Chapter 11

Cell Communication

PowerPoint Lectures for

Biology, Seventh Edition

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Lectures by Chris Romero

- Overview: The Cellular Internet
- Cell-to-cell communication
  - Is absolutely essential for multicellular organisms

- Biologists
  - Have discovered some universal mechanisms of cellular regulation

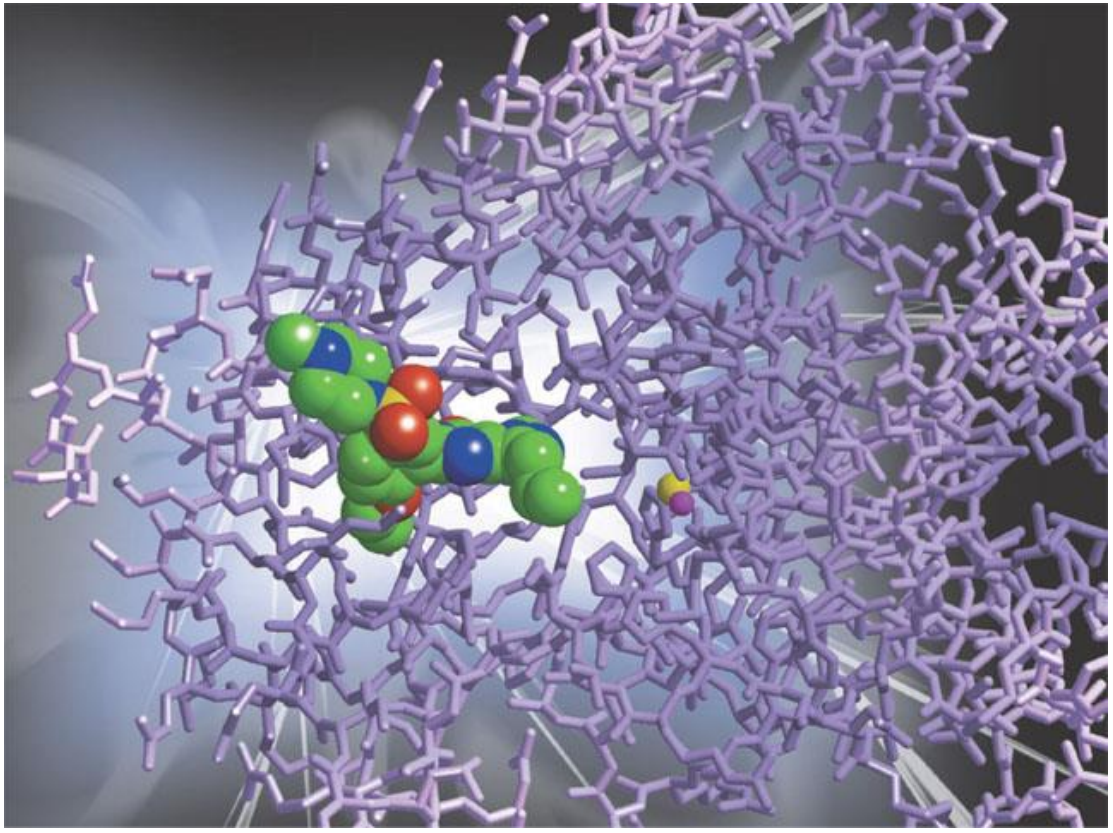


Figure 11.1

- Concept 11.1: External signals are converted into responses within the cell

Evolution of Cell Signaling

- Yeast cells
  - Identify their mates by cell signaling

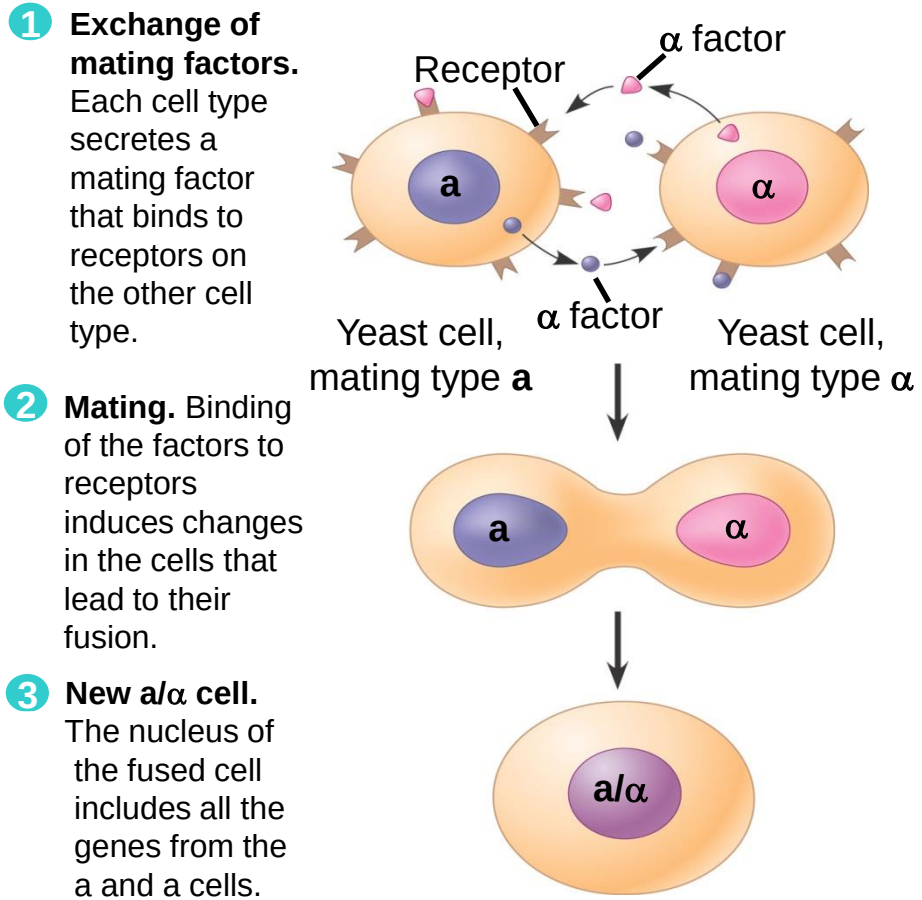


Figure 11.2

- 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
  - Communicate via chemical messengers

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

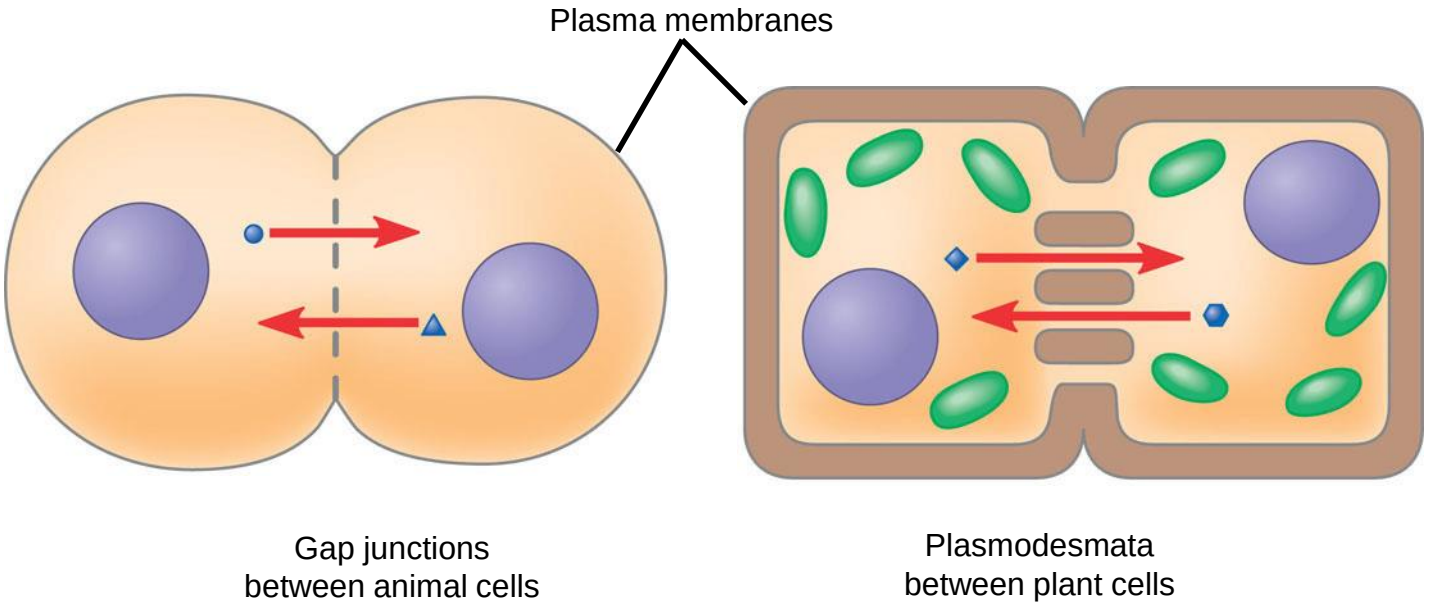


Figure 11.3 **(a) Cell junctions.** Both animals and plants have cell junctions that allow molecules to pass readily between adjacent cells without crossing plasma membranes.

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

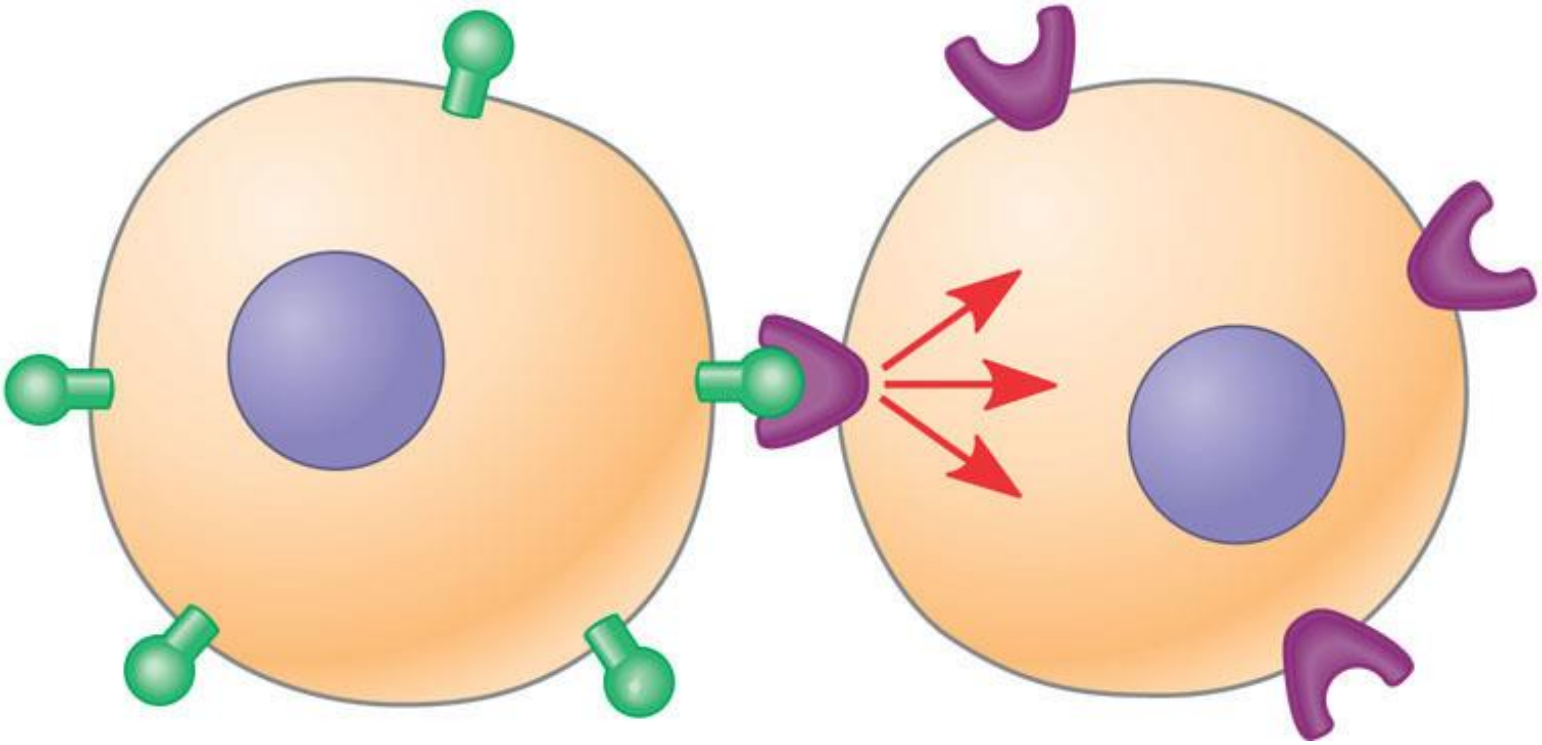
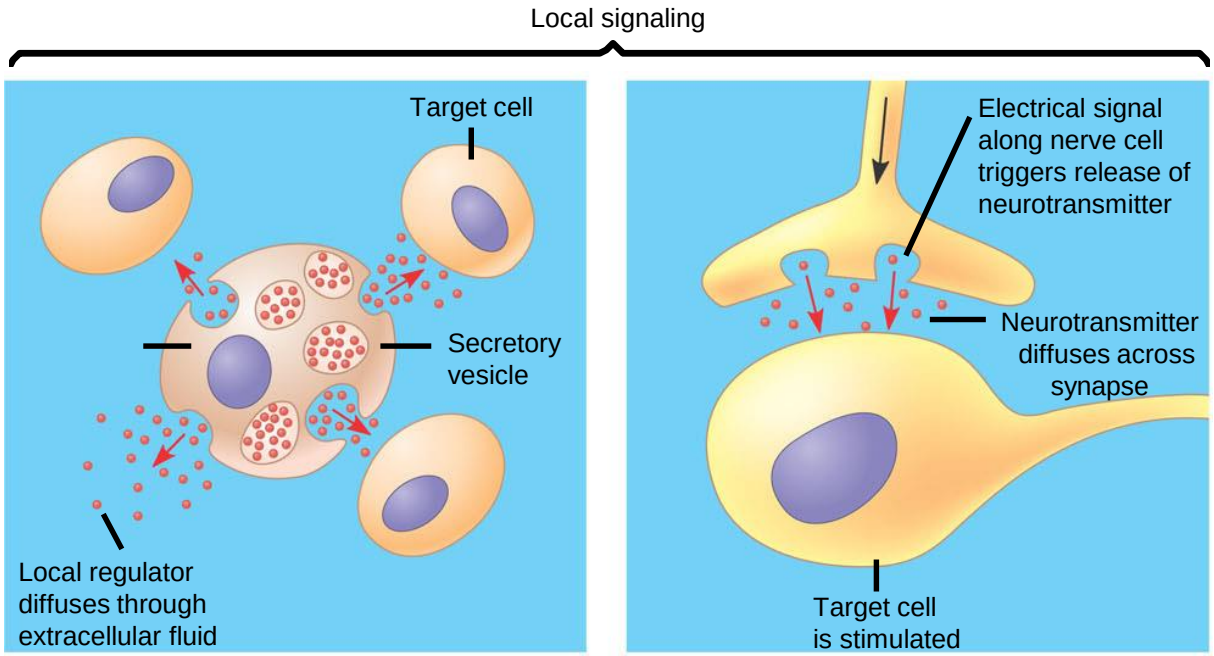


Figure 11.3 **(b) Cell-cell recognition.** Two cells in an animal may communicate by interaction between molecules protruding from their surfaces.

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

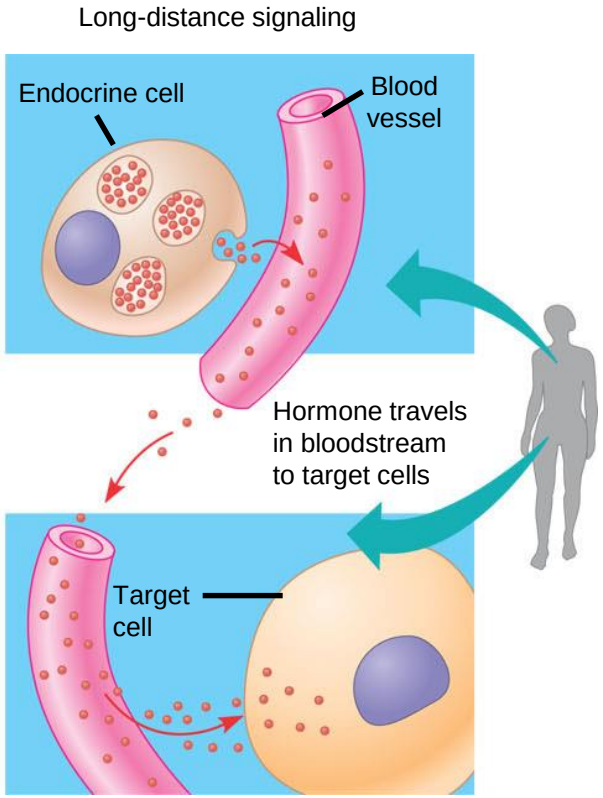


(a) Paracrine signaling. A secreting cell acts on nearby target cells by discharging molecules of a local regulator (a growth factor, for example) into the extracellular fluid.

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

Figure 11.4 A B

- In long-distance signaling
  - Both plants and animals use hormones



(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: *A Preview*

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

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

- Overview of cell signaling

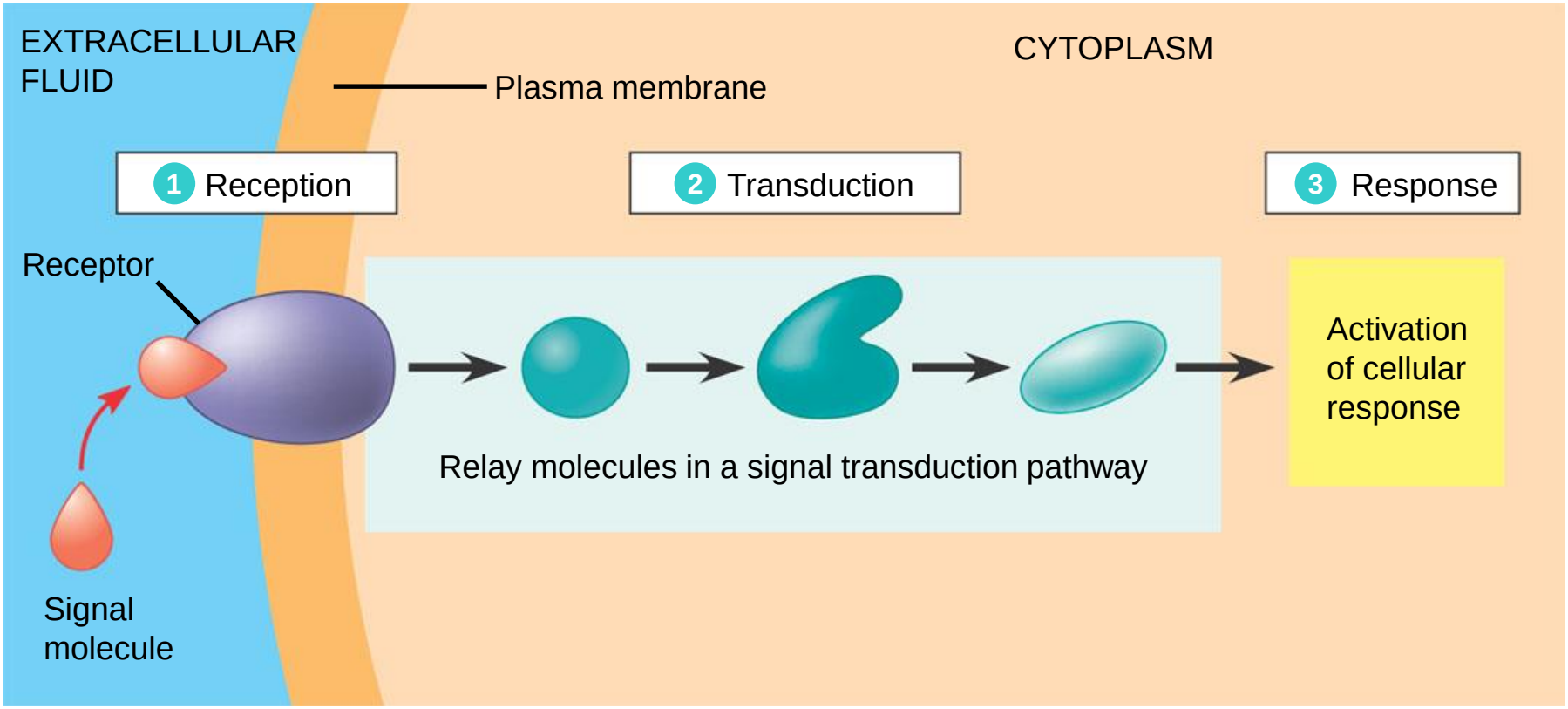


Figure 11.5

- Concept 11.2: Reception: A signal molecule binds to a receptor protein, causing it to change shape

- 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

Intracellular Receptors

- Intracellular receptors
  - Are cytoplasmic or nuclear proteins

- Signal molecules that are small or hydrophobic
  - And can readily cross the plasma membrane use these receptors

- Steroid hormones
  - Bind to intracellular receptors

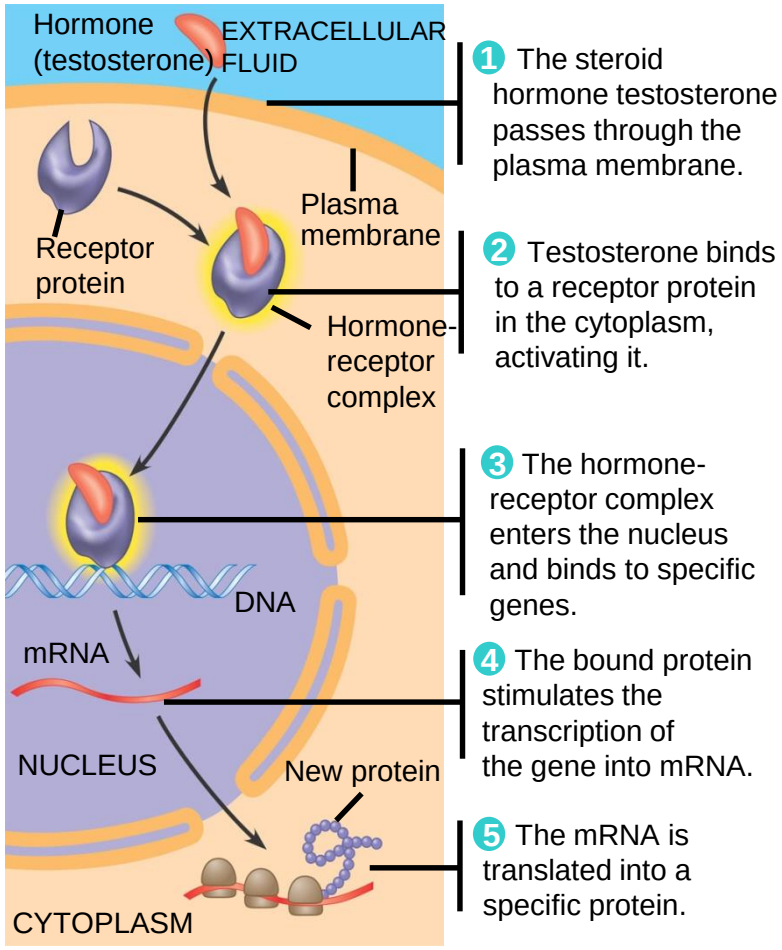


Figure 11.6

Receptors in the Plasma Membrane

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

- G-protein-linked receptors

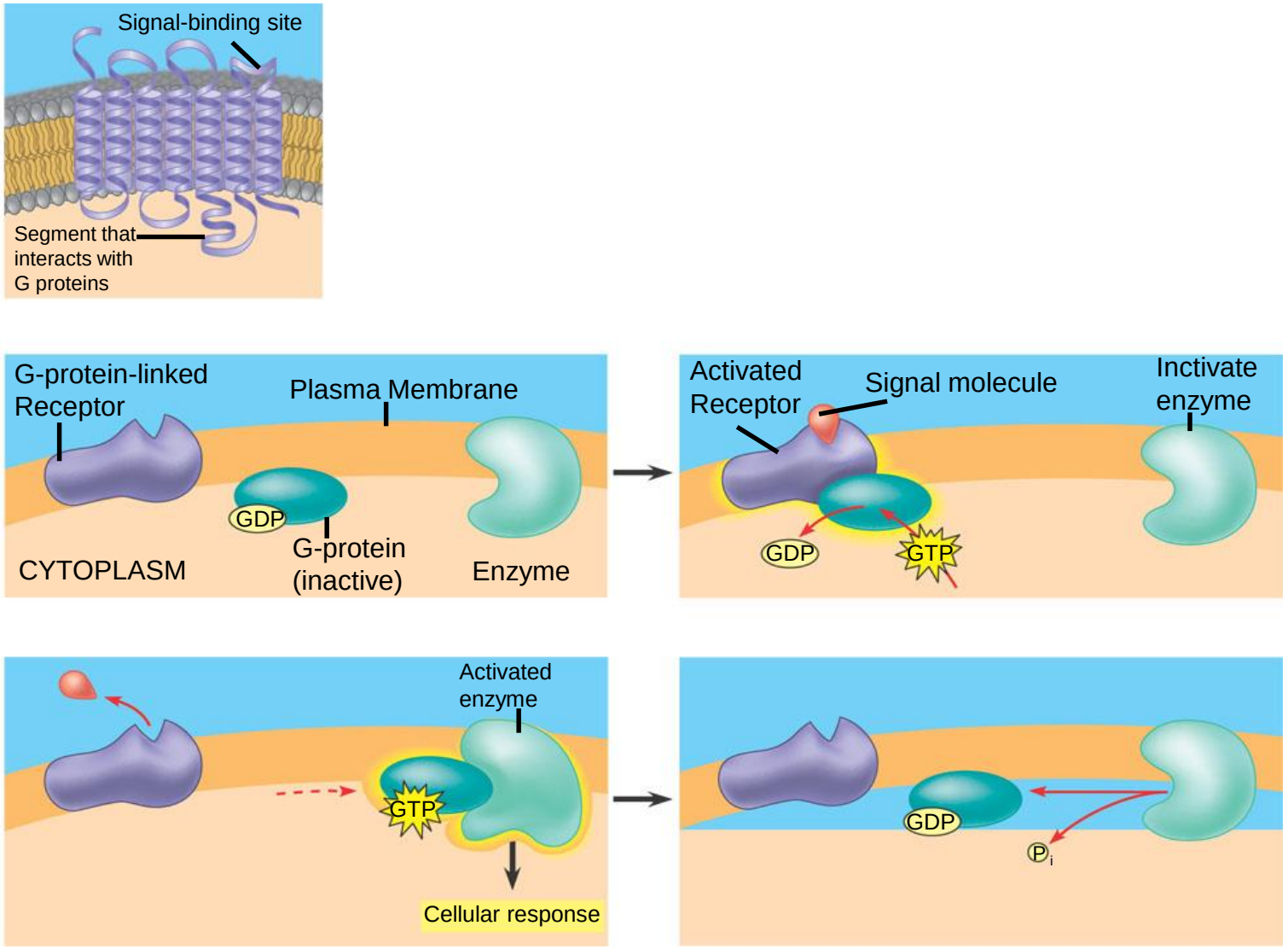


Figure 11.7

- Receptor tyrosine kinases

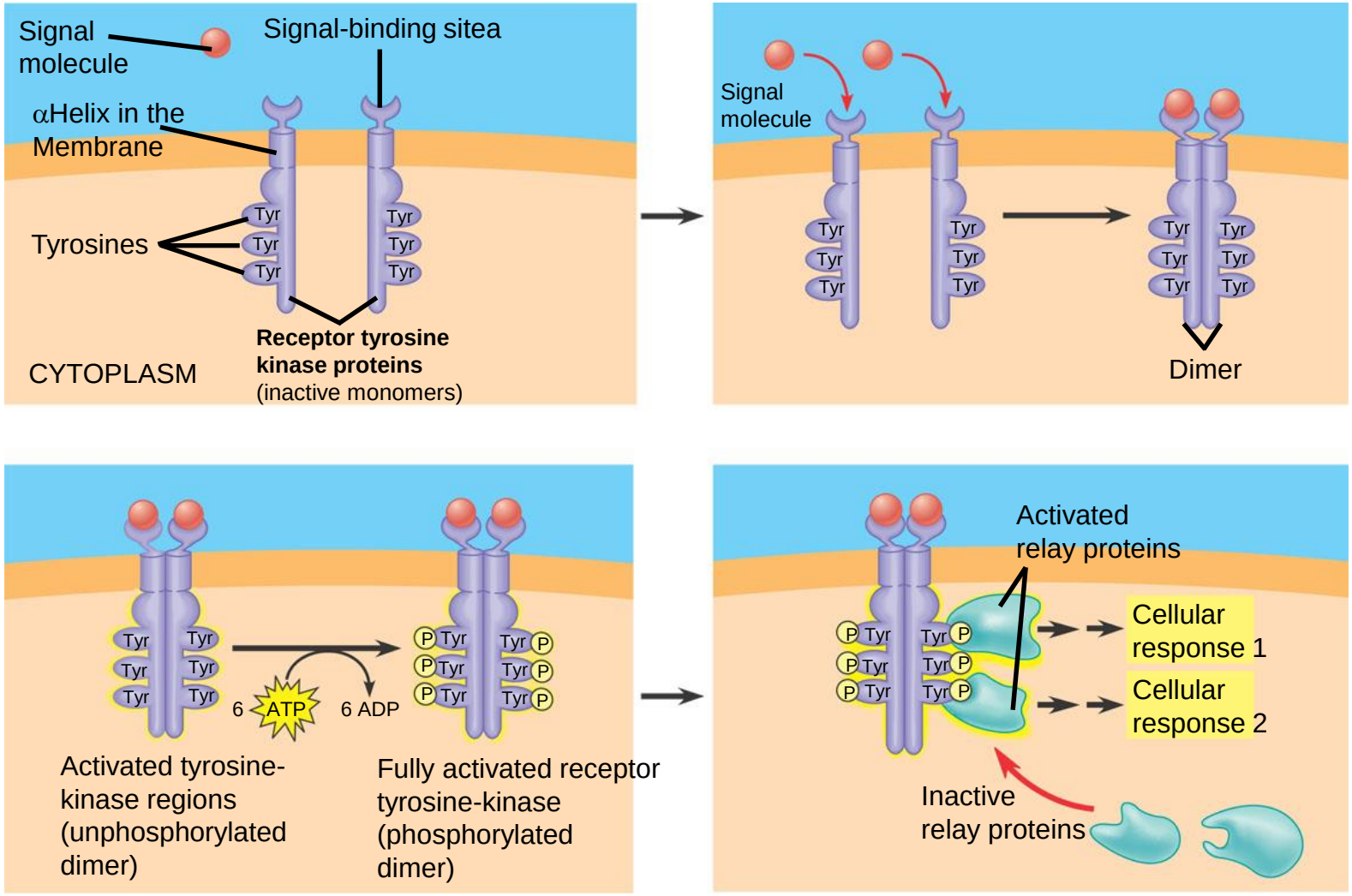


Figure 11.7

- Ion channel receptors

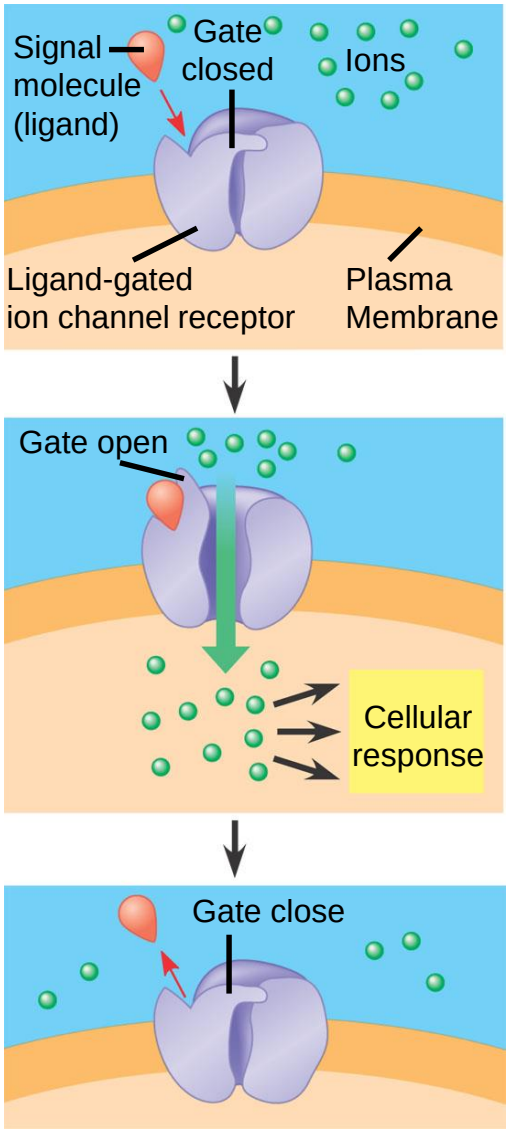


Figure 11.7

- Concept 11.3: Transduction: Cascades of molecular interactions relay signals from receptors to target molecules in the cell
- Multistep pathways
  - Can amplify a signal
  - Provide more opportunities for coordination and regulation

Signal Transduction Pathways

- At each step in a pathway
  - The signal is transduced into a different form, commonly a conformational change in a protein

Protein Phosphorylation and Dephosphorylation

- Many signal pathways
  - Include phosphorylation cascades

- In this process
  - A series of protein kinases add a phosphate to the next one in line, activating it
  - Phosphatase enzymes then remove the phosphates

- A phosphorylation cascade

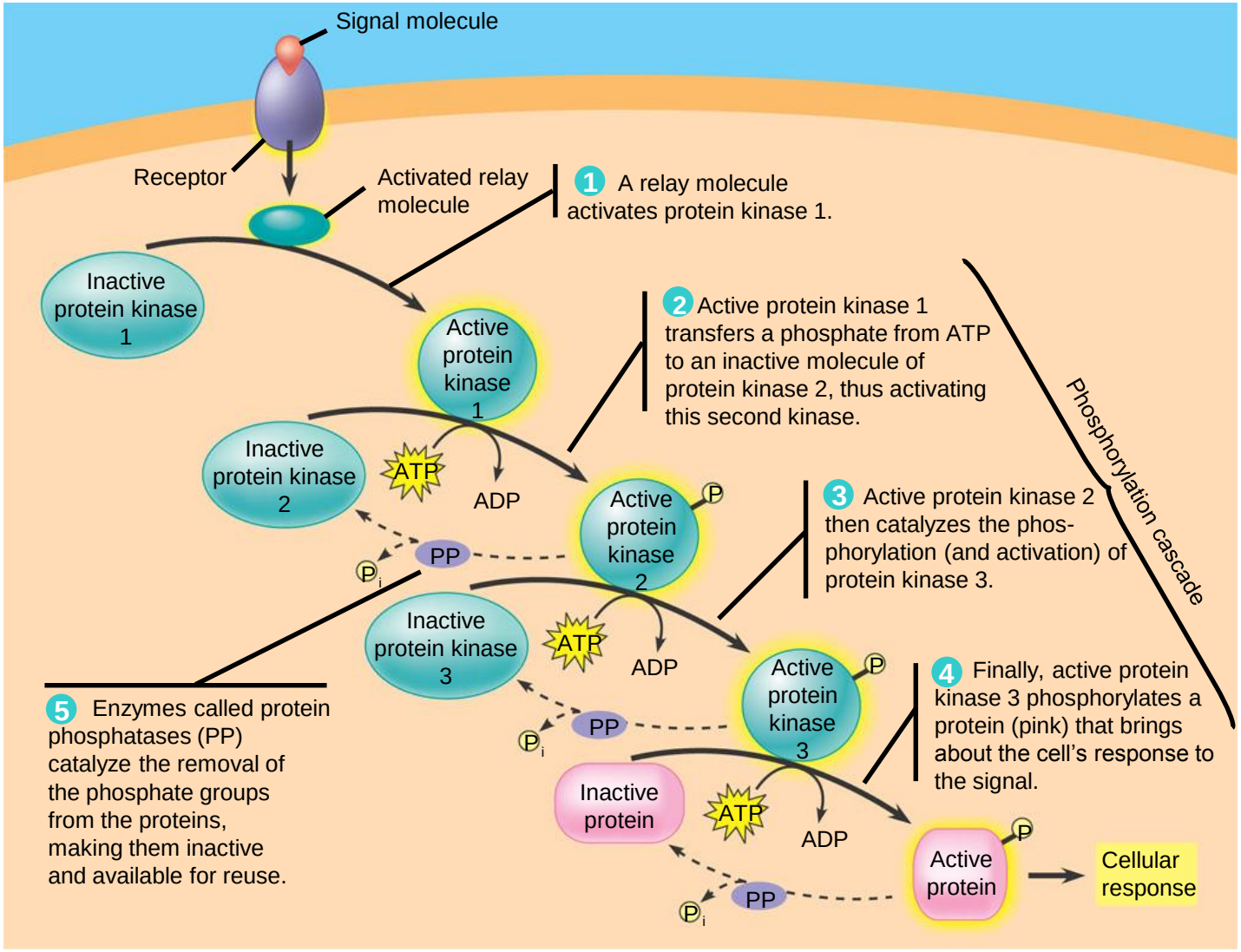


Figure 11.8

Small Molecules and Ions as Second Messengers

- Second messengers
  - Are small, nonprotein, water-soluble molecules or ions

Cyclic AMP

- Cyclic AMP (cAMP)
  – Is made from ATP

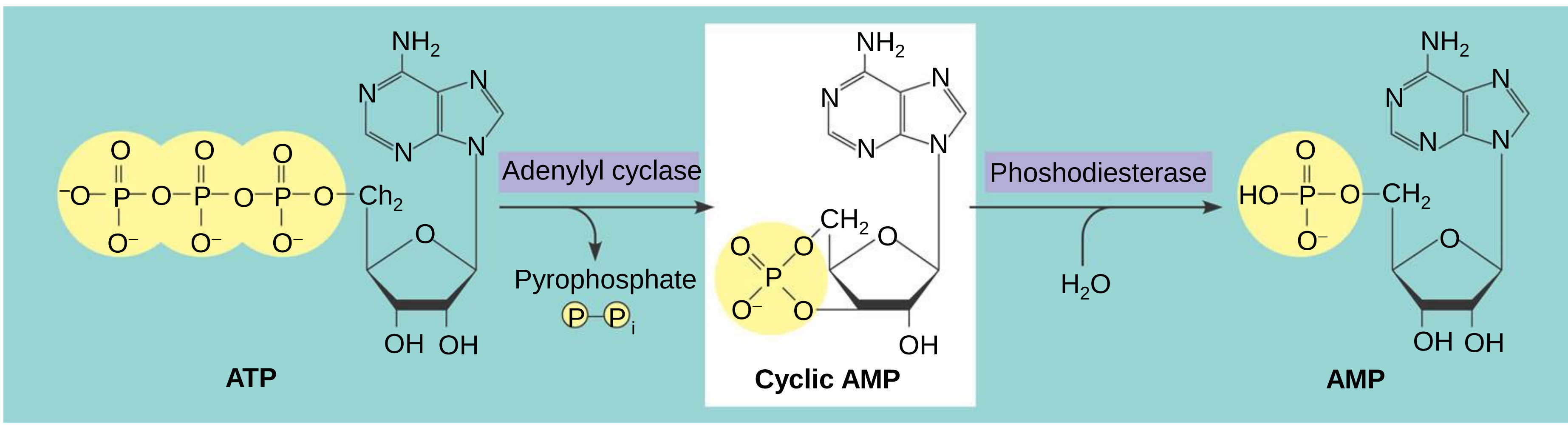


Figure 11.9

- Many G-proteins
  - Trigger the formation of cAMP, which then acts as a second messenger in cellular pathways

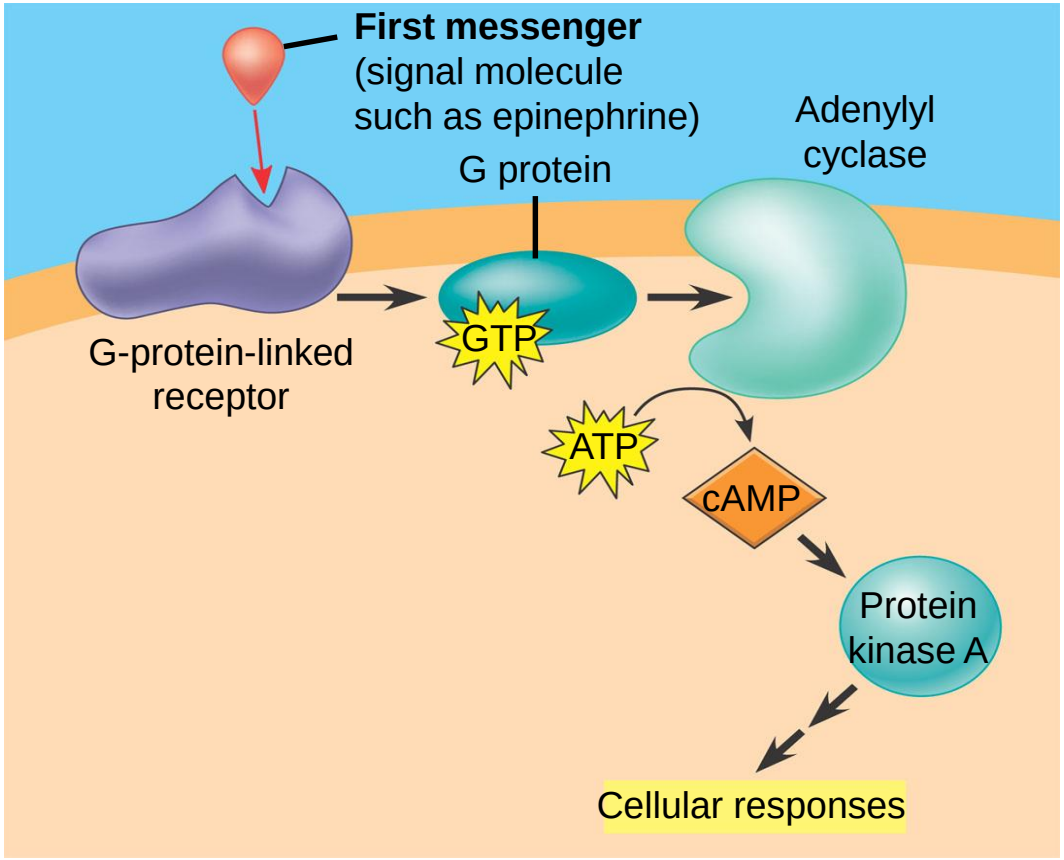


Figure 11.10

Calcium ions and Inositol Triphosphate (IP_3)

- Calcium, when released into the cytosol of a cell
  - Acts as a second messenger in many different pathways

- Calcium is an important second messenger
  - Because cells are able to regulate its concentration in the cytosol

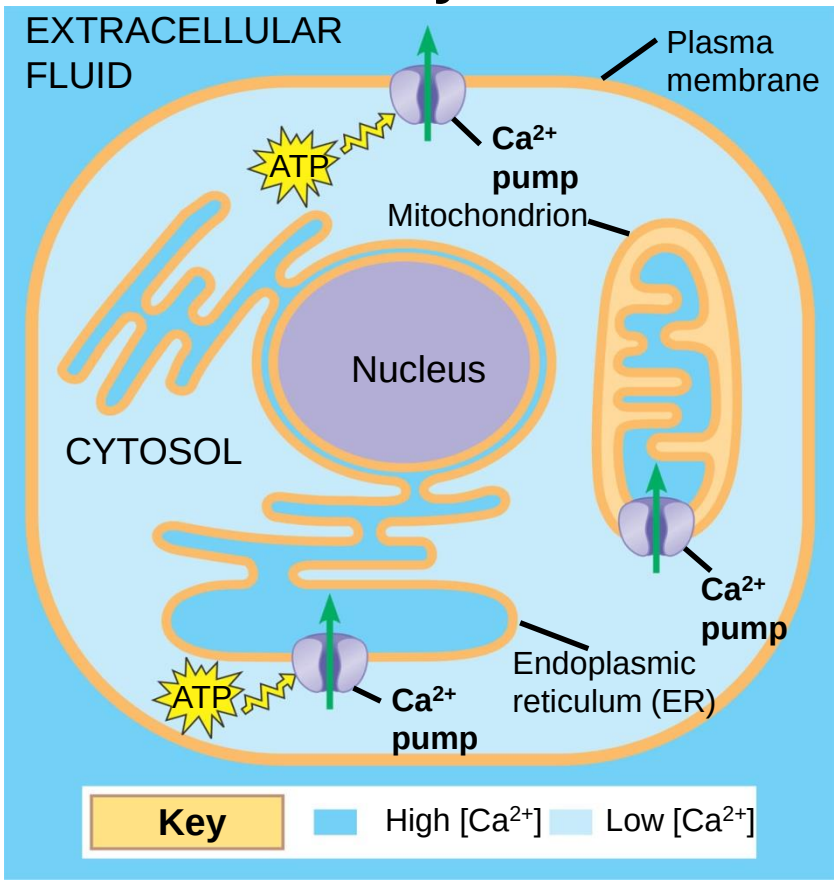


Figure 11.11

- Other second messengers such as inositol triphosphate and diacylglycerol
  - Can trigger an increase in calcium in the cytosol

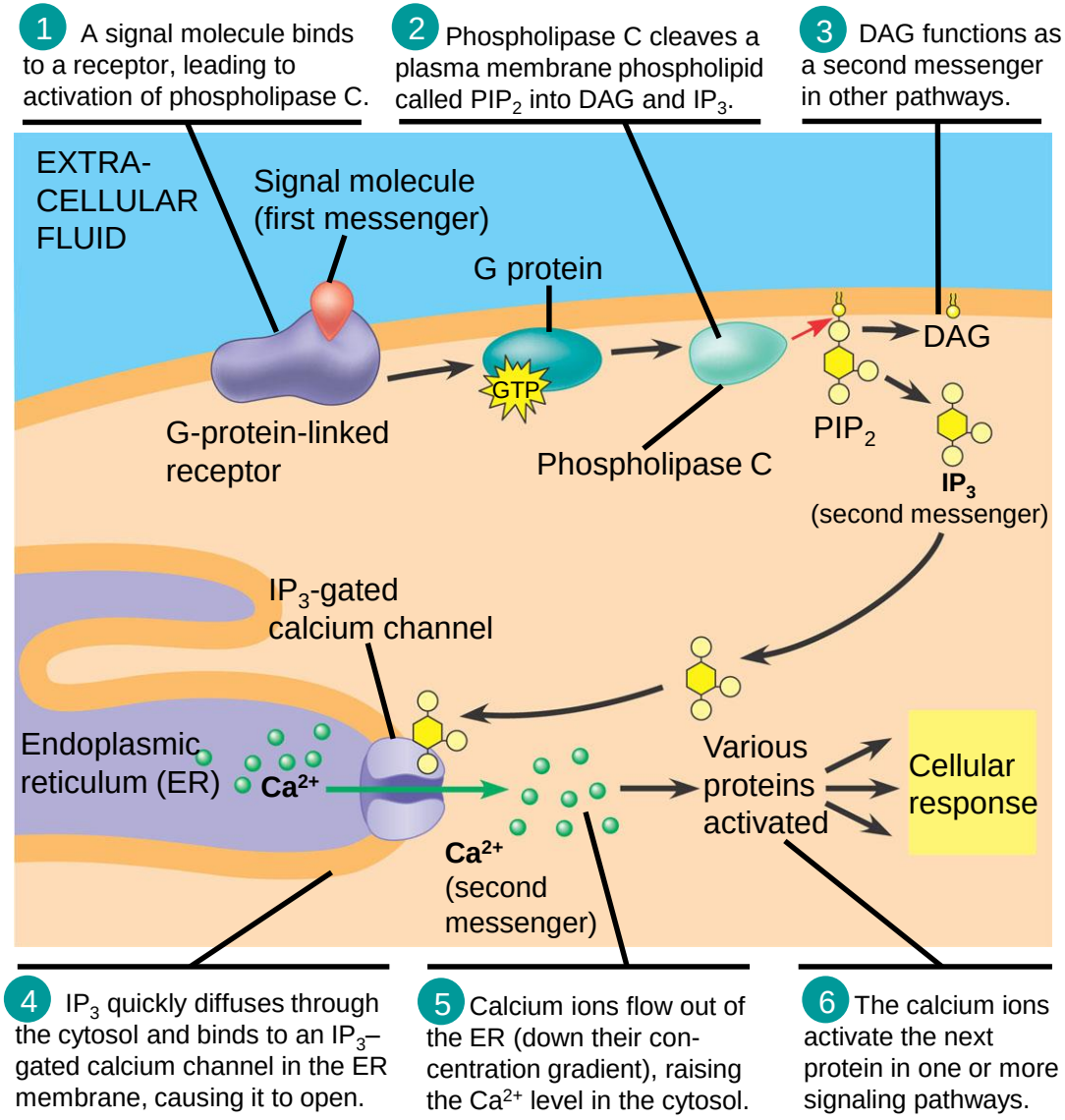


Figure 11.12

- Concept 11.4: Response: Cell signaling leads to regulation of cytoplasmic activities or transcription

Cytoplasmic and Nuclear Responses

- In the cytoplasm
  - Signaling pathways regulate a variety of cellular activities

- Cytoplasmic response to a signal

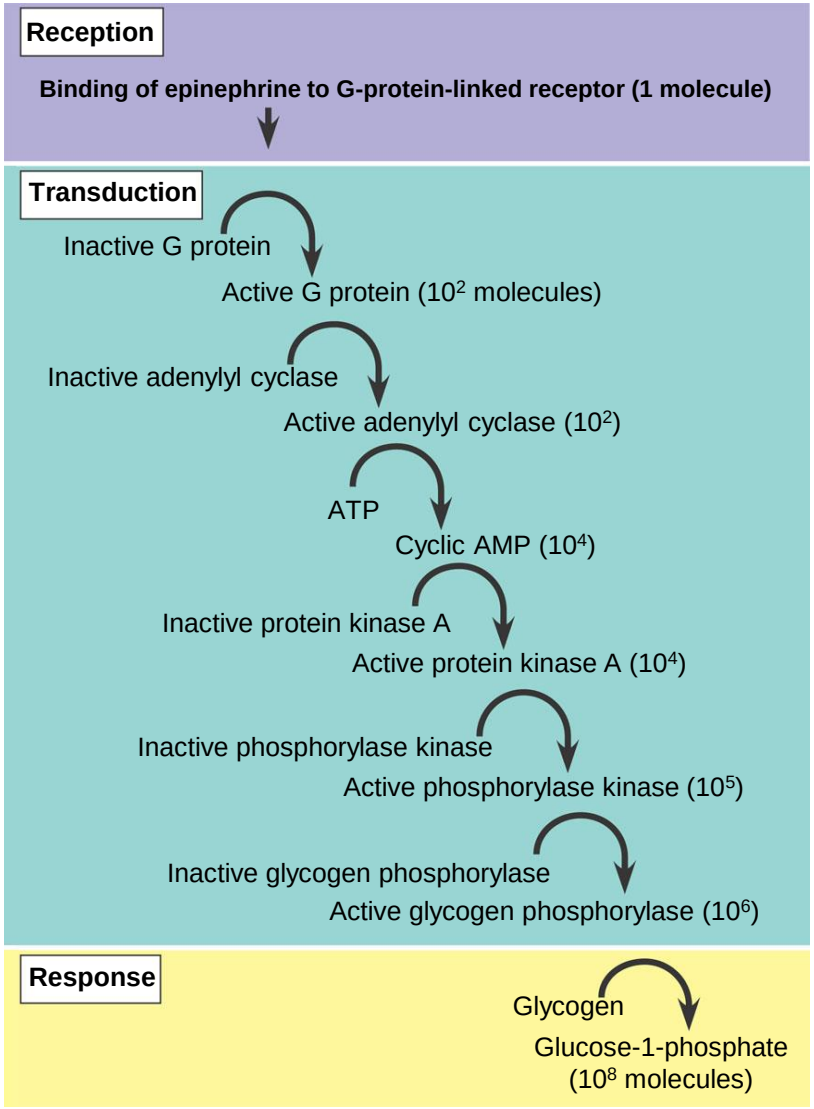


Figure 11.13

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

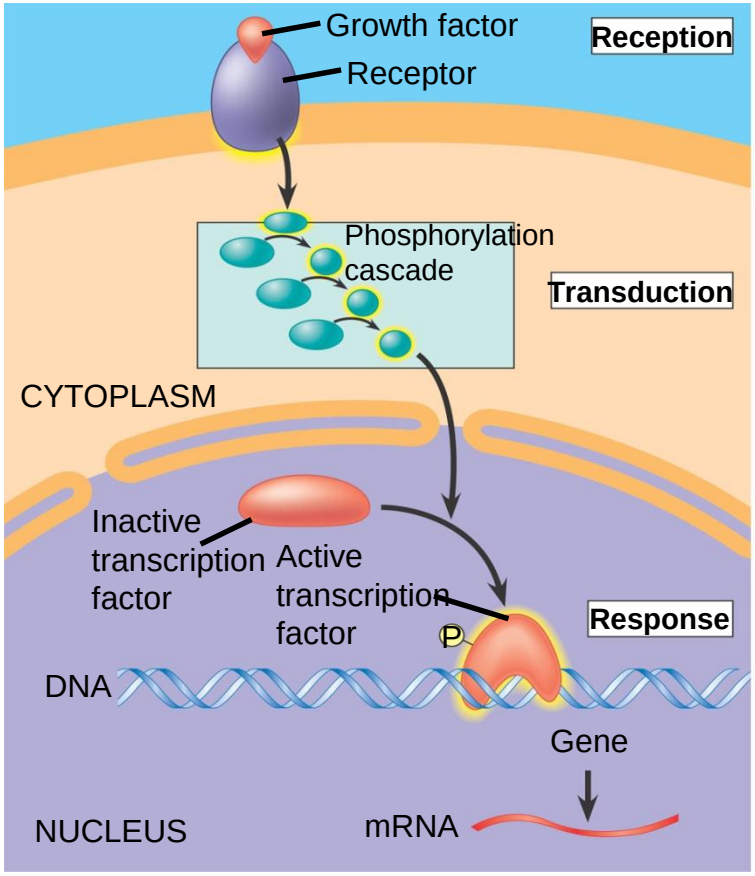


Figure 11.14

Fine-Tuning of the Response

- Signal pathways with multiple steps
  - Can amplify the signal and contribute to the specificity of the response

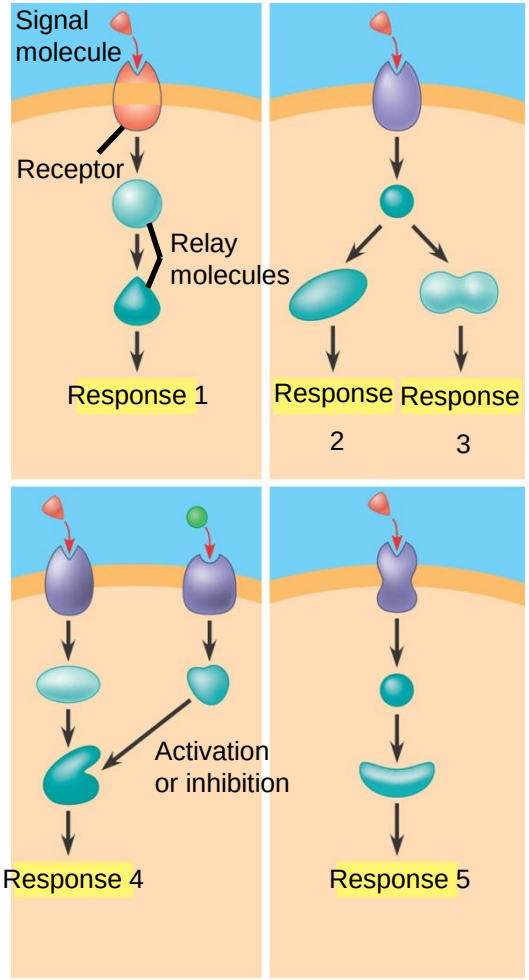
Signal Amplification

- Each protein in a signaling pathway
  - Amplifies the signal by activating multiple copies of the next component in the pathway

The Specificity of Cell Signaling

- The different combinations of proteins in a cell
  - Give the cell great specificity in both the signals it detects and the responses it carries out

- Pathway branching and “cross-talk”
  - Further help the cell coordinate incoming signals



Cell A. Pathway leads to a single response

Cell B. Pathway branches, leading to two responses

Cell C. Cross-talk occurs between two pathways

Cell D. Different receptor leads to a different response

Figure 11.15

Signaling Efficiency: Scaffolding Proteins and Signaling Complexes

- Scaffolding proteins
  - Can increase the signal transduction efficiency

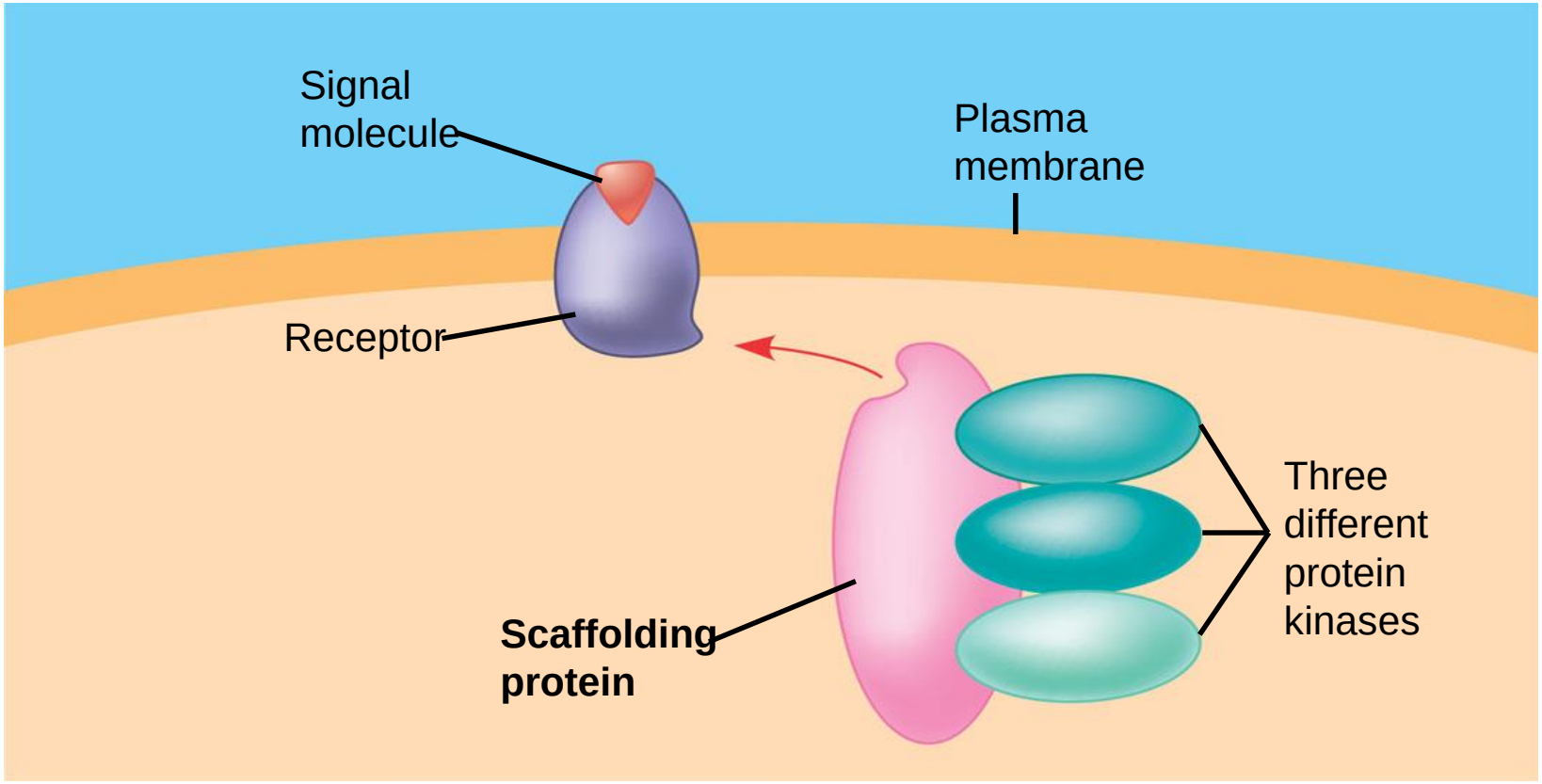


Figure 11.16

Termination of the Signal

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