The cell, cellular membrane, endoplasmic reticulum

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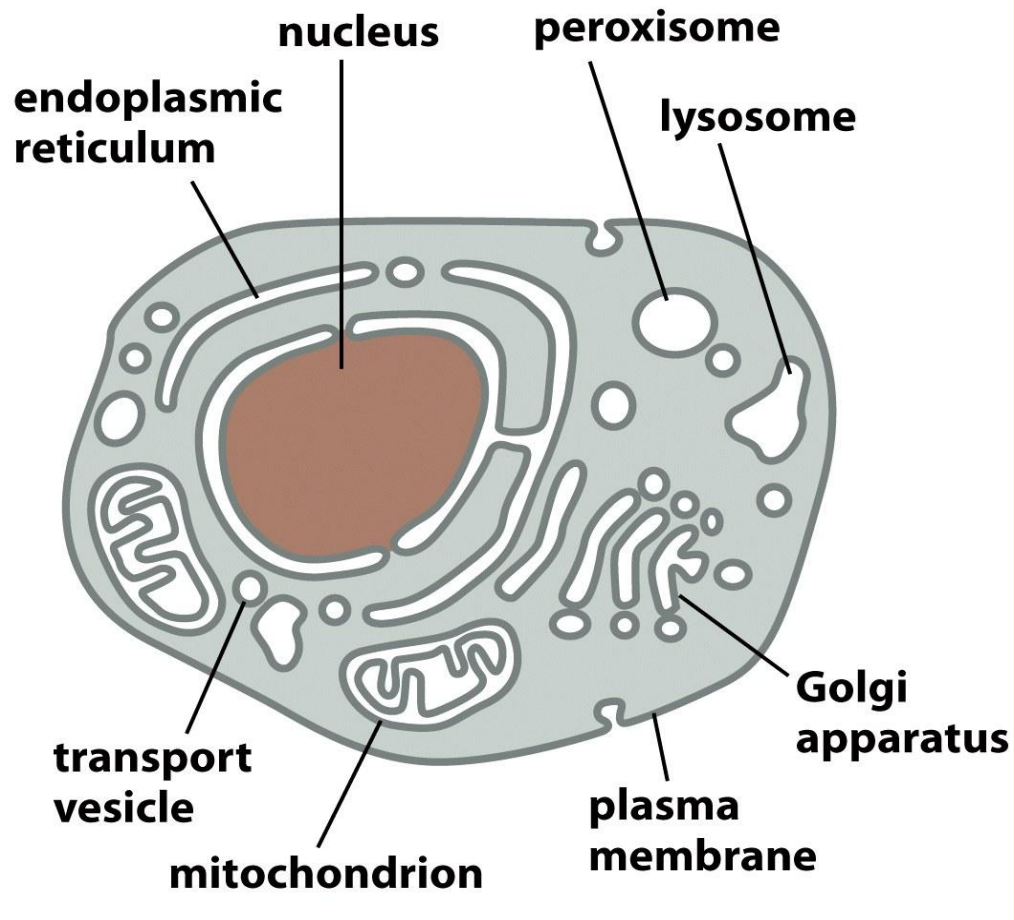
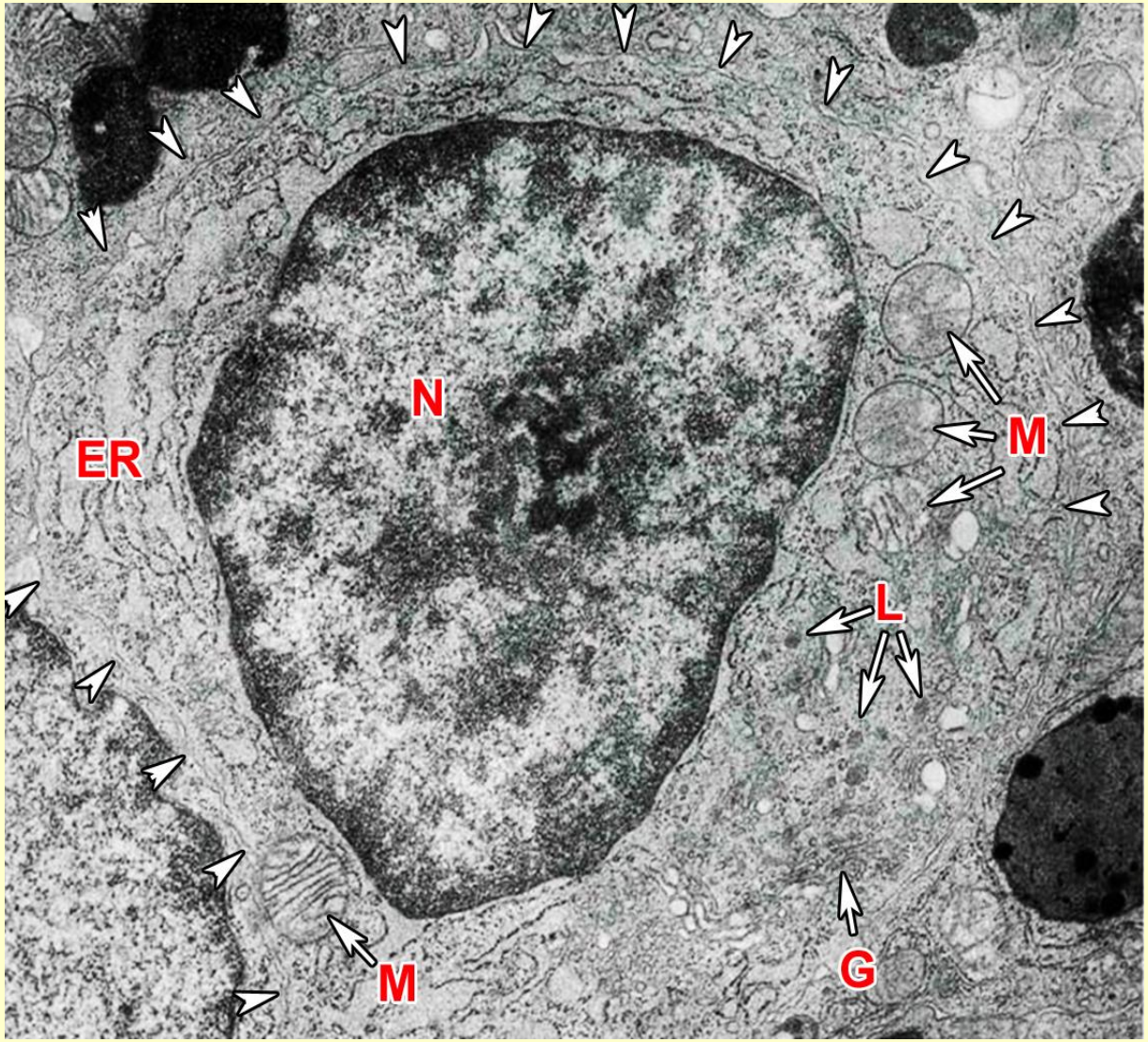
CELL

The structural and functional unit of the living organism

- The cell consists of ***protoplasm*** surrounded by ***cellular membrane*** (plasma membrane or plasmalemma)
- The protoplasm comprises of the ***nucleus***, the ***cellular organelles*** and the ***cytosol***
- ***Cellular organelles are*** those parts of the protoplasm, which are ***surrounded by membranes*** (internal membranes)



Electron microscopic image of the cell



Arrowheads:
plasma membrane

N: Nucleus

M: Mitochondrium

ER: Endoplasmic reticulum

L: Lysosome

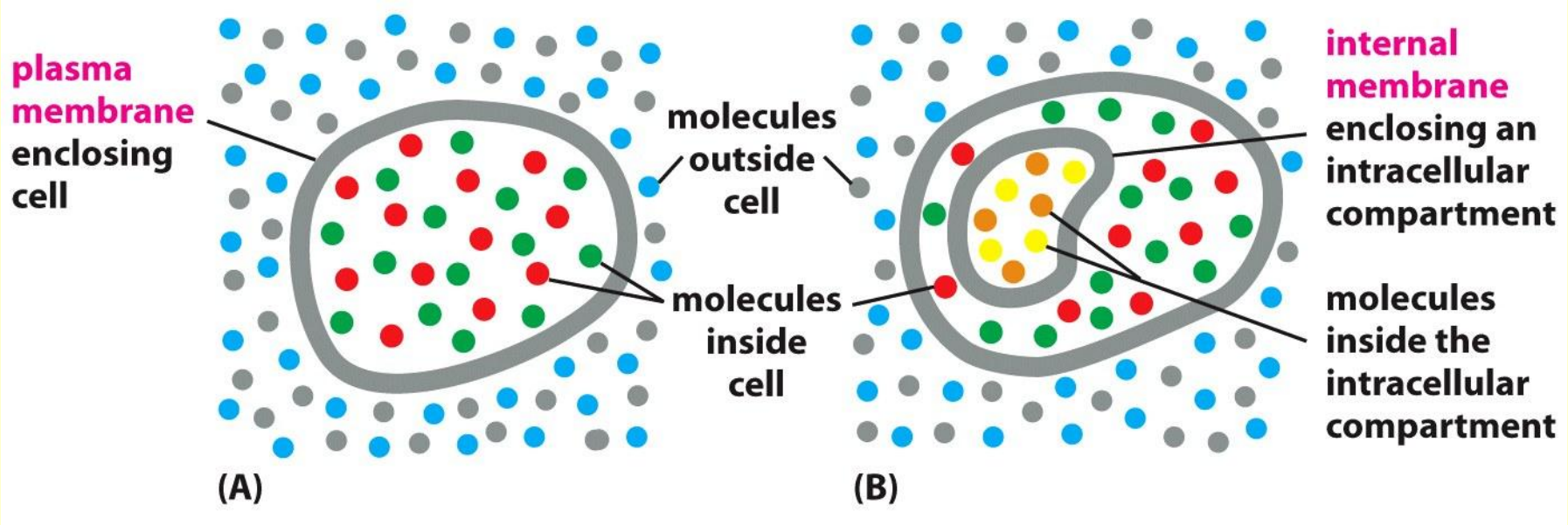
G: Golgi apparatus

The volume and number of cell organelles in an „average" human cell (liver cell)

INTRACELLULAR COMPARTMENT	PERCENTAGE OF TOTAL CELL VOLUME	APPROXIMATE NUMBER PER CELL
Cytosol	54	1
Mitochondria	22	1700
Endoplasmic reticulum	12	1
Nucleus	6	1
Golgi apparatus	3	1
Peroxisomes	1	400
Lysosomes	1	300
Endosomes	1	200

CELLULAR MEMBRANE

The major function is the separation of different compartments so that their composition can be different:



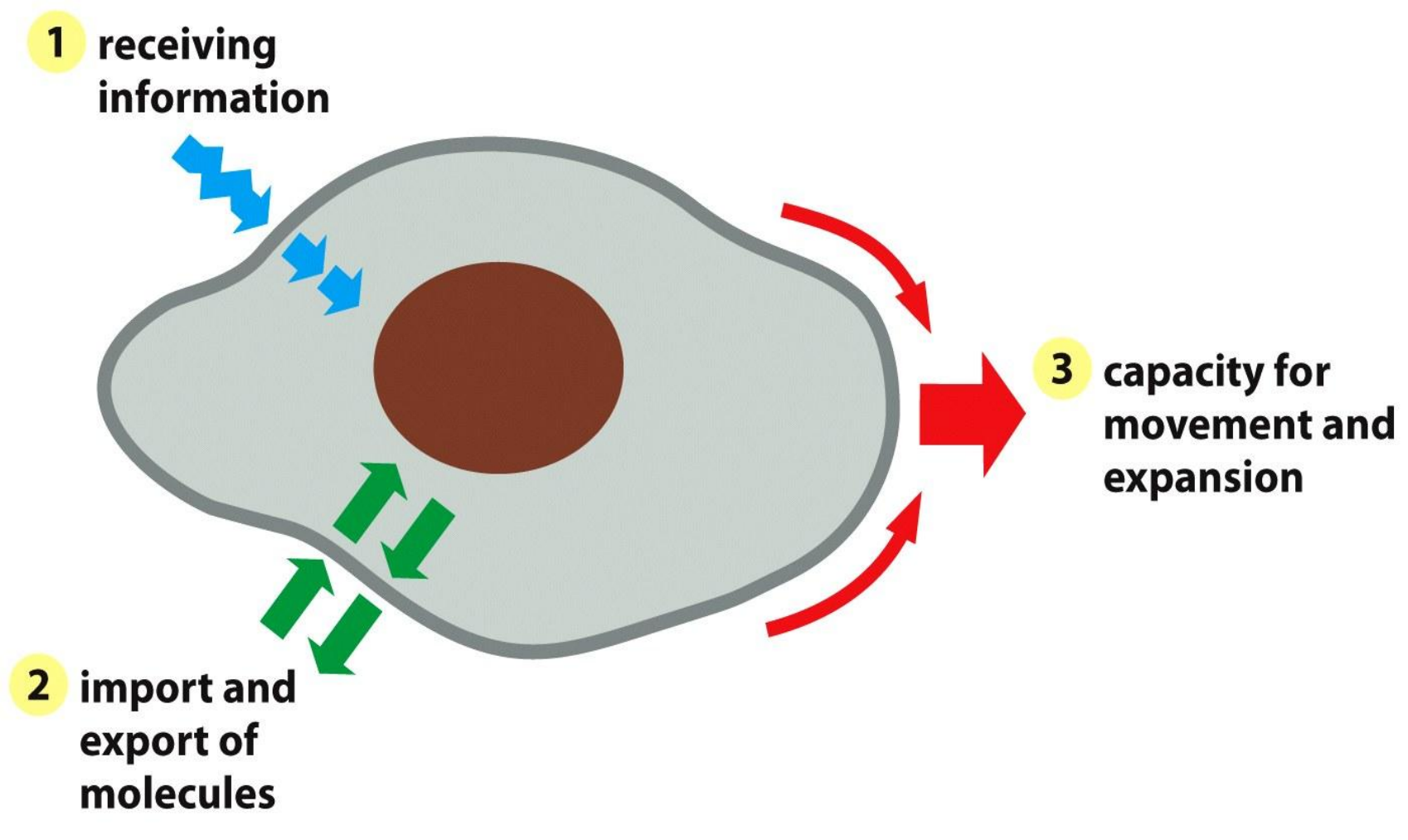
The concentration of macromolecules (e.g. nucleic acids and proteins) is much higher inside the cells

Ion concentrations within and outside a typical mammalian cell

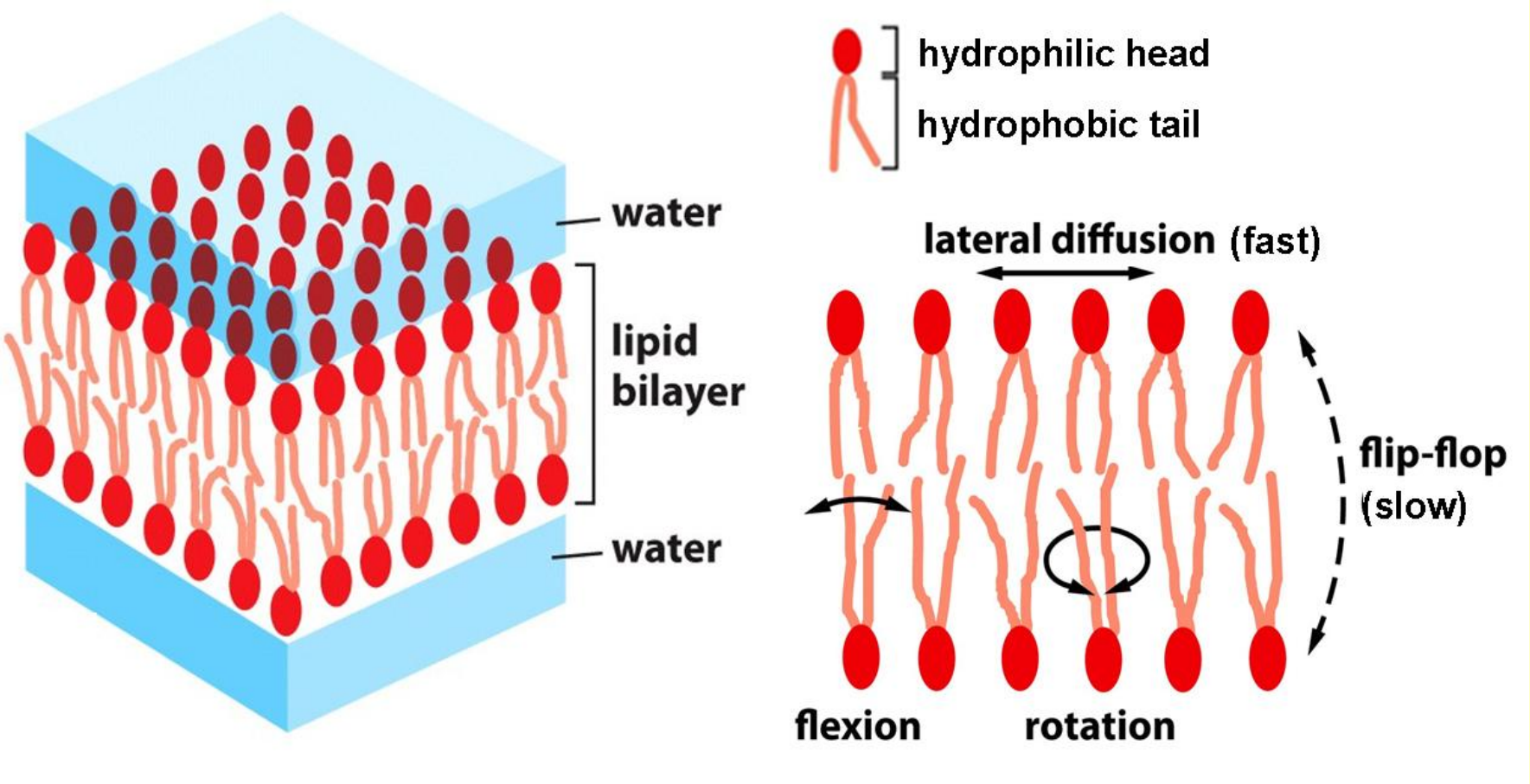
COMPONENT	INTRACELLULAR CONCENTRATION (mM)	EXTRACELLULAR CONCENTRATION (mM)
Cations		
Na^+	5–15	145
K^+	140	5
Mg^{2+}	0.5	1–2
Ca^{2+}	10^{-4}	1–2
H^+	$\sim 7 \times 10^{-5}$ ($10^{-7.2}$ M or pH 6.9-7.2)	4×10^{-5} ($10^{-7.4}$ M or pH 7.4, mildly basic)
Anions*		
Cl^-	5–15	110

* The cell must contain equal quantities of positive and negative charges (that is, be electrically neutral). Thus, in addition to Cl^-, the cell contains many other anions not listed in this table; in fact, most cellular constituents are negatively charged (HCO_3^-, PO_4^{3-}, proteins, nucleic acids, metabolites carrying phosphate and carboxyl groups, etc.). The concentrations of Ca^{2+} and Mg^{2+} given are for the free ions. There is a total of about 20 mM Mg^{2+} and 1–2 mM Ca^{2+} in cells, but this is mostly bound to proteins and other substances and, for Ca^{2+}, stored within various organelles.

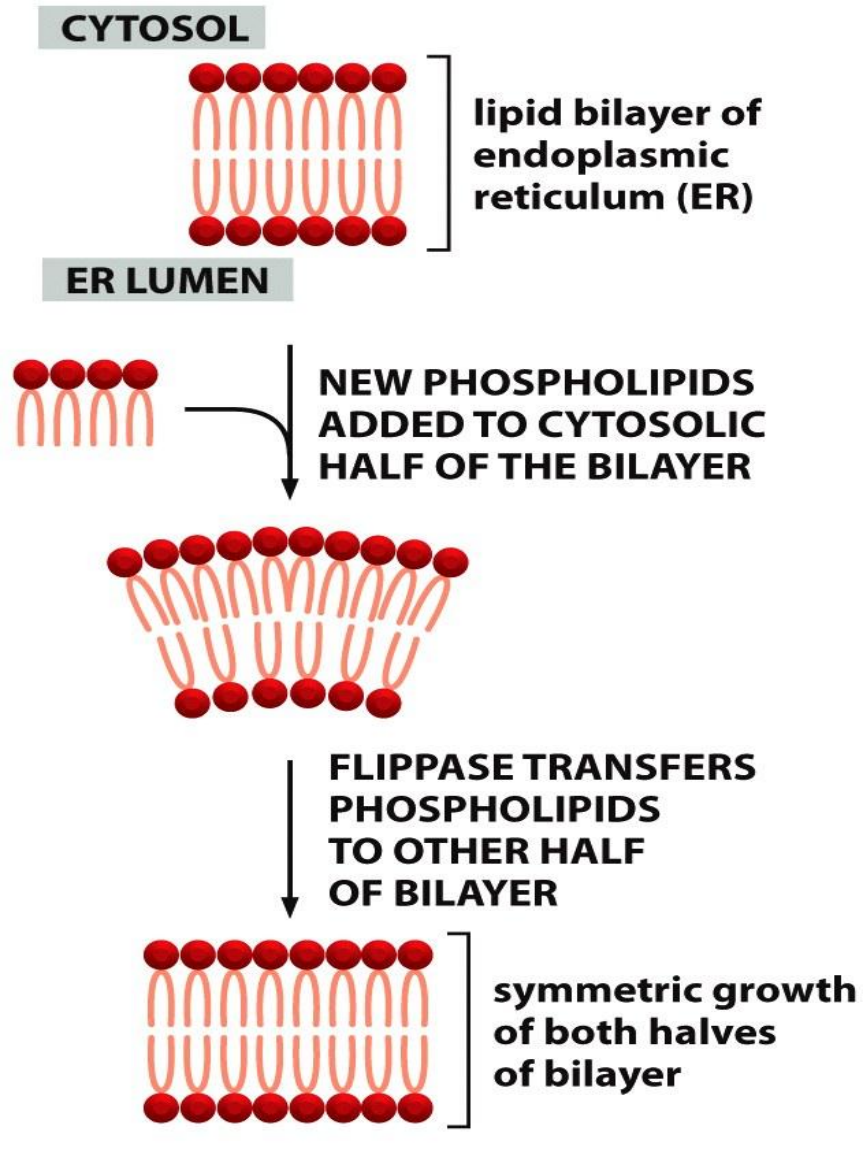
Additional functions of the plasma membrane



Structure of the cellular membrane: amphipathic molecules form a lipid bilayer, which is a 2-dimensional fluid

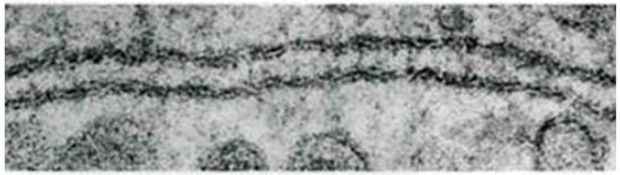


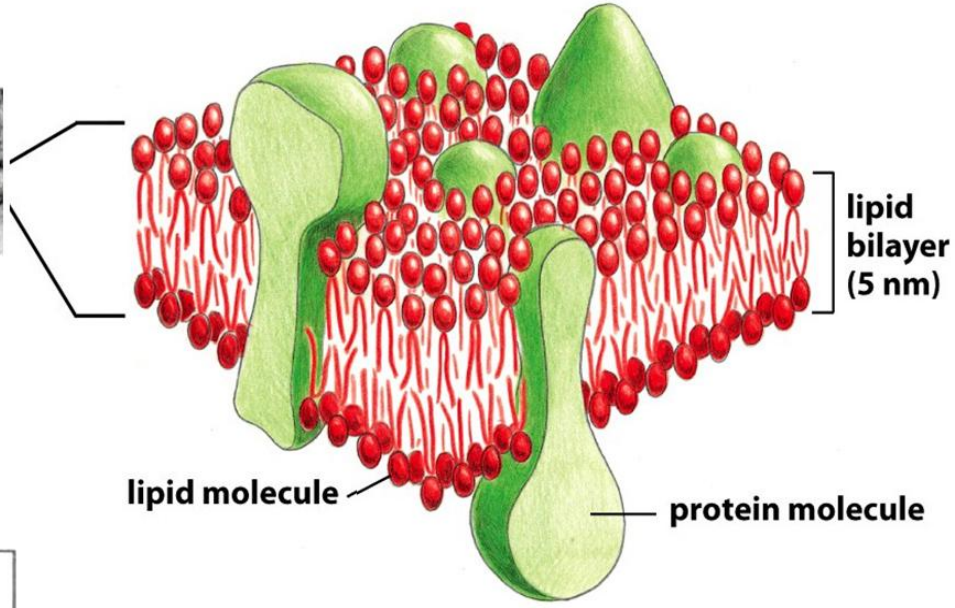
The synthesis of cellular membranes



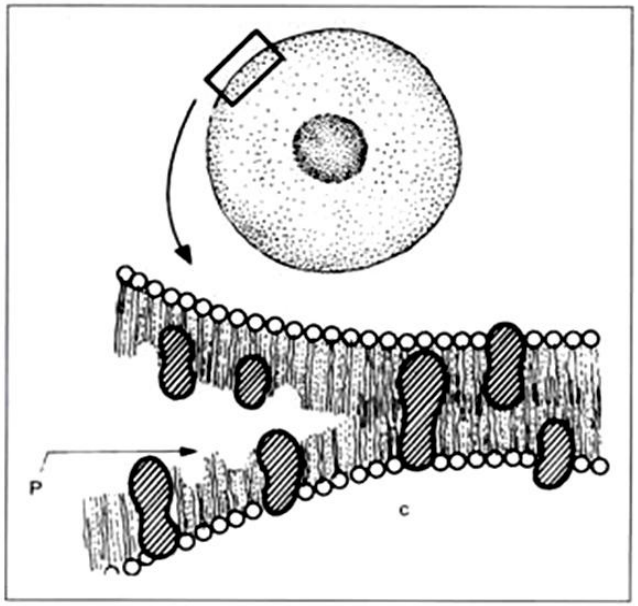
Cellular membranes also contain proteins

transmission electron microscopy:

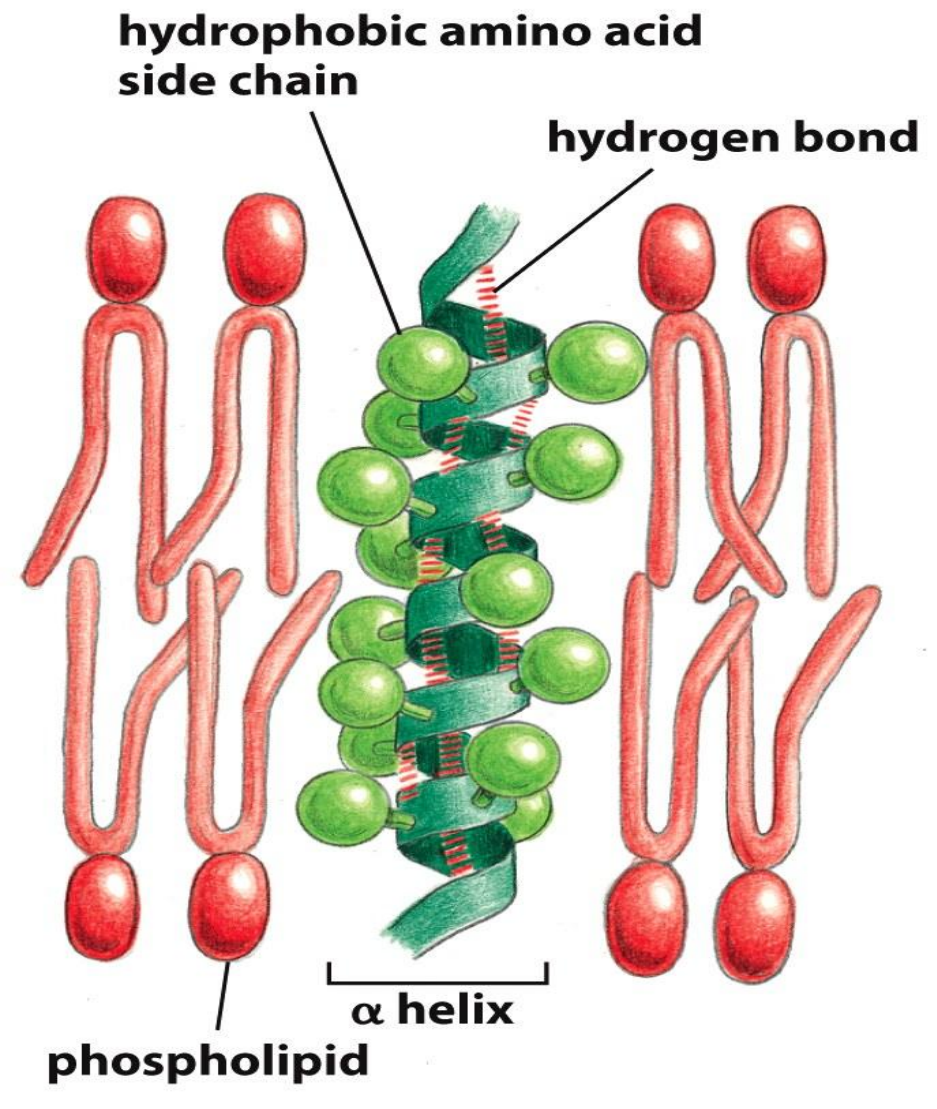




freeze-fracture electron microscopy:

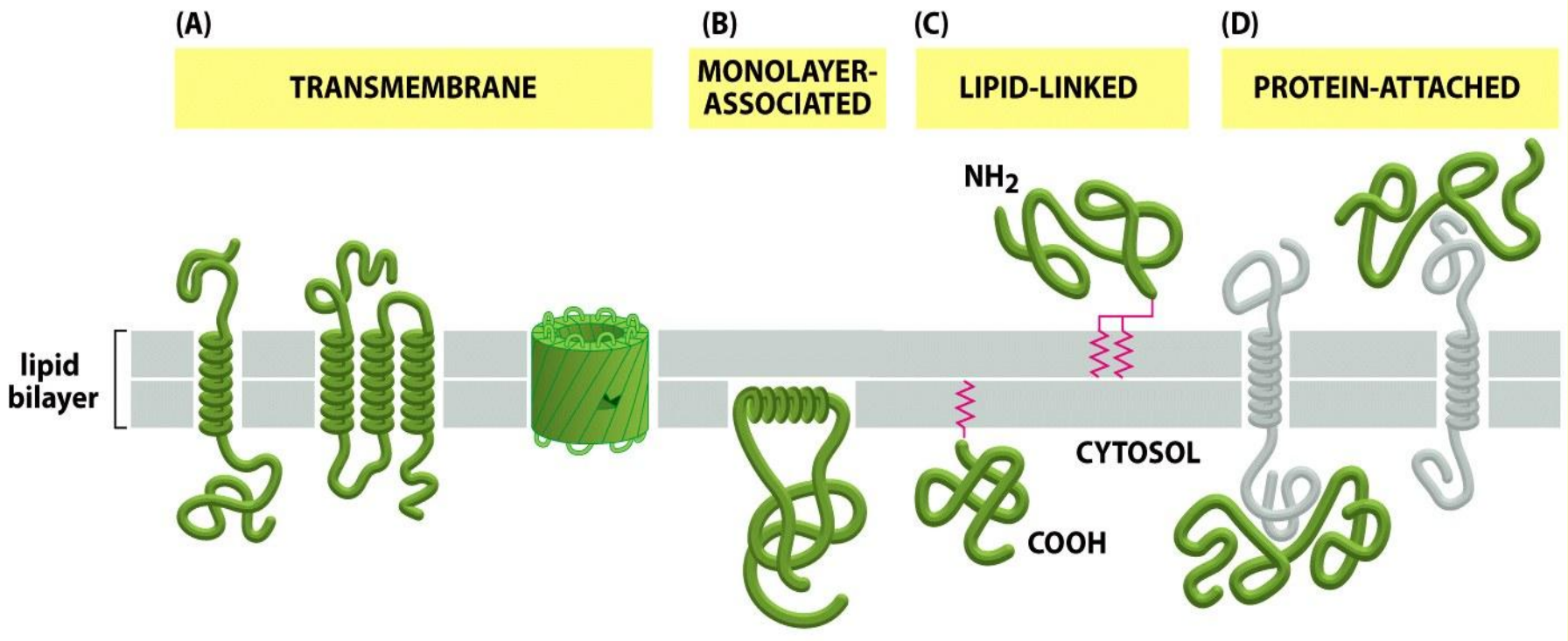


Membrane spanning regions of proteins



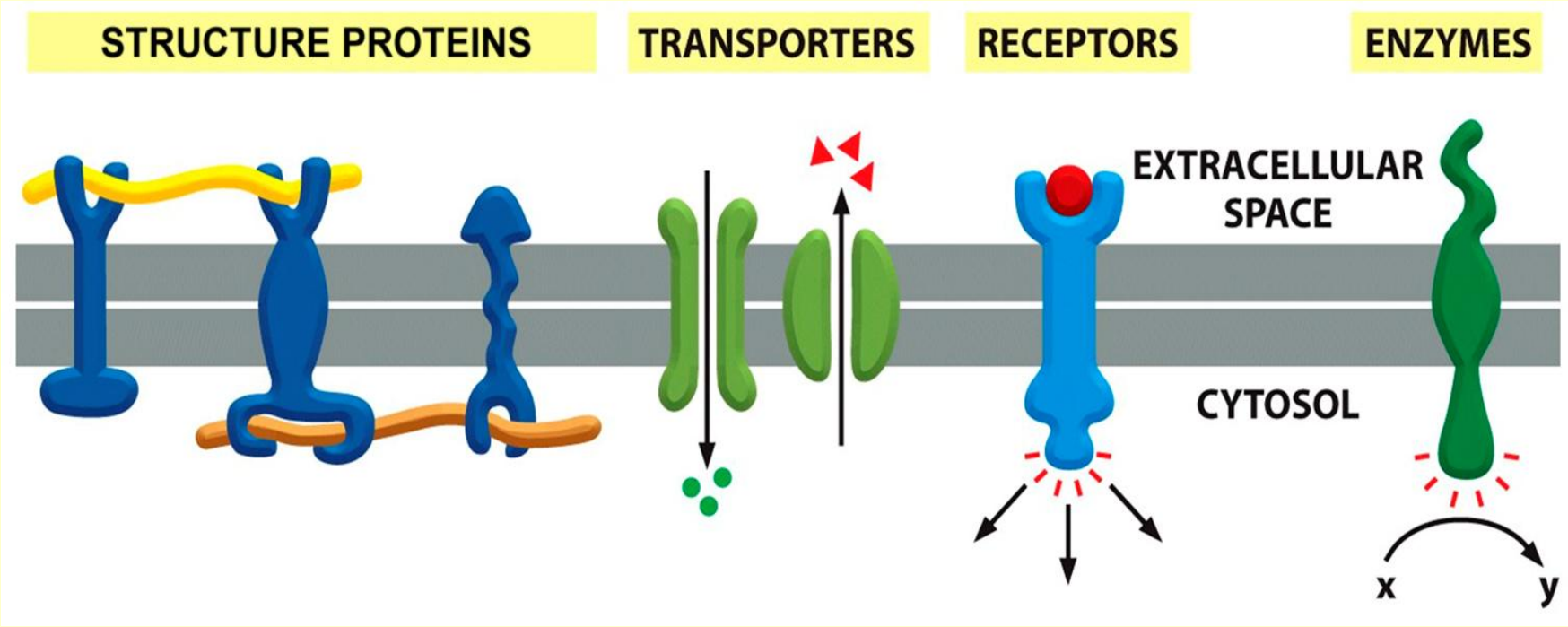
Types of membrane-associated proteins based on their positions in the membrane

Integral proteins (A, B) **Peripheral (inner or outer) proteins (C, D)**



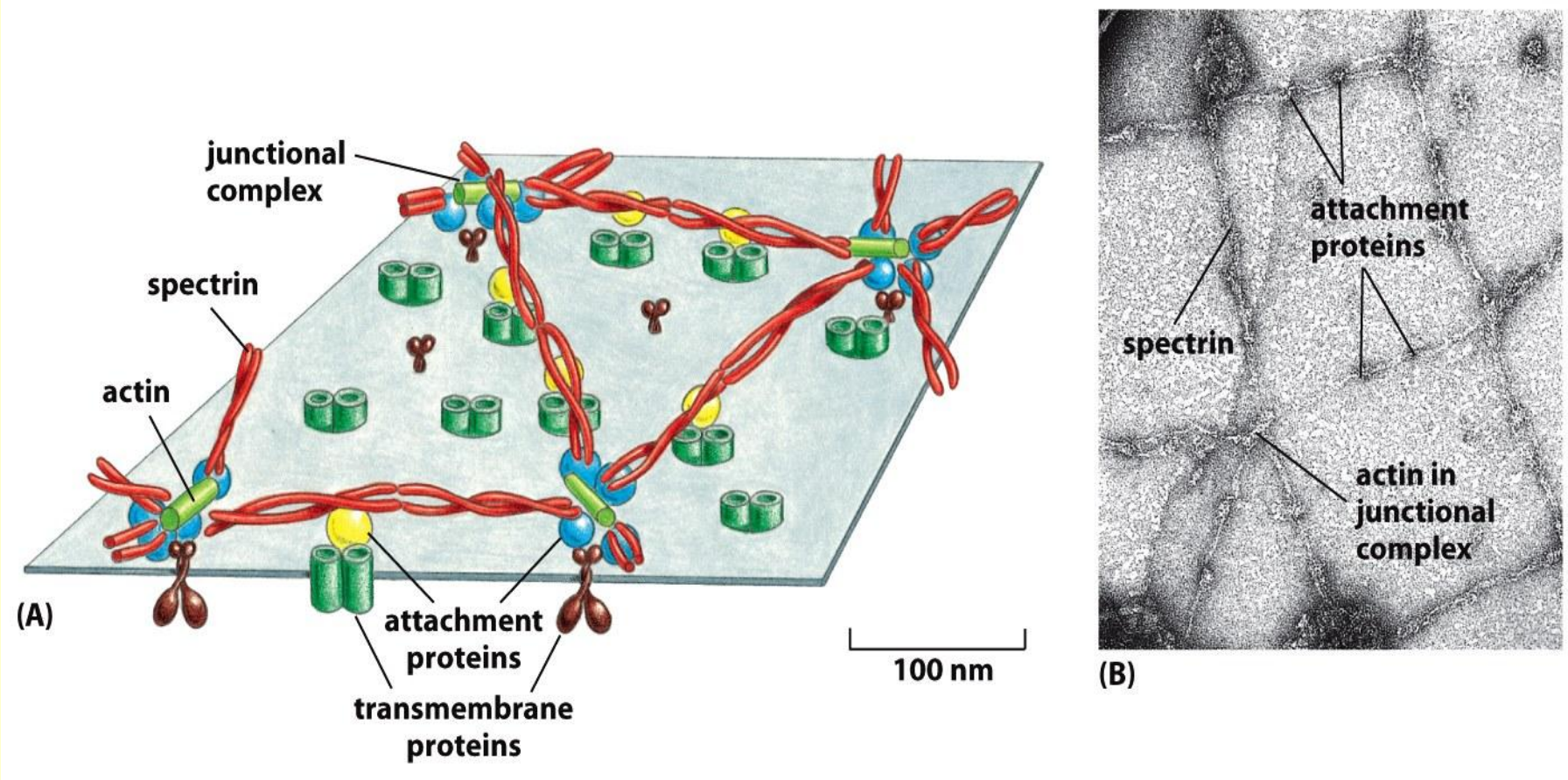
Essential Cell Biology (© Garland Science 2010)

Functional classification of membrane proteins



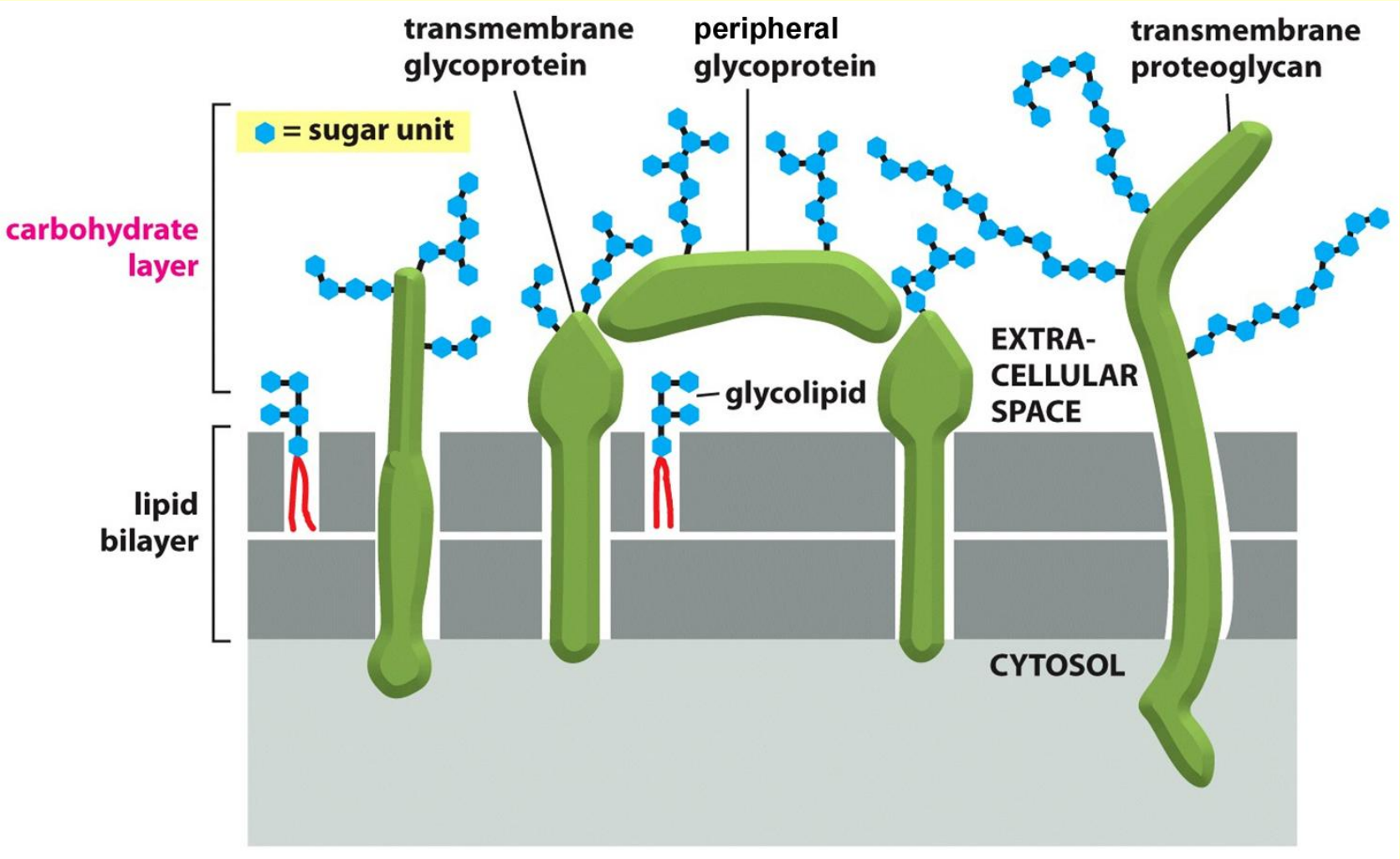
Examples:	anchors	pumps,	platelet-derived	adenylate-cyclase
	cell contact prot.	channels	growth factor rec.	

Example of **inner surface anchoring system**: A protein network on the inner surface of cell membranes best studied in red blood cells



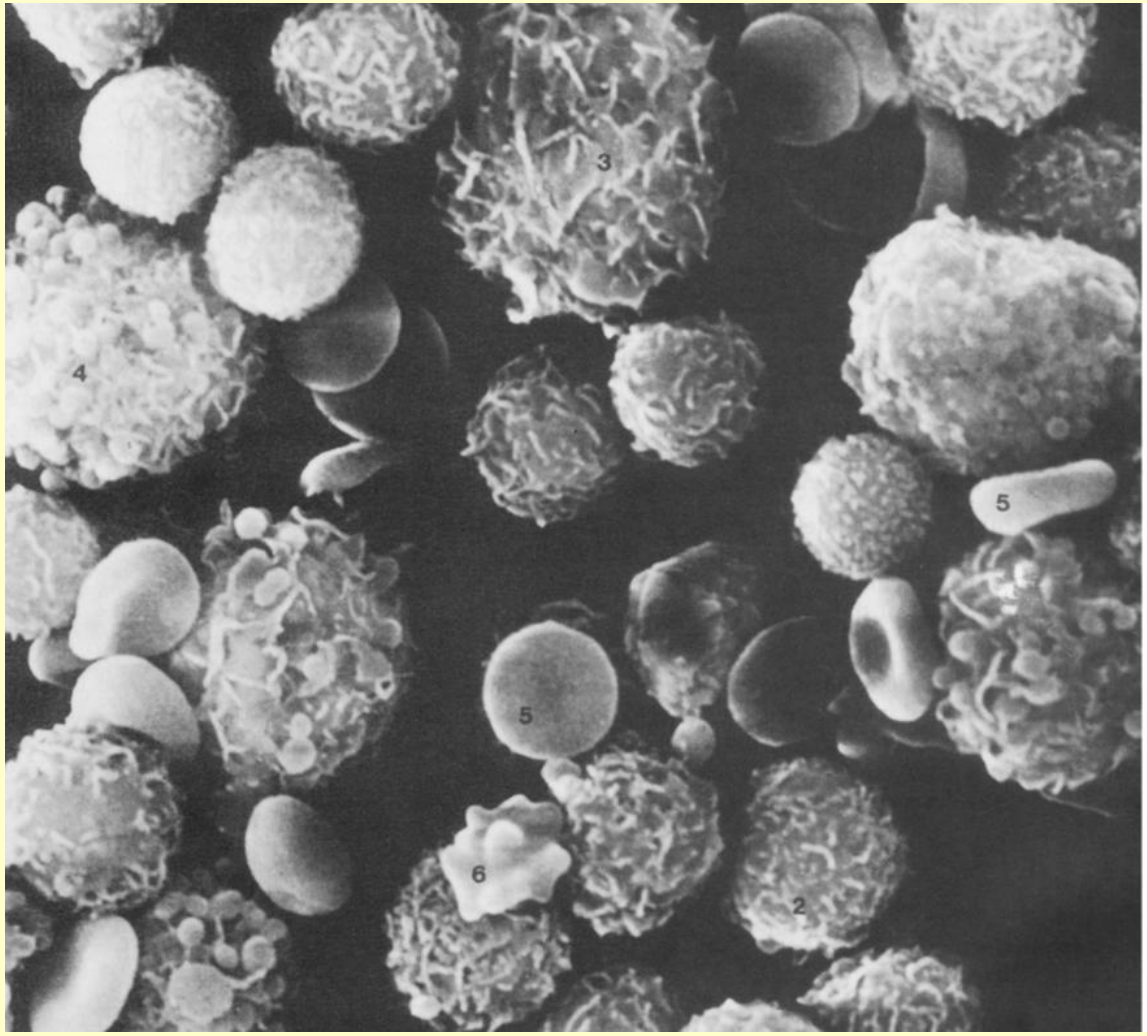
The shape of red blood cells

Glycocalix: a carbohydrate network on the cell surface attached to lipids, integral and outer peripheral proteins



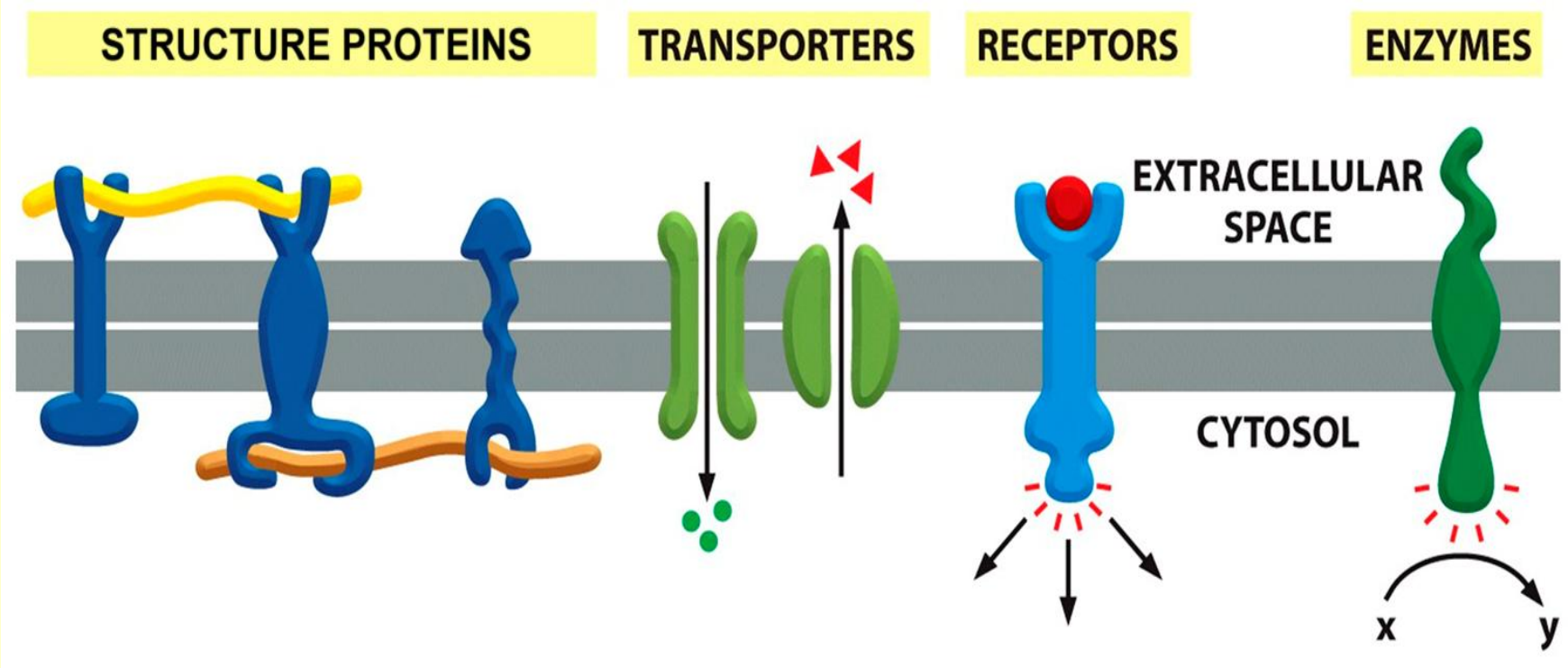
Variations in the surface of the cells

Scanning electron microscopy of ascites:



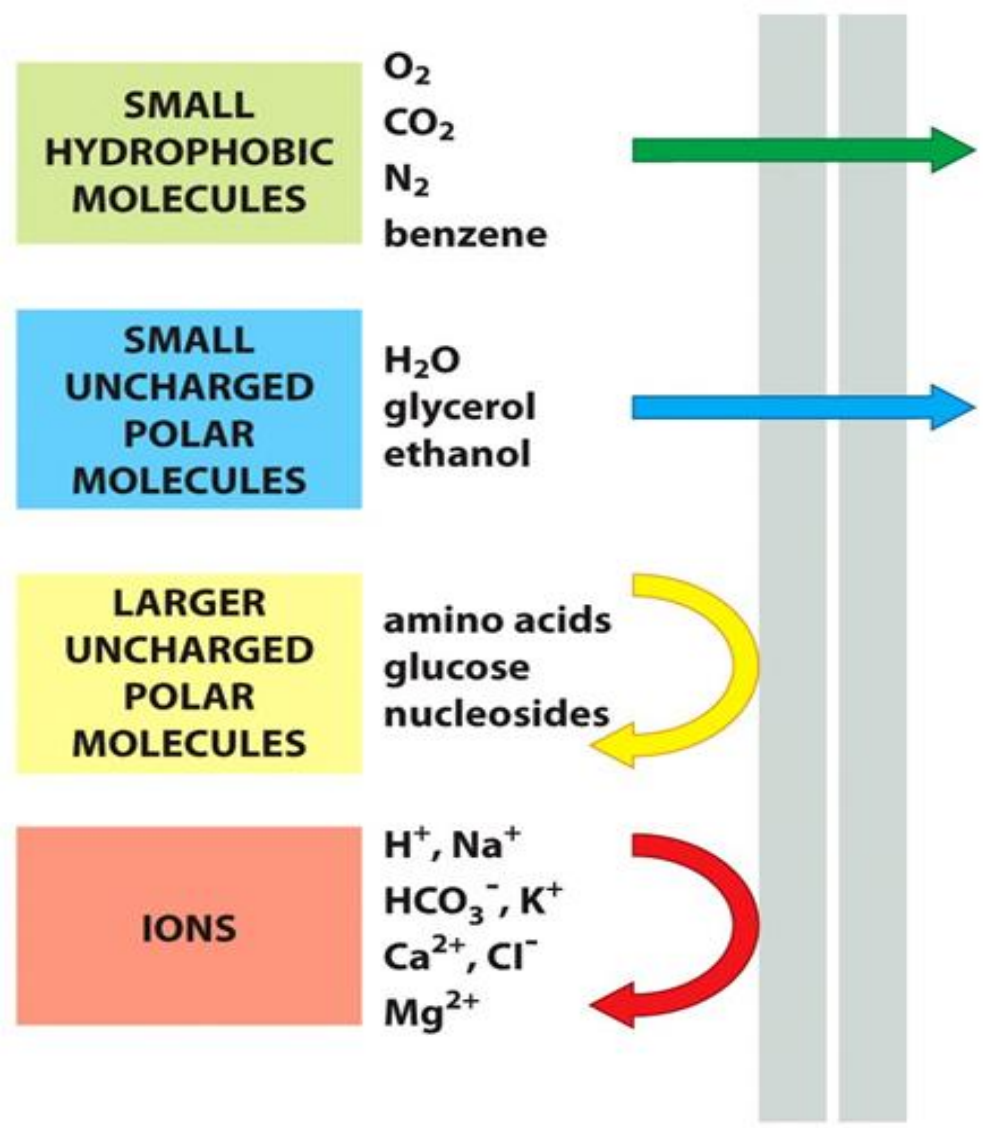
Microvilli:

Transporters allow regulated flux of chemicals across the cell membrane

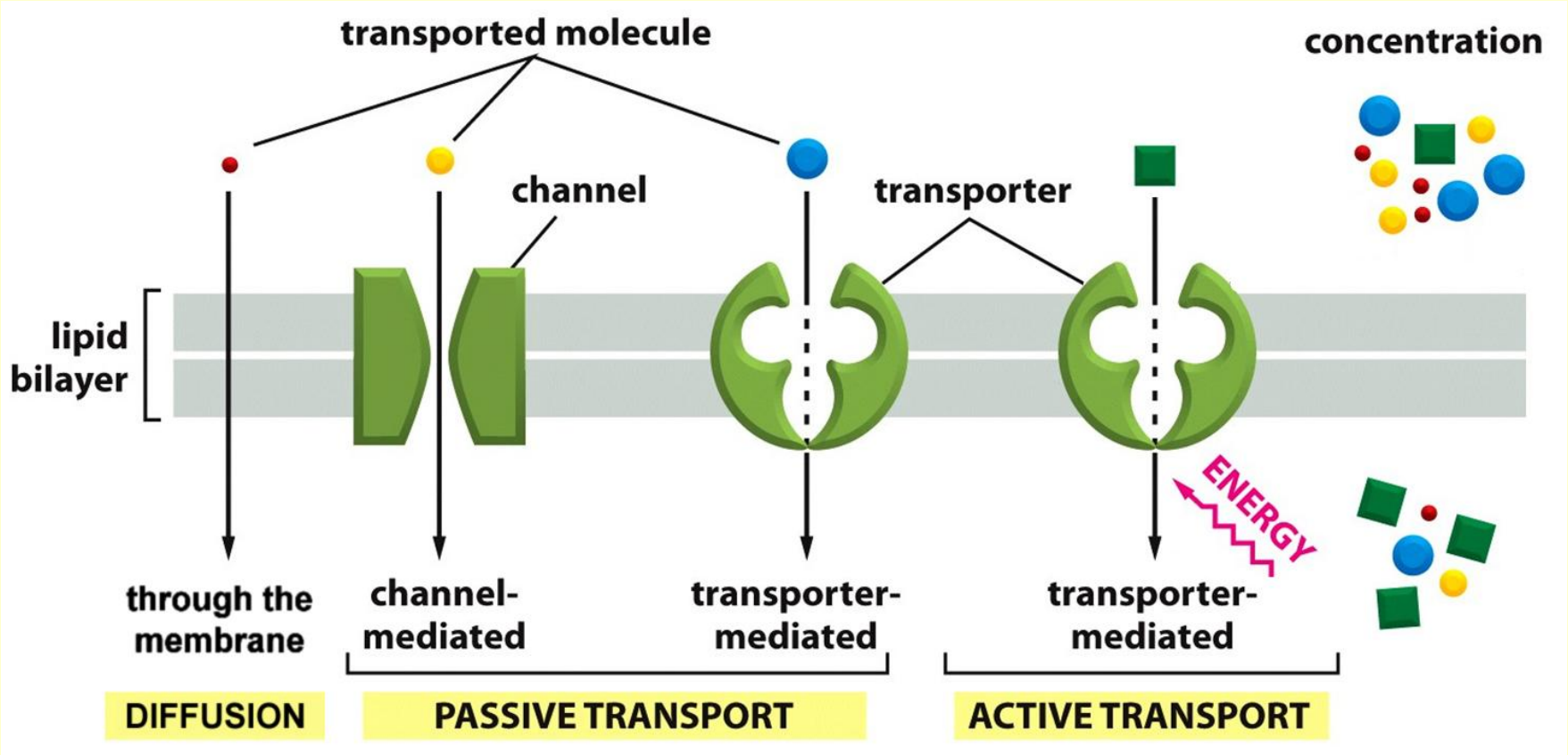


Examples:	anchors cell contact prot.	pumps, channels	platelet-derived growth factor rec.	adenylate-cyclase

Diffusion of substances across lipid bilayers



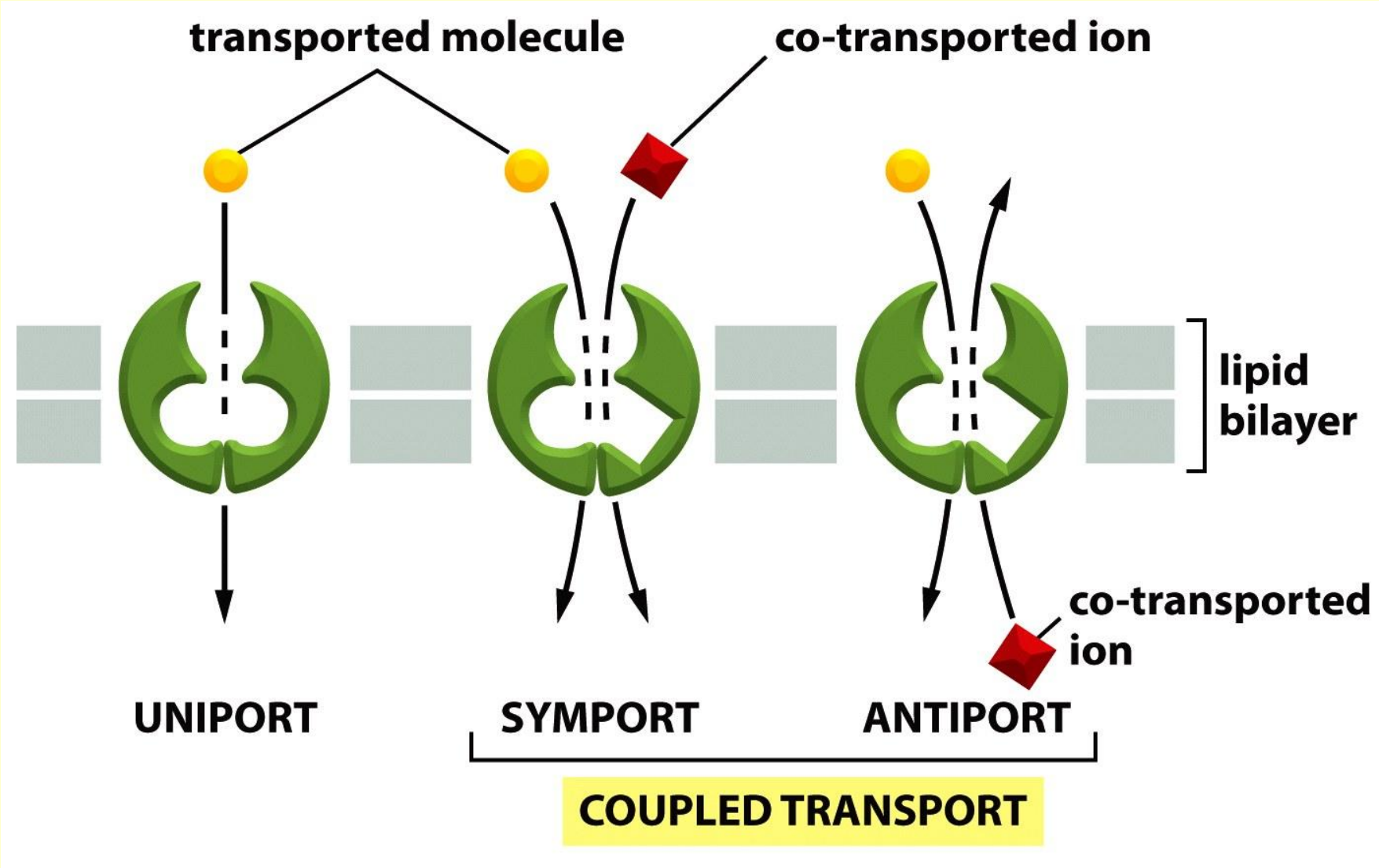
Types of transport across membranes



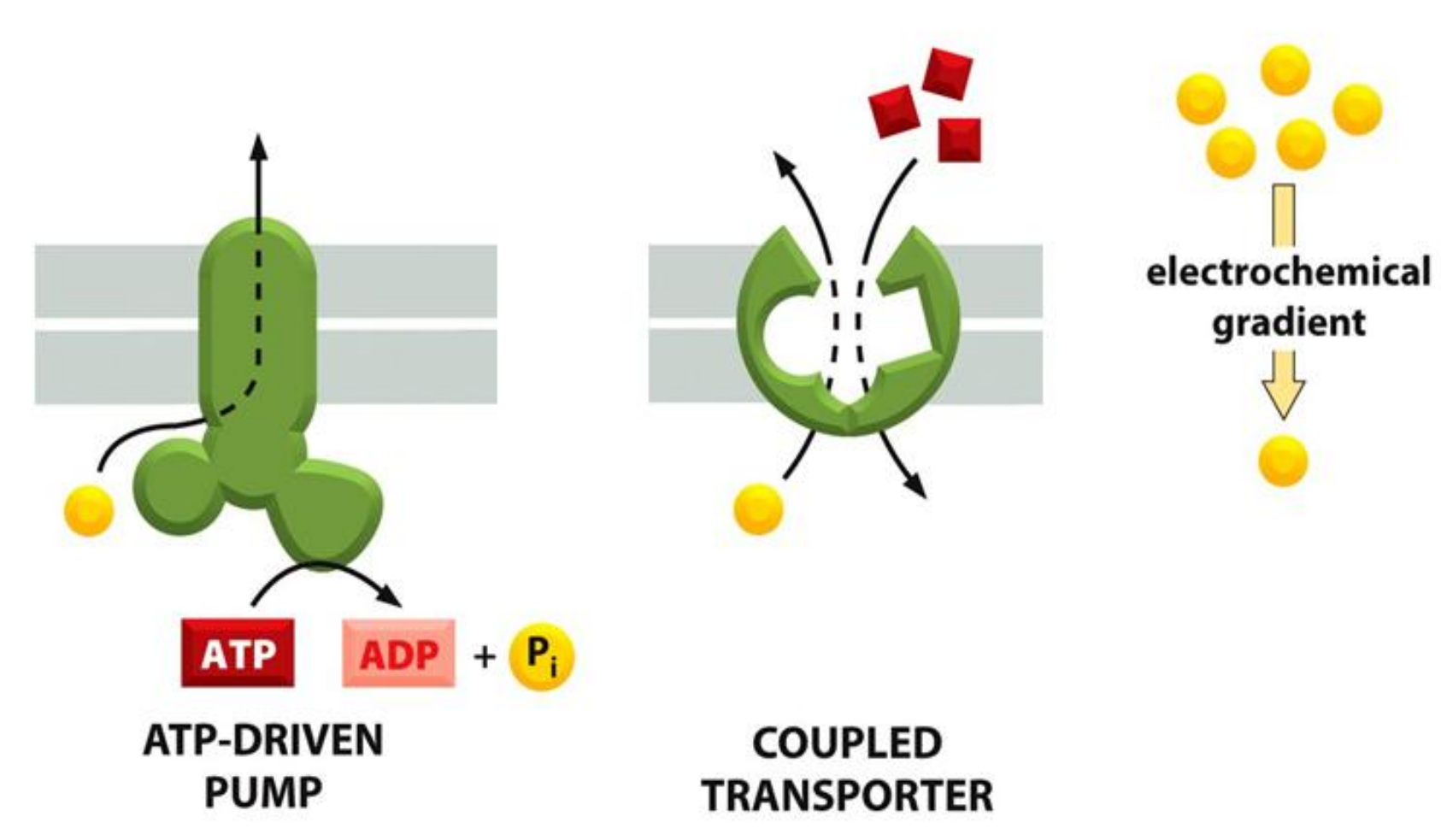
A channel is a hole formed by transmembrane proteins, along which molecules can pass the membrane.

A transporter (carrier) binds the molecule-to-be-transported, transports it to the other side of the membrane, and releases it.
The transporter-mediated passive transport is also called *facilitated diffusion*.

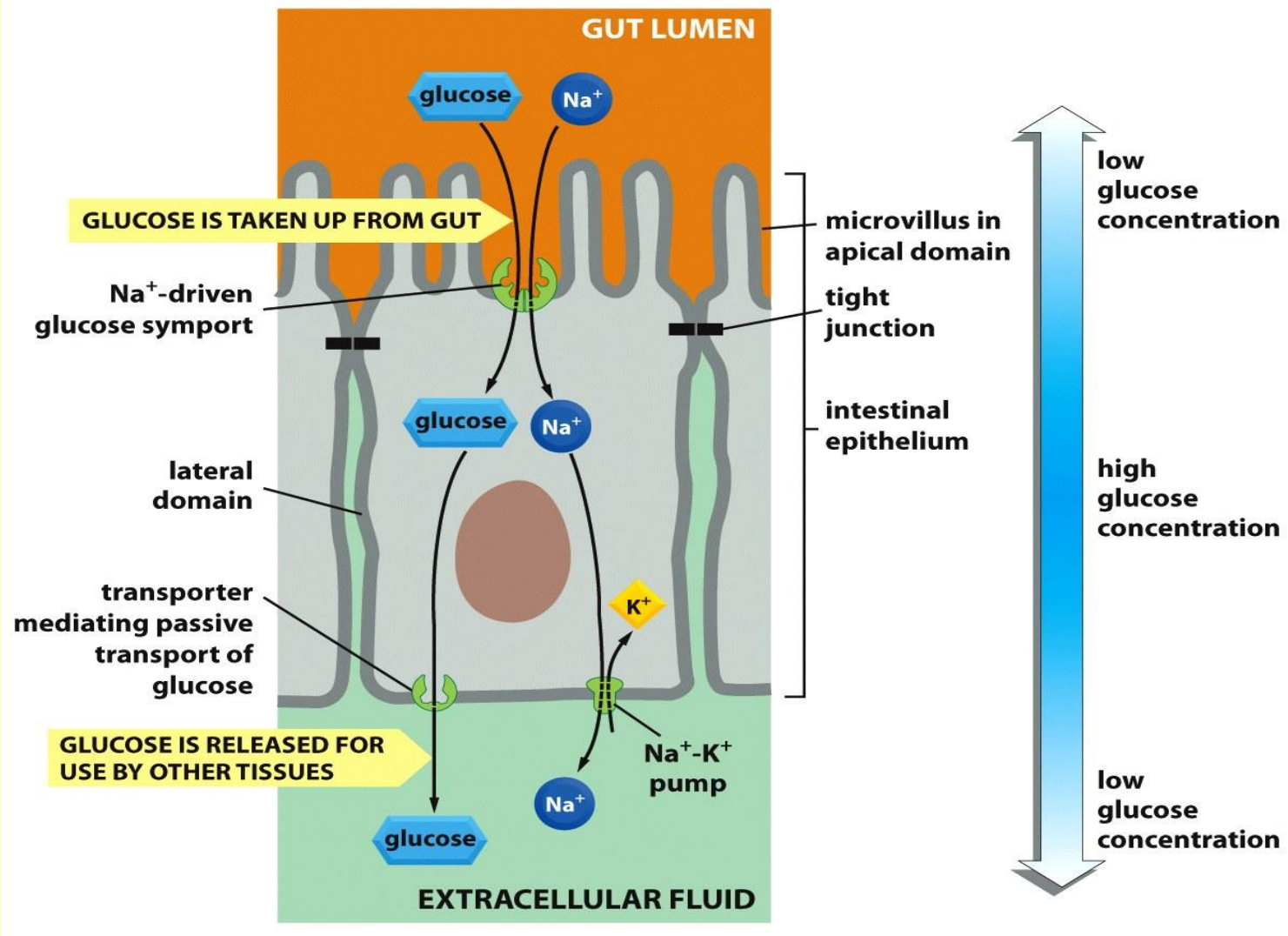
Transporters often perform coupled transport



Types of active transport



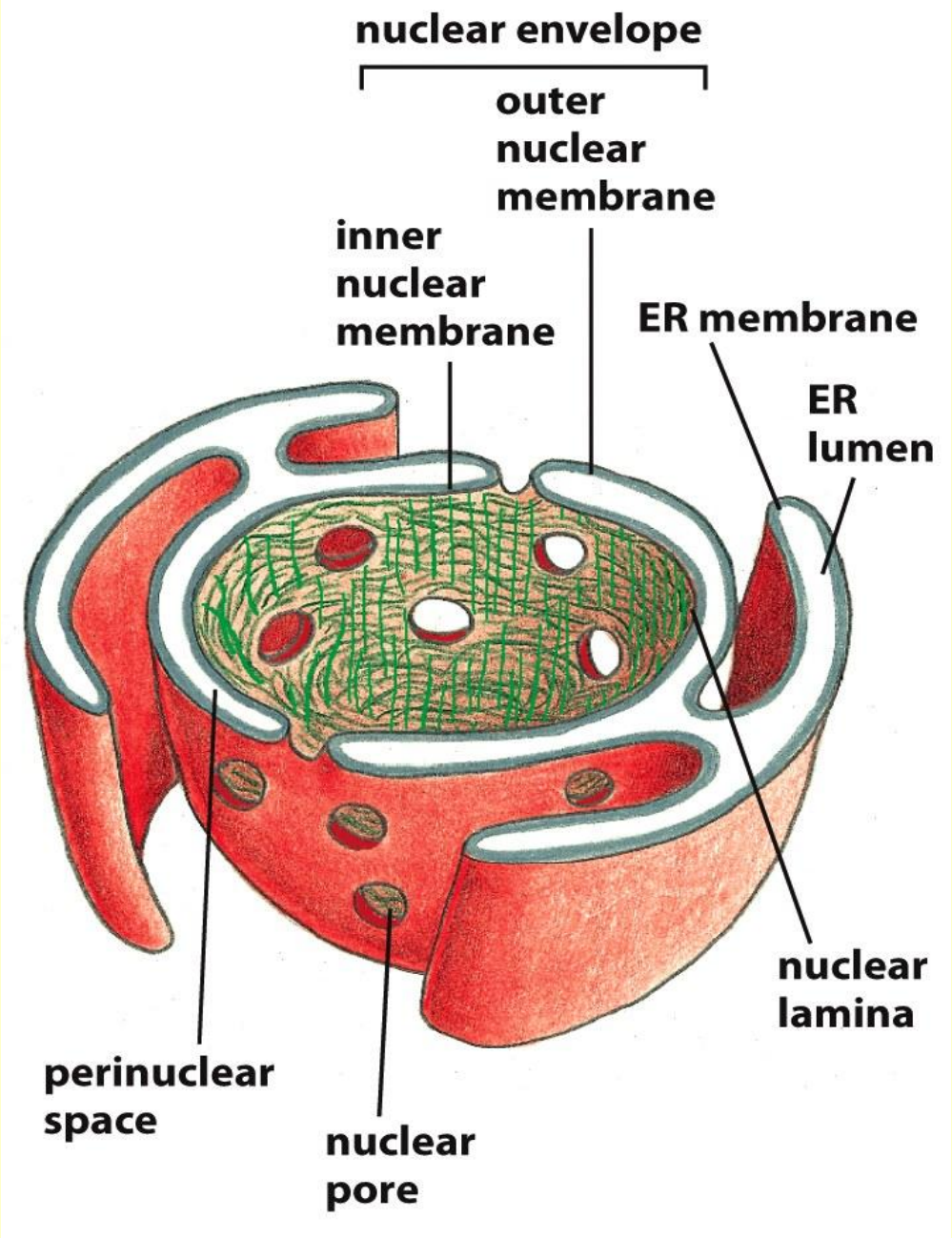
Absorption of glucose from the gut with the interaction of 3 different transporters of epithelial cells



Endoplasmic reticulum

The endoplasmic reticulum is a cellular organelle, which means it is surrounded by cellular membrane

It has the shape of lamellae (or sheets), which are continuous with the nuclear envelope surrounding the cell nucleus



The nuclear envelope and the endoplasmic reticulum may have evolved through the invagination of the plasma membrane

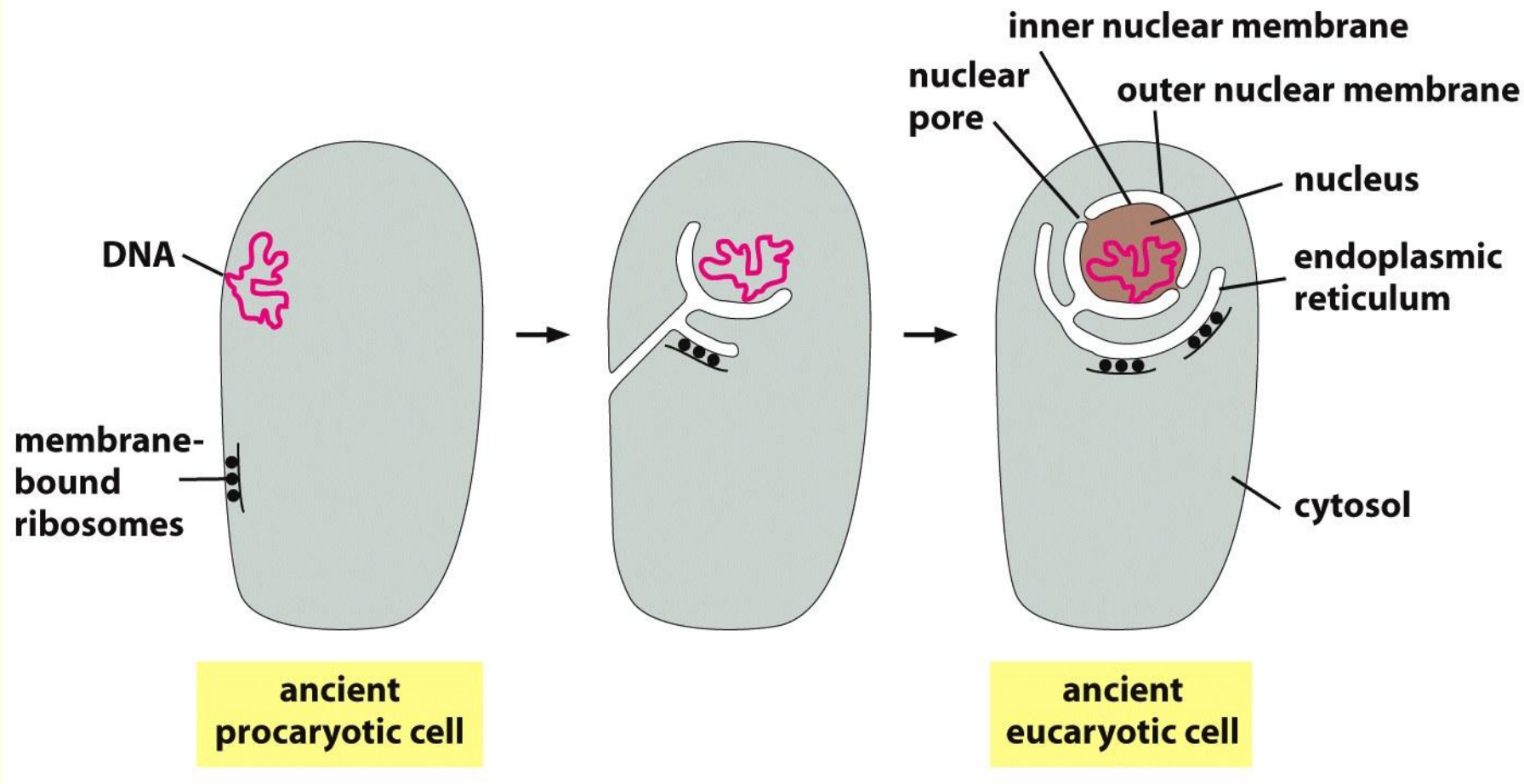
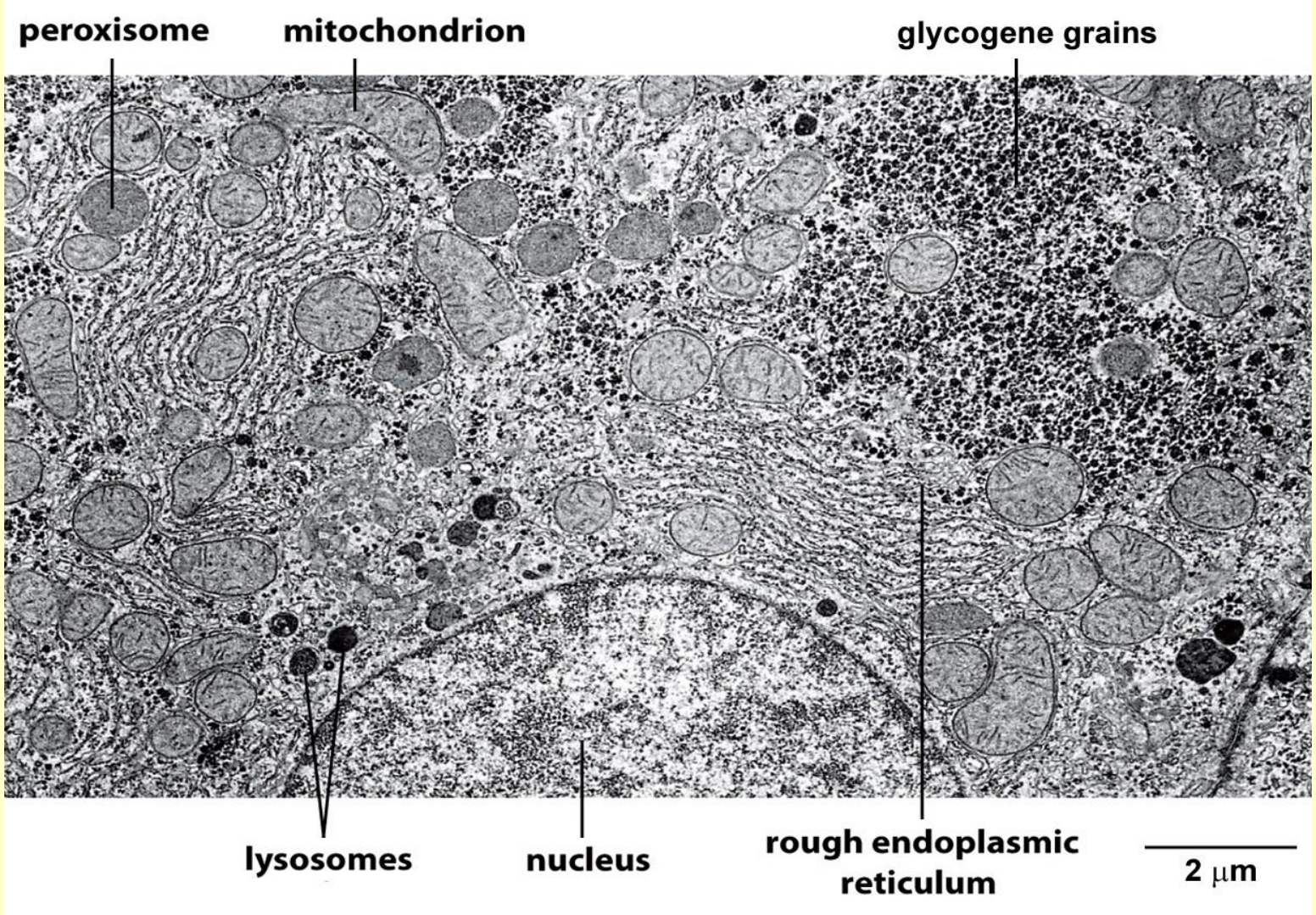
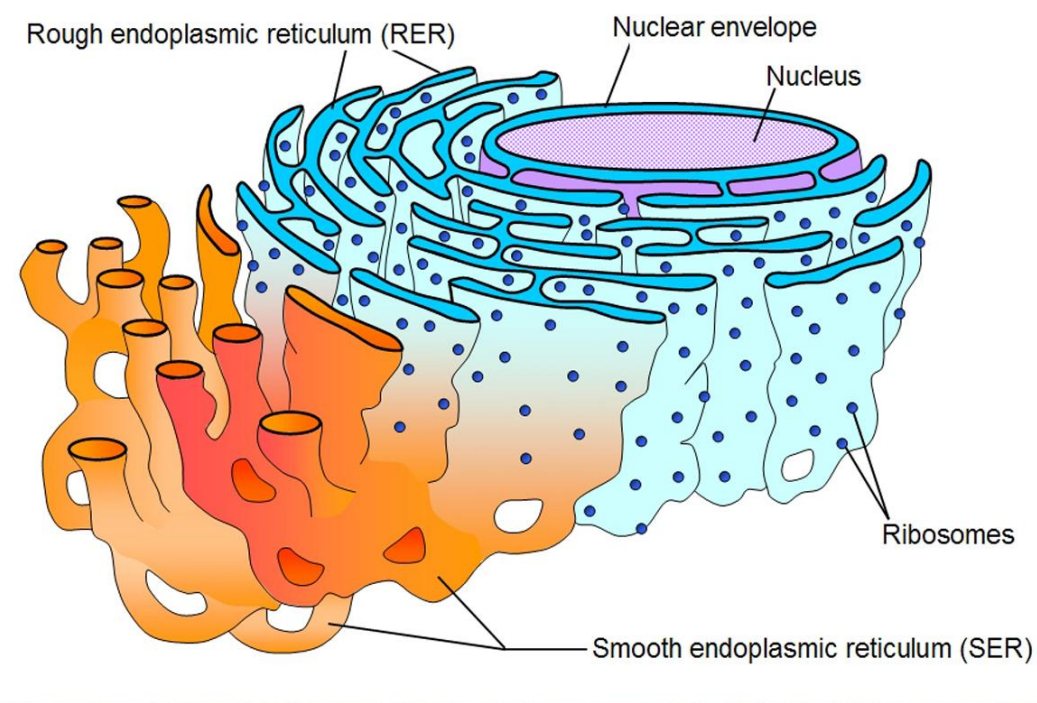


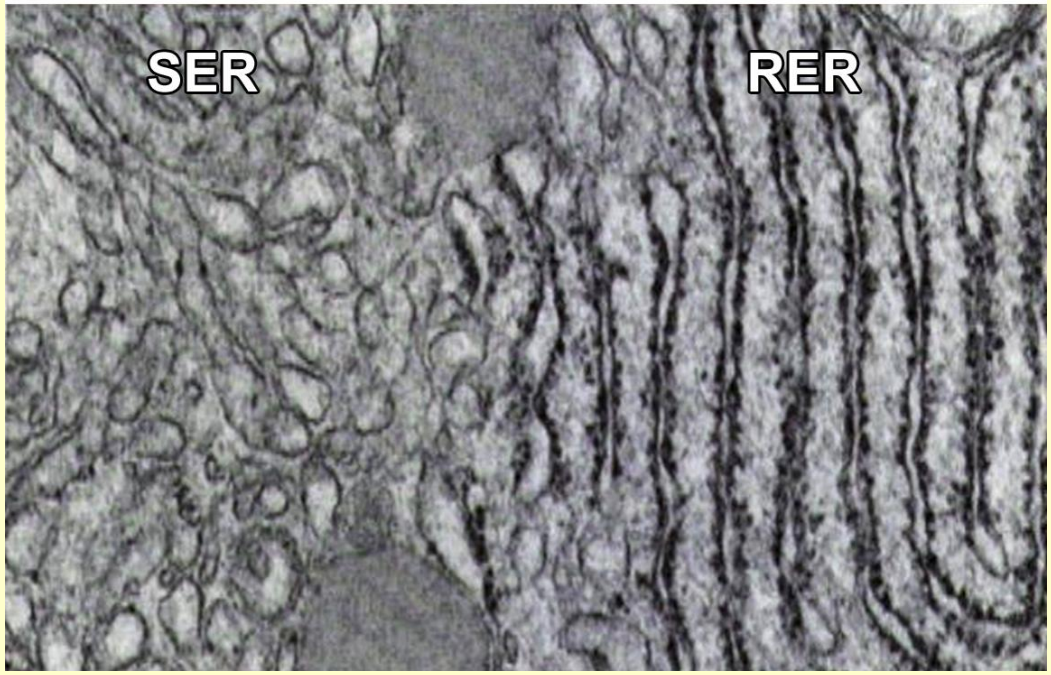
Figure 15-3 *Essential Cell Biology* (© Garland Science 2010)

Electron microscopic image of the area next to the nucleus

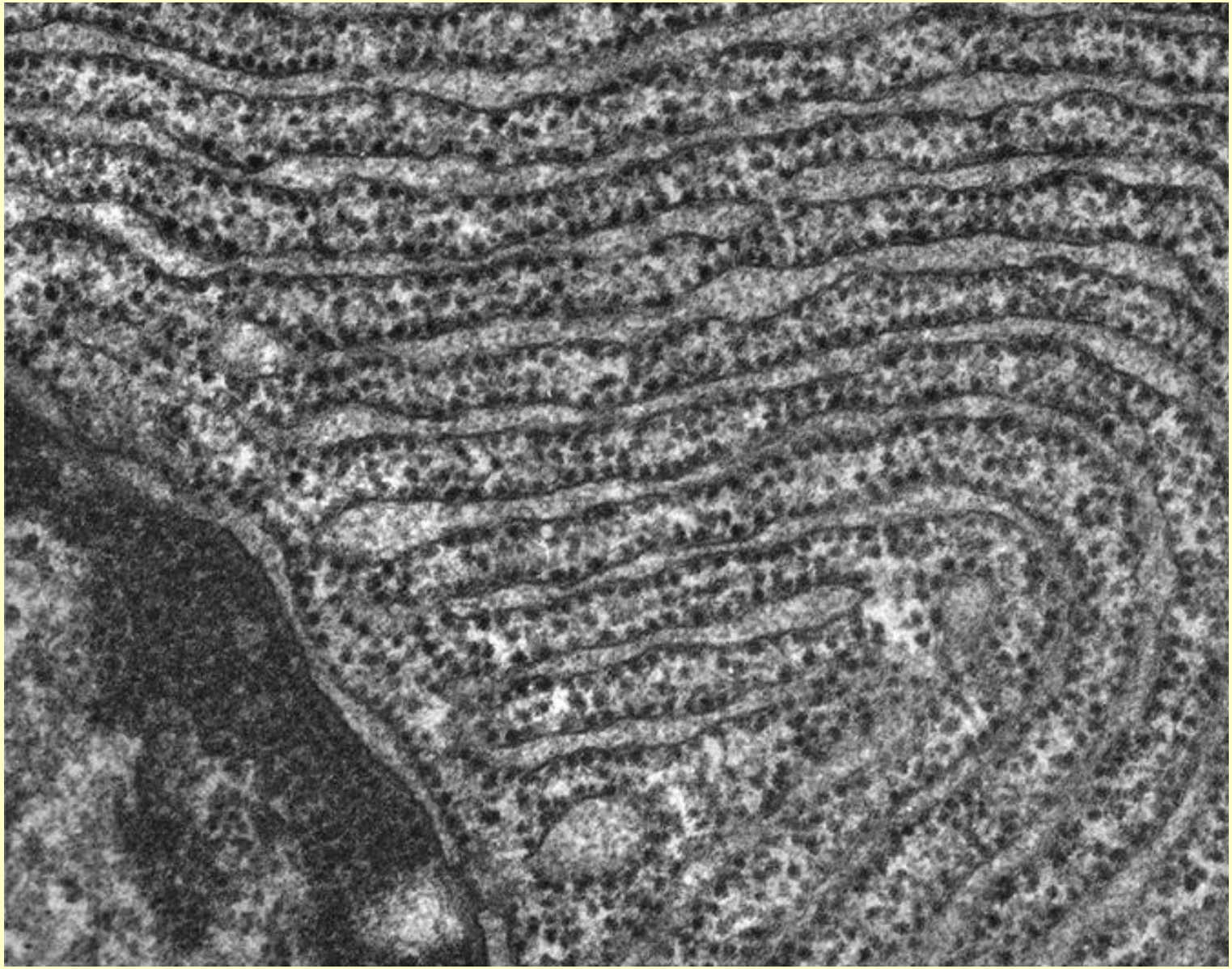


Rough (RER) and smooth (SER) endoplasmic reticulum

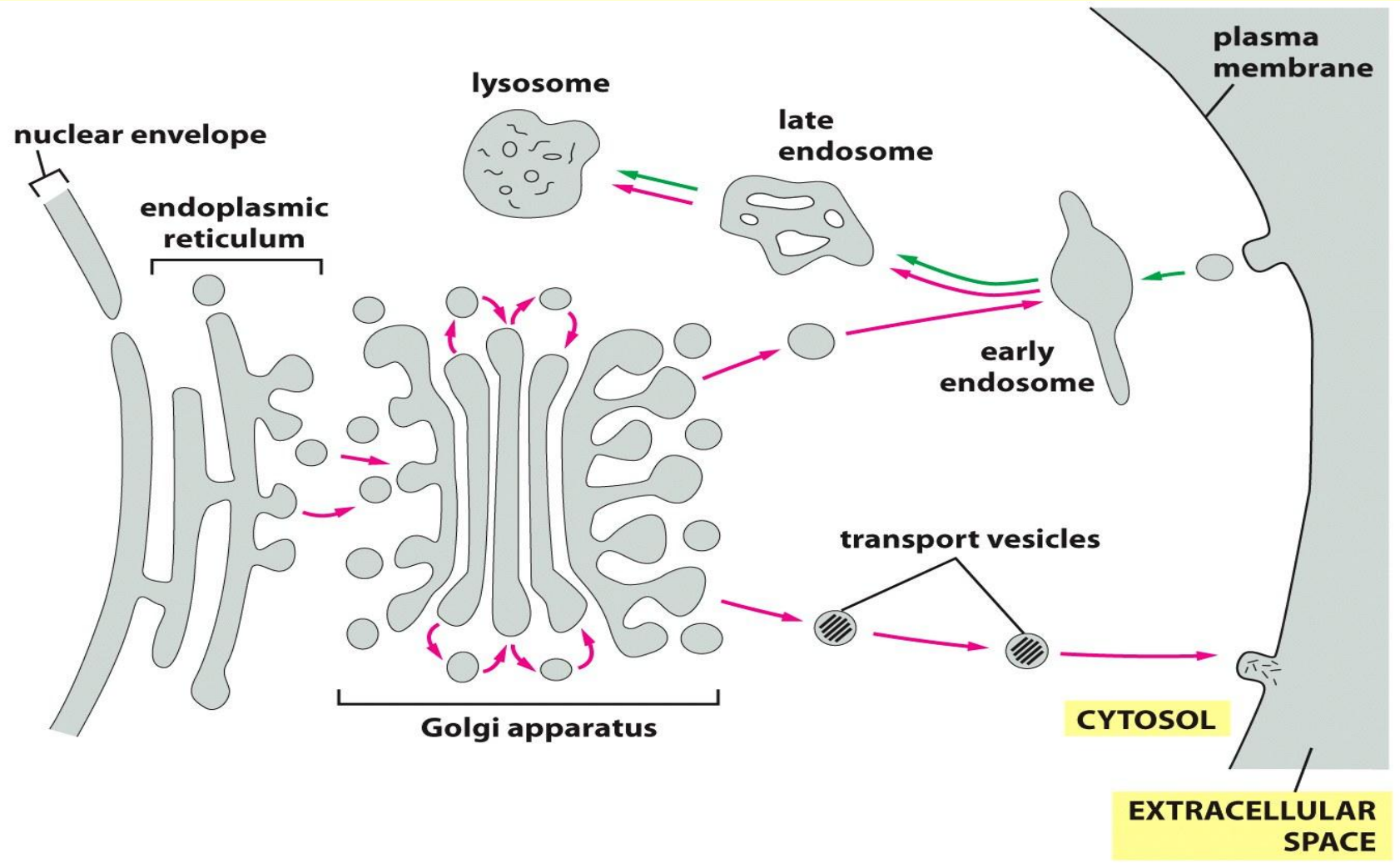




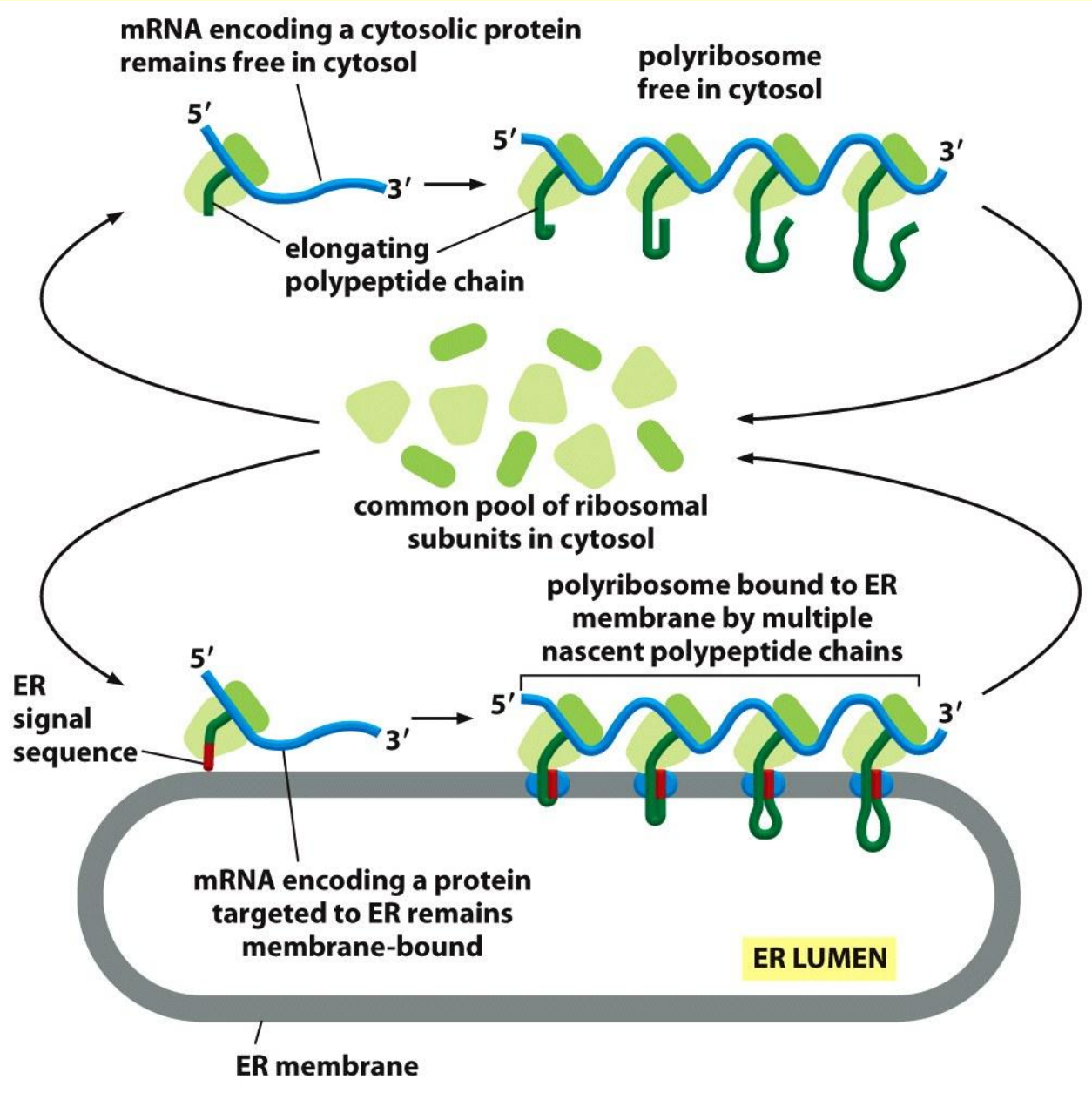
Closely packed sheets of rough ER with ribosomes



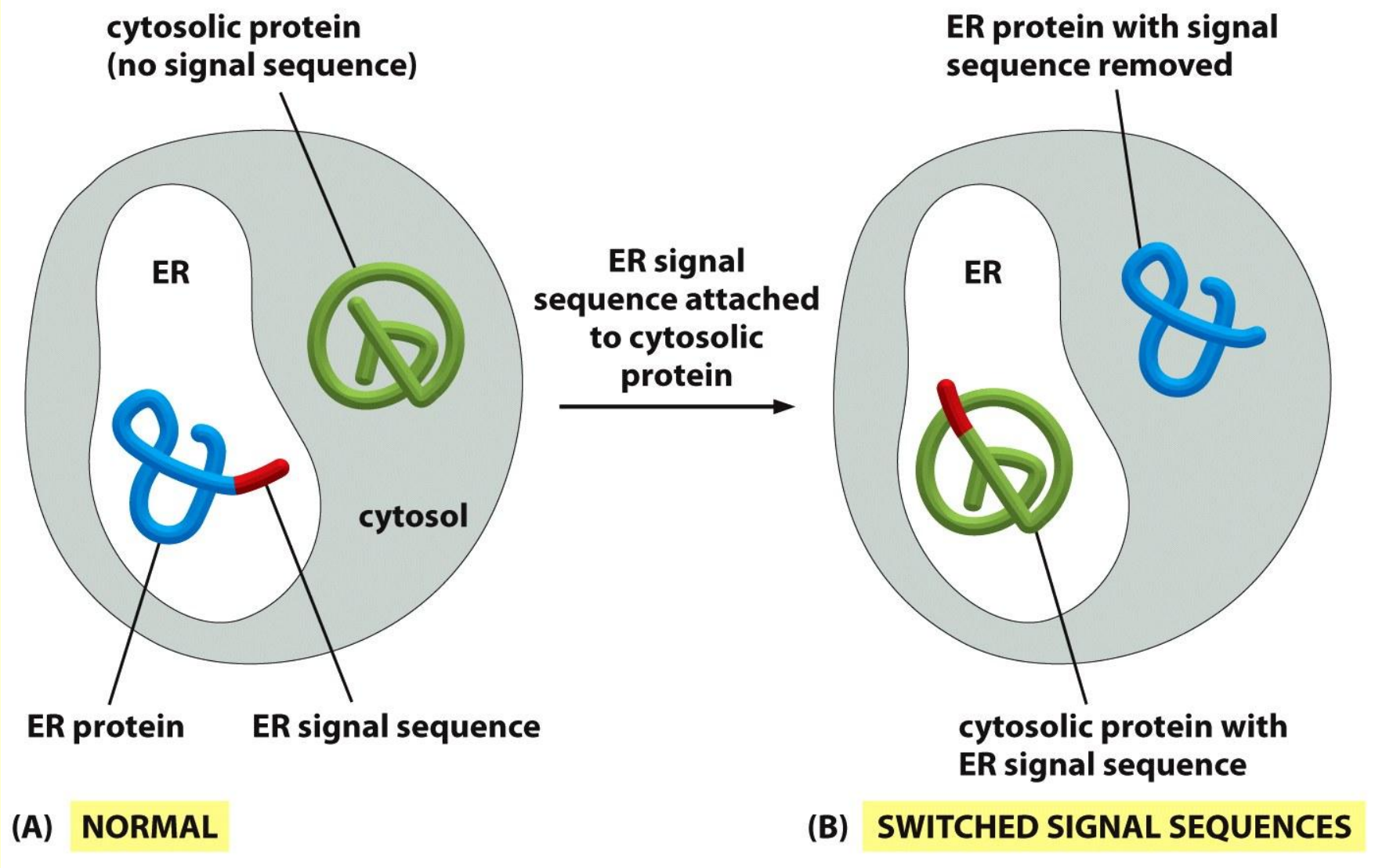
The primary role of ER: synthesis of secreted and membrane proteins



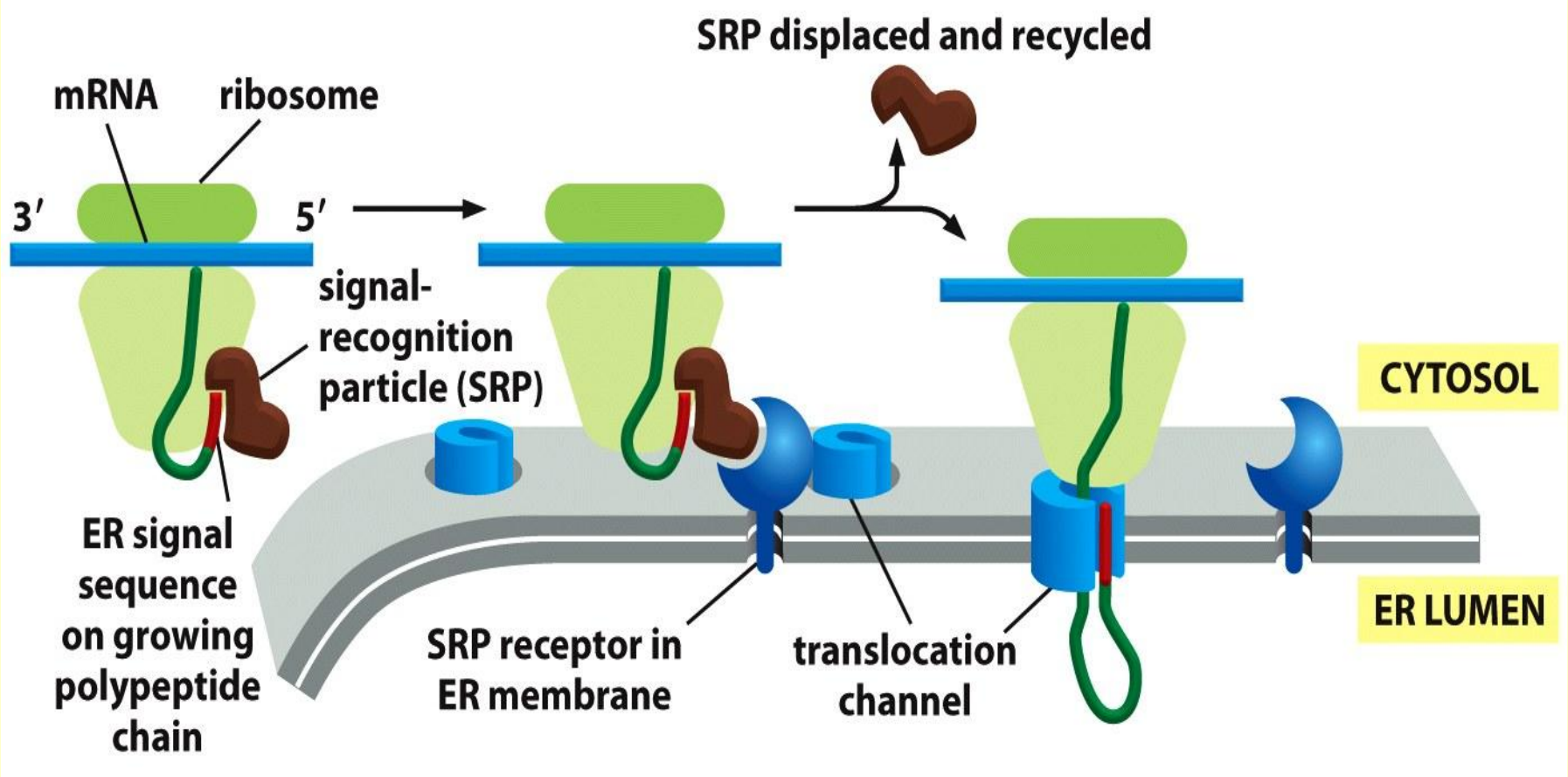
Secreted and membrane proteins contain an ER signal sequence, which takes them (together with a ribosome) to the ER during their synthesis.



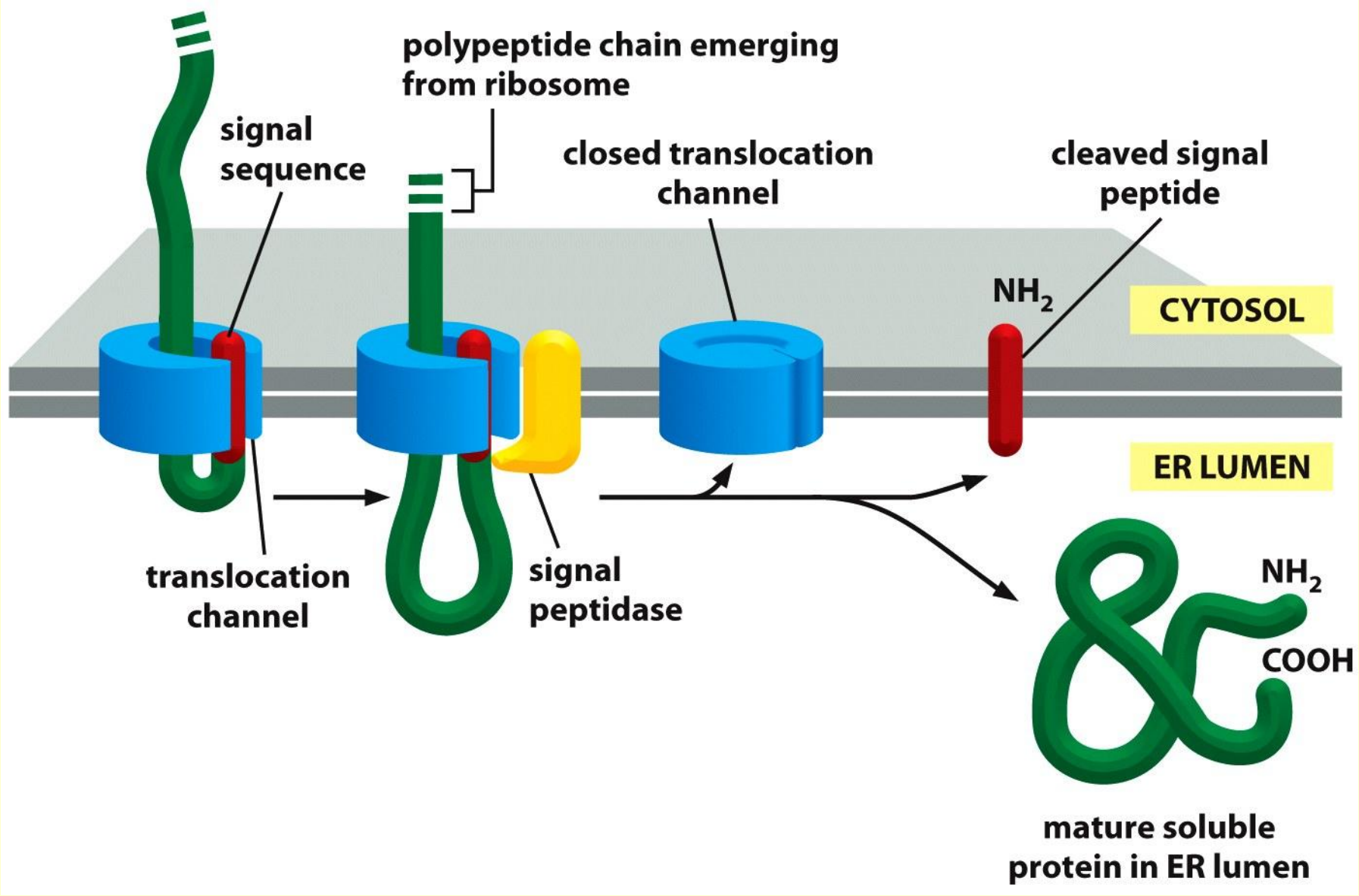
Evidence that ER signal sequence determines the localization of synthesized proteins



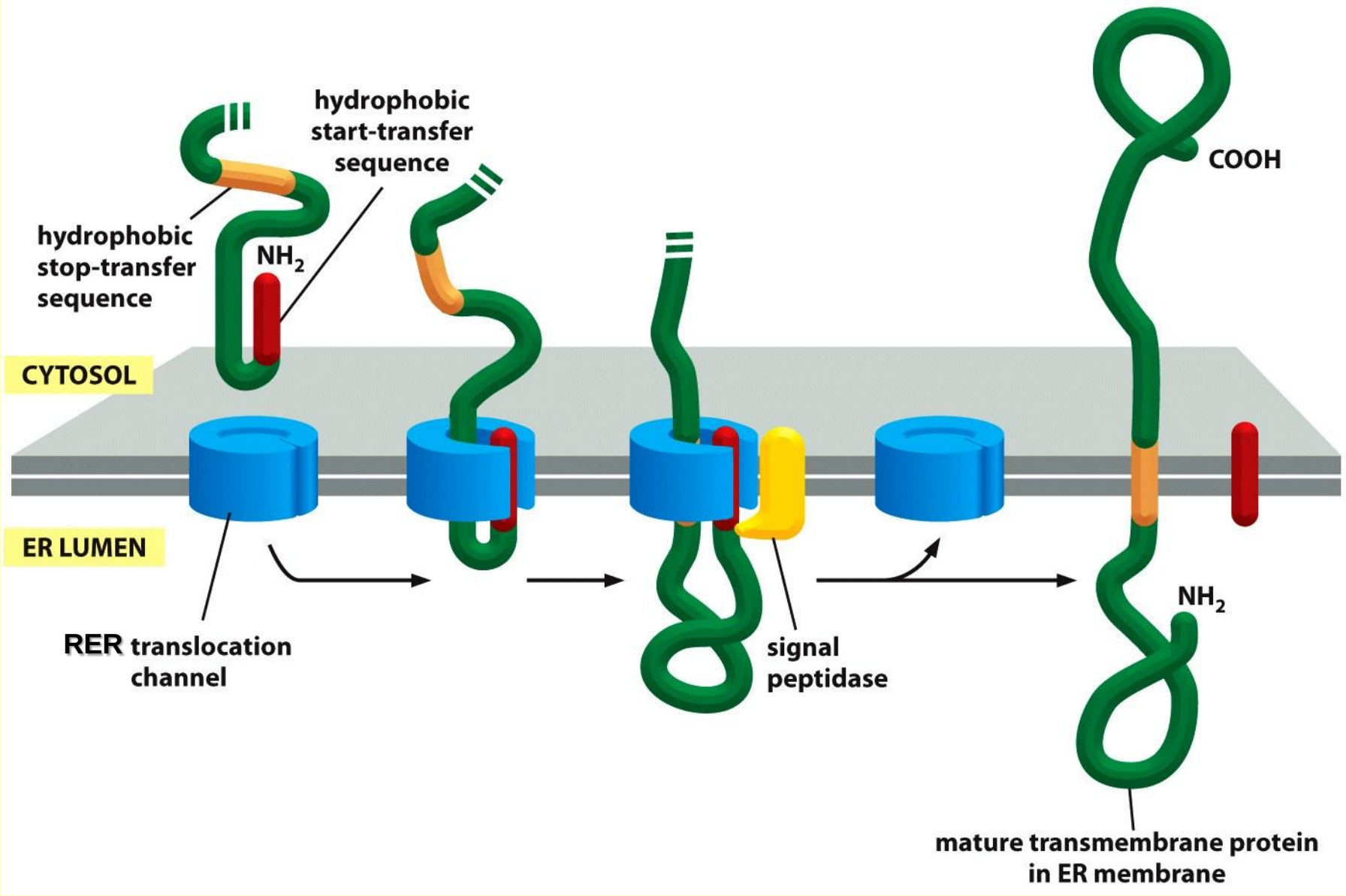
The mechanism how the ER signal sequence leads to protein synthesis into the ER



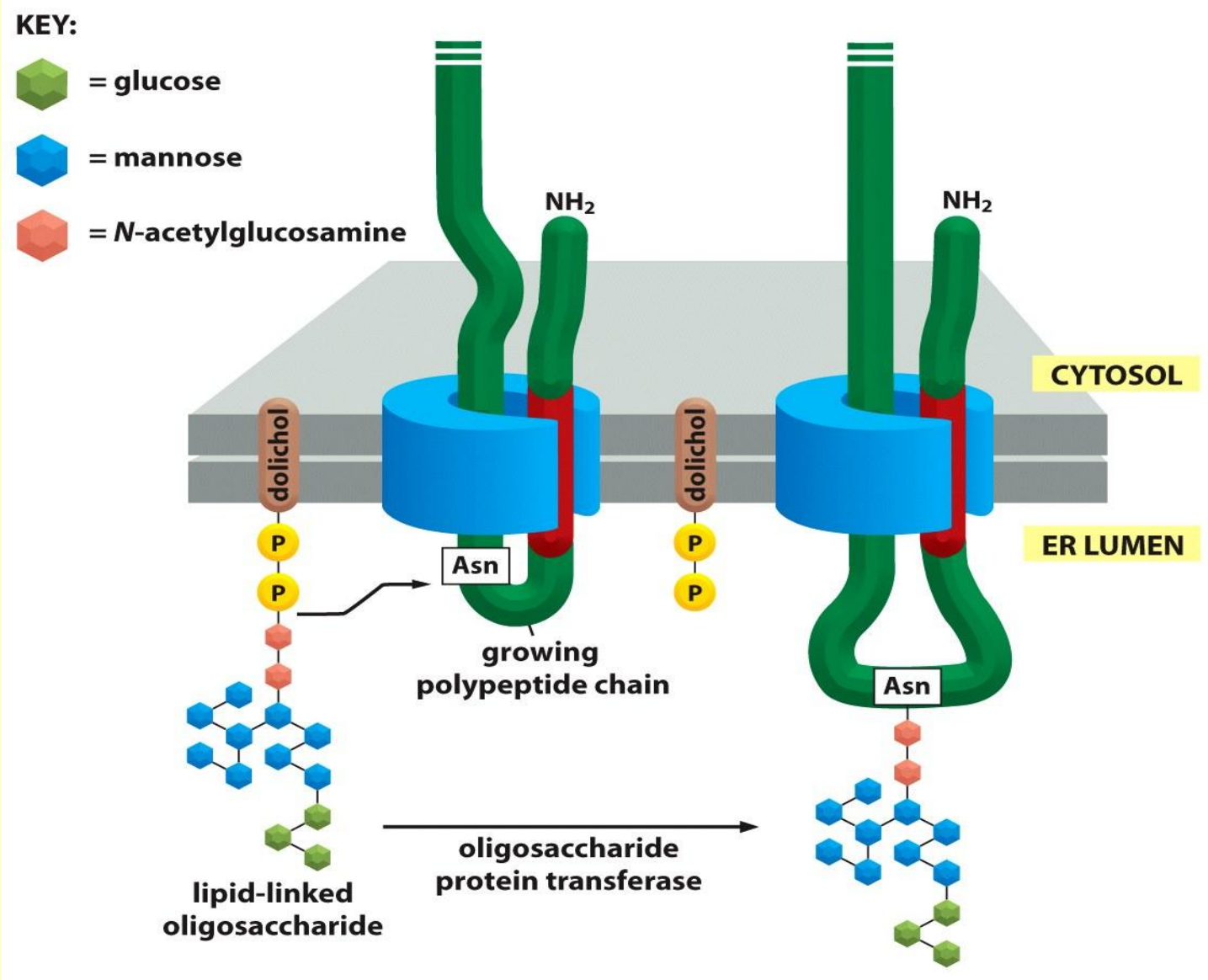
The synthesis of soluble proteins in the ER



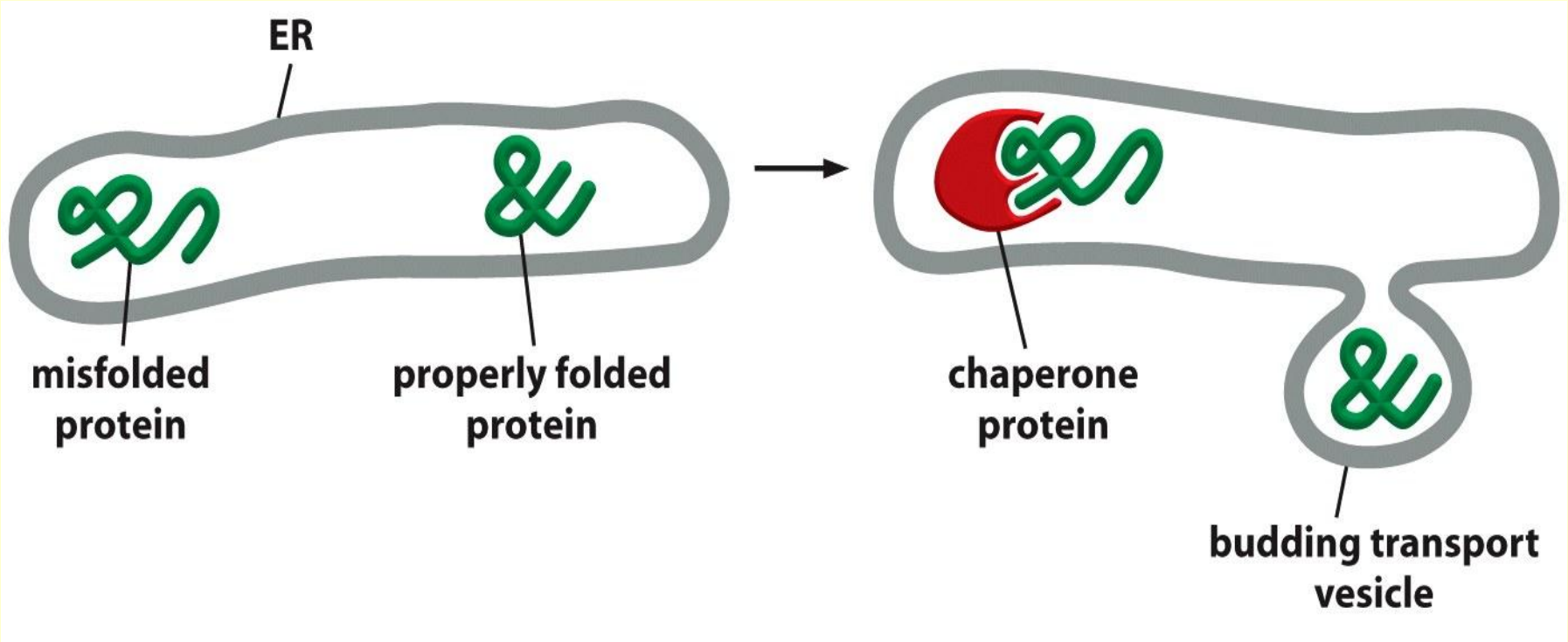
The synthesis of transmembrane proteins



Glycosylation in the ER

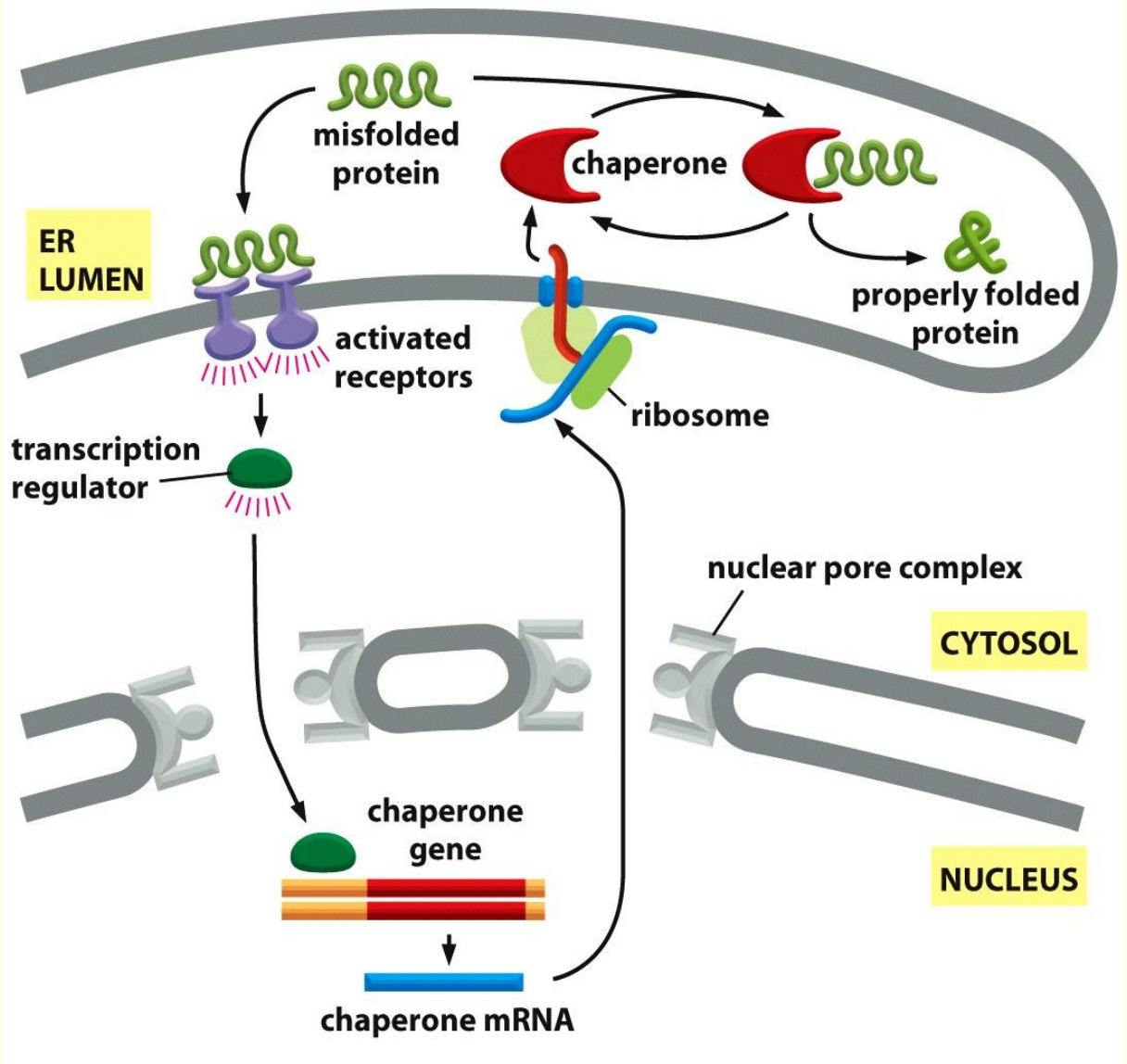


Proteins reach their final conformation within the ER



Chaperons help to reach the desired structure of proteins and prevent misfolded proteins leaving the ER

The unfolded protein response



High level of un- or mis-folded proteins in the ER induce gene expressional changes to

1. Increase the expression of chaperones
2. Lead to the expansion of the ER
3. Ultimately trigger apoptotic cell death

Functions of the ER

1. Synthesis of cellular membrane
2. Synthesis of transmembrane proteins, extracellular proteins, and internal proteins of the ER, Golgi apparatus, and the lysosomes
3. To assist and certify the proper folding of synthesized proteins
4. Posttranslational modification of proteins including the formation of disulphide bridges, glycosylation
5. Lipid synthesis
6. Glycogen and steroid synthesis (smooth endoplasmic reticulum)
7. Storage and regulated release of Ca ions

Thank you
for your attention!