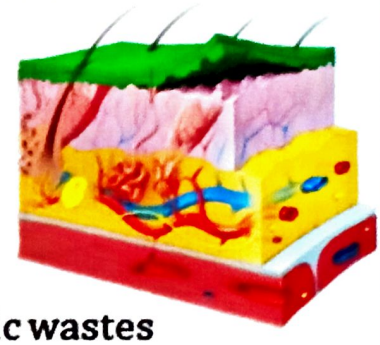
✓ **Functions:**

- Produces body movements such as **walking** and **running**
- Stabilizes **body posture.**
- Generation of **heat**.

❖ Integumentary System

✓ **Organs**: Skin, hair, nails, sebaceous glands and sweat glands

✓ **Functions**



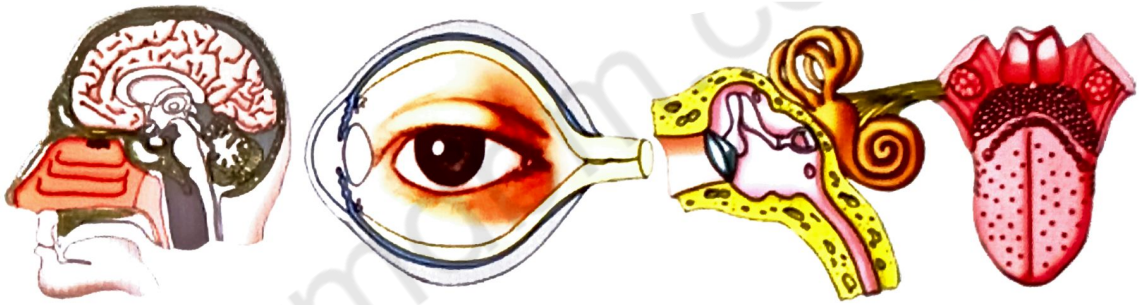
- **Protects** underlying tissues
- Prevents loss of **body fluids**
- Maintains normal **body temperature**
- **Secretion** of substances such as salt, water and organic wastes

❖ Special Sense

✓ **Organs** : Eyes, ears, skin, tongue and nose.

✓ **Functions**

- Detects changes in the body's **internal and external environments**
- Vision
- Hearing
- Smell
- Taste
- Touch
- Sensations

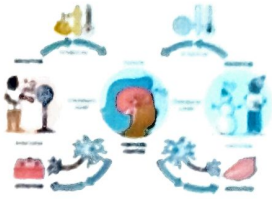


BASIC LIFE PROCESSES

S. NO	LIFE PROCESSES	ITS CHARACTERISTICS
1.	**Responsiveness**	• It is the body's ability to detect and respond to changes. . • Different cells in the body respond to environmental changes in different ways.
2.	**Metabolism**	• It is the sum of all the chemical processes that occur in the body. • Catabolism is the breakdown of complex chemical substances into simpler components. • Anabolism is the building up of complex chemical substances from smaller components

S. NO	LIFE PROCESSES	ITS CHARACTERISTICS
3.	**Movement**	• Movement includes motion of the whole body, individual organs, and single cells even tiny structures inside cells
4.	**Growth**	• It is an increase in body size that results from an increase in the size of existing cells, an increase in the number of cells or both. between bone.
5.	**Differentiation**	• It is the development of a cell from an unspecialized to a specialized state . • Through differentiation process, a fertilized egg develops into an embryo, and then into a fetus, an infant, a child, and finally an adult.
6.	**Reproduction**	• It refers either to the formation of new cells for tissue growth, repair or replacement, or to the production of a new individual. • In humans, fertilization of an ovum by a sperm cell results in the development of an embryo.
7.	**Respiration**	• It involves the exchange of oxygen and carbon dioxide between the cells and the external environment. • It includes the diffusion of oxygen and carbon dioxide and the transport of the gases in the blood
8.	**Digestion**	• It involves breaking down complex ingested foods into simple molecules that can be absorbed into the blood and utilized by the body for energy source • It involves both mechanical as well as chemical processes
9.	**Excretion**	• It is the process that removes the waste products of digestion and metabolism from the body • Kidney plays an important role in elimination of nitrogenous waste materials.

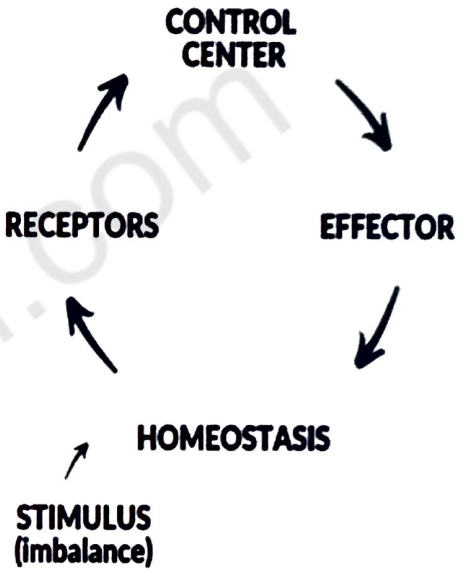
HOMEOSTASIS



❑ INTRODUCTION

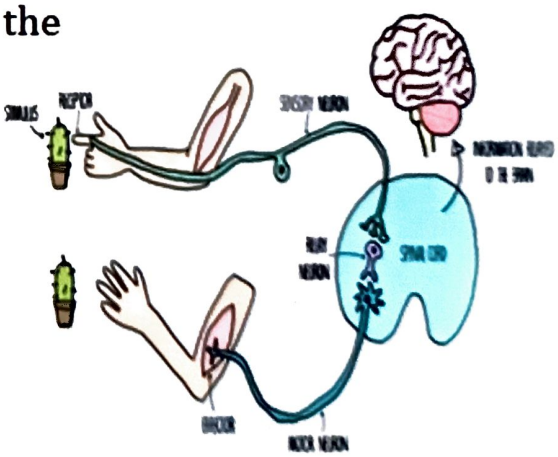
- It is the **ability** of the **body** or a **cell** to maintain a condition of **equilibrium** within its **internal environment** when dealing with external changes.
- Homeostasis is a **dynamic condition.**
- The conditions such as water balance, body temperature, blood sugar levels and blood pH need to be maintained constant in order to set the different **physiological processes** to occur

❖ Control of Homeostasis



- The body undergoes **constant** change as a result of which there is a **shift** in the **equilibrium**
- Some disruptions come from the external environment in the form of **intense heat.** lack of oxygen or fall in blood glucose level
- It may also occur due to **psychological stress**
- In most cases the **disruption** of homeostasis is mild and temporary, and the response of body cells quickly **restores** balance in the internal environment.

❖ Feedback Systems

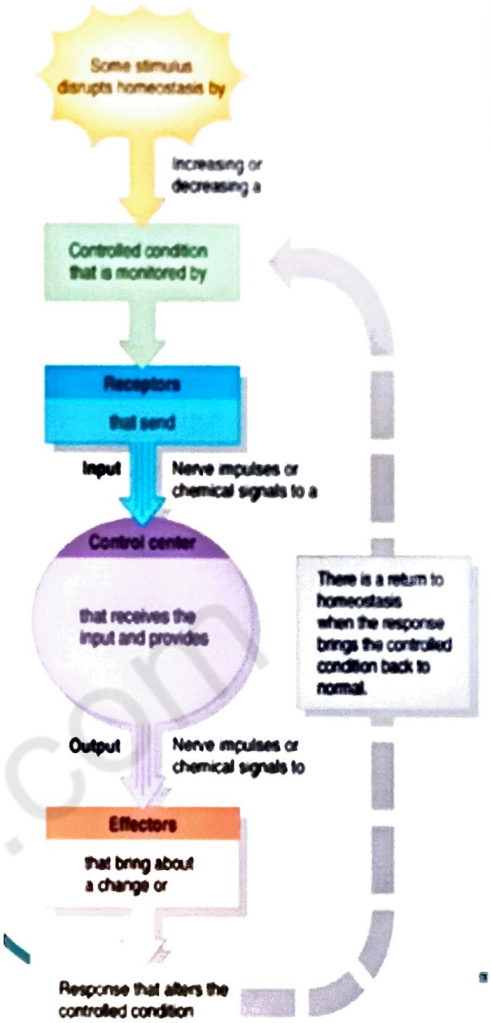


- A feedback system in cycle of events in which the status of **body condition** is monitored, evaluated, altered, remonitored , re-evaluated and so on.
- Each **monitored variable,** such as body temperature, blood pressure, or blood glucose level, is termed **controlled condition**
- Any **disruption** that changes controlled condition is called **Stimulus.**

❖ A feedback system includes three basic components

✓ Receptor

- A receptor is **a body structure** that **monitors** changes in controlled condition and **sends** input to **control center.**
- The input is present in the form of **nerve impulses** or chemical signals.



✓ Control center

- It is the **brain** in body which sets the range of values within which controlled condition should be **maintained**, it **evaluates** the input receives from receptors and generates output **commands**
- Nerve impulses, hormones or other chemical signals are the various **forms** of nerve impulses through which output occurs

✓ Effector

- An effector is a **body structure** that receives **output** from the control center and **produces** a response or effect that changes the controlled condition
- Every organ or tissue in the body can behave as **an effector.**
- When body temperature drops sharply, the brain (control center) sends **nerve impulses** (output) to skeletal muscles (effectors). The response to such stimulus is shivering, which generates heat and raises the body temperature.

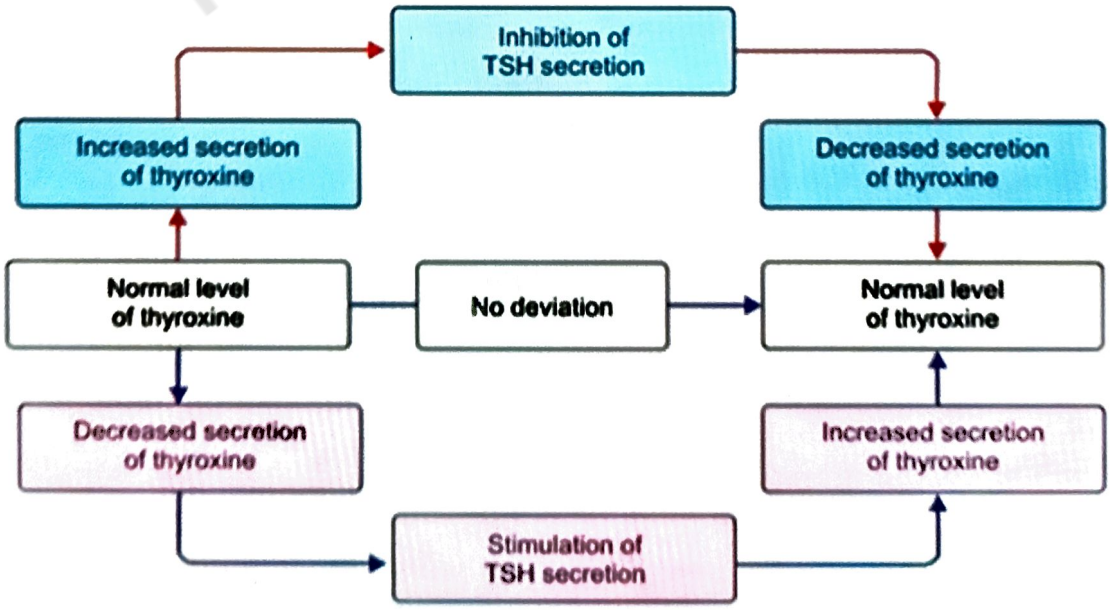
❖ Whenever any change occurs, system receives and reacts to two types of feedback:

1. Negative feedback 2. Positive feedback

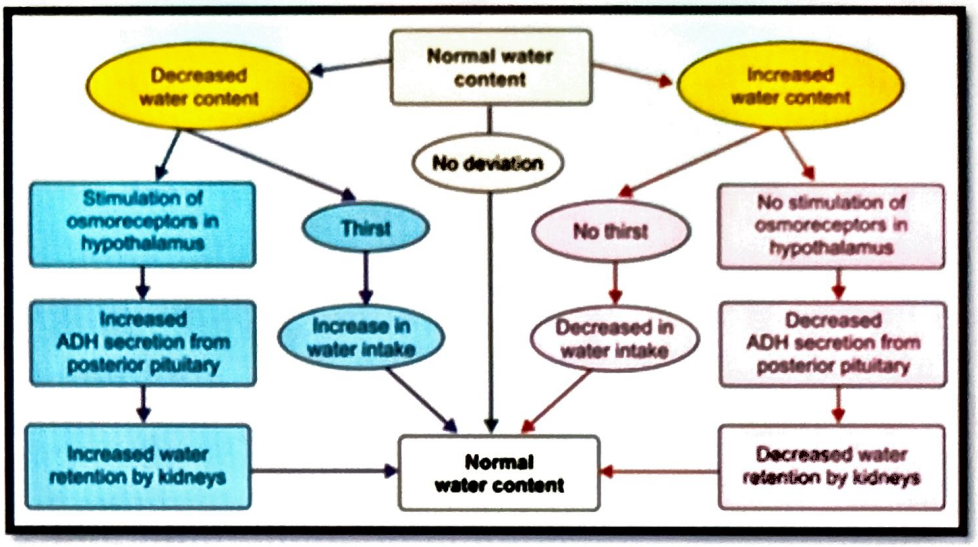
1. Negative Feedback

- Negative feedback is the one to which the **system reacts** in such a way as to arrest the **change** or **reverse** the direction of change.
- 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**
- Many homeostatic mechanisms in the body function through **negative** feedback.

- **For example,**
- Thyroid-stimulating hormone (TSH) released from **pituitary gland** stimulates **thyroid gland** to secrete **thyroxine.**
- When thyroxine level **increases** in blood, it **inhibits** the secretion of TSH from pituitary so that, the secretion of thyroxin from thyroid gland decreases
- On the other hand, if thyroxine **secretion** is less, its low blood level induces pituitary gland to **release** TSH. Now, TSH stimulates thyroid gland to secrete thyroxine
- Another example for negative feedback mechanism is maintenance of water balance in the body.

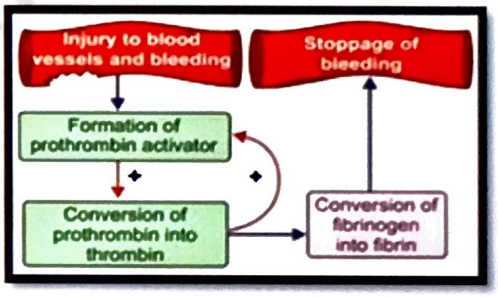


Negative feedback mechanism – maintenance of water balance

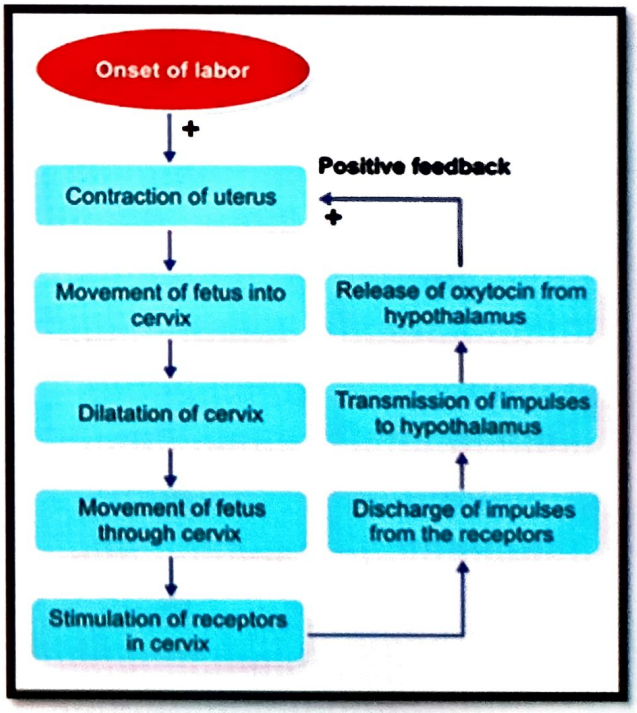


2. Positive feedback

- It is the one to which the system reacts in such a way as to **increase** the **intensity** of the change in the **same direction.**
- 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. The three stages are:
  - **i. Formation of prothrombin activator**
  - **ii. Conversion of prothrombin into thrombin**
  - **iii. Conversion of fibrinogen into fibrin.**



- **Thrombin** formed in the second stage stimulates the formation of more **prothrombin activator** in- addition to converting **fibrinogen** into **fibrin.**
- It causes **formation** of more and more amount of **prothrombin activator** so that the blood clotting process is accelerated and **blood loss** is prevented quickly.
- Other processes where positive feedback occurs are milk ejection reflex and parturition and both the processes involve oxytocin secretion.



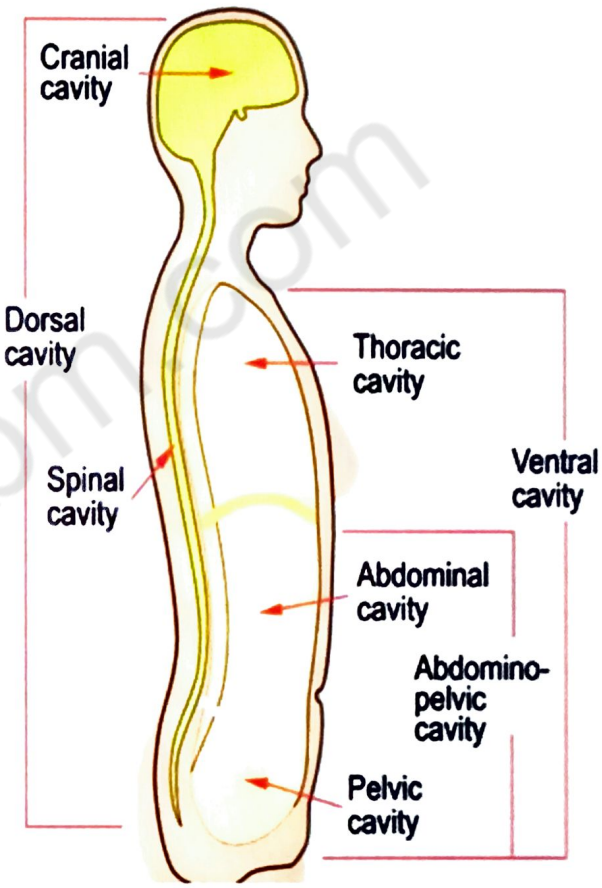
BASIC ANATOMICAL TERMINOLOGIES

❑ INTRODUCTION

- To communicate **effectively** and **precisely** researchers and clinicians have developed **terms** for describing **anatomy**.
- Use of such terms always refer body is in **anatomical position**.
- It means **face** facing the observer, **feet** at the distance of **shoulders** width with toes parallel, **upper limbs** hanging sidewise and **palms** facing forward.

❖ Regional Terms

- To avoid confusion and describe the human body more precisely, these terms are used to describe the regions of the body. They are as.



✓ Cephalic region

- The cephalic region or cranial region consists of **entire head region.**
- It includes Frontal (forehead). Nasal (nose), Occipital(base of skull), Oral (mouth) and Orbital/ocular (eyes) parts

✓ Cervical region.

- It starts below the **head** and end at the **thorax** It consists of seven cervical vertebrae **(C1-C7)**

✓ Dorsal region

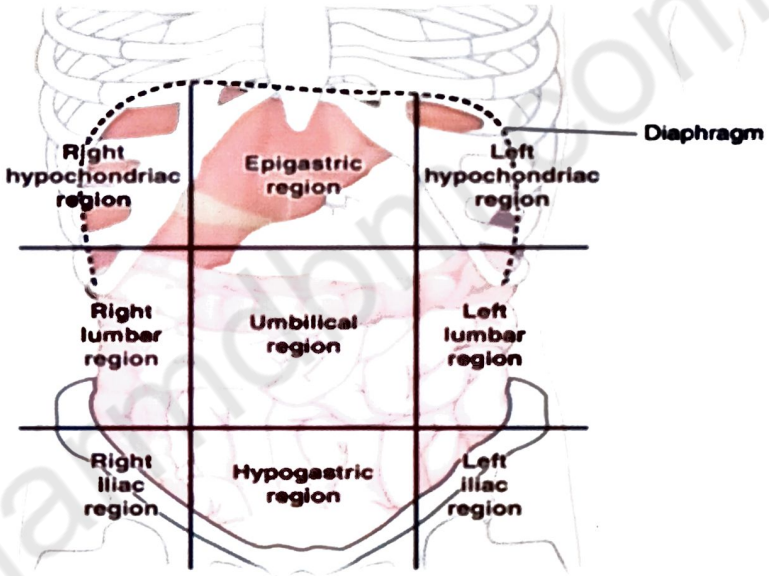
- It includes **back** portion of the body immediately below the **neck** up to the area below the **waist** excluding the shoulders

✓ Thorax region:

- The Thorax region refers to the **upper area** of the trunk, between the **base** of the neck, at the clavicles up to the **bottom** of the **ribcage**.
- It includes axillary (armpit), Costal (ribs), Deltoid (shoulder).
- Mammary (breast). Pectoral (chest), Scapular (shoulder blade) Sternal (breastbone) and Vertebral (backbone).

✓ Abdomen region:

- It starts along the **bottom** of the ribcage and extends up to the **hips**.
- It is divided into **nine parts**: right and left hypochondrium epigastrium, right and left lumbar regions, umbilical region, right and left inguinal regions, hypogastrium



✓ Pelvic region:

- The pelvis region lies below the **abdomen** and takes up the area between the **hip bones** .

➢ Upper extremity region:

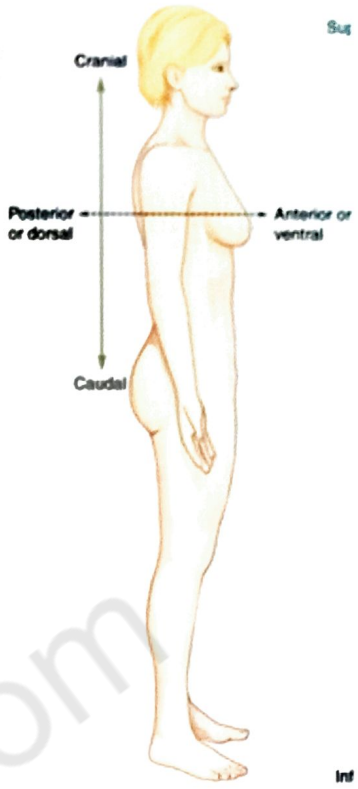
- It includes antebrachial (forearm). Antecubital (inner elbow), Brachial (upper arm), Carpal (wrist), Cubital (elbow), Digital (fingers/toes), Manual (hand) and Palmar (palm)

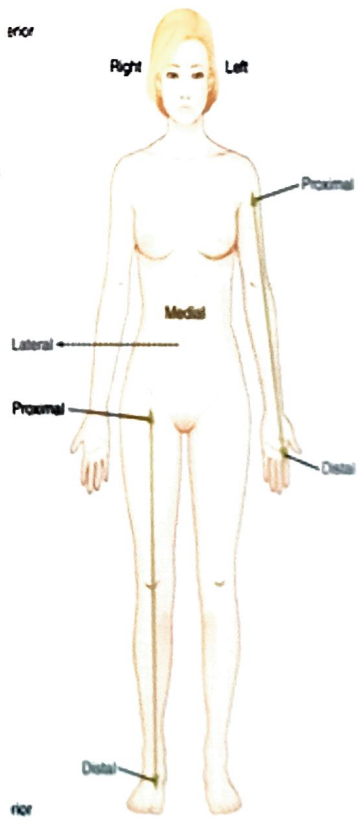
➢ Lower extremity region

- It includes the Crural (shin, front of lower leg), femoral (thigh). Patellar (front of knee). Pedal, Plantar (arch of foot), Popliteal (back of knee),Sural (calf, back of lower leg) and Tarsal (ankle).

❖ Directional terms

Terms	Meaning
Superior	means that a body part is above another body part. (The orbits are superior to the oris)
Inferior	means that a body part is below another body part. (The thorax is inferior to the cephalon.)
Anterior (or ventral)	means toward the front. (The toes are anterior to the foot)
Posterior (or dorsal)	means toward the back. (The pharynx is posterior to the oral cavity).
Medial	refers to an imaginary midline dividing the body into two equal halves, right and left. A body part is medial if it is closer to the midline than another part. (The nose is medial to the eyes.)
Lateral	means away from the midline of the body. (The ears are lateral to the eyes.)
Distal	means farther from the point of attachment or away the trunk of the body. (The wrist is distal to the elbow)
Superficial	means toward the surface of the body. (The skin is superficial to the stomach)
Deep	means under the surface of the body. (The stomach is deep to the skin)Cranial





❖ Planes

- Body planes are imaginary **flat surfaces** that pass through the body parts
- Sagittal, frontal and transverse planes are at **right angles** to one another

The anatomical planes that pass through the body are

✓ **Sagittal plane**: It is a **vertical plane** that divides the body or an organ into right and left halves

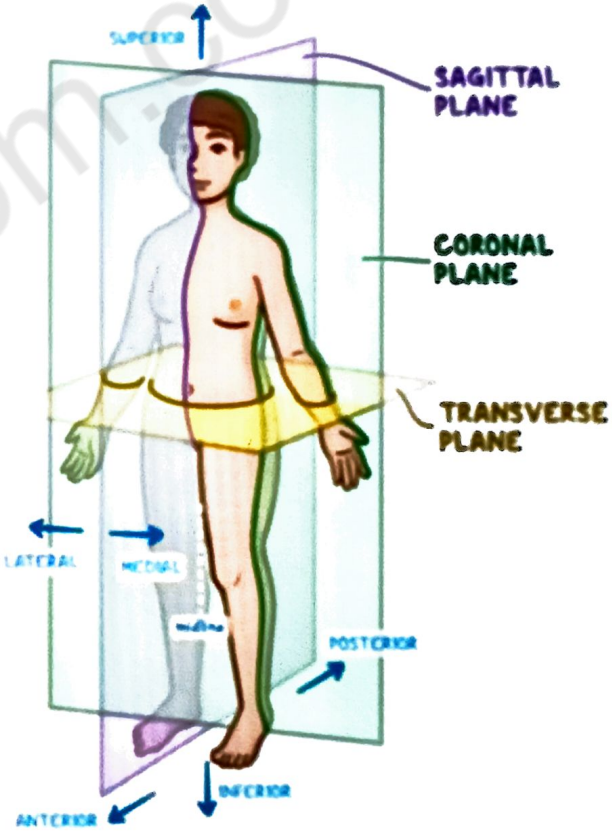
(1) **Mid-sagittal plane**: When sagittal plane passes through the **midline** of the body of an organ and divides it into equal right and left halves, it is called a mid-sagittal plane or a median plane.

(2) **Para-sagittal plane**: If sagittal plane **does not** pass through the **midline** divides the body or an organ into unequal right and left halves, it is called a para-sagittal plane

✓ **Frontal or coronal plane**: It divides the body or an organ into anterior (**front**) and posterior (**back**) portions.

✓ **Transverse plane/horizontal plane/cross sectional plane**:
It divides the body or an organ into superior (**upper**) and inferior (**lower**) portions

✓ **Oblique plane**: It passes through the body or an organ at an angle between a **transverse plane** and a **sagittal plane** or between a transverse plane and a frontal plane

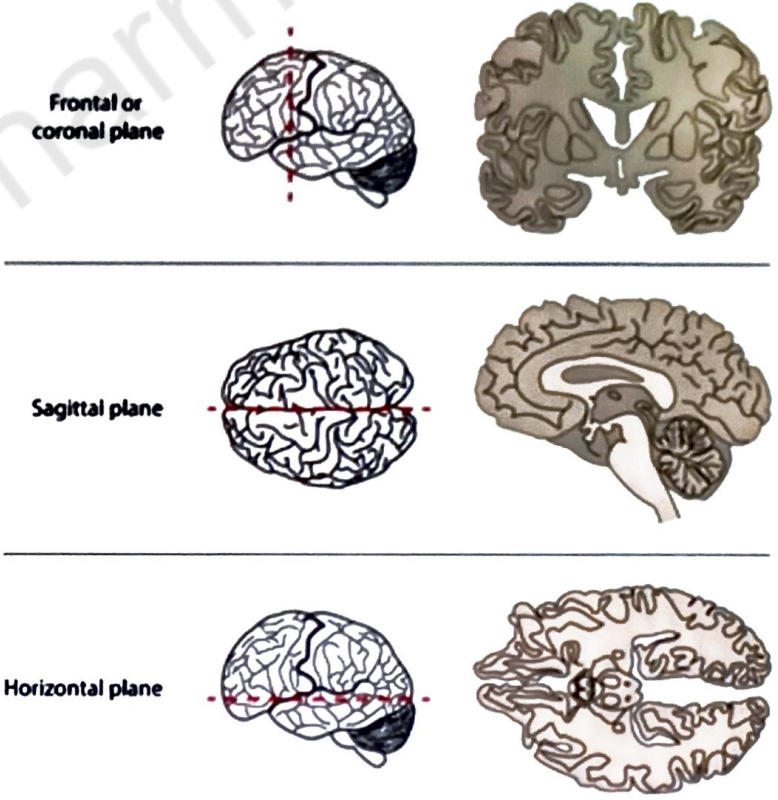


❖ Sections

- A section is a **cut** made on the body or organ along one of the planes .
- There are **three sections-**

1. **Transverse section**: A section formed by a transverse plane cutting through an object, usually at **right angles** to an axis.

2. **Frontal section**: A section formed by a **frontal plane** cutting through an object dividing the body into **dorsal** and **ventral portions.**
3. **Midsagittal section**: A section formed by a **mid-sagittal plane** cutting through as object, dividing the body into right and left halves.



TISSUE LEVEL OF ORGANIZATION

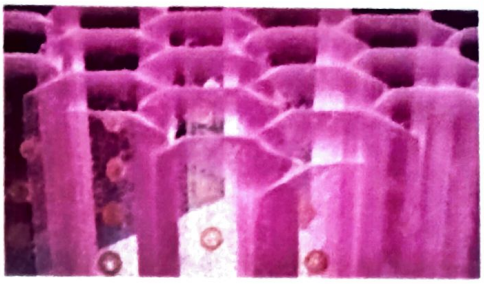
Points to be covered in this topic

1. INTRODUCTION
2. CLASSIFICATION OF TISSUE
3. STRUCTURE, LOCTION & FUNCTIONS OF VARIOUS TISSUE
   - (a) Epithelial tissue
   - (b) Muscular tissue
   - (c) Nervous tissue
   - (d) Connective tissue

TISSUE LEVEL OF ORGANIZATION

❑ TISSUE

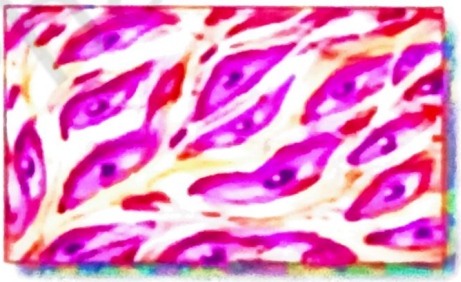
- It is a **group** of cells that usually have a common **embryonic** origin and **function** together to carry out **specialized activities**



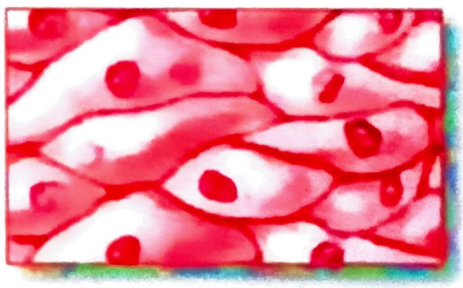
❖ Classification of Tissue

1. **Epithelial tissue :** Covers **body surfaces** and lines **hollow organs**, **body cavities**, and **ducts**. It also forms **glands**.
2. **Muscular tissue :** Generates the physical **force** needed to make **body** structures **move** and **generates** body heat.
3. **Nervous tissue :** Detects changes in a variety of conditions **inside** and **outside** the body and responds by generating **action potentials** (nerve impulses) that activate **muscular contractions** and **glandular secretions.**
4. **Connective tissue :** **Protects** and **supports** the **body** and its **organs**. Various types of connective tissue bind **organs together**, **store energy** reserves as **fat**, and help provide **immunity** to disease-causing organisms.

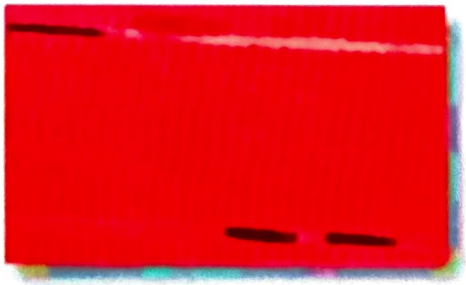
Four types of tissue



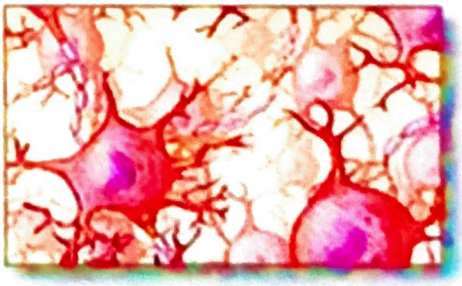
Connective tissue



Epithelial tissue



Muscle tissue

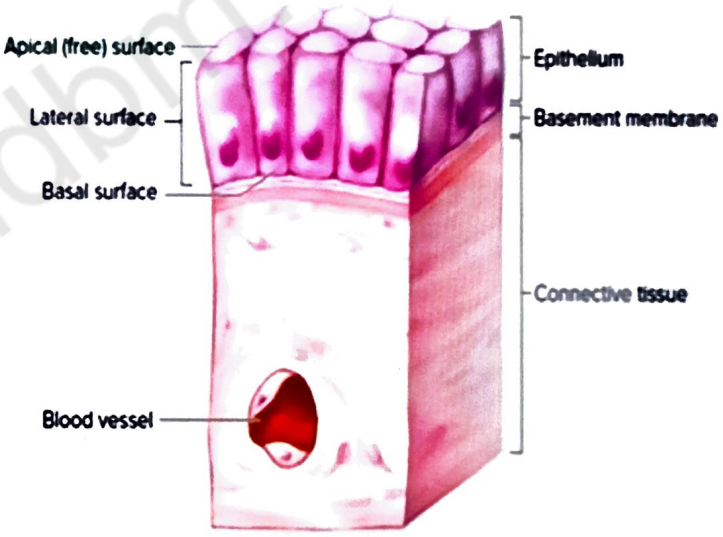


Nervous tissue

1. Epithelial tissue

Structure

- An epithelial tissues consists of cells arranged in **continuous sheets**, in **single** or **multiple** layers.
- The **apical** (free) **surface** of an epithelial cell faces the body surface, a body cavity.
- The **lumen** (interior space) of an **internal organ**, or a **tubular duct** that receives **cell secretions**
- Apical surfaces may contain **cilia** or **microvilli**.
- The **lateral** surfaces of an epithelial cell face the **adjacent** cells on either side.
- The **basal surface** of an epithelial cell is opposite the **apical surface**, and the basal surfaces of the deepest layer of cells adhere to **extracellular materials**.
- **Hemidesmosomes** in the basal surfaces of the deepest layer of epithelial cells anchor the epithelium to the basement extracellular membrane.



Location

Epithelial tissue forms **coverings** and **linings** throughout the body.

Functions

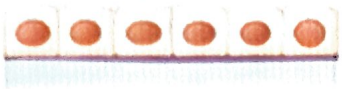
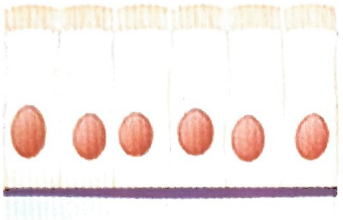
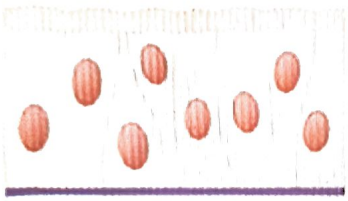
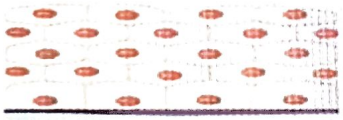
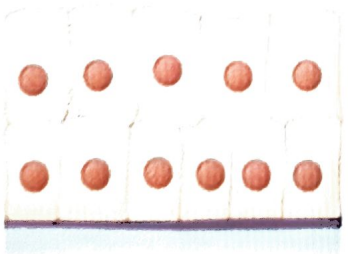
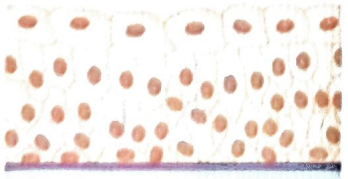
Epithelial tissues have **three** major functions:

(1) **Selective barriers** that limit or aid the transfer of substances into and out of the body.

(2) **Secretory surfaces** that release products produced by the cells onto their free surfaces.

(3) **Protective surfaces** that resist the **abrasive** influences of the environment.

Types of Epithelial tissue and their functions

Cells	Location	Function
Simple squamous epithelium 	Air sacs of lungs and the lining of the heart, blood vessels, and lymphatic vessels	Allows materials to pass through by diffusion and filtration, and secretes lubricating substance
Simple cuboidal epithelium 	In ducts and secretory portions of small glands and in kidney tubules	Secretes and absorbs
Simple columnar epithelium 	Ciliated tissues are in bronchi, uterine tubes, and uterus; smooth (nonciliated tissues) are in the digestive tract, bladder	Absorbs; it also secretes mucous and enzymes
Pseudostratified columnar epithelium 	Ciliated tissue lines the trachea and much of the upper respiratory tract	Secretes mucus; ciliated tissue moves mucus
Stratified squamous epithelium 	Lines the esophagus, mouth, and vagina	Protects against abrasion
Stratified cuboidal epithelium 	Sweat glands, salivary glands, and the mammary glands	Protective tissue
Stratified columnar epithelium 	The male urethra and the ducts of some glands	Secretes and protects
Transitional epithelium 	Lines the bladder, uretha, and the ureters	Allows the urinary organs to expand and stretch

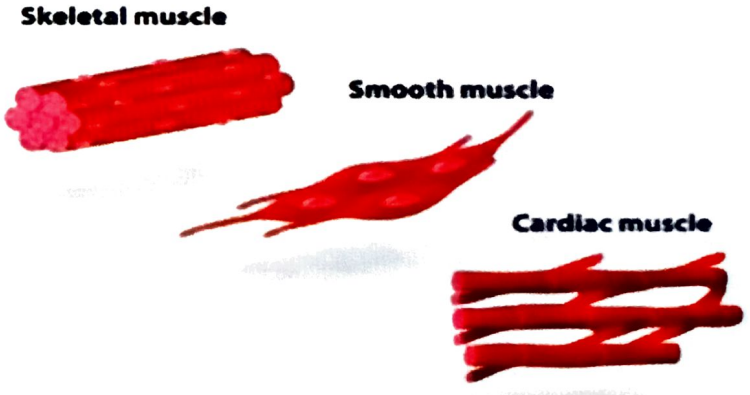
2. Muscular Tissue

- Muscular tissue consists of **elongated cells** called **muscle fibers** or **myocytes** that can use ATP to generate force.
- As a result, muscular tissue produces **body movements**, maintains **posture**, and generates **heat.**
- It also provides **protection.**

➢ **Muscular tissue is classified into three types:**

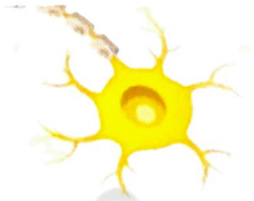
1. Skeletal 2. Cardiac 3. Smooth

Type of Muscular Tissue	Description	Location	Function
Skeletal muscle fiber	• Long, • Cylindrical, • Striated Fibers With Many Peripherally Located Nuclei Voluntary control	Attached to bones by tendons	• Motion, • Posture • Heat production • Protection
Smooth muscle tissue	• Spindle-shaped • Nonstriated fibers with one centrally located nucleus involuntary control.	Iris of the eyes, walls of hollow internal structures such as blood vessels, airways to the lungs, stomach, intestines, gallbladder, urinary bladder, and uterus.	Motion



Cardiac muscle tissue	Motion (constriction of blood vessels and airways, propulsion of foods through gastrointestinal tract, contraction of urinary bladder and gallbladder)	Branched striated fibers with one or two centrally located nuclei; contains intercalated discs involuntary control.	Pumps blood to all parts of the body

3. Nervous tissue



➢ Structure

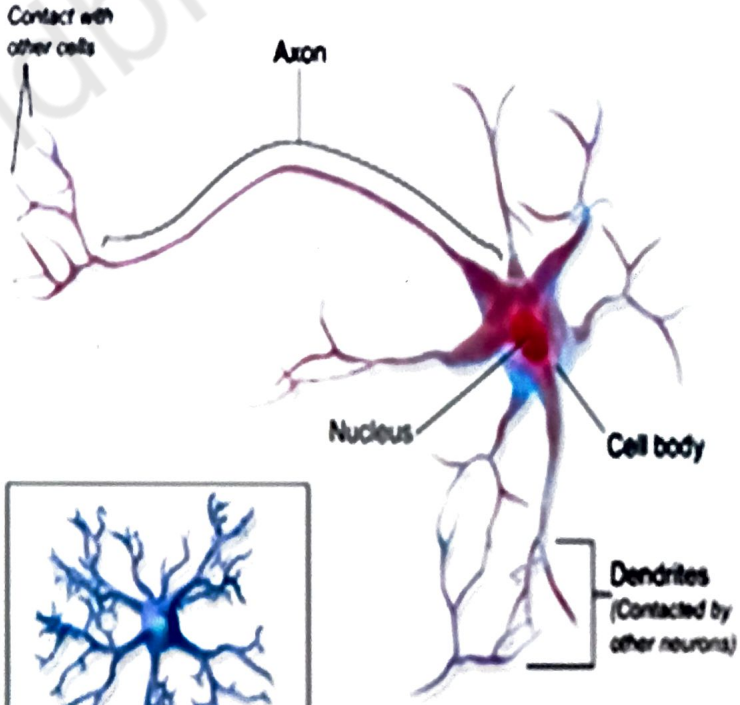
- Consists of **neurons** (nerve cells) and **neuroglia**.
- Neurons consist of a **cell body** and processes extending from the cell body.
- Neuroglia do not generate or conduct **nerve impulses** but have other important supporting functions.

➢ Location

- Nervous system.

➢ Function

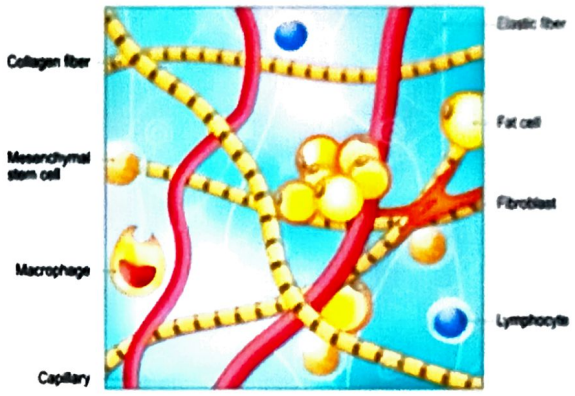
- Exhibits **sensitivity** to various types of **stimuli**, converts stimuli into nerve impulses (action potentials)
- Conducts **nerve impulses** to other **neurons**, **muscle fibers**, or **glands**.



Neuron
(Sizes and Shapes Vary)

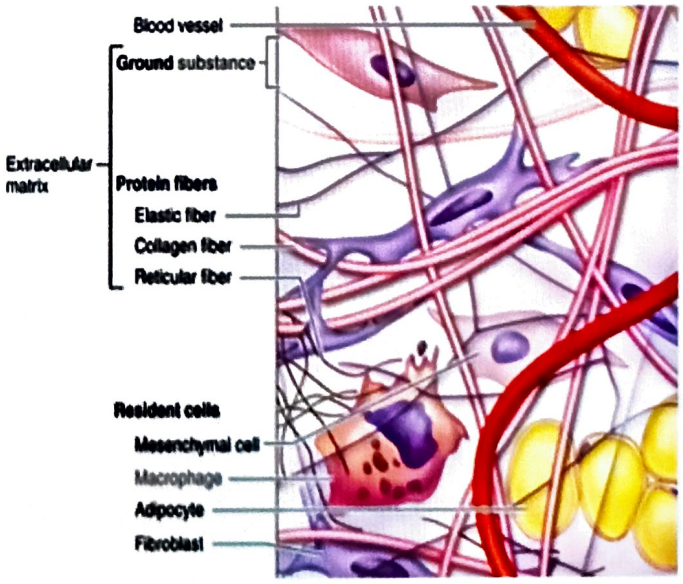
4. Connective tissue

- It is one of the most **abundant** and widely **distributed** tissues in the body.
- It **binds** together, **supports**, and **strengthens** other body tissues
- It **protects** and **insulates** internal organs; compartmentalizes structures such as **skeletal muscles**
- Serves as the major **transport system** within the body
- It is the **primary location** of stored energy reserves and is the main source of **immune responses**



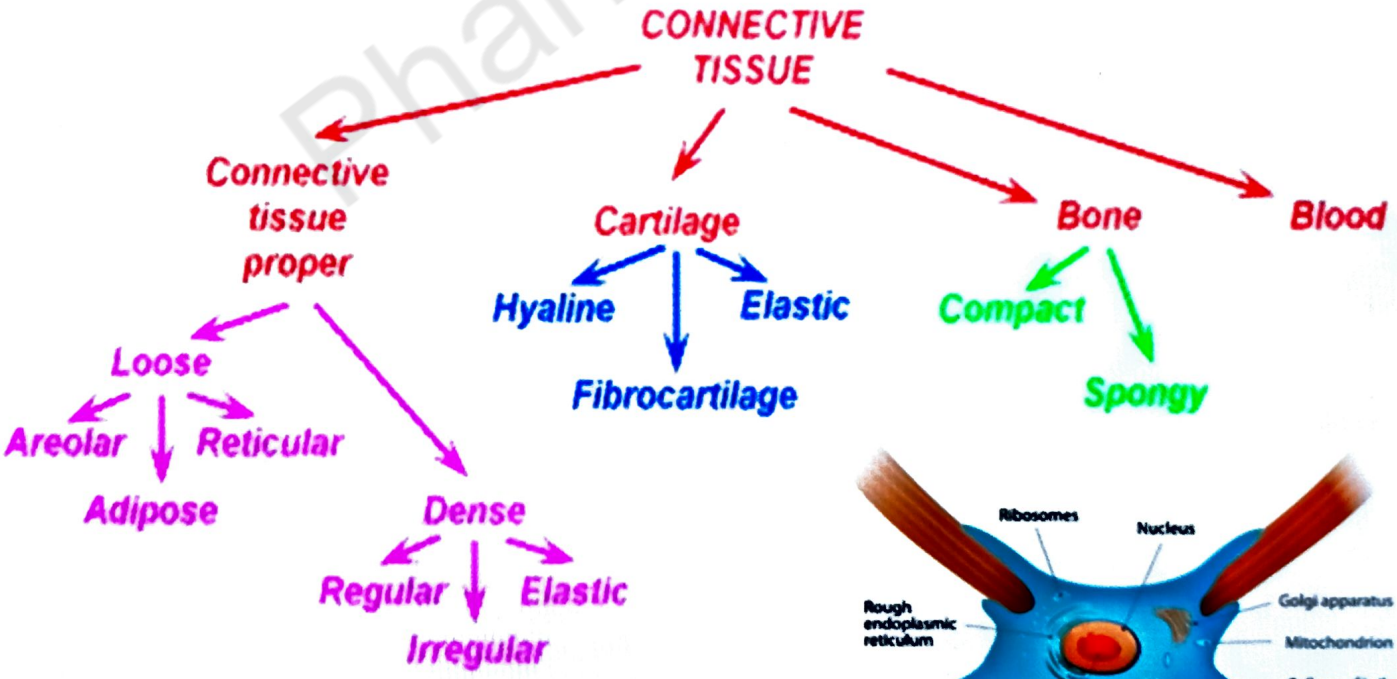
General features of Connective tissues

- Connective tissue consists of two basic elements: **extracellular matrix** and **cells**.
- A connective tissue's extracellular matrix is the material located between its **widely spaced cells.**
- The extracellular matrix consists of **protein fibers** and **ground substance,** the material between the cells and the fibers.
- The extracellular matrix is secreted by the **connective tissue cells** and determines the tissue's **qualities.**
- The extracellular matrix of bone is **hard** and **inflexible**.
- They are **highly vascular**
- They have a **rich blood supply**
- Mesodermal embryonic cells called **mesenchymal cells** give rise to the cells of connective tissue.
- Mature cells have reduced **capacities** for **cell division** and extracellular **matrix formation** and are mostly involved in maintaining the **matrix**



Classification of Connective tissues

Embryonic connective tissue	Mature connective tissue
Mesenchyme	**Loose connective tissue :** 1. Areolar connective tissue 2. Adipose tissue 3. Reticular connective tissue
Mucous connective tissue	**Dense connective tissue :** 1. Dense irregular connective tissue 2. Dense irregular connective tissue 3. Elastic connective tissue
	Cartilage : 1. Hyaline cartilage 2. Fibrocartilage 3. Elastic cartilage
	Bone tissue
	Liquid connective tissue : 1. Blood tissue 2. Lymph



1. Embryonic connective tissue

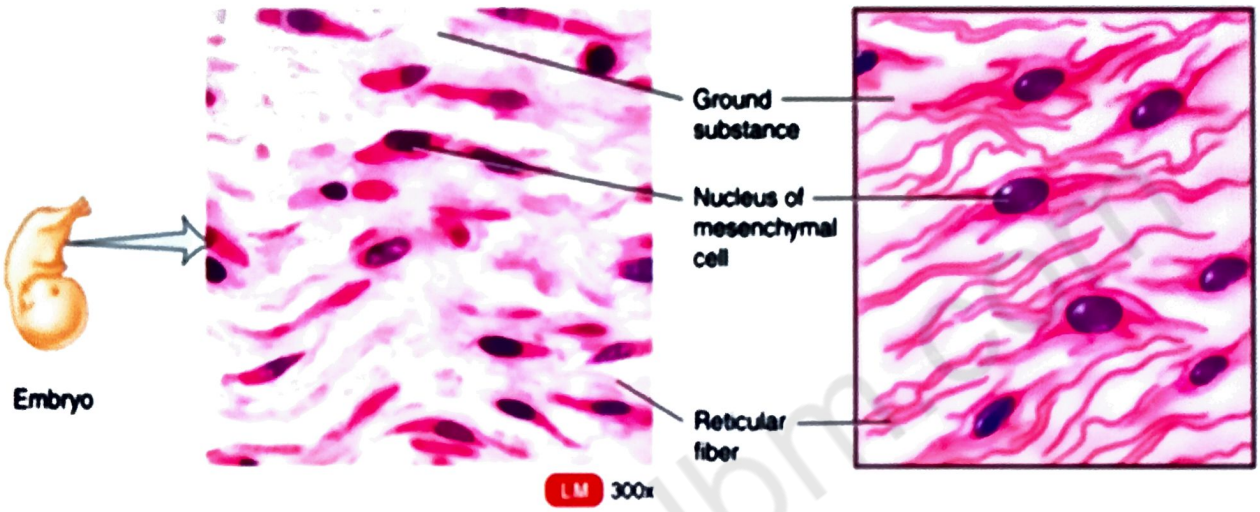
A. Mesenchyme

❖ **Description:**

- Consists of **irregularly shaped mesenchymal cells** embedded in a **semifluid** ground substance that contains **reticular fibers.**

❖ **Location:** Under **skin** and along **developing bones** of embryo; also present along **blood vessels**

❖ **Function:** **Forms** all other types of **connective tissue**



Sectional view of mesenchyme of a developing embryo

Mesenchyme

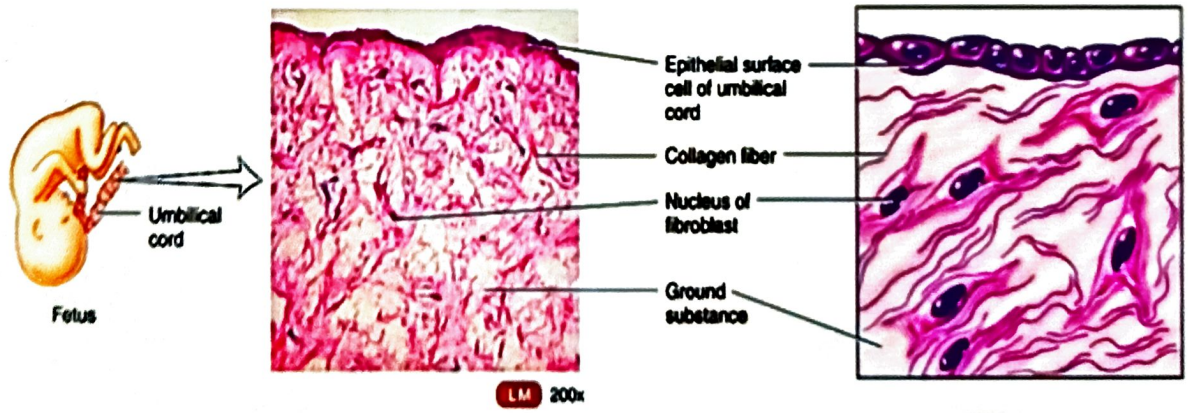
B. Mucous connective tissue

❖ **Description:**

- Consists of widely scattered **fibroblasts** embedded in a **viscous, jellylike** ground substance that contains **fine collagen fibers.**

❖ **Location:** **Umbilical cord** of fetus.

❖ **Function:** Support.



Sectional view of mucous connective tissue of the umbilical cord

Mucous connective tissue

2. Mature Connective Tissues

A. Loose Connective Tissue

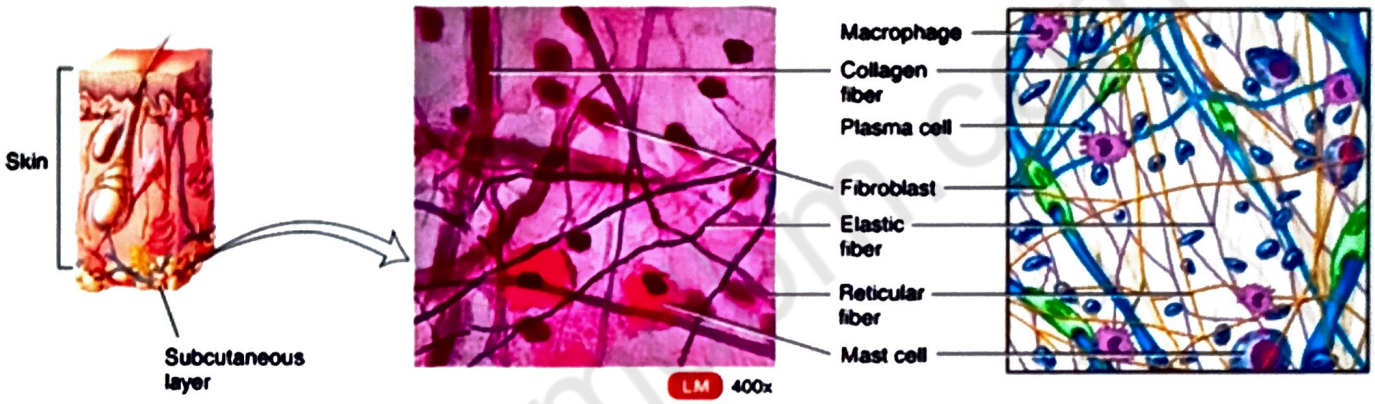
i. Alveolar Connective Tissue

❖ **Description:**

Consists of fibers (collagen, elastic, and reticular) and cells (fibroblasts, macrophages, plasma cells, adipocytes, and mast cells) embedded in a semifluid ground substance.

❖ **Location:** Subcutaneous layer deep to skin; (superficial) region of dermis of skin; lamina propria of; mucous membranes and around blood vessels, nerves, and body organs.

❖ **Function:** Strength, elasticity, and support.



Sectional view of subcutaneous areolar connective tissue

Areolar connective tissue

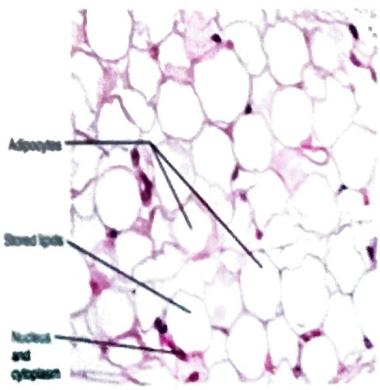
ii. Adipose tissue

❖ **Description:** It Consists of Adipocytes, it stores triglycerides (fats), large centrally located droplet; nucleus and cytoplasm are located at peripheral.

❖ **Location:** It is subcutaneous layer present around heart and kidneys, yellow bone marrow, joint pads, and behind eyeball

❖ **Function:**

- Heat loss is decreased through skin, energy reservoir supports, and protects.
- Brown adipose tissue in new born generates heat that helps maintain proper body temperature.



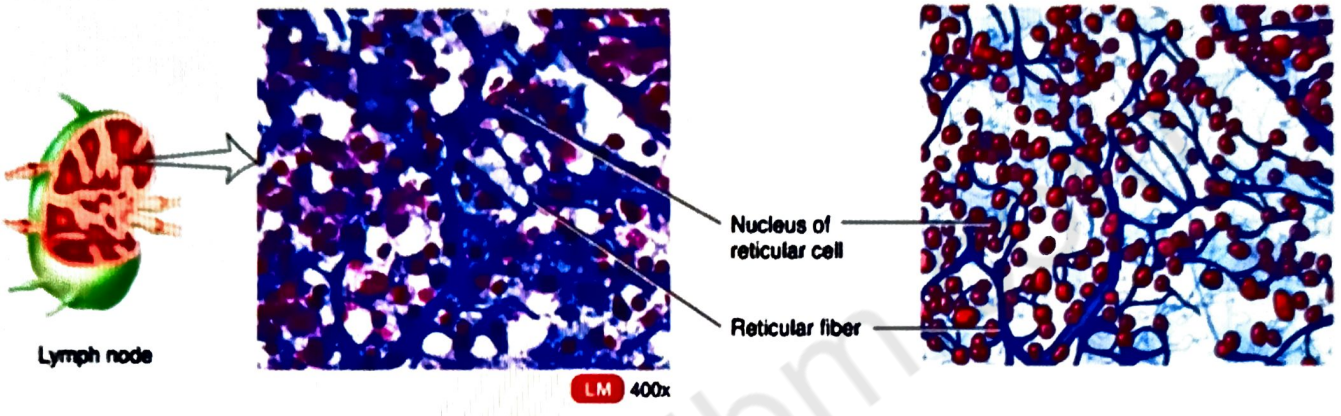
iii. Reticular connective tissue

- **Description:**

  A network of interlacing **reticular fibers** and **reticular cells.**

- **Location:** Stroma of **liver, spleen, lymph nodes; red bone marrow**, which gives rise to **blood cells**; **reticular lamina** of the basement membrane; and around blood vessels and muscles.

- **Function:** Forms **stroma** of organs; binds together smooth muscle tissue cells; filters and removes **worn-out** blood cells in the spleen and microbes in lymph nodes.



Sectional view of reticular connective tissue of a lymph node

Reticular connective tissue

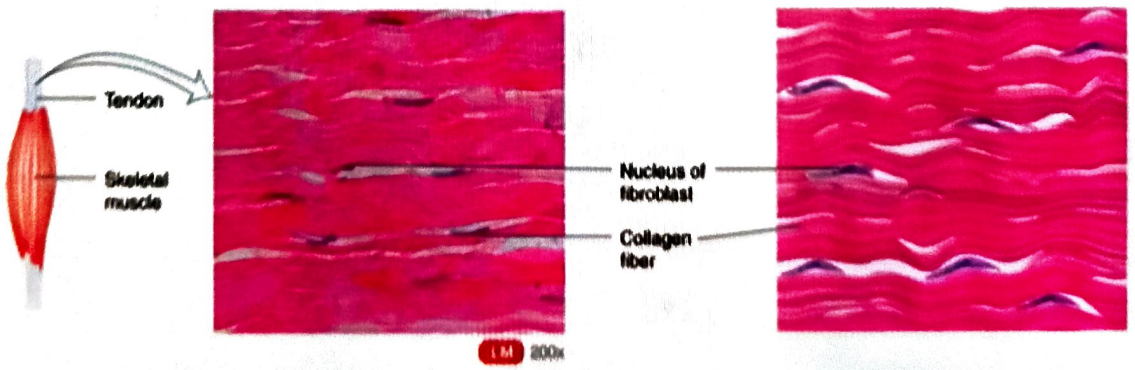
B. Dense connective tissue

i. Regular connective tissue

- **Description:** Extracellular matrix looks **shiny white**; consists of **collagen fibers**, arranged in **bundles**; **fibroblasts** present in rows between bundles.

- **Location:** Forms **tendons** , most **ligaments** , and **aponeuroses** (sheetlike tendons that attach muscle to muscle or muscle to bone).

- **Function:** Provides **strong attachment** between various structures.

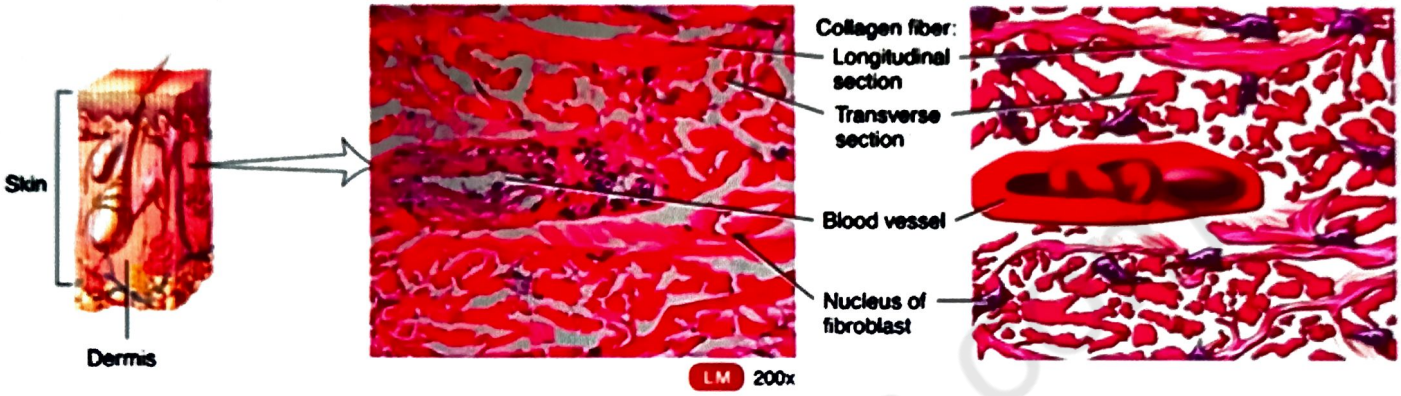


Sectional view of dense regular connective tissue of a tendon

Dense regular connective tissue

ii. Dense irregular connective tissue

- **Description**: Consists **collagen fibers** and a few **fibroblasts.**
- **Location**: **Fasciae** (Tissue beneath skin and around muscles and other organs), **reticular region** of dermis of skin, **periosteum** of bone, **perichondrium** of cartilage, **joint capsules, membrane capsules** around various organs (kidneys, liver, testes, lymph nodes), **pericardium** of the heart, and heart valves.
- **Function**: Provides **strength.**

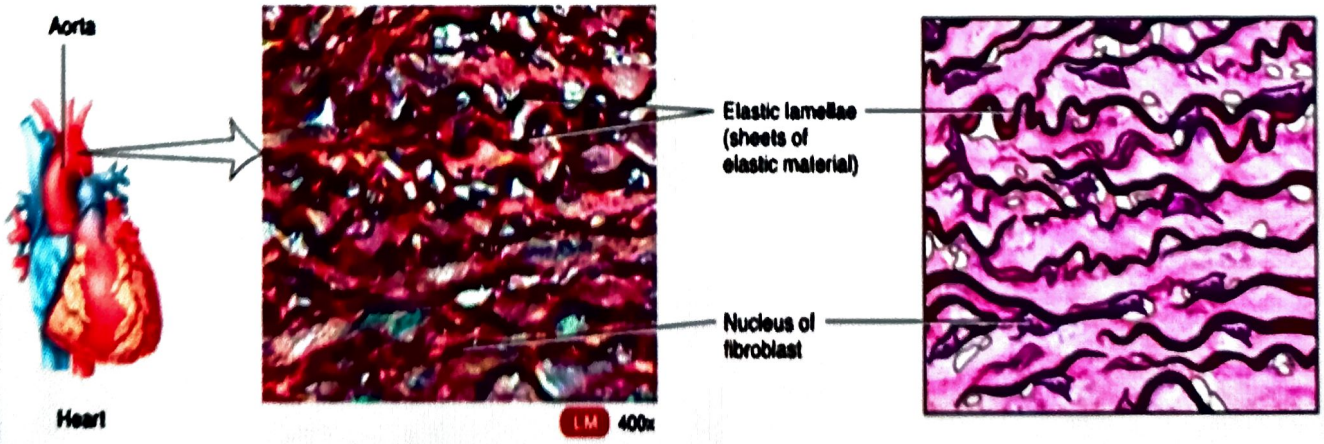


Sectional view of dense irregular connective tissue of reticular region of dermis

Dense irregular connective tissue

iii. Elastic connective tissue

- **Description**: Consists of **branching elastic fibers**; **fibroblasts** are present in between fibers.
- **Location**: **Lung tissue**, walls of **elastic arteries**, **trachea**, **bronchial tubes**, true vocal cords, suspensory ligament of penis, and some ligaments between **vertebrae**.
- **Function**: Allows stretching of various organs



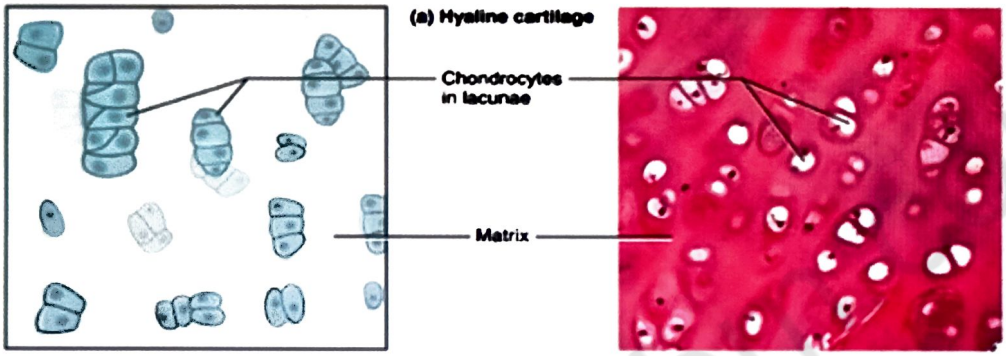
Sectional view of elastic connective tissue of aorta

Elastic connective tissue

C. Cartilage

i. Hyaline cartilage

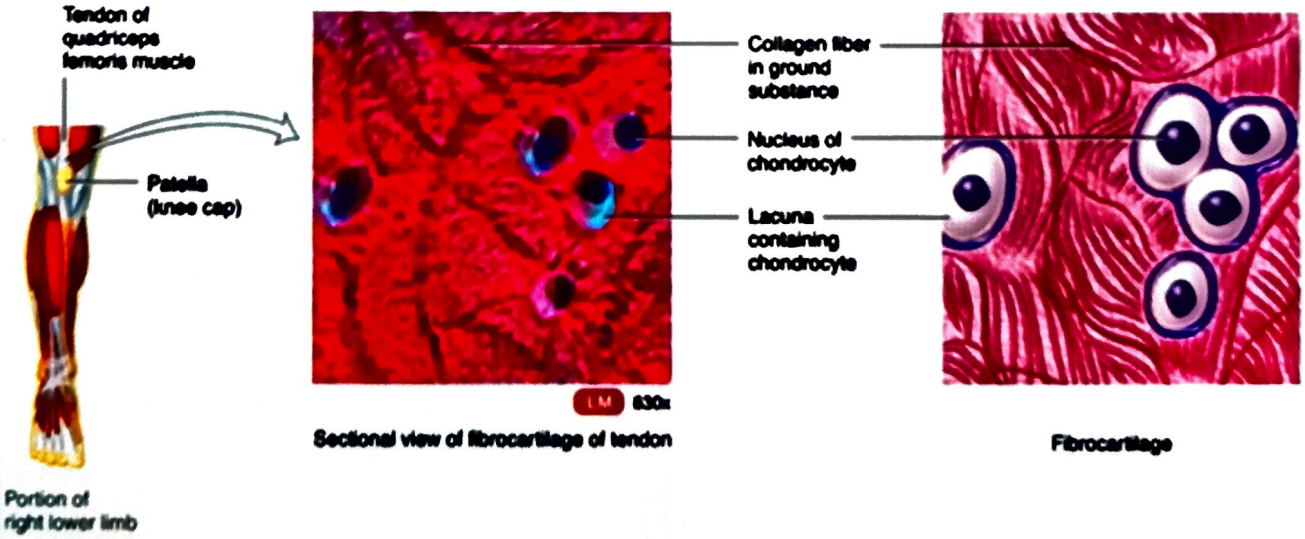
- **Description**: Consists of a **bluish-white, shiny** ground substance with thin, fine **collagen fibers** and many **chondrocytes**; most abundant type of cartilage.
- **Location**: Ends of **long bones**, anterior ends of ribs, nose, parts of larynx, trachea, bronchi, bronchial tubes, and embryonic and fetal skeleton.
- **Function**: Provides **smooth surfaces** for movement at joints, as well as flexibility and support.



ii. Fibrocartilage

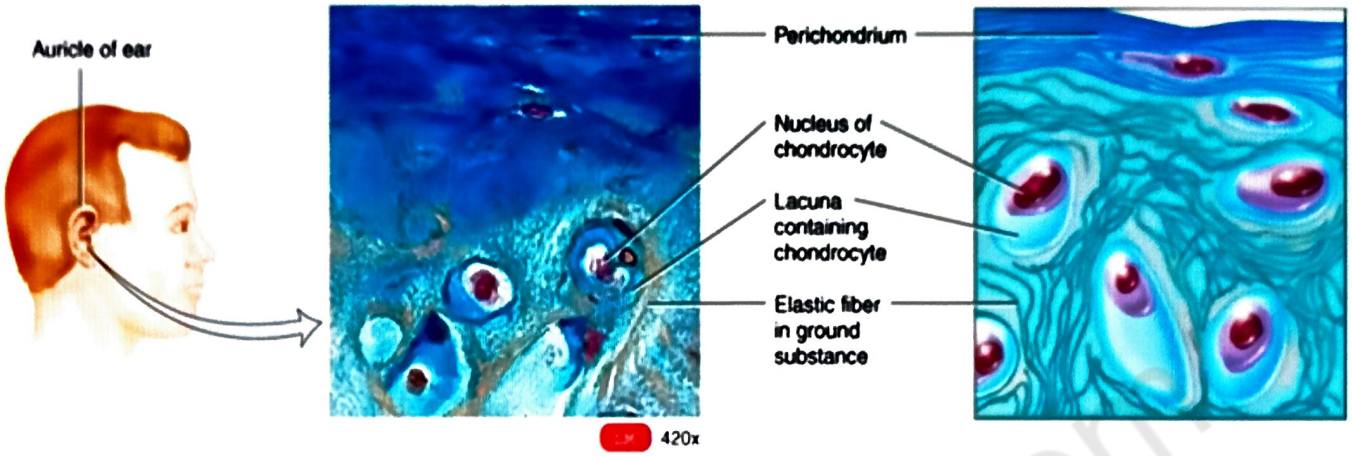
- **Description:**

  Consists of **chondrocytes** scattered in **thick bundles** of collagen fibers within the extracellular matrix.
- **Location**: **Pubic symphysis** intervertebral discs , menisci (cartilage pads) of knee, and portions of **tendons** that insert into cartilage.
- **Function**: Support and fusion.



iii. Elastic cartilage

- **Description**: Consists of **chondrocytes** located in a threadlike network of elastic fibers within the extracellular matrix.
- **Location**: **Epiglottis , auricle ,** and **eustachian tubes.**
- **Function**: Gives support and maintains **shape**



Sectional view of elastic cartilage of auricle of ear

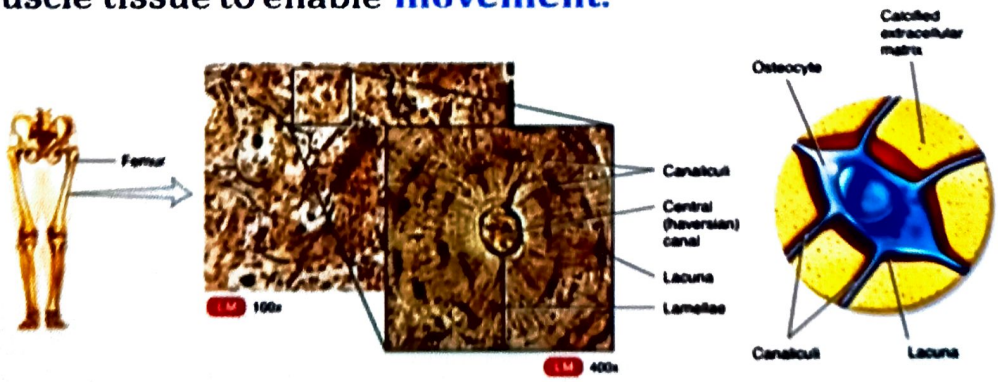
Elastic cartilage

D. Bone tissue

- **Description:**

- **Compact bone tissue** consists of **osteons** (haversian systems) that contain lamellae, lacunae, osteocytes, canaliculi, and central (haversian) canals.
- **Spongy bone tissue** consists of thin columns called **trabeculae**; spaces between trabeculae are filled with red bone marrow.

- **Location**: Both compact and spongy bone tissue make up the various parts of bones of the body.
- **Function**: Supports, protects , storage; blood-forming tissue; act with muscle tissue to enable **movement.**



Sectional view of several osteons (haversian systems) of femur (thigh bone) and details of one osteon

Details of an osteocyte

E. liquid connective tissue

i. Blood

❖ **Description:**

Consists of **blood plasma** and formed **elements**: **red blood cells** (erythrocytes), **white blood cells** (leukocytes), and **platelets** (thrombocytes).

❖ **Location:**

Within **blood vessels** (arteries, arterioles, capillaries, venules, and veins) and within the **chambers** of the heart.

❖ **Function:**

Red blood cells transport **oxygen** and some **carbon dioxide**; white blood cells carry on phagocytosis and are involved in **allergic reactions** and immune system responses; platelets are essential for the clotting of blood.