

Cell Communication

CHAPTER 5.6



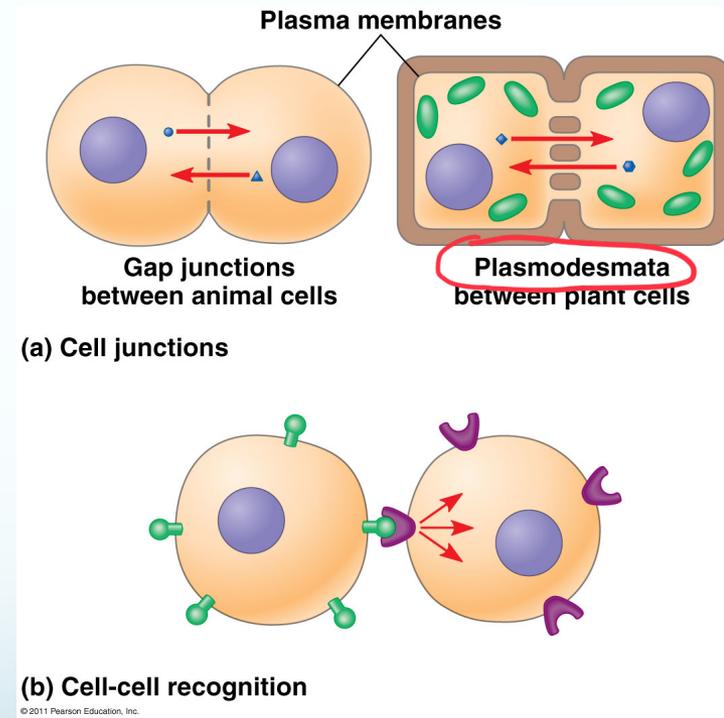
Do bacteria communicate?

Bonnie Bassler on How Bacteria “Talk”

Cell Signaling

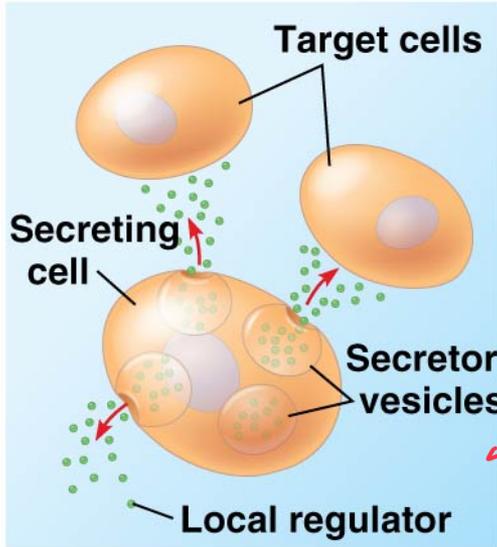
Animal cells communicate by:

- Direct contact (gap junctions) *animal cells*
- Secreting local regulators (growth factors, neurotransmitters) *paracrine*
- Long distance (hormones) *endocrine*

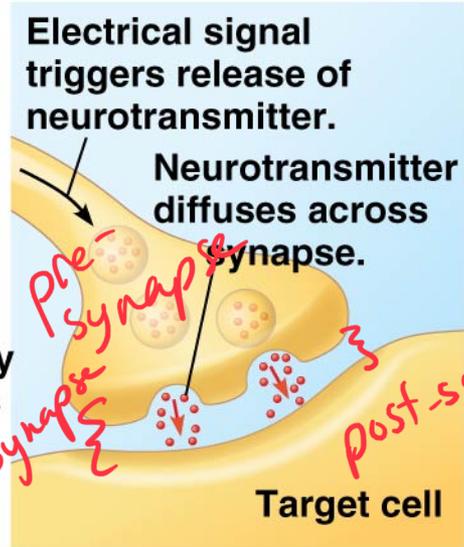


Basics

Local signaling

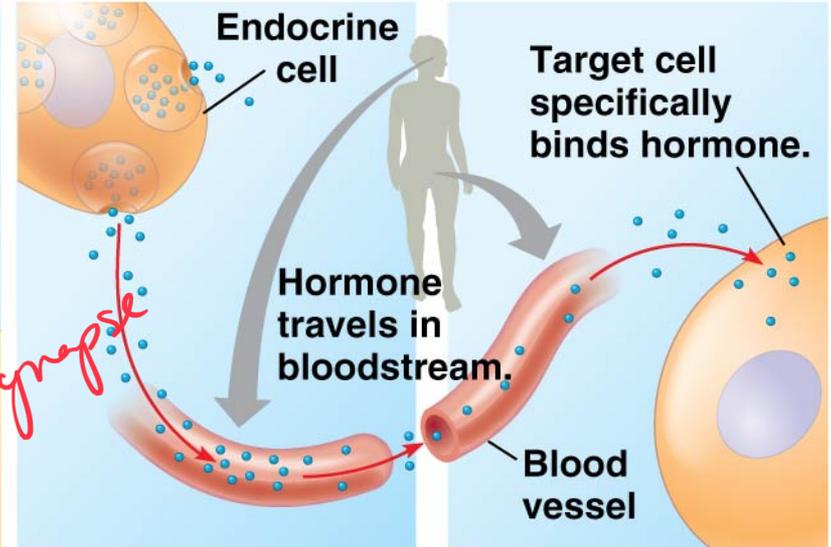


(a) Paracrine signaling



(b) Synaptic signaling

Long-distance signaling



(c) Endocrine (hormonal) signaling

Signal transduction

3 Stages of Cell Signaling:

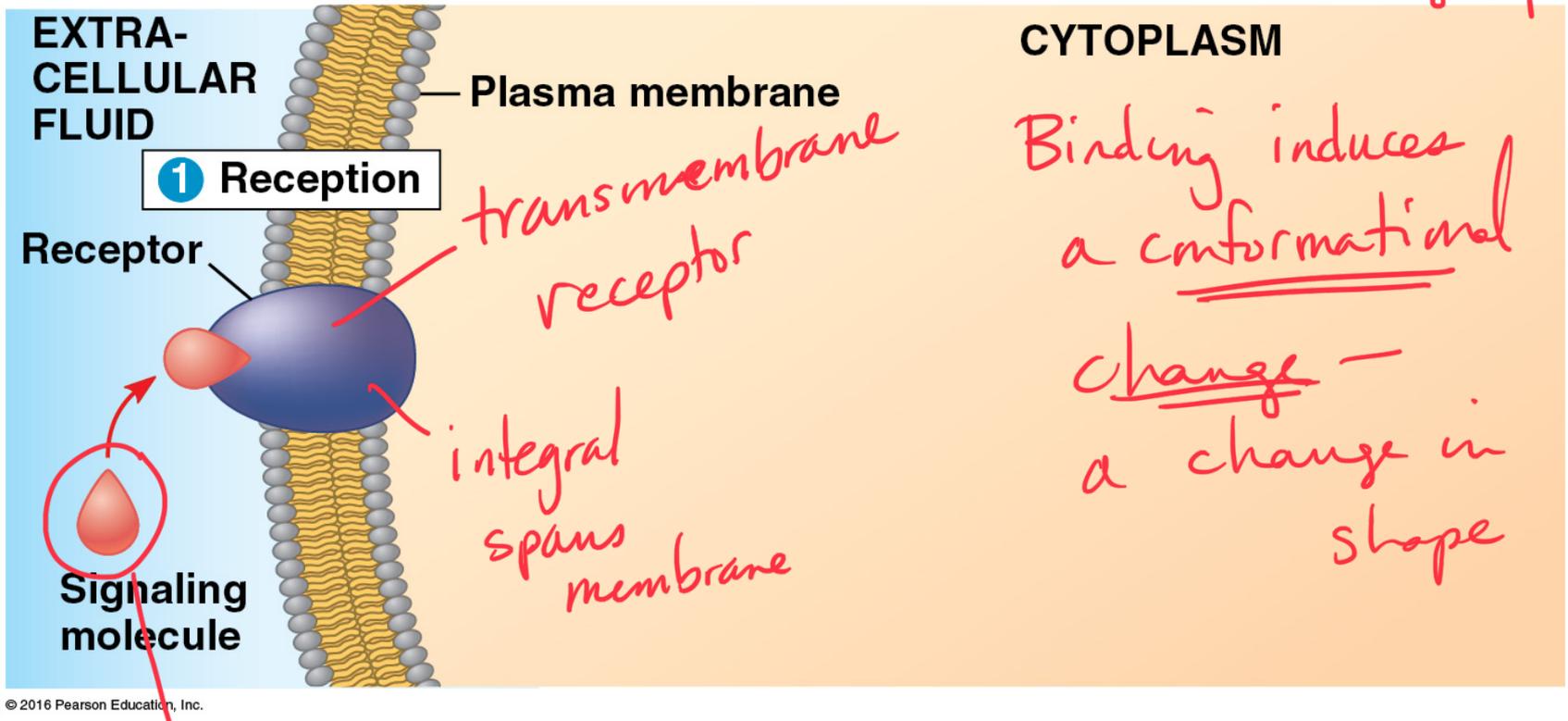
1. **Reception:** Detection of a signal molecule (**ligand**) coming from outside the cell
2. **Transduction:** Convert signal to a form that can bring about a cellular response
3. **Response:** Specific cellular response to the signal molecule

selective permeability

passive diffusion: small, nonpolar

Reception

facilitated diffusion: requires protein intermediary channel port

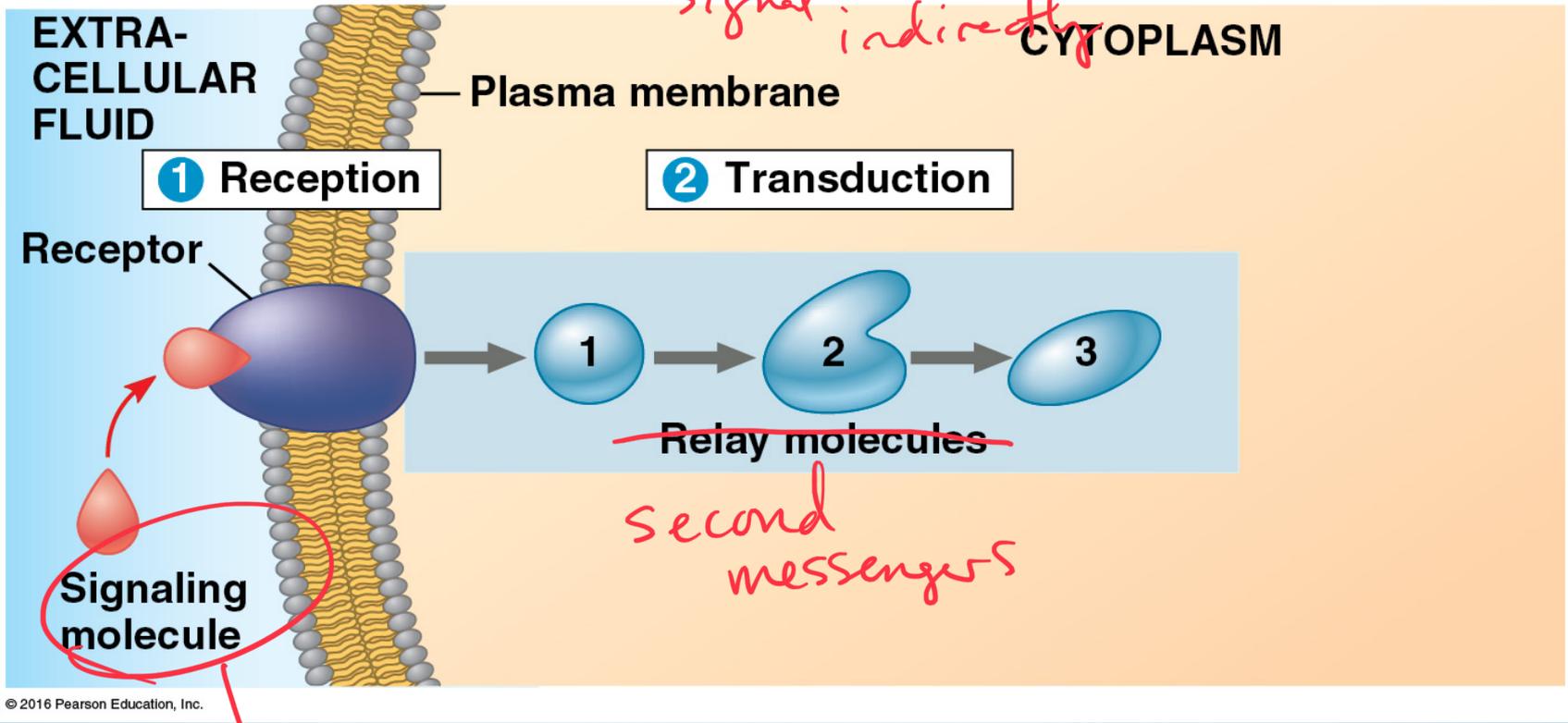


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adrenaline protein large/polar

Transduction

Extracellular $\xrightarrow{\text{Signal indirectly}}$ Intracellular

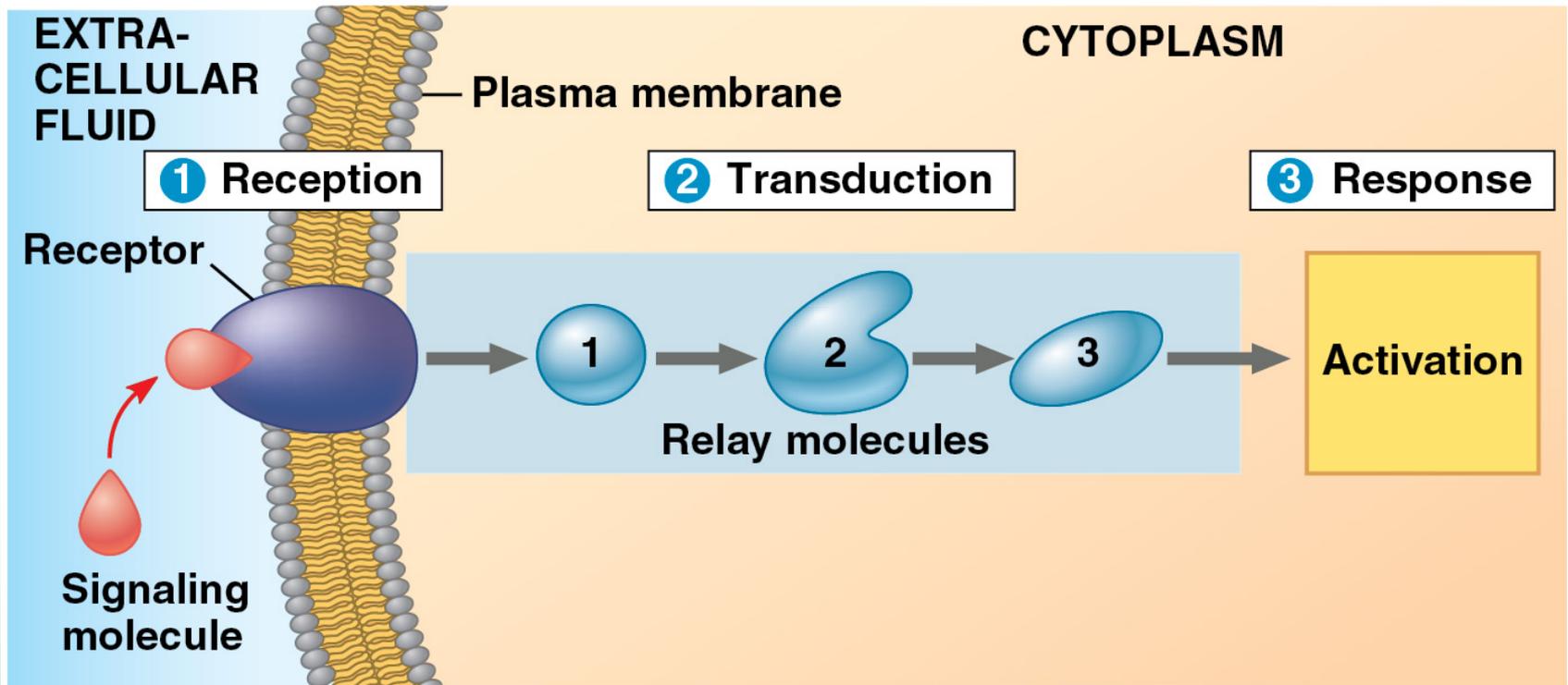


primary messenger

second messengers

cellular response

Response



1. Reception

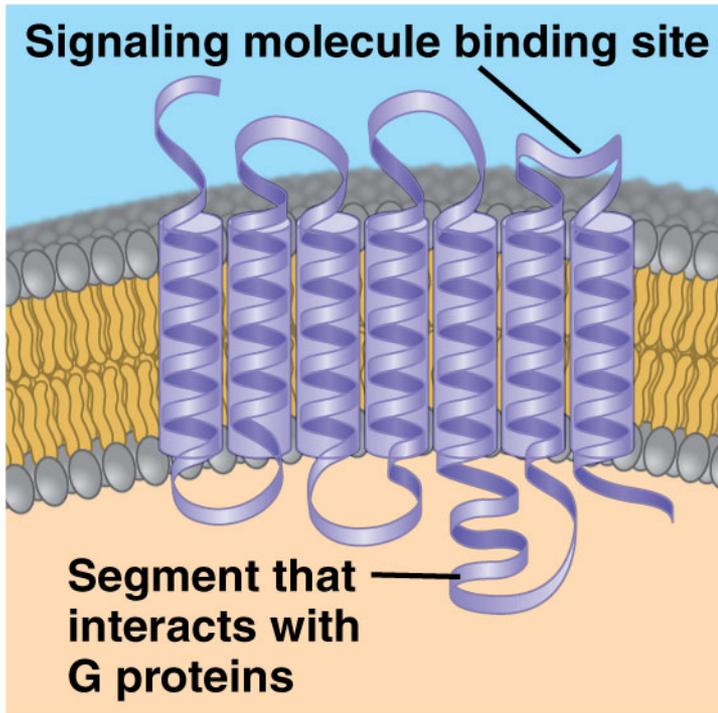
- Binding between signal molecule (**ligand**) + **receptor** is *highly specific*.
- Types of Receptors:
 - a) Plasma membrane receptor
 - water-soluble ligands
 - b) Intracellular receptors (cytoplasm, nucleus)
 - small or hydrophobic ligand molecules
 - Eg. testosterone or nitric oxide (NO)
- Ligand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

Plasma Membrane Receptors

Don't Worry

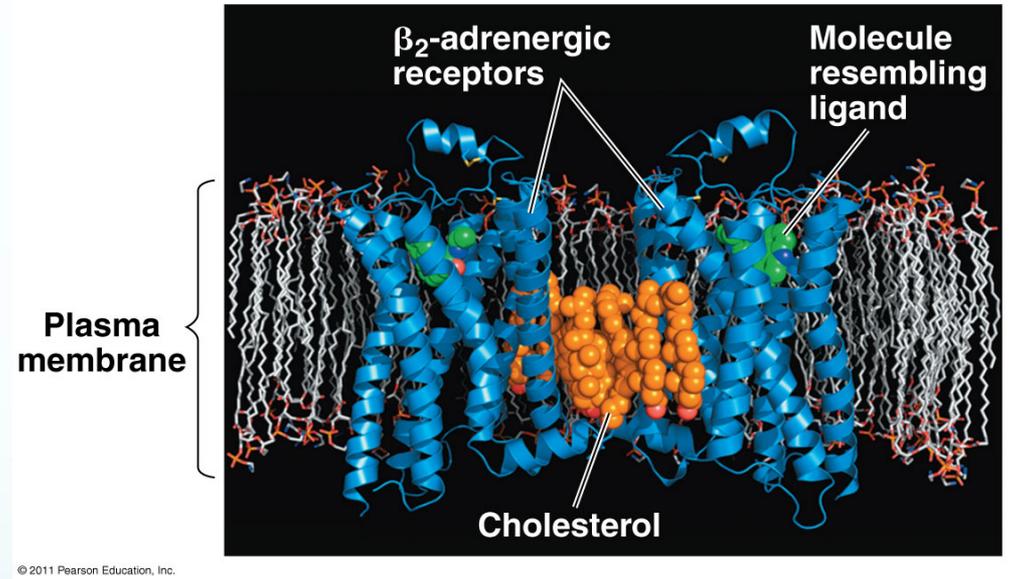
G-Protein Coupled Receptor (GPCR)	Tyrosine Kinase	Ligand-Gated Ion Channels

G-Protein-Coupled Receptor



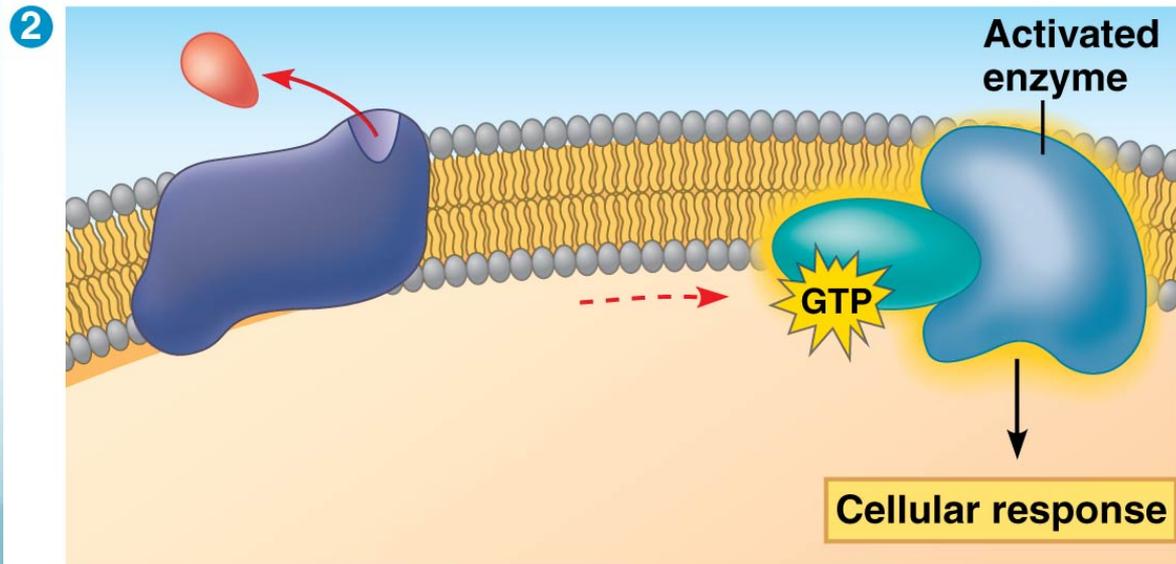
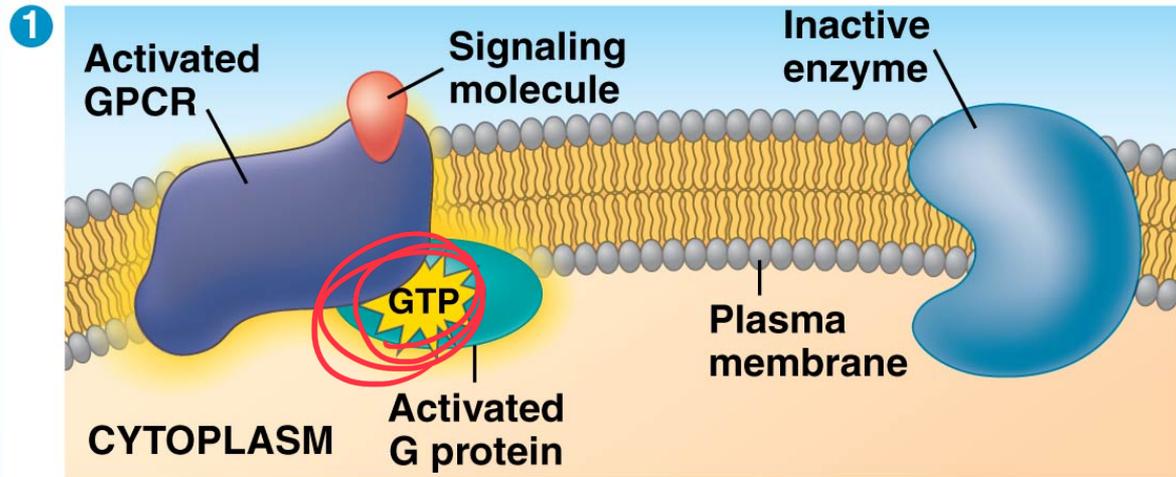
G protein-coupled receptor

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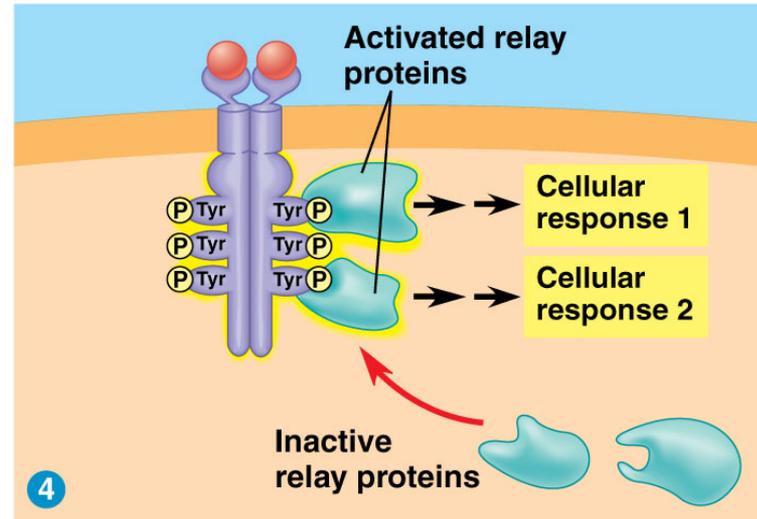
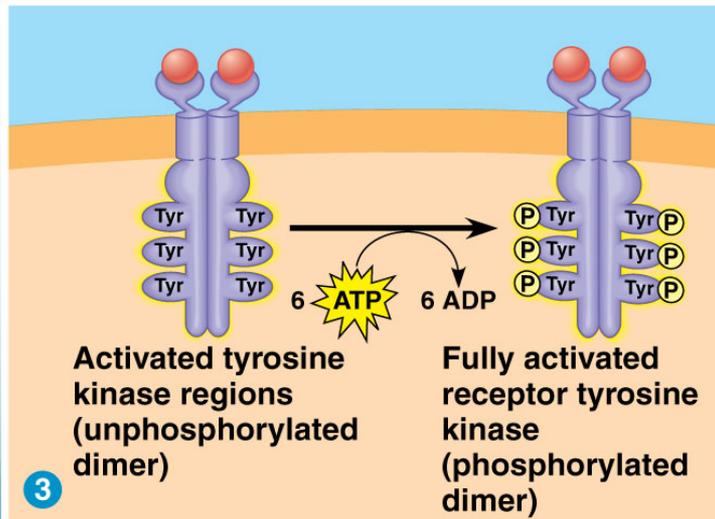
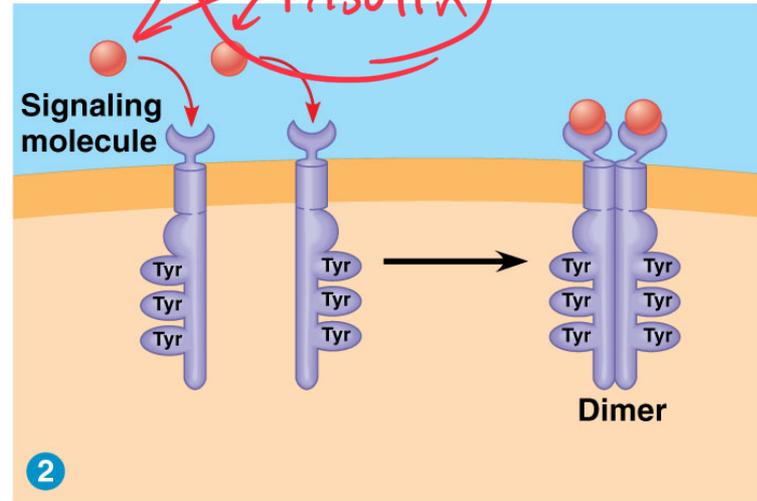
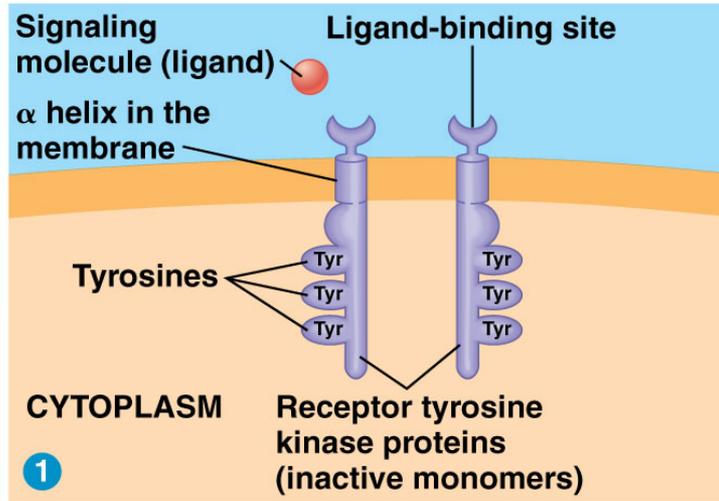
G-Protein-Coupled Receptor



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		

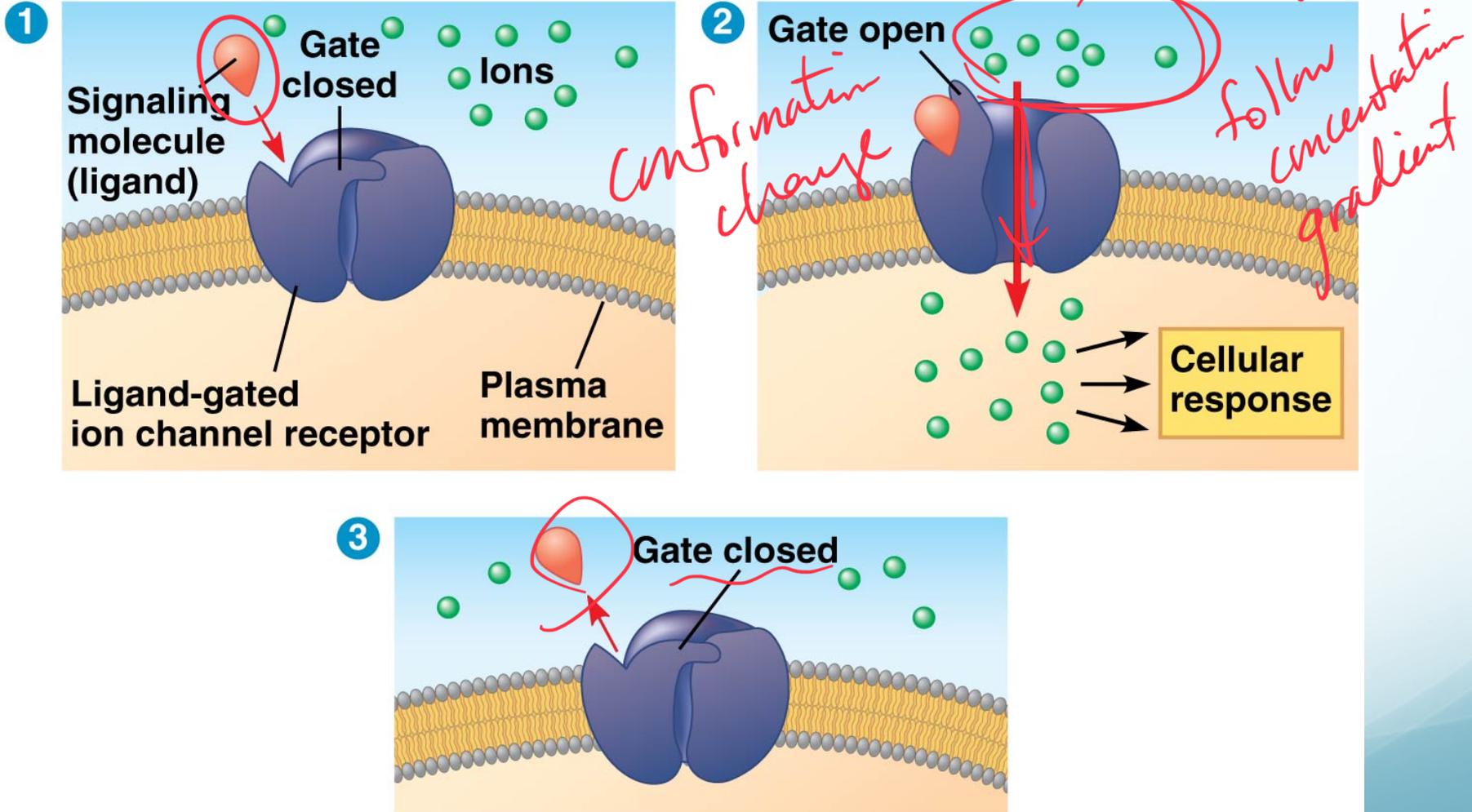
Receptor Tyrosine Kinase



Plasma Membrane Receptors

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

Ligand-Gated Ion Channel

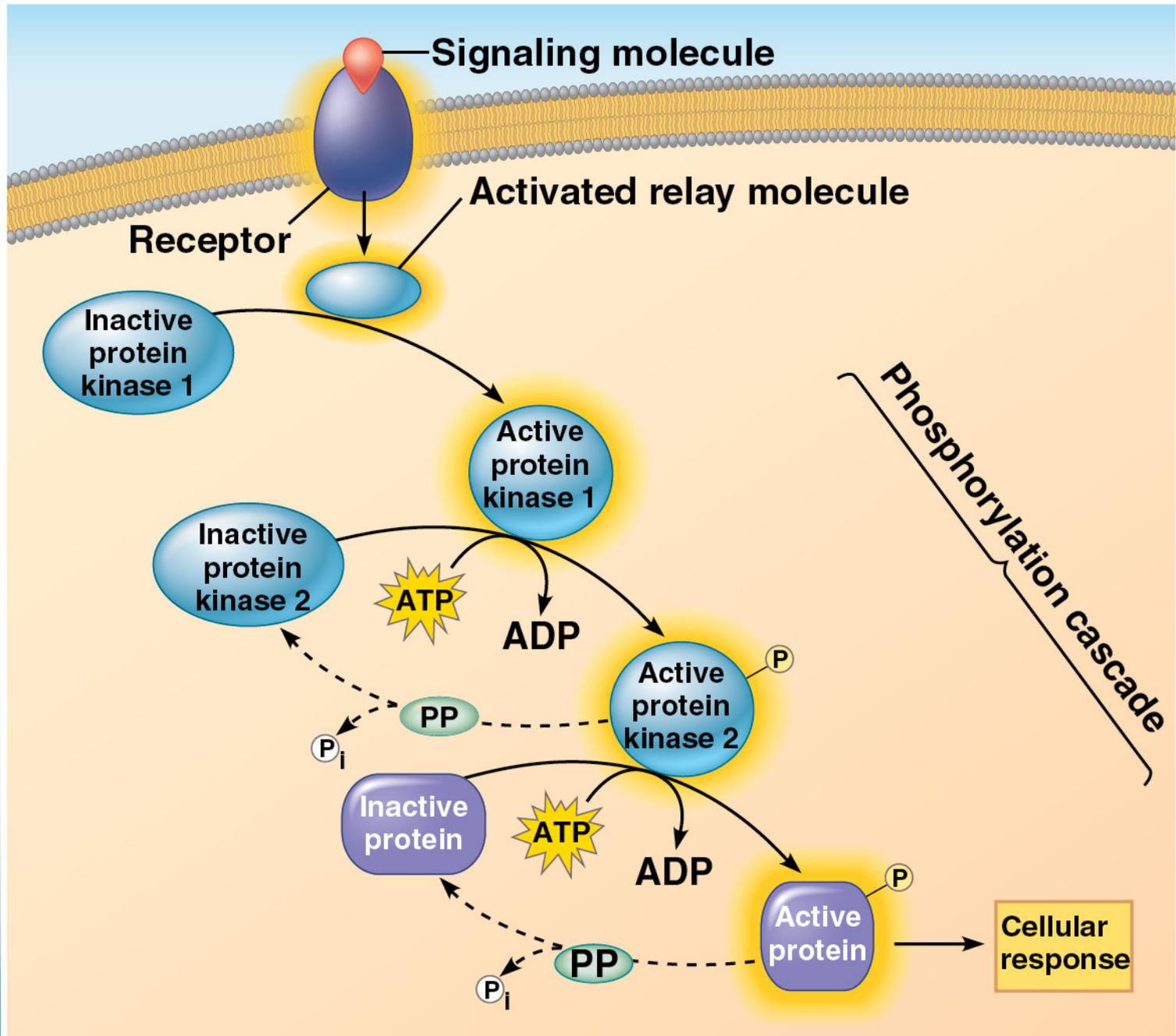


Plasma Membrane Receptors

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

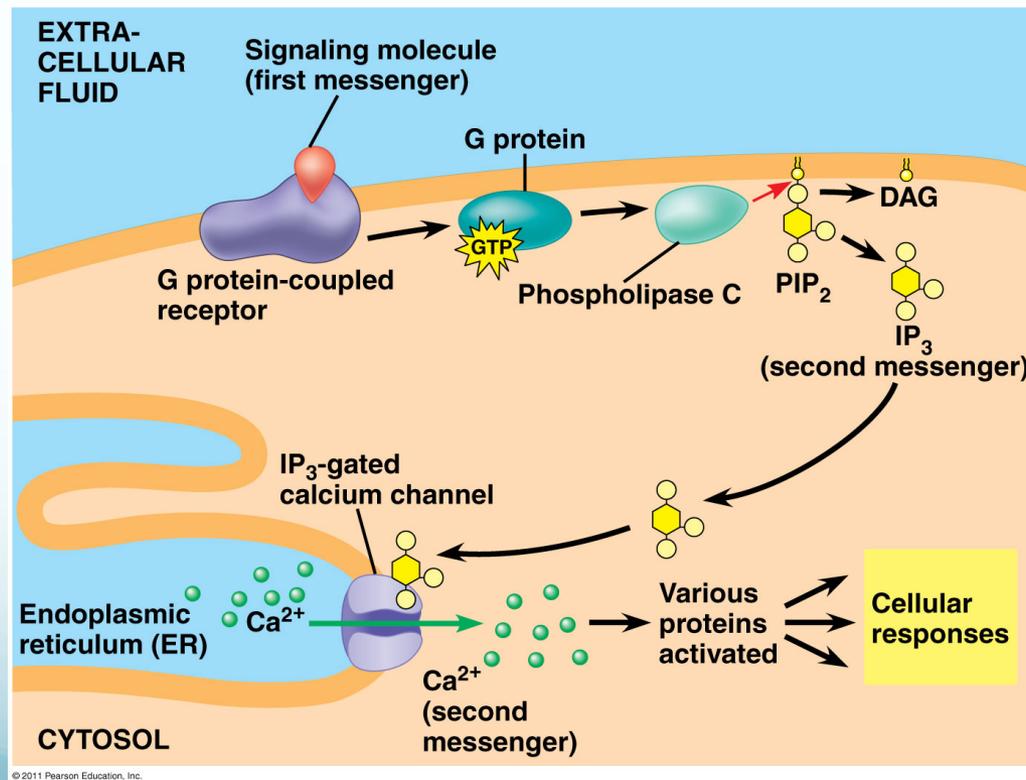
2. Transduction

- 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



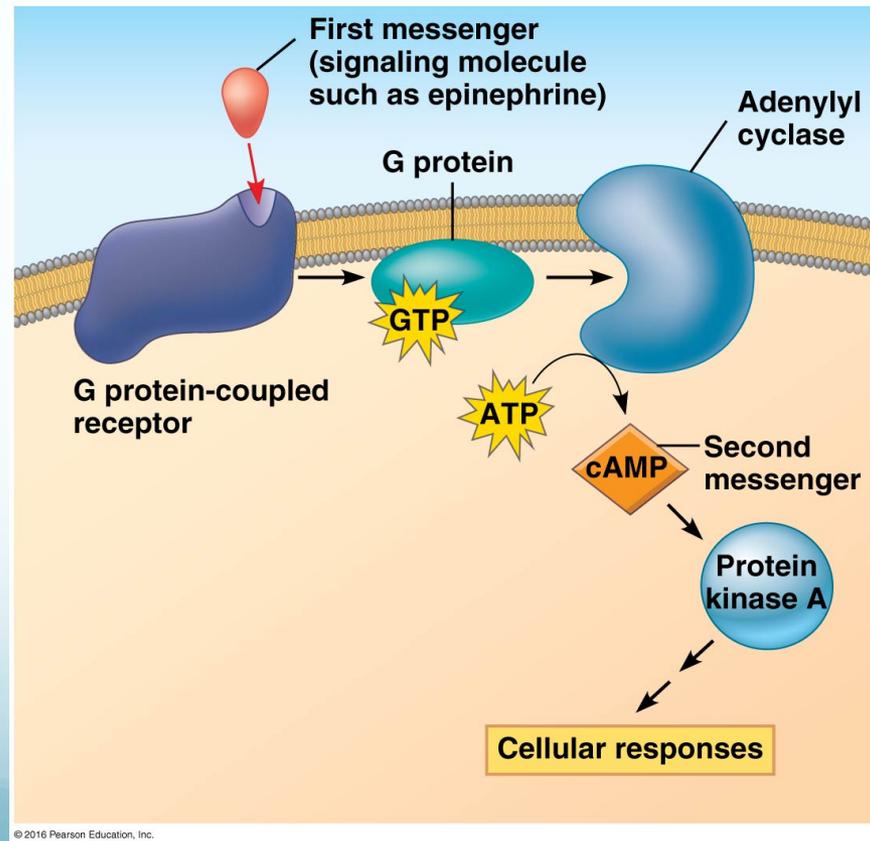
Second Messengers

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



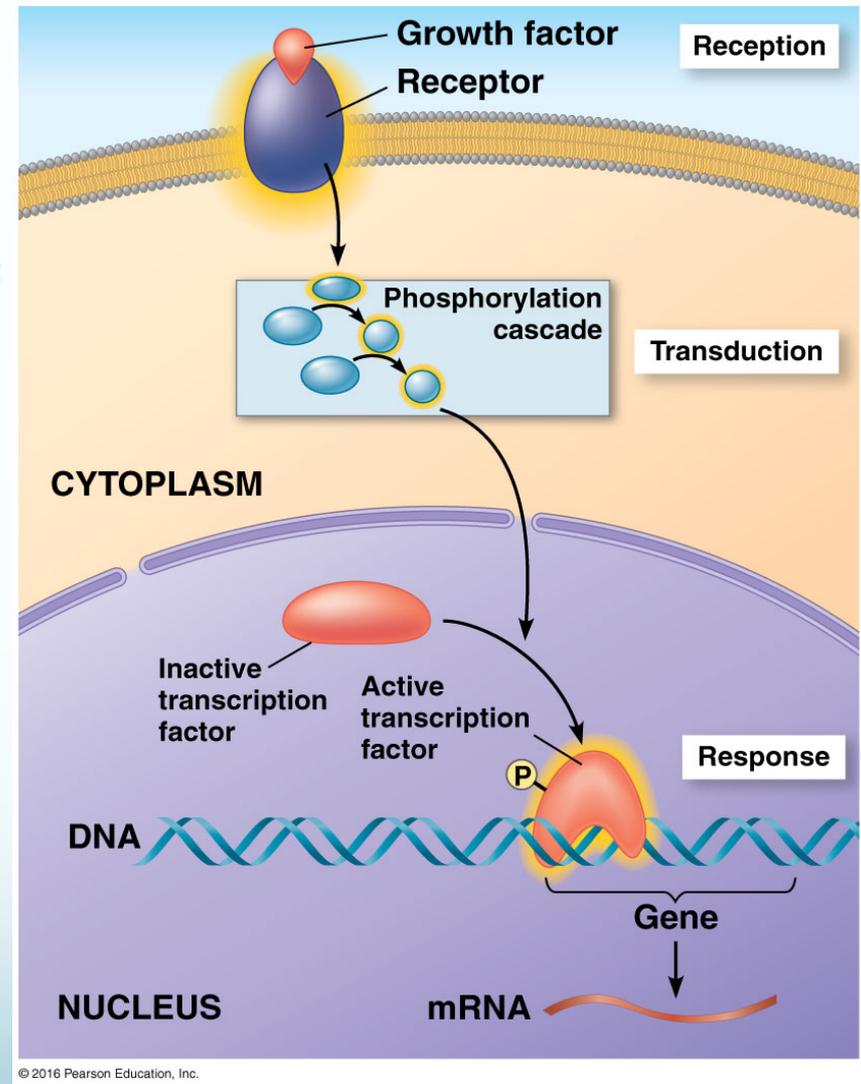
cAMP

- 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



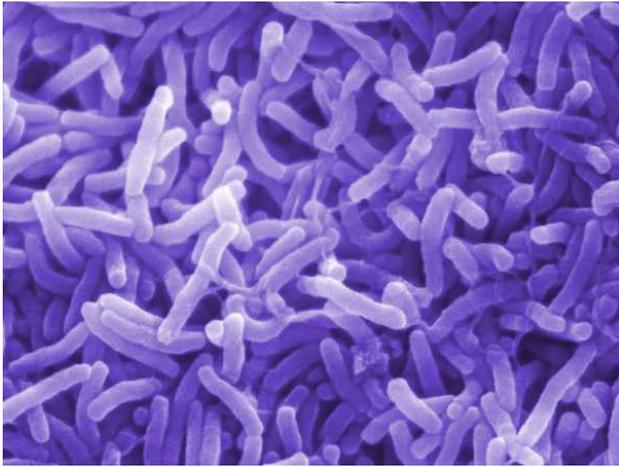
An Example of Cell Communication

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

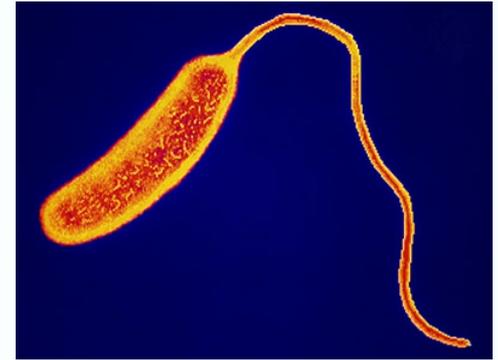
Signal Transduction Pathway Problems/Defects:

Examples:

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

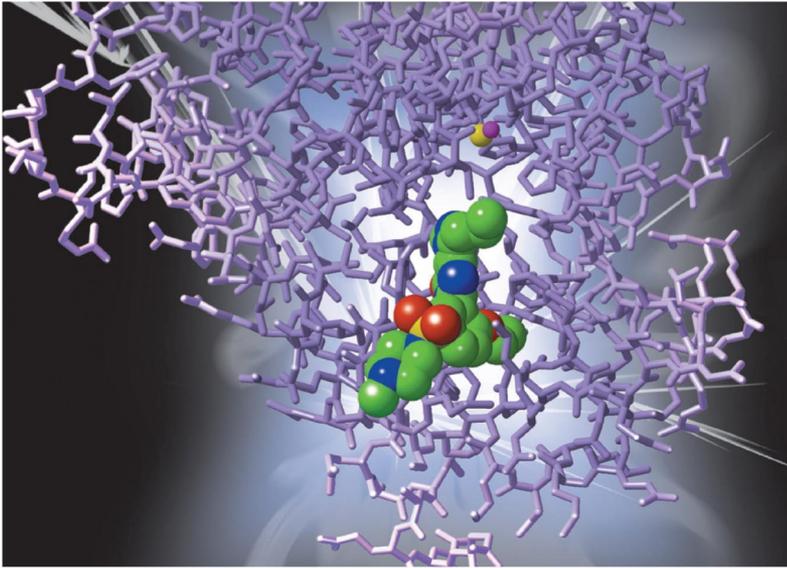


Cholera



- 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

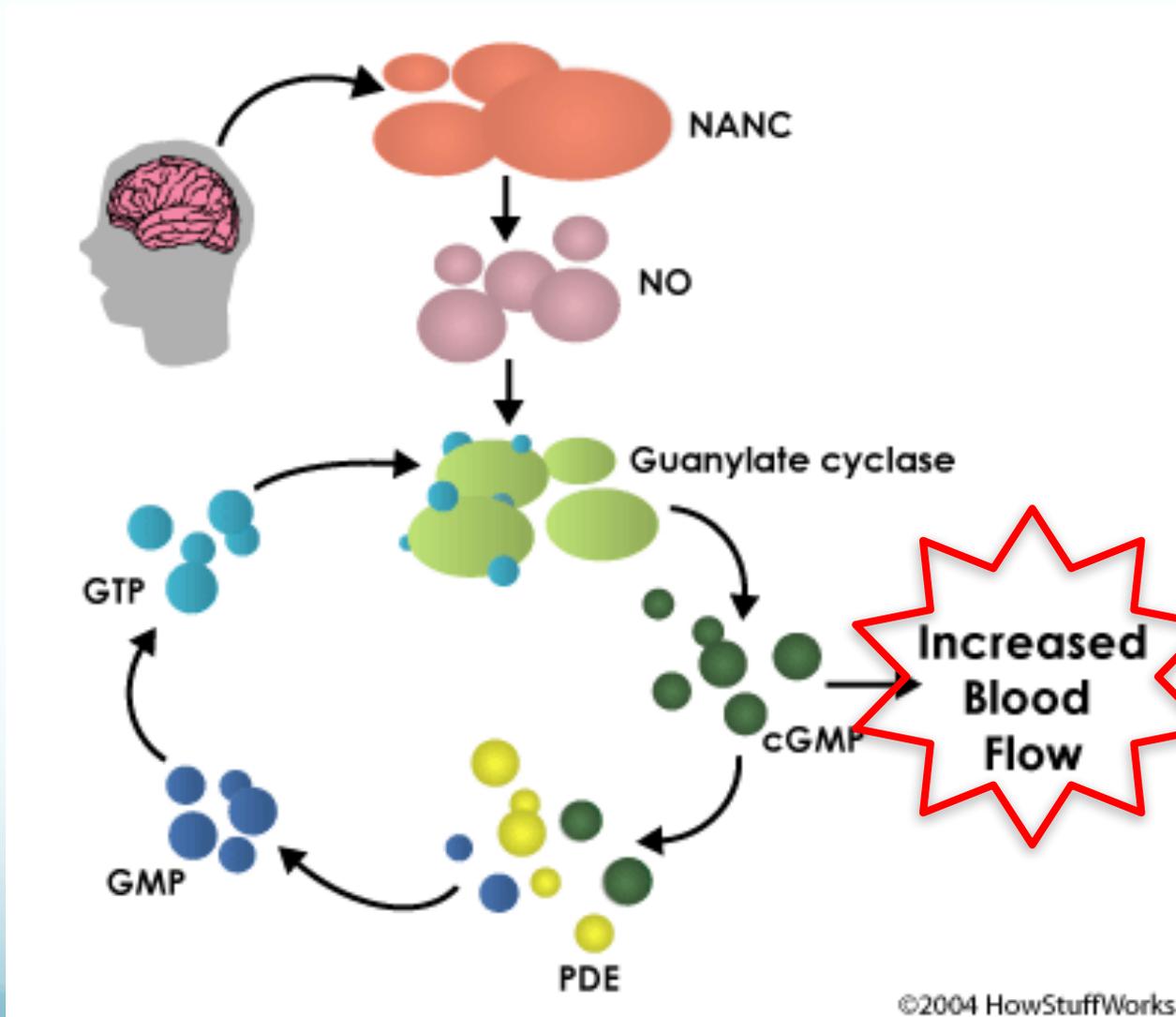


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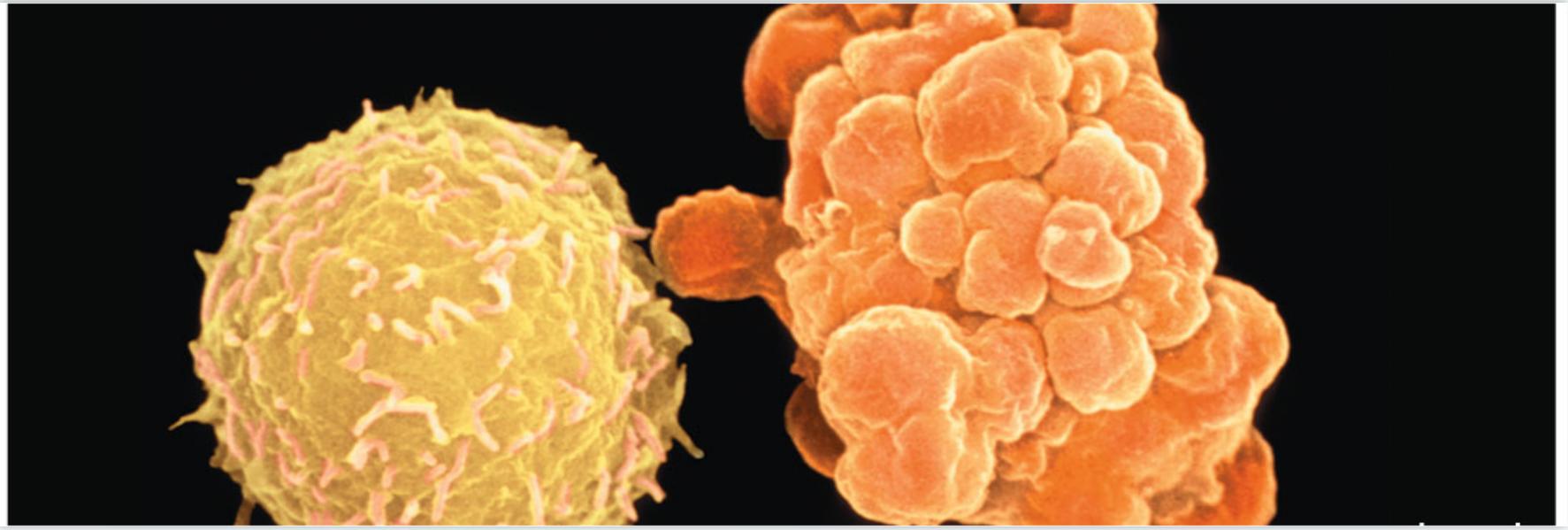
- Used as treatment for erectile dysfunction
- Inhibits hydrolysis of cGMP → GMP
- Prolongs signal to relax smooth muscle in artery walls; increase blood flow to penis

Viagra inhibits cGMP breakdown



Apoptosis = cell ~~suicide~~ *programmed death*

- 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

