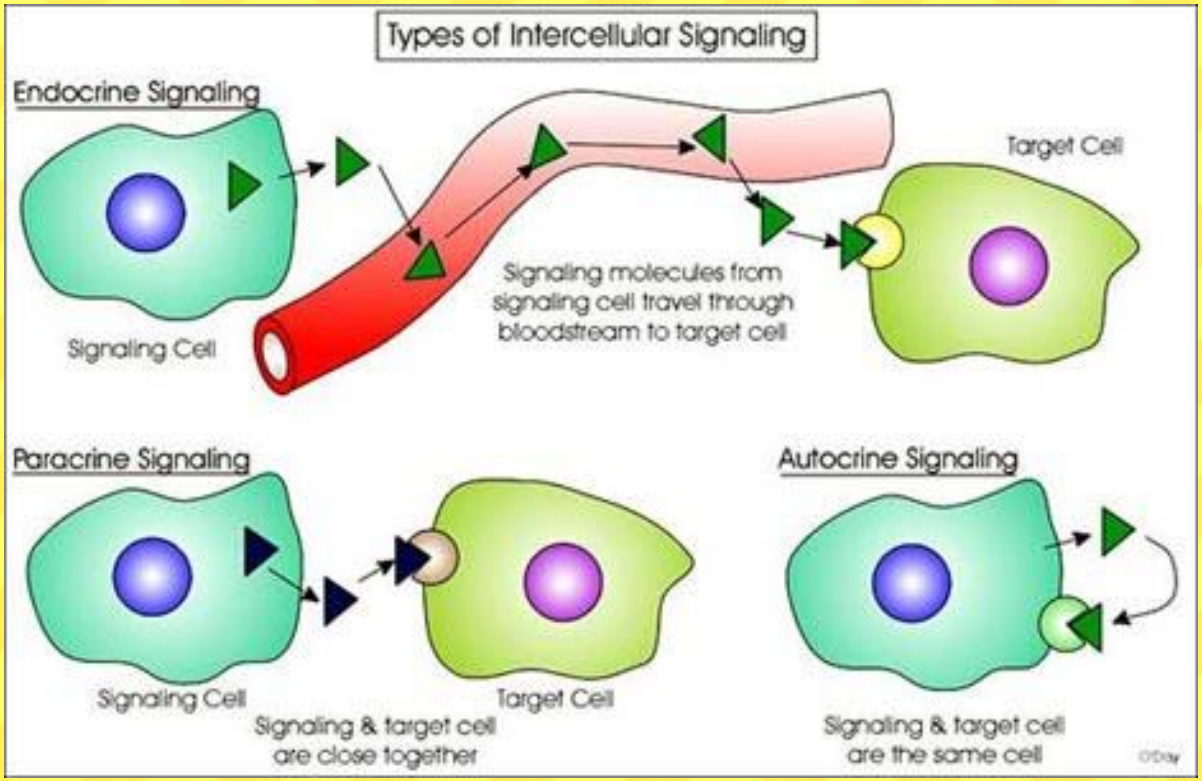
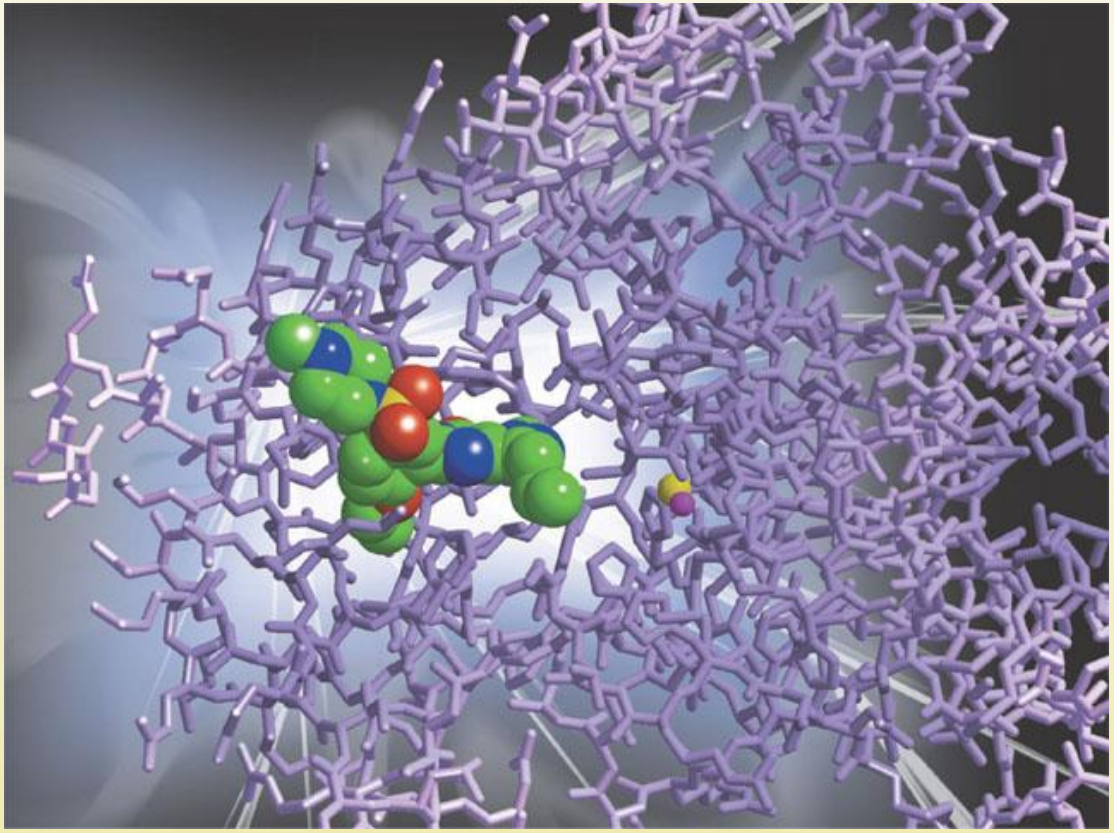
Cell Communication



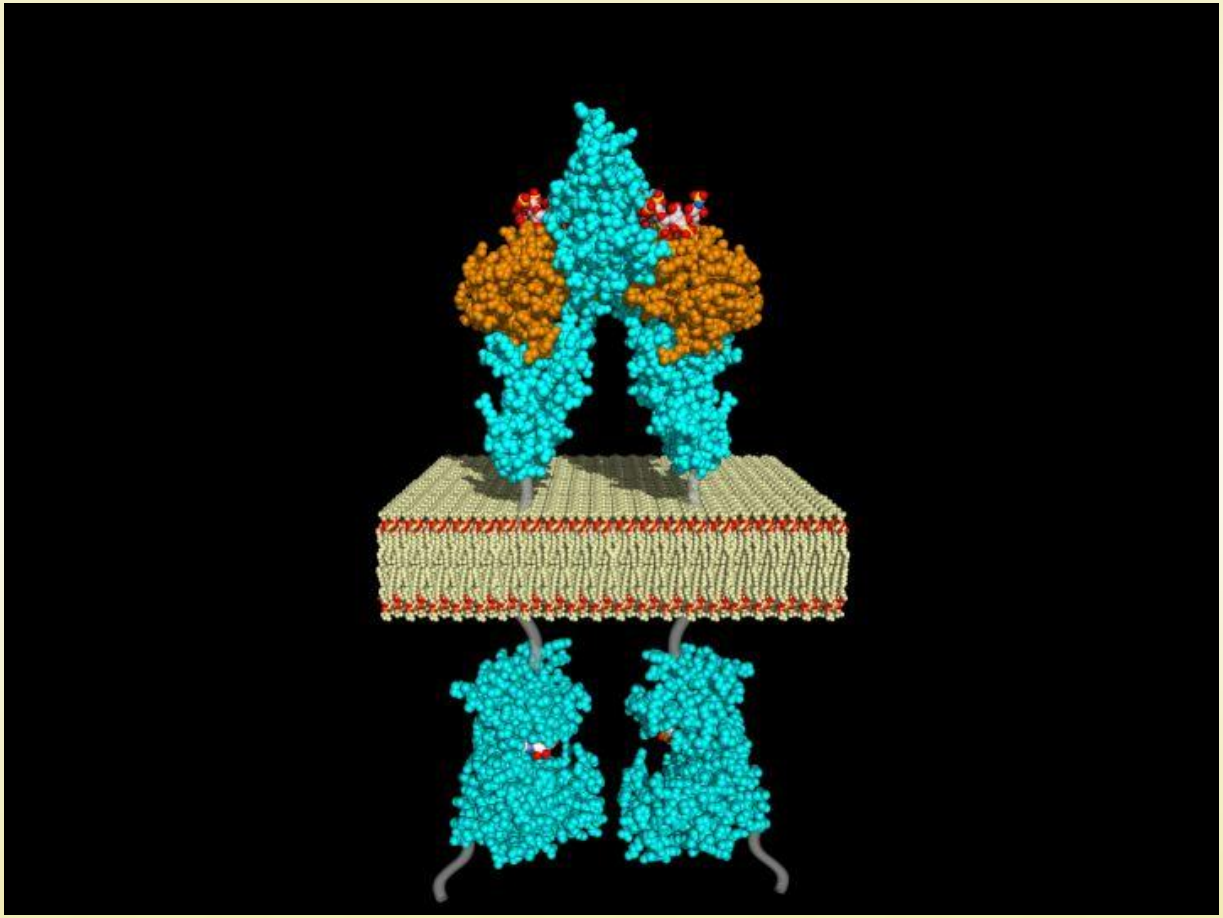
Overview: The Cellular Internet

- Cell-to-cell communication is absolutely essential for multicellular organisms
- Nerve cells must communicate pain signals to muscle cells (stimulus) in order for muscle cells to initiate a response to pain

- Biologists have discovered some **universal mechanisms** of cellular regulation



External Signals



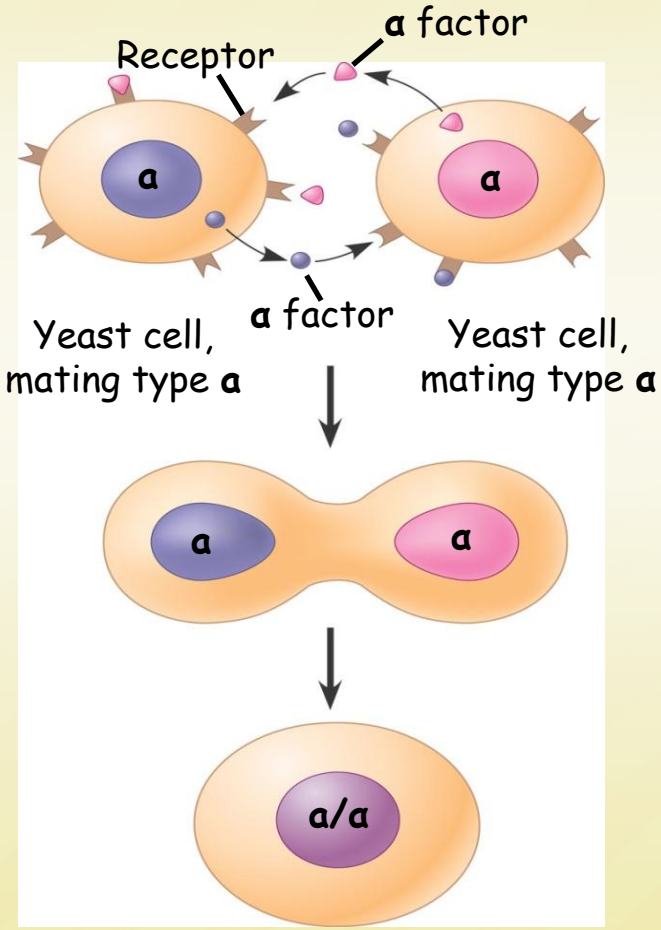
Signal Transduction Pathway

Yeast cells identify their mates by cell signaling (early evidence of signaling)

1. **Exchange of mating factors.** Each cell type secretes a mating factor that binds to receptors on the other cell type.

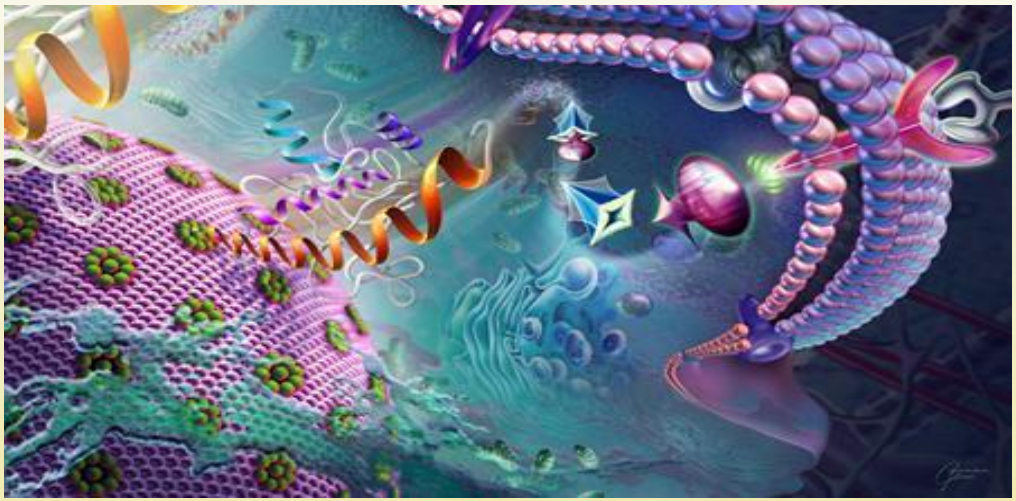
2. **Mating.** Binding of the factors to receptors induces changes in the cells that lead to their fusion.

3. **New a/α cell.** The nucleus of the fused cell includes all the genes from the a and α cells.



Signal Transduction Pathways

- Convert signals on a cell's surface into cellular responses
- Are similar in microbes and mammals, suggesting an early origin



Local and Long-Distance Signaling

- Cells in a multicellular organism (tissues, organs, systems) communicate via chemical messengers
- A hormone is a chemical released by a cell in one part of the body, that sends out messages that affect cells in other parts of the organism
- All multicellular organisms produce hormones
- Plant hormones are also called phytohormones
- Hormones in animals are often transported in the blood

- Animal and plant cells
  - Have cell junctions that directly connect the cytoplasm of adjacent cells

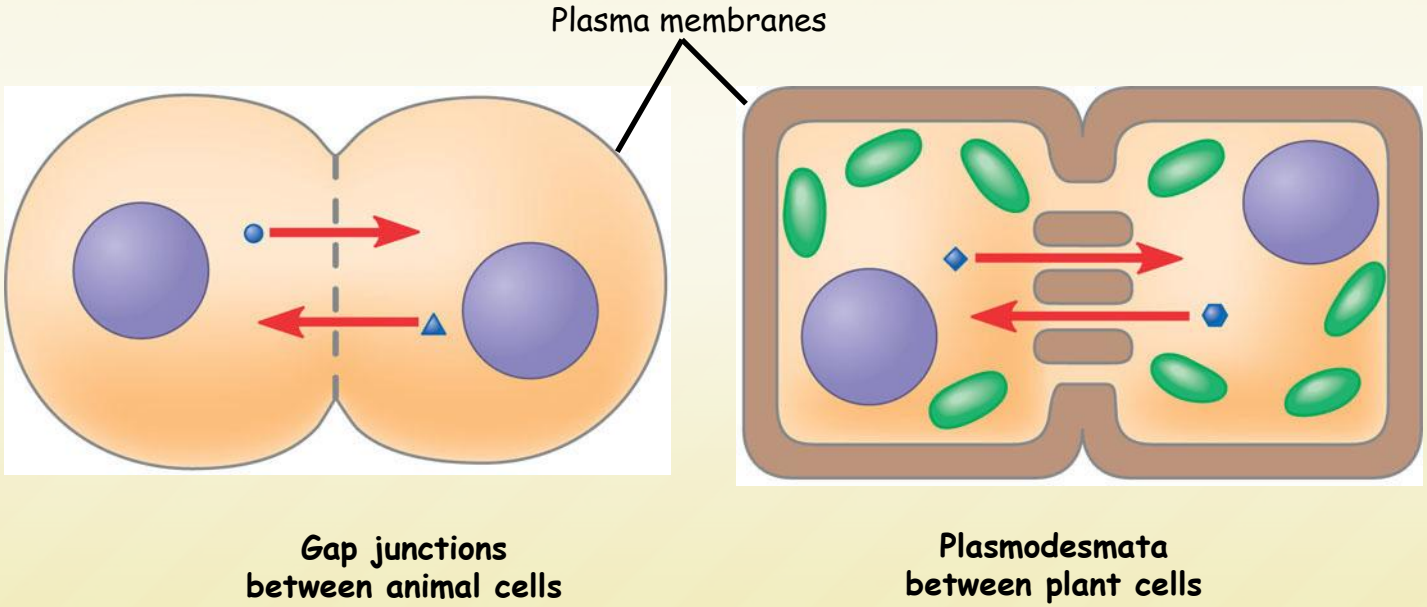


Figure 11.3(a) Cell junctions. Both animals and plants have cell junctions that allow molecules to pass readily between adjacent cells without crossing plasma membranes.

- In local signaling, animal cells
  - May communicate via direct contact

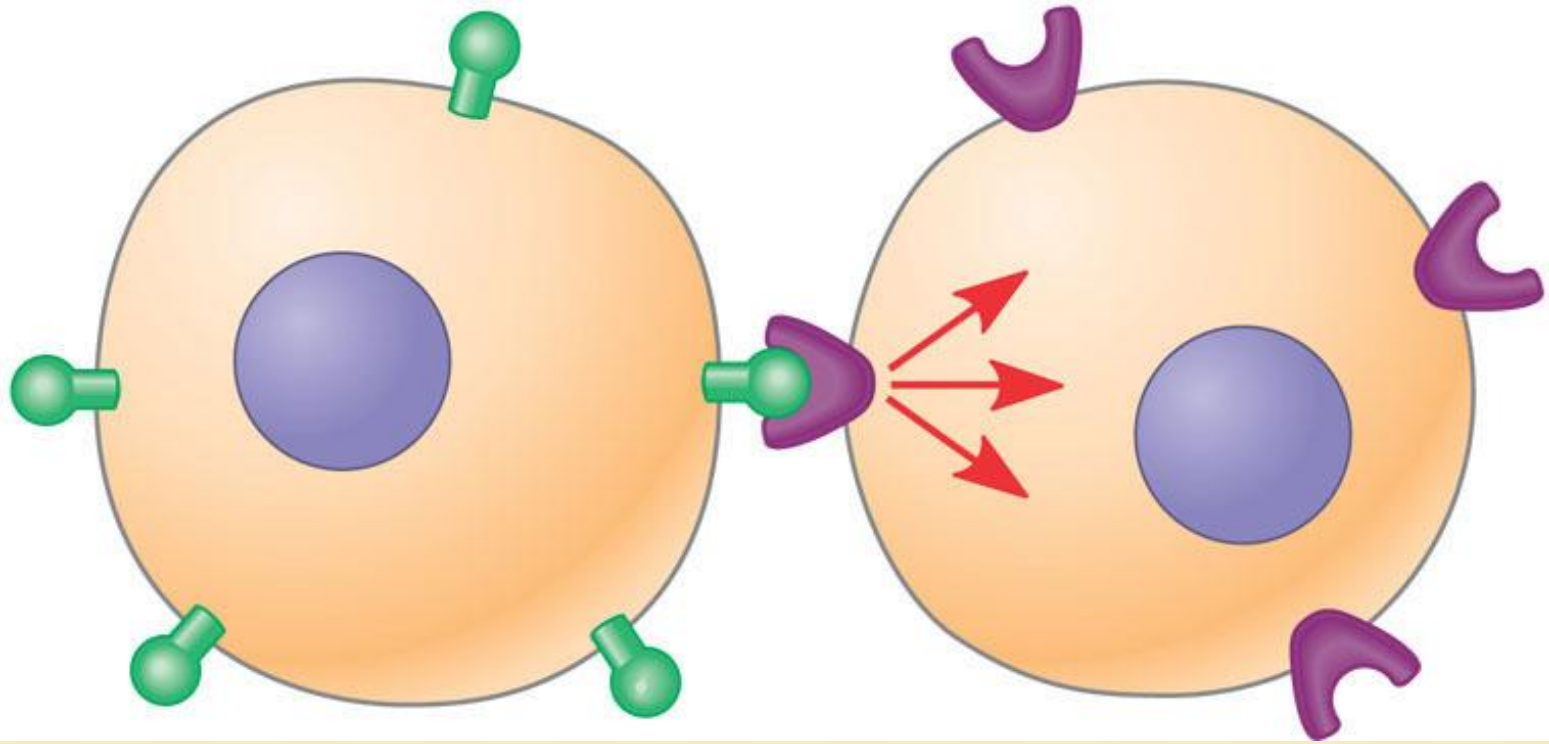
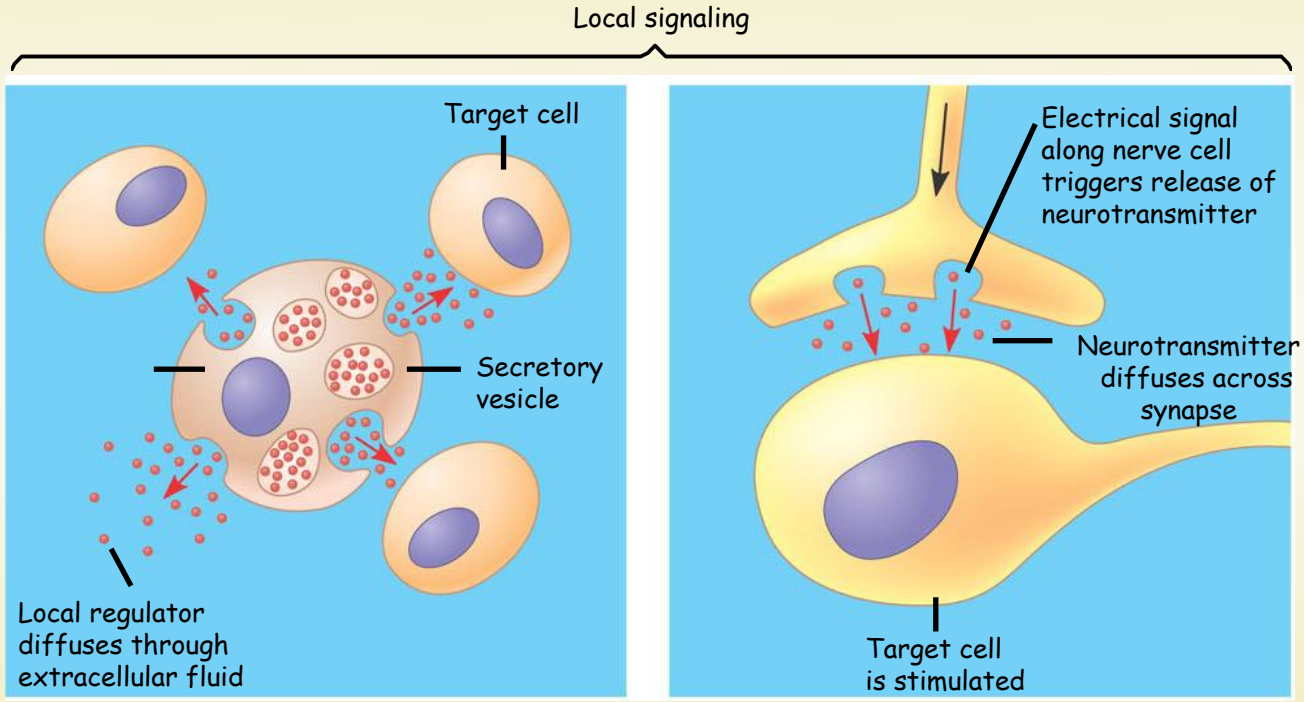


Figure 11.3(b) Cell-cell recognition. Two cells in an animal may communicate by interaction between molecules protruding from their surfaces.

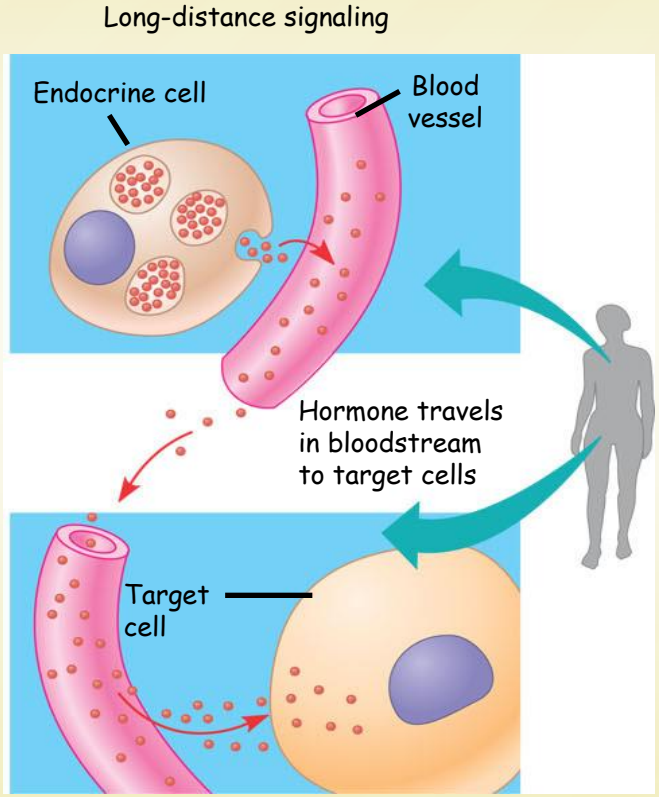
- In other cases, animal cells
  - Communicate using local regulators



(a) Paracrine signaling. A secreting cell acts on nearby target cells by discharging molecules of a local regulator (a growth factor, for example) into the extracellular fluid.

(b) Synaptic signaling. A nerve cell releases neurotransmitter molecules into a synapse, stimulating the target cell.

- In long-distance signaling
  - Both plants and animals use hormones (e.g. Insulin)

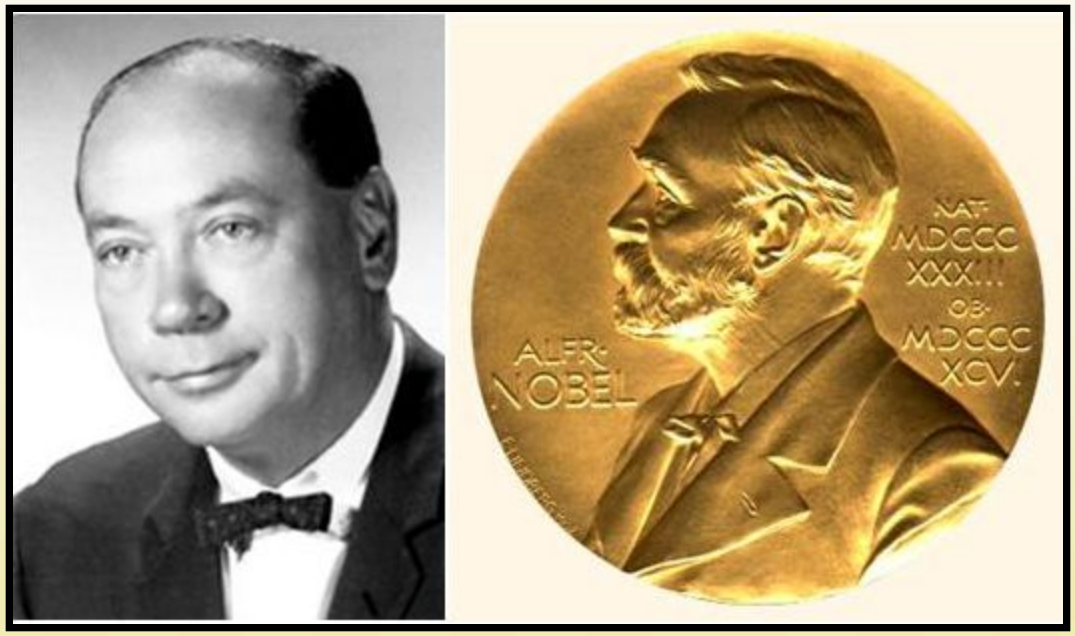


(c) Hormonal signaling. Specialized endocrine cells secrete hormones into body fluids, often the blood. Hormones may reach virtually all body cells.

Figure 11.4 C

The Three Stages of Cell Signaling

- Earl W. Sutherland
  - Discovered how the hormone epinephrine acts on cells



Sutherland's Three Steps

- Sutherland suggested that cells receiving signals went through three processes
  - Reception
  - Transduction
  - Response

Overview of cell signaling

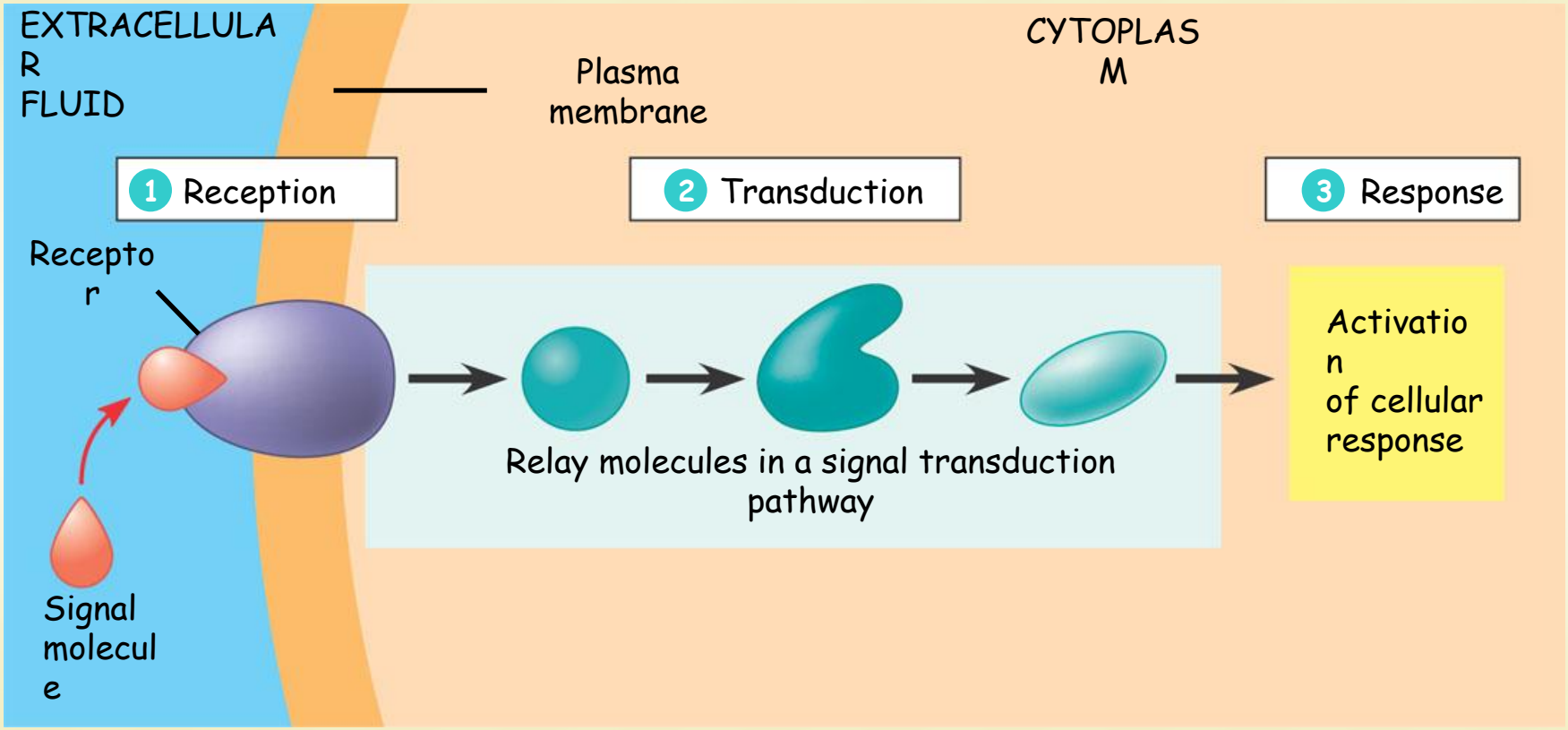
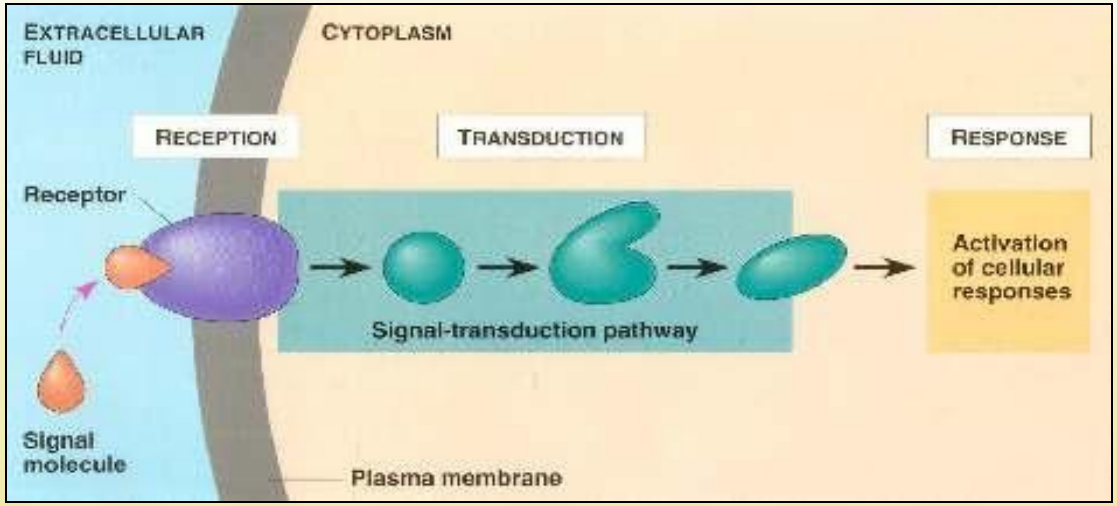


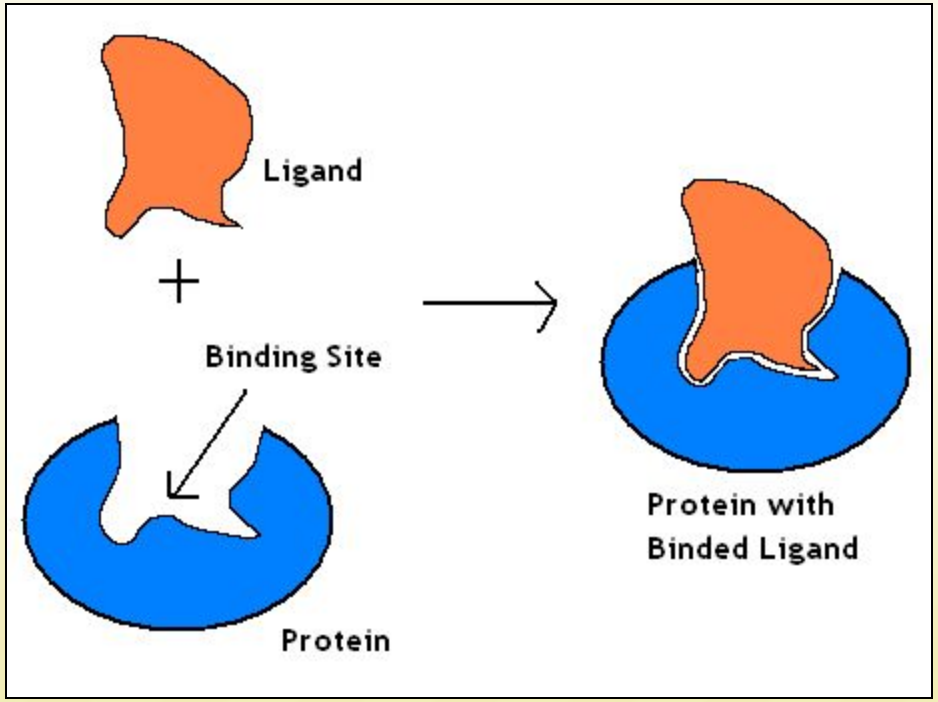
Figure 11.5

Step One - Reception

- Reception occurs when a signal molecule binds to a receptor protein, causing it to change shape
- Receptor protein is on the cell surface

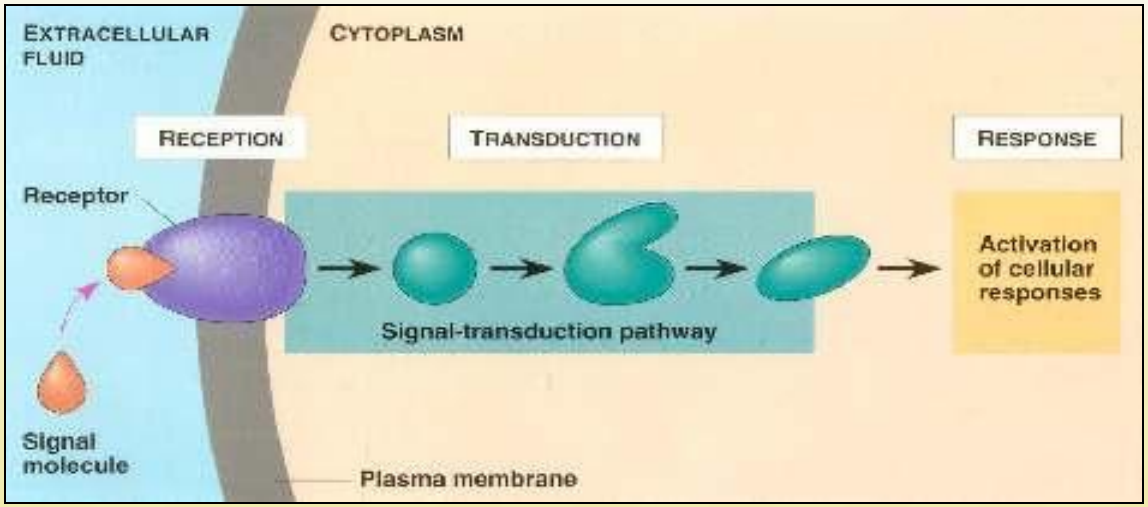


- The binding between signal molecule (ligand) and receptor is highly specific
- A conformational change in a receptor is often the initial transduction of the signal



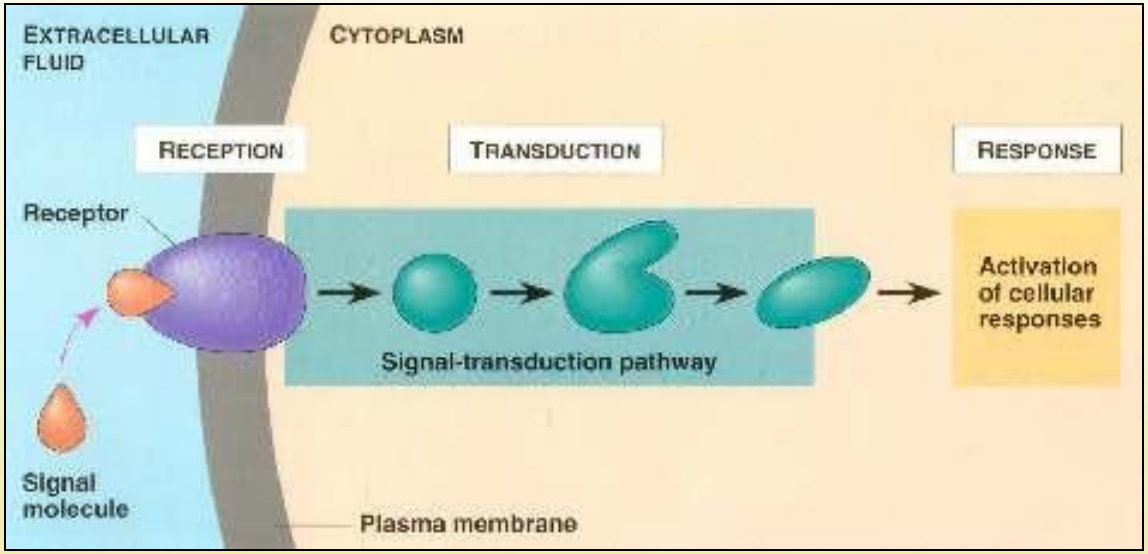
Step Two - Transduction

- The binding of the signal molecule alters the receptor protein in some way
- The signal usually starts a cascade of reactions known as a signal transduction pathway
- Multistep pathways can amplify a signal



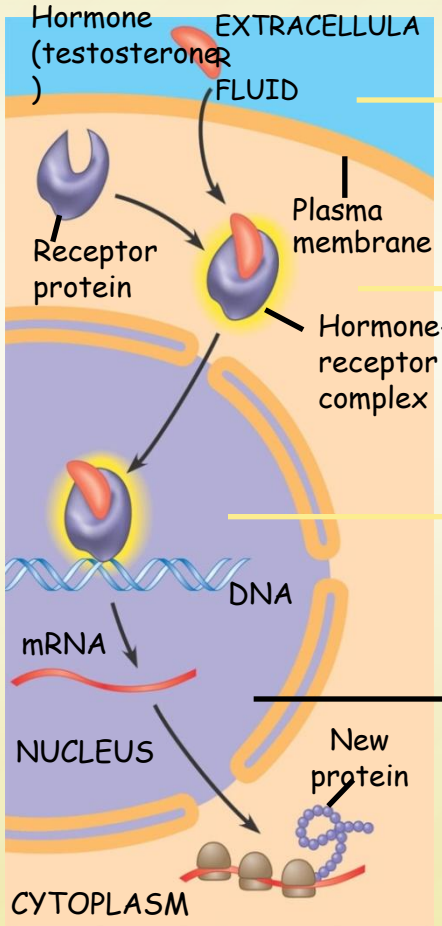
Step Three - Response

- Cell signaling leads to regulation of cytoplasmic activities or transcription
- Signaling pathways regulate a variety of cellular activities



Example of Pathway

- **Steroid hormones** bind to intracellular receptors



1. The steroid hormone testosterone passes through the plasma membrane.
2. Testosterone binds to a receptor protein in the cytoplasm, activating it.
3. The hormone-receptor complex enters the nucleus and binds to specific genes.
4. The bound protein stimulates the transcription of the gene into mRNA.
5. The mRNA is translated into a specific protein.

Figure 11.6

- Other pathways regulate genes by activating transcription factors that turn genes on or off

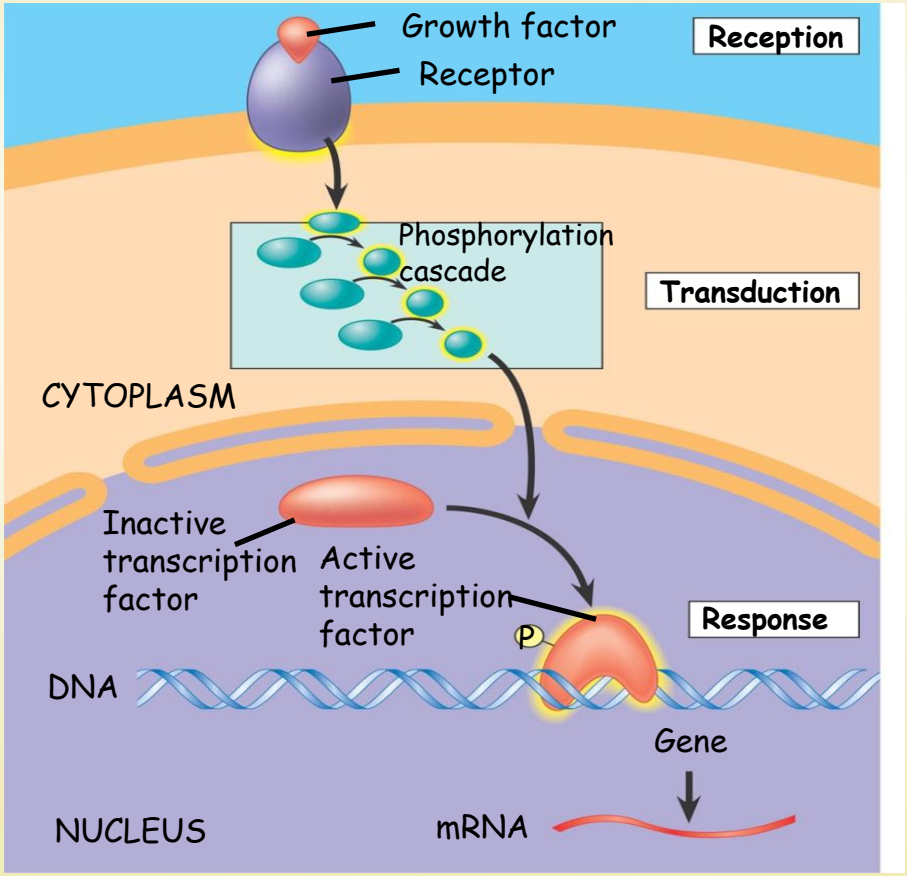
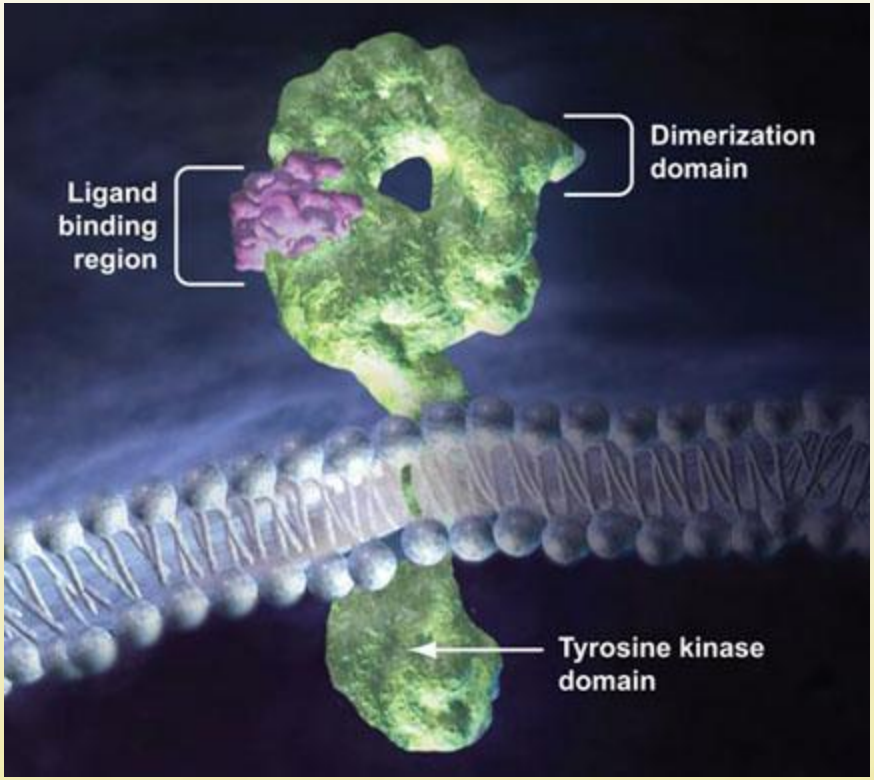


Figure 11.14

Termination of the Signal

- Signal response is terminated quickly by the reversal of ligand binding



Receptors in the Plasma Membrane

- There are three main types of membrane receptors:
  - G-protein-linked
  - Tyrosine kinases
  - Ion channel

G-protein-linked receptors

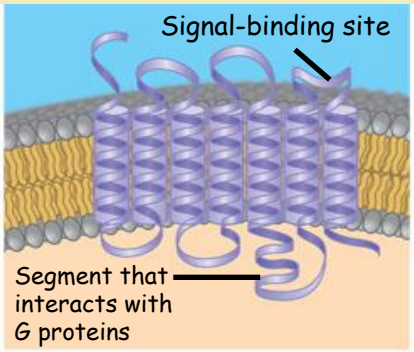
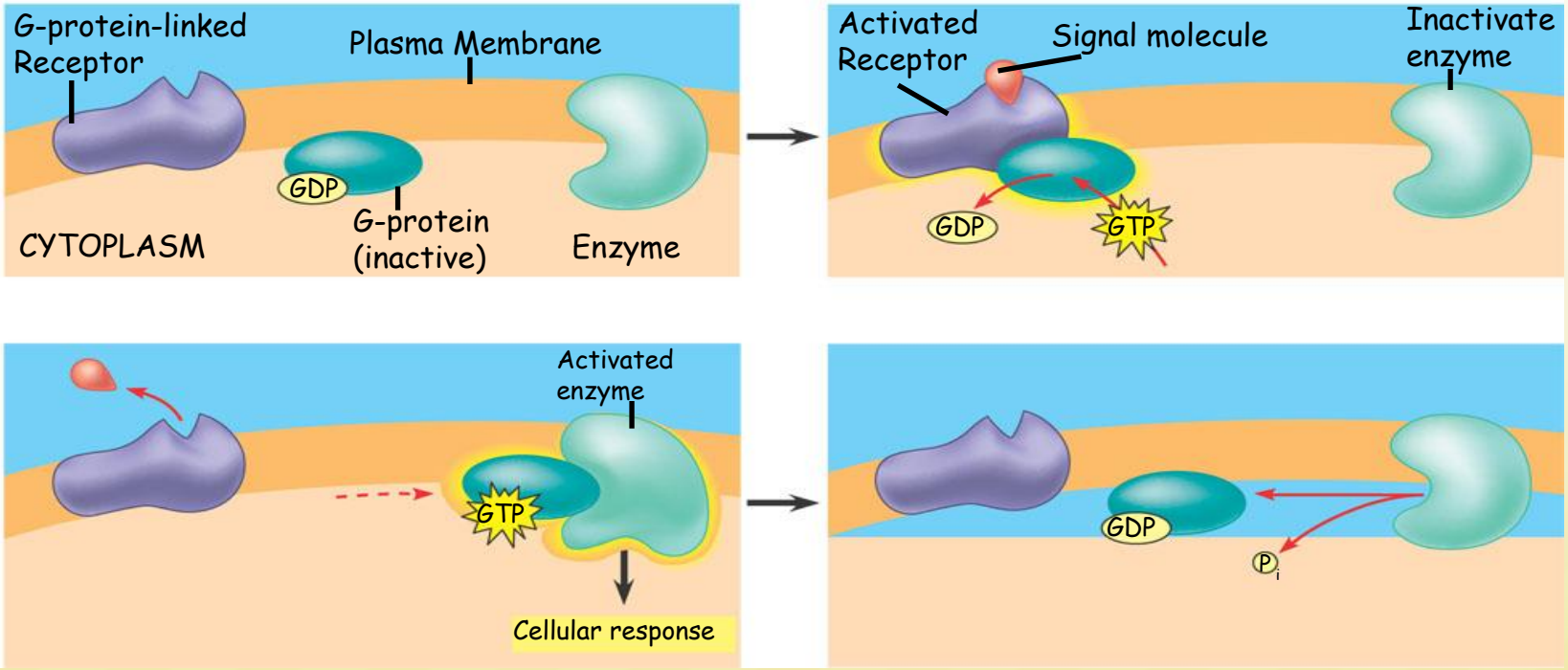


Figure 11.7



Receptor tyrosine kinases

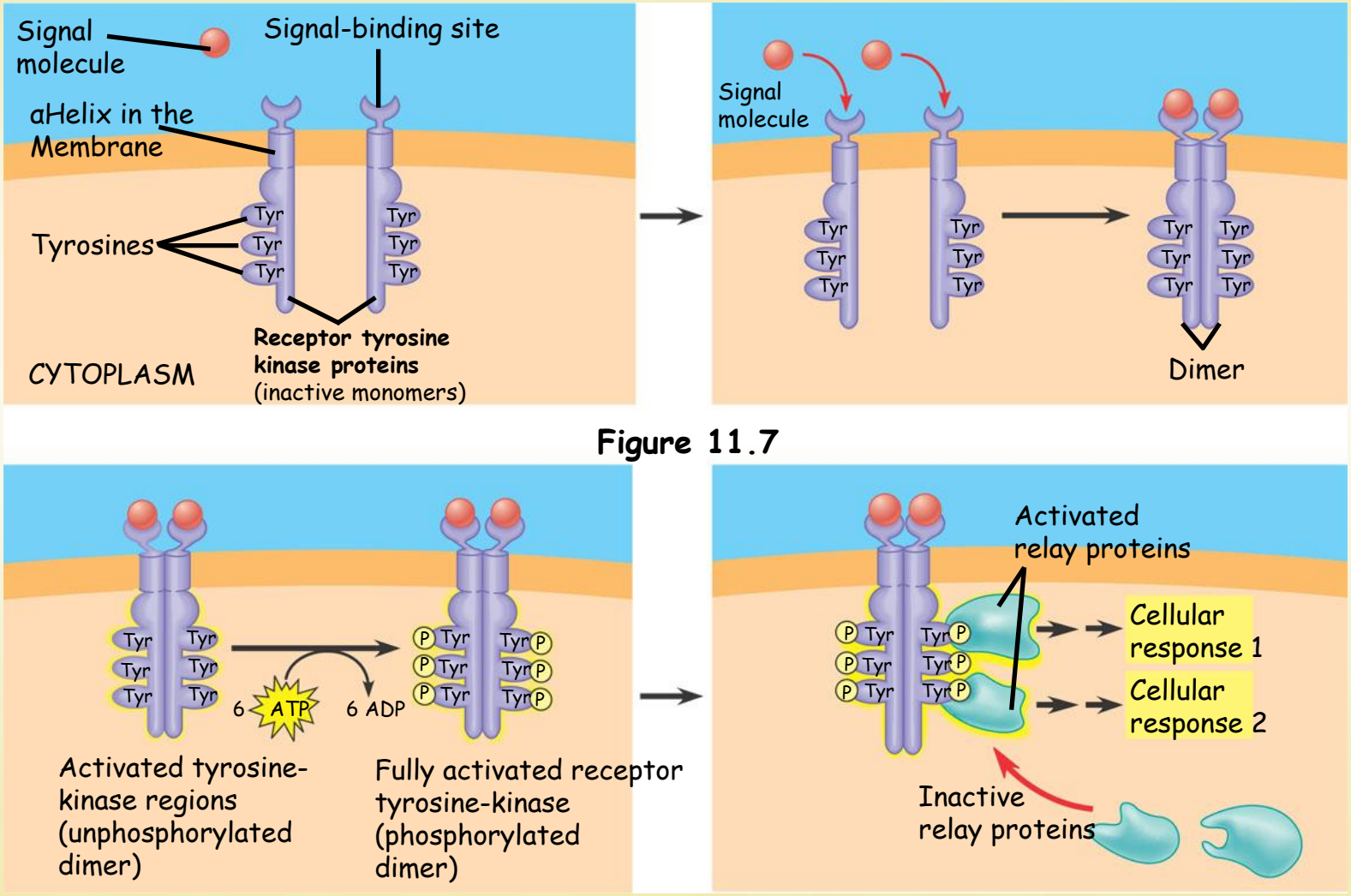


Figure 11.7

Ion channel receptors

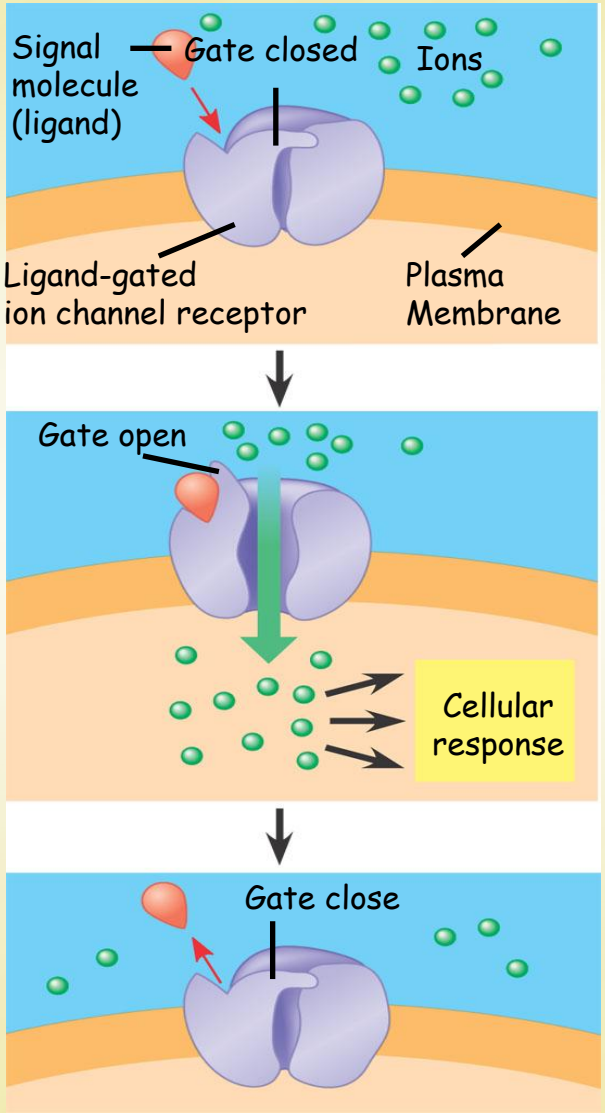


Figure 11.7