CHAPTER - 2ND

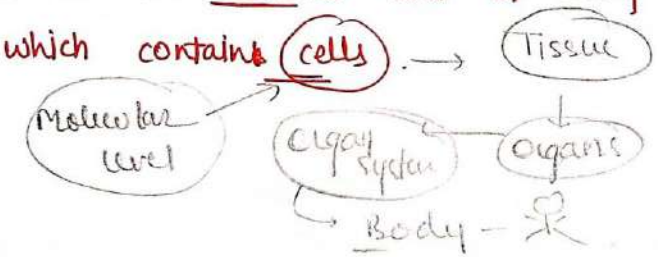
CELLULAR LEVEL OF ORGANISATION

- Syllabus →

① Structure and functions of cell, Transport across cell membrane, Cell division, cell Junctions. General principles of cell communication, Intracellular signalling pathway activation by extracellular signal molecule, forms of intracellular signalling ; a) Contact-dependent b) paracrine c) Synaptic d) Endocrine

---

- This is the cellular level of body which contains cells → Tissue → Organs → Organ System → Body



- Cell →

It is a structural, basic and functional unit of our body. (all living organism).

- A human body consist of about 10^{14} or 100 trillions cells with a size and mass of about 10 μm and 1 nanogram respectively.
- Cells are of two types :—

i) Prokaryotic cells →

These are those cells which are not fully developed. they have less developed nucleus and some organelles. eg. Bacteria etc.

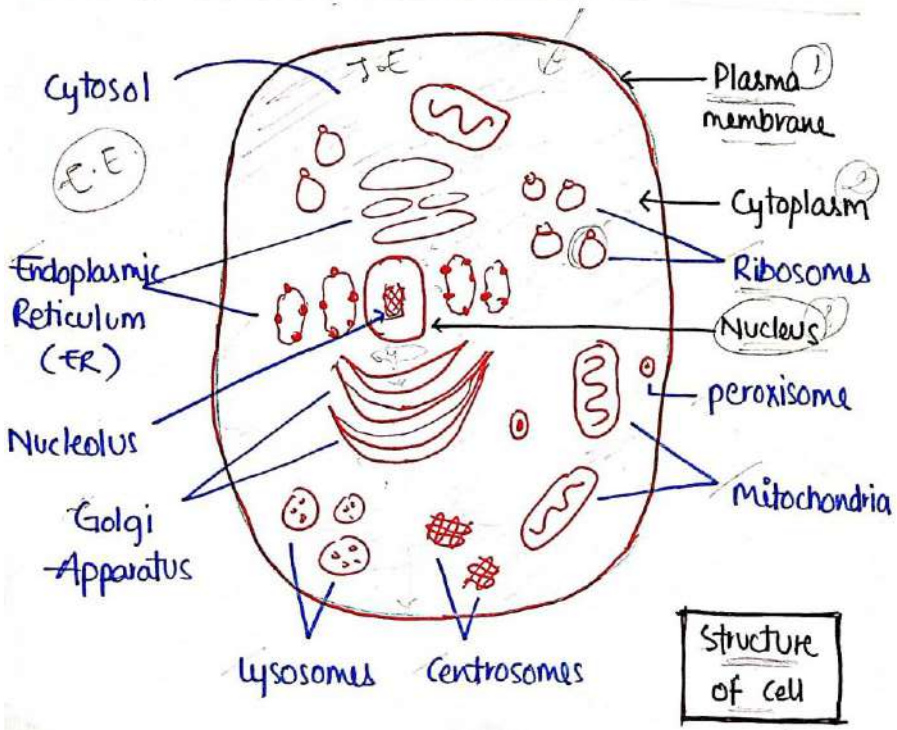
ii) Eukaryotic cells →

These are those cells which are fully developed, they

have well developed nucleus and other organelles present in cell.

(eg) plants, animals, fungi etc..

CELL → A cell is the basic living structural and functional unit of body enclosed within a membrane.

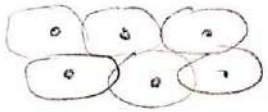


Structure of cell

- There are about 200 different types of cells in our body.

⊙ functions of cell →

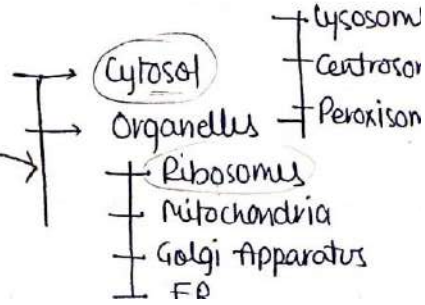
- Movement of substance across the cell membrane
- Cell growth and metabolism by cell division.
- protein synthesis by transcription and translation.



⊙ Structure of the cell →

It is divided into three major parts :—

i) Plasma membrane
ii) Cytoplasm and
iii) Nucleus.



i) Plasma Membrane →

Also known as Cell membrane.

- It is the outermost membrane of cell which (separate) out the internal environment of cell to the external environment.
- It is selectively (permeable) which allowing substances to pass through it.

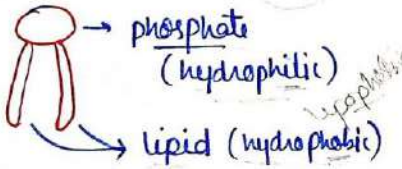
• **Structure** →

The **fluid-mosaic model** of plasma membrane was given by S.T. Singer and G.L. Nicholson.

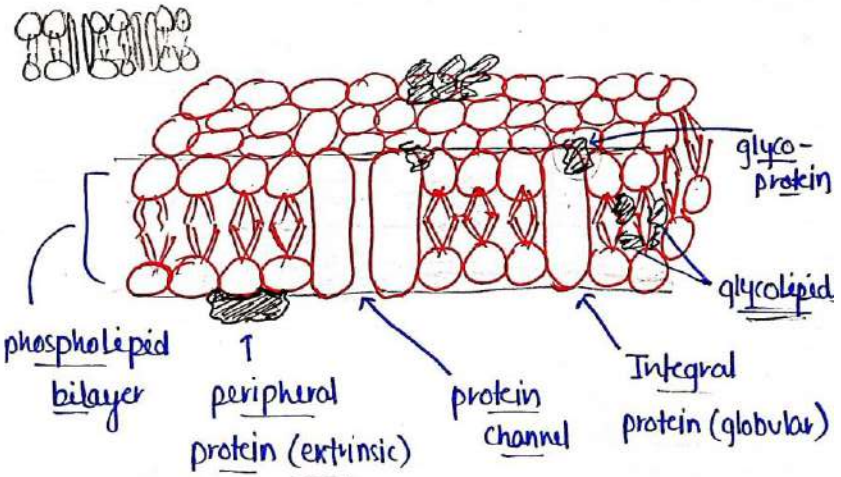
• It is made up with (bilayer) of (phospholipids)

• Chemical composition →

- Phospholipid → phosphate + lipids



- proteins, the lipid bilayer is embedded with proteins of various shape and sizes.
  (eg) Integral, Transmembrane & Peripheral proteins
- Carbohydrates, these molecules are attached with proteins (glycoprotein) and lipids (glycolipid



• **Functions** →

- It provide (protection) from external environment
- It give (shape) to the cell
- It (regulates) the flow of material into and

out to the cell.

- It also play a keyrole in communication with other cells or external environment.

ii) Cytoplasm →

It is the total area between the plasma membrane to the nucleus.

It further divided into two parts

2) Organelles 1) Cytosol

1) Cytosol → It is the fluid present inside the cells. It is transparent, viscous which contain about 75% to 90% mostly → water, proteins, lipids & carbohydrates. + organelles. (10%)

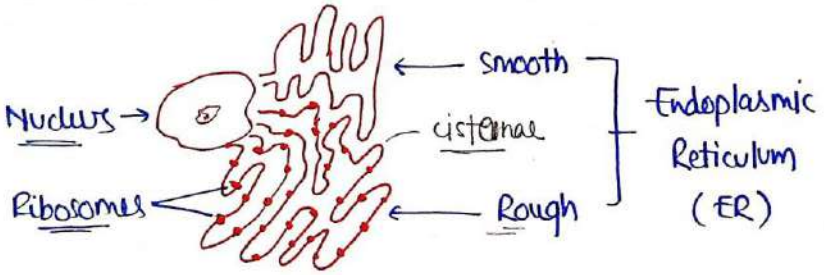
Cytoplasmic

2) Organelles → These are the organelles present in cytoplasm and perform specific function for cell.

- Endoplasmic Reticulum (ER)
- Golgi Apparatus / Body / complex
- Ribosomes
- Mitochondria
- Lysosomes
- Centrosomes
- peroxisome.

⊙ Endoplasmic Reticulum (ER) →

It is a complex channel system enclosed within the membrane in the form of three dimensional network that consists of vesicles, flattened sacs and branched tubules.



- It is of two types :—

i) Rough ER → those ER which have ribosomes attached, helped in protein and membrane synthesis.

ii) Smoth ER → Rebosomes are not attached.

- functions →

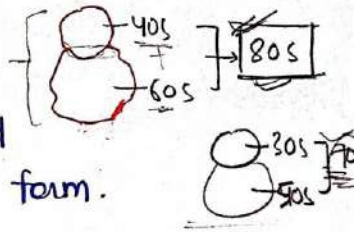
- Act as a structural framework of cytoplasm
- exchange materials
- SER → help in synthesis of phospholipids, cholesterol and triglycerides.

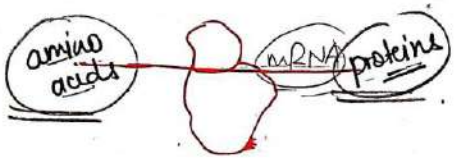
⊙ Ribosomes →

There are tiny spheres that contain ribosomal RNA & several ribosomal proteins.

- Also known as factory of proteins, because protein synthesis is takes placed in it.

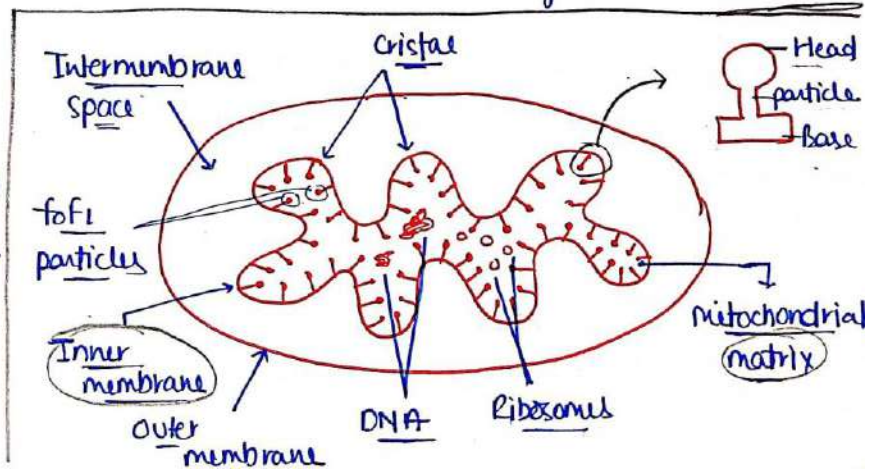
- There are made up with two subunits i.e. smaller subunits (40s) and the larger subunit (60s).
- two types → one is attached with E.R. and one is present in free form.





⊙ Mitochondria →

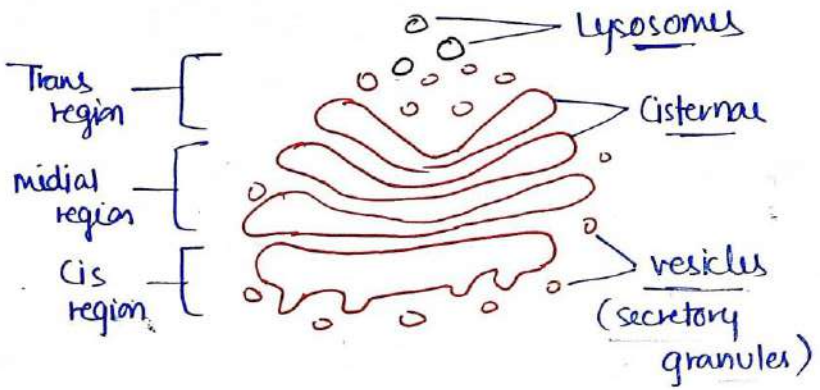
It is known as the Power House of cell, because it generate ATP.



- It is made up with two membranes i.e. inner and outer.
- the main function is to generate energy.
- also perform cellular signalling and regulates cellular (proliferation) - spread..

⊙ Golgi Apparatus / Body →

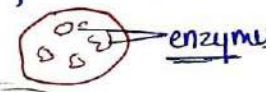
It consists of four to six flattened sacs called as cistern placed upon each other, like a pile of plates with expanded bulges at their ends.



- they (stores) proteins, (modify) them and also moved to the plasma membran through secretory granules, when required.
- Also helping in excreting excess amount of (water).

⊙ Lysosomes →

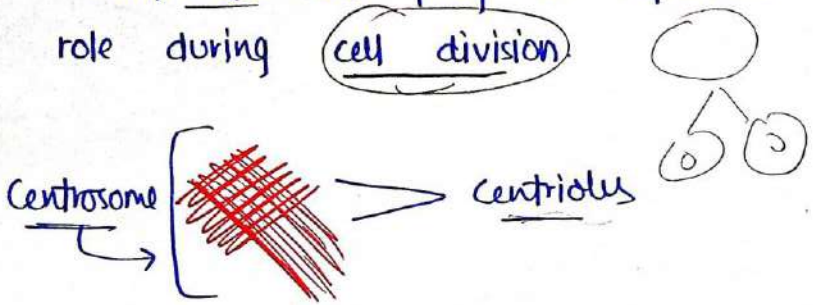
they are secretory formed from the golgi complex.



- they worked as the (digestive) system of cell, which contain digestive and hydrolytic enzymes and hydrolyse large molecules, such as RNA and DNA, proteins and lipids.
- vary in size, ranging from 0.1 - 1.2 micrometer.
- they also work as defencing against microorganism.

⊙ Centrosomes →

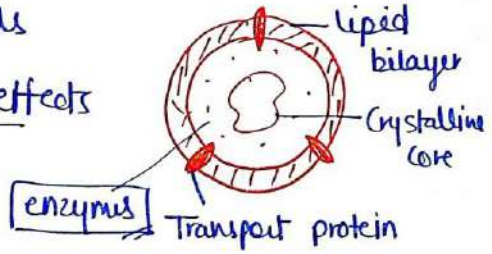
It consists of a pair of centrioles and play an important role during cell division



⊙ Peroxisome →

It contain many oxidases enzymes that can oxidize various organic substances such as fatty acid, amino acids, uric acid etc..

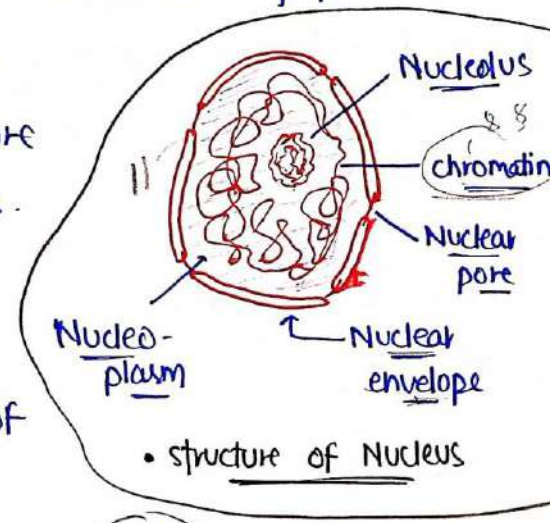
- It contain the enzyme catalase, and protect the cells against toxic effects of substances.



iii) Nucleus →

The nucleus is usually a spherical and oval shaped structure, which is largest in the cell.

- It consist of double membrane, which separate nucleus from the Cytoplasm.
- It contain a spherical structure called nucleolus.
- It is also known as the "control centre" of the cell.

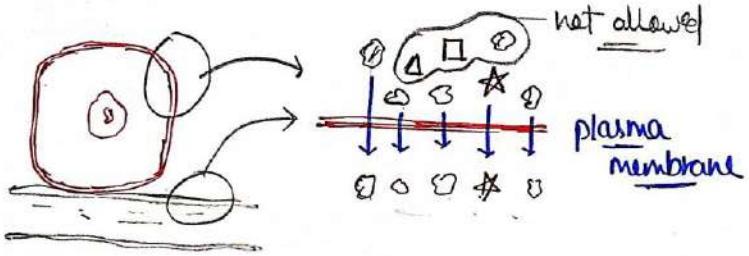


• structure of Nucleus

- It contains the genetic material including aggregations of protein DNA & RNA.
- It directly involves in the reproduction, and transfer all genetic information from parent cell to daughter cells.

TRANSPORT ACROSS MEMBRANES

- Plasma membrane of cells are selectively permeable, which allow only some substance to cross it.



- Membrane is a biological membrane, which is made up with phospholipids bilayer and allow substance to move through it, It is known as membrane transport

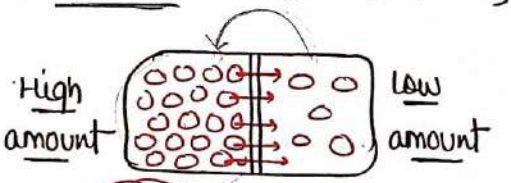
- Substances are transported across the cell membrane through :—

i) Passive transport — Passive diffusion, facilitated diffusion
ii) Active transport — Primary, secondary — transport
iii) Endocytosis

- Concentration Gradient →

When any drug / substance move from high concentration to lower concentration. [ज्यादा से कम]

against concentration gradient [कम से ज्यादा]



across conc^n gradient

i) Passive transport →

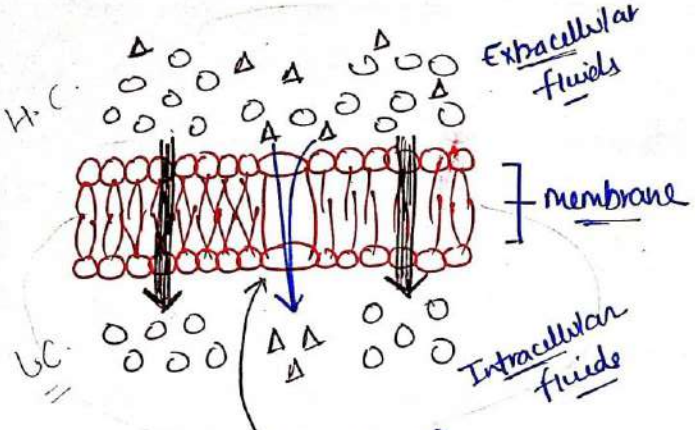
In this, substance transport across the conc^n gradient i.e. High to low

- passive diffusion →

It is the transport of substance across the conc^n gradient i.e. from the region of higher conc^n to lower conc^n without use of energy.

eg. diffusion of lipid soluble molecules like O_2 &

CO_2 across the cell membrane



for water soluble drugs ← pore (any channel) ← filtration → aq. diffusion

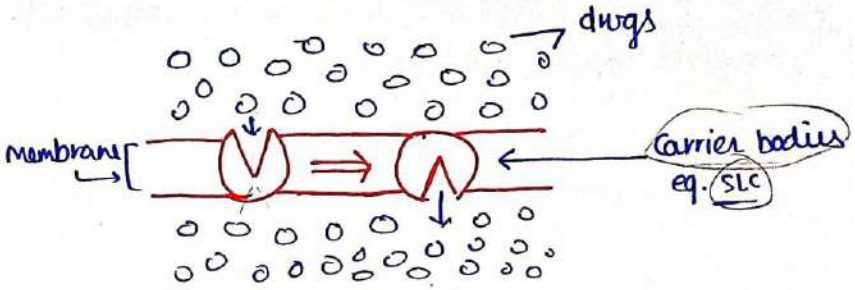
High to low, through aq. protein channel.

- facilitated diffusion →

In this, substance transport across the conc^n gradient, but with the help of any carrier bodies (that's why it is also called carrier mediated transport).

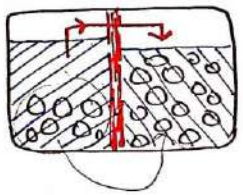
- It is suitable for poorly diffusible substance
- carrier used such as SLC (Solute carrier transporter)

eg. Entry of glucose into RBCs.
Intestinal absorption of Vit. B_1 & B_2.



- Osmosis →

It is the movement of solvent (water) particle from high to (solvent) low conc^n through semipermeable membrane. (from low solute conc^n to high solute conc^n).



ii) Active transport →

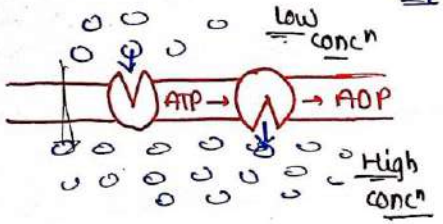
In this, substance transport opposite against the conc^n gradient with the help of energy.

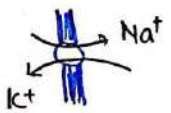
- In this, ATP is used, ATP $\xrightarrow{\text{hydrolysis}}$ ADP
- It is of two types :—
  - Primary active transport
  - Secondary active transport

- Primary active transport →

In this, ATP is used as a energy. eg. Absorption of glucose.

eg. Na^+K^+ ATPase pump.



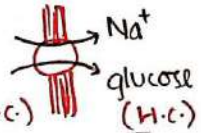


- Secondary active transport →

In this, electrochemical gradient are used instead of energy.

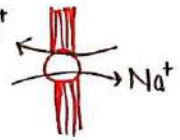
Symport (co-transport) → movement of both substance in same direction.

eg. Na^+-glucose symporter



Antiport (counter-transport) → movement of molecules in opposite direction.

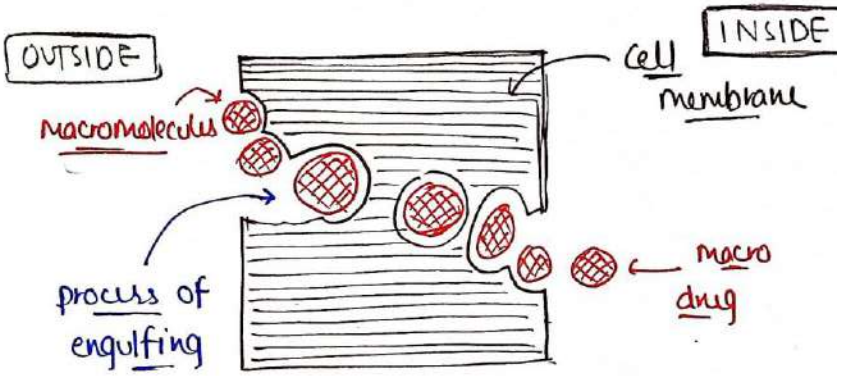
eg. H^+ Na^+ pump.



iii) Endocytosis →

In this transport, drugs of very large size molecules get transported via engulfment by cell membrane.

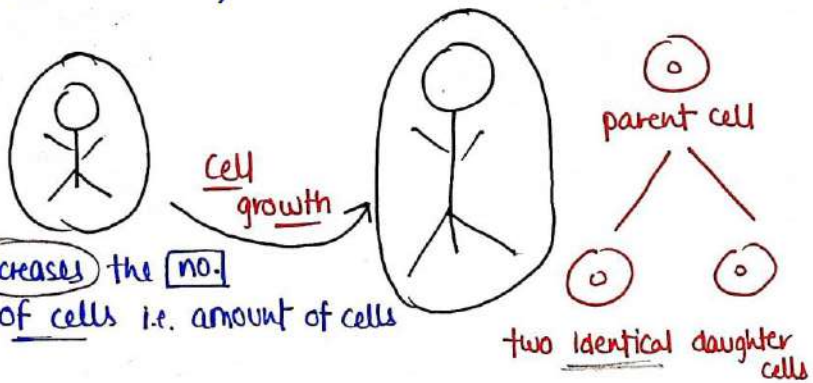
eg. Cellular uptake of macromolecular like fat, starch, oil-soluble vitamins like A, D, E, K and drug like Insulin.



- Phagocytosis [cell eating] → adsorptic uptake of solid particulates.
- Pinocytosis [cell drinking] → uptake of fluid solute

CELL DIVISION

It is a process by which a parent cell divides into two daughter cells. The genetic content (DNA) of newly formed cell is exactly same to the parent cell.



- Increases the no. of cells i.e. amount of cells

⊙ Cell division is of two types :-

i) Mitosis → responsible for growth of cells. (mitotic (M-phase)) no. of chromosome same [equational division] occurs in somatic cells.

ii) Mejosis → responsible for formation of gametes (sperm & eggs) cells. occurs in reproductive cells and no. of chromosome decreased [Reductional division]

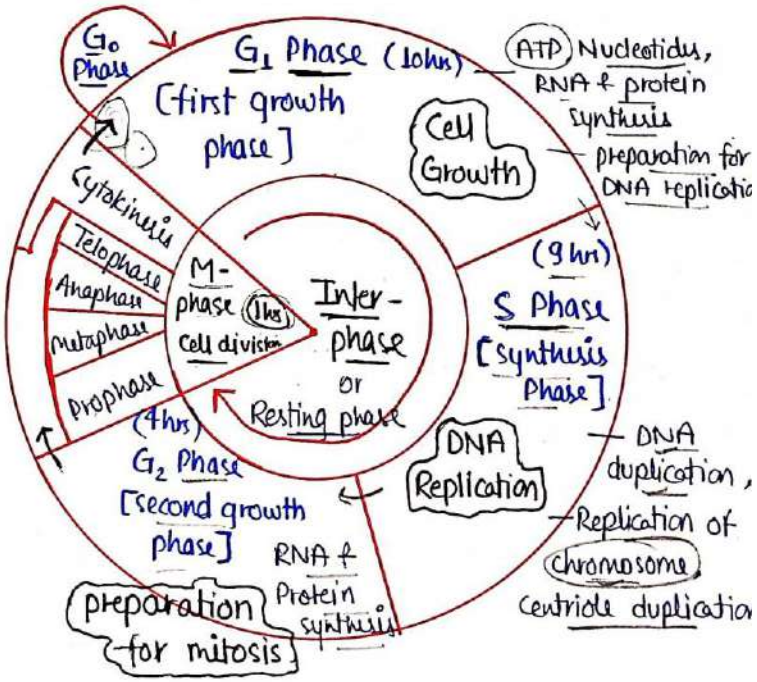
- Cell cycle → (24 hrs)

The sequence of events by which a cell duplicates its genome, synthesis the other constituents (organelles) of the cell and eventually divides into two daughter cells.

- It has two phases :-

i) Interphase - preparation.

ii) M-phase - cell division



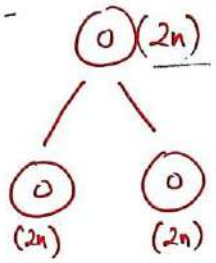
1) Mitosis →

Also known as (M-phase) or Mitotic phase [Equational division]. (animal cells)

- It is occurs in (somatic cell) in which already existing parent cell divides into two identical daughter cells.
- In this, the no. of chromose in daughter cell is (same) as the no. of chromosome in parent cell.
- It is occurs into two parts--

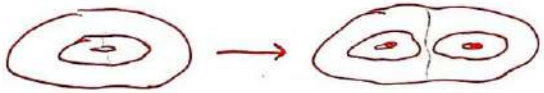
i) Karyokinesis
ii) Cytokinesis

- Prophase
- Metaphase
- Anaphase
- Telophase

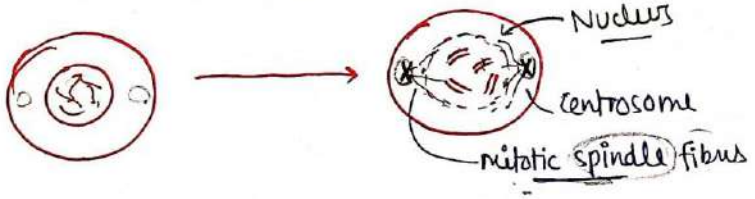


i) Karyokinesis →

It is a process by which the cell (nucleus) divides into two daughter nuclei.



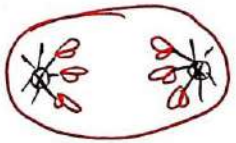
- Prophase → This phase begins with initiation of (condensation of) the chromosal material i.e. (chromatin)
  - Centrioles [centrosome] move towards the opposite poles of the cell.
  - Organelles like golgi complex, ER, Nucleolus, and Nuclear envelope disappear at the end of prophase



- Metaphase → This phase begins with complete disintegration of nuclear envelope.
  - chromosomal condensation completed and two sister chromatids are holds together by centromere
  - kinetochores (small disc shaped) at the surface of centromere
  - ⊙ Spindle fibre attaches to kinetochores and chromosomes are moved to spindle equator and get alligned.

• Anaphase → Begins with splitting of each chromosomes.

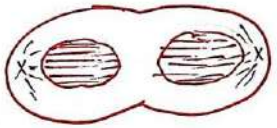
- Separation of chromatids and move towards opposite poles.



• Telophase →

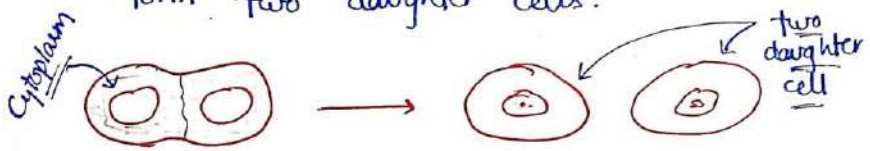
Last stage of mitosis and in this, chromosomes loose individuality (decondensation) and chromatin material is collected as a mass at two poles.

- Nuclear membrane reappear and two nuclear formed
- other organelles reappears..



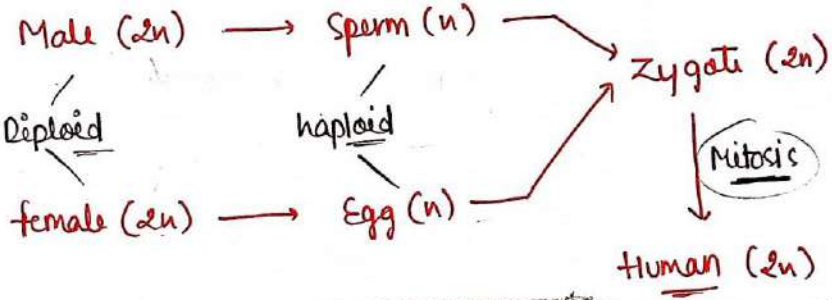
ii) Cytokinesis →

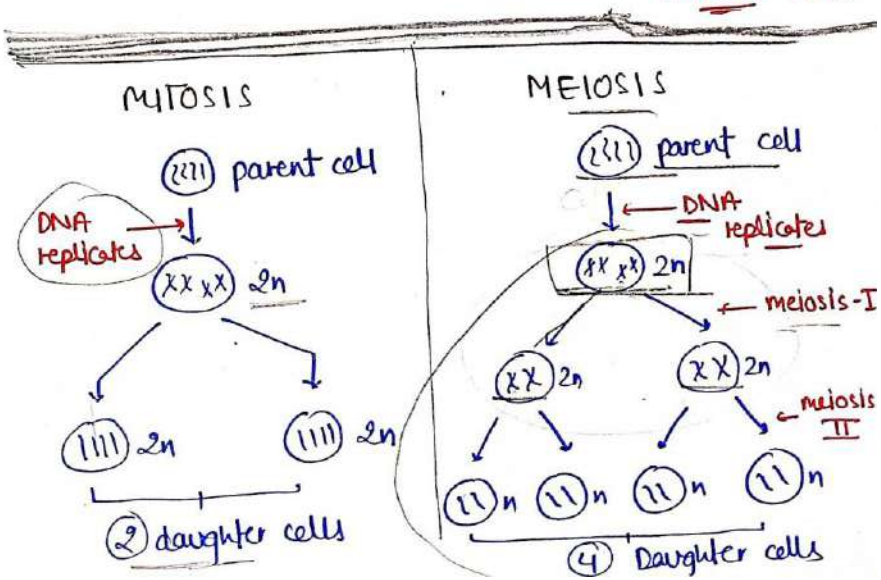
It is the division of parent cell cytoplasm after nucleus division to form two daughter cells.



2) Meiosis →

It occurs in gamete cells (reproductive cells). In this, offsprings are produced by the fusion of a female gamete and a male gamete





- It occurs in two stages :—

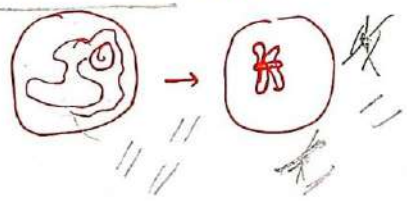
i) Meiosis - I
- Prophase - I
  - Leptotene
  - Zygotene
  - Pachytene
  - Diplotene
  - Diakinesis
- Metaphase - I
- Anaphase - I
- Telophase - I

ii) Meiosis - II
- Prophase - II
- Metaphase - II
- Anaphase - II
- Telophase - II

i) Meiosis - I → It is divided into four phases.

- Prophase - I → It is longer and more complex, It is further sub-divided into five phases —

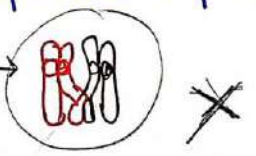
a) Leptotene phase →
condensation of chromosome starts.



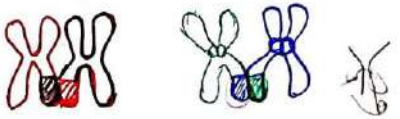
b) Zygotene phase →
pairing of chromosomes, and the paired chromosome refered as homologous chromosomes
- process is known as synapsis and
- formed synaptonemal complex.

c) Pachytene phase →
exchange of genetic material b/w two homologous chromosomes.
i.e. crossing over

d) Diplotene phase →
dissolution of synaptonemal complex and formed x-shaped structure termed as chiasmata

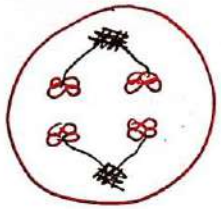


e) Diakinesis phase →
Terminalisation (separation) of chiasmata,
chromosome condensation completed, mitotic spindle is assembled, Nucleolus and nuclear envelop disappear.



• **Metaphase - I** →

chromosomes allign at the equatorial plate. microtubules are seen attaching to the pair.

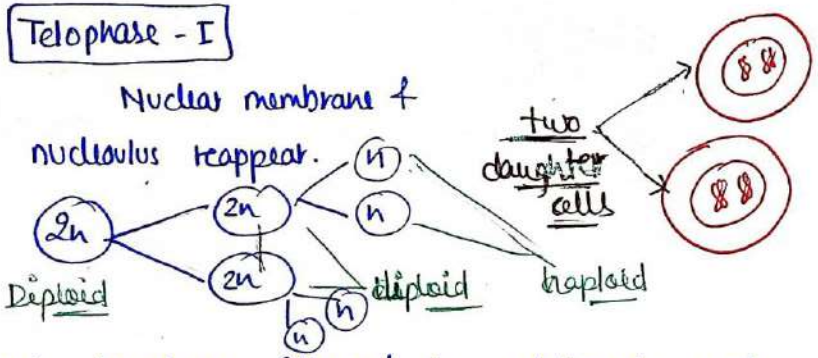


• **Anaphase - I**

Homologous chromosomes separated.

• **Telophase - I**

Nuclear membrane & nucleolus reappear.



this telophase followed by cytokinesis and formed two haploid (gametes) cells.

⊙ Interkinesis → It is the stage between two meiotic divisions and usually lasts for a short period of time

ii) Meiosis II →

It is similar as normal mitosis. It also comprises of four stages :-

• **Prophase - II** →

condensation of chromosomes, formation of spindles and disappearance of nucleus.

• **Metaphase - II**

equatorial alignment of chromosomes.

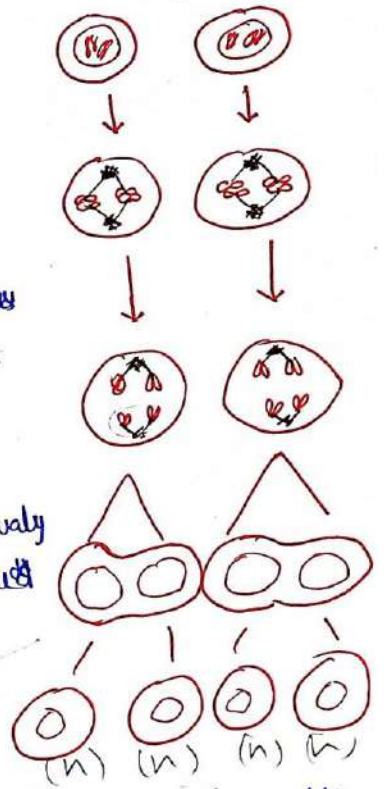
• **Anaphase - II**

separation of chromatides and move towards opposite polls.

• **Telophase - II**

chromosomes loose indivisualy and chromatin material is collected as mass of two polls.

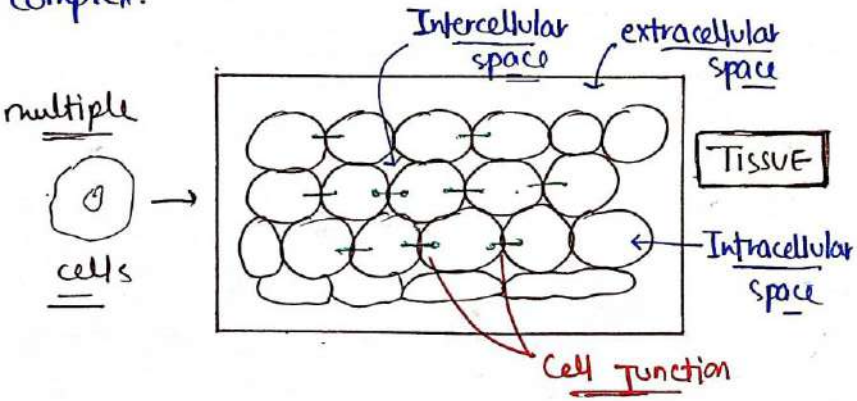
- Nuclear membrane reappear & organelles - -



• **Cytokinesis** → separation of cytoplasm & formed four daughter cells.

CELL JUNCTION

- It is the contact/connection (adhesion) between the neighboring cells or between a cell and the extracellular matrix.
- These are made up with multiprotein complex.



- They are present in various cells, but their number is more in epithelial tissue (skin, glands, organs like kidney & lungs).

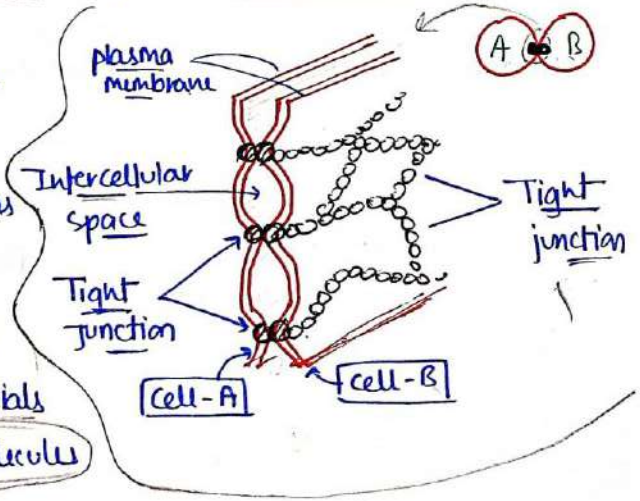
- functions →
  - they creates the (1) communications between the cells.
  - they maintain the paracellular (2) barrier and prevent the movement of unwanted water solutes and other substances.
  - helps in (3) attachment of cells and also responsible for (4) transfer of substances & ions
  - also provide (5) stregnth to the cells.

- Types →
  they are divided into five parts :—
  i) Tight Junction — seal / prevent leakage
  ii) Adhevens Junction
  iii) Desmosome
  iv) Hemi-desmosome
  (ii, iii, iv) — prevent separation of cells
  v) Gap Junction — communication

i) Tight Junction →

It is also known as zonula and occluding Junctions.

- It is a tight, (seal) packed junction b/w two adjacent cells.
- In this, cells are (held) (tightly) against each other by proteins i.e. claudins & occludins.

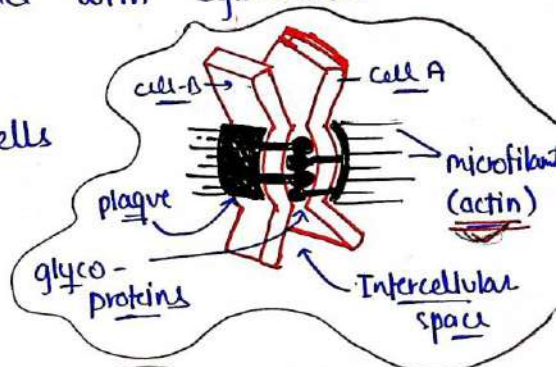


- prevent the (leakage) of various substances b/w cells.
- prevent the entry of materials like (macromolecules) and fluids.
- They are mostly found in epithelial tissue includes organs (i.e skin), blood vessels and cavities.
  (eg.) Urinary bladder.

ii) Adherens junction →

These are the strong adhesion site b/w the cells.

- they provide strong mechanical attachement b/w the adjacent cells through the linkage of cytoplasmic face with cytoskeleton.
- they prevent separation of cells during contractile process.
- (eg.) present in cells of epithelial & (cardiac) muscle tissue
  heart working



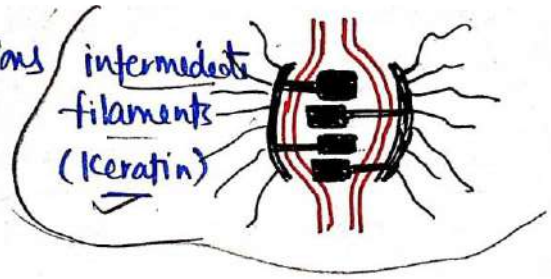
iii) Desmosomes →

macula adherens

they are also work same as adherens junction, i.e. they are the type of these junctions.

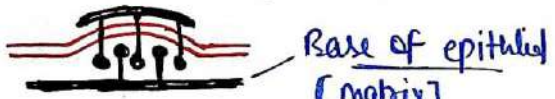
- they present in the form of continuous, belt like or scattered filaments i.e (keratin)

- spot-like adhesive junctions
- function, location same.



iv) Hemidesmosome →

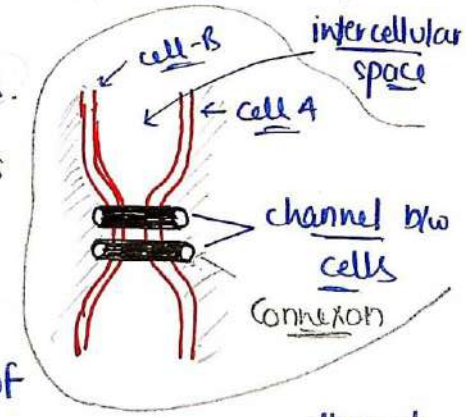
Another type of adhering junction. In this, cell is connect with the base of epithelial cells.



v) Gap Junction →

Also known as Nexus.

- In this junctions, channels are formed which connects adjacent the cytoplasm of two cells.



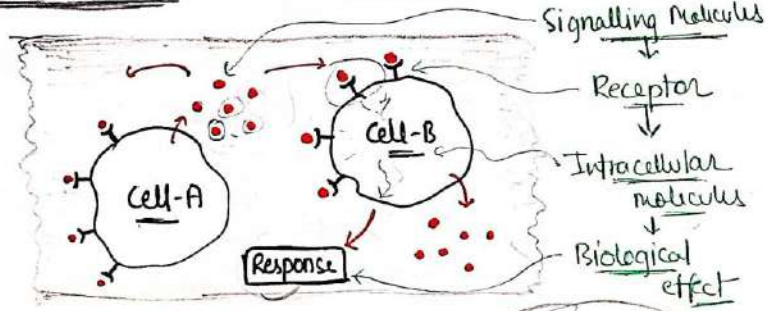
- It allows rapid transfer of ions, small molecules, nutrients etc.. (substances) through channels.
- conduction of electrical signals from one cell to another. (eg.) b/w adjacent cardiac muscle cells.

b/w smooth muscle cells.

CELL COMMUNICATION

Also known as "Cell Signalling".

- It is the communication b/w the cells.
- In this, the cell transmit (send), receive and process the signal from one cell to another cell or with itself.



- It is important to maintain homeostasis.
  - for growth and development of cells.
- they communicate with each other to help in transport substances, generate electrical potential across cell membrane and respond to change occuring in internal & external environment.

- General principle →

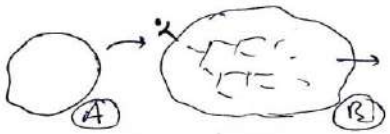
In cell communication, one cell send it signals (i.e. Ligands) which received by the receptor of another cell, then receptor activates and give response through secondary messengers [eg. cAMP, IP3]. (target cell)

- Intracellular signalling pathway activation by extracellular signal molecule →

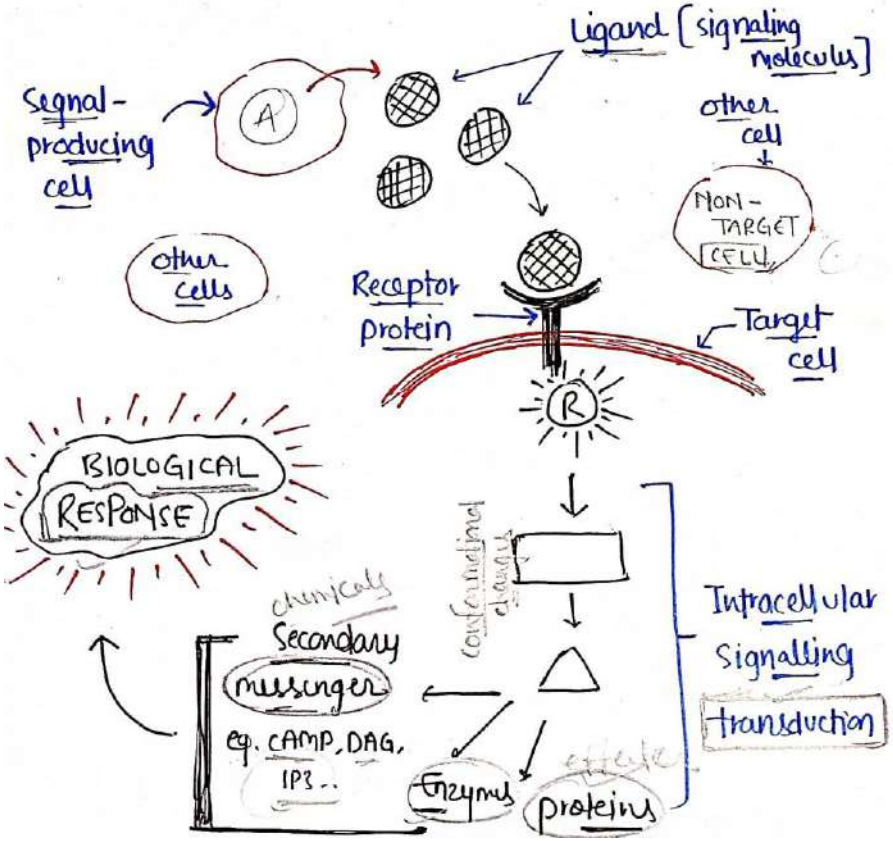
Cell communication is of two types:-

i) Intercellular signalling [extracellular] → It refers to the communication between the cells.

ii) Intracellular signalling → It refers to the pathway which involves various chain within the cell → Inside the cell.



• Intracellular signalling primarily uses external signal in the form of messenger or hormones.
- these signal are produced by 'signal-producing cells' and recognised by 'target cells' (receptors).
- these signals then transduced into an intracellular signalling chain.



- It is completed in three steps:-

Reception → Ligand + Receptor (signalling molecules) — where the ligand binds

↓

Transduction → intracellular signalling

↓

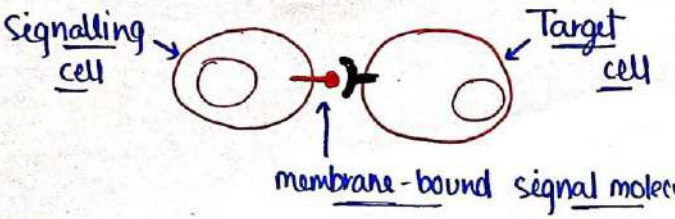
Response → cellular responses..

@ forms of Intracellular Signalling

these are of following types:-

a) Contact-dependent
b) Paracrine
c) Synaptic
d) Endocrine
e) Autocrine Signalling

a) Contact-dependent →
In this, one cell is directly in contact with another cell through membrane-membrane contact.

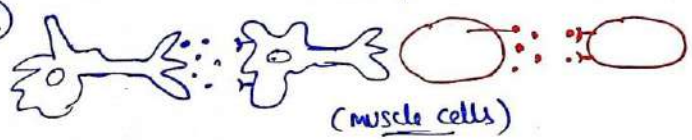


(eg) b/w immune cells - initiation of immune response

b) Paracrine signalling →

In this, target cell is very close signaling cell and communication occured b/w nearby cells.

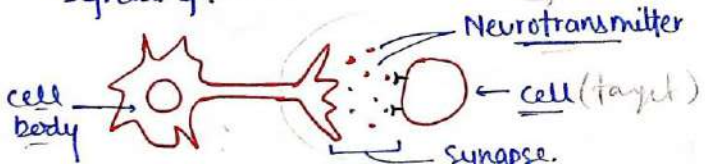
eg.



c) Synaptic signalling →

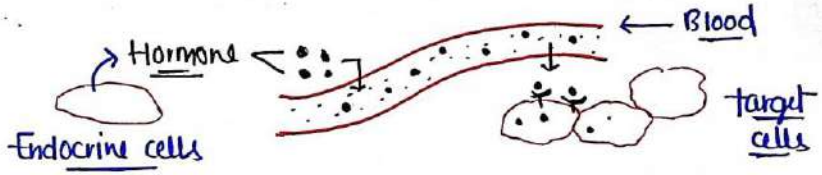
It is occurs between neurons and target cells, which is one type of juxtacrine (electrical) synapse and paracrine (chemical) synapse signalling.

eg



d) Endocrine Signalling →

In this, signalling molecules i.e. hormones reached into its target cells through blood. eg. Estrogen etc..



e) Autocrine signalling →

It this, signalling molecules attached on the receptor of same cell from which signalling molecules was produced

eg.

the growth of cancer cell