Chem 352 - Lecture 6
Part II: Membranes

Question for the Day: Why do phospholipids spontaneously form lipid membranes?

Introduction to Membranes

Biological membranes define the external boundaries of cells and the separate compartments within cells.

- In the very first lecture of this course we discussed theories on the origins of life on earth.
- Crucial to this development was the appearance of membrane-bound vesicles.

A brief history of Biochemistry

The origin of life on earth is still one of the big questions in biology.

- In the essay that I sent to you, there is a discussion of the current progress that is being made to try and discover how that first cell arose. It is a good introduction to some of the major players that we will encounter this semester.

Carl Zimmer, "On the Origin of Life on Earth", Science 2009, 323, 198-199.

Introduction to Membranes

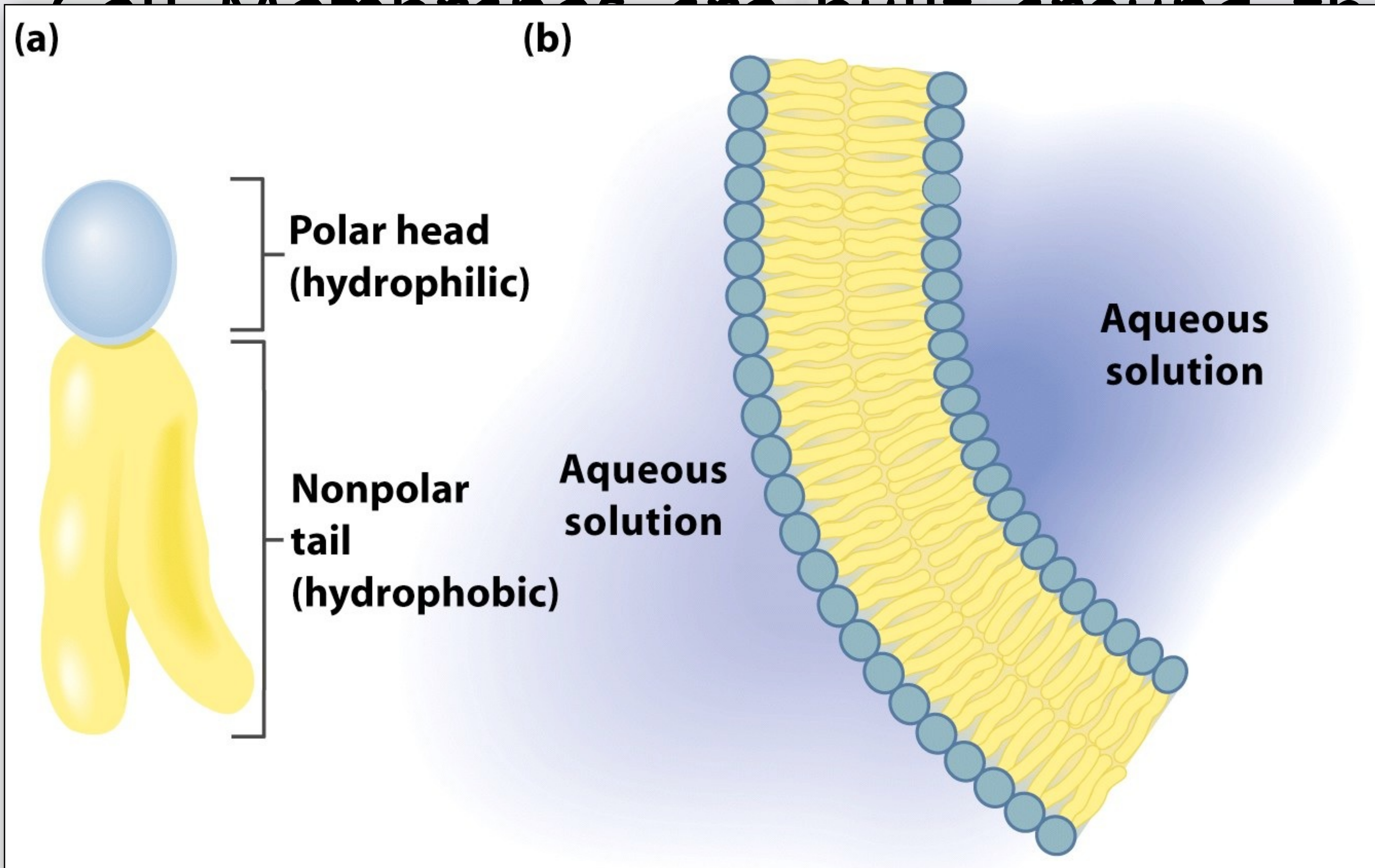
- Membranes have a wide variety of functions as they allow cells to communicate with their environments.
  - Control the transport of ions and small molecules
  - Used to store energy as concentration gradients across the membrane.
    - e.g. A proton gradient is used in the synthesis of ATP
  - The location of cell surface receptors, which convert external signals to internal responses

Lipid Bilayers

- Cell Membranes are built around the lipid bilayers.
  - Lipid bilayers spontaneously form when glycerophospholipids and glycosphingolipids are placed in an aqueous environment.

Lipid Bilayers

Cell Membranes are built around the

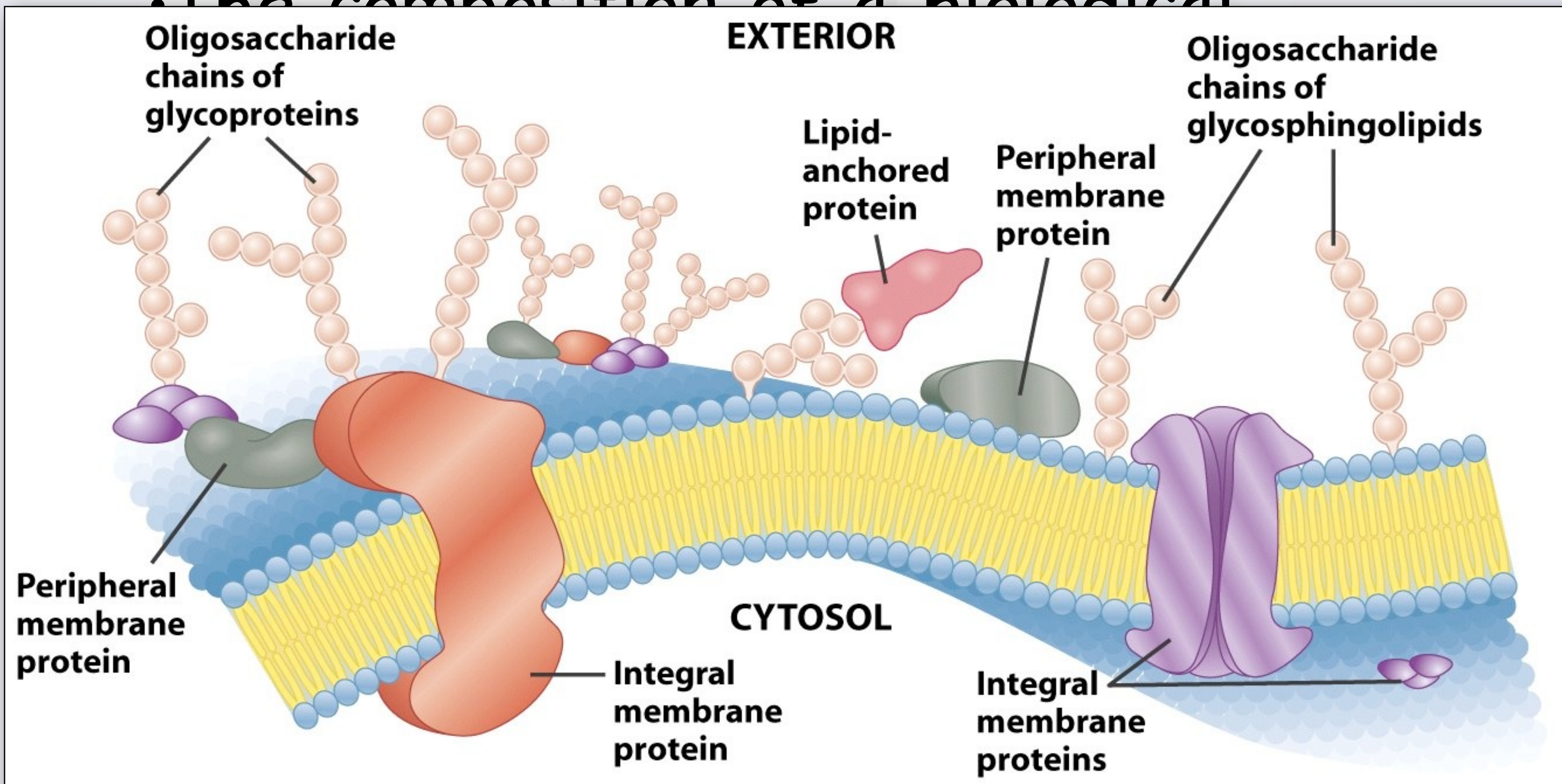


The Fluid Mosaic Model

- The composition of a biological membrane is
  - 25% to 50% lipid
  - 50% to 75% protein
- The lipids comprise
  - phospholipids
  - glycosphingolipids (animals)
  - cholesterol (some eukaryotes)
- The **fluid mosaic mode** was proposed in 1972 by Singer and Nicolson.

The Fluid Mosaic Model

•The composition of a biological



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Membranes are Dynamic Structures

- Functional membranes must remain fluid.
  - Membrane lipids can diffuse laterally or transversely.
    - Transverse diffusion is much slower than lateral diffusion.
- Membranes can modulate their fluidity with
  - Unsaturated fatty acids.
  - Dissolved cholesterol (mammals)
  - Dissolved ergosterol (fungi)

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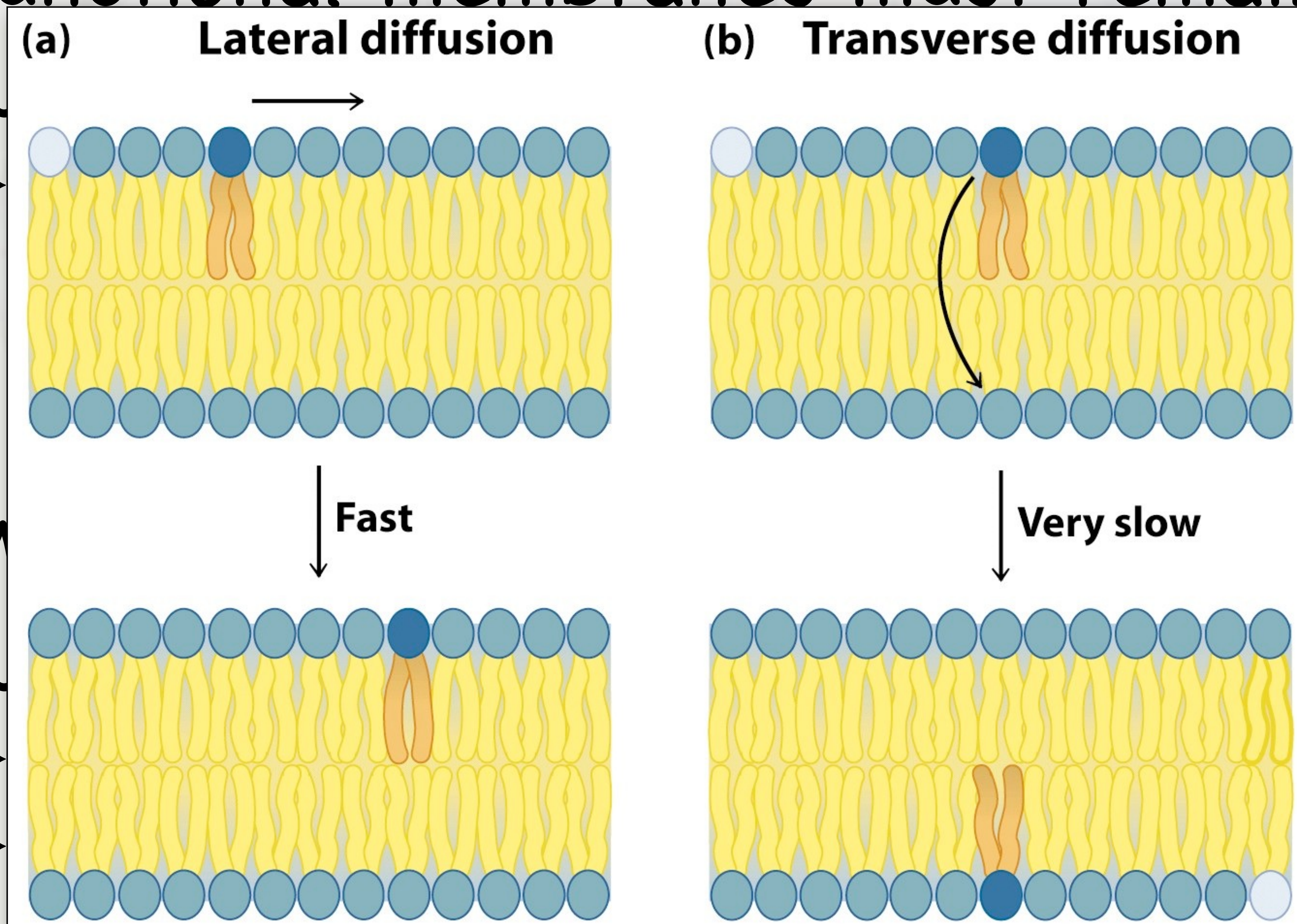

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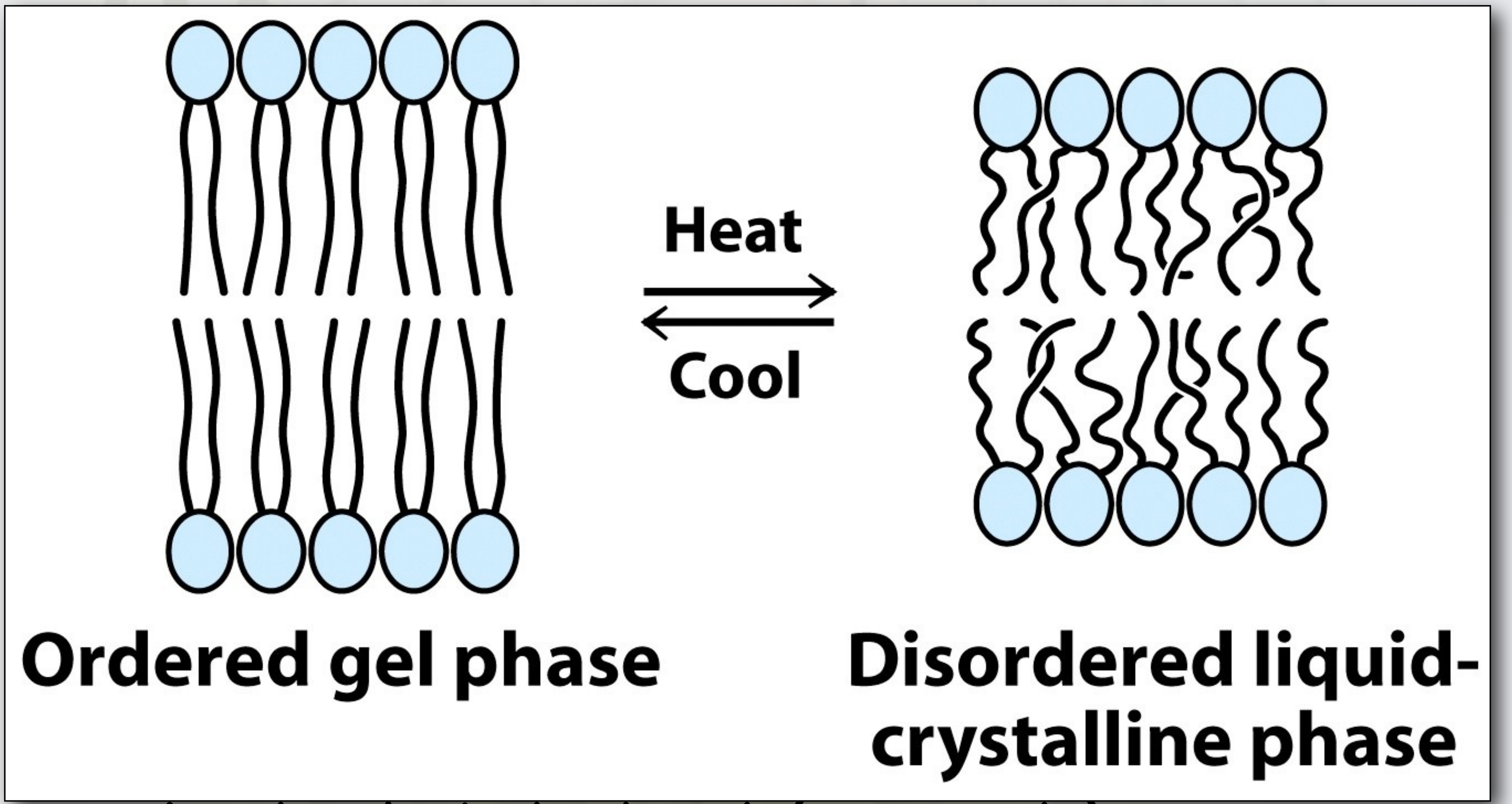

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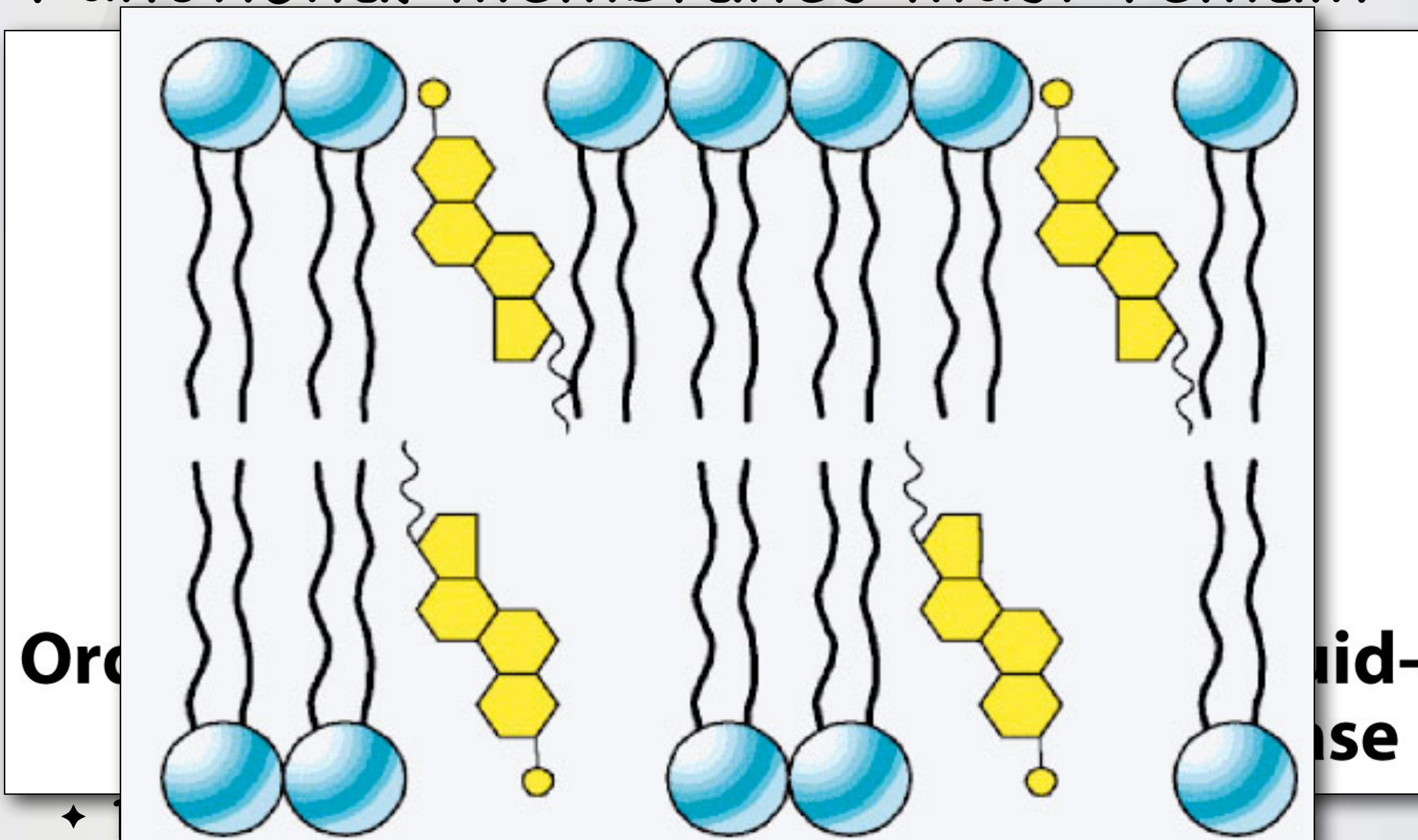

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Membrane Proteins

- There are three classes of membrane proteins.
  - Integral membrane proteins
  - Peripheral membrane proteins
  - Lipid-anchored membrane proteins

Membrane Proteins

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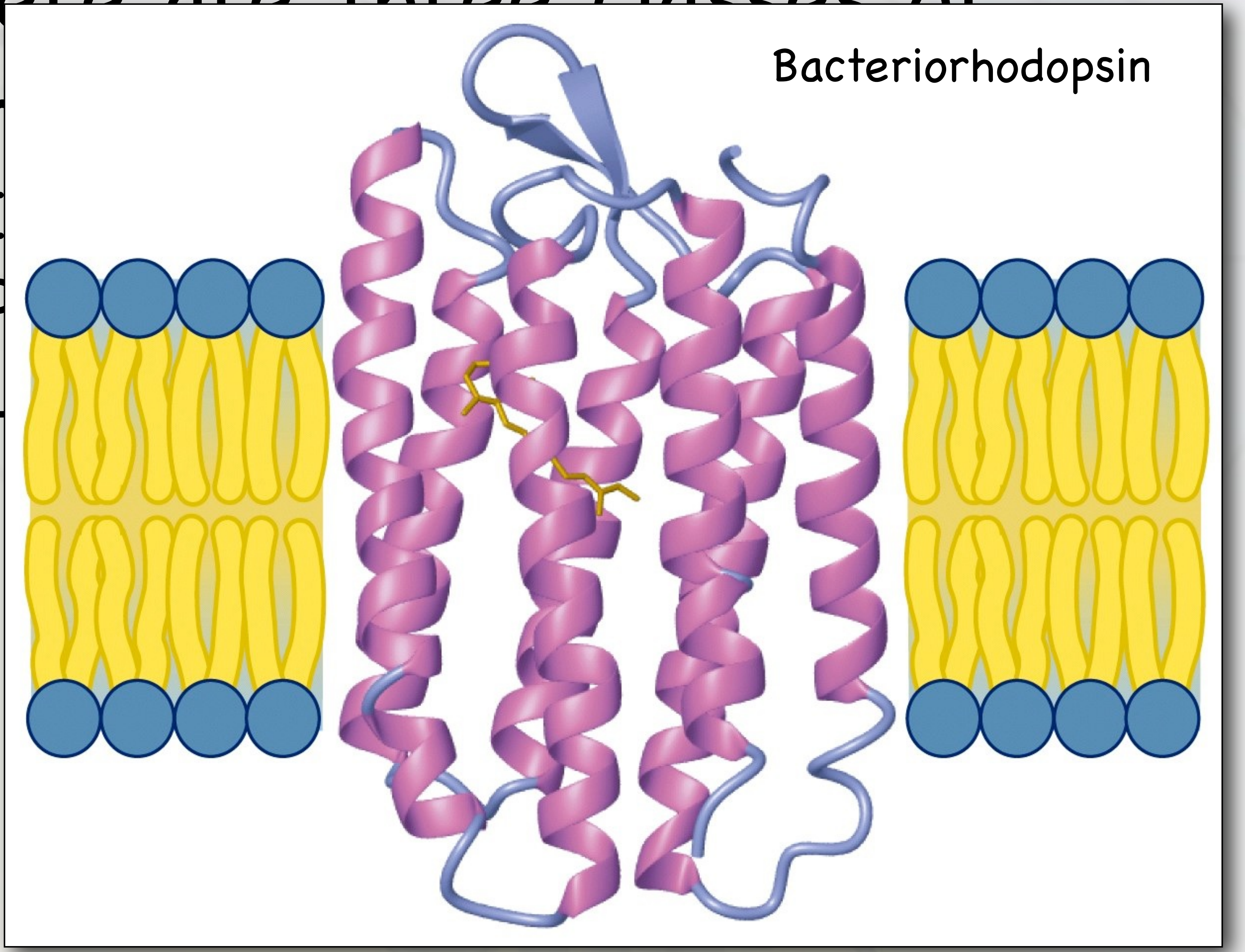

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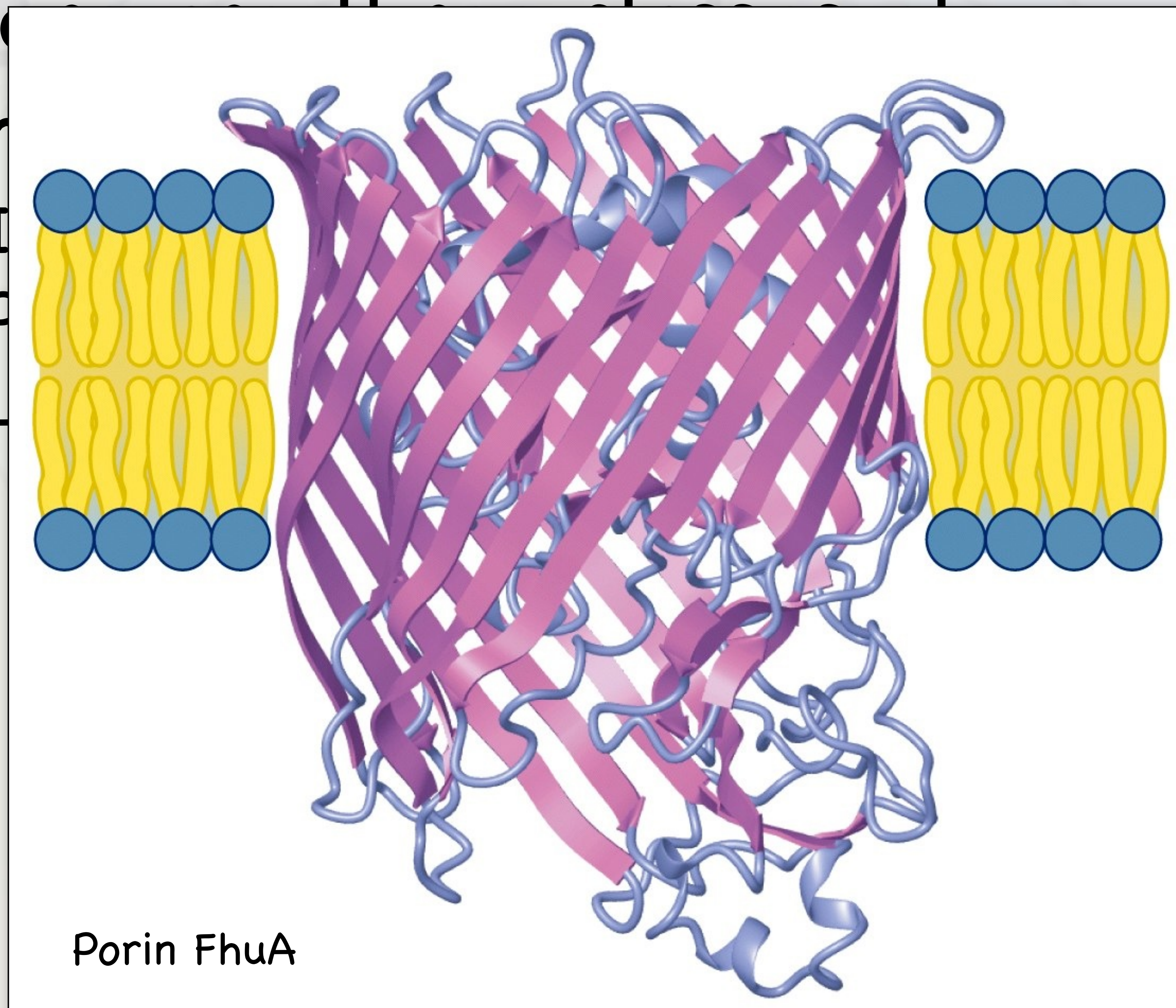

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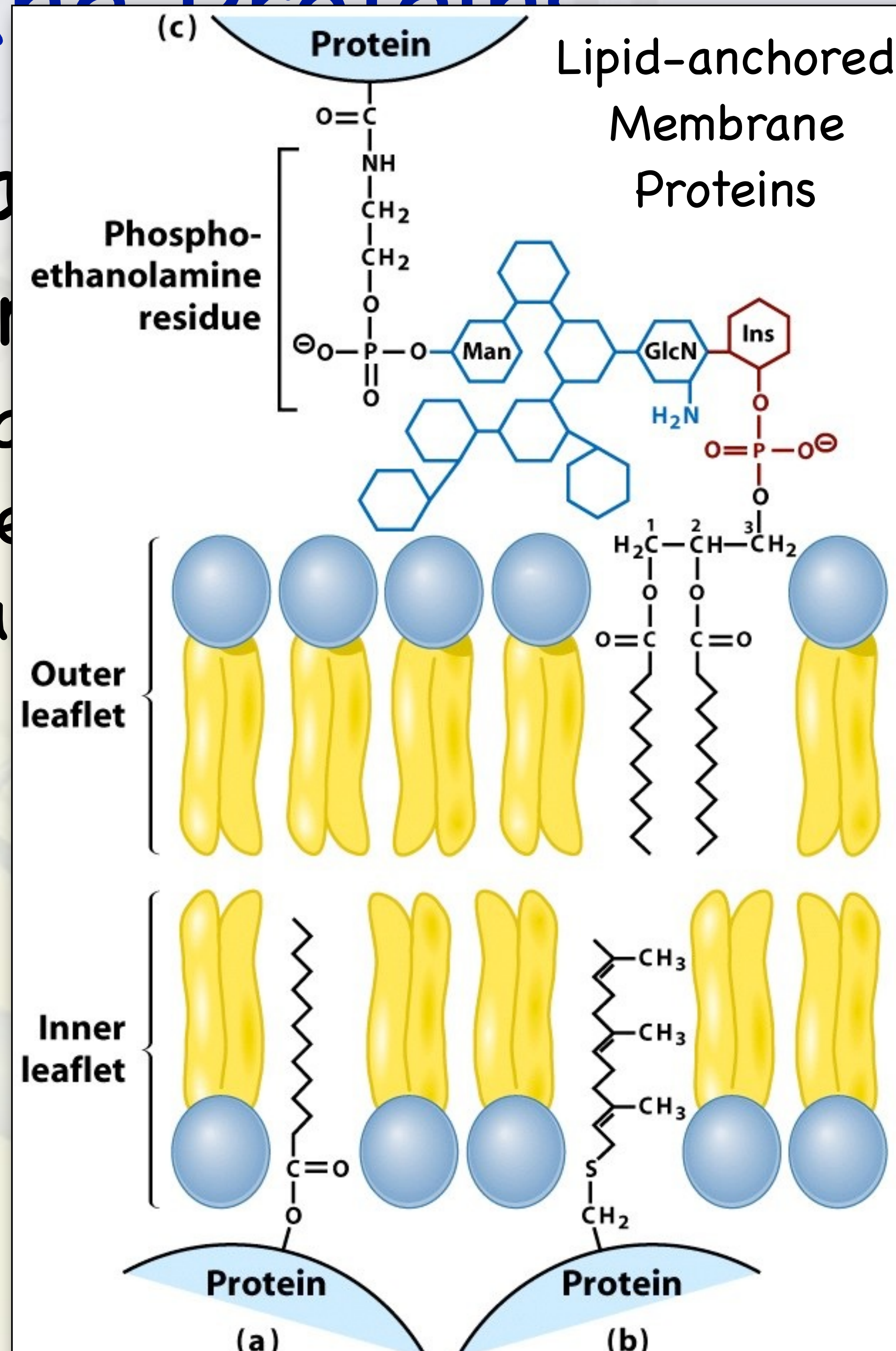

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Membrane Transport

- There are a variety of ways to get materials across a membrane.
  - Considerations:
    - What is a polarity of the molecule being transported?
      - Is a carrier required?
    - Is the movement up or down a concentration gradient (is energy required)?

Membrane Transport

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TABLE 9.3 Characteristics of different types of membrane transport

	Protein carrier	Saturable with substrate	Movement relative to concentration gradient	Energy input required
Simple diffusion	No	No	Down	No
Channels and pores	Yes	No	Down	No
Passive transport	Yes	Yes	Down	No
Active transport				
Primary	Yes	Yes	Up	Yes (direct source)
Secondary	Yes	Yes	Up	Yes (ion gradient)

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Membrane Transport

- The Free energy of transport:

$$\Delta G_{transport} = RT\ln\left(\frac{[A]_{in}}{[A]_{out}}\right), \text{ When A is uncharged}$$

Membrane Transport

- If the molecule being transported is charged, there is also an electrical potential term.

$$\Delta\Psi = \Psi_{in} - \Psi_{out}$$

$(\Delta\Psi$ is the electrical potential across the membrane in volts.$)$

$$\Delta G_{electrical} = z\mathscr{F}\,\Delta\Psi$$

$\left(\text{z is the charge and } \mathscr{F} \text{ Faraday's constant}\right)$

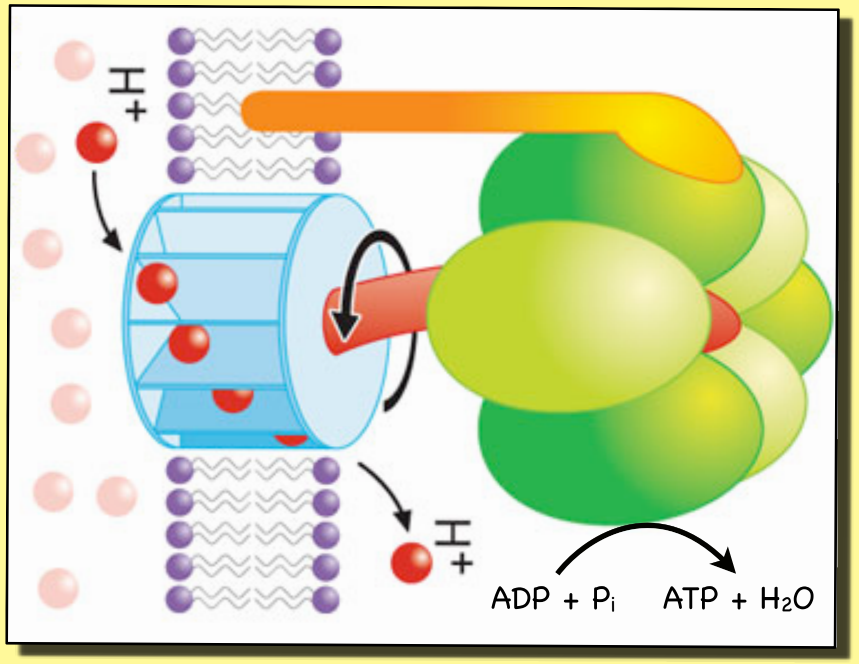
$$\Delta G_{transport} = RT\ln\left(\frac{[A_{in}]}{[A_{out}]}\right) + z\mathscr{F}\,\Delta\Psi$$

$$\mathscr{F} = 9.646 \text{ x } 10^4 \ \frac{C}{mol} = 9.646 \text{ x } 10^4 \ \frac{J}{V \bullet mol}$$

Membrane Transport

Problem:

If the pH of the intermembrane space in a mitochondrium is 6.5 compared to the matrix, which is 7.4, and the membrane potential of the inner membrane is -60 mV (Ψin - Ψout), What is the change in the free energy (in kJ) for a mole of protons moving through the ATP Synthase complex at 37°C?



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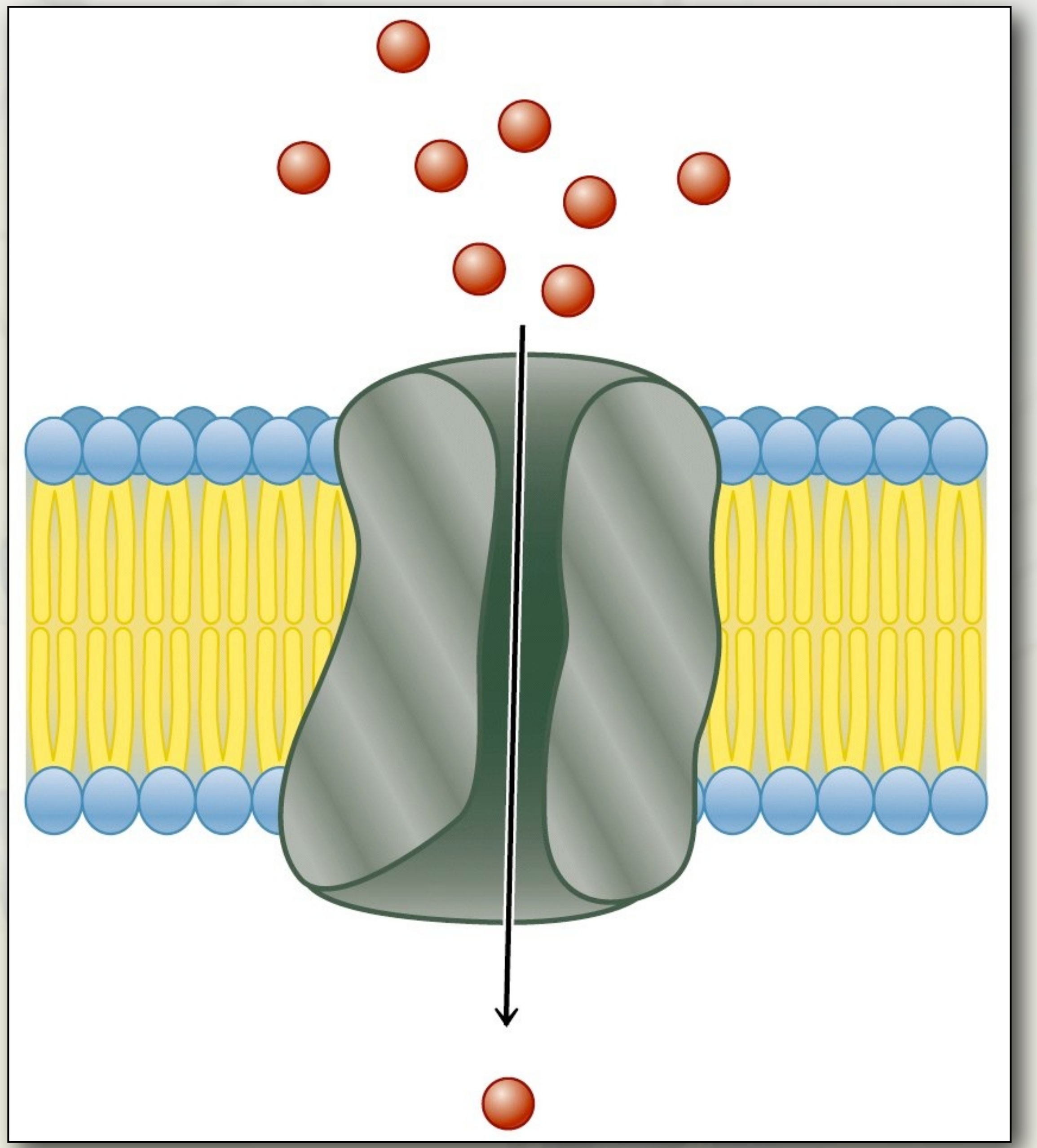
Membrane Transport

- Pores and Channels



(No energy required)

Membrane Transport

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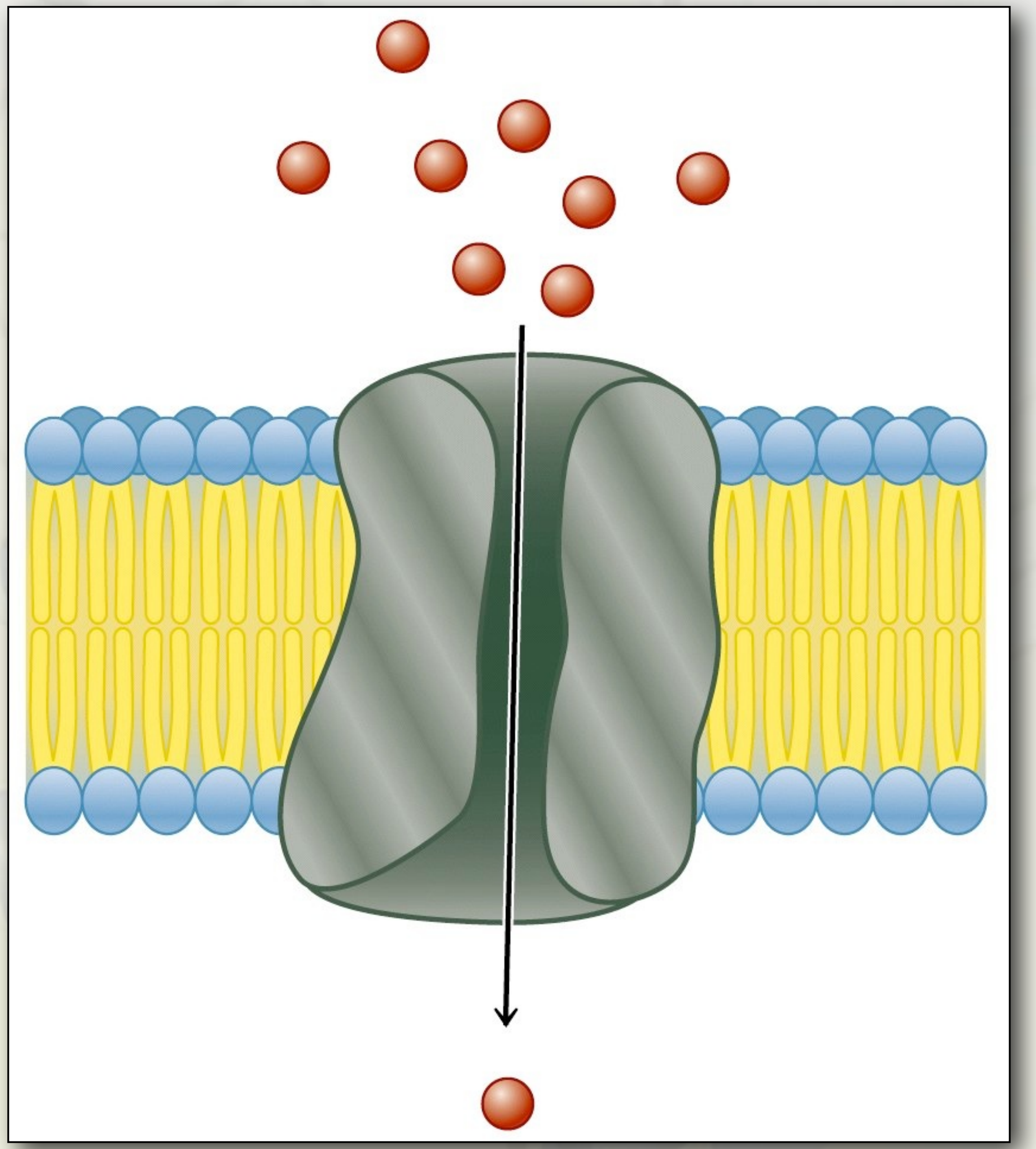

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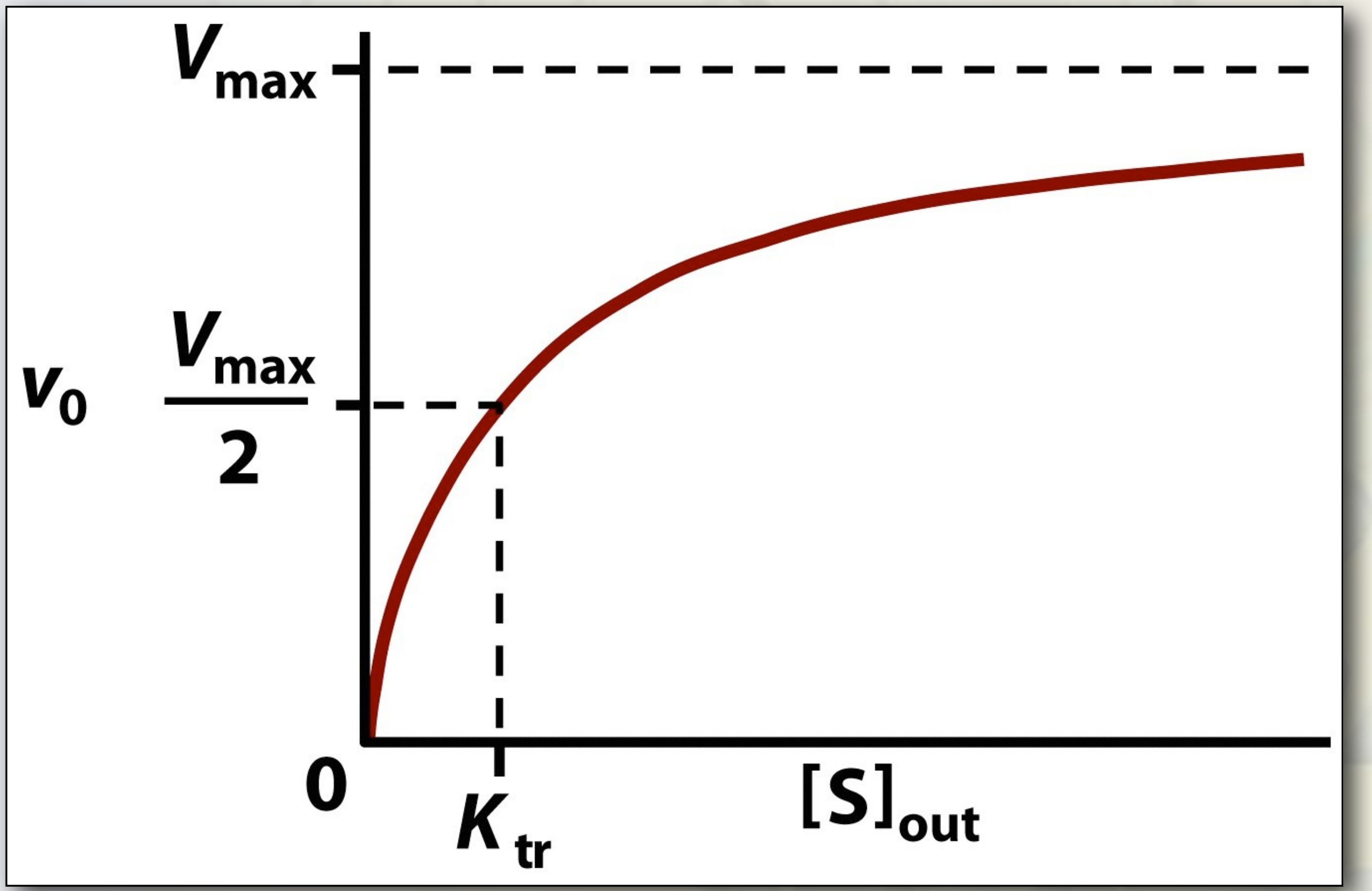
Membrane Transport

- Passive transport proteins
  - Facilitated diffusion

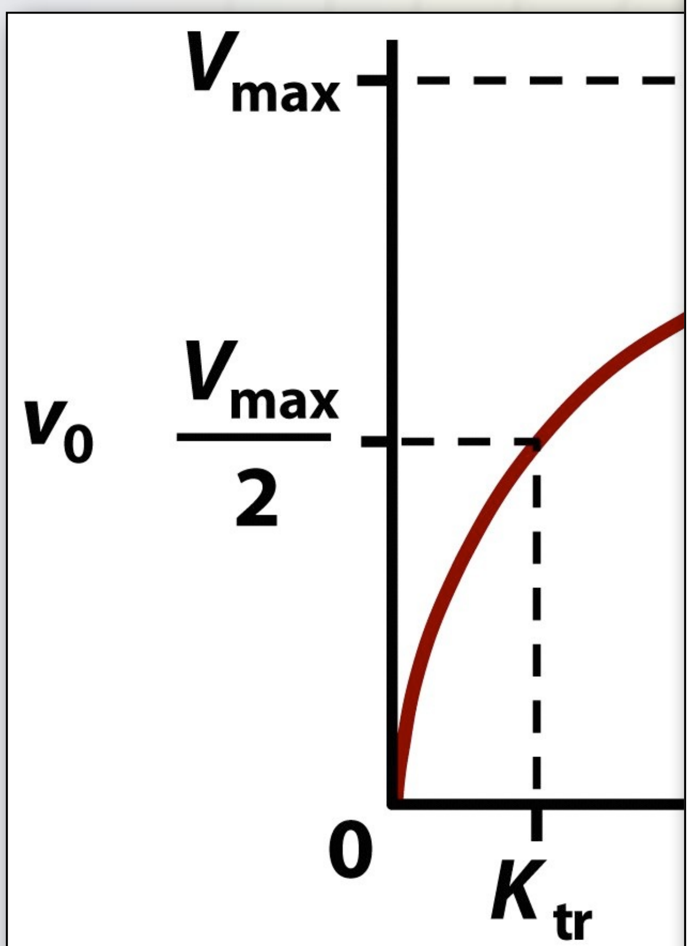


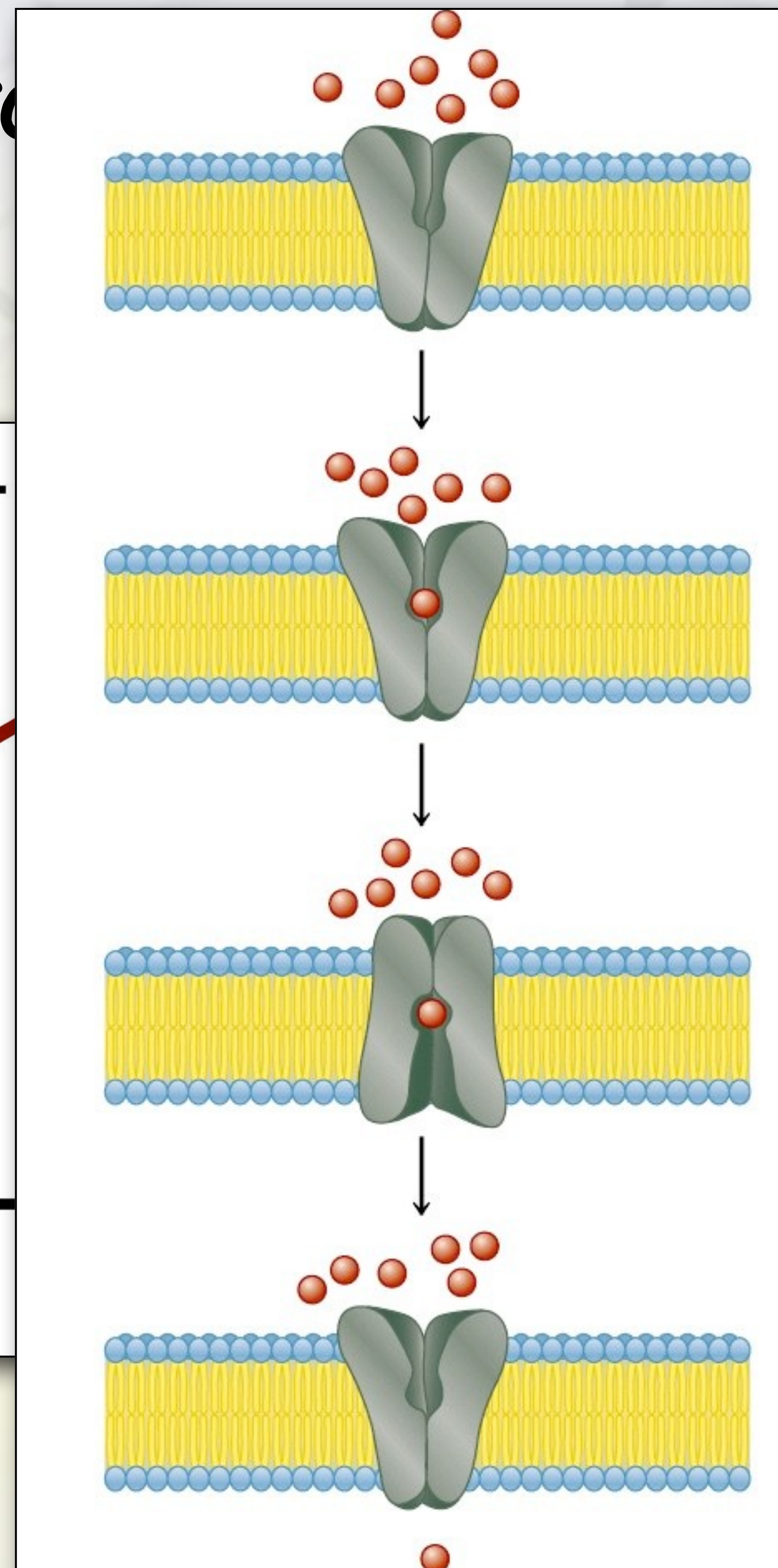
If transport across a membrane can be saturated,
this implies a transport protein is used instead of a pore or channel

Passive Transport also requires no input in energy

Membrane Transport

- •Passive tr… ns
  - ✦ Facilitated





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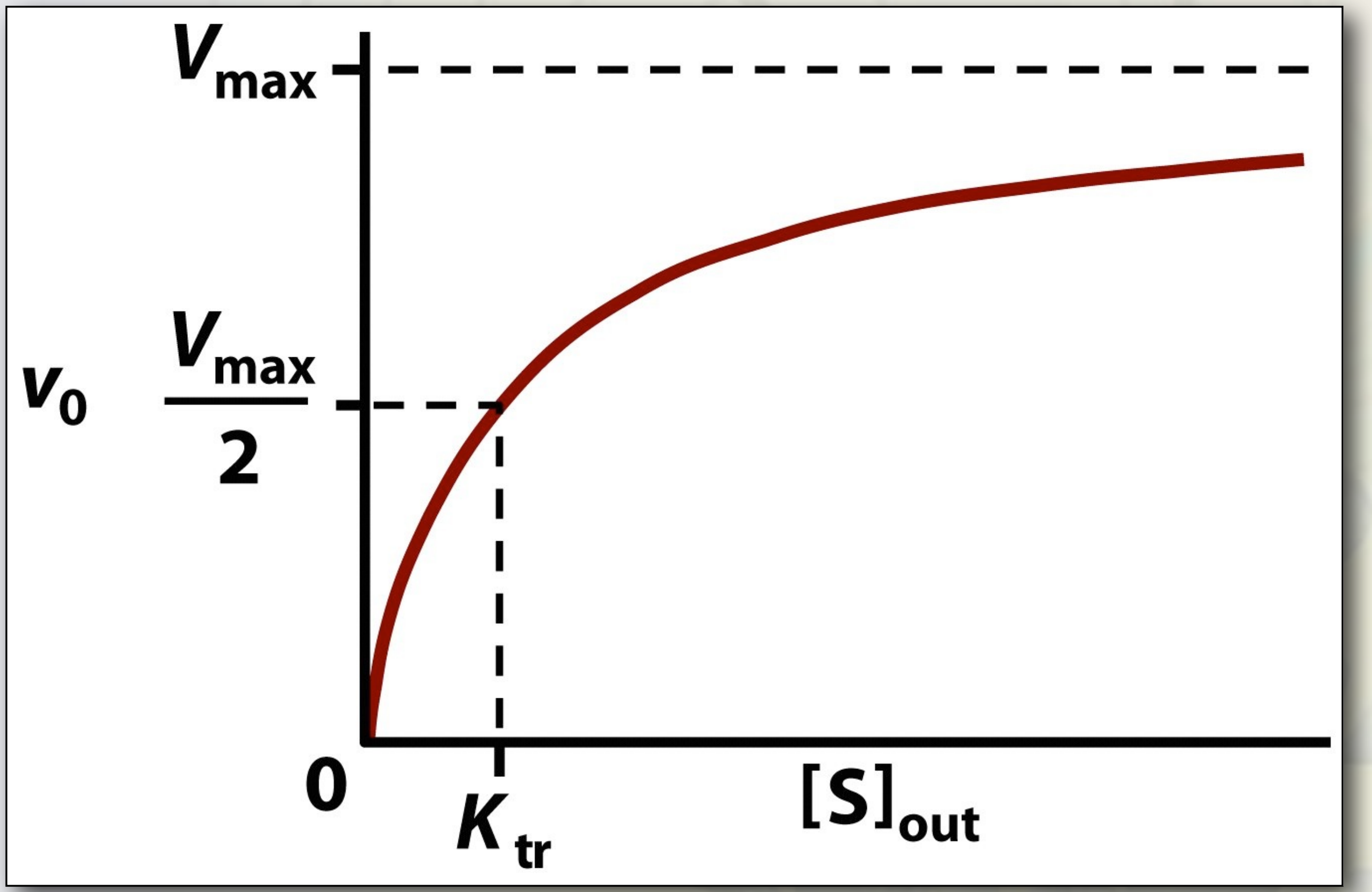

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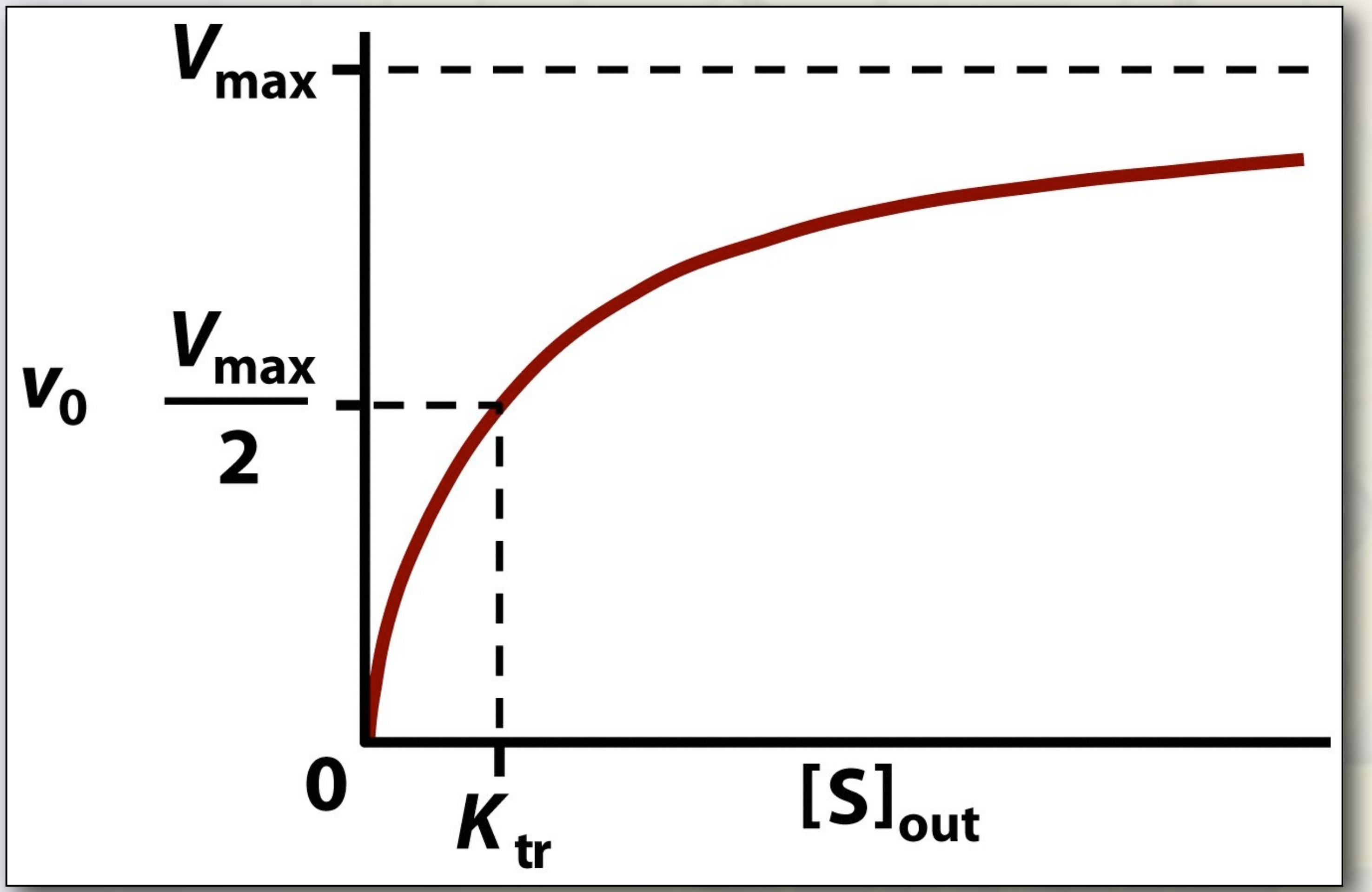

If transport across a membrane can be saturated,
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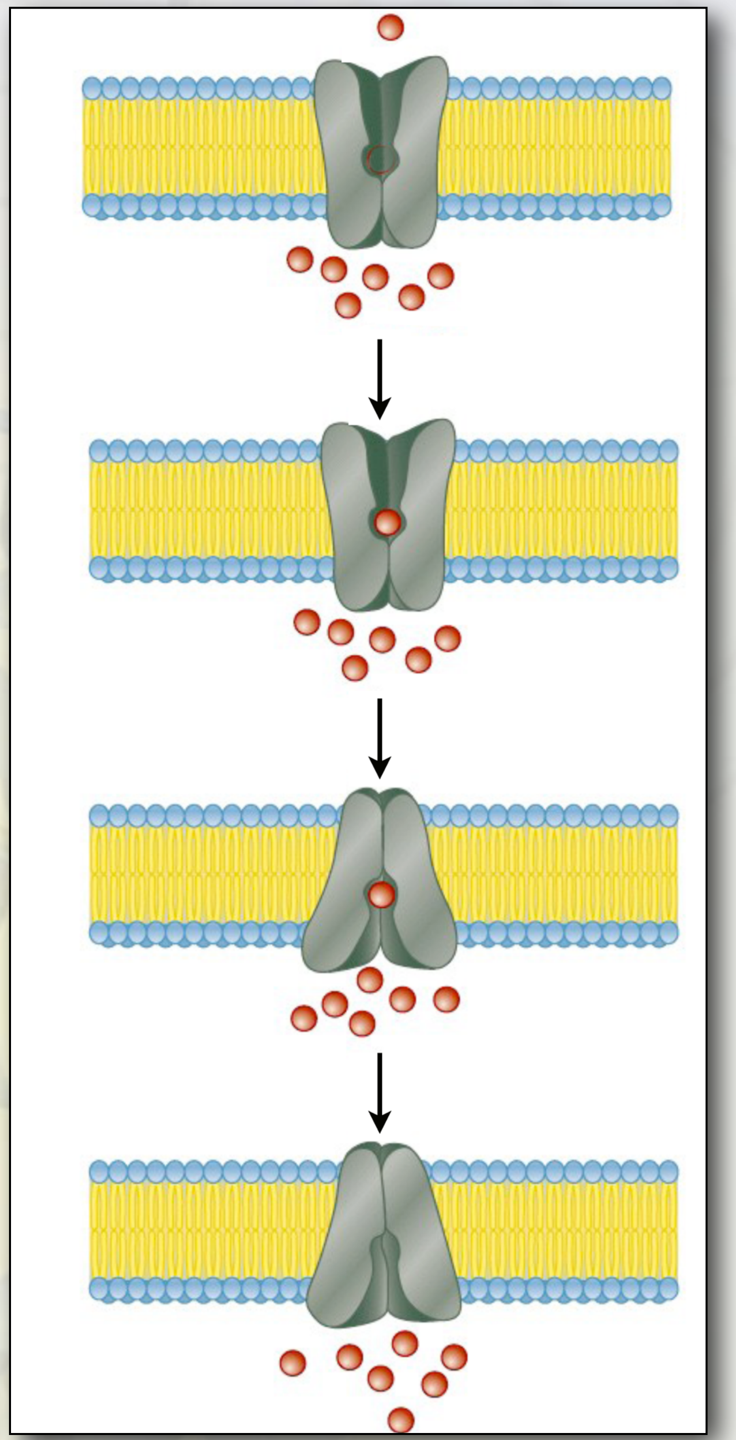
Passive Transport also requires no input in energy

Membrane Transport

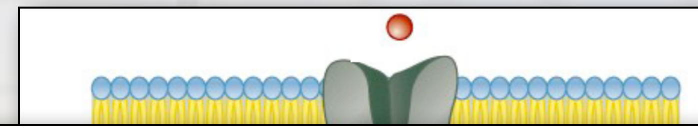
- Active transport
  - Transport occurs up the concentration gradient



Active transport requires a source of energy

Membrane Transport

- Active transport



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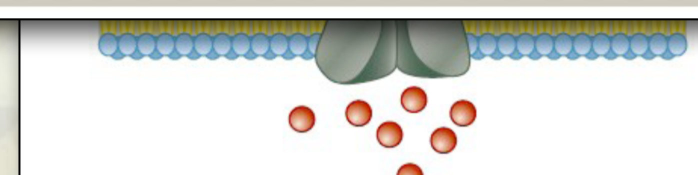

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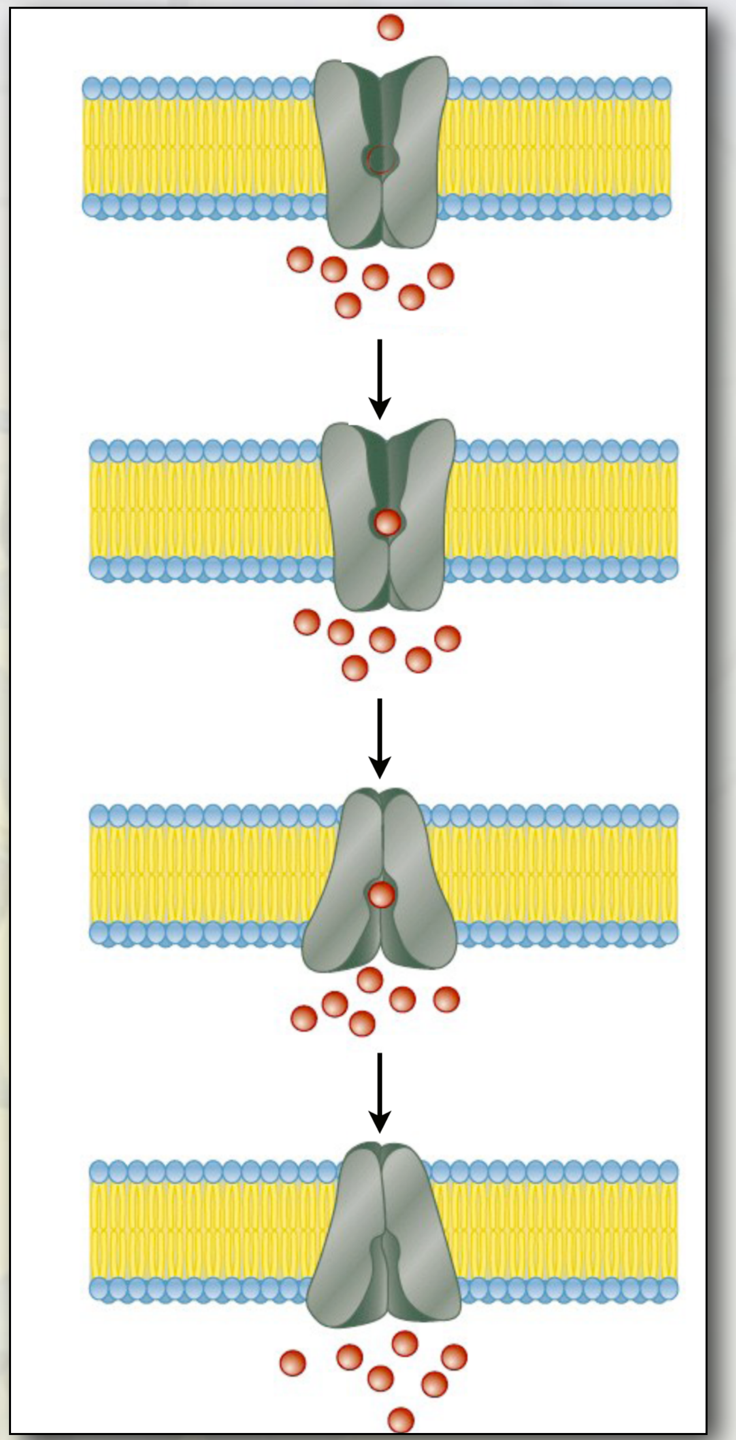
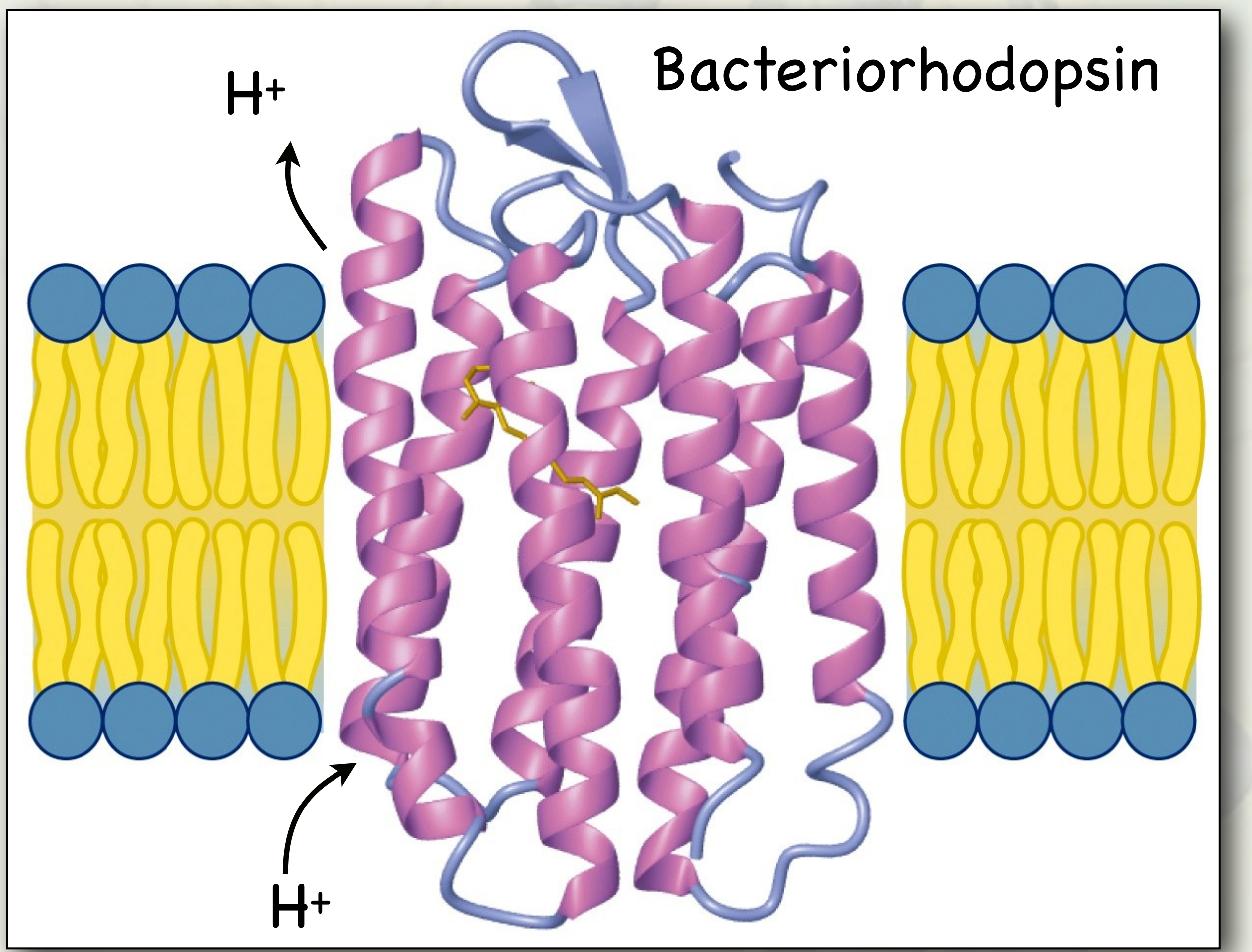


Active transport requires a source of energy

Membrane Transport

- Active Transport
  - Primary active transport



Primary Transport that uses light energy to pump protons up a concentration gradient

Membrane Transport

- Modes of Active and Passive transport
  - Uniport
  - Symport
  - Antiport

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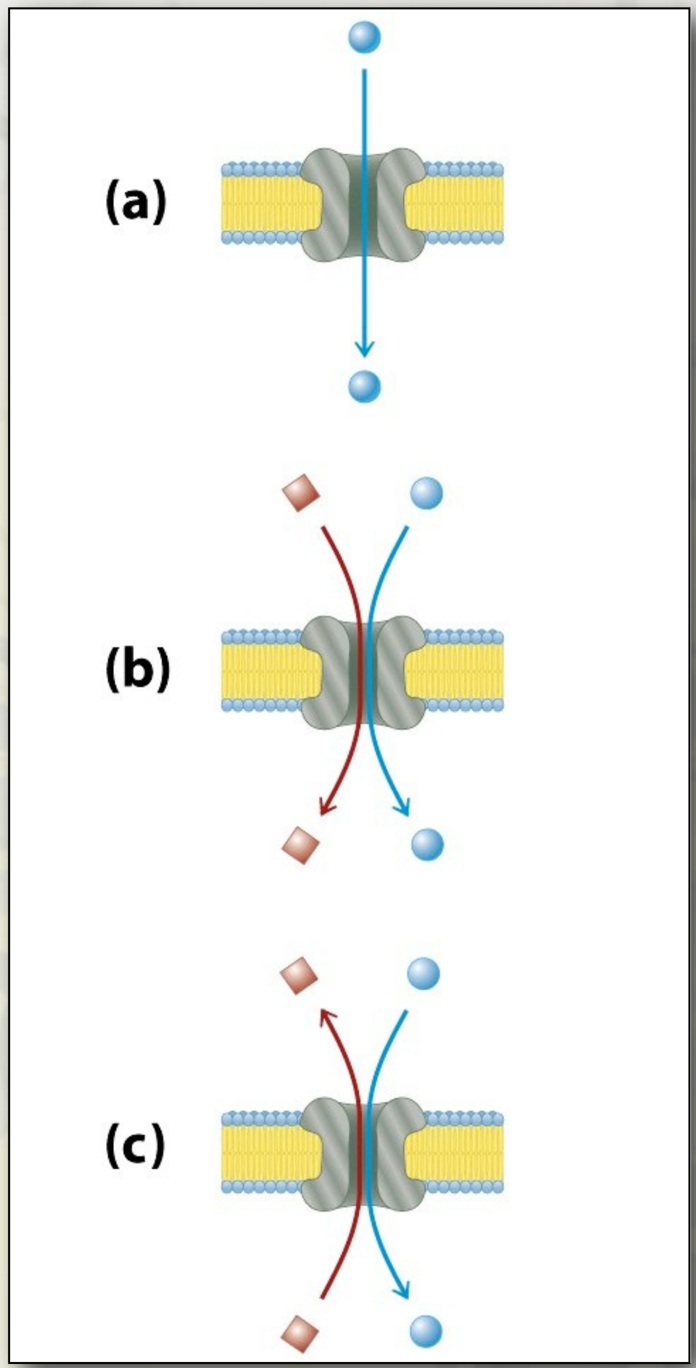
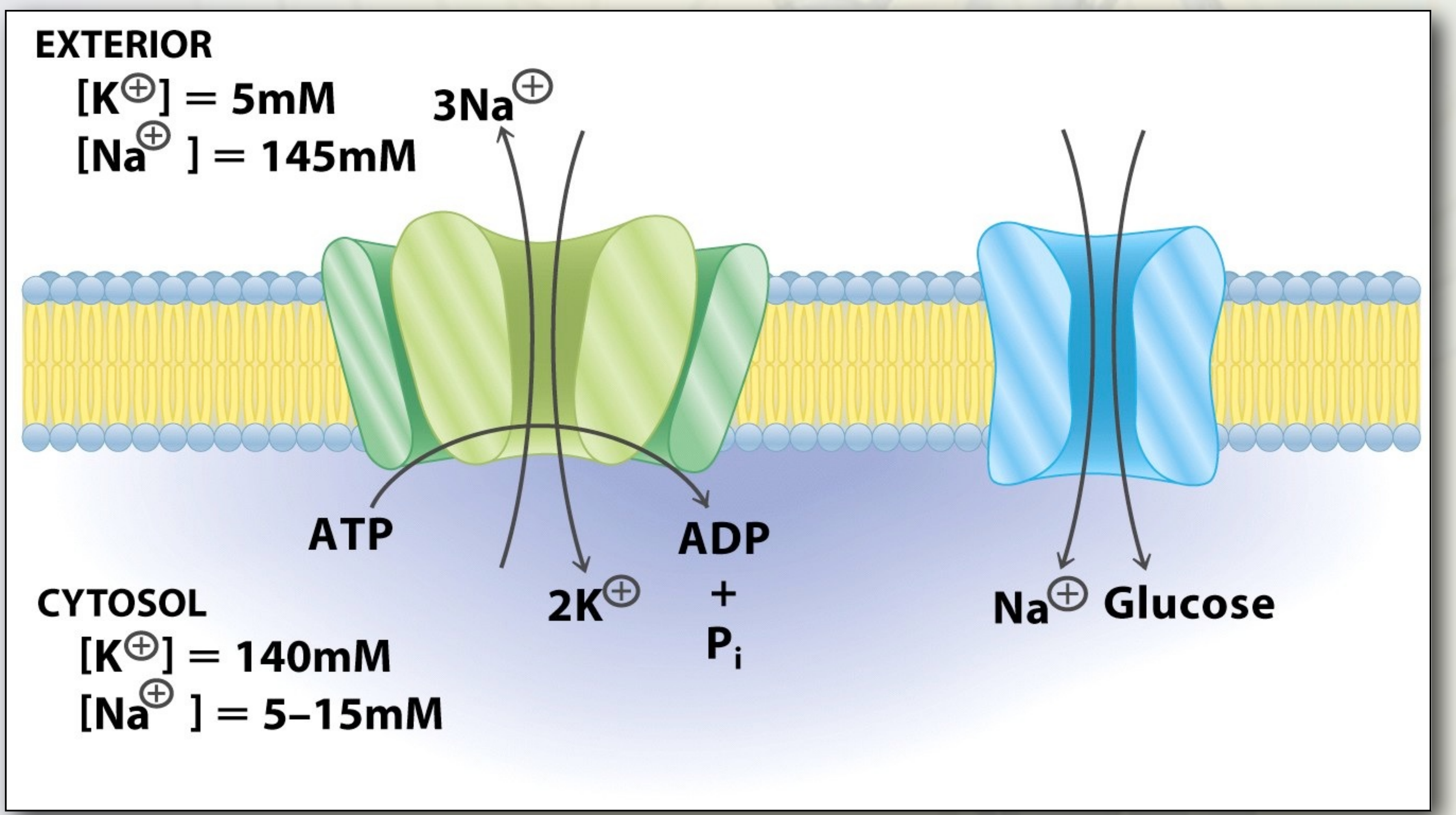


Membrane Transport

- Active Transport
  - Primary active transport
  - Secondary active transport



Secondary transport that uses a sodium ion gradient as the source of energy.

Membrane Transport

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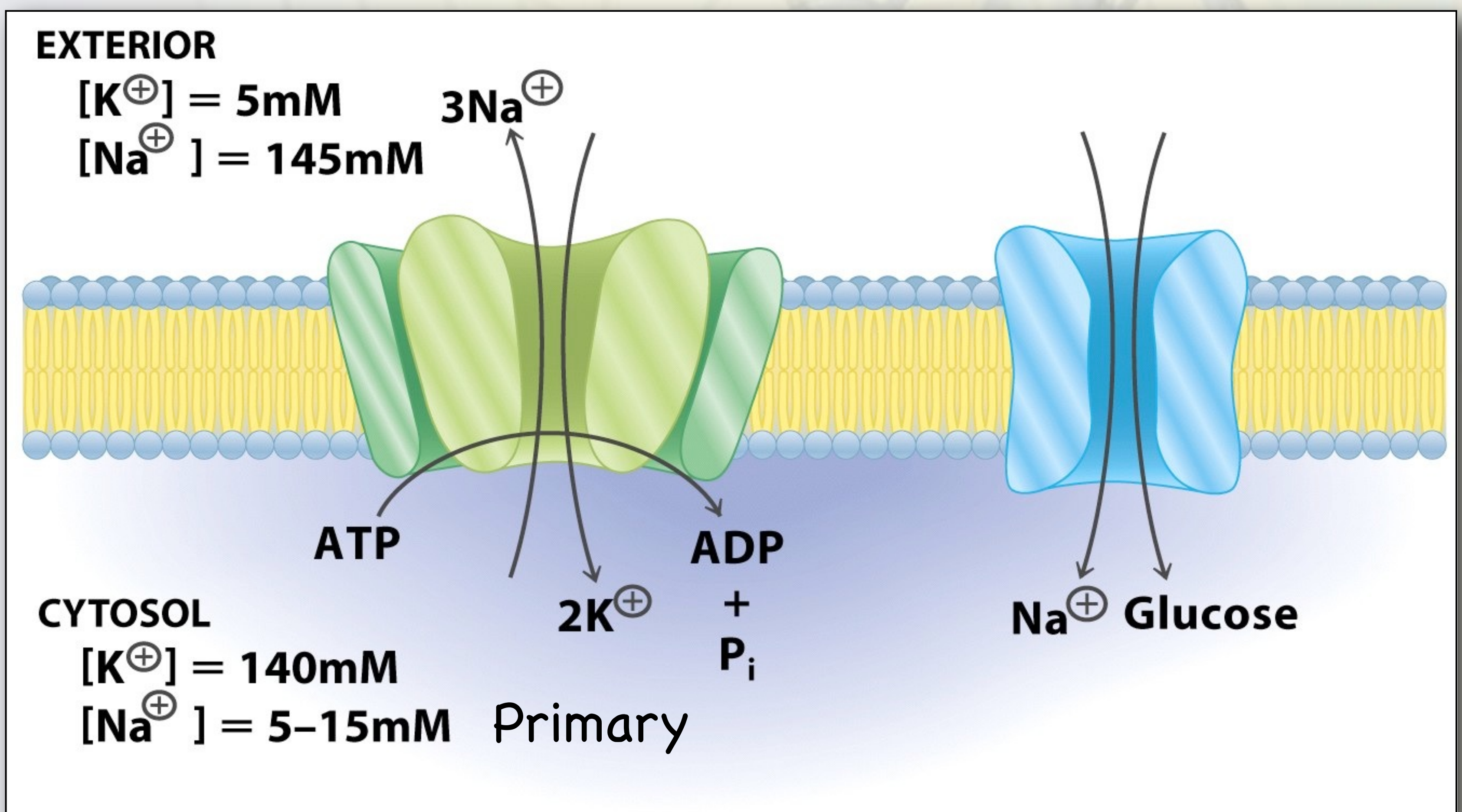

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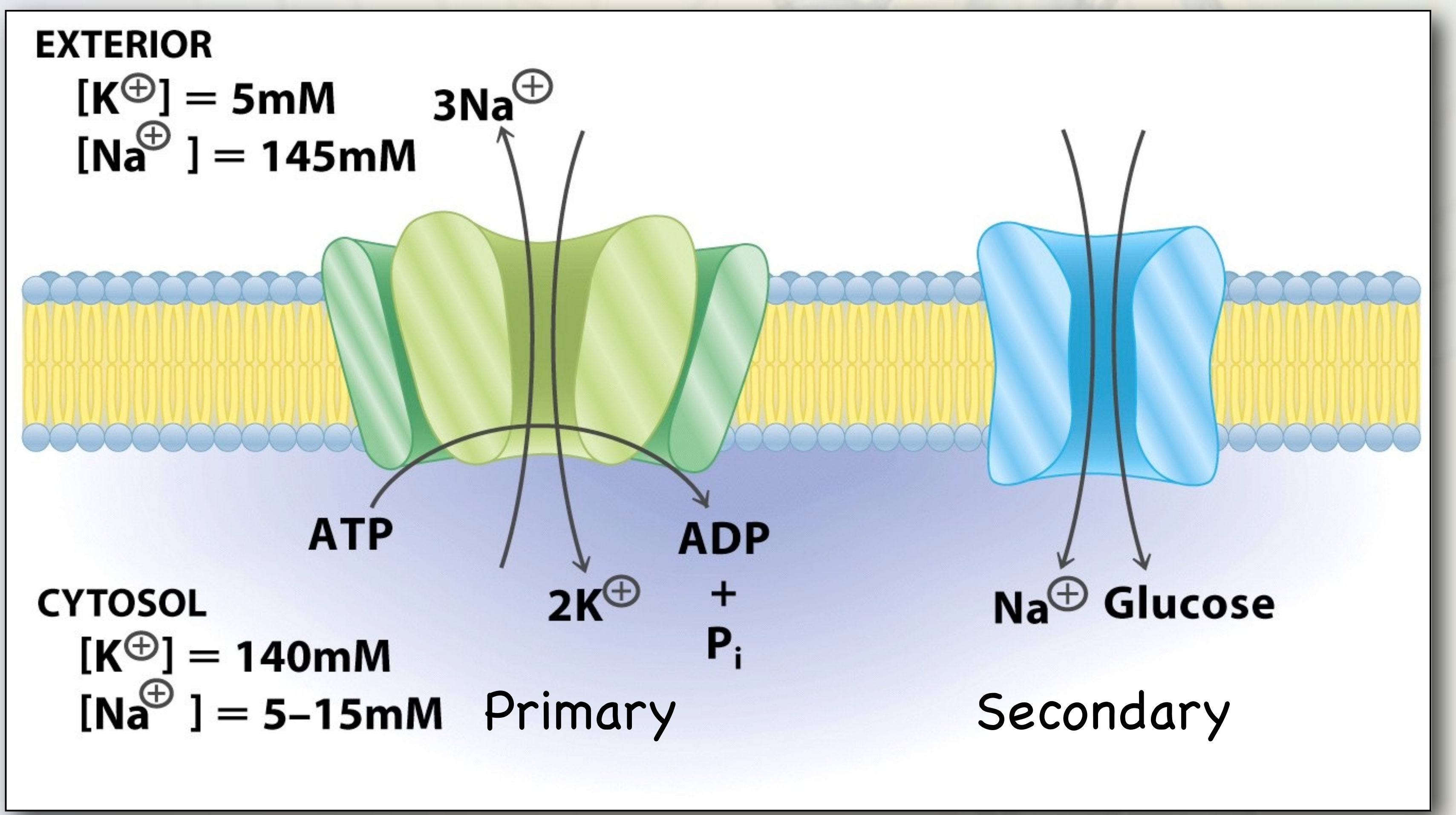

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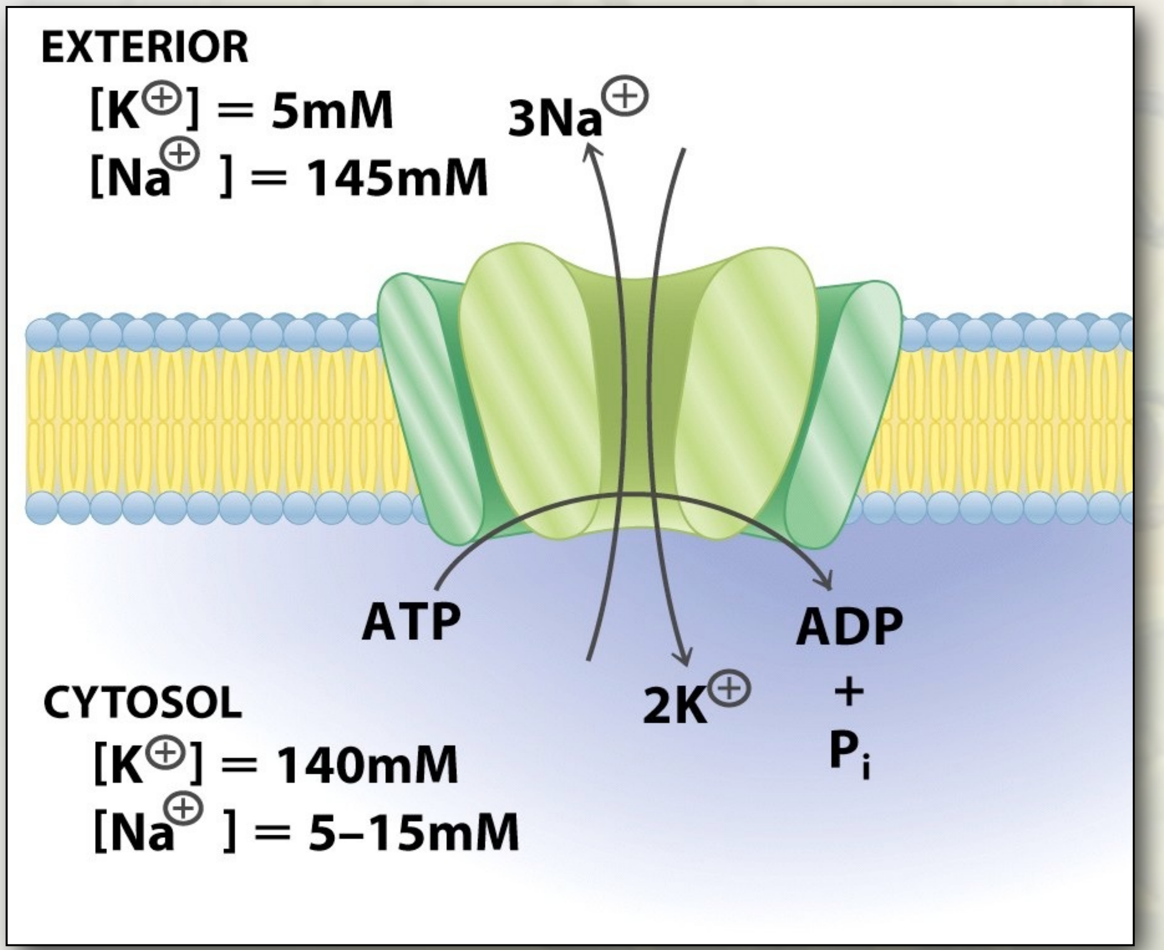

Primary transport that uses the free energy from hydrolysis of ATP to pump both Na^+ and K^+ ions up a concentration gradient

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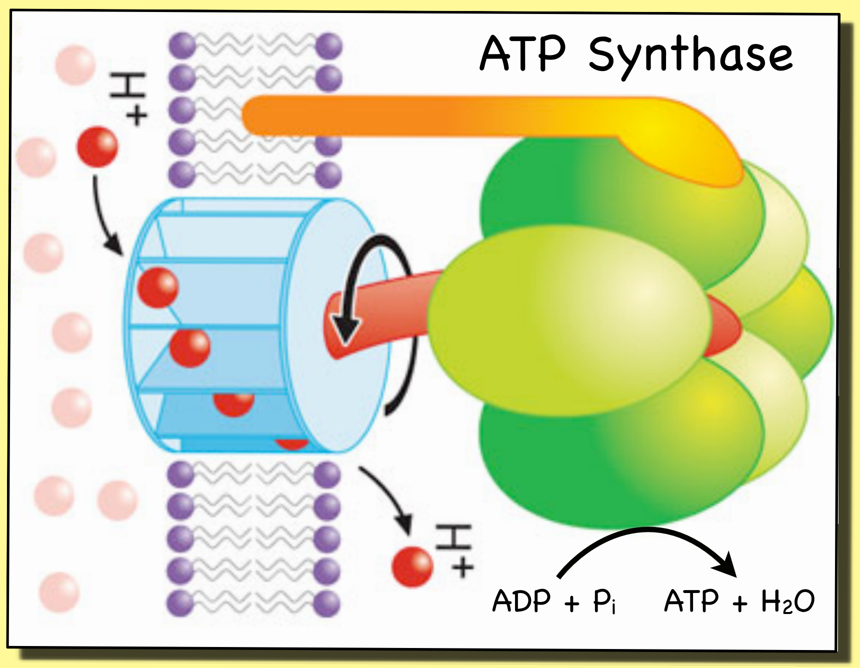

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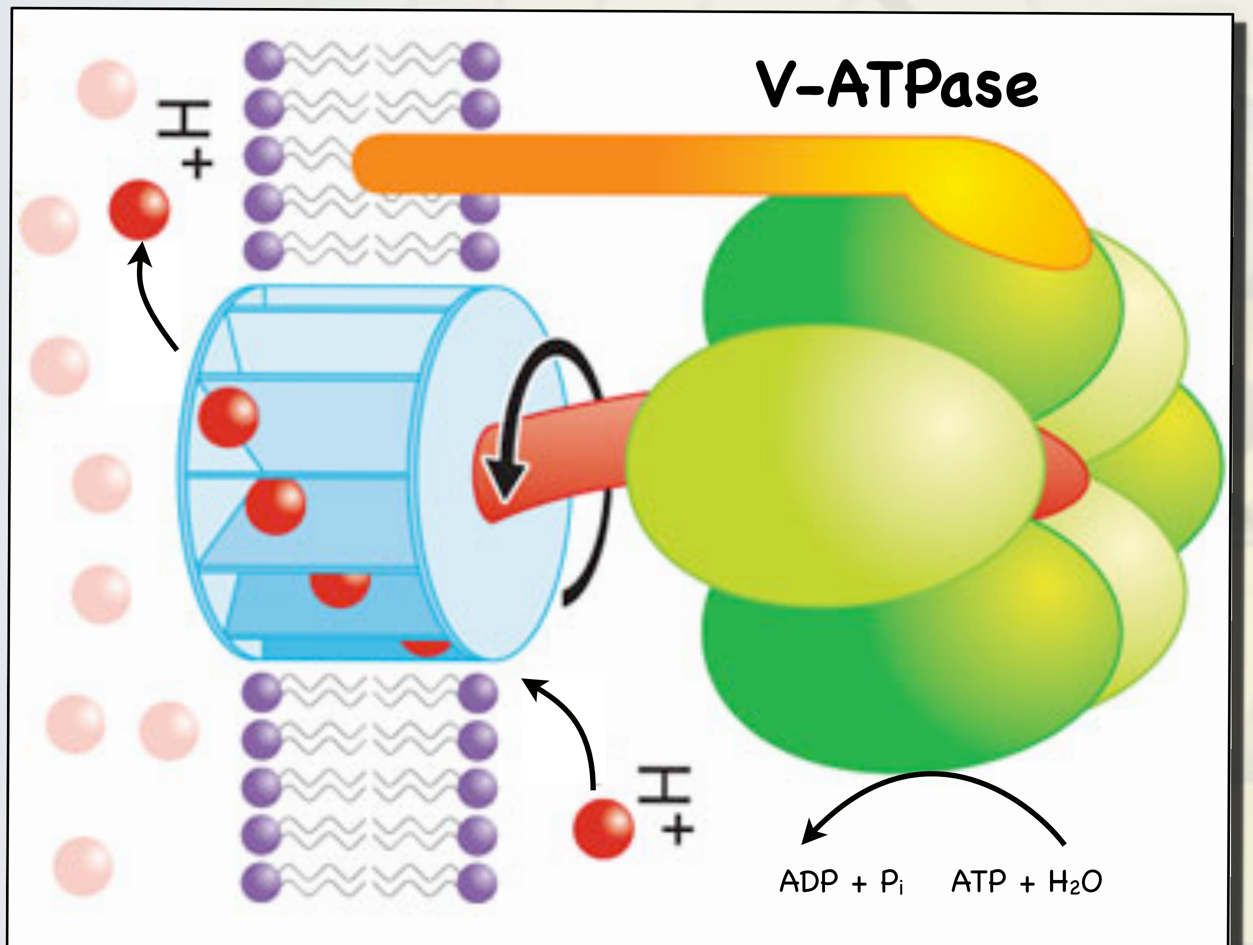
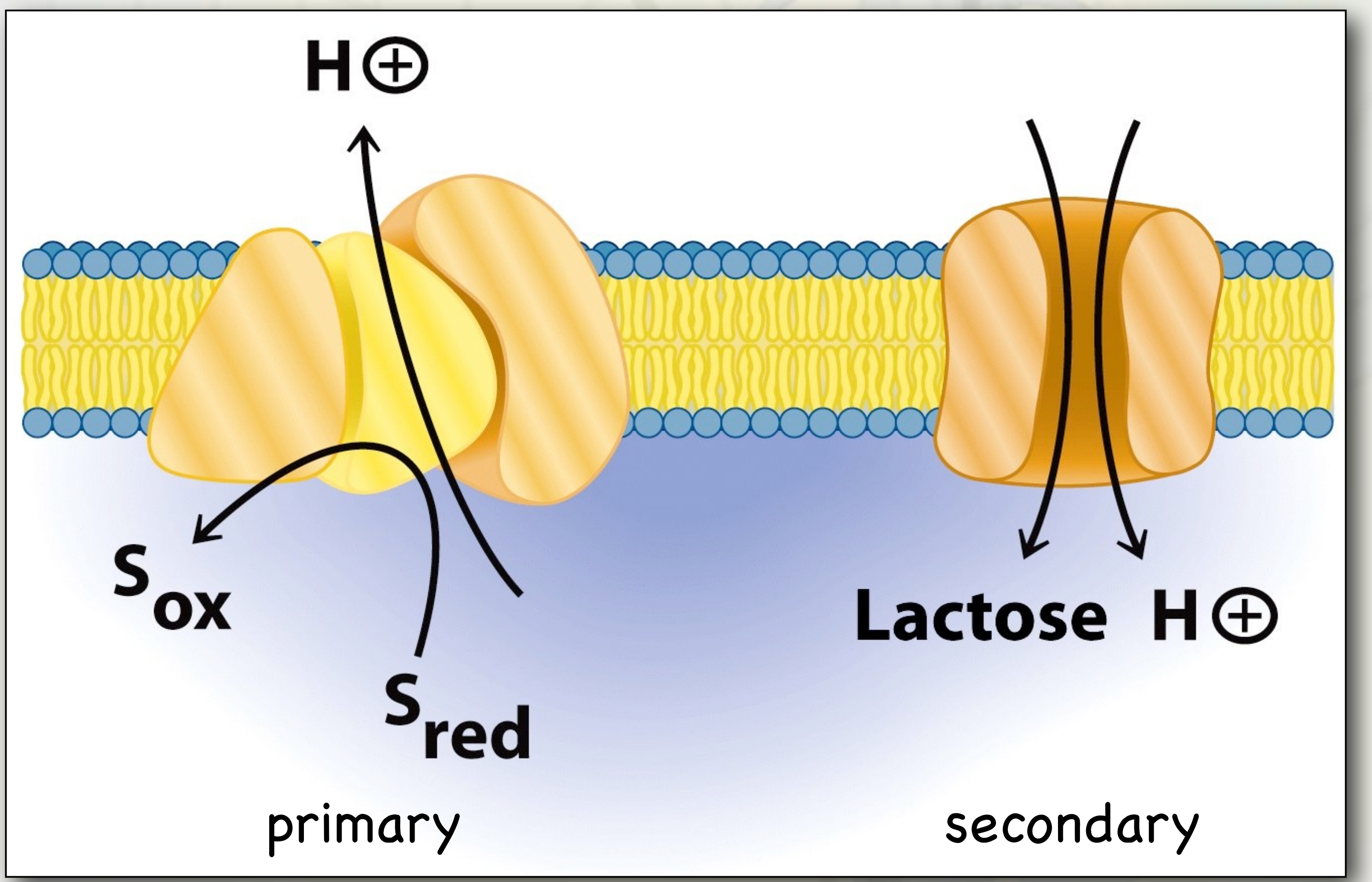


Primary Transport
that uses chemical energy
as the source of energy

ATPase can reverse the process
carried out by ATP synthase

Membrane Transport

- Active Transport
  - Primary active transport
  - Secondary active transport

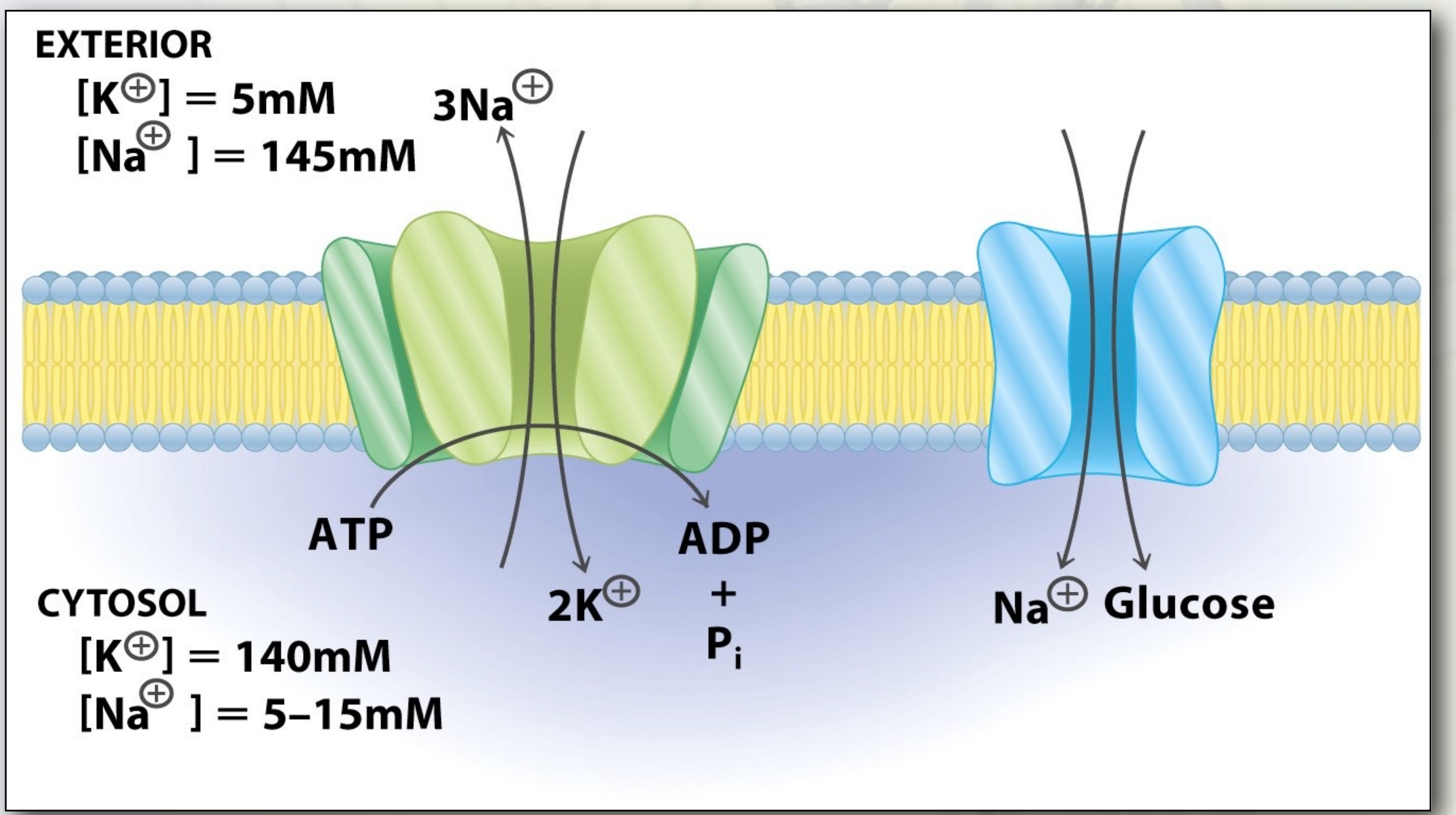


Secondary transport that uses proton gradient as the source of energy.

Membrane Transport

•Active Transport

- Primary active transport
- Secondary active transport



Secondary transport that uses a sodium ion gradient as the source of energy.

Transduction of Extracellular Signals

- Cellular response to external signals; the transport of information across a membrane
  - Chemotaxis
  - Hormones
  - Neurotransmitters
  - Growth factors

Transduction of Extracellular Signals

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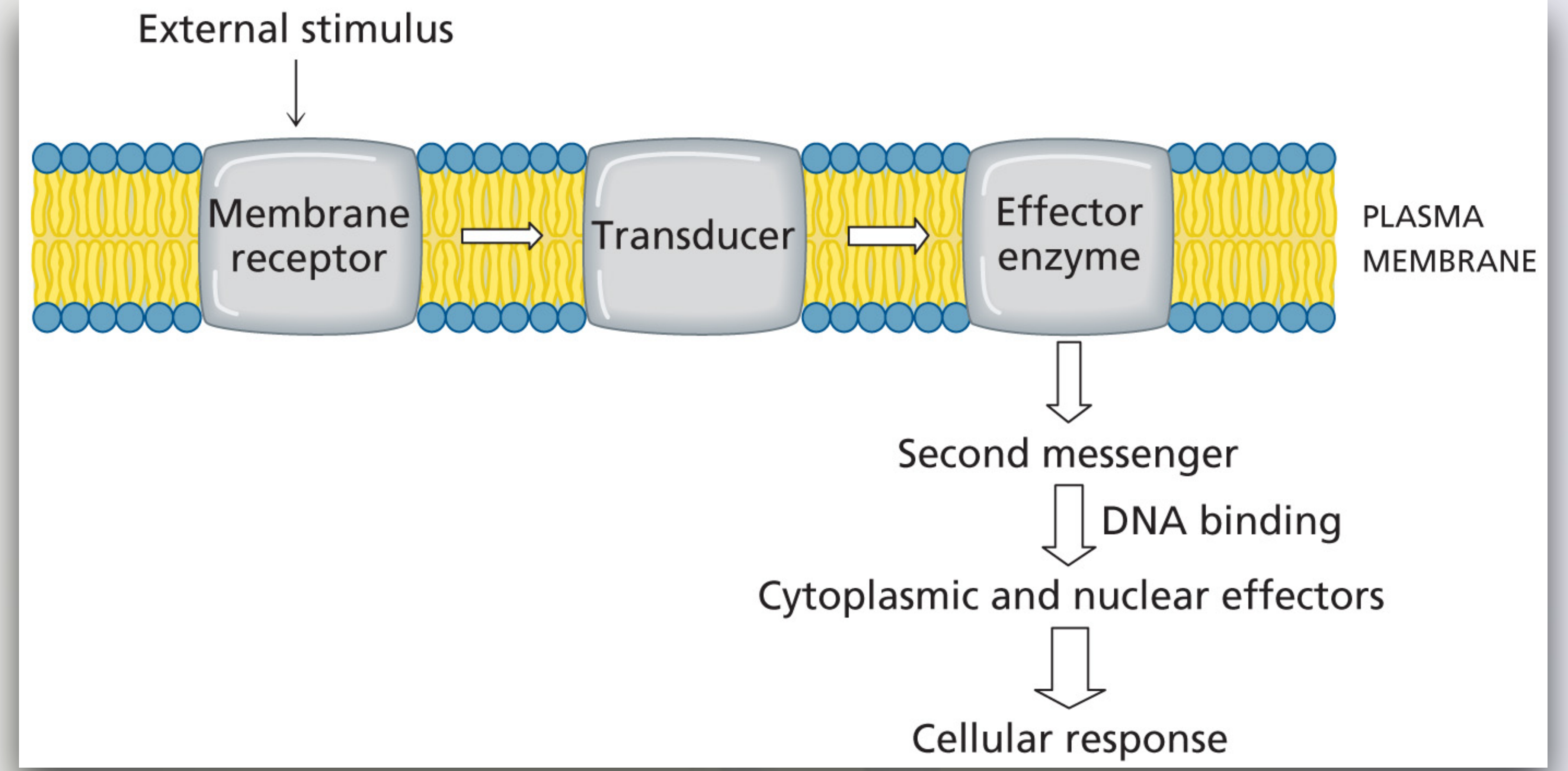

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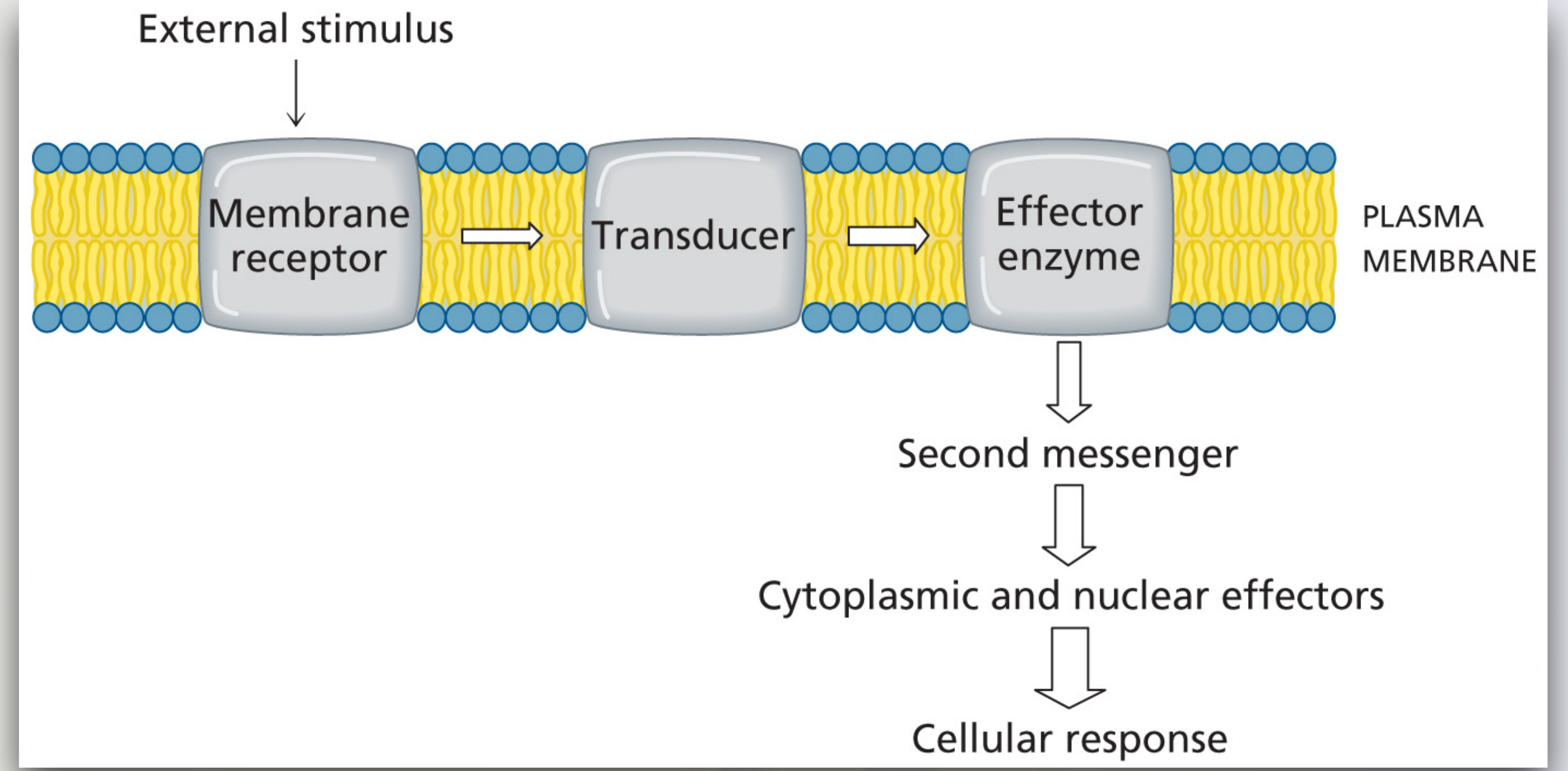

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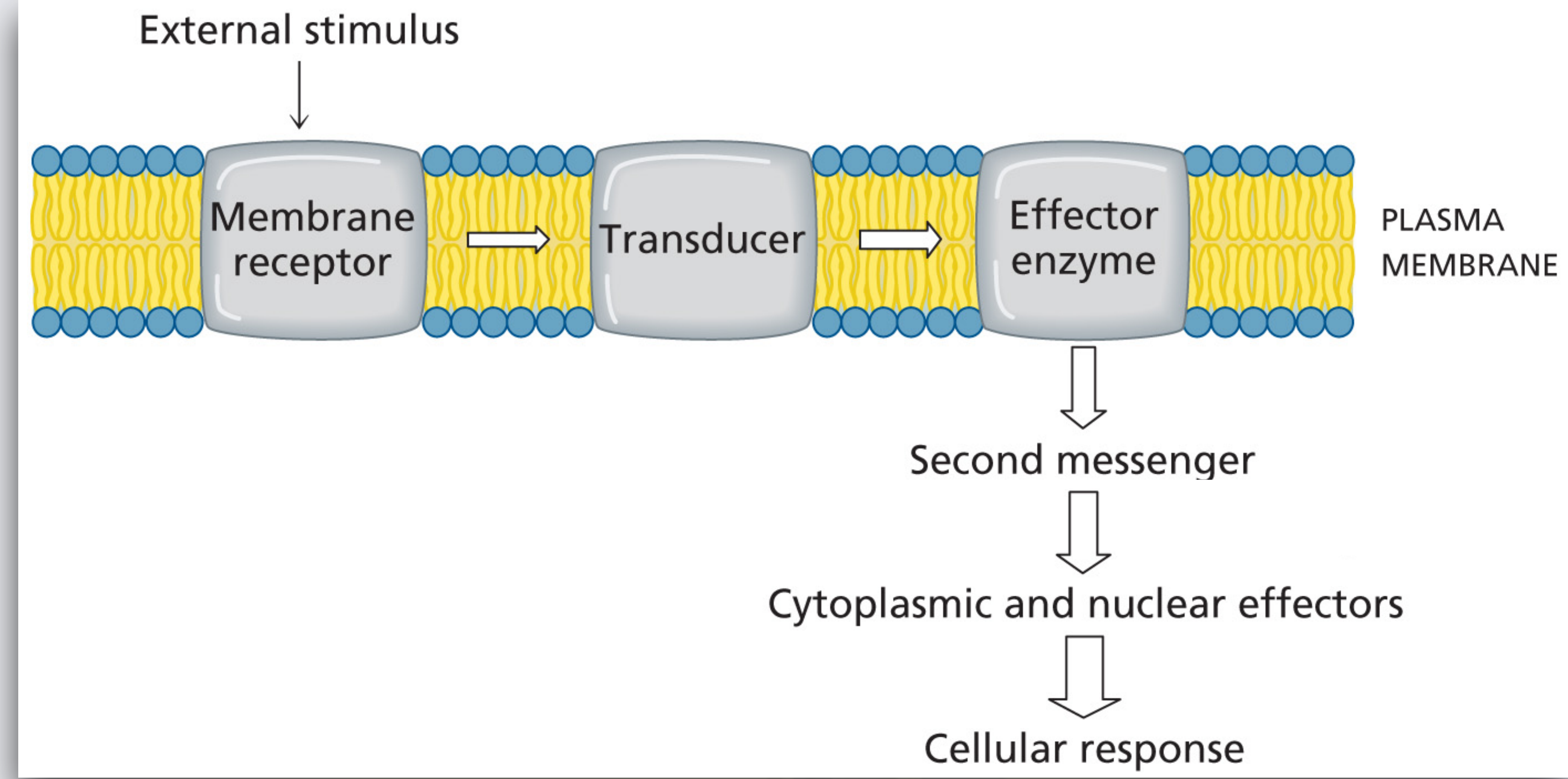
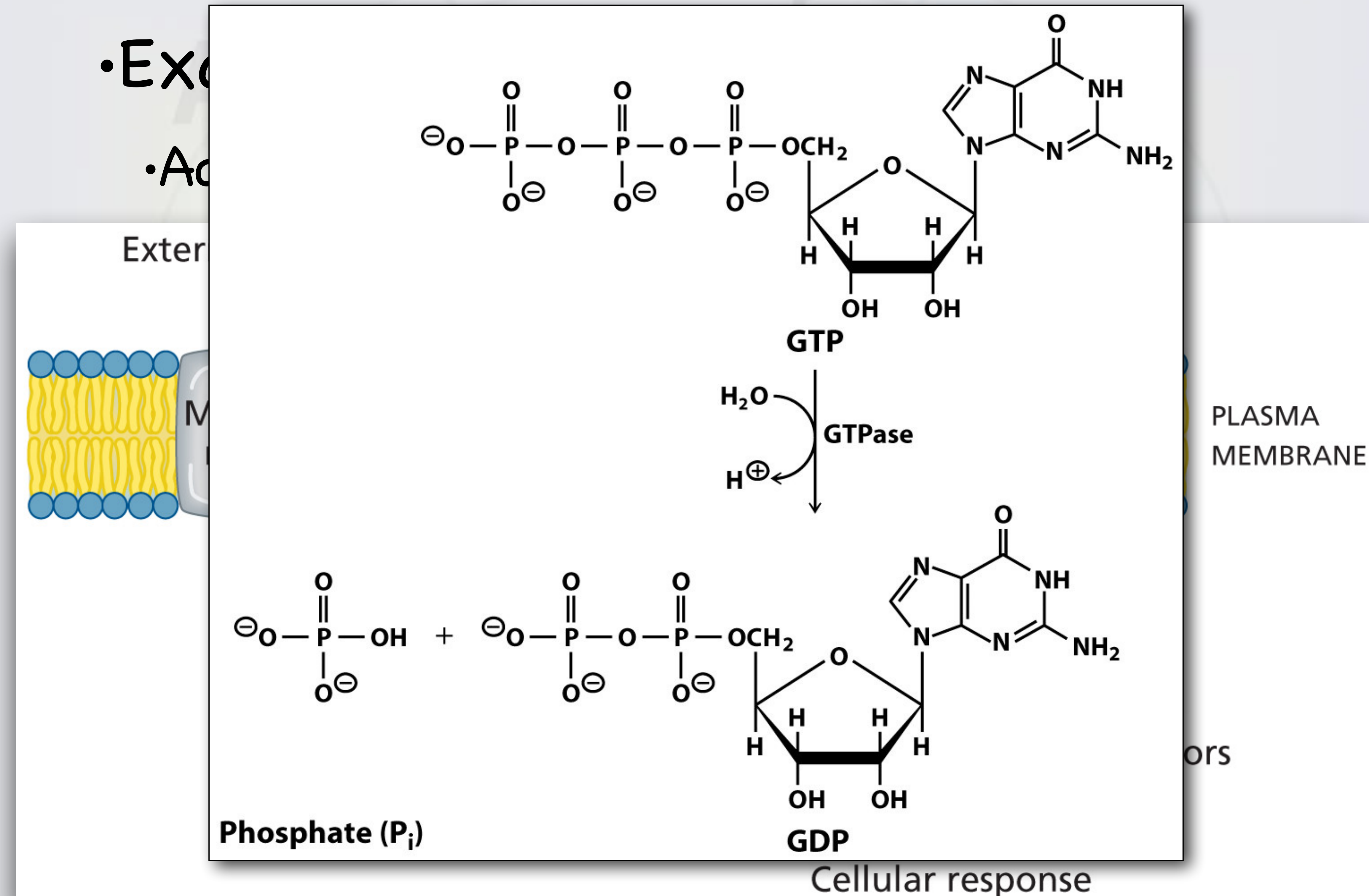
Transduction of Extracellular Signals

- Example - G-Proteins
  - Adenyl cyclase pathway



Transduction of Extracellular Signals

- Exc
  - Ac



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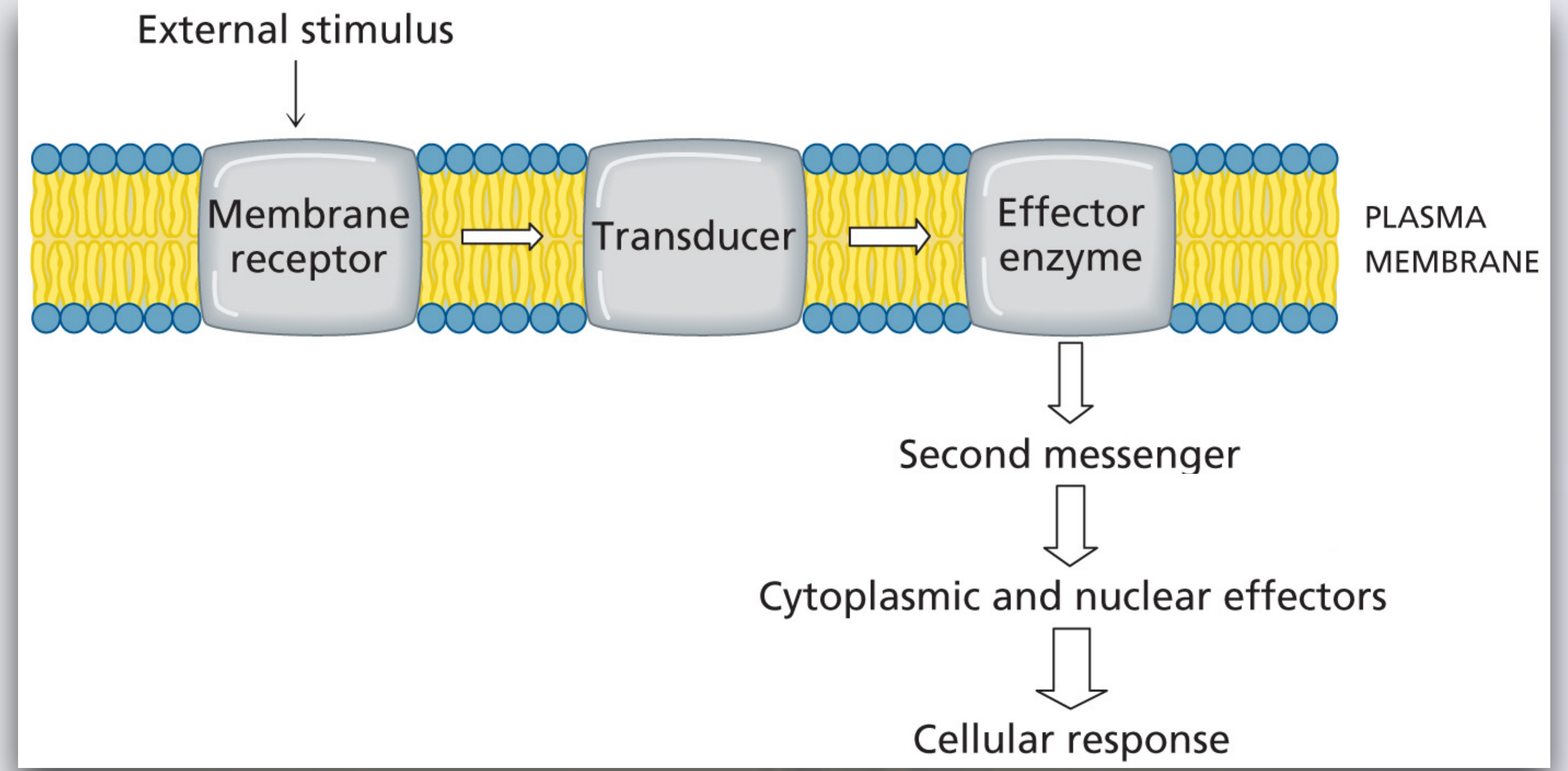

Transduction of Extracellular Signals

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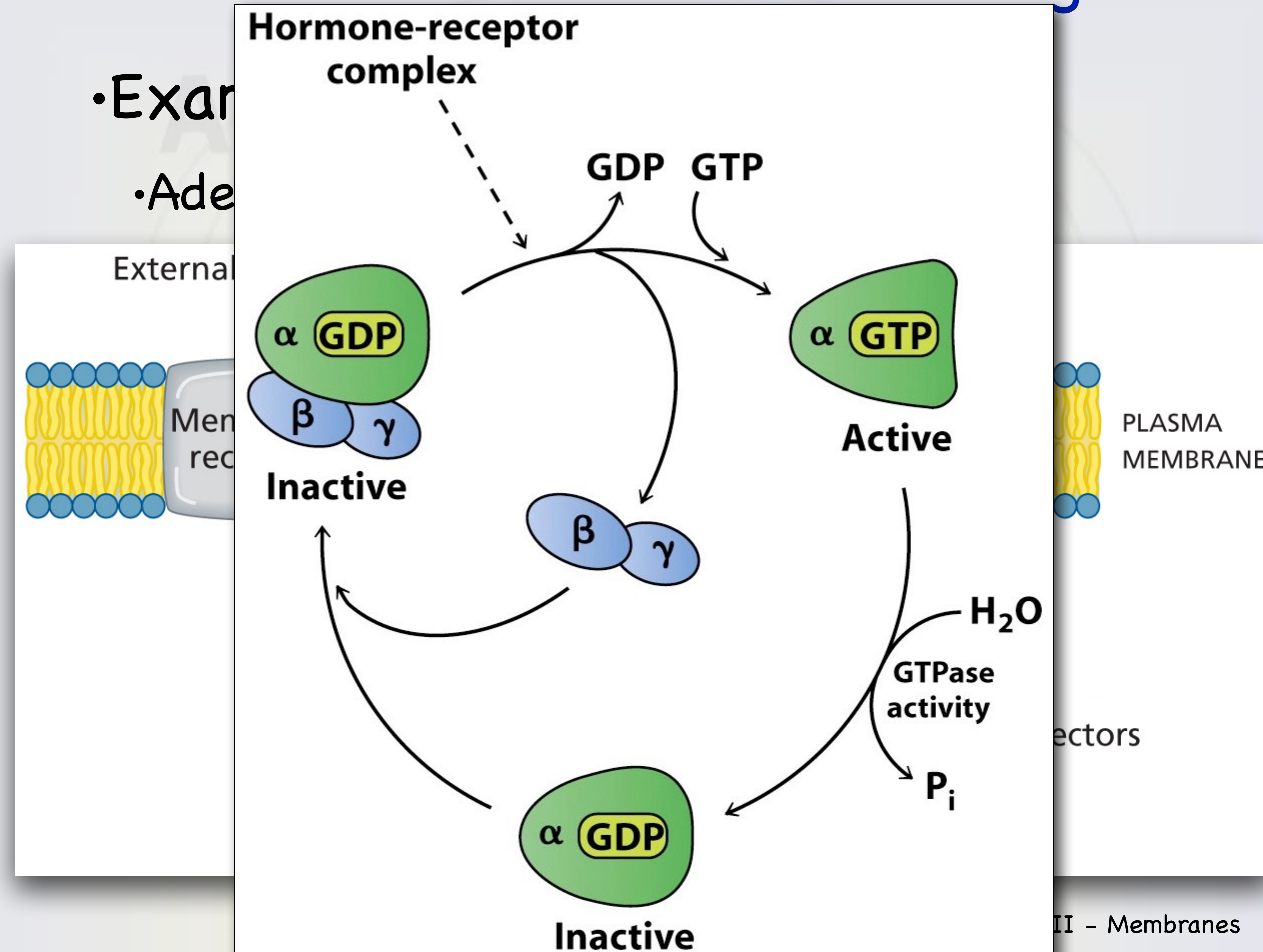

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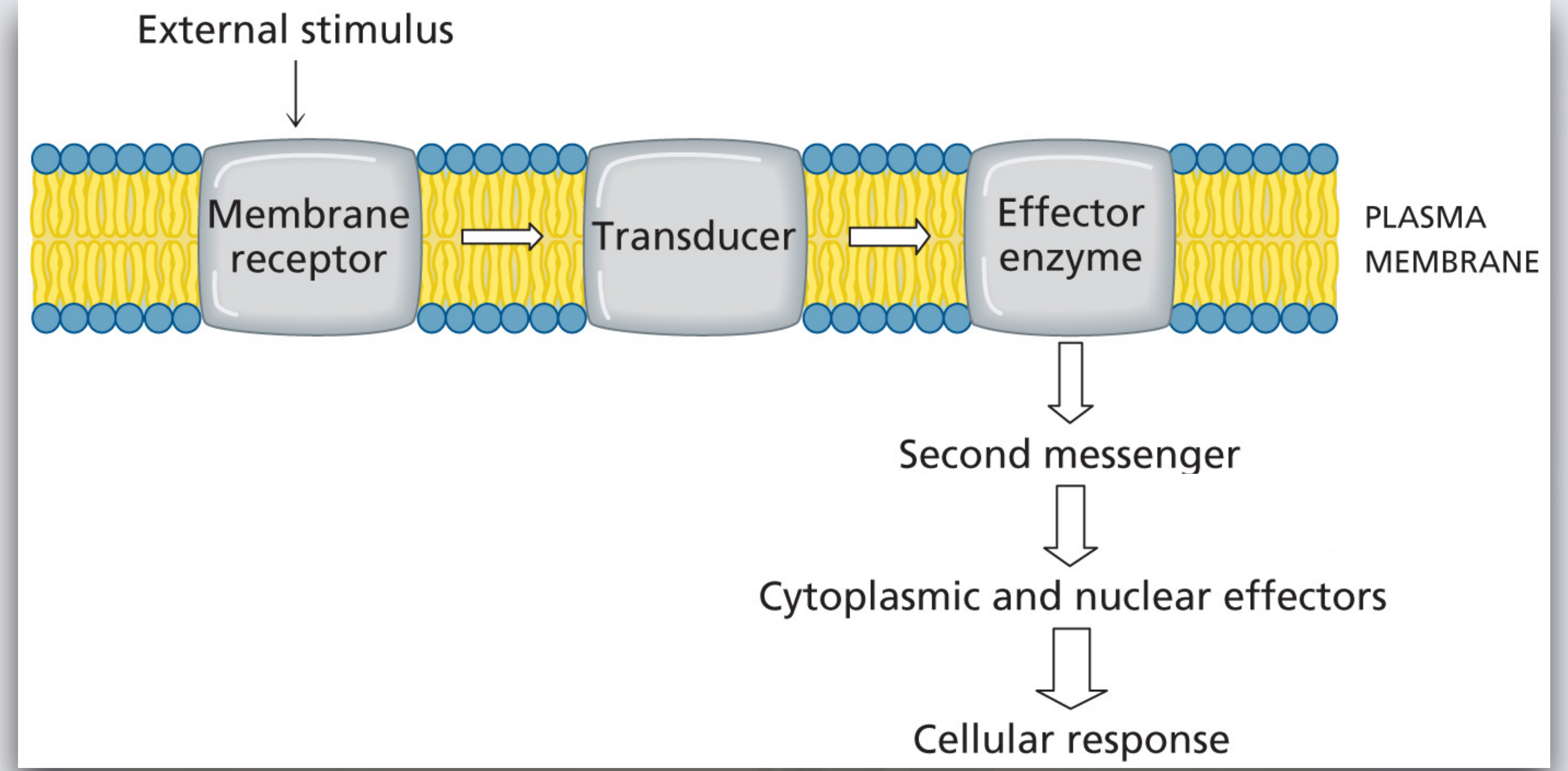

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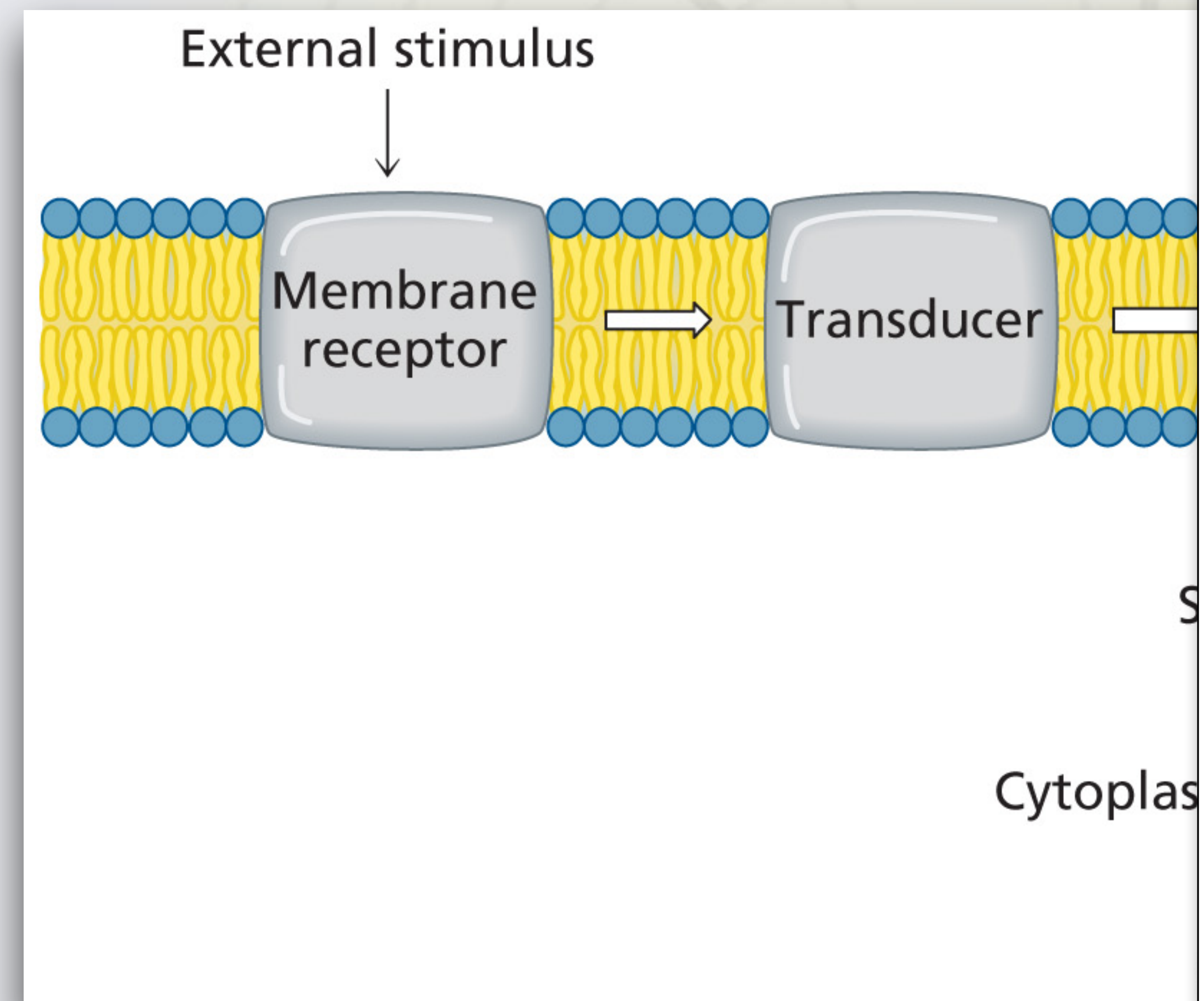

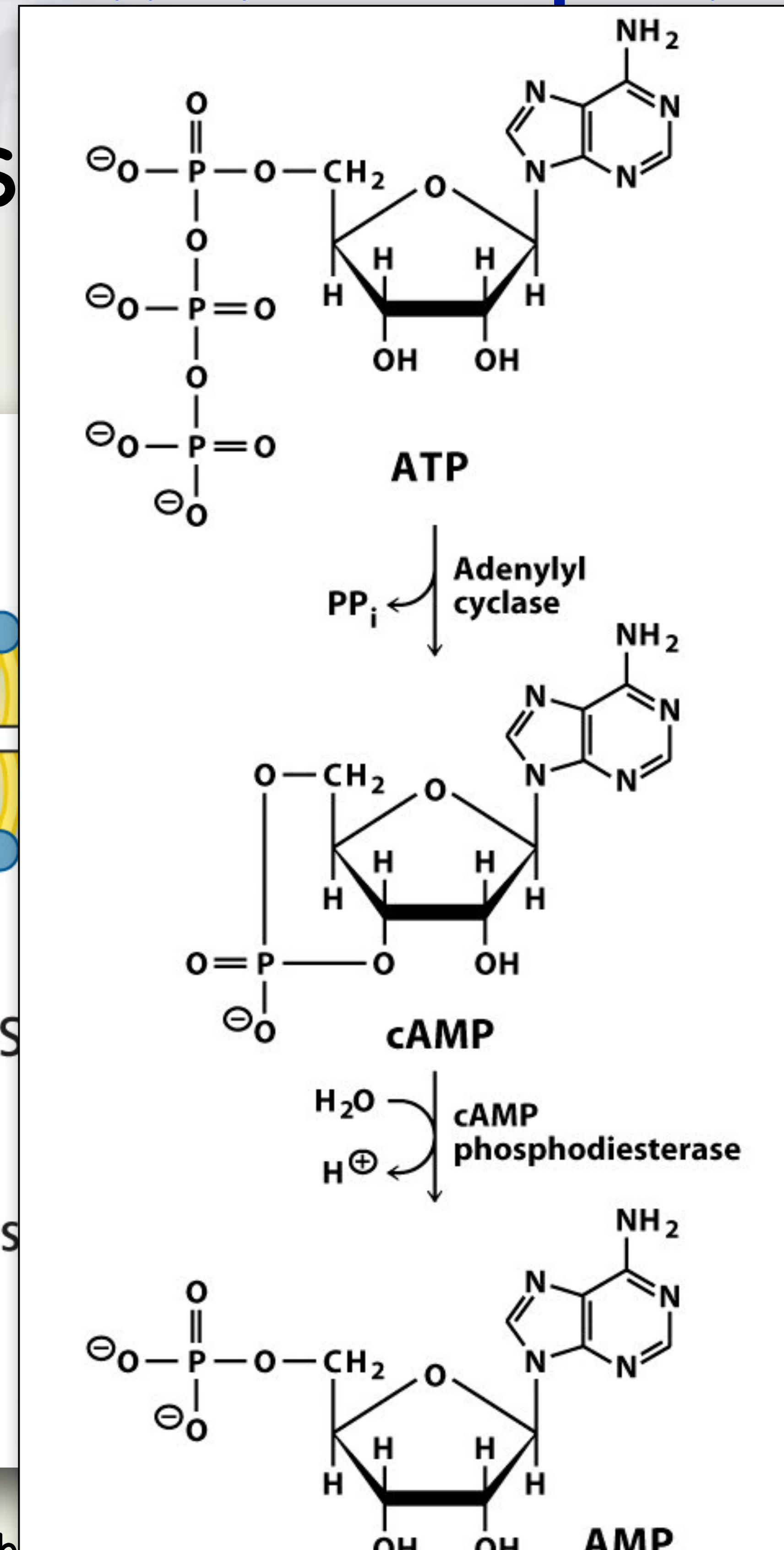

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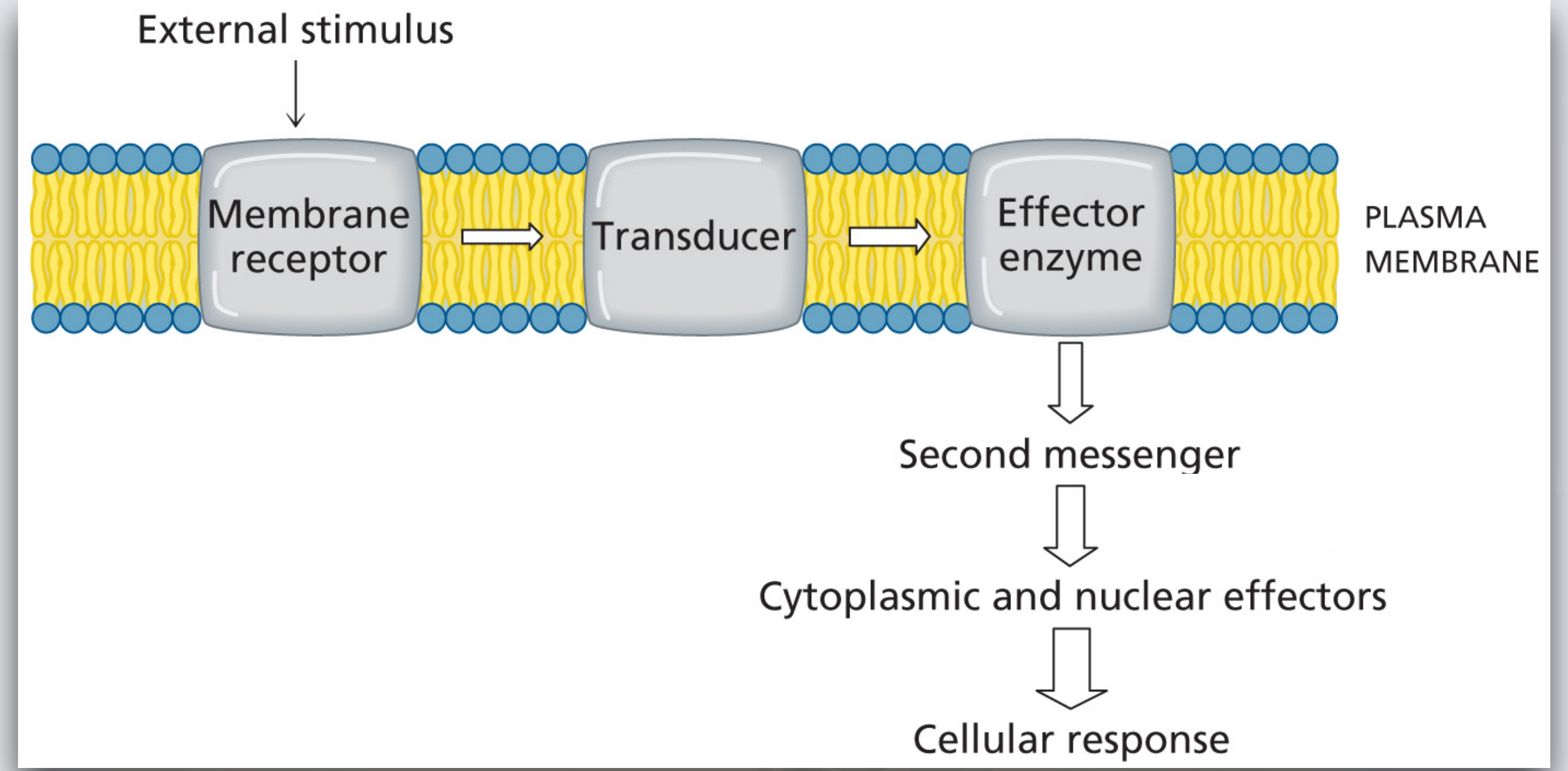

Transduction of Extracellular Signals

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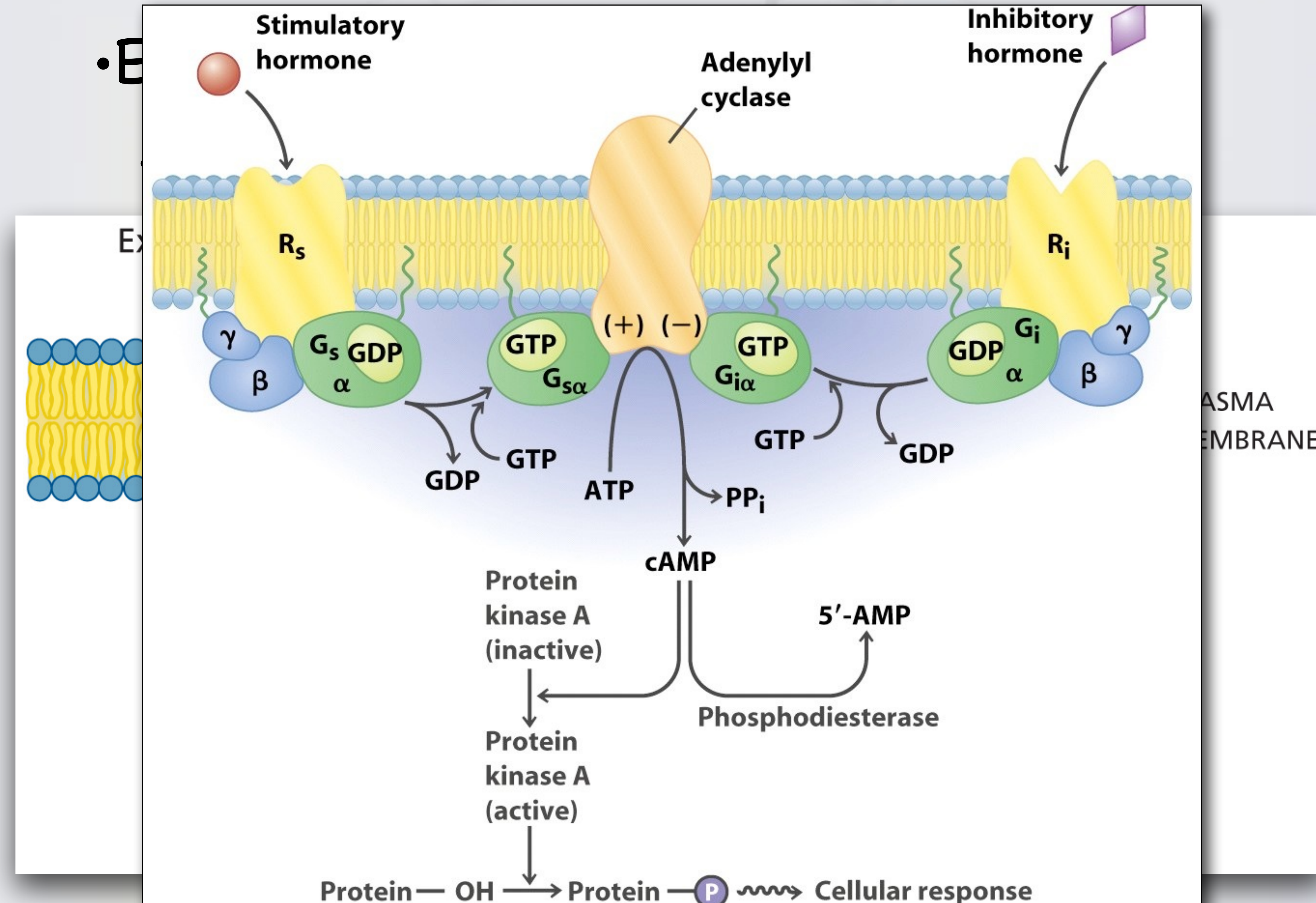
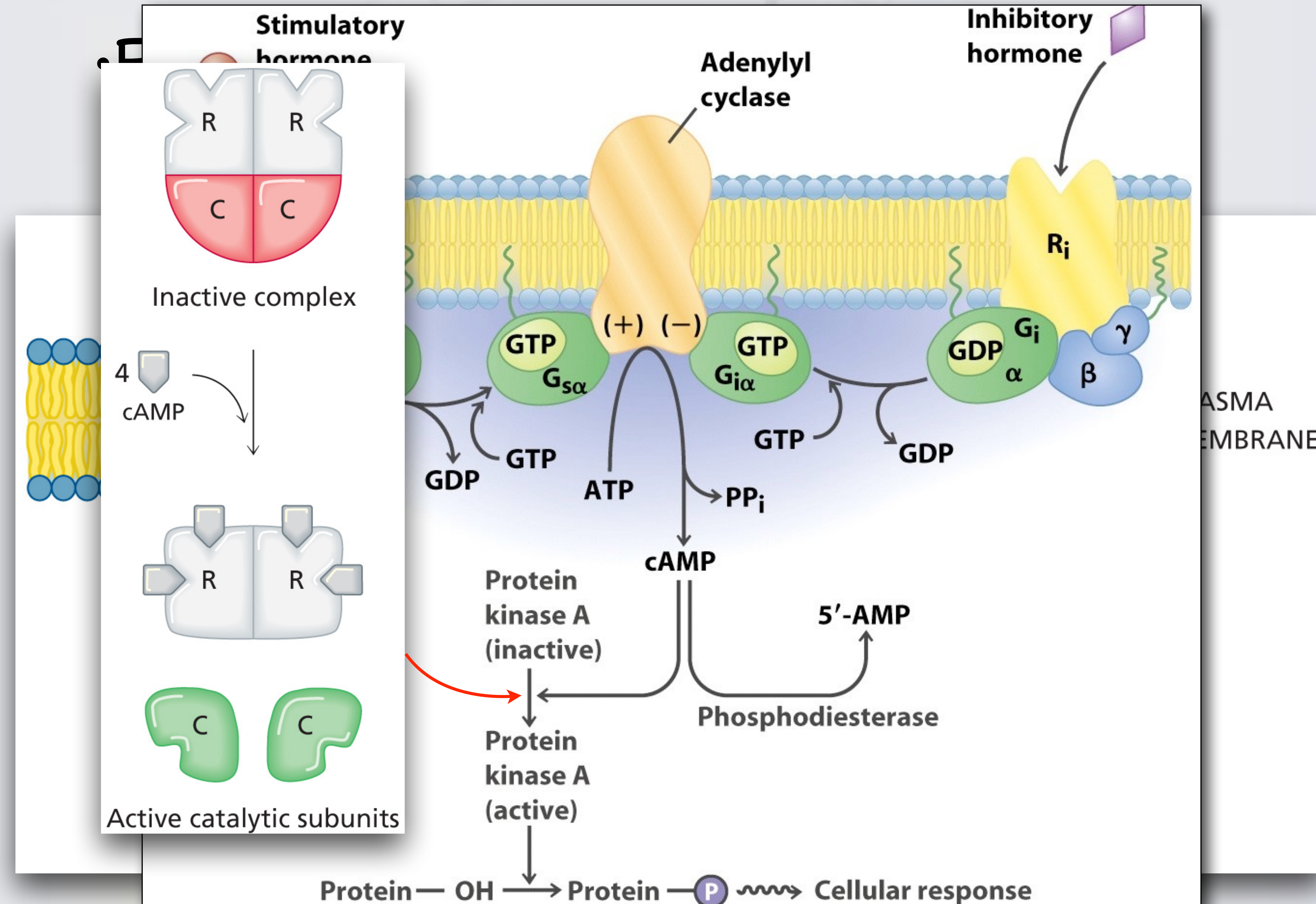


Transduction of Extracellular Signals



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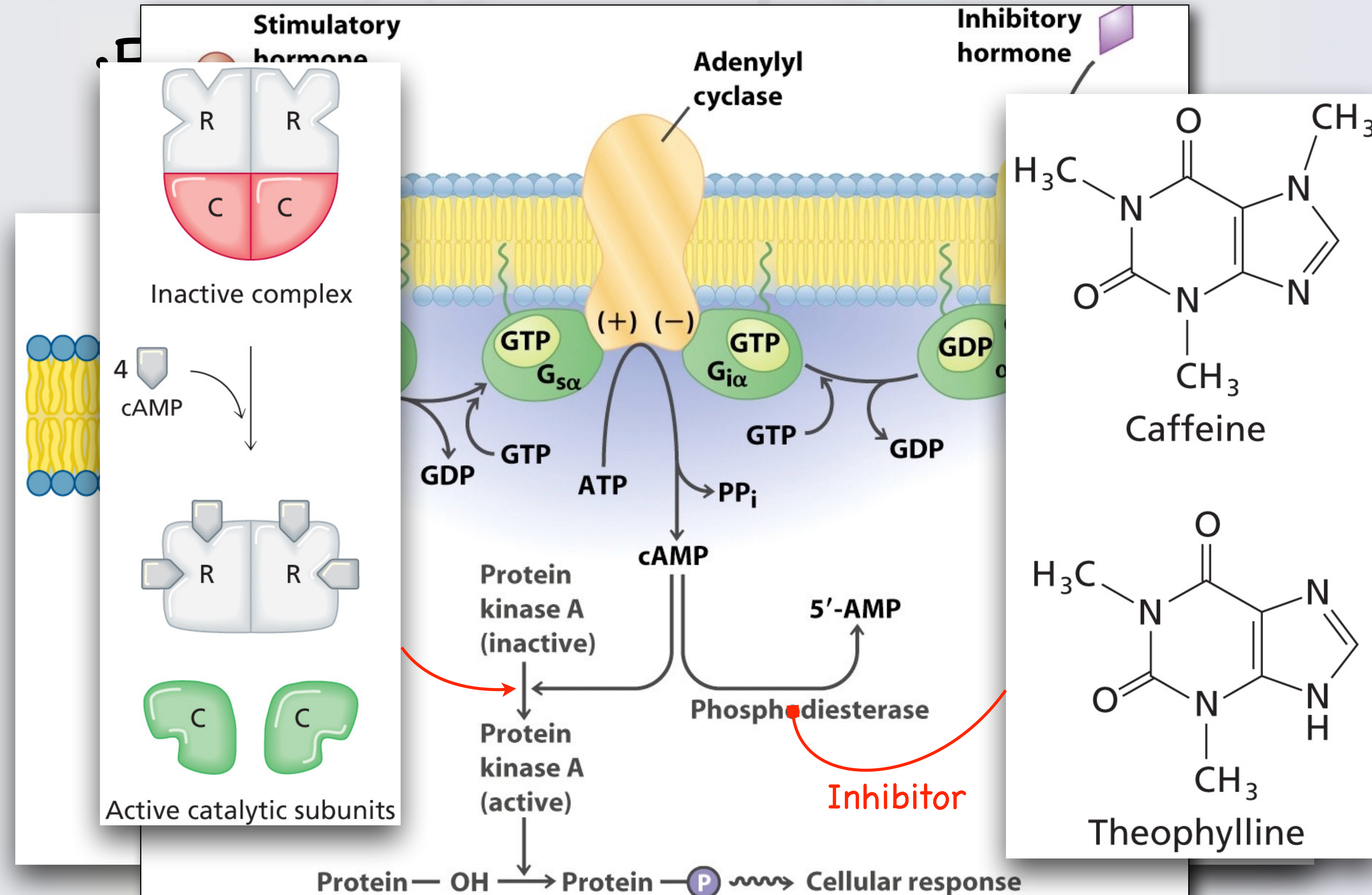

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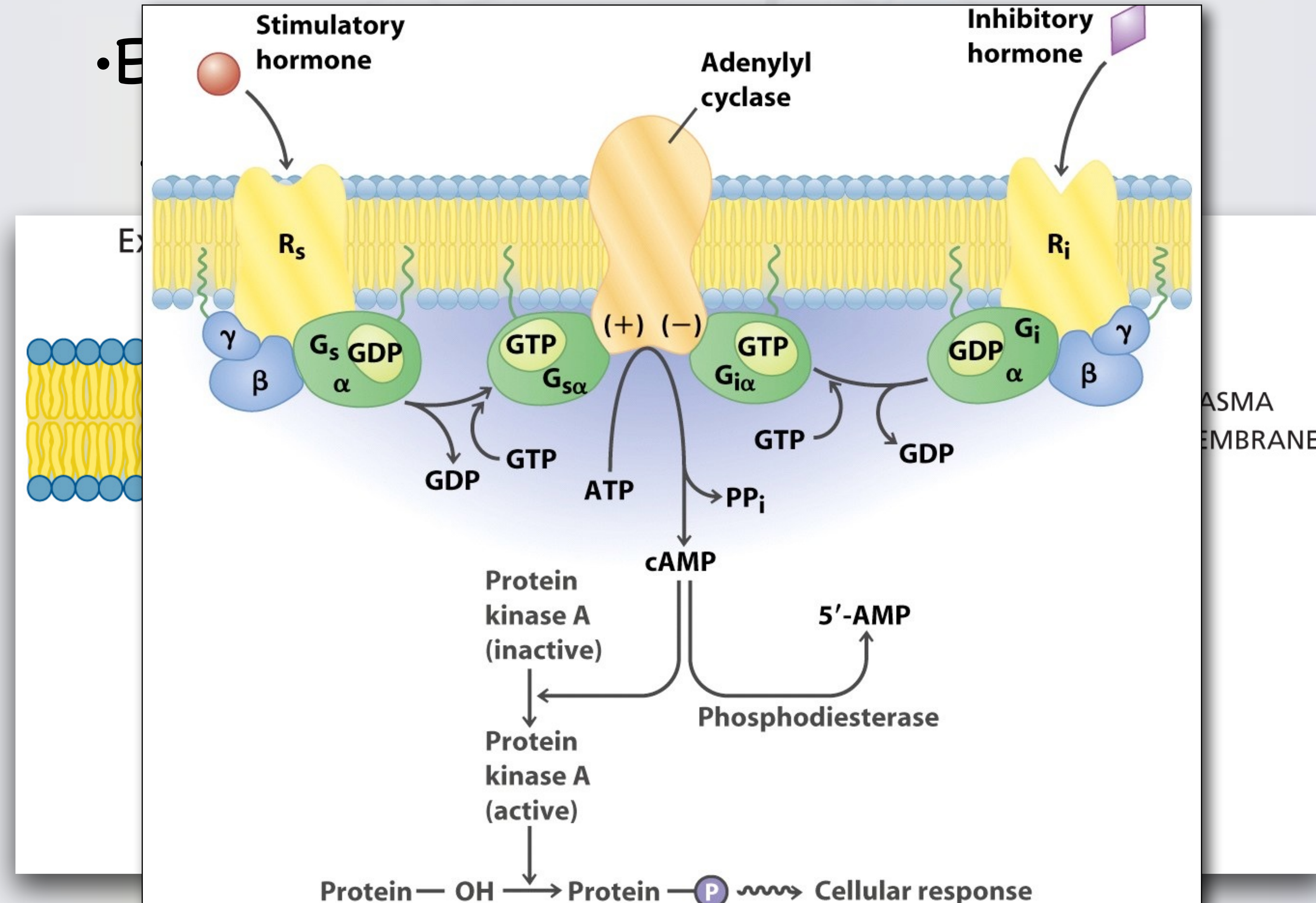

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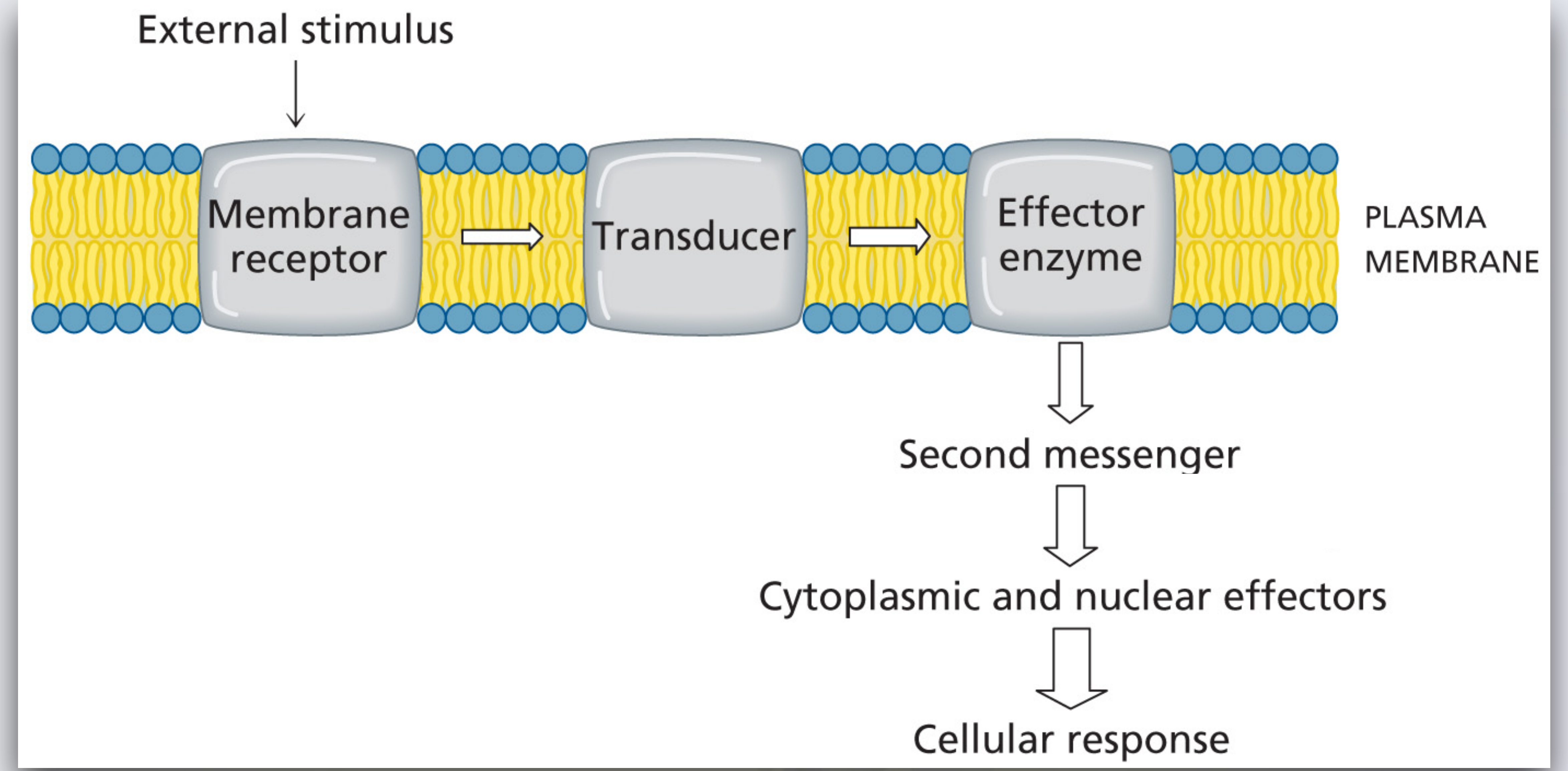

Transduction of Extracellular Signals

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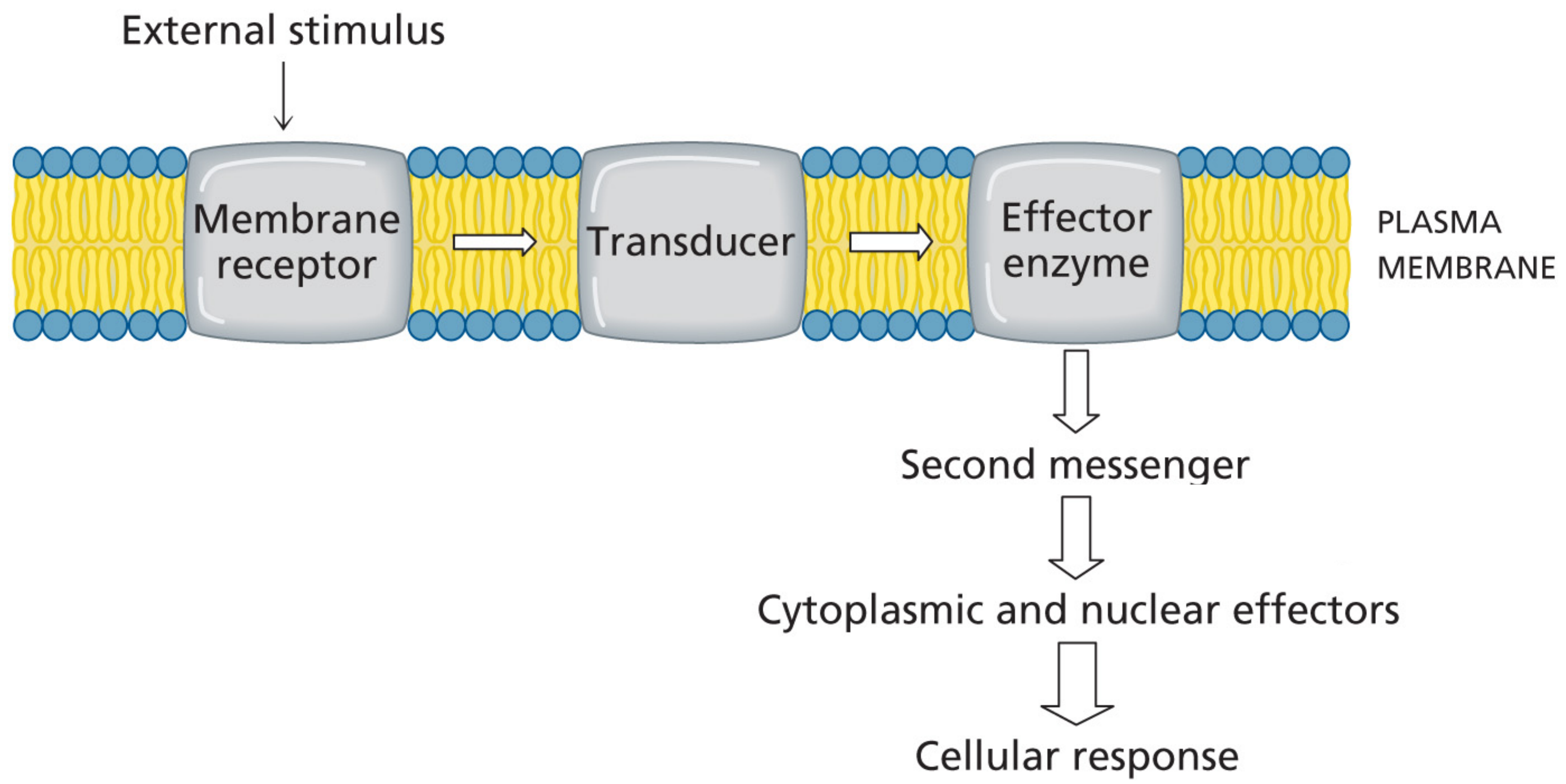

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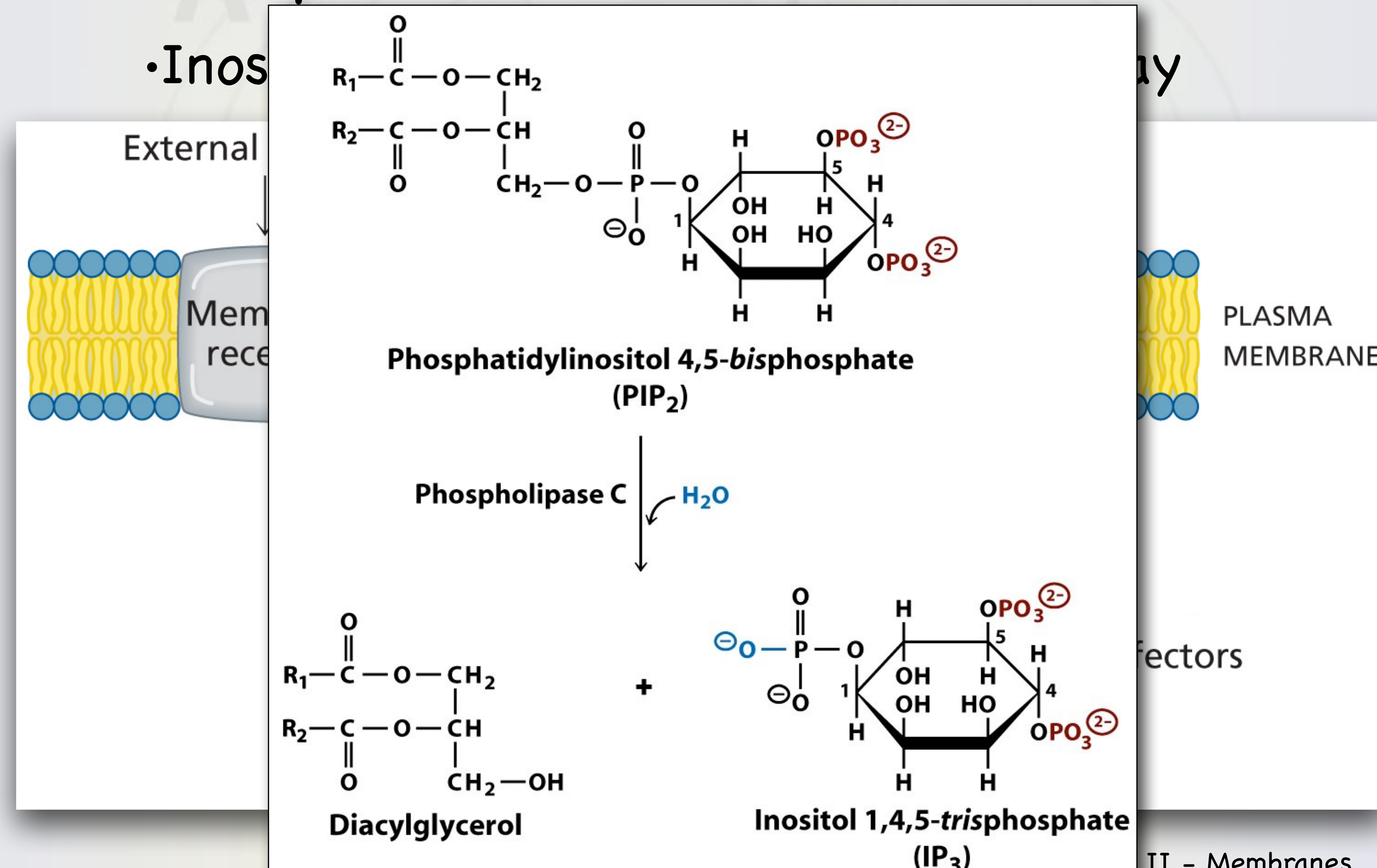
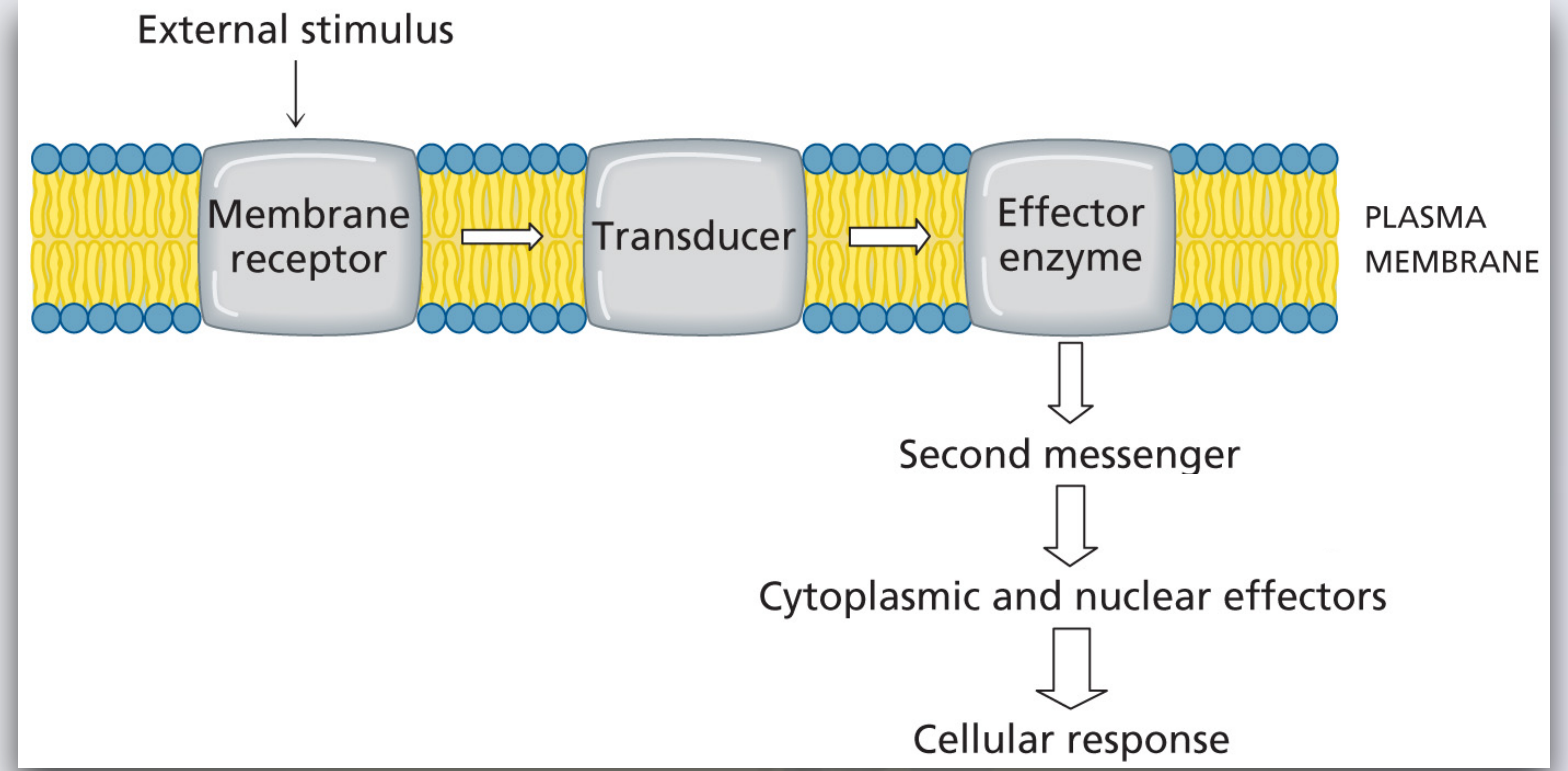
- Example - G-Proteins
  - Inos ay

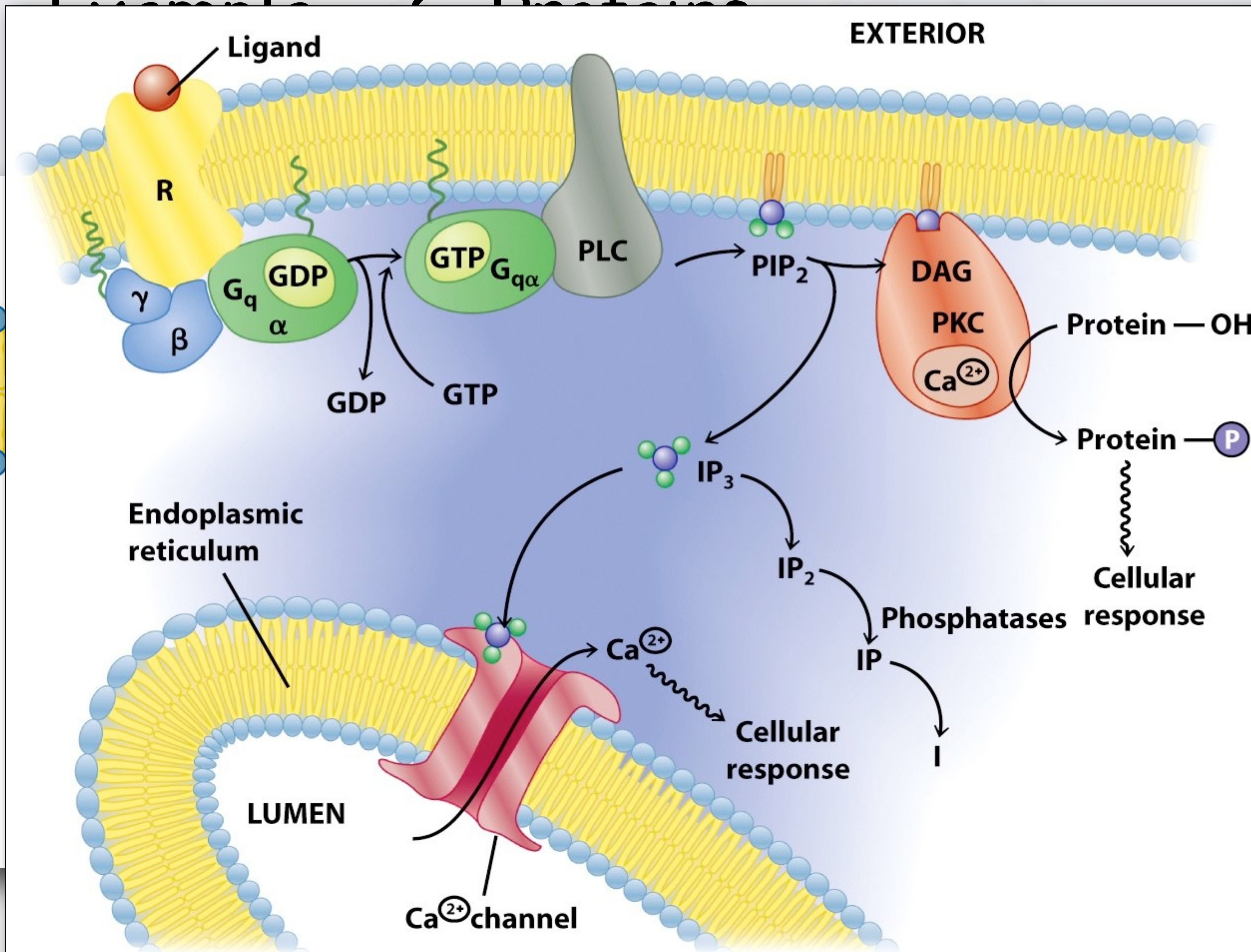


Transduction of Extracellular Signals

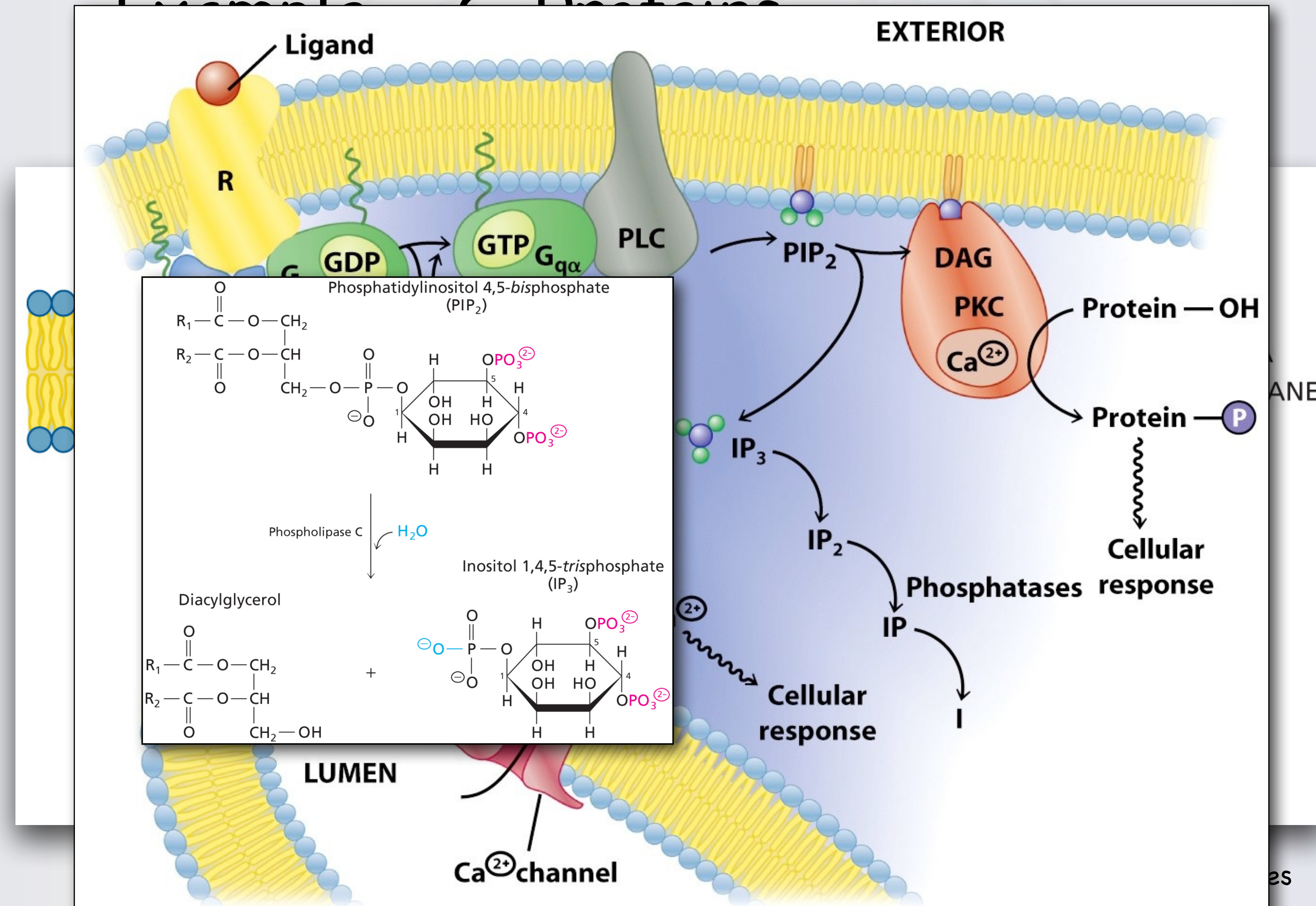
- Example - G-Proteins
  - Inositol-phospholipid signalling pathway



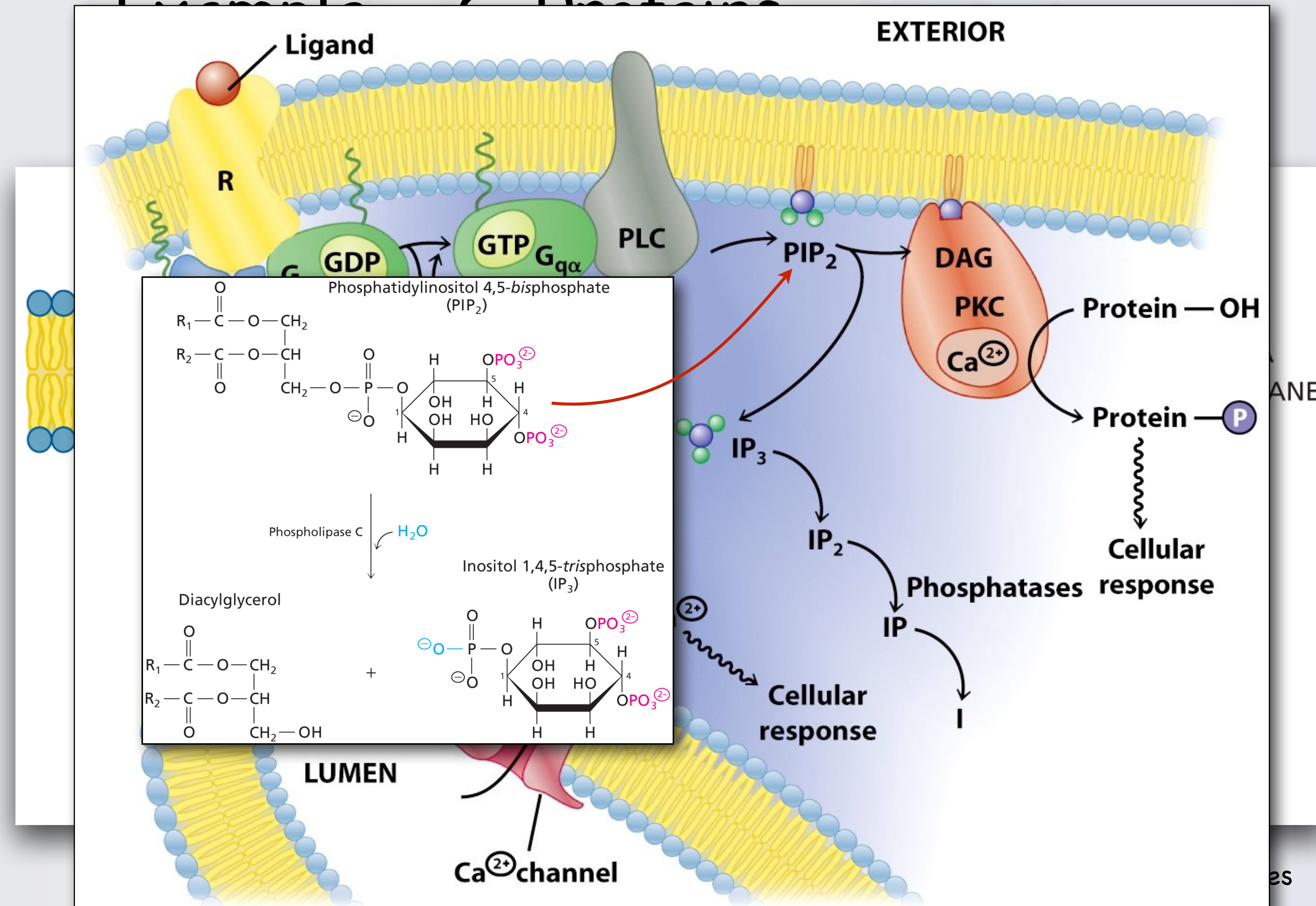
Transduction of Extracellular Signals



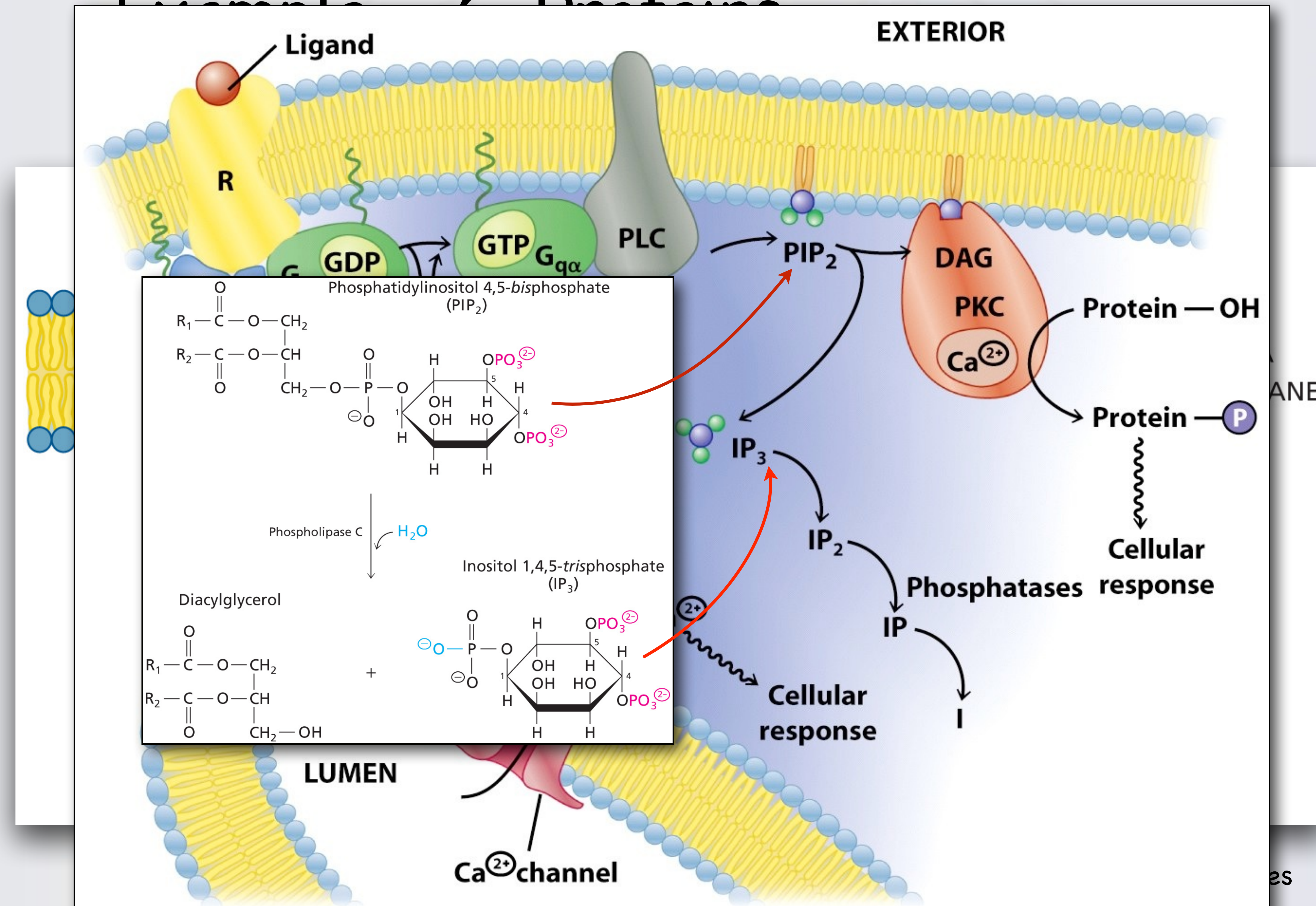
Transduction of Extracellular Signals



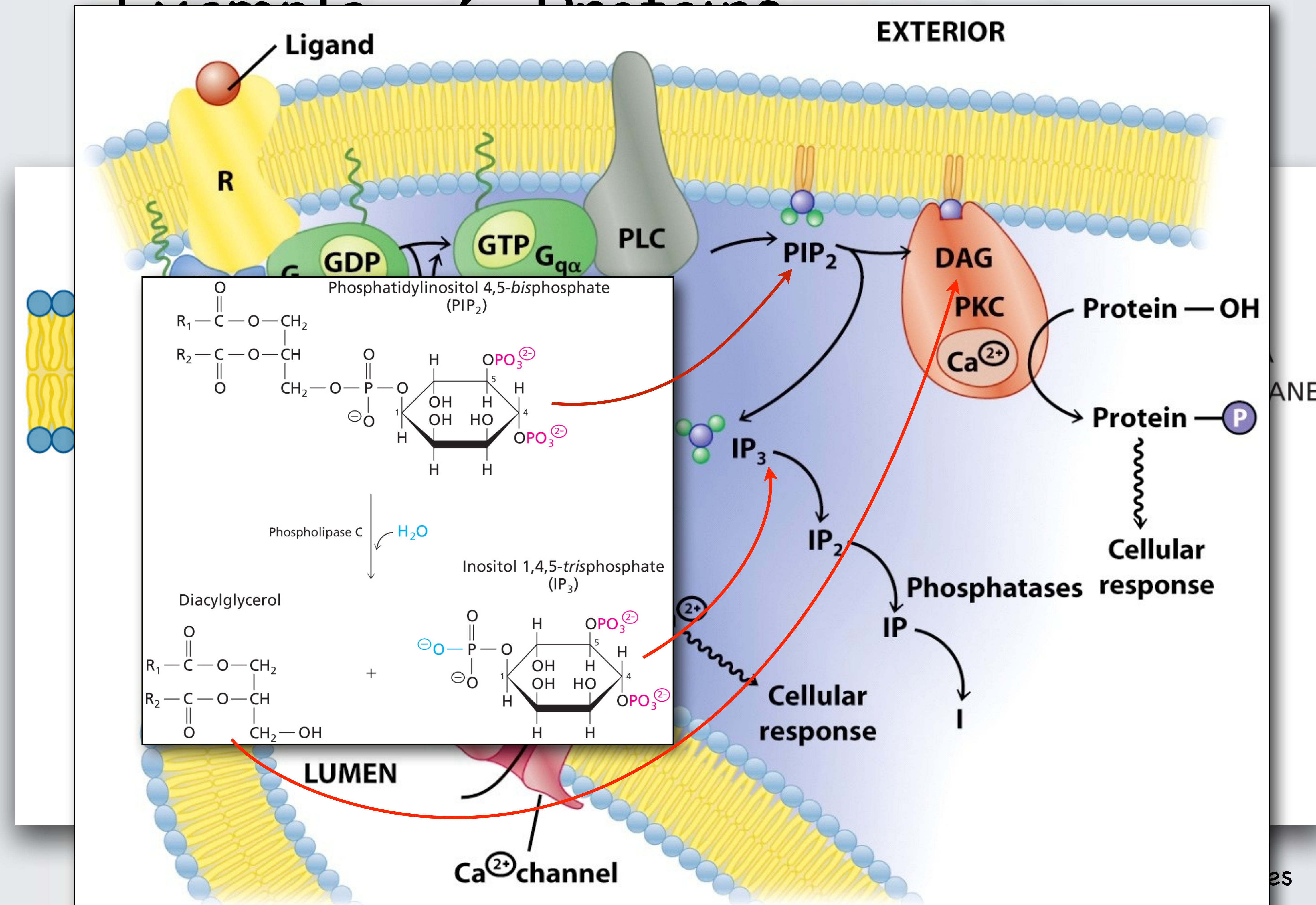
Transduction of Extracellular Signals



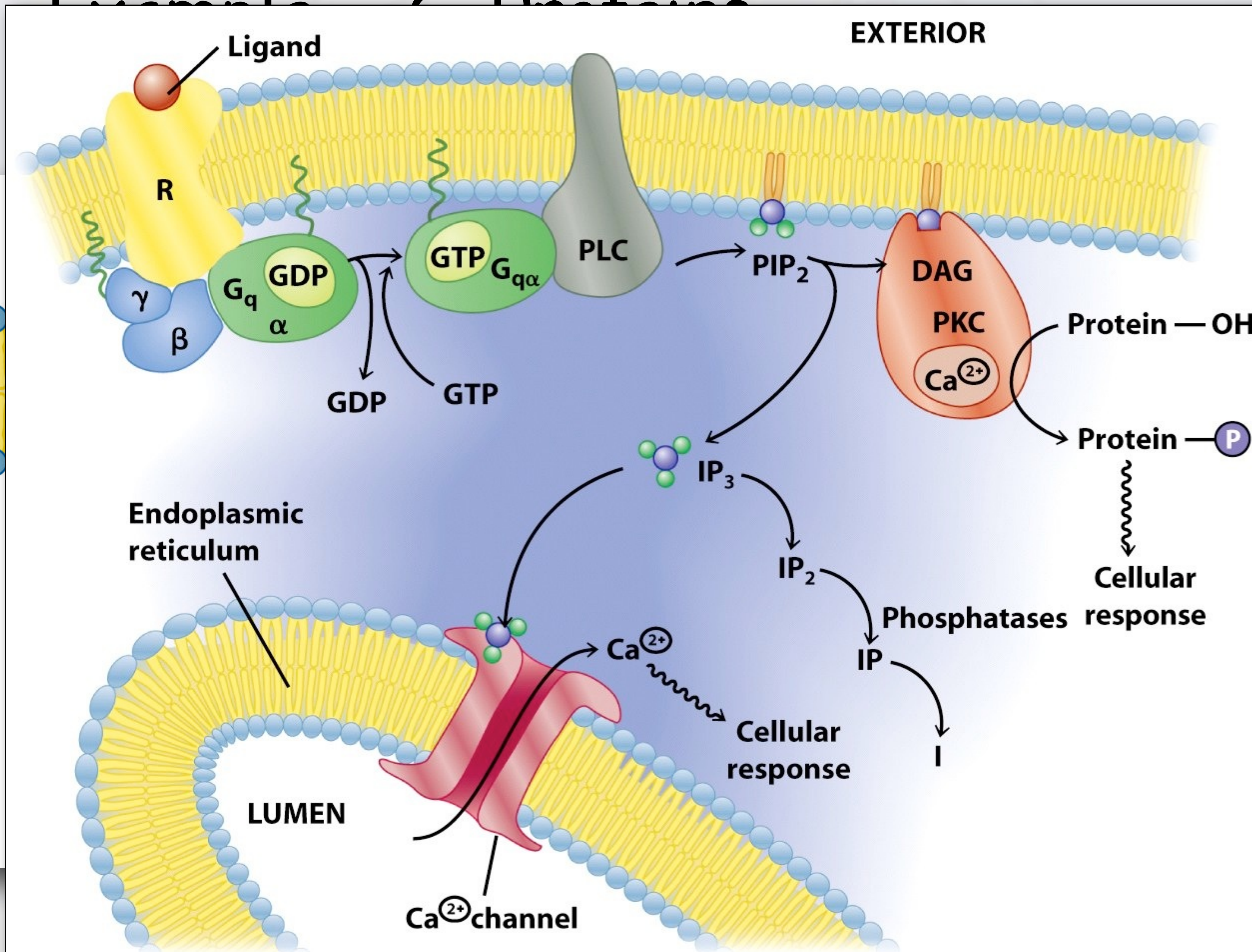
Transduction of Extracellular Signals



Transduction of Extracellular Signals

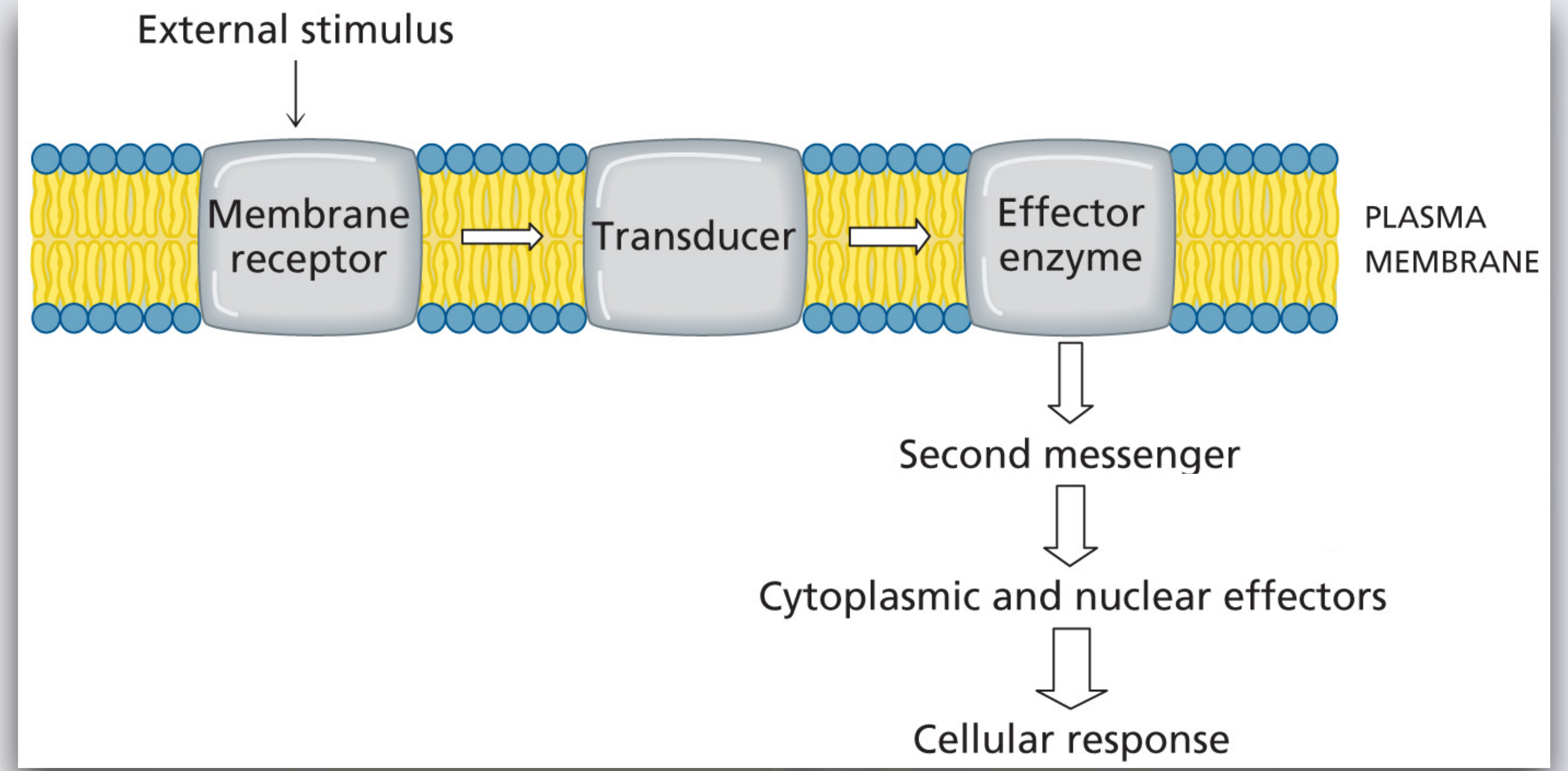


Transduction of Extracellular Signals



Transduction of Extracellular Signals

- Example - G-Proteins
  - Inositol-phospholipid signalling pathway



Next Up

- Lecture 7: Introduction to Metabolism (Chapter 10)
- Exam II on 3. April, 2018
  - Over Lectures 4-6