Cell communication

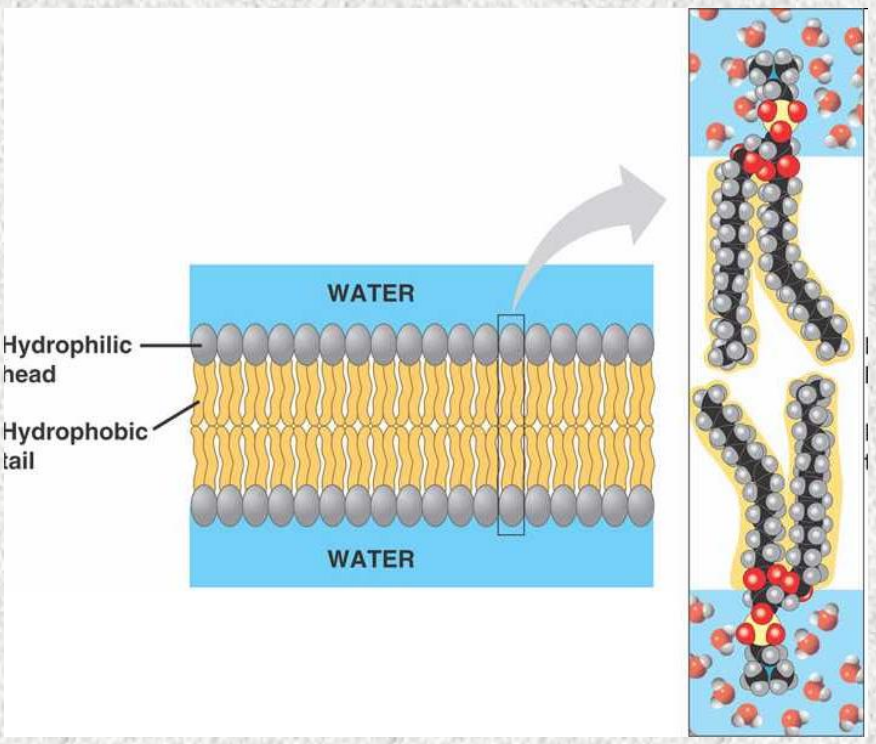
Premedical Biology

Plasma membrane

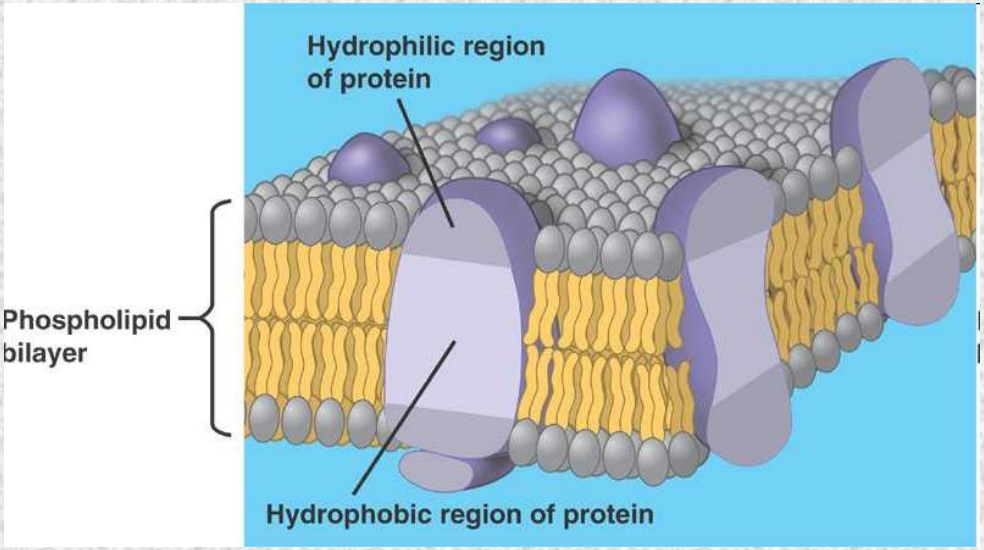
- half-fluid mosaic of lipids and proteins, it consists of double layer of phospholipids and proteins (embedded or attached)
- controls traffic inward and outward the cell
- **is selectively permeable**, it allows sufficient passage of oxygen and nutrients, and elimination of wastes

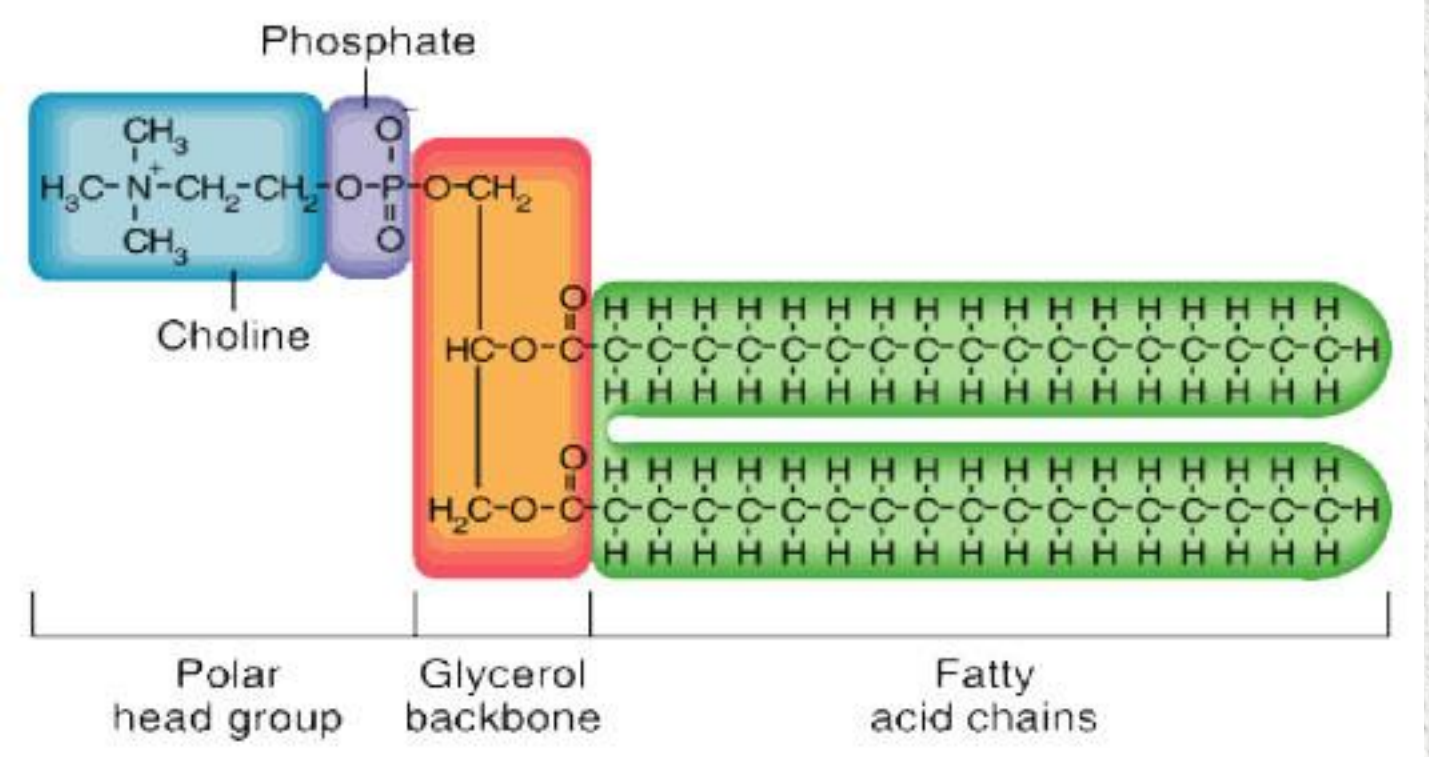
Lipids and proteins

Phospholipids are **amphipatic** molecules

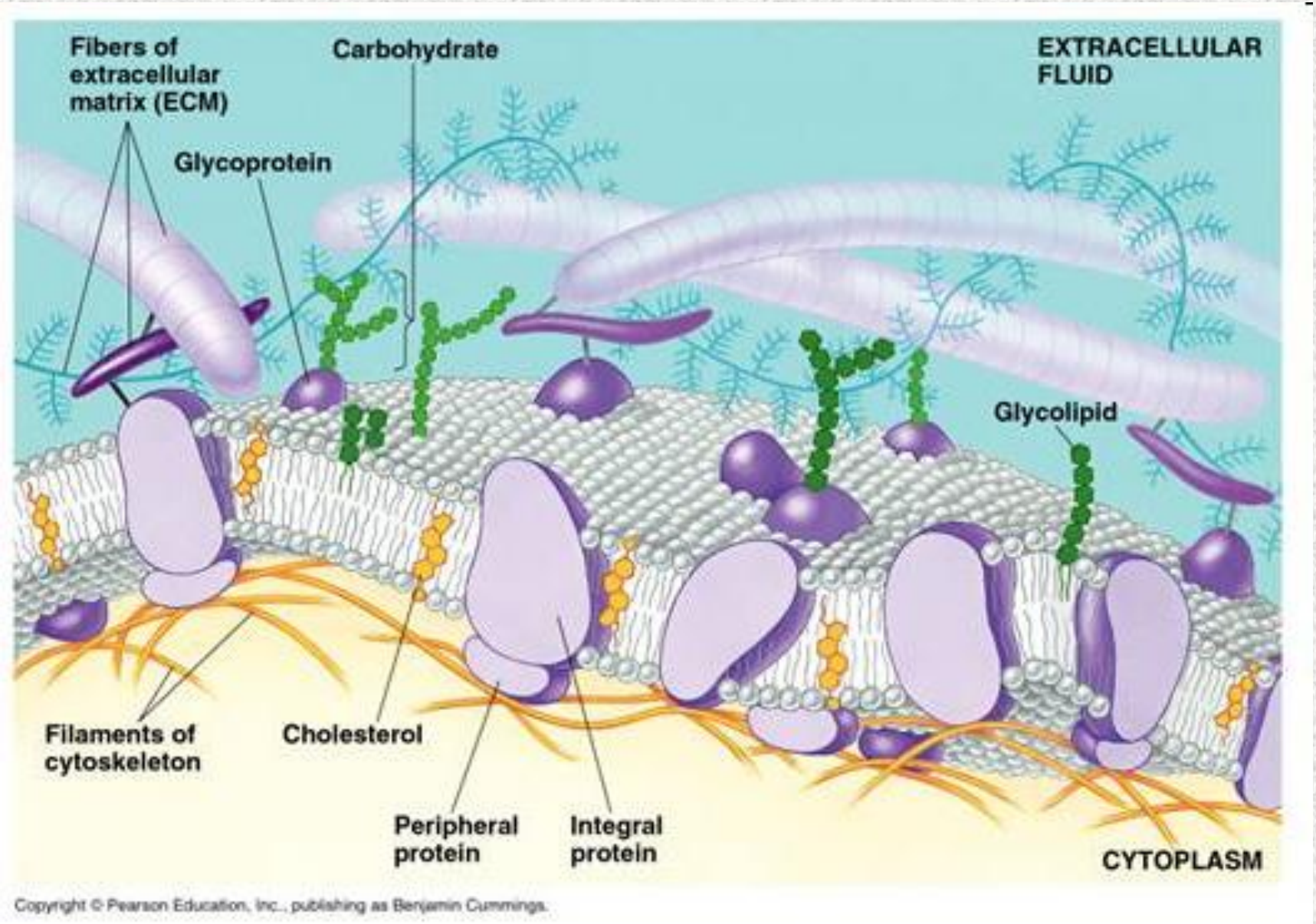


Proteins are embeded or attached to surface.





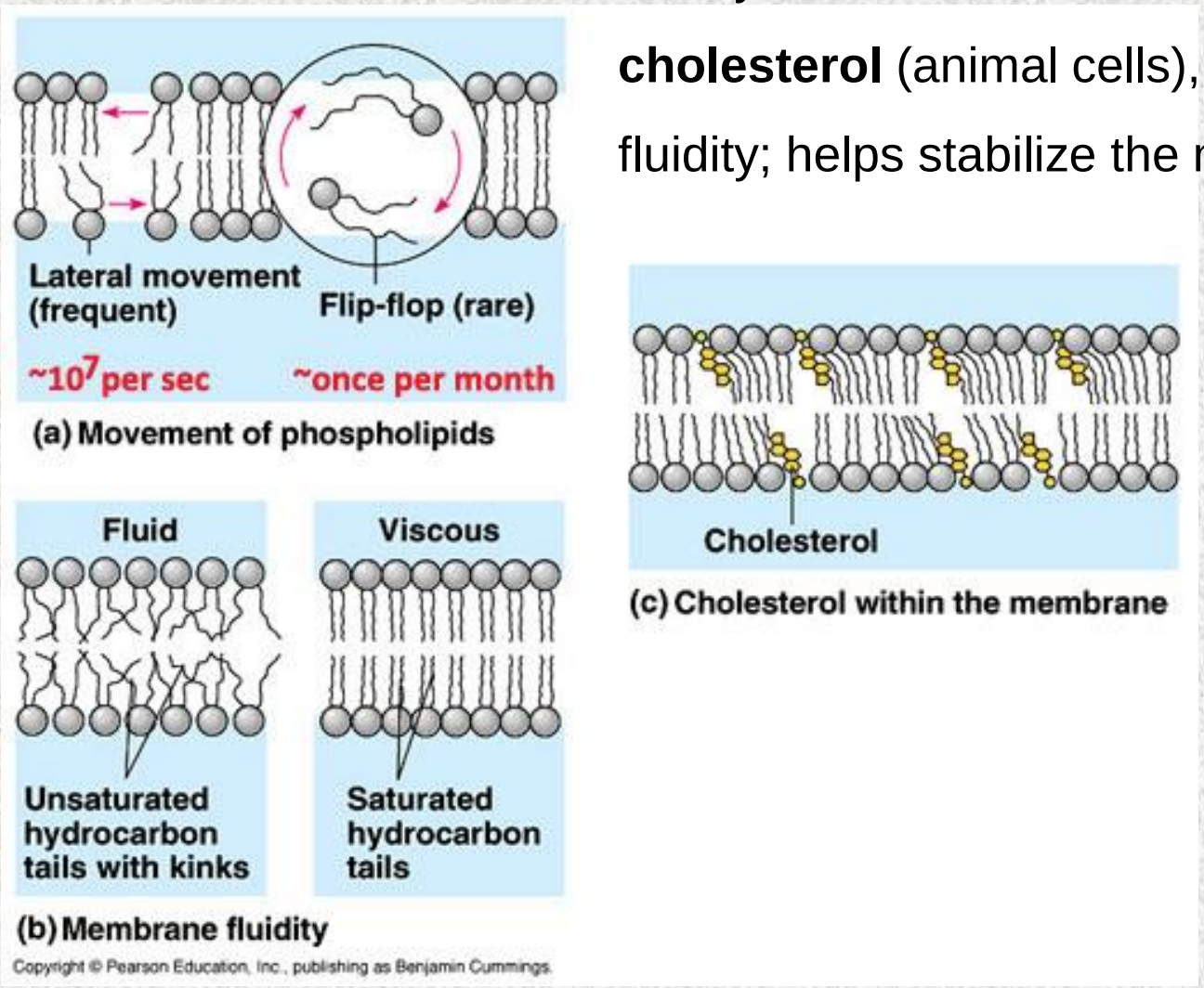
Fosfolipid: hydrofilic hydrofobic regions



Proteoglycan: glycoaminoglycans bound to protein chains in covalent complexes; found in extracellular matrix of connective tissue.

The fluidity

Is due to the presence of **unsaturated hydrocarbons, which** increase fluidity and **cholesterol** (animal cells), which reduces fluidity; helps stabilize the membrane

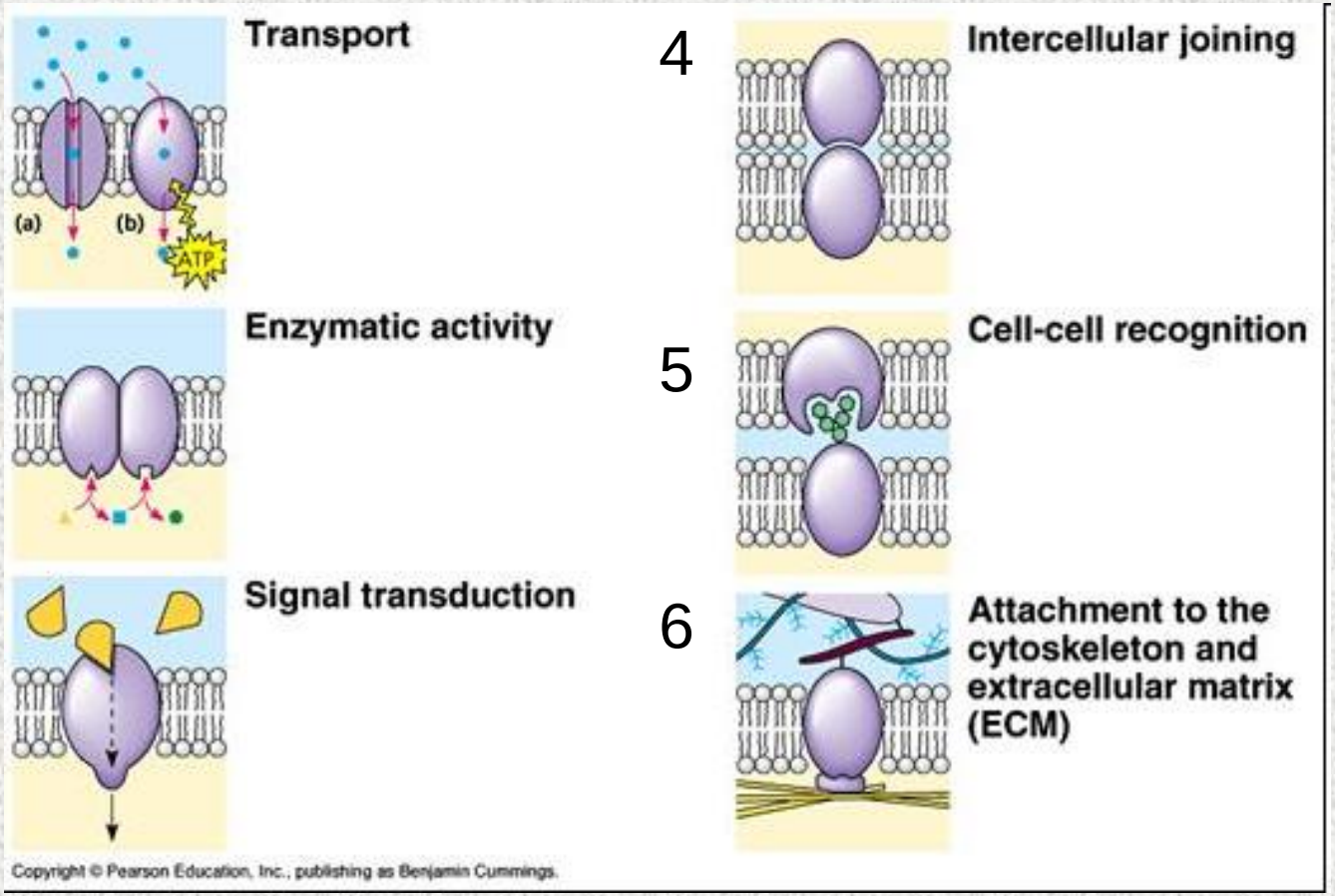


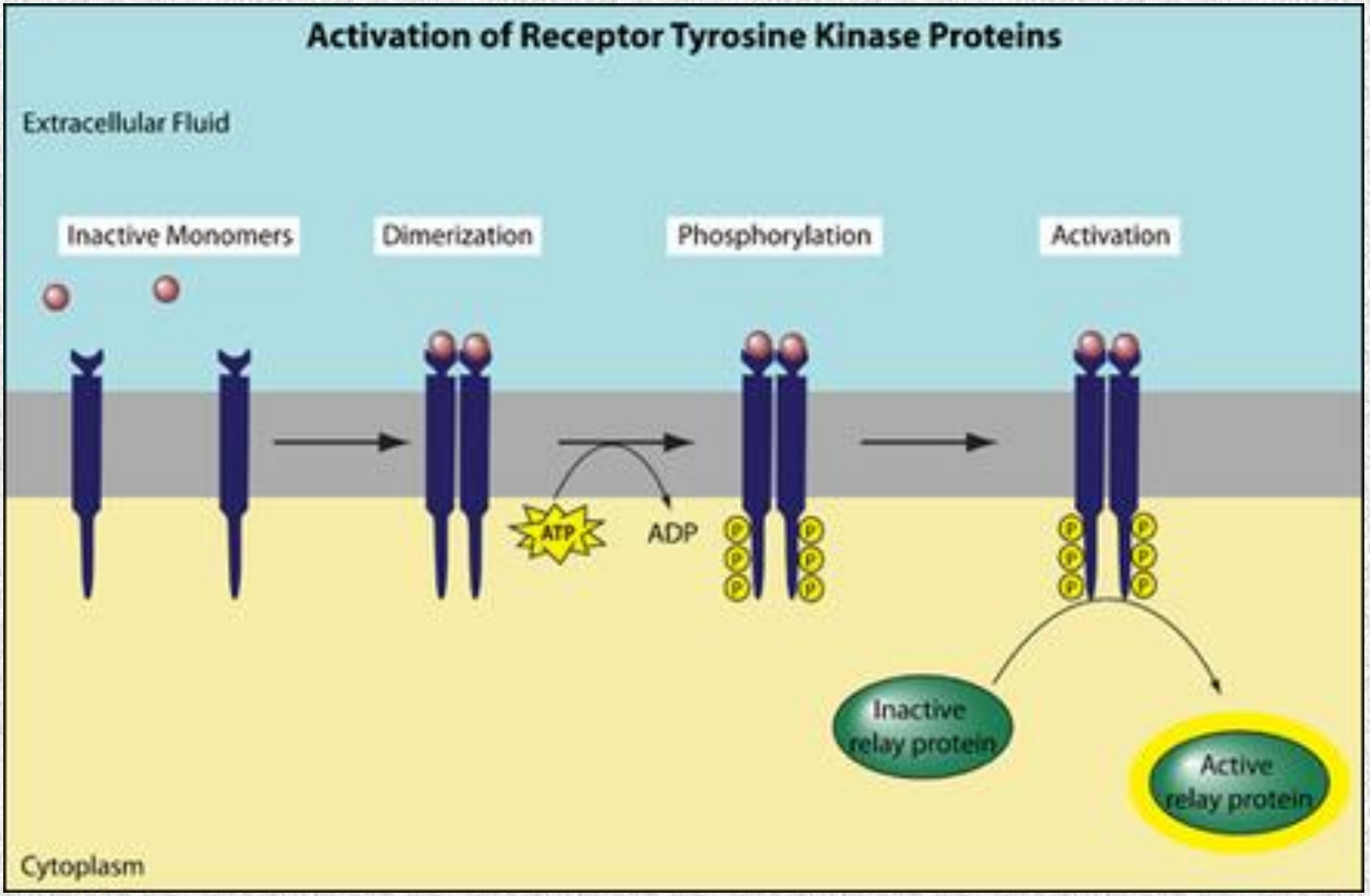
Proteins in membrane

determine many of the membrane‘s specific functions

Integral proteins – transmembrane proteins

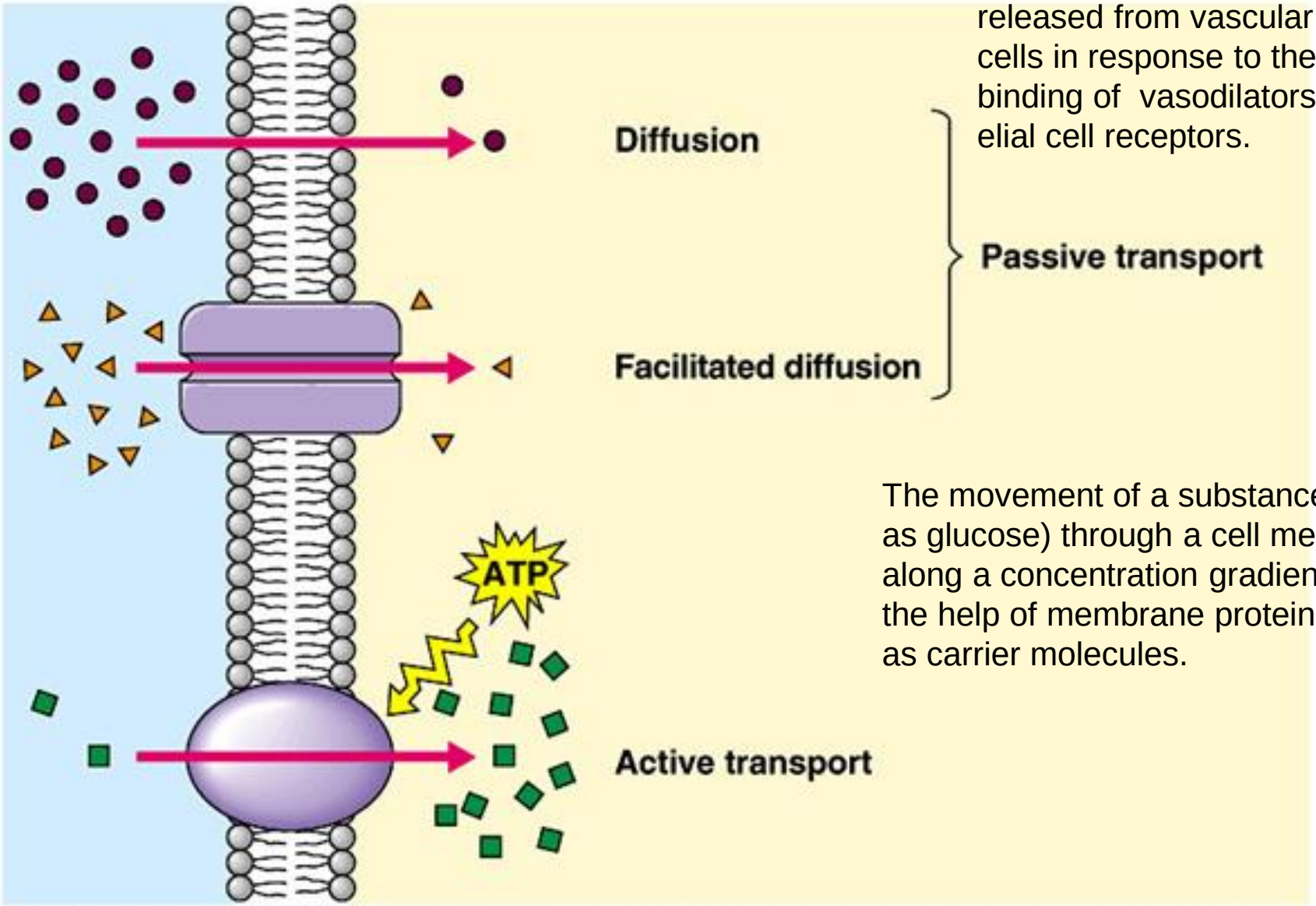
Peripheral proteins – are not embeded in the lipid bilayer




Activation of Receptor Tyrosine Kinase Proteins
Extracellular Fluid
Inactive Monomers
Dimerization
Phosphorylation
Activation
ATP
ADP
Inactive relay protein
Active relay protein
Cytoplasm

Ad 1. Transport summary

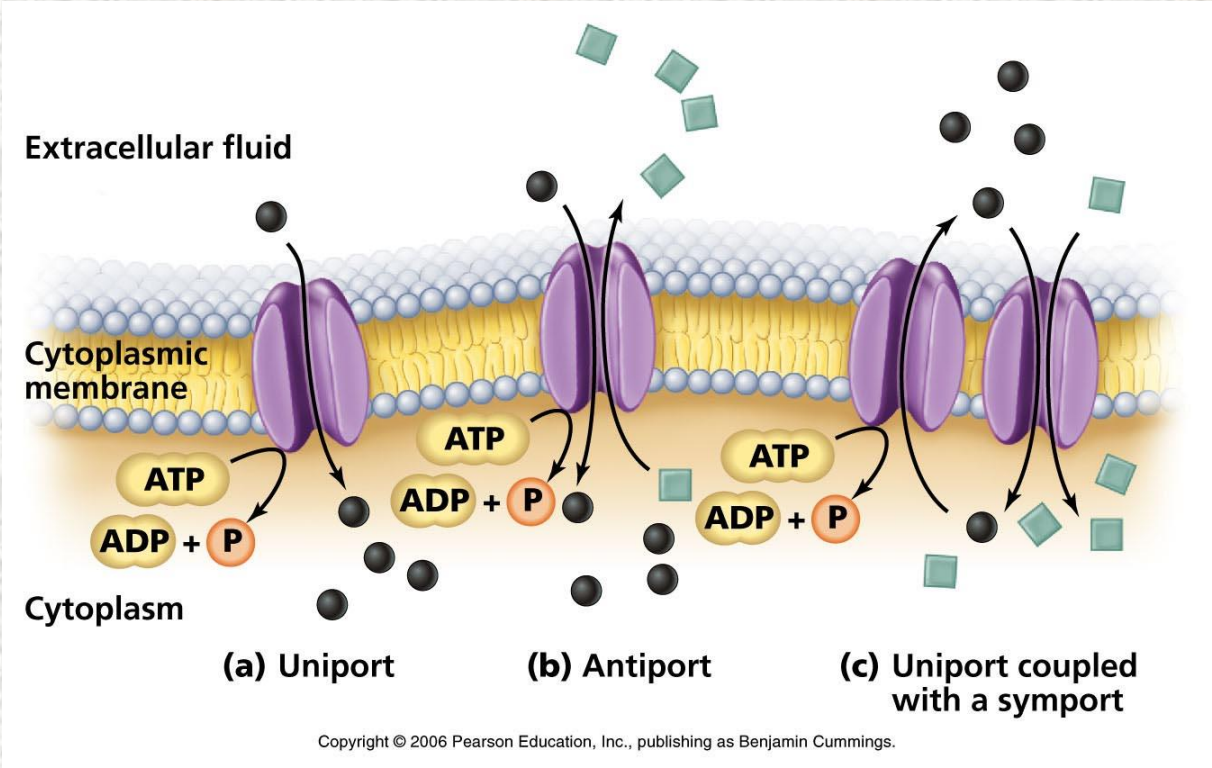
NO, nitrogen oxide
a naturally occurring gas that in t he body is a short-lived dilator released from vascular epithelial cells in response to the binding of vasodilators to endoth elial cell receptors.



The movement of a substance (such as glucose) through a cell membrane along a concentration gradient with the help of membrane proteins acting as carrier molecules.

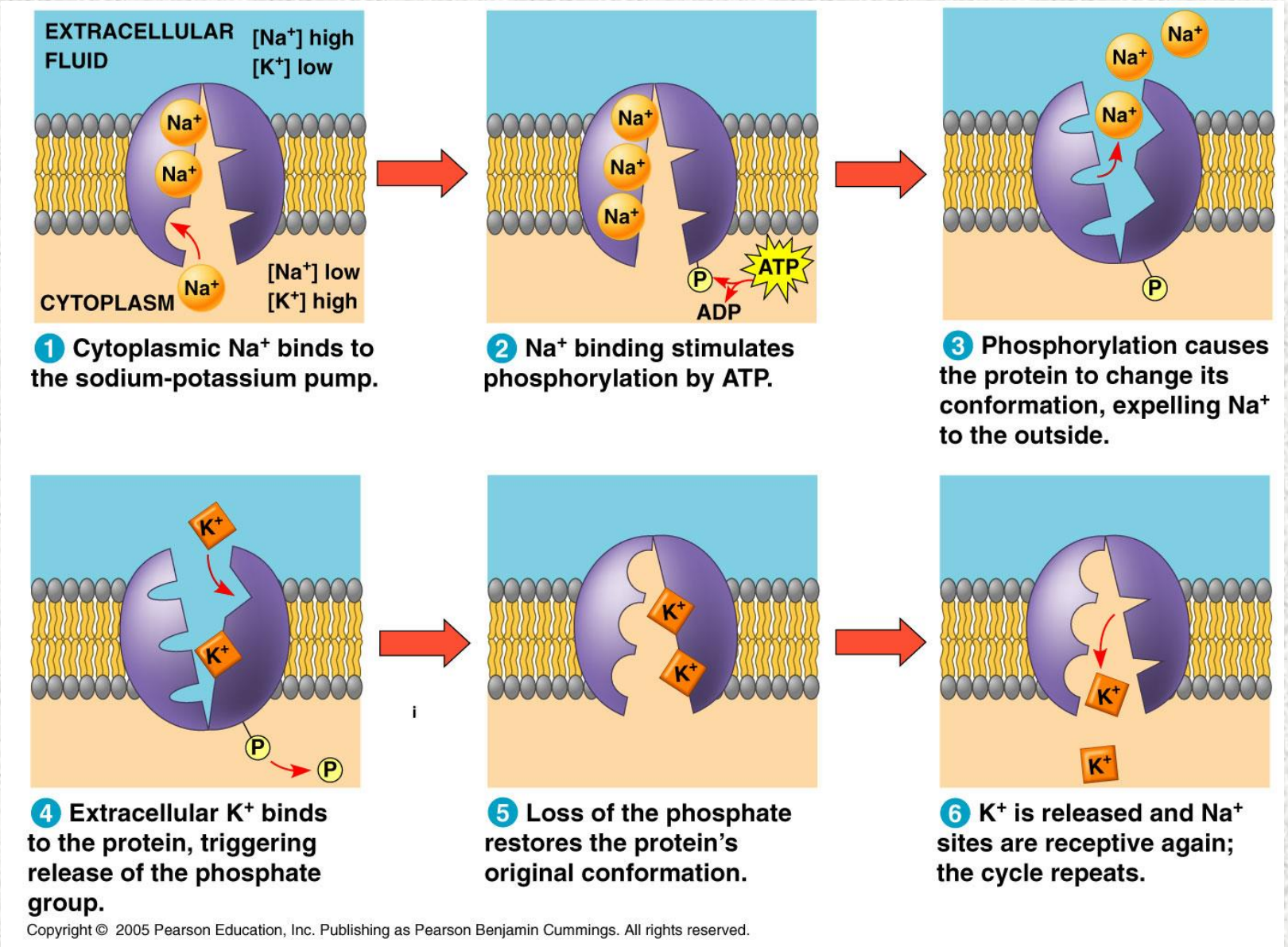
Active transport is the pumping of solutes against concentration gradients = „uphill“

It is the major mechanism of an ability of cell to maintain internal concentrations of small molecules that differ from concentrations in environment.



Animal cells-sodium-potassium pump - three out, and two in. It is coupled transport of two molecules.

Animal cells-sodium-potassium pump



Potassium is intracellular, sodium is extracellular

Ad 4. Intracellular junctions (joining)

Cell walls of plant cells perforated with channels called plasmodesma**.**

In animals are **intracellular junctions**.

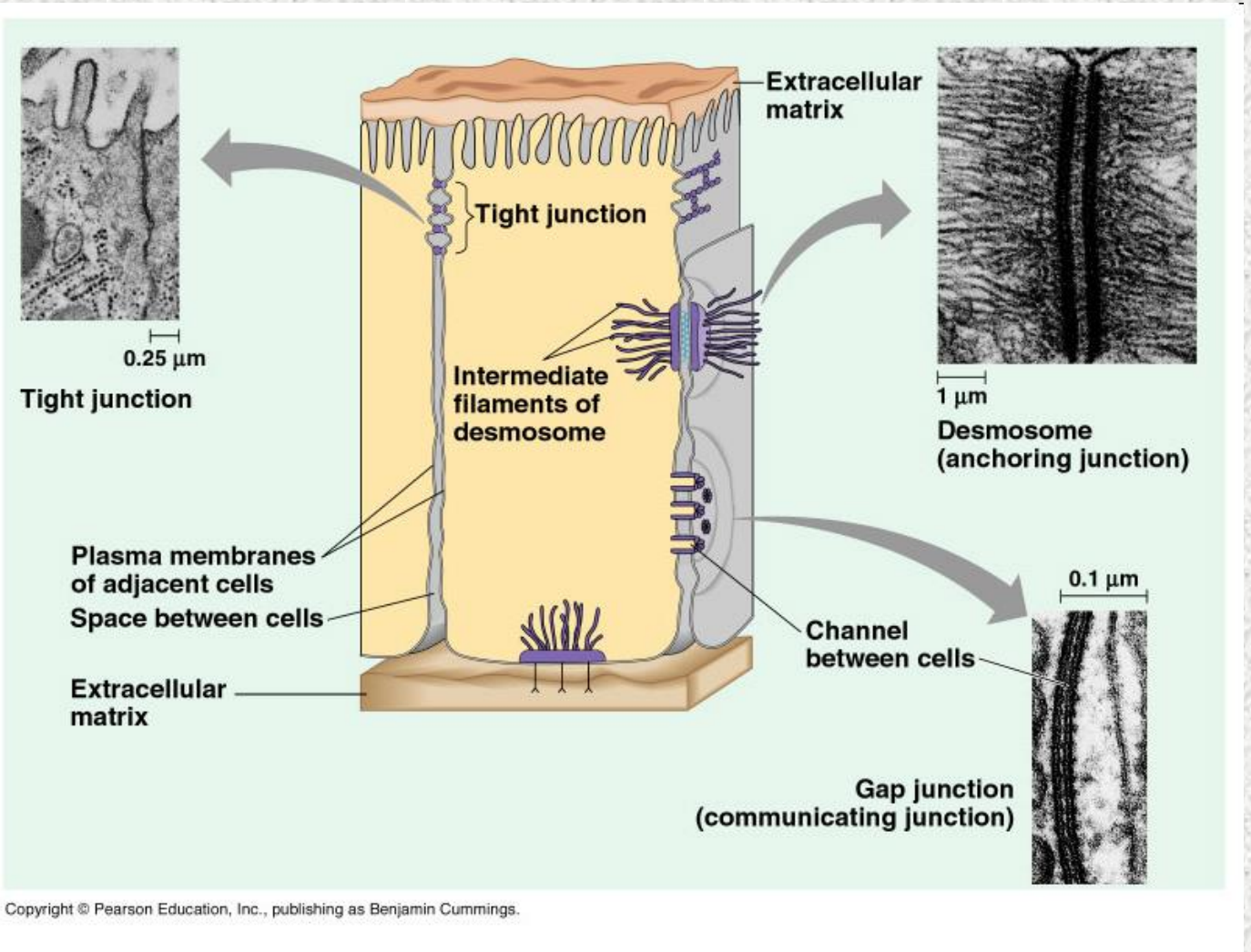
Tight junction

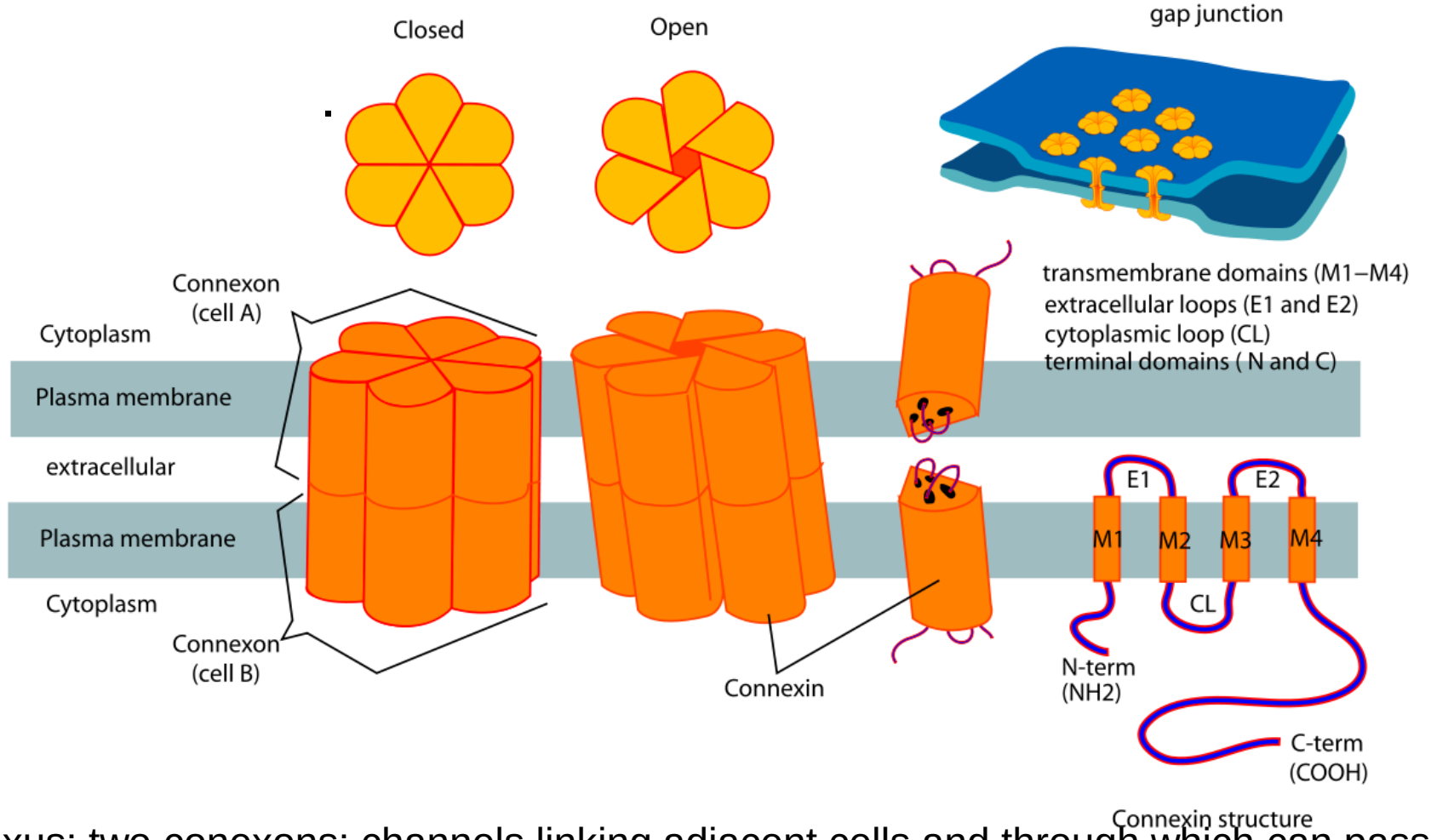
Desmosomes

Gap junctions

Adhere, interact

and communicate





Nexus: two conexons: channels linking adjacent cells and through which can pass ions, most sugars, amino acids, nucleotides, vitamins, hormones, and cyclic AMP. In electrically excitable tissues the gap junctions serve to transmit electrical impulses via ionic currents and are known as electronic synapses; they are present in such tissues as myocardial tissue

Ad 5. Cell-cell recognition

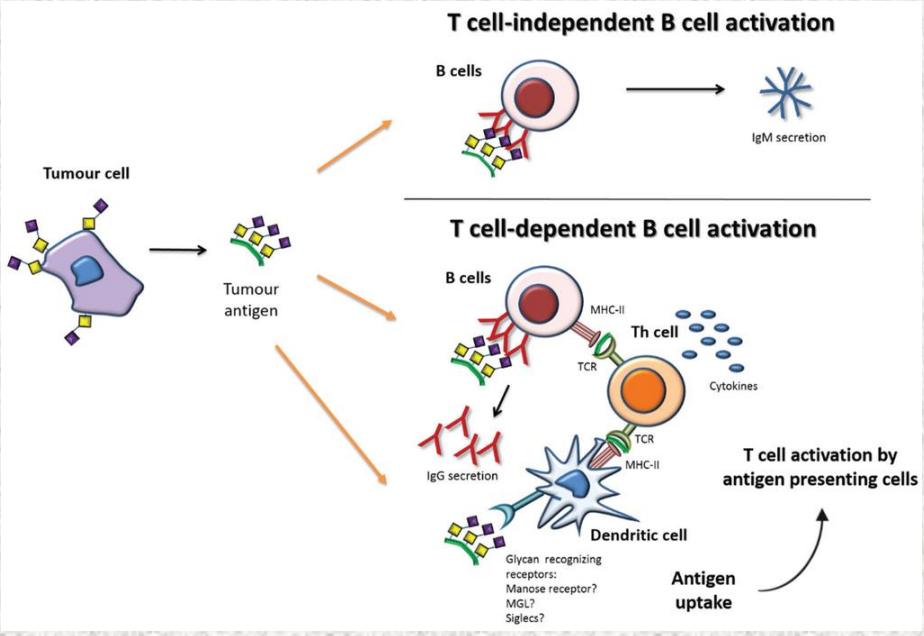
- **by carbohydrates** (linked to proteins and lipids),
- to sort cell into tissues and organs in embryo
- helps to recognize and reject the foreign cells in the immune system

Role:

sorting cell into tissues and organs in embryo

responsible for **cell** type specificity = antigenic **properties of cell** membranes.

recognition of microorganisms, transplanted tissue, or transfuse blood as foreign because their membrane glycoproteins contain different **carbohydrate** markers



Liliana R. Loureiro, Mylène A. Carrascal, Ana Barbas, José S. Ramalho, Carlos Novo , Philippe Delannoy and Paula A. Videira Challenges in Antibody Development against Tn and Sialyl-Tn Antigens, B*iomolecules* 2015, *5*(3), 1783-1809; doi:10.3390/biom5031783,

Ad 6. Attachment with ECM

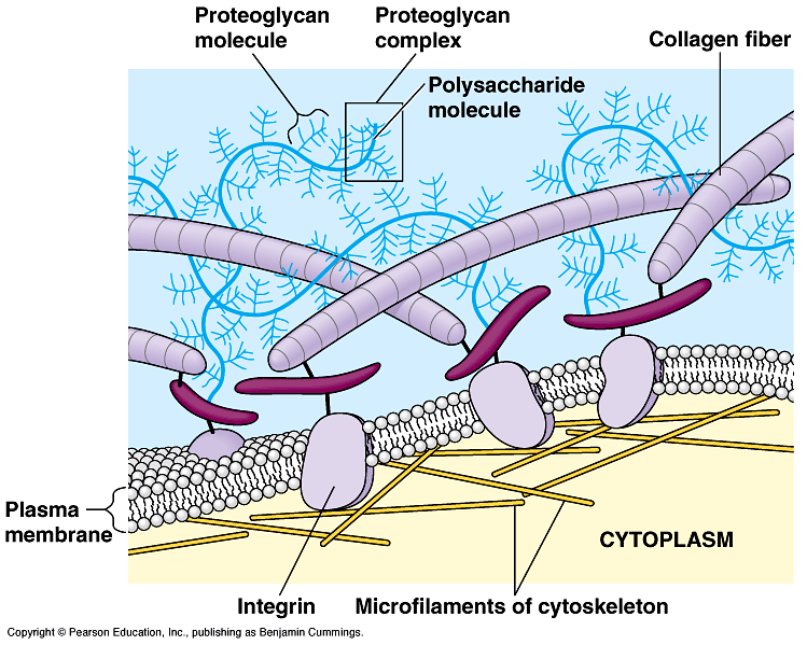
Plant cells (some Protists, prokaryotes, fungi) are encased by **cell walls**

Animal extracellular matrix – ECM with **glycoproteins:**

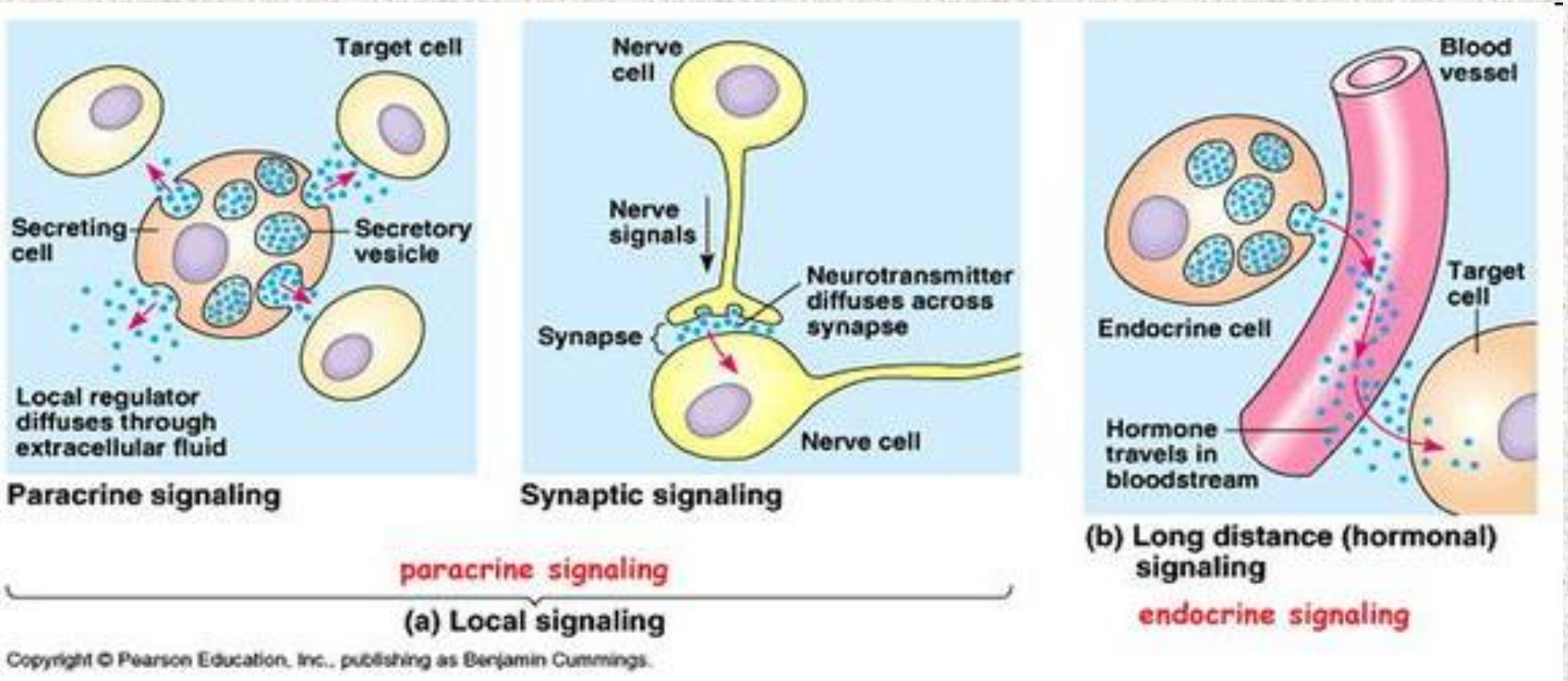
Collagen fibers are embedded in network of proteoglycans.

Fibronectins bind to receptor protein called **integrins** in plasma membrane. Integrins bind to microfilaments (cytoskeletal pr.) on cytoplasmatic side.

Role of ECM:structural and biochemical support to the surrounding cells, support of tissues and organs



Ad.3. Local and long-distance signaling



Ad 3. Signal transduction function of protein

Cell responds to external signals.

Signal molecule (ligand/first messenger) binds to **receptor** protein in membrane and causes **change of its shape, conformation**

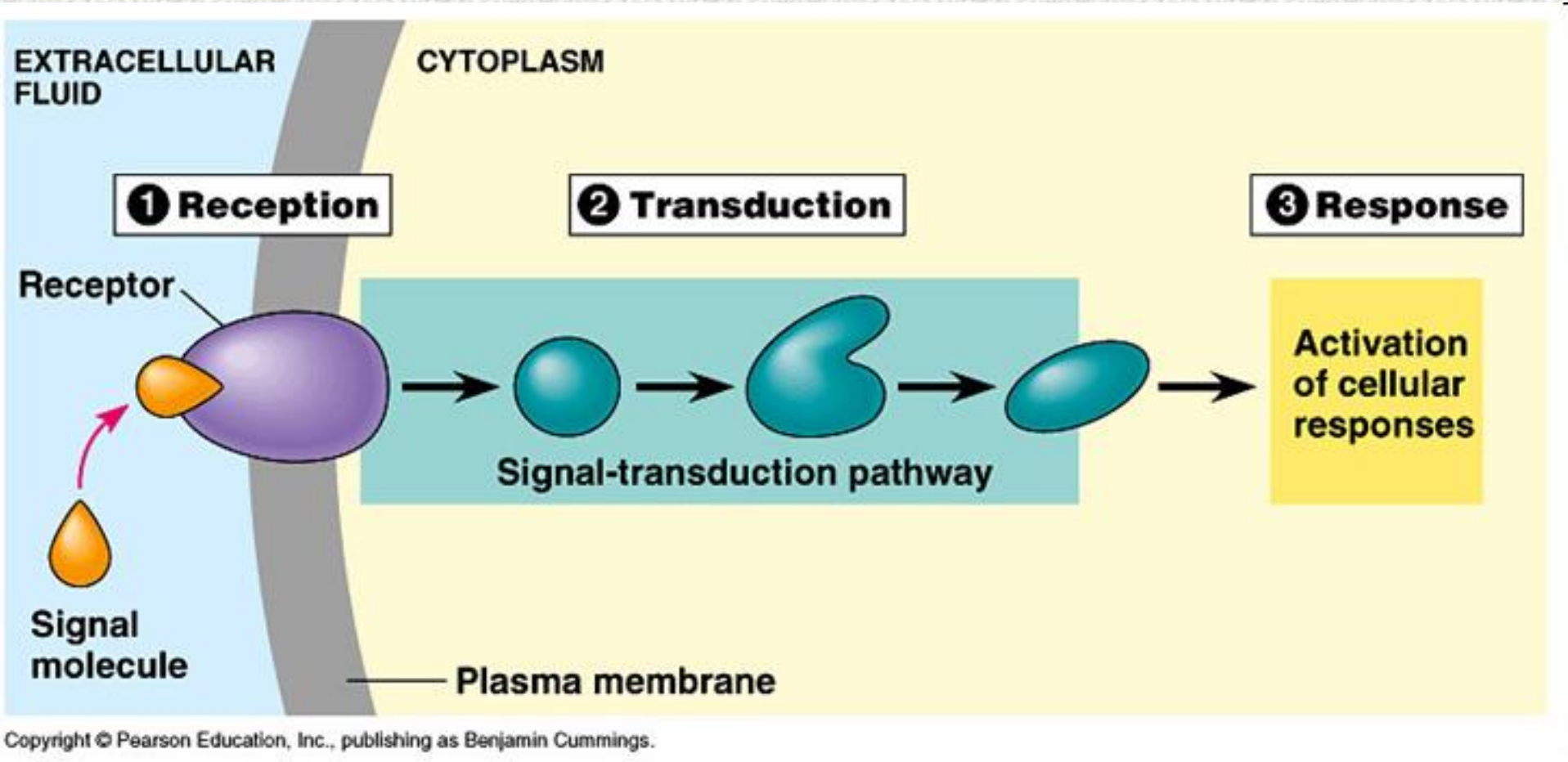
On internal side the signal is transformed into the **cascade of molecular interactions** (mediated by **second messengers**)

The signal leads to **regulation of transcriptio**n in nucleus or some **cytoplasmatic activities**.

Cell signaling - stages

1. **Reception**: target cell detects a signaling molecule coming from outside
2. **Transduction:** change of the receptor protein, initiating process of cellular response
3. **Response:** cellular activity: catalysis, rearrangement of the cytoskeleton, activation of genes…

Cell signaling - stages



Ad 1. cell signaling - reception

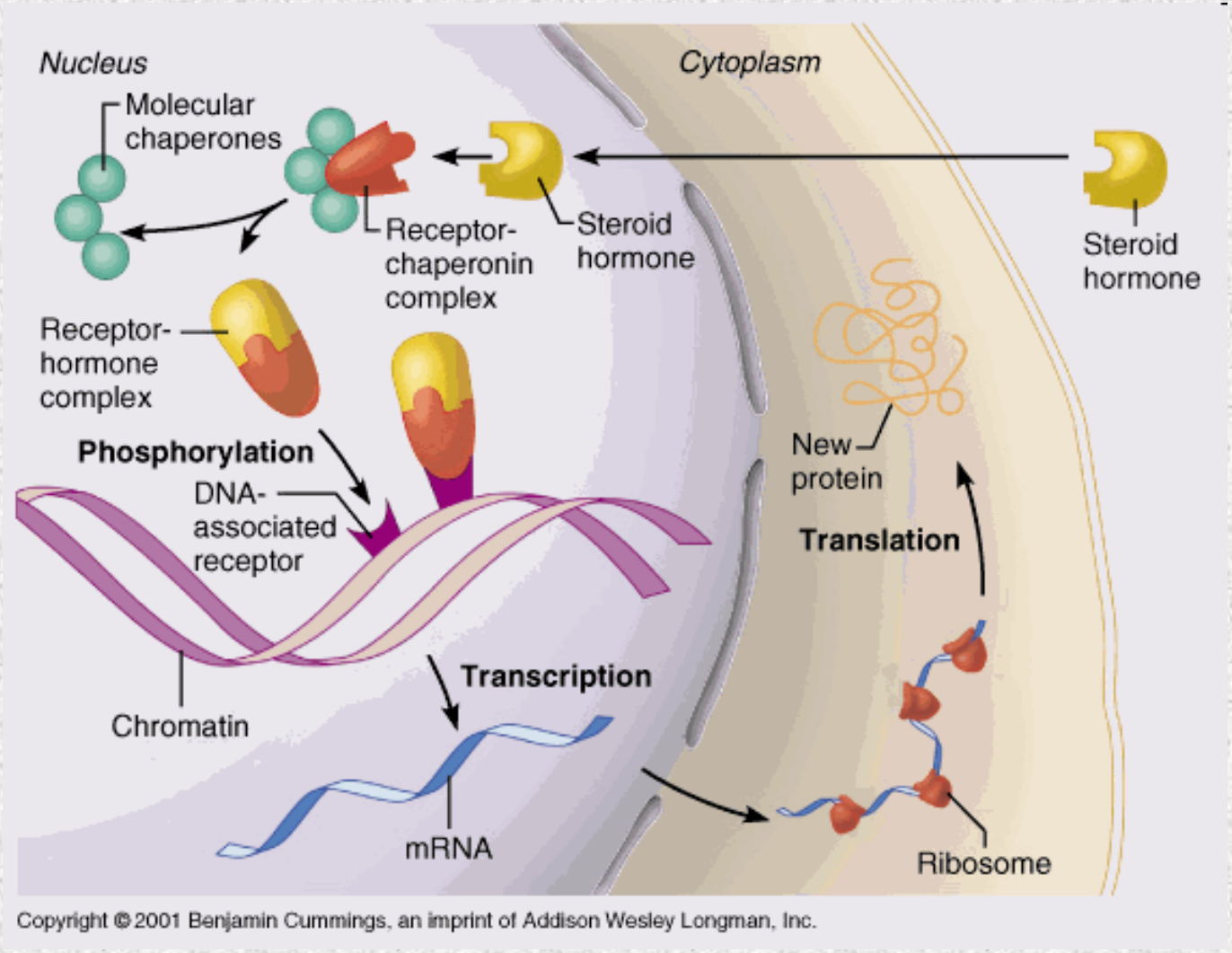
Signaling molecule + receptor

Receptor or protein associated with receptor gets activated and is able to transfer the signal into the cell.

Four systems (and more):

- **G protein associated to receptors** – on/off
- **Tyrosine kinase receptors** have enzymatic activity and catalyze transfer of phosphate groups
- **Ion channel receptors** - gate is open or closed

- **Intracellular receptors** for steroid and thyroid hormones, nitric oxide



Ad 2.cell signaling - transduction

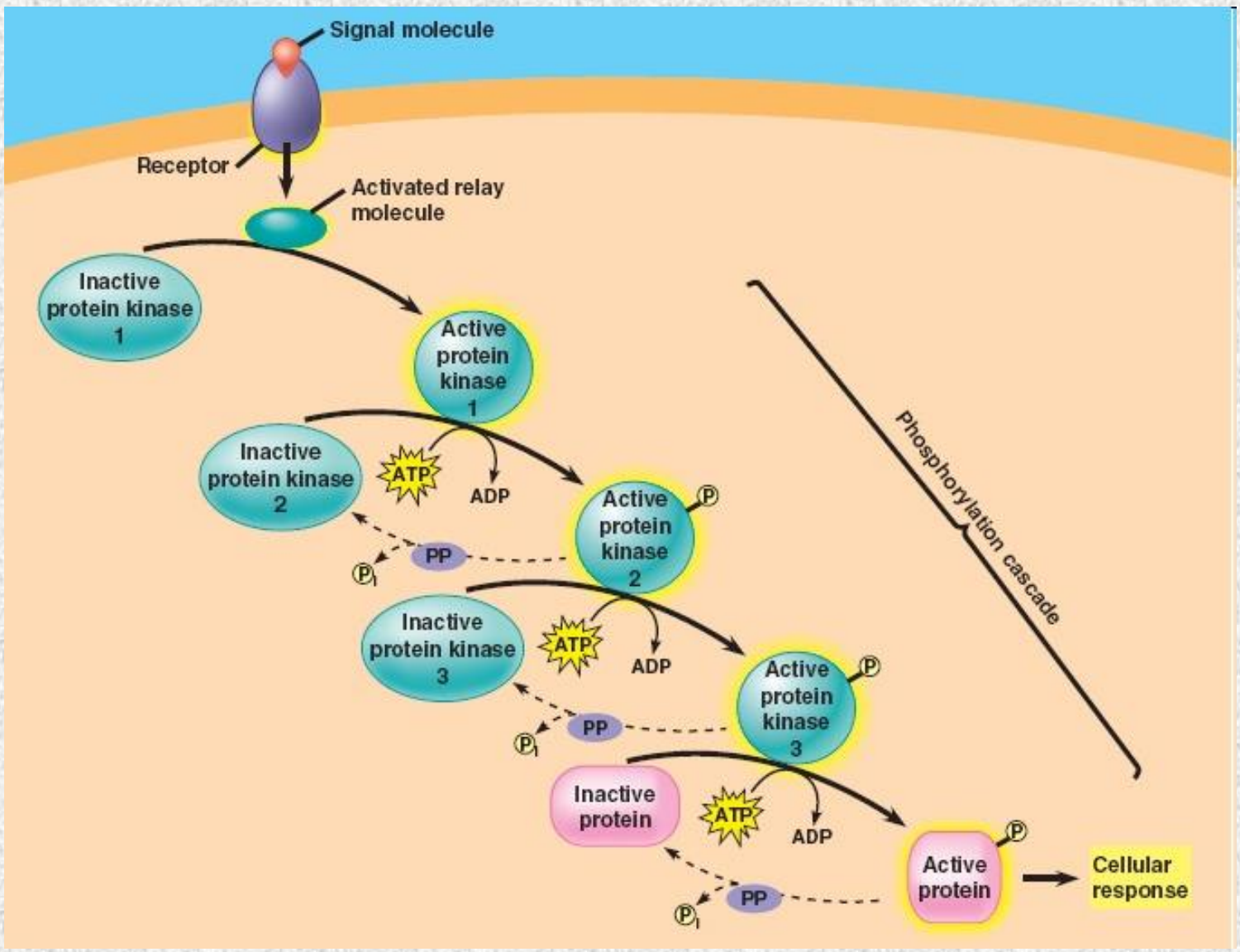
Multistep cascade of **activation** of proteins by **addition** or **removal** of phosphate groups

It starts by formation of **small molecules** or **ions** that act as **second messengers**.

Phosphorylation and dephosphorylation of proteins acts as molecular switch.

Protein kinases transfer phosphate groups from ATP to protein.

A phosphorylation cascade



The signal is **greatly amplified in each step of** cascade of transduction stage.

The number of activated products is much higher than the number of last product in the step before.

Multiple steps also provide different points, at which the response can be regulated and also provide a specificity of cell signaling and coordination.

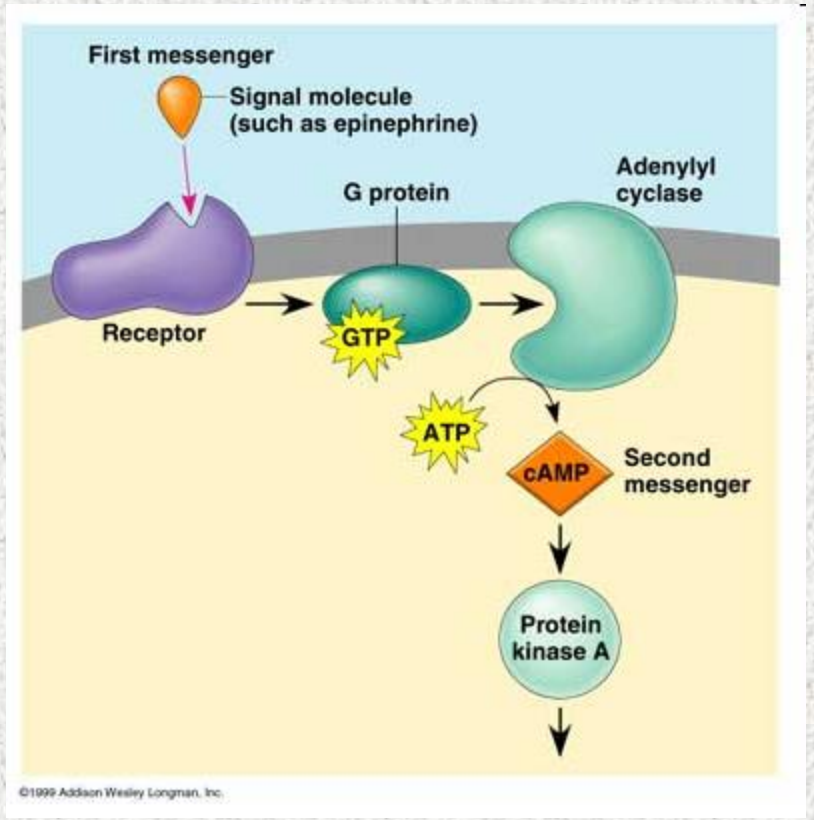
Second messengers

= **non-protein** molecules inside cells that transmit signals from a receptor to a target and can be distributed by diffusion

e.g. **cAMP and calcium ions = second messengers**

cAMP

first messenger (hormone) activates G-protein coupled **receptor** – it activates **G protein.** G protein activate **enzyme** which converts **ATP to cAMP** = **second messenger** which activates another protein – **kinase**



Second messengers: calcium ions

Neurotransmitters, growth factors, hormones induce cell‘s response via signal transduction pathways that increase the concentration of calcium ions.

Responses: muscle contraction, secretion of substances, cell division

Second messengers:

inositol triphosphate and diacylglycerol

Ad 3. Responses:

End of the pathway may occur in the nucleus or in the cytoplasm = change of gene transcription or cytoplasmic activities.

Nuclear response = **regulation** of gene activity **–** by **transcription factors** (= final activated molecule)

Cellular activity: regulation of protein activity

change in metabolism, activation of enzymes

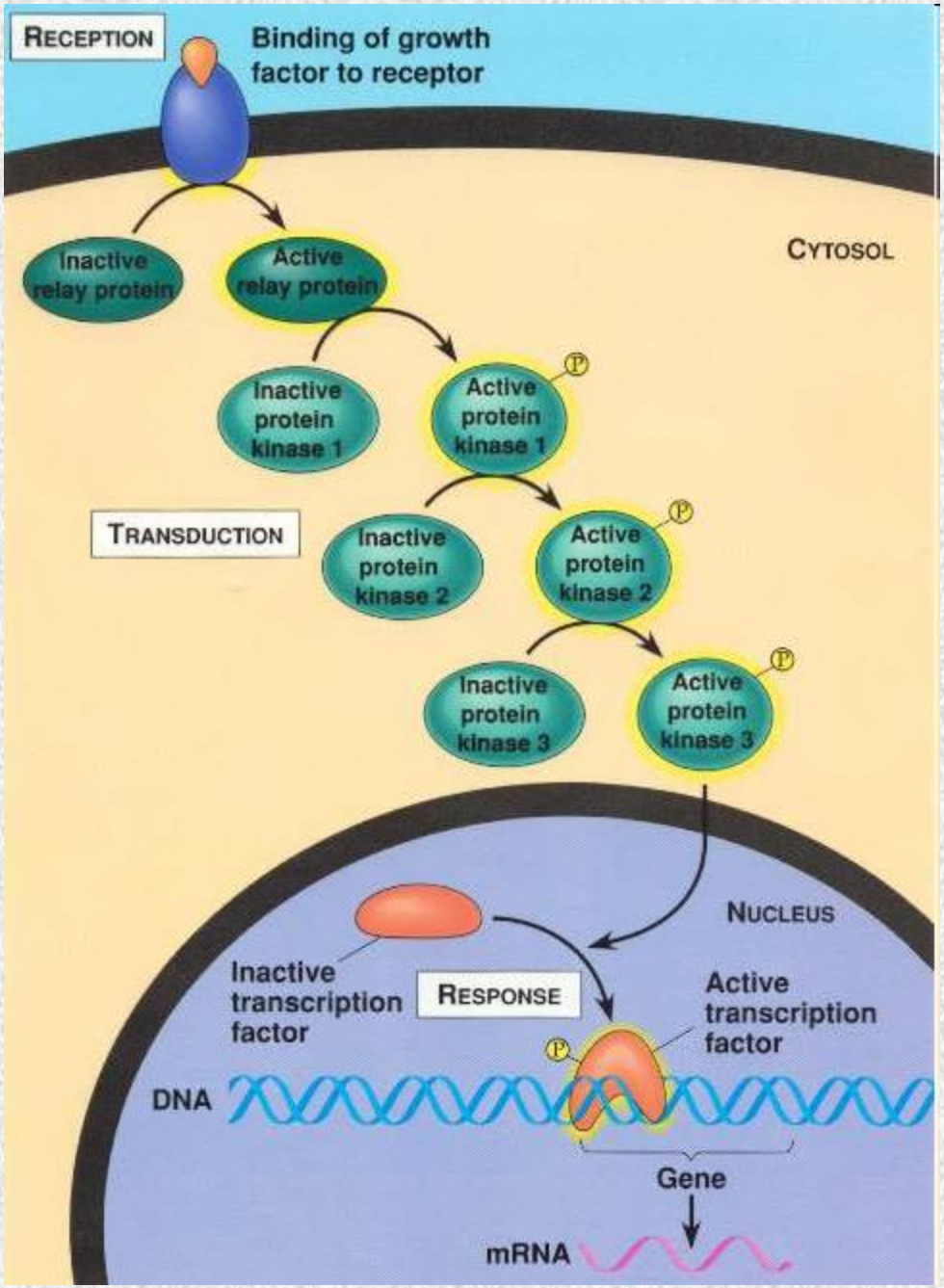
rearrangement of cytoskeleton

opening/closing of ion channels

Some of pathways leads to **regulation of cell division**

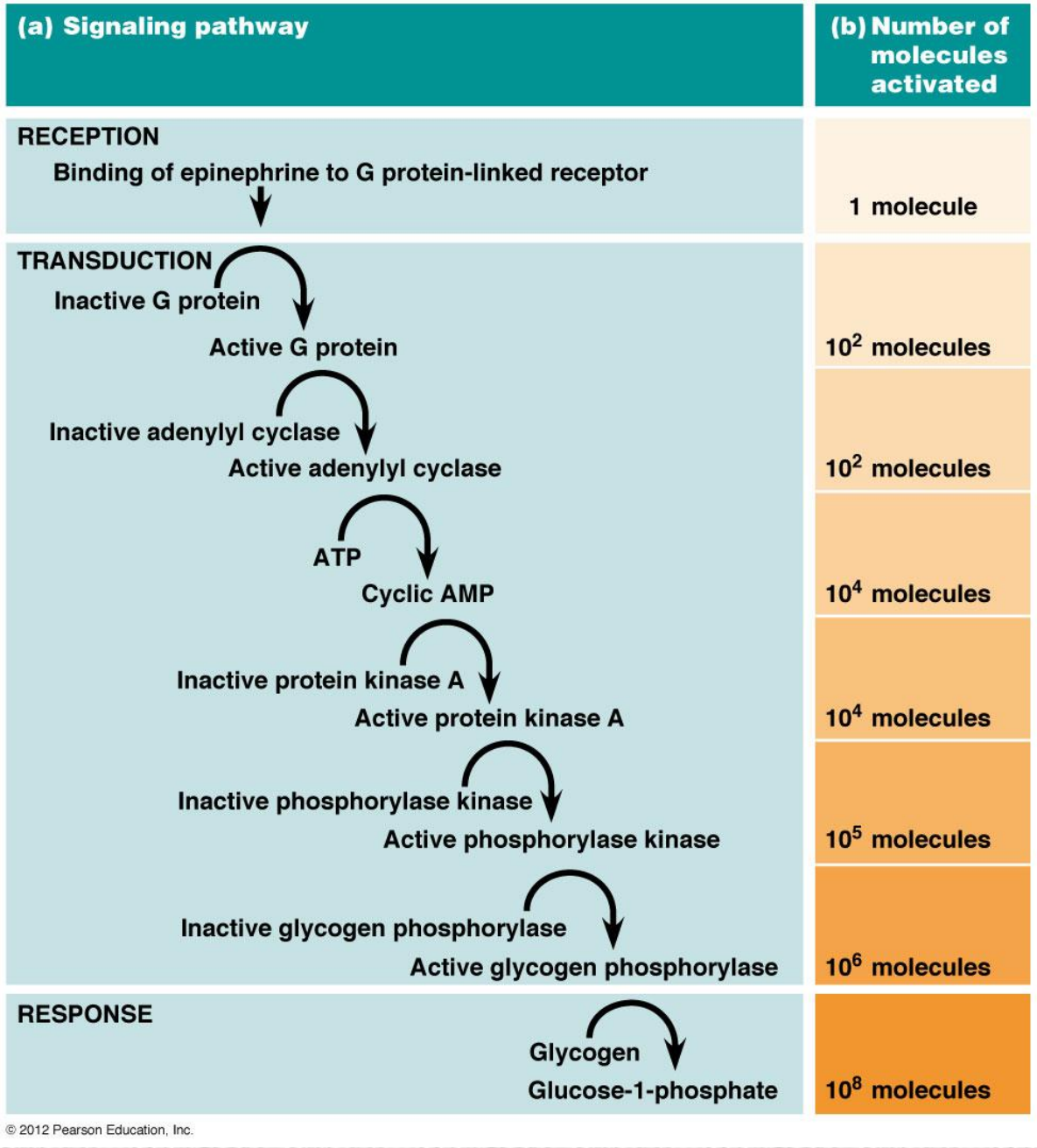
(stimulated by growth factors and hormones – first messengers)

Nuclear response to a signal

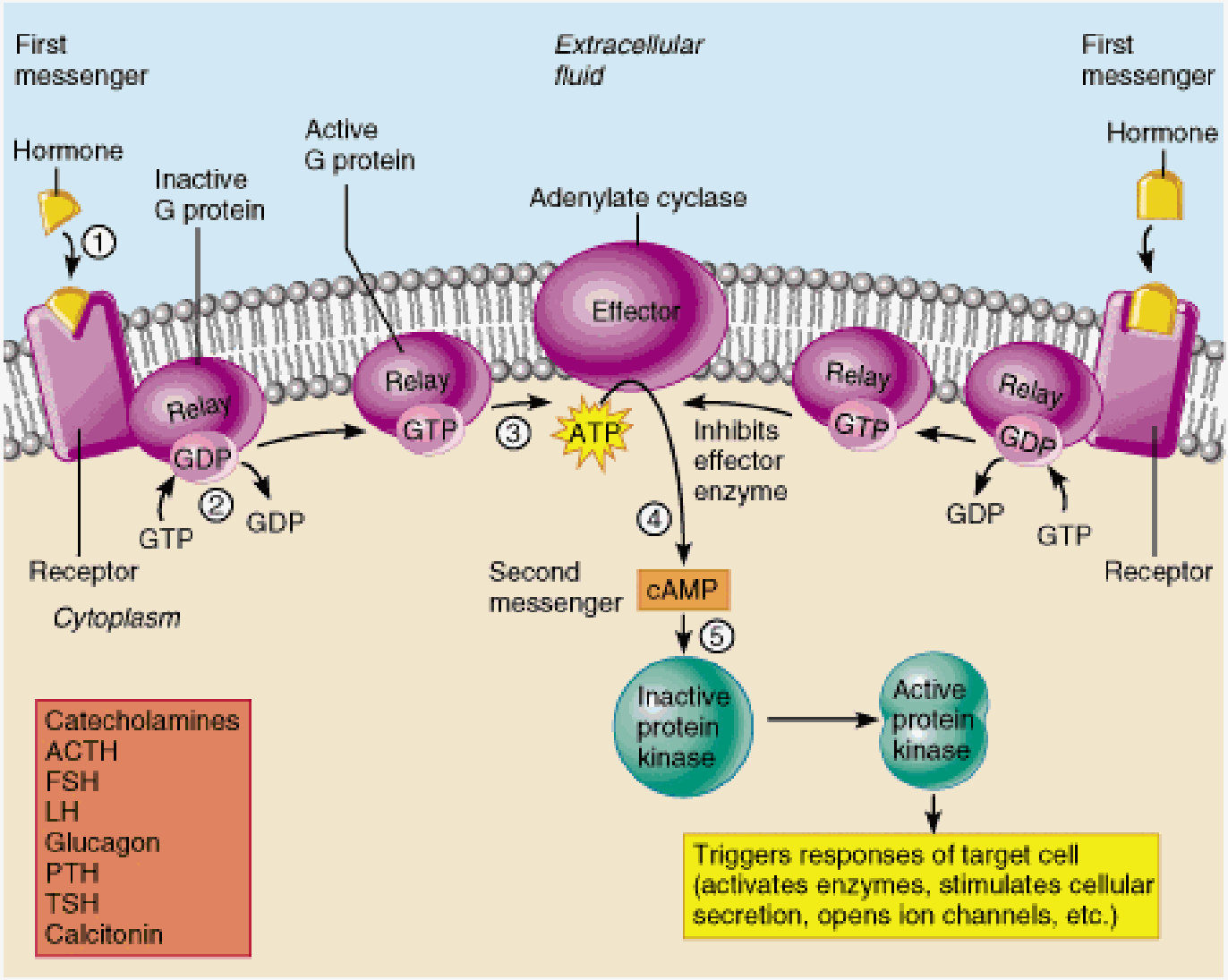


Cytoplasmic response to the signal

Stimulation of glycogen breakdown by epinephrine

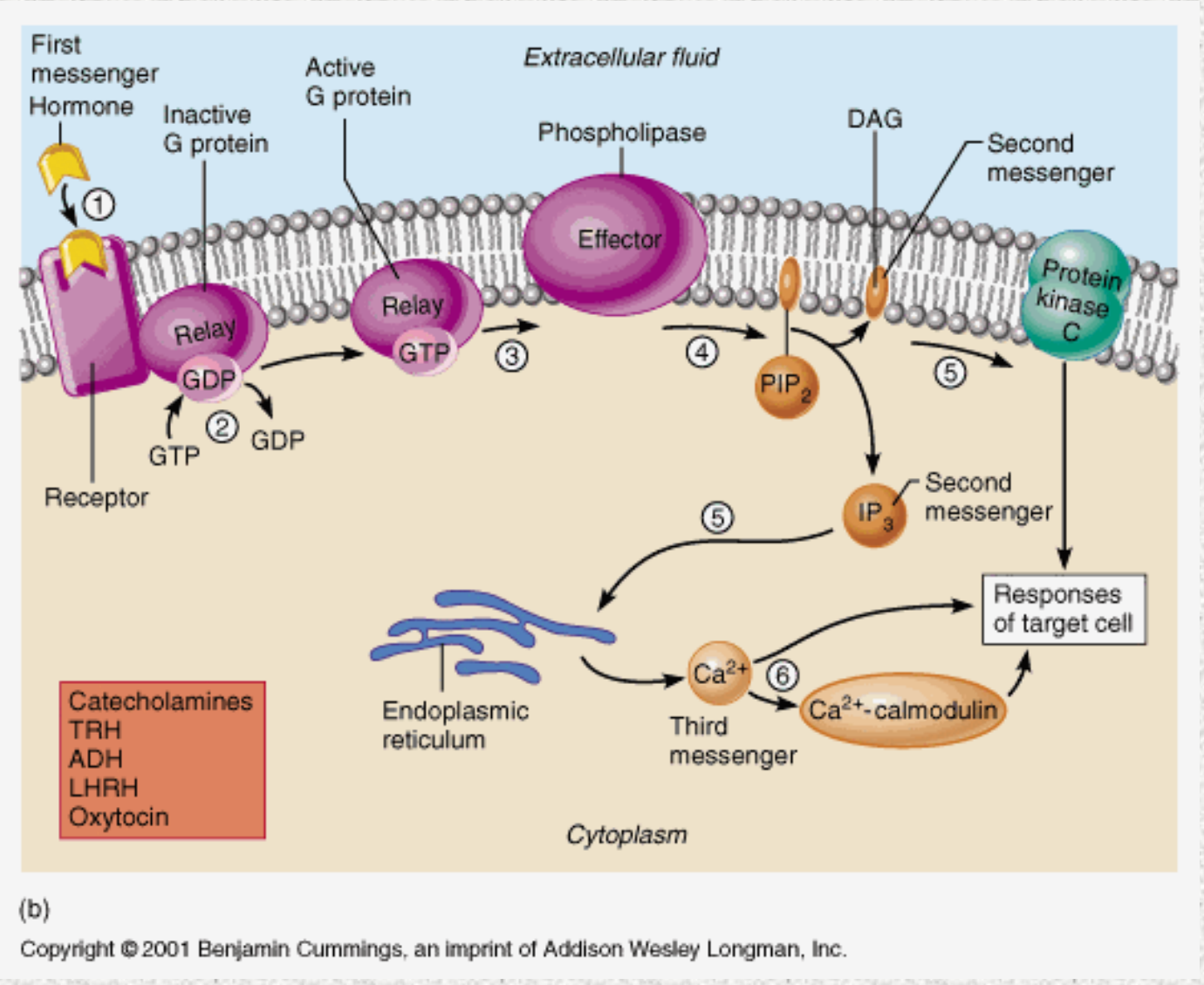


B). **Second Messenger: <u>Cyclic-AMP (cAMP)</u>**



(a)

Second Messenger: Diacylglycerol, **IP3**,
Ca++, PIP- calcium,



(b)

IP3

Thank you for your attention

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**, Biology**, Benjamin-Cummings Publishing Company, 1996 –2010.