Cell Communication

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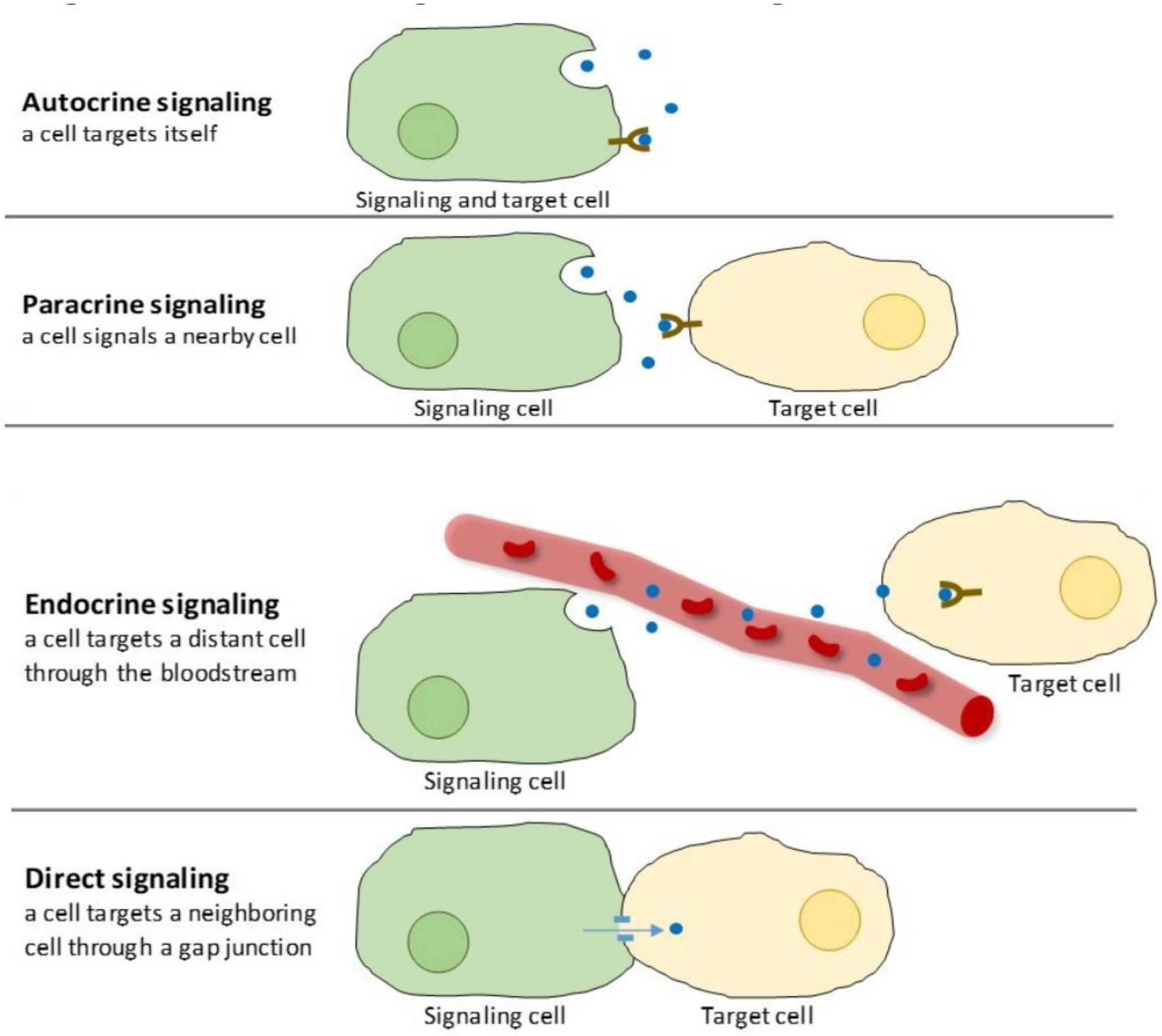
Categories of chemical signaling

- Autocrine
- Paracrine
- Endocrine
- Direct signaling

The main difference between the different categories of signaling is **the distance** that the signal travels to reach the target cell.

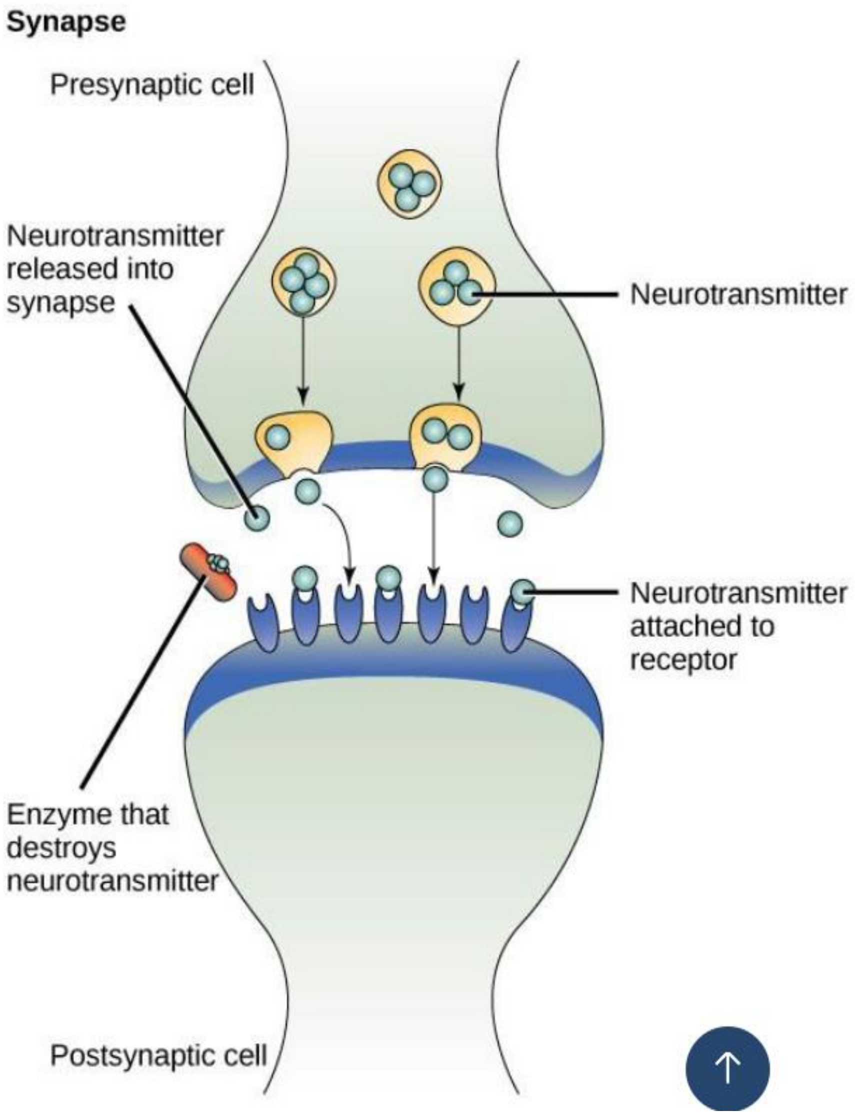


Autocrine Signaling

- When a cell responds to its own signaling molecule, it is called **autocrine** signaling (auto = “self”).
- Autocrine signaling often occurs during early development of an organism to ensure that cells develop into the correct tissues.
- Autocrine signaling also regulates pain sensation and inflammatory responses. Further, if a cell is infected with a virus, the cell can signal itself to undergo programmed cell death, killing the virus in the process.

Paracrine Signaling

- Signals that act locally between cells that are close together are called **paracrine** signals.
- Paracrine signals move **by diffusion** through the extracellular matrix. These types of signals usually elicit quick responses that last only a short amount of time. One example of paracrine signaling is the transfer of signals between nerve cells.
- The tiny space between nerve cells where signal transmission occurs is called **a synapse**. Signals are propagated along nerve cells by fast-moving electrical impulses.
- When these impulses reach the end of one nerve cell, chemical ligands called **neurotransmitters** are released into the synapse by the presynaptic cell (the cell emitting the signal). The neurotransmitters diffuse across the synapse.
- When the neurotransmitter binds the receptor on the surface of the postsynaptic cell, the next electrical impulse is launched. The neurotransmitters are degraded quickly or are reabsorbed by the presynaptic cell so that the recipient nerve cell can recover quickly and be prepared to respond rapidly to the next synaptic signal.



Endocrine Signaling

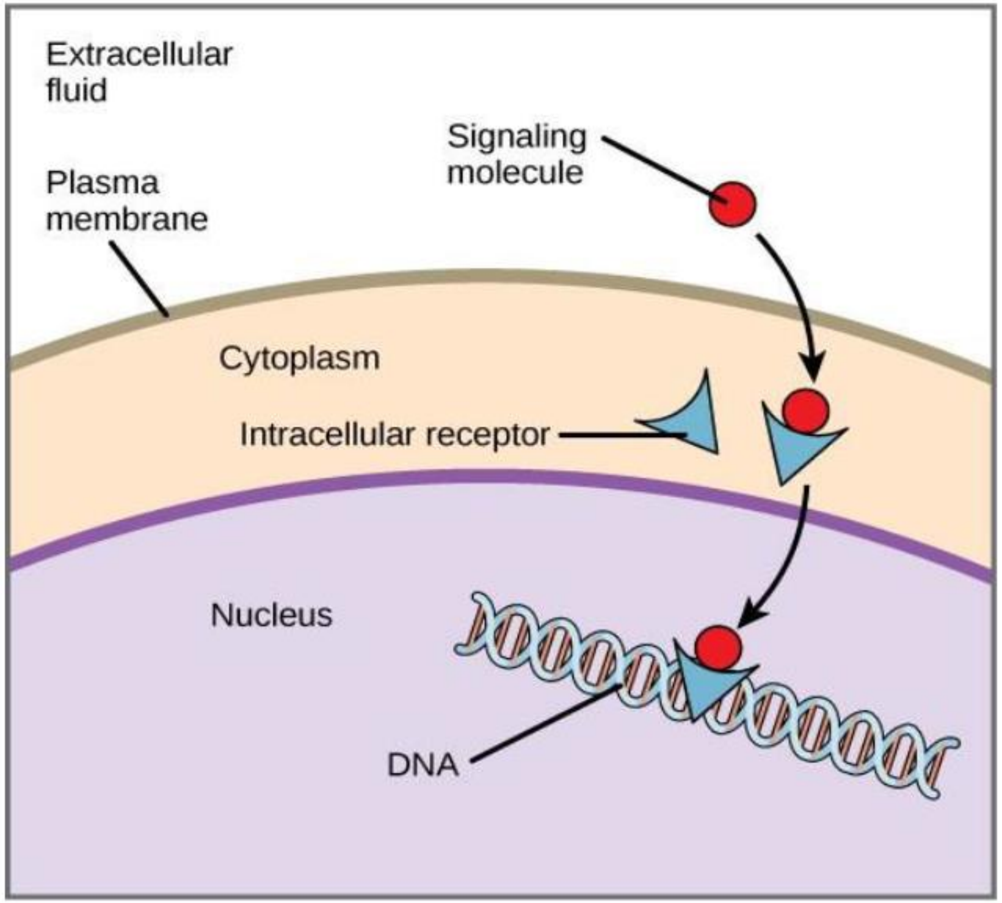
- Signals from distant cells are called **endocrine signals**, and they originate from **endocrine cells** (many endocrine cells are located in endocrine glands, such as the thyroid gland, the hypothalamus, and the pituitary gland). These types of signals usually produce a slower response but have a longer-lasting effect.
- The ligands released in endocrine signaling are called **hormones**, signaling molecules that are produced in one part of the body but affect other body regions some distance away
- Hormones travel the large distances between endocrine cells and their target cells via the bloodstream, which is a relatively slow way to move throughout the body. Because of their form of transport, hormones get diluted and are present in low concentrations when they act on their target cells. This is different from paracrine signaling, in which local concentrations of signaling molecules can be very high.

Direct Signaling

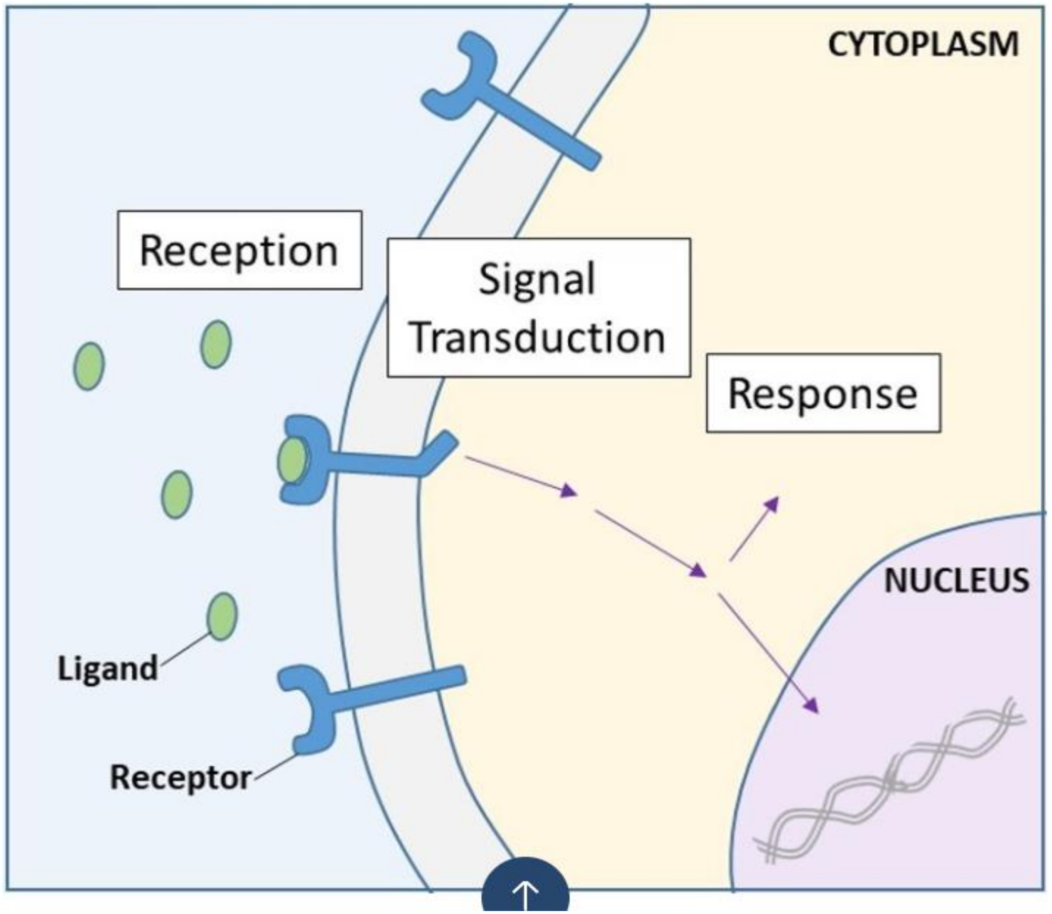
- Gap junctions in animals and plasmodesmata in plants are connections between the plasma membranes of neighboring cells. These water-filled channels allow small signaling molecules to diffuse between the two cells.
- Small molecules, such as calcium ions (Ca2+), are able to move between cells, but large molecules like proteins and DNA cannot fit through the channels. The specificity of the channels ensures that the cells remain independent but can quickly and easily transmit signals.
- Direct signaling allows a group of cells to coordinate their response to a signal that only one of them may have received. In plants, plasmodesmata are ubiquitous, making the entire plant into a giant communication network.

Receptors types

Internal Receptor=Intracellular/cytoplasmic receptor



External Receptor= Cell surface receptor



Receptors types

Internal Receptor

- Found in the cytoplasm of target cells and respond to hydrophobic ligand molecules that are able to travel across the plasma membrane.
- Once inside the cell, many of these molecules bind to proteins that act as regulators of mRNA synthesis (transcription) to mediate gene expression.
- Gene expression is the cellular process of transforming the information in a cell’s DNA into a sequence of amino acids, which ultimately forms a protein.
- When the ligand binds to the internal receptor, a conformational change is triggered that exposes a DNA-binding site on the receptor protein. The ligand-receptor complex moves into the nucleus, then binds to specific regulatory regions of the chromosomal DNA and promotes the initiation of transcription. Transcription is the process of copying the information in a cell’s DNA into a special form of RNA called messenger RNA (mRNA); the cell uses information in the mRNA to link specific amino acids in the correct order, producing a protein.
- Thus, when a ligand binds to an internal receptor, it can directly influence gene expression in the target cell.

External Receptor

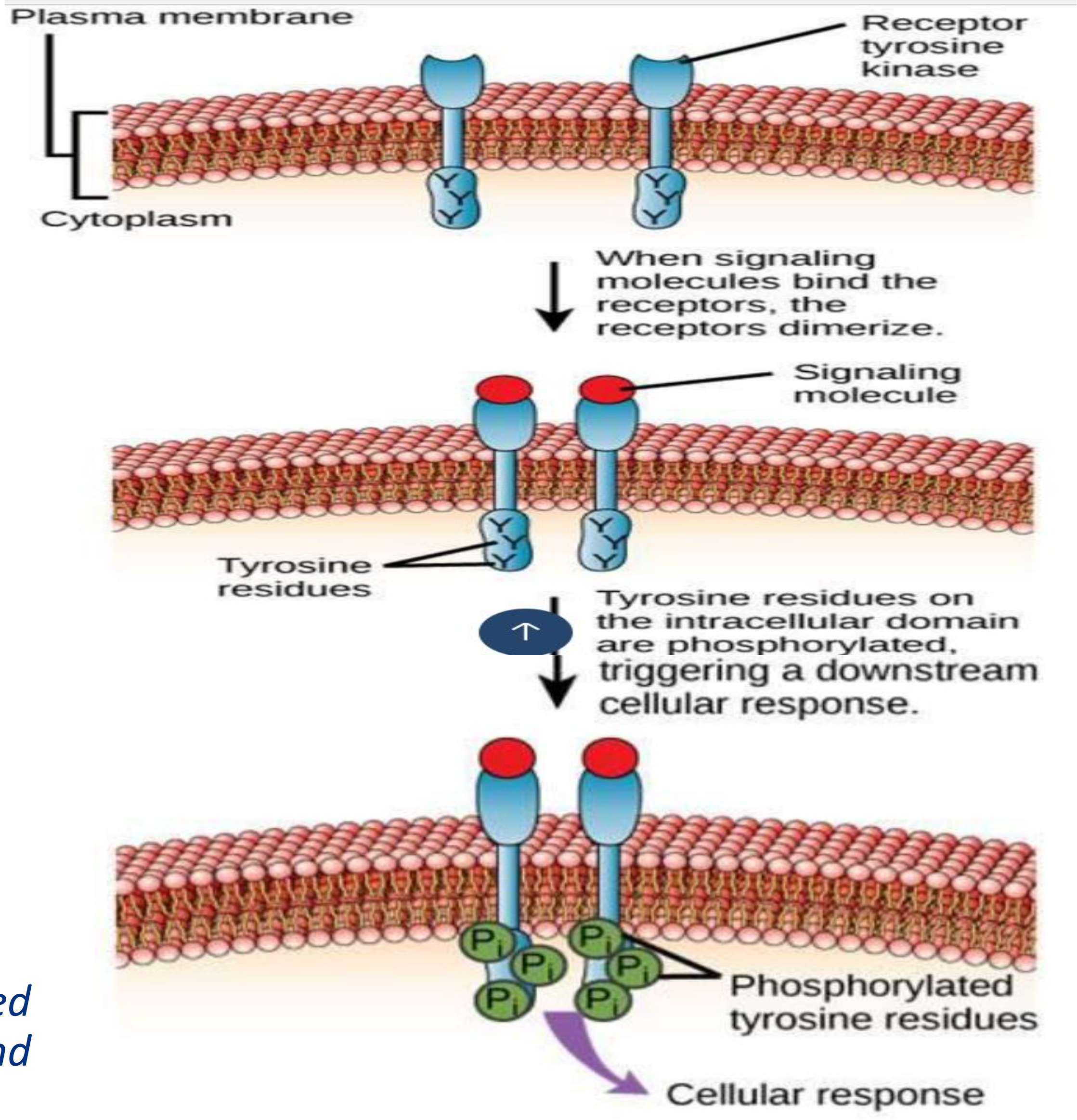
- **Cell-surface receptors**=transmembrane receptors, are integral proteins that bind to external signaling molecules.
- These receptors span the plasma membrane and perform **signal transduction**, in which an extracellular signal is converted into an intercellular signal. Because cell-surface receptor proteins are fundamental to normal cell functioning, it should come as no surprise that a malfunction in any one of these proteins could have severe consequences. Errors in the protein structures of certain receptor molecules have been shown to play a role in hypertension (high blood pressure), asthma, heart disease, and cancer.
- Each cell-surface receptor has three main components: an external ligand-binding domain, or **extracellular domain**; a hydrophobic membrane-spanning region; and an intracellular domain. Cell-surface receptors are involved in most of the signaling in multicellular organisms. There are three general categories of cell-surface receptors: enzyme-linked receptors, ion channel-linked receptors, and G-protein-linked receptors.

Three general categories of cell-surface receptors

1. Enzyme-linked receptors

- Cell-surface receptors with intracellular domains that are associated with an enzyme.
- In some cases, the intracellular domain of the receptor itself is an enzyme.
- Other enzyme-linked receptors have a small intracellular domain that interacts directly with an enzyme.

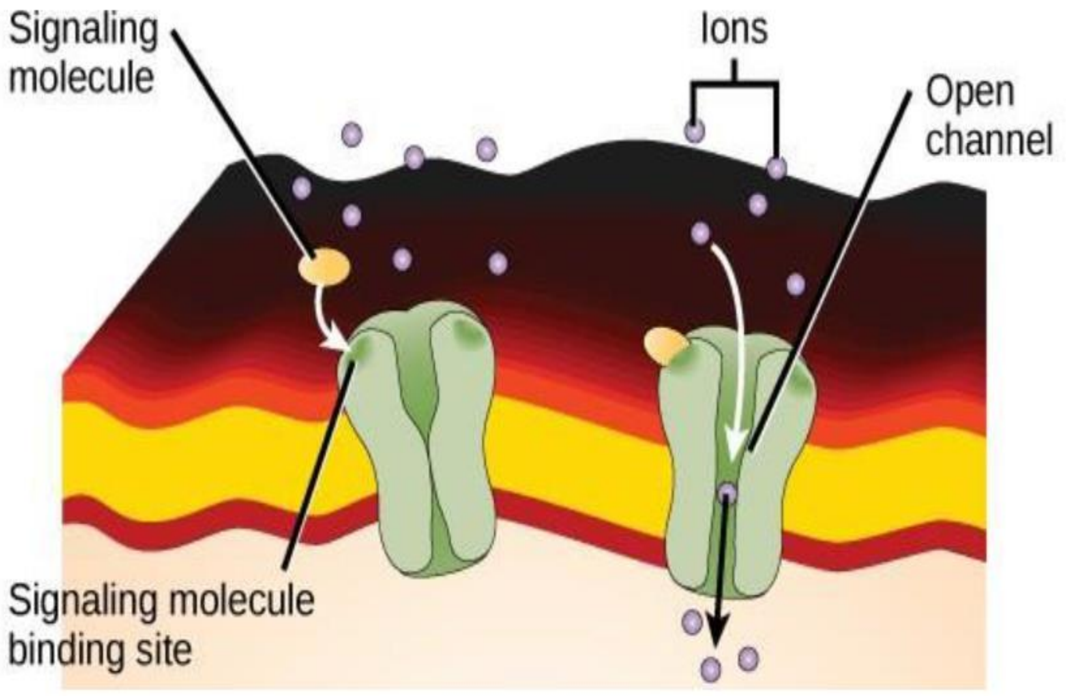
A receptor tyrosine kinase is an enzyme-linked receptor with a single transmembrane region, and extracellular and intracellular domains.



Three general categories of cell-surface receptors

2. Ion channel-linked receptors

- Bind to a ligand and open a channel through the membrane that allows specific ions to pass through. This type of cell-surface receptor has an extensive membrane-spanning region with hydrophobic amino acids.
- Conversely, the amino acids that line the inside of the channel are hydrophilic to allow for the passage of ions.
- When a ligand binds to the extracellular region of the channel, there is a conformational change in the protein's structure that allows ions such as sodium, calcium, magnesium, or hydrogen to pass through

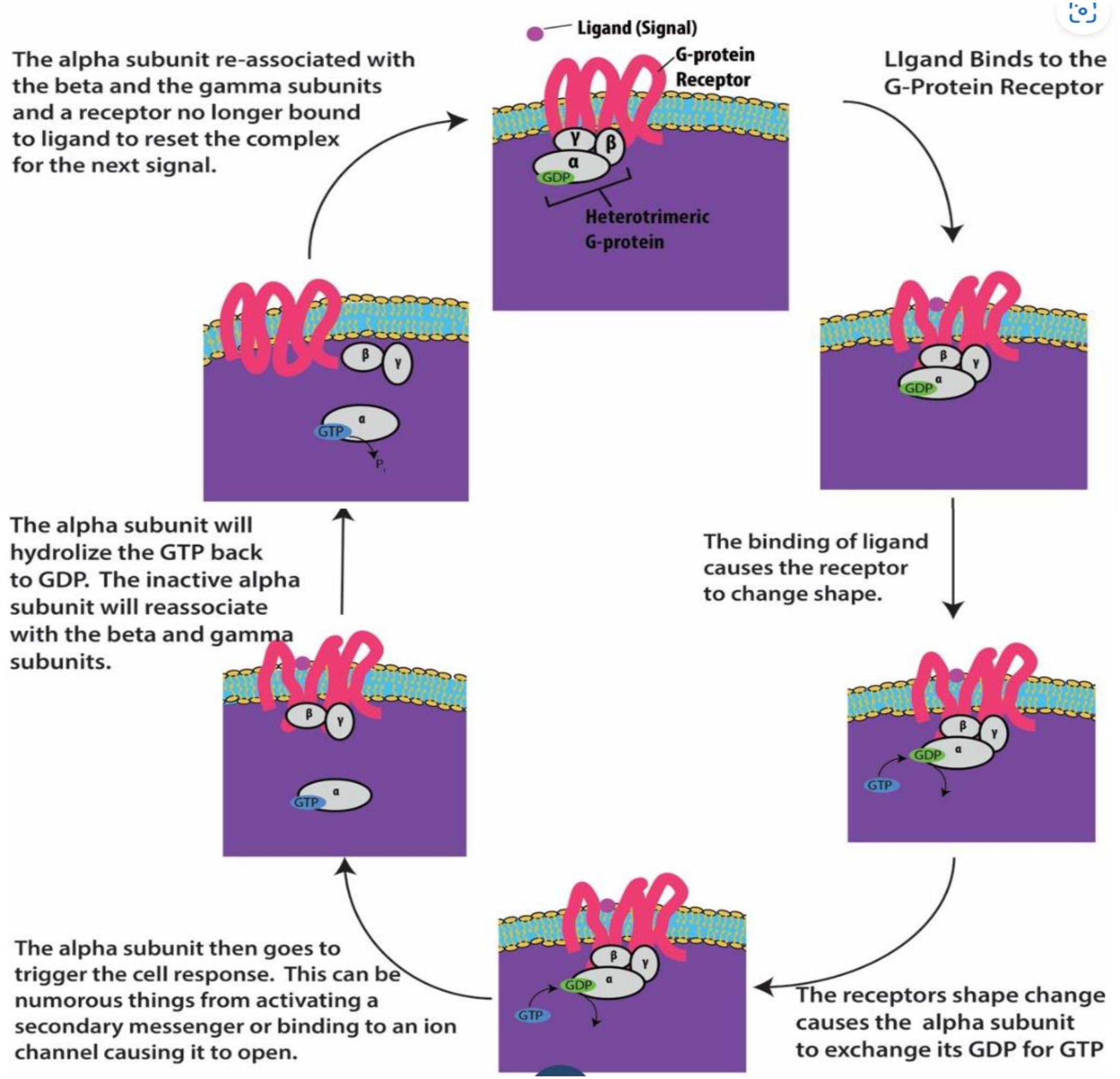


Ion channel-linked receptors open and allow ions to enter a cell. An example of an ion channel-linked receptor is found on neurons. When neurotransmitters bind to these receptors, a conformational change allows sodium ions to flow across the cell membrane, causing a change in the membrane potential.

Three general categories of cell-surface receptors

3. G protein-linked receptors

- Bind to a ligand and activate an associated G-protein.
- The activated G- protein then interacts with a nearby membrane protein, which may be an ion channel or an enzyme
- All G-protein-linked receptors have seven transmembrane domains, but each receptor has a specific extracellular domain and G-protein-binding site.



Some G proteins have three subunits: α, β, and γ. When a signaling molecule binds to a G- protein receptor, a GDP molecule associated with the α subunit is exchanged for GTP. The β and γ subunits dissociate from the α subunit, and a cellular response is triggered. Hydrolysis of GTP to GDP terminates the signal. Image by Chris Wrobel.

3. G protein-linked receptors

- Cell signaling using G-protein-linked receptors occurs as a cycle. Once the ligand binds to the receptor, the resultant shape change activates the G-protein, which releases GDP and picks up GTP.
- The subunits of the G-protein then split into α and βγ subunits. One or both of these G-protein fragments may be able to activate other proteins in the cell. After a while, the GTP on the active α subunit of the G-protein is hydrolyzed to GDP and the βγ subunit is deactivated. The subunits re-associate to form the inactive G-protein and the cycle begins again
- G-protein linked receptors are used in many physiological processes including those for vision transduction, taste, and regulation of immune system and inflammation.

Referensi

- https://rwu.pressbooks.pub/bio103/chapter/cell-communication/