Ch. 5
Cell Communication

Section 5.6

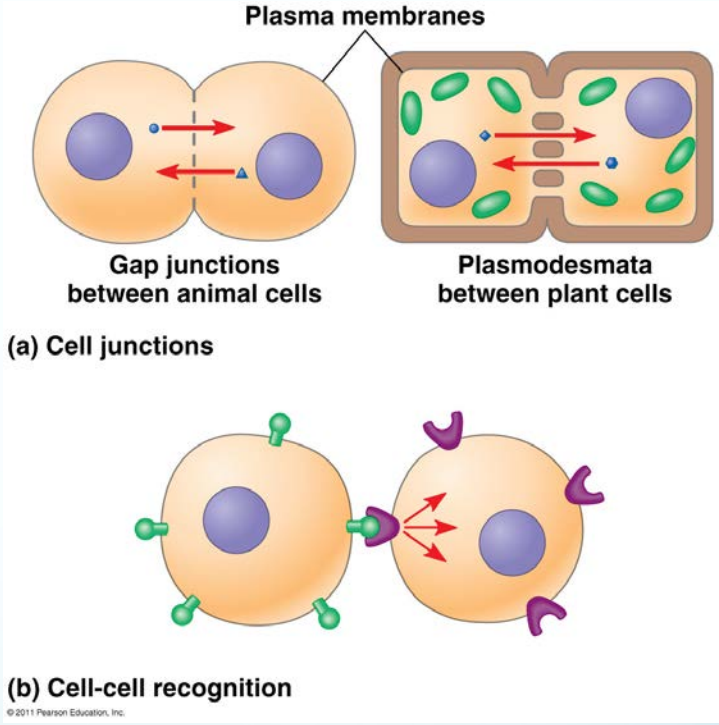
Do bacteria communicate?

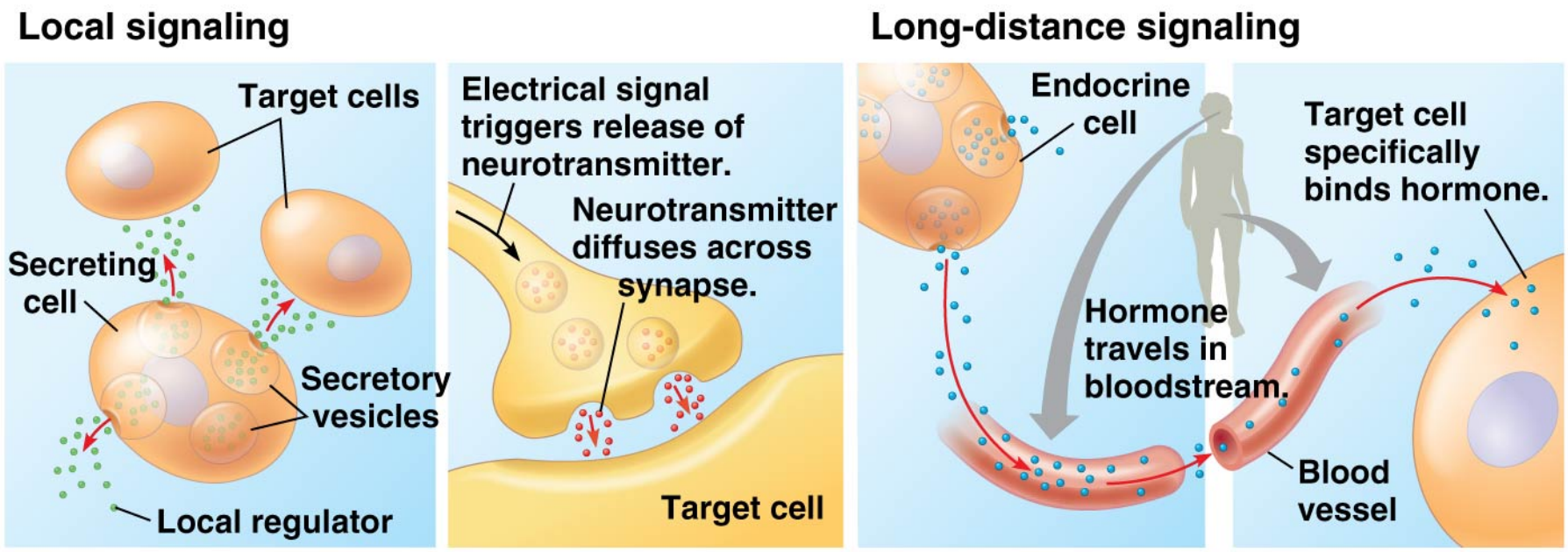
Bonnie Bassler on How Bacteria "Talk"

Cell Signaling

Animal cells communicate by:

- Direct contact (gap junctions)
- Secreting local regulators (growth factors, neurotransmitters)
- Long distance (hormones)

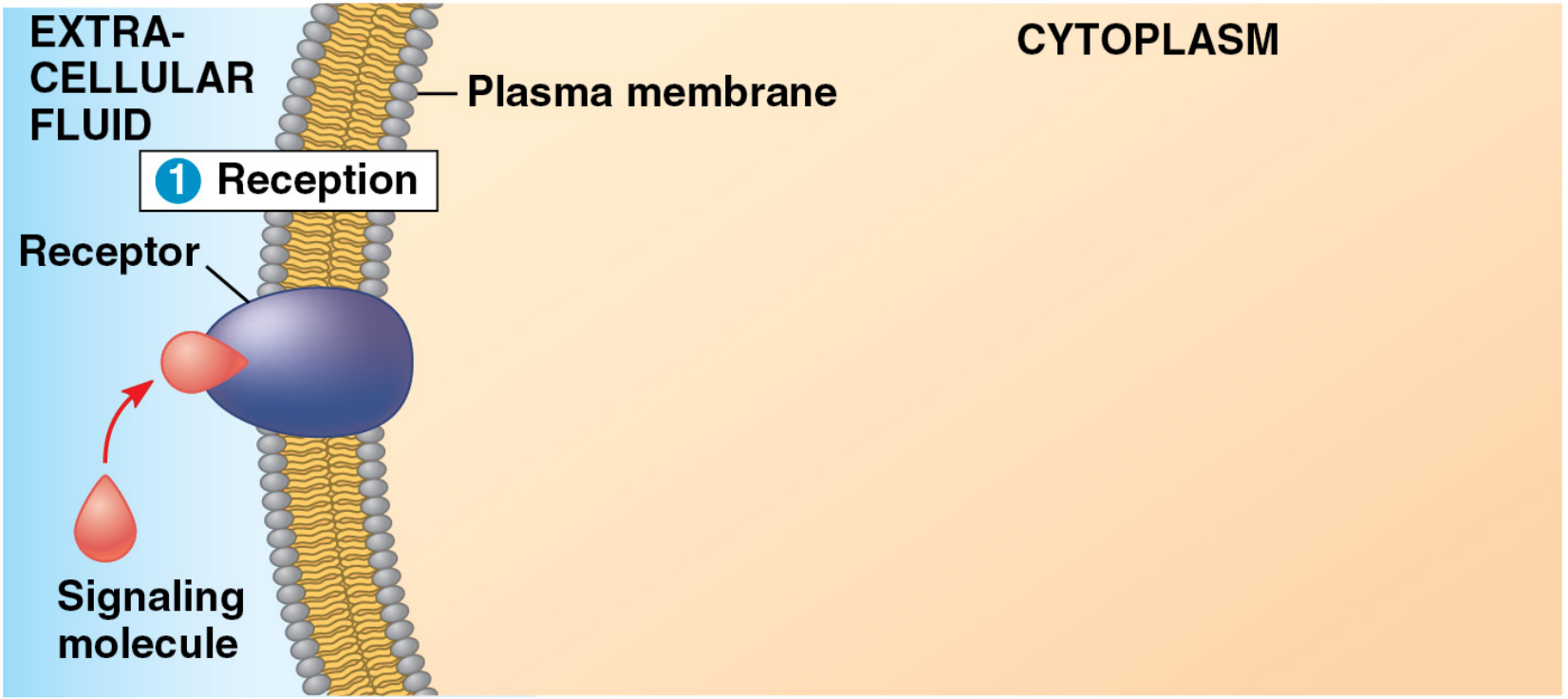




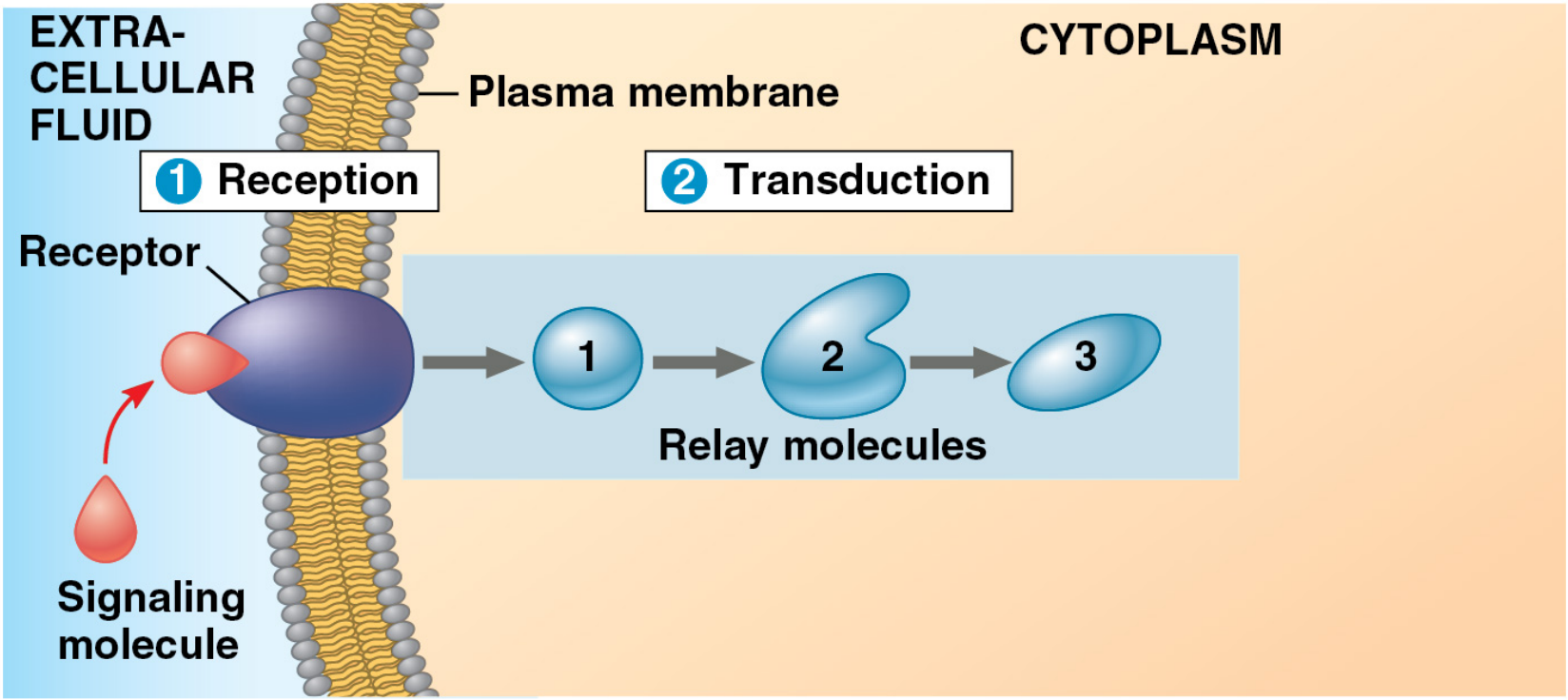
3 Stages of Cell Signaling:

1. **Reception**: Detection of a signal molecule (ligand) coming from outside the cell
2. **Transduction**: Convert signal to a form that can bring about a cellular response
3. **Response**: Specific cellular response to the signal molecule

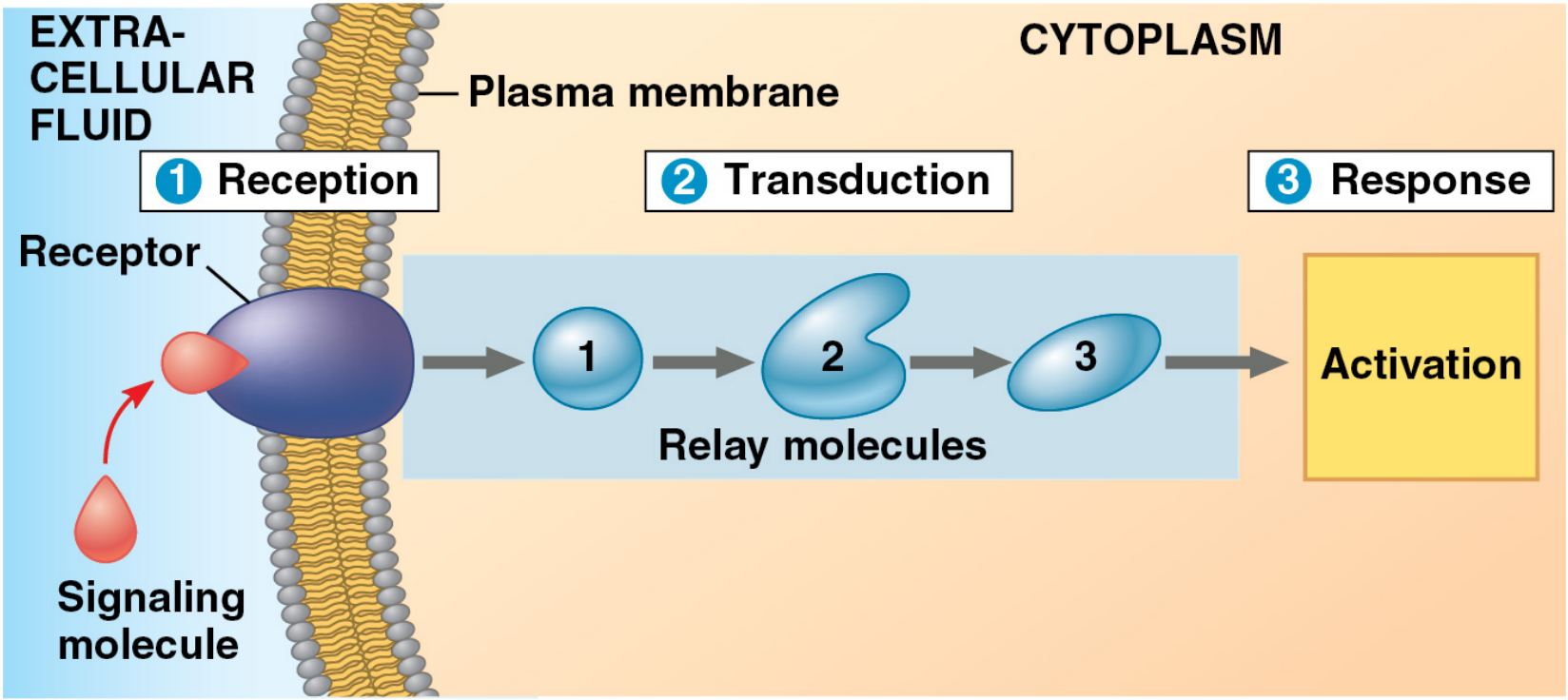
Reception



Transduction



Response



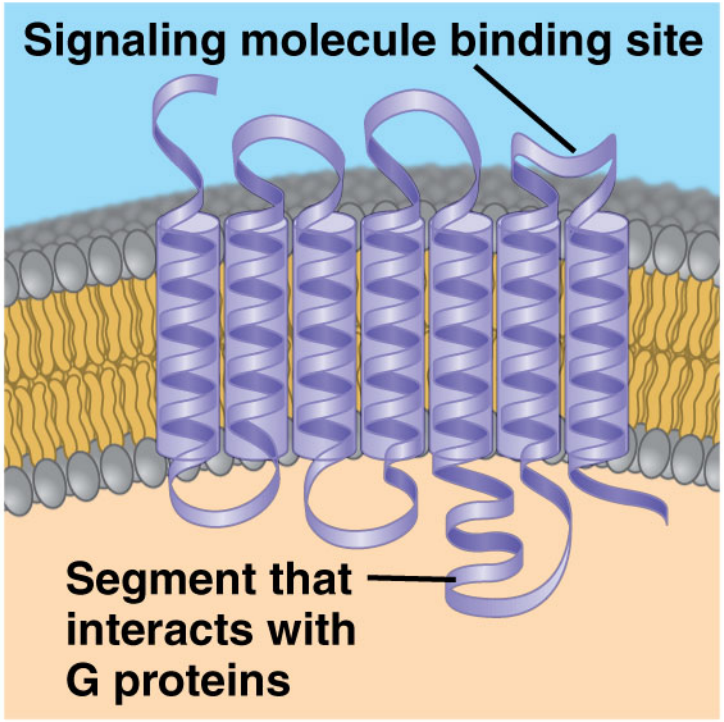
1. Reception

- Binding between signal molecule (ligand) + receptor is *highly specific*.
- Types of Receptors:
  a) Plasma membrane receptor
     - water-soluble ligands
  b) Intracellular receptors (cytoplasm, nucleus)
     - small or hydrophobic ligand molecules
     - Eg. testosterone or nitric oxide (NO)
- Ligand binds to receptor protein → protein changes *SHAPE* → initiates transduction signal

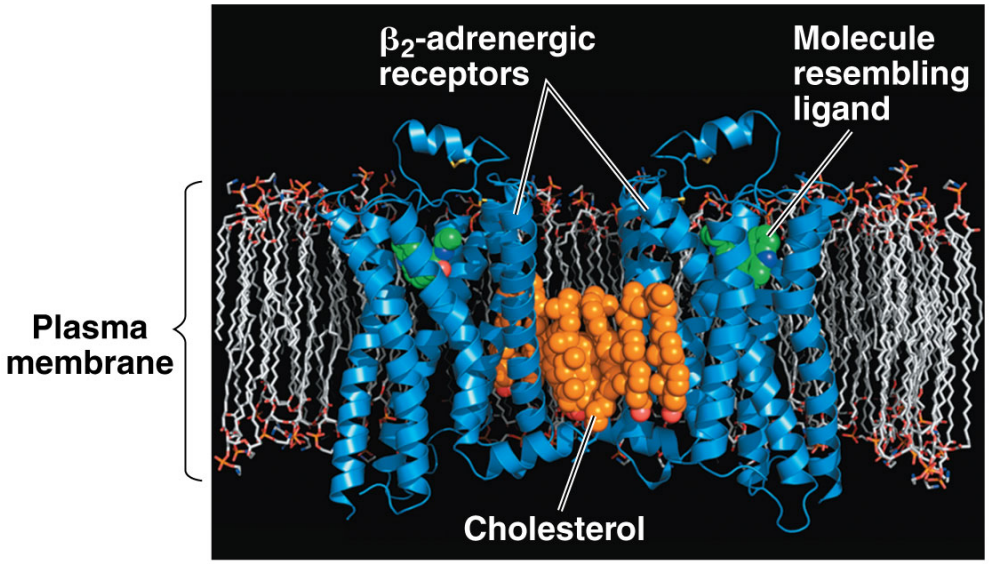
Plasma Membrane Receptors:

G-Protein Coupled Receptor (GPCR)	Tyrosine Kinase	Ligand-Gated Ion Channels

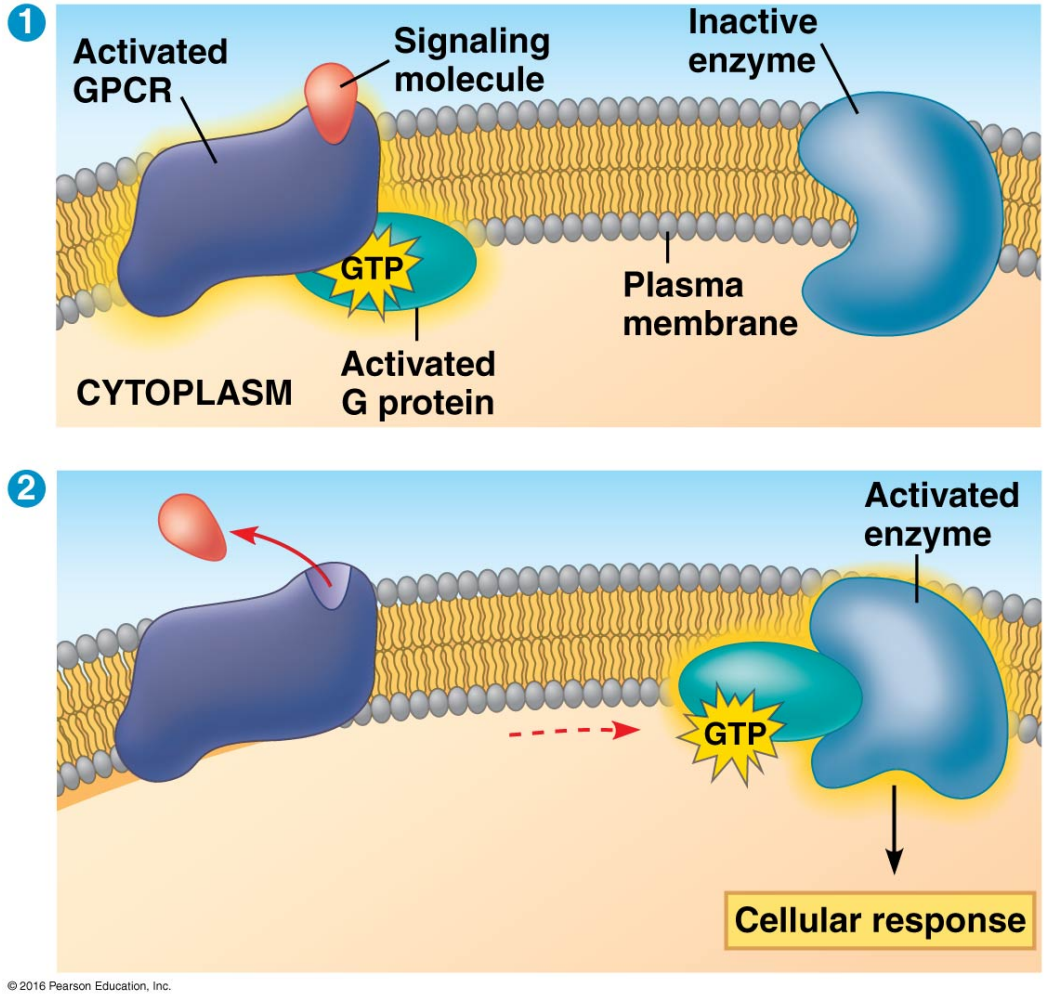
G-Protein-Coupled Receptor



G protein-coupled receptor



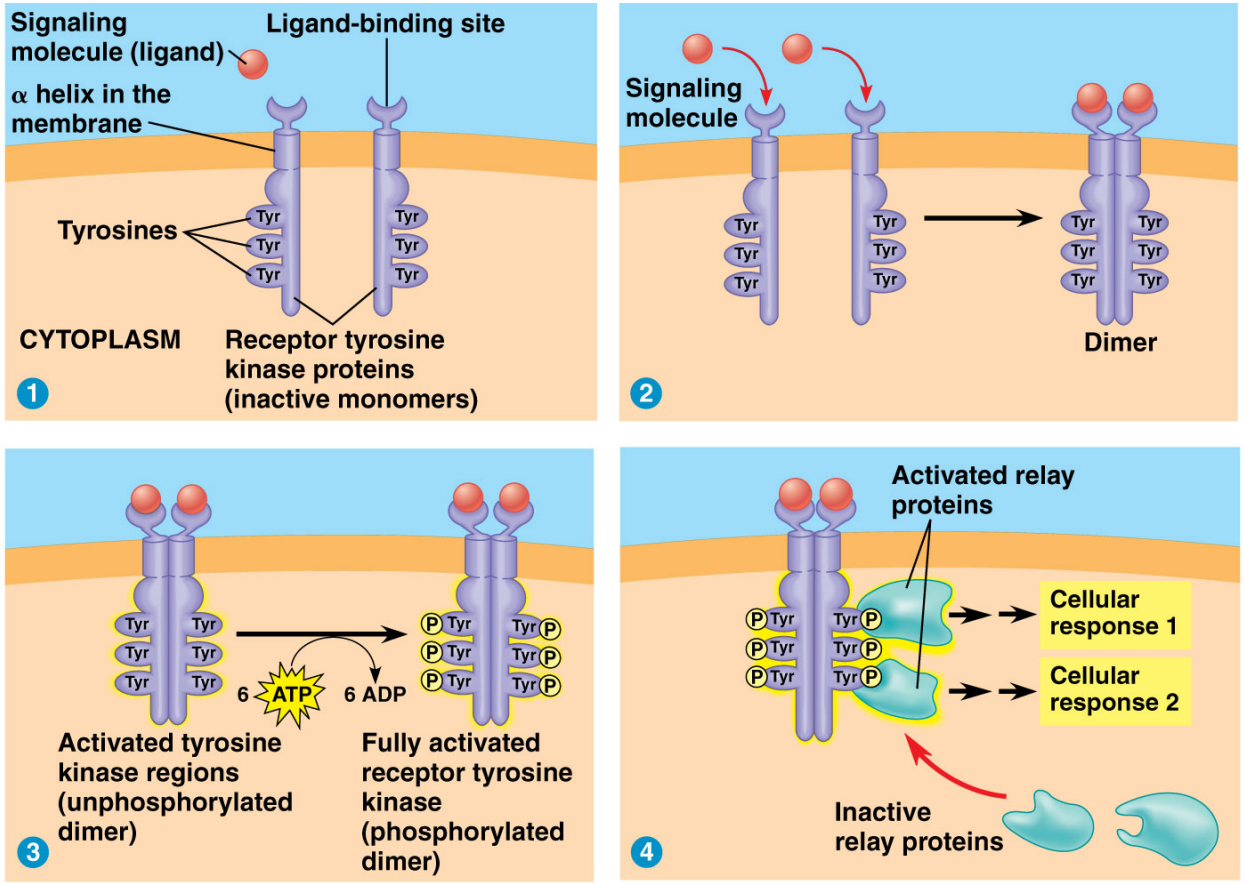
G-Protein-Coupled Receptor



Plasma Membrane Receptors

G-Protein Coupled Receptor (GPCR)	Tyrosine Kinase	Ligand-Gated Ion Channels
7 transmembrane segments in membrane		
G protein + GTP activates enzyme → cell response		

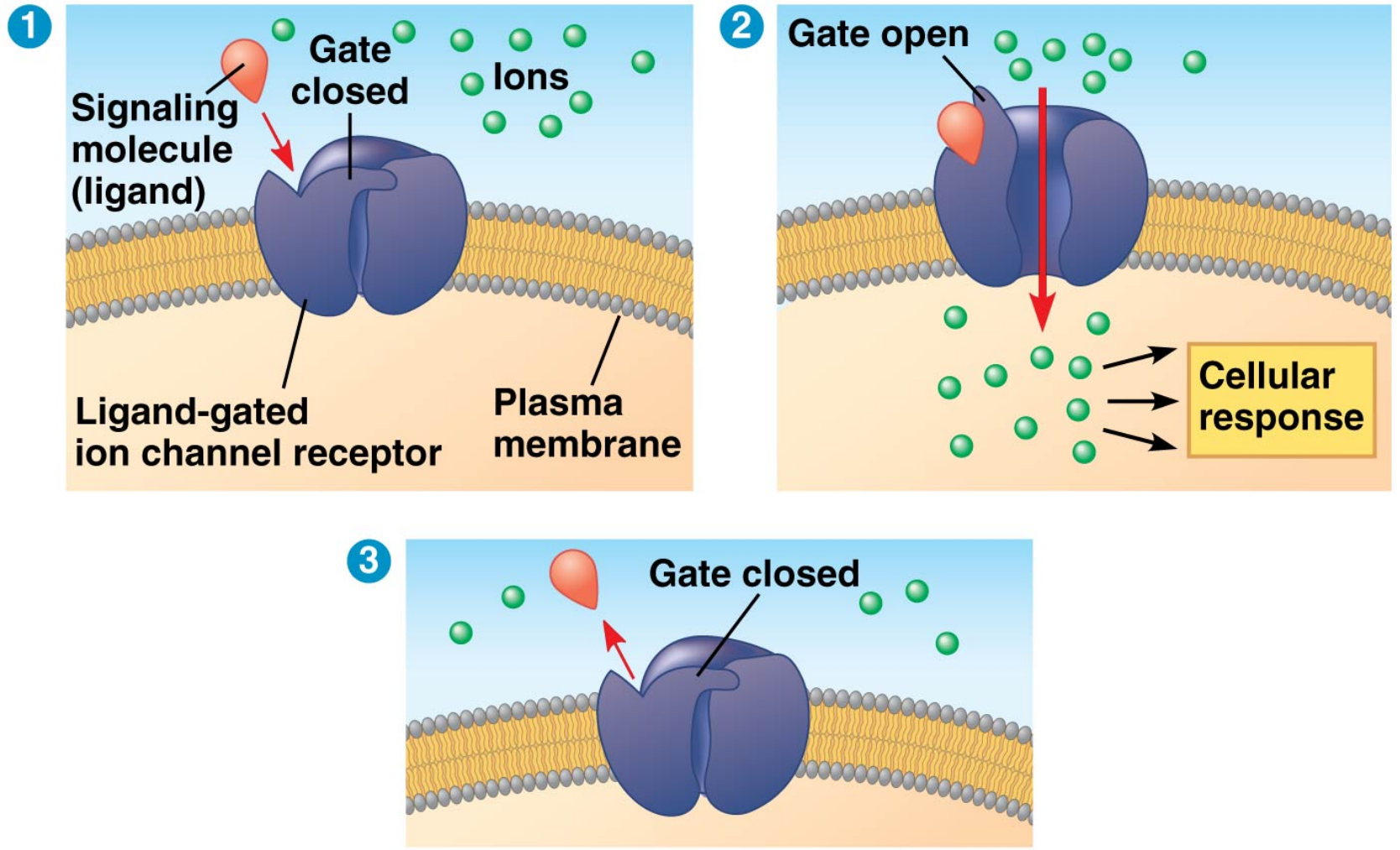
Receptor Tyrosine Kinase



Plasma Membrane Receptors

G-Protein Coupled Receptor (GPCR)	Tyrosine Kinase	Ligand-Gated Ion Channels
	Attaches (P) to tyrosine	
	Activate multiple cellular responses at once	

Ligand-Gated Ion Channel



Plasma Membrane Receptors

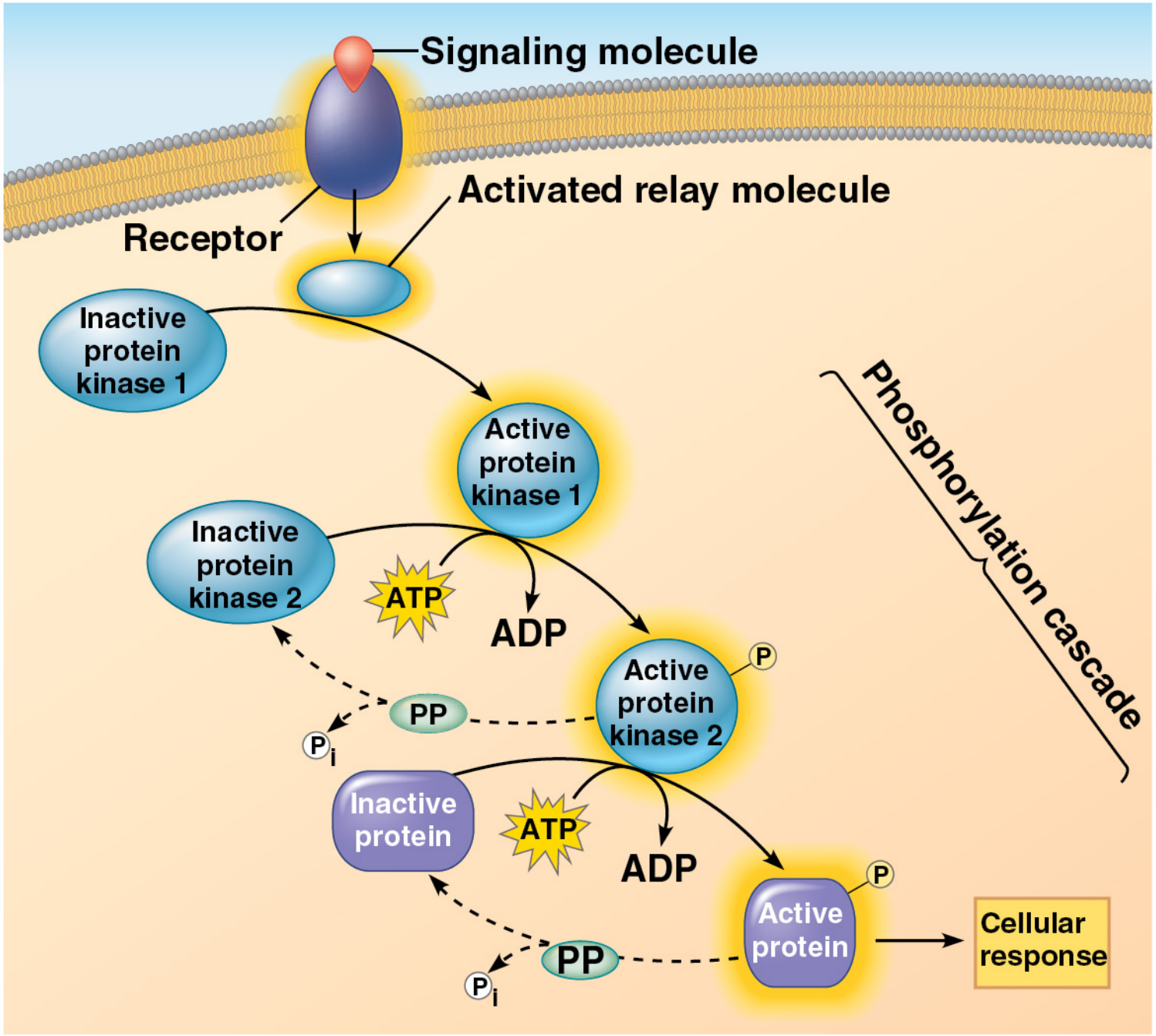
G-Protein Coupled Receptor (GPCR)	Tyrosine Kinase	Ligand-Gated Ion Channels
		Signal on receptor changes shape
		Regulate flow of specific ions (Ca^{2+}, Na^{+})

2. Transduction

- Cascades of molecular interactions relay signals from receptors → target molecules

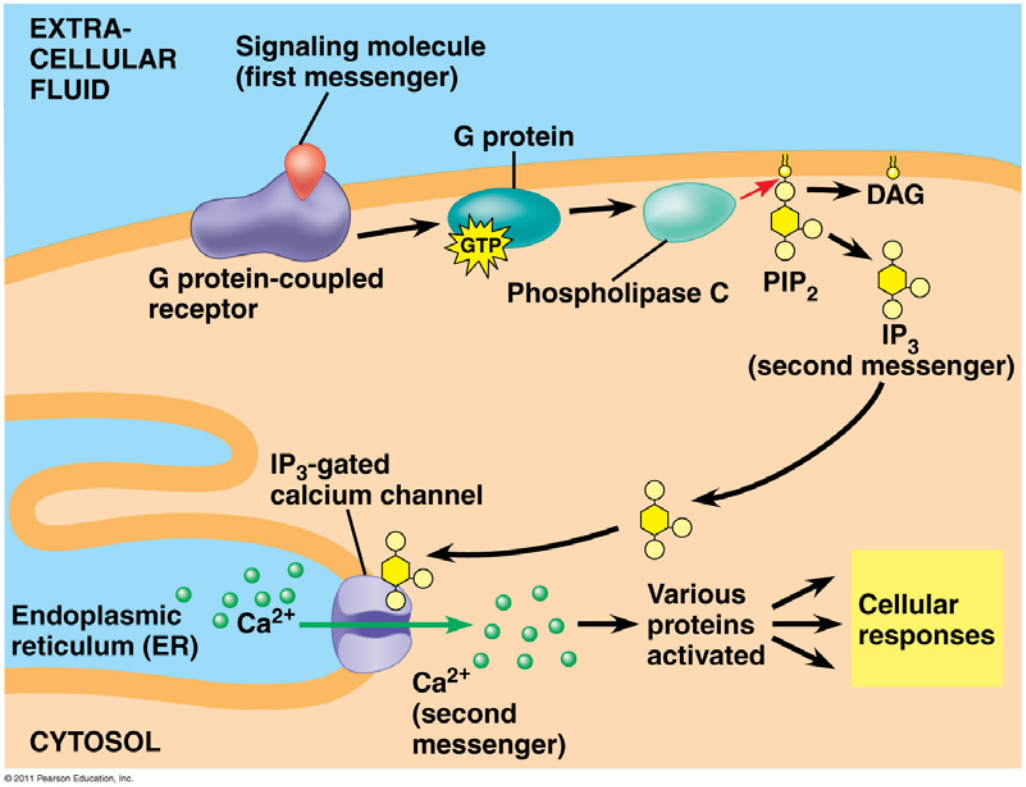
- **Protein kinase**: enzyme that phosphorylates and activates proteins at next level

- Phosphorylation cascade: enhance and amplify signal



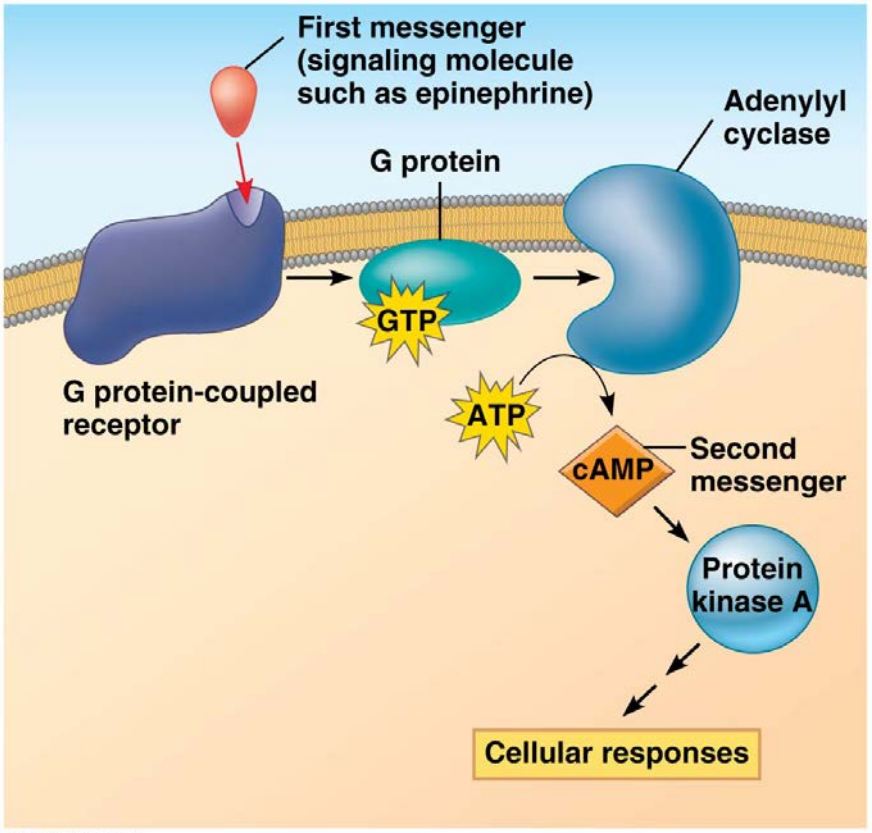
Second Messengers

- Small, non-protein molecules/ions that can relay signal inside cell
  - Eg. cyclic AMP (cAMP), calcium ions (Ca^{2+}), inositol triphosphate (IP_3)



cAMP

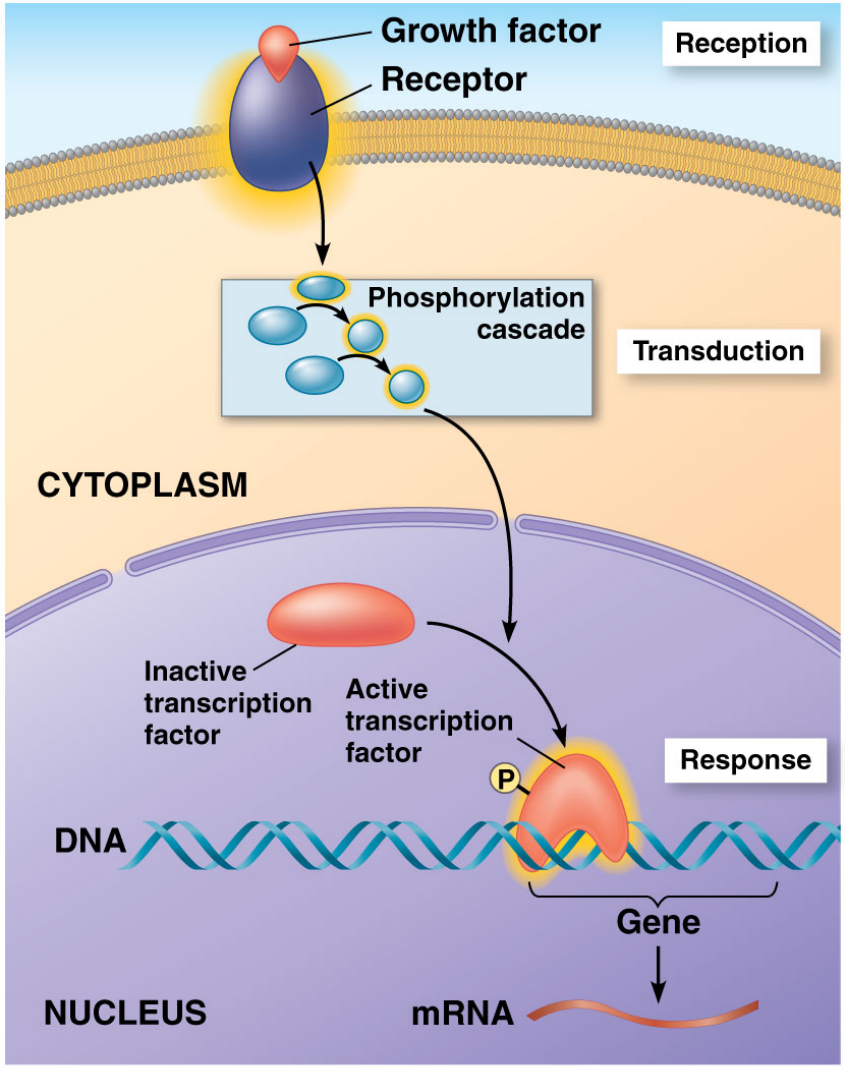
- cAMP = cyclic adenosine monophosphate
- GPCR → adenylyl cyclase (convert ATP → cAMP) → activate protein kinase A



3. Response

- Regulate protein synthesis by turning on/off genes in nucleus (gene expression)

- Regulate activity of proteins in cytoplasm



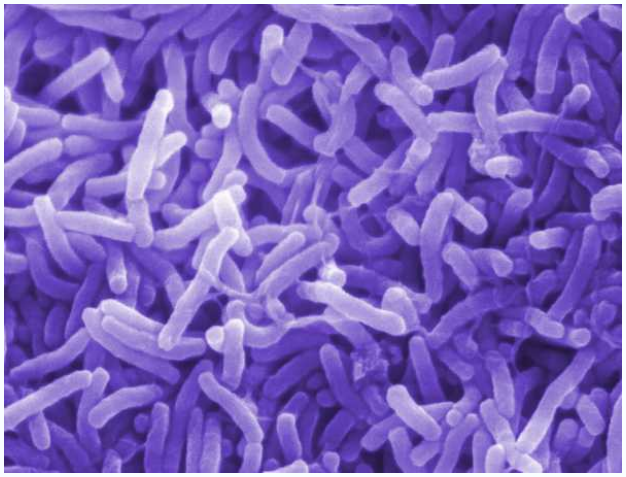
An Example of Cell Communication

http://learn.genetics.utah.edu/content/begin/cells/cellcom/

Signal Transduction Pathway Problems/Defects:

Examples:

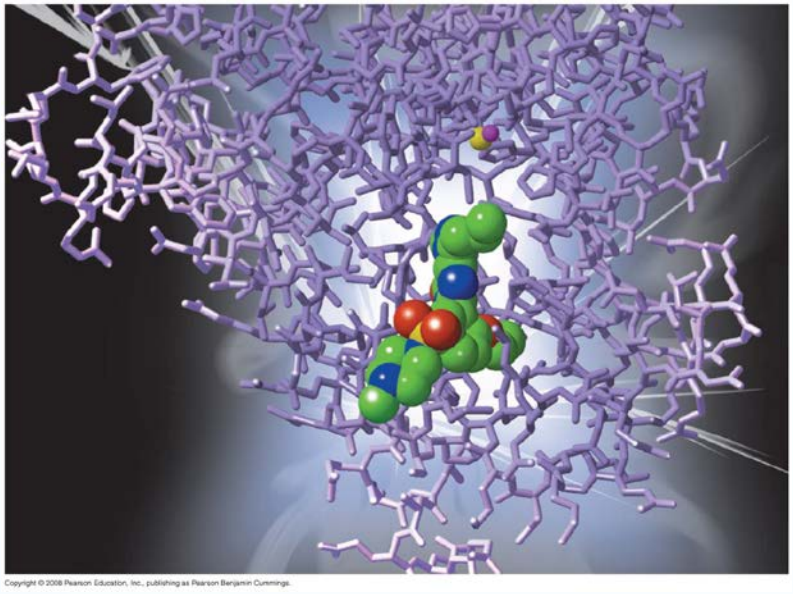
- Diabetes
- Cholera
- Autoimmune disease
- Cancer
- Neurotoxins, poisons, pesticides
- Drugs (anesthetics, antihistamines, blood pressure meds)



Cholera

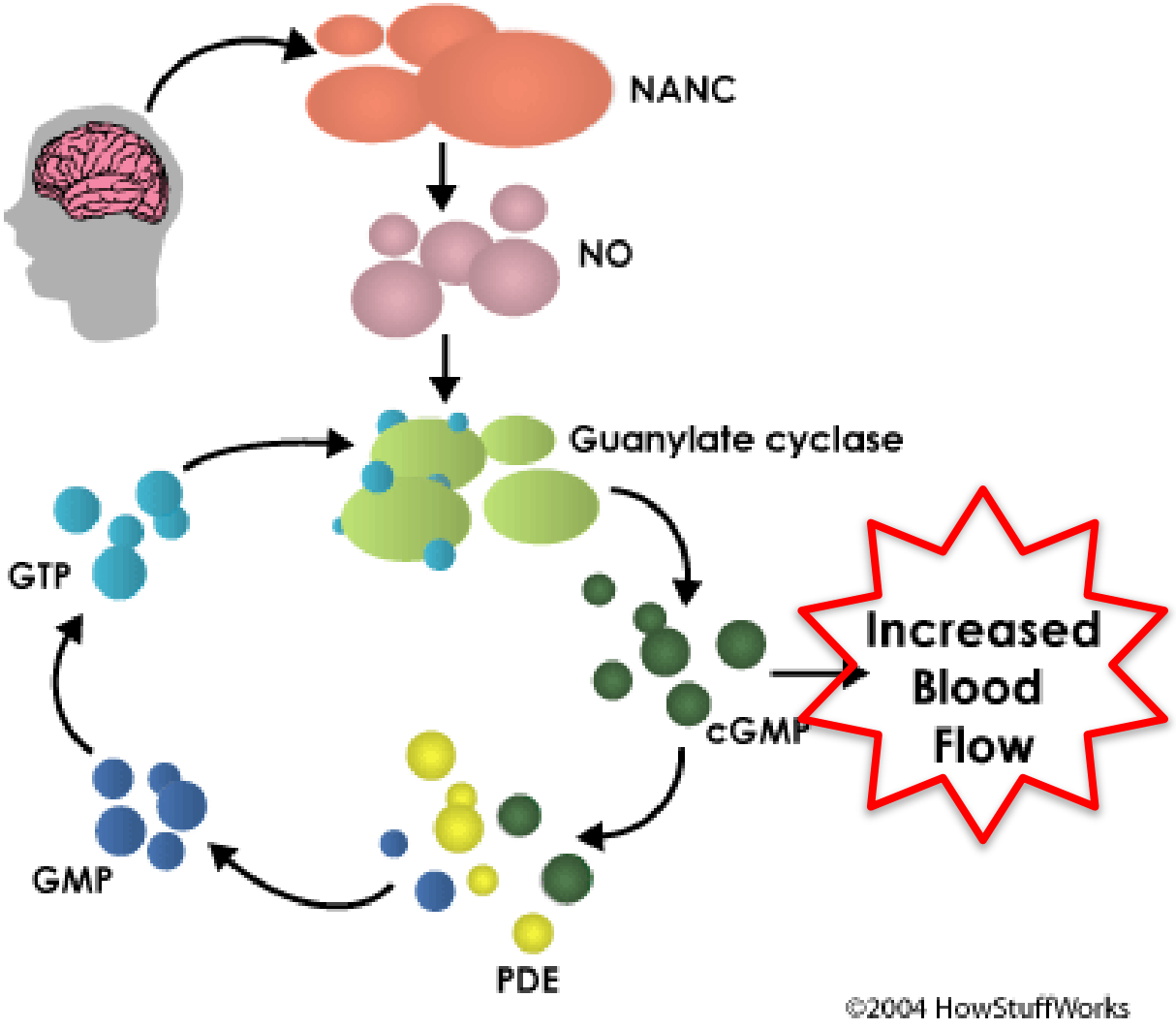
- Disease acquired by drinking contaminated water (w/human feces)
- Bacteria (*Vibrio cholerae*) colonizes lining of small intestine and produces toxin
- Toxin modifies G-protein involved in regulating salt & water secretion
- G protein stuck in active form → intestinal cells secrete salts, water
- Infected person develops profuse diarrhea and could die from loss of water and salts

Viagra



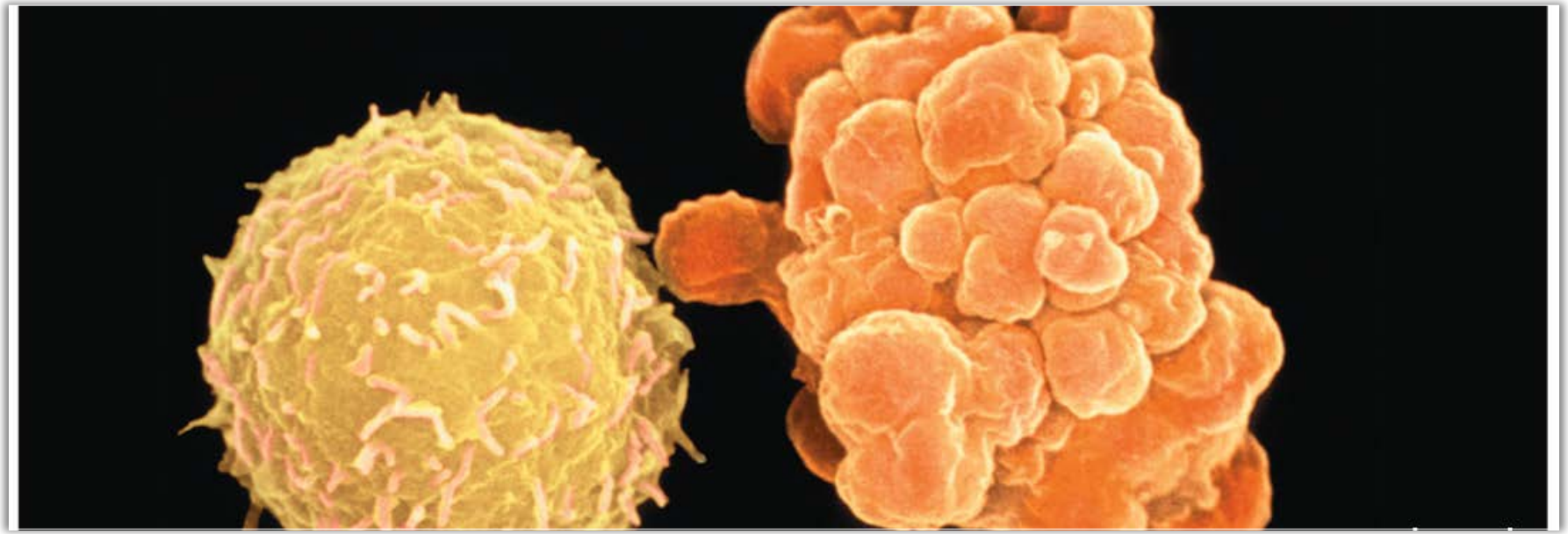
- Used as treatment for erectile dysfunction
- Inhibits hydrolysis of cGMP → GMP
- Prolongs signal to relax smooth muscle in artery walls; increase blood flow to penis

Viagra inhibits cGMP breakdown



Apoptosis = cell suicide

- Cell is dismantled and digested
- Triggered by signals that activate cascade of "suicide" proteins (caspase)
- Why?
  - Protect neighboring cells from damage
  - Animal development & maintenance
- May be involved in some diseases (Parkinson's, Alzheimer's)



Apoptosis of a human white blood cell

Left: Normal WBC
Right: WBC undergoing apoptosis – shrinking and forming lobes (“blebs”)

Effect of apoptosis during paw development in the mouse