DEPTH OF BIOLOGY

Unit - I

Introduction to human body

Definition and scope of anatomy and physiology, levels of structural organization and body systems, basic life processes, homeostasis, basic anatomical terminology.

Cellular level of organization

Structure and functions of cell, transport across cell membrane, cell division, [*cell junctions. General principles of cell communication, intracellular signaling pathway activation by extracellular signal molecule, Forms of intracellular signaling: a) Contact-dependent b) Paracrine c) Synaptic d) Endocrine]

Tissue level of organization

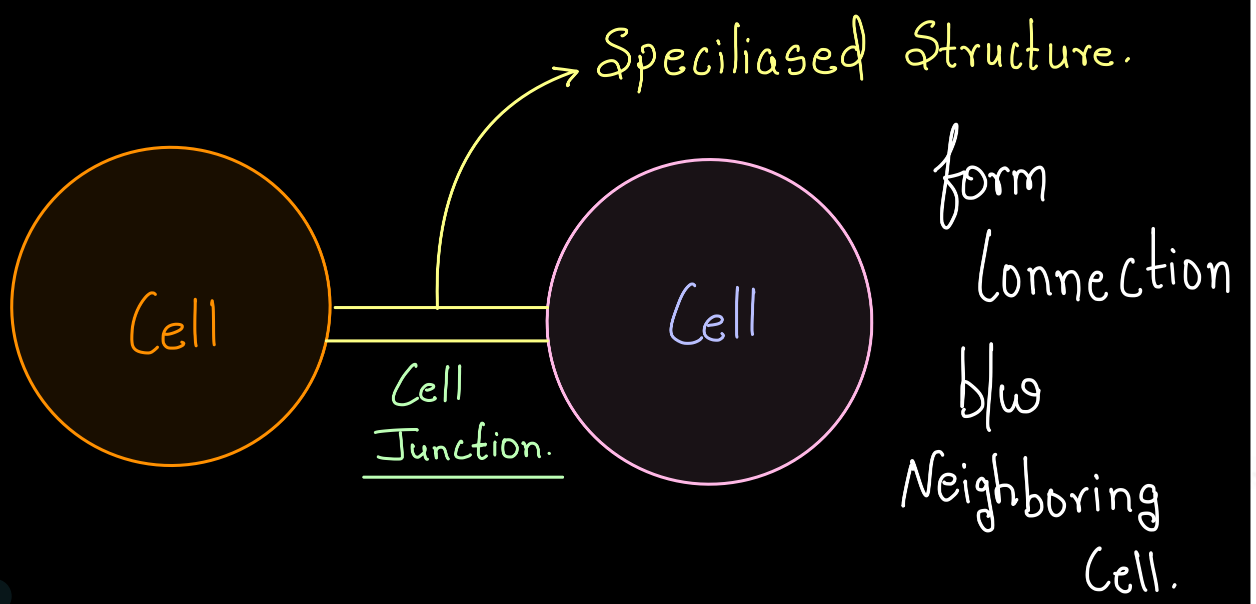
Classification of tissues, structure, location and functions of epithelial, muscular and nervous and connective tissues.

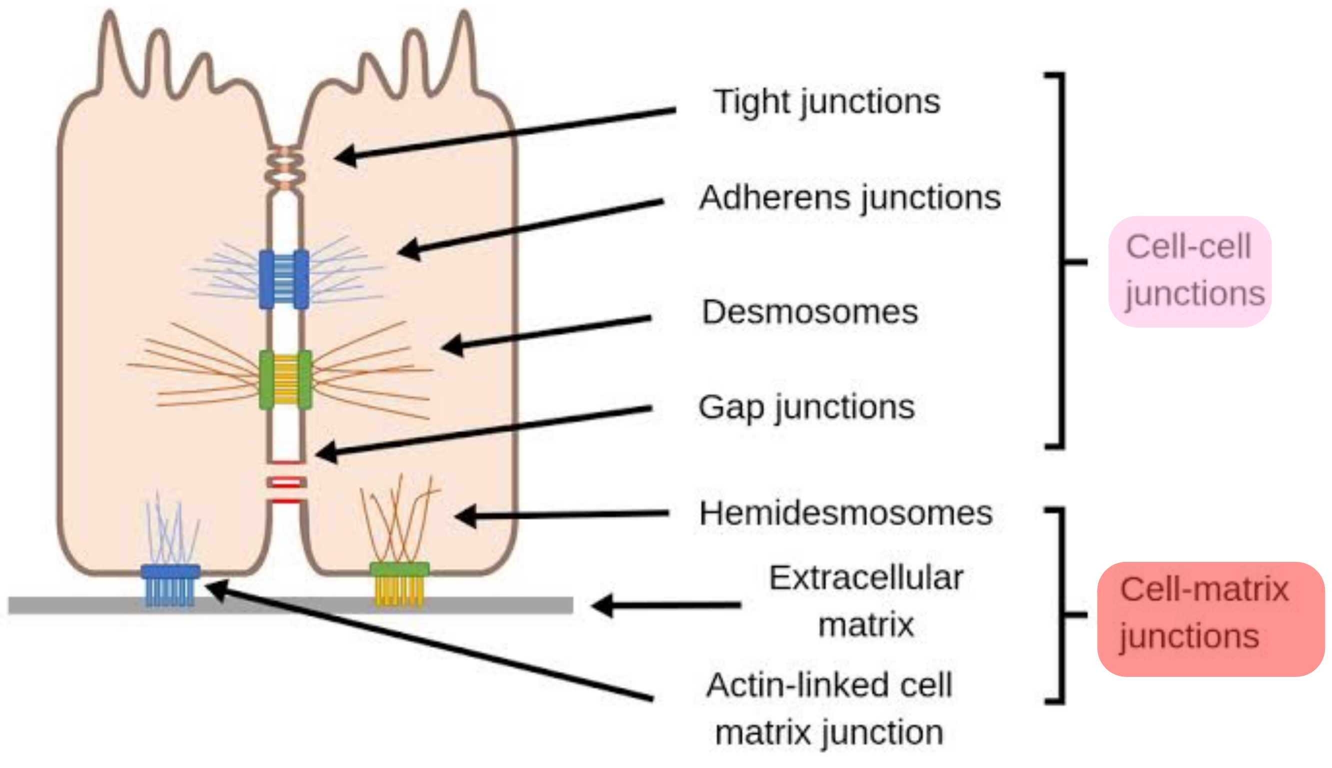
Transport across Cell Membrane ← **Cell junctions** → (Helps in) Cell Communication, Adhere Each Other

Cell junctions are specialized structures that form connections between neighboring cells. These connections enable cells to communicate with each other, maintain tissue integrity, and perform coordinated functions.

There are several types of cell junctions, each with specific roles in cellular interaction and tissue organization.

Here are the main types of cell junctions:





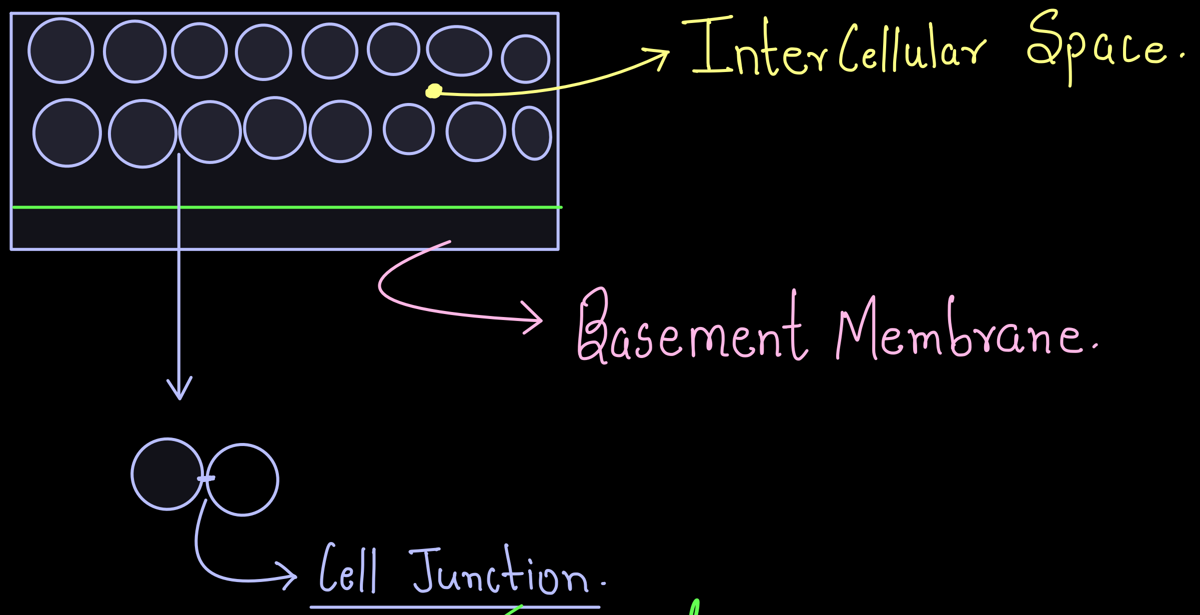
Cell Junctions

Cell Junctions → Connection b/w 2 Cell.

Or

Connection b/w Cell & Extracellular Matrix.

Cells → Tissue.



Cell Junction:

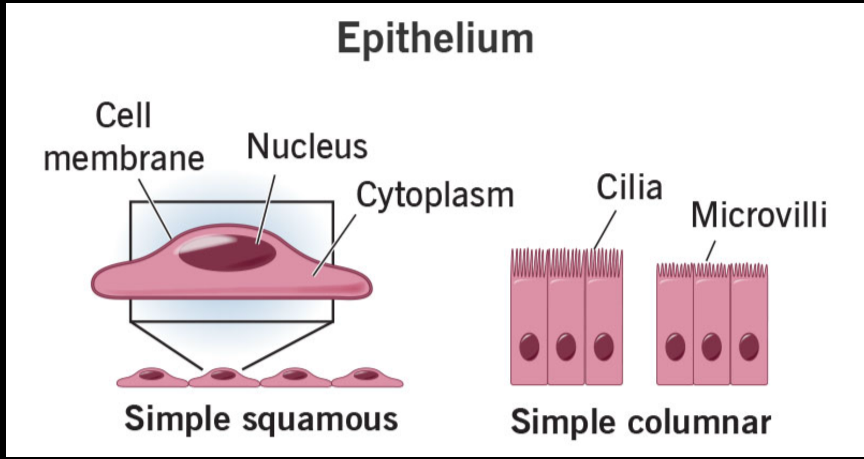
- → formed by Protein Complex.
- → Play Crucial role in Cell Communication, Adhere each other. & transport of Substance across Cell Membrane.

Tight Junction

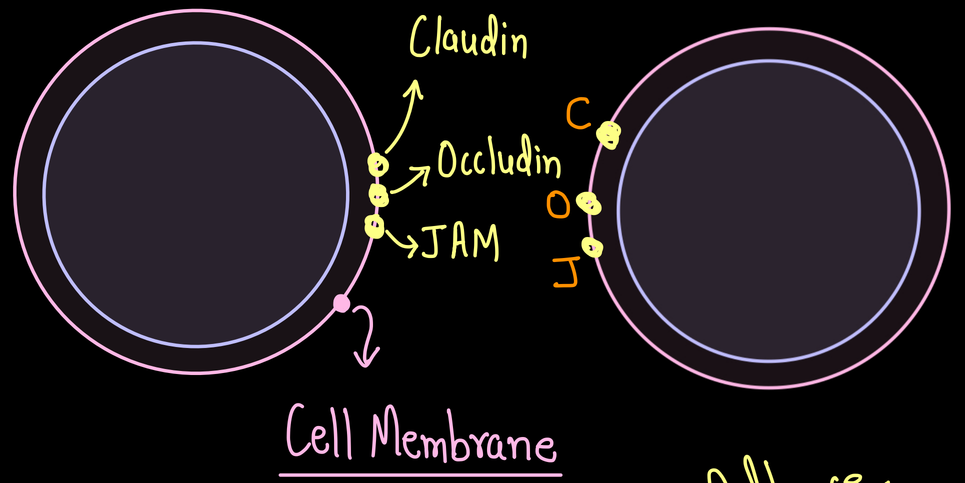
Or Also Known as Occluding or Zona Occluden

- Found in Epithelial Cell & Endothelial Cell

Endothelial Cell → found in Inner Surface of Blood Vessel.



* Formed by fusion of two adjacent Cell Membrane.



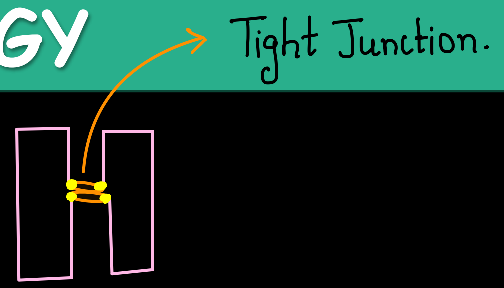
[C – C
O – O] → Adhere.

[C – C, O – O] → that Creates Seal & Barrier

Claudins: The most important and diverse family; determine the permeability of the tight junction.

Occludin: Regulates tight junction stability and barrier function.

Junctional Adhesion Molecules (JAMs): Involved in adhesion and signaling.



1. Tight Junctions (Occluding Junctions)

Structure: Tight junctions are formed by the fusion of adjacent cell membranes at specific points, creating a seal between neighboring cells.

Function:

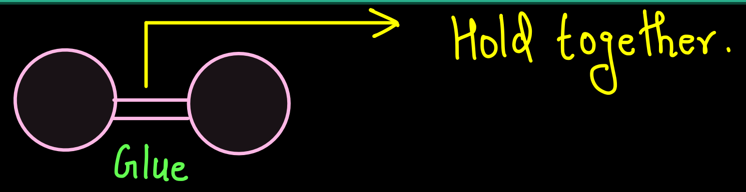
Functions of Tight Junctions

Barrier Function: Controls the movement of water, ions, and solutes between cells.

Fence Function: Maintains cell polarity by separating the apical and basolateral membrane domains.

Signaling Hub: Involved in intracellular signaling that regulates cell proliferation, differentiation, and gene expression.

2. Adherens Junctions-



Adherens junctions are connections between cells that help hold them together, like a belt or glue.* They are especially important in tissues that stretch or move a lot, like your skin or intestines. They are found in epithelial cells (cells that line the surfaces of your body and organs), usually just below the tight junctions

Present

Function:

Provide mechanical strength by linking the cytoskeletons of neighboring cells.

Play a role in maintaining the shape and stability of tissues, especially during tissue development and morphogenesis.

Facilitate cell signaling and contribute to cell-cell communication.

Example: Adherens junctions are abundant in epithelial tissues, such as the skin and gut lining.

3. Desmosomes (Macula Adherens)

→ A structure made up of protein which Connect two adjacent Cell.

Structure: A structure by which two adjacent cells are attached, formed from protein plaques in the cell membranes linked by filaments.

They are especially important in tissues that go through a lot of *stretching, like the skin, heart, and uterus.

Function:

Provide strong adhesion between cells, allowing them to resist mechanical stress.

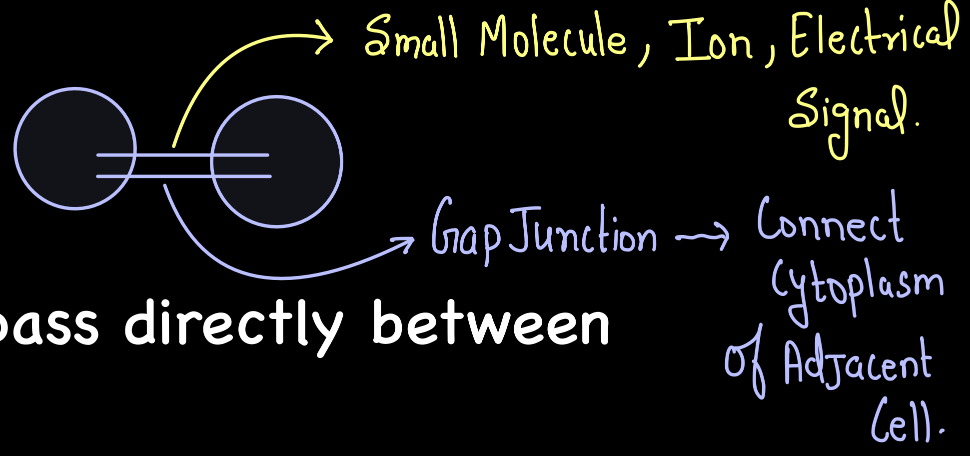
Play a crucial role in maintaining tissue integrity, particularly in tissues that experience frequent mechanical forces (like the skin and heart muscle).

Example: Desmosomes are abundant in tissues like the skin (epidermis), cardiac muscle, and uterine epithelium.

4. Gap Junctions

Half Channel or Hemi Channel.

Structure: Gap junctions consist of connexins, which form channels that connect the cytoplasm of adjacent cells. Each gap junction is made up of connexons (hemichannels), which allow direct communication between cells.



Function:

Allow small molecules (ions, nutrients, signaling molecules) to pass directly between neighboring cells.

Facilitate intercellular communication, which is crucial for processes like coordinated muscle contractions (e.g., in the heart and smooth muscle).

Play a role in metabolic and electrical coupling between cells.

Example: Gap junctions are found in cardiac muscle, smooth muscle, and epithelial cells.

5. Hemidesmosomes

Structure: Hemidesmosomes are similar to desmosomes but instead of connecting adjacent cells, they anchor cells to the extracellular matrix (ECM). They are composed of integrins and other plaque proteins.

Function:

They play a crucial role in maintaining tissue integrity and providing mechanical stability

Example: Hemidesmosomes are found in epithelial cells, especially in the skin, where they anchor the epidermis to the underlying dermis.

General Principles of Cell Communication

Cell communication, also known as cell signaling, is the process by which cells detect and respond to signals in their environment. This allows cells to coordinate their activities and adapt to changes in their surroundings. The general principles of cell communication include:

Signal Reception: A signaling molecule (ligand) binds to a specific receptor on the target cell, initiating the signaling process.

Signal Transduction: The binding of the signal molecule to its receptor activates an intracellular signaling pathway that transduces the external signal into a functional response within the cell.

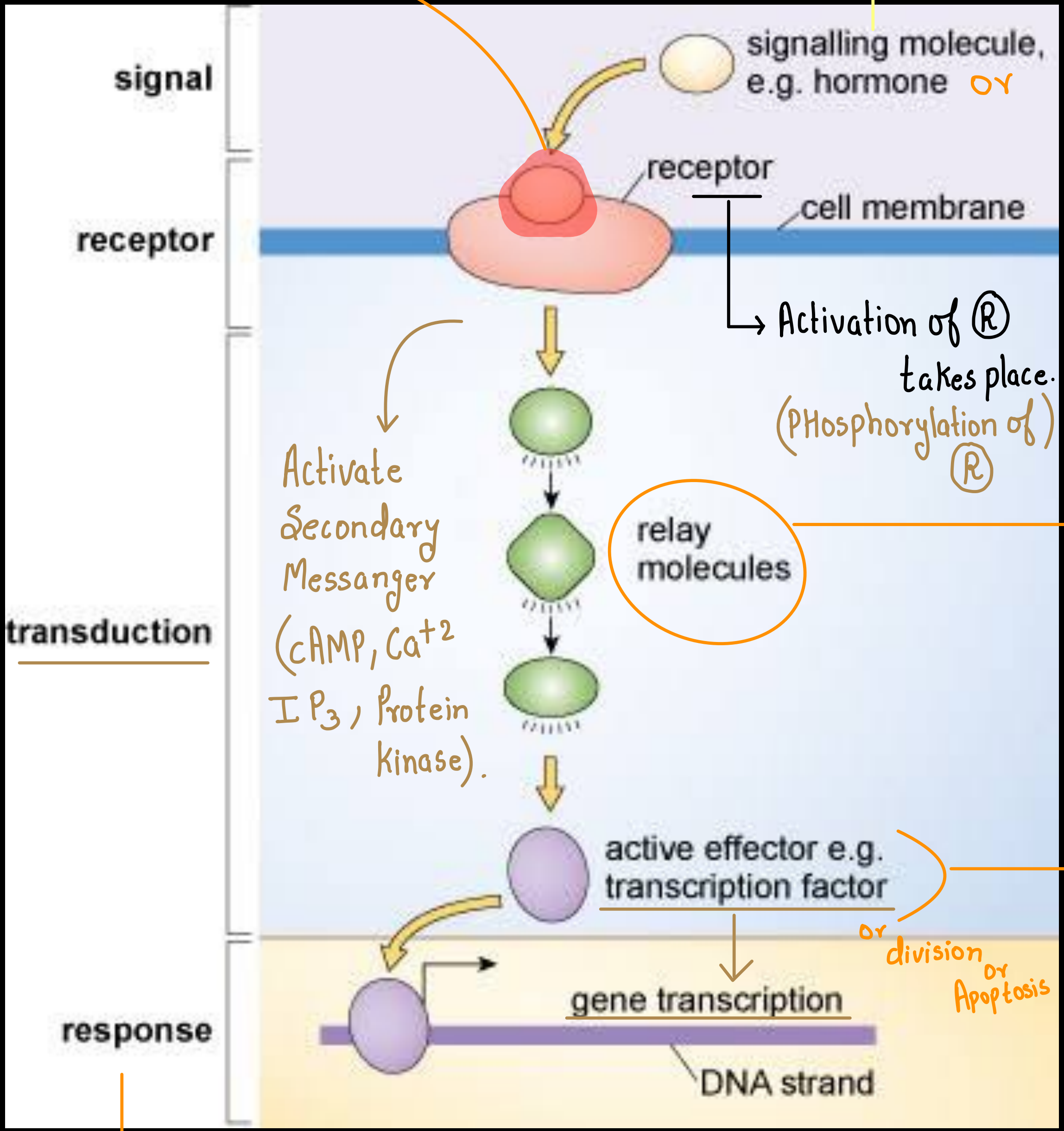
Cellular Response: The signaling cascade results in a variety of cellular responses, such as changes in gene expression, alterations in cell metabolism, or changes in cell movement or shape.

Signal Termination: Once the response has been achieved, the signaling process must be turned off or regulated to prevent overstimulation or inappropriate responses.

DEPTH OF BIOLOGY

Lock & Key System.

Bind with Specific Ⓡ.



Ligand / Drug / Substance / Neurotrans.

or Conformational CHange

Process by which a Cell Converts Extracellular Signal into a Cellular response.

Molecule that transmit Signal Within the Cell.

Respond to Stimulus & perform Specific function.

Signal Termination.

Intracellular Signaling Pathway Activation by Extracellular Signal Molecule

Extracellular signals (such as hormones, growth factors, cytokines, and neurotransmitters) activate intracellular signaling pathways by binding to specific receptors on the surface of the target cell or within the cell. The steps in this process generally include:

Signal Reception: The extracellular signal molecule (ligand) binds to a specific receptor protein located on the cell membrane (in the case of hydrophilic signals) or inside the cell (in the case of hydrophobic signals).

Receptor Activation: The receptor undergoes a conformational change upon ligand binding, which activates the receptor. This activation often involves phosphorylation of the receptor or associated proteins.

Intracellular Signaling Cascade: The activated receptor triggers a series of intracellular signaling events involving secondary messengers (like cAMP, calcium ions, or IP3) and protein kinases. These molecules amplify the signal and propagate it through the cell.

Effector Activation: The signaling cascade eventually activates effector molecules such as transcription factors, enzymes, or structural proteins that mediate the cell's response.

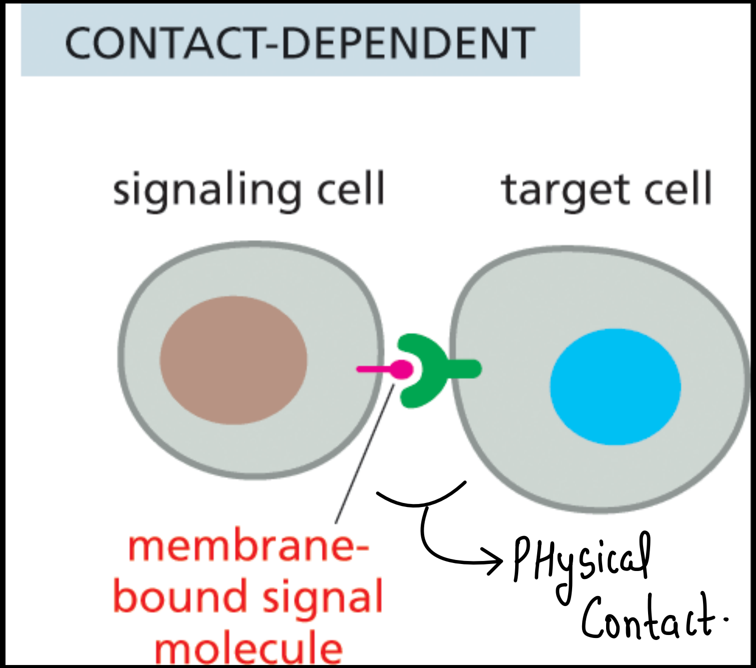
Cellular Response: The final result may include changes in gene expression, alterations in metabolic processes, or changes in cell behavior (e.g., division, migration, or apoptosis).

Forms of Intracellular Signaling

Classified on the basis of the distance b/w Signalling Cell & Targeted Cell.

Cell signaling can be classified into different forms based on the distance between the signaling cell and the target cell, as well as the mechanism of signal transmission. Here are the four main forms of intracellular signaling:

a) Contact-Dependent Signaling



Description: In this type of signaling, signaling molecules on the surface of one cell directly interact with receptors on the surface of a neighboring cell.

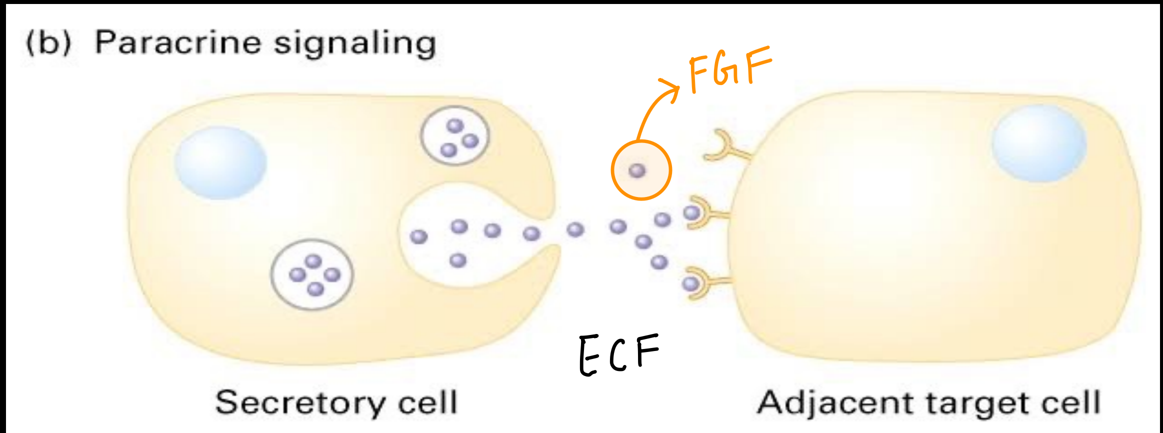
Mechanism: This requires physical contact between the signaling cell and the target cell. The signal molecule is often a membrane-bound protein or lipid.

b) Paracrine Signaling

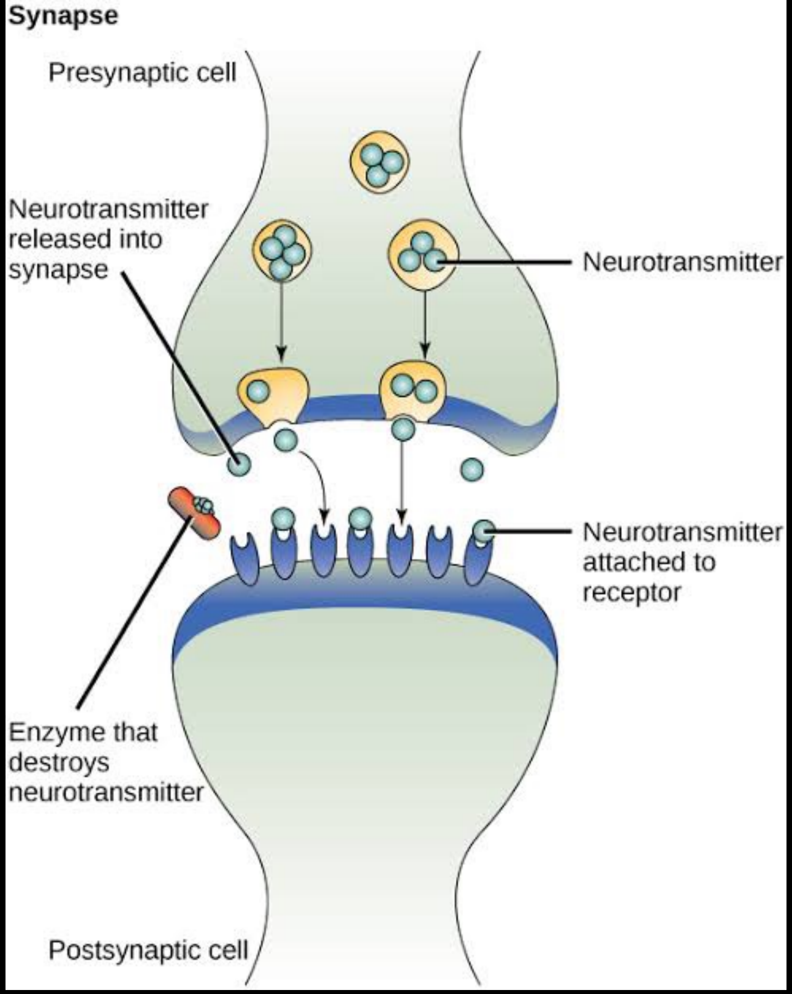
Description: Paracrine signaling occurs when a cell secretes signaling molecules that act on nearby target cells. The signaling molecules have a short-range effect and travel through the extracellular fluid to reach their target cells.

Mechanism: Signaling molecules are released by the signaling cell and diffuse locally to bind receptors on neighboring cells.

Example: Growth factors like fibroblast growth factor (FGF) or transforming growth factor-beta (TGF-β) that regulate cell growth and differentiation in the local environment.



C). Synaptic Signaling



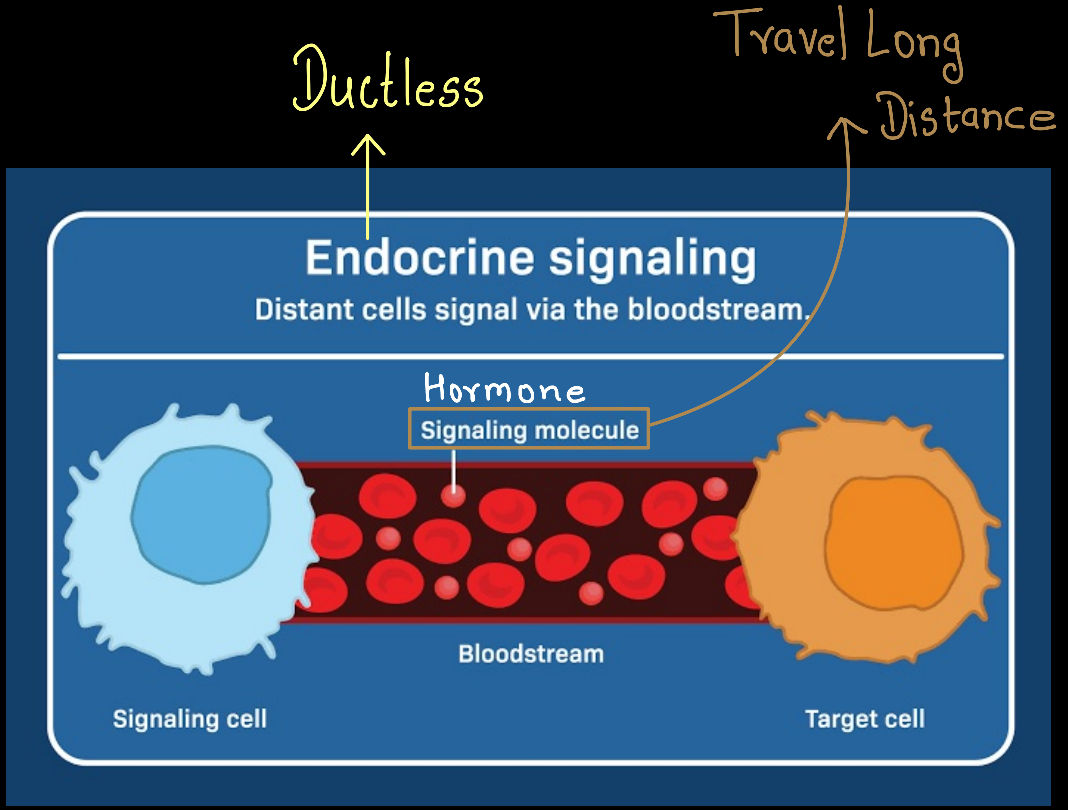
Description: Synaptic signaling is a specialized form of paracrine signaling that occurs in the nervous system. It involves the transmission of signals across synapses (the junctions between nerve cells).

Mechanism: A neuron releases neurotransmitters at the synapse, which then bind to receptors on the target cell (often another neuron or a muscle cell), transmitting an electrical or chemical signal.

Example: Neurotransmission in the brain, such as the release of dopamine, acetylcholine, or serotonin, which influences mood, muscle contraction, or cognition.

d) Endocrine Signaling

Description: Endocrine signaling involves the release of signaling molecules (hormones) into the bloodstream, which travel long distances to affect target cells in distant tissues or organs.



Mechanism: The signaling molecule, typically a hormone, is secreted by an endocrine gland and travels through the circulatory system to reach its target cells, where it binds to receptors either on the cell surface or within the cell.

Example: Insulin secretion from the pancreas, which regulates glucose uptake in various tissues such as liver, muscle, and fat cells.