Fisica do Corpo Humano (4300325)

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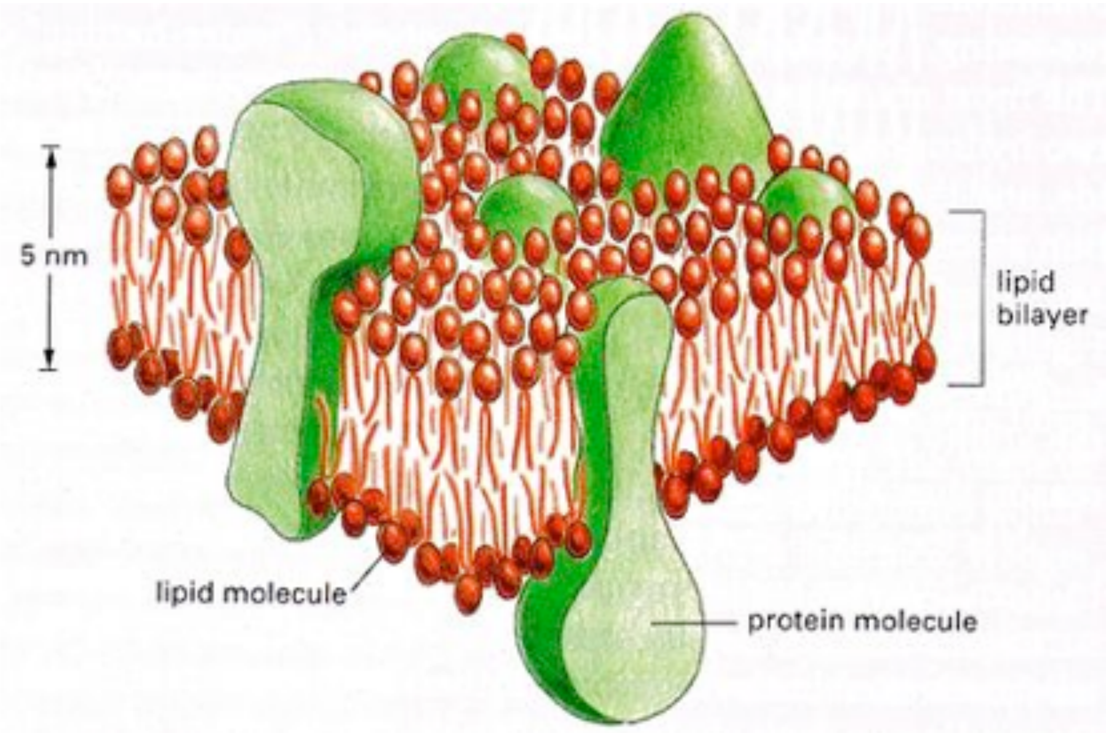
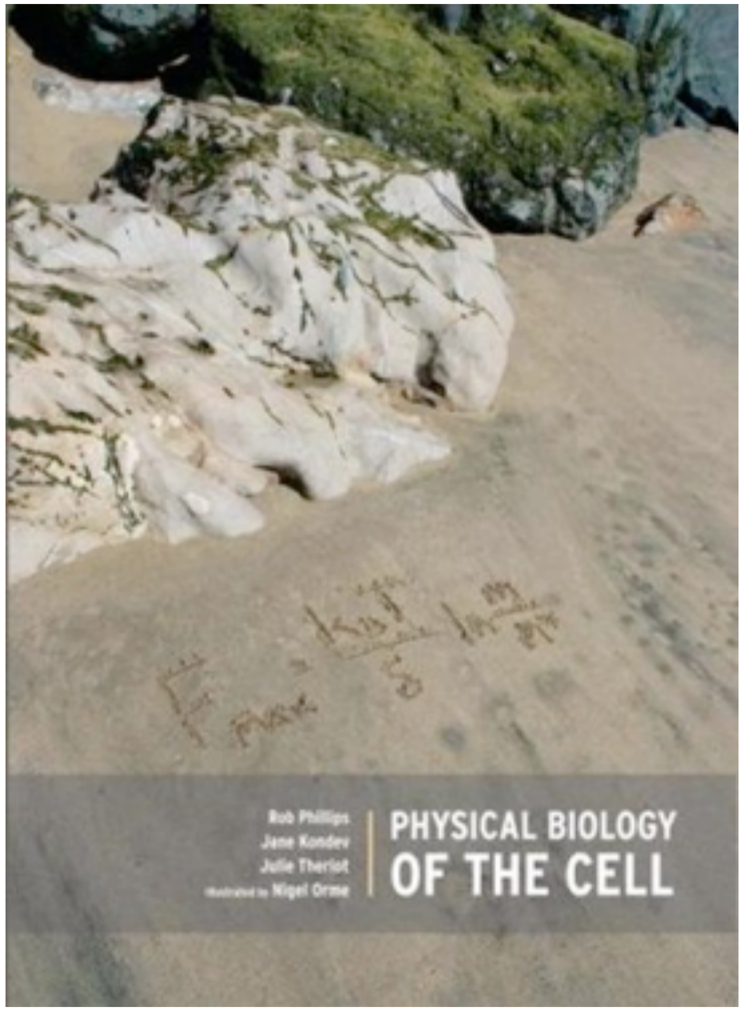
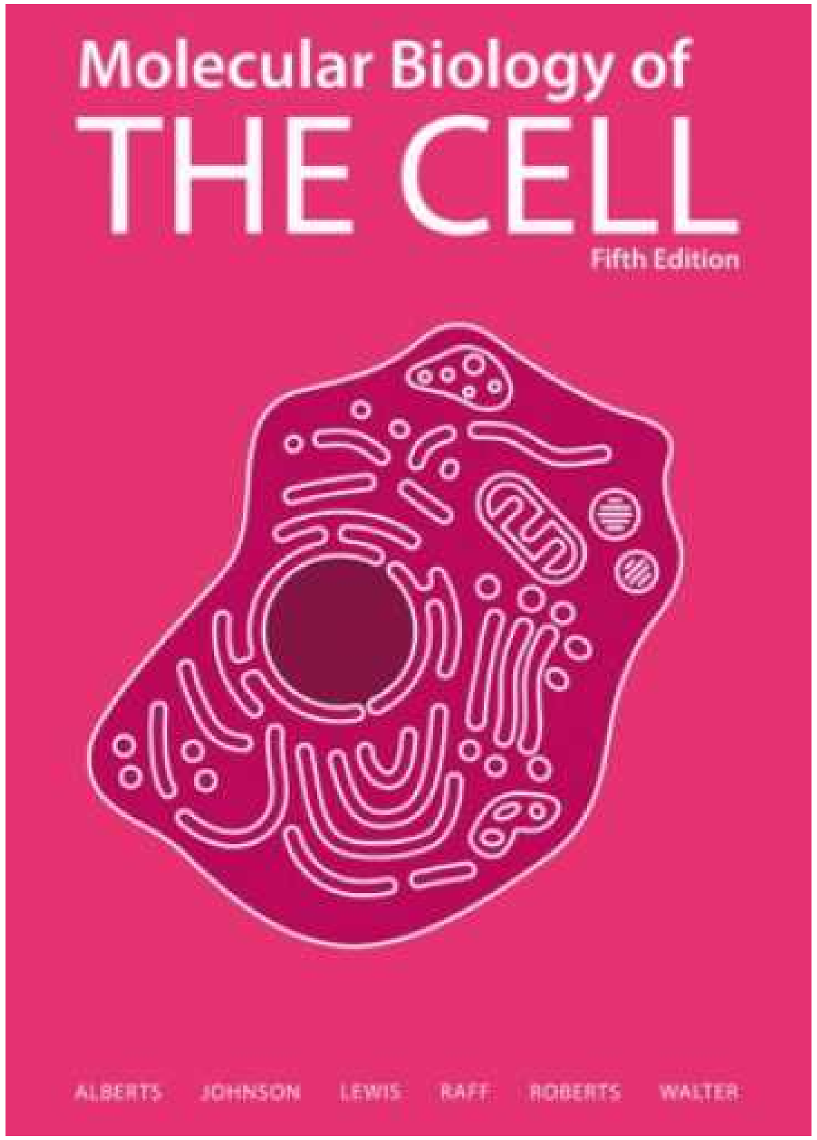
B07

Transporte na Célula
Aula 12 e 13

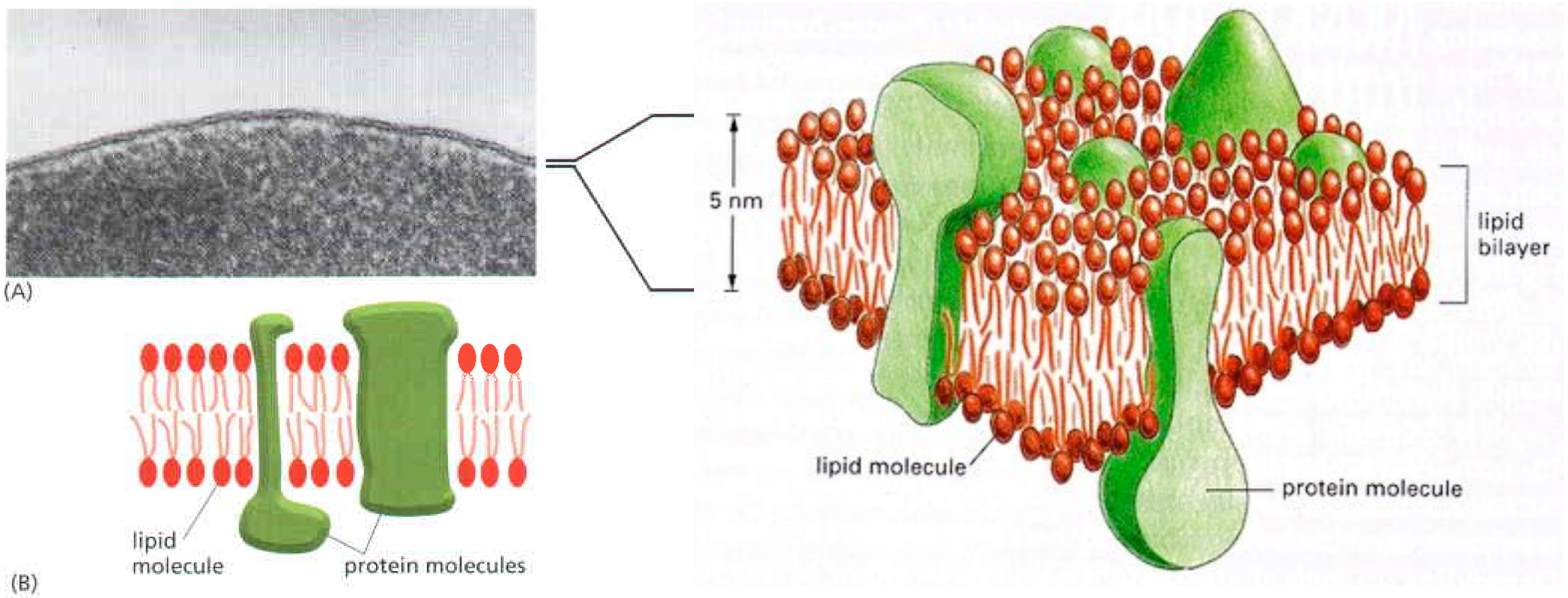


Princípios Físicos Aplicados à Fisiologia (PGF5306-1)





Membranas Celulares



Fosfogliceridio

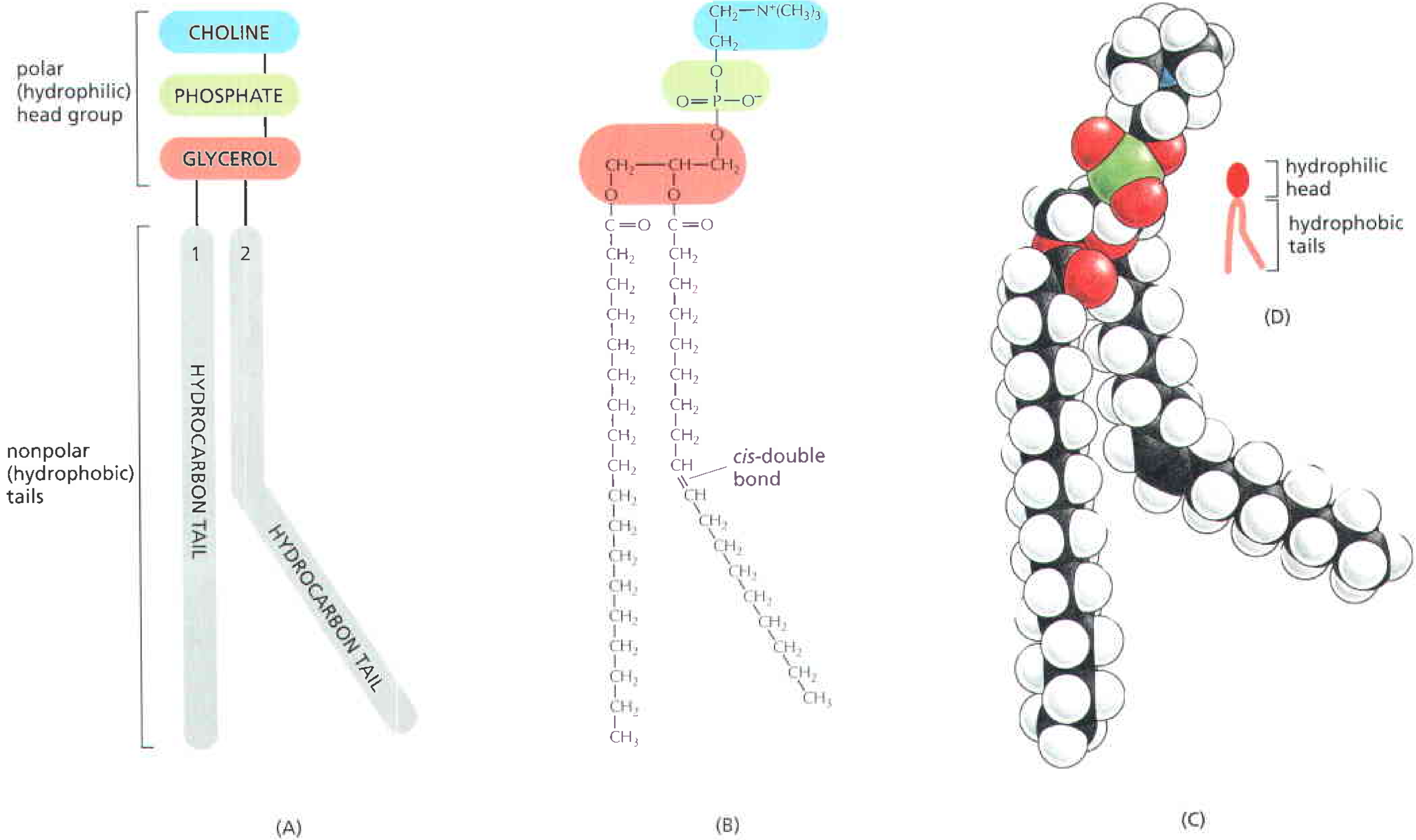
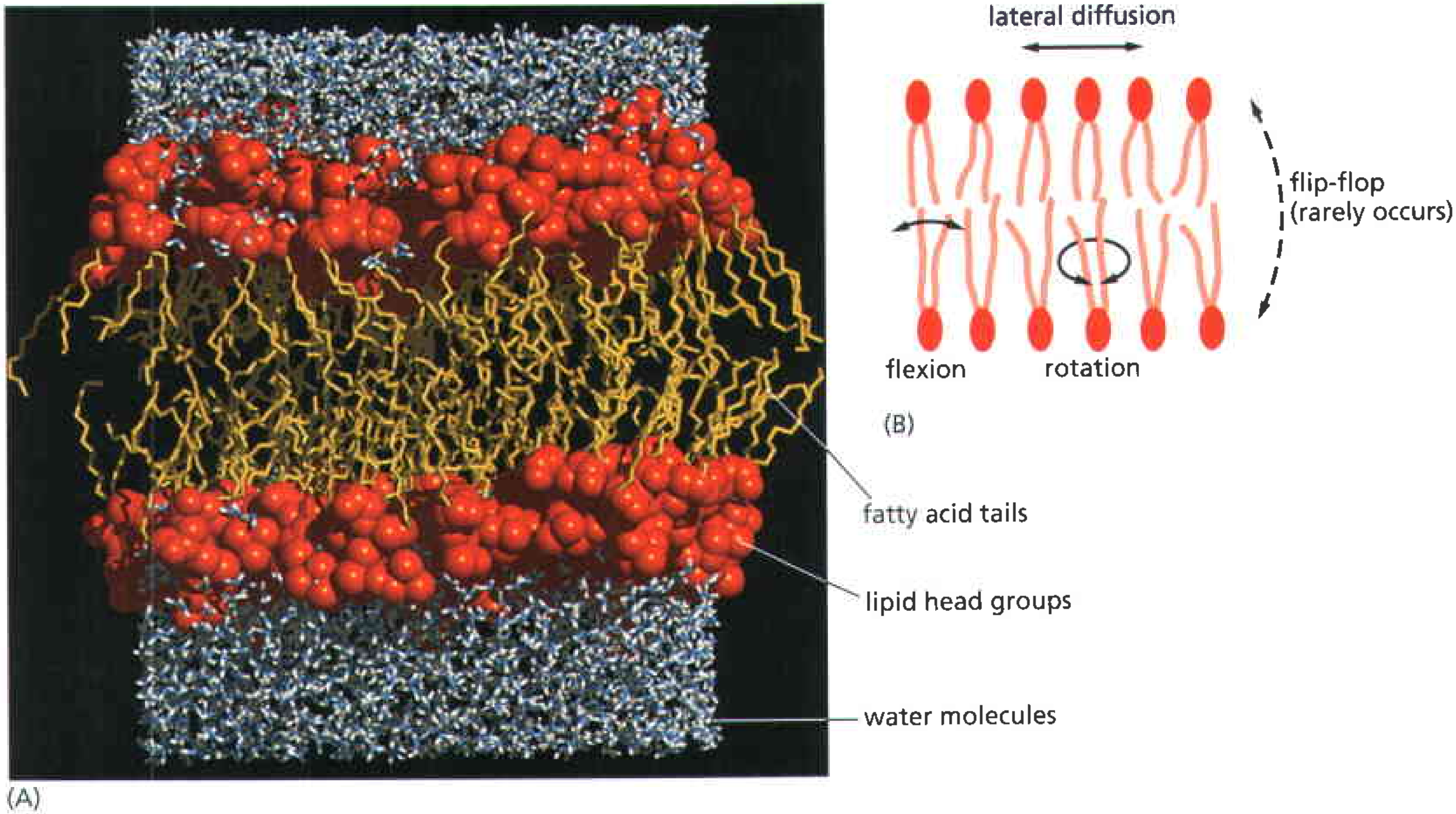


Figure 10–2 The parts of a phosphoglyceride molecule. This example is a phosphatidylcholine, represented (A) schematically, (B) by a formula, (C) as a space-filling model, and (D) as a symbol. The kink resulting from the *cis*-double bond is exaggerated for emphasis.

Bicamada



lateral diffusion
flip-flop
(rarely occurs)
flexion
rotation
(B)
fatty acid tails
lipid head groups
water molecules
(A)

Energia da Bicamada

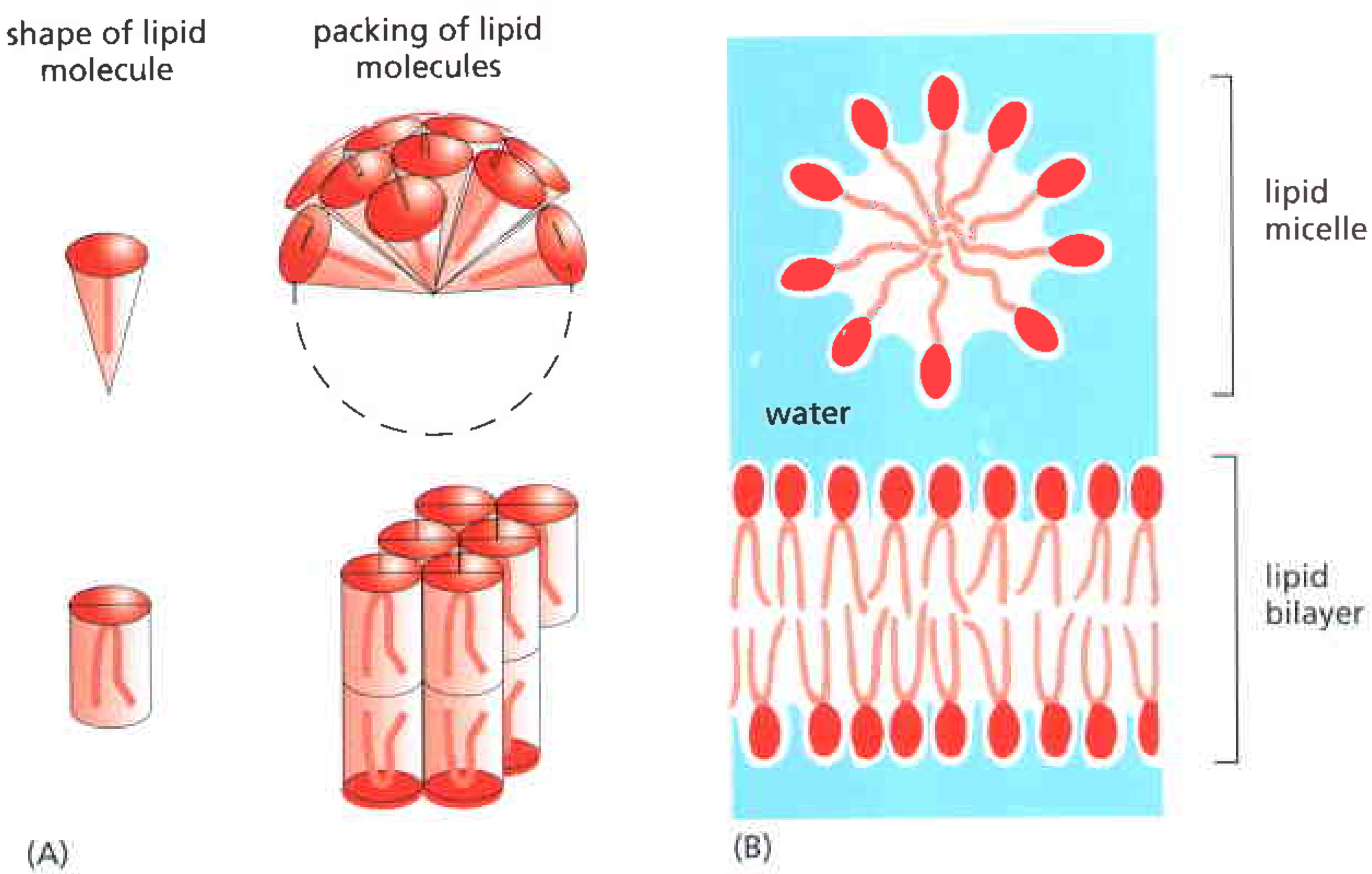


Figure 10–7 Packing arrangements of lipid molecules in an aqueous environment. (A) Cone-shaped lipid molecules *(above)* form micelles, whereas cylinder-shaped phospholipid molecules *(below)* form bilayers. (B) A lipid micelle and a lipid bilayer seen in cross section. Lipid molecules spontaneously form one or the other structure in water, depending on their shape.

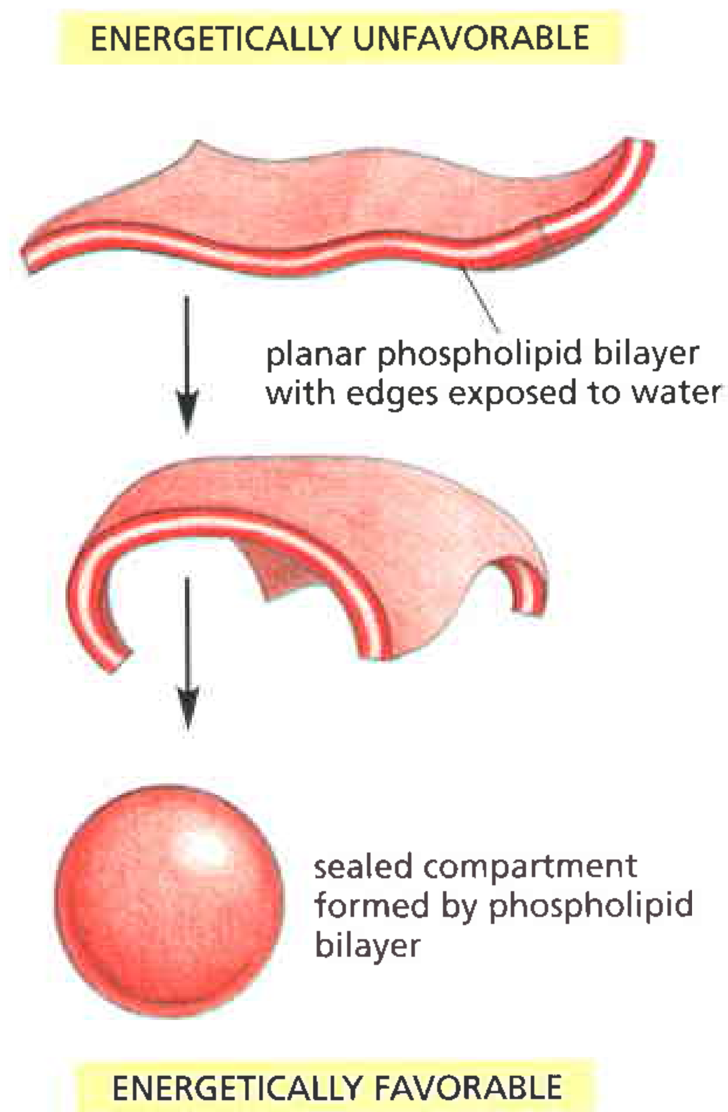


Figure 10–8 **The spontaneous closure of a phospholipid bilayer to form a sealed compartment.** The closed structure is stable because it avoids the exposure of the hydrophobic hydrocarbon tails to water, which would be energetically unfavorable.

Energia da Bicamada

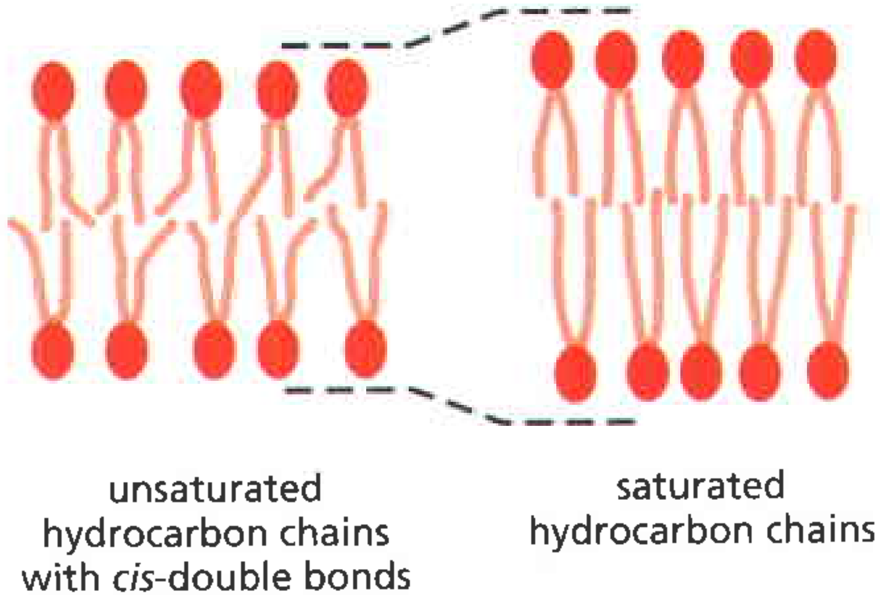


Figure 10–12 The influence of *cis*-double bonds in hydrocarbon chains. The double bonds make it more difficult to pack the chains together, thereby making the lipid bilayer more difficult to freeze. In addition, because the hydrocarbon chains of unsaturated lipids are more spread apart, lipid bilayers containing them are thinner than bilayers formed exclusively from saturated lipids.

Colesterol modula as propriedades das bicamadas. Por exemplo, pode reduzir a permeabilidade para pequenas moléculas soluceis em agua

Table 10–1 Approximate Lipid Compositions of Different Cell Membranes

	PERCENTAGE OF TOTAL LIPID BY WEIGHT					
LIPID	LIVER CELL PLASMA MEMBRANE	RED BLOOD CELL PLASMA MEMBRANE	MYELIN	MITOCHONDRION (INNER AND OUTER MEMBRANES)	ENDOPLASMIC RETICULUM	*E. COLI* BACTERIUM
Cholesterol	17	23	22	3	6	0
Phosphatidylethanolamine	7	18	15	28	17	70
Phosphatidylserine	4	7	9	2	5	trace
Phosphatidylcholine	24	17	10	44	40	0
Sphingomyelin	19	18	8	0	5	0
Glycolipids	7	3	28	trace	trace	0
Others	22	14	8	23	27	30

Hidrofobicidade

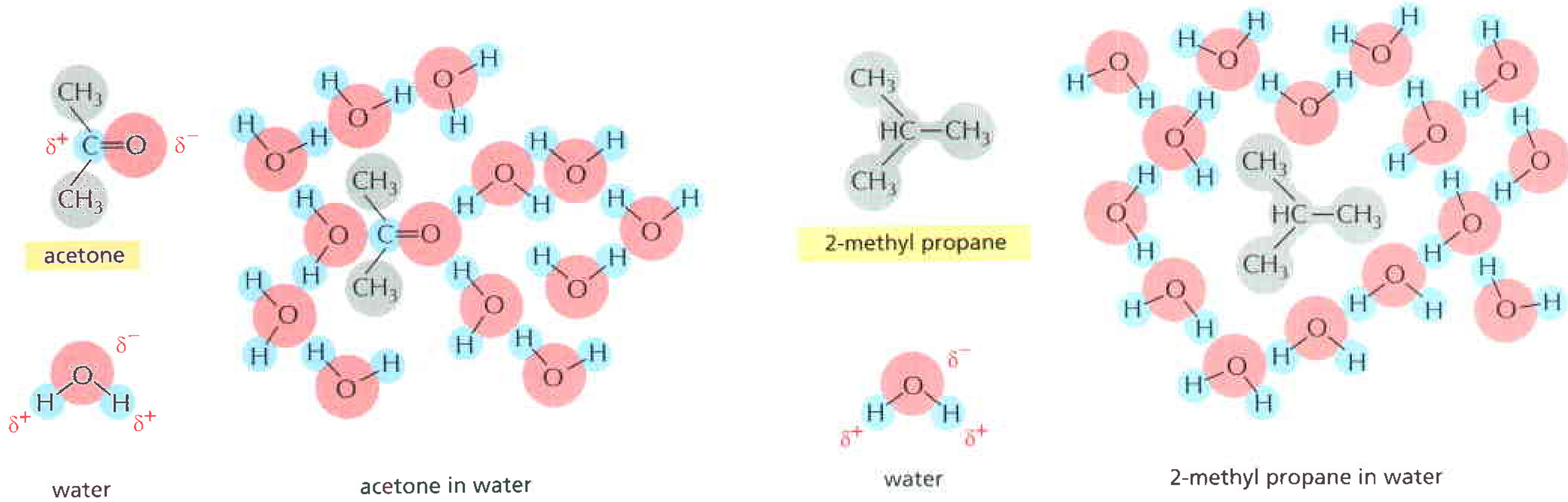


Figure 10–6 How hydrophilic and hydrophobic molecules interact differently with water. (A) Because acetone is polar, it can form favorable electrostatic interactions with water molecules, which are also polar. Thus, acetone readily dissolves in water. (B) By contrast, 2-methyl propane is entirely hydrophobic. Because it cannot form favorable interactions with water, it would force adjacent water molecules to reorganize into icelike cage structures, which increases the free energy. This compound is therefore virtually insoluble in water. The symbol δ^- indicates a partial negative charge, and δ^+ indicates a partial positive charge. Polar atoms are shown in color and nonpolar groups are shown in *gray*.

Sinalização

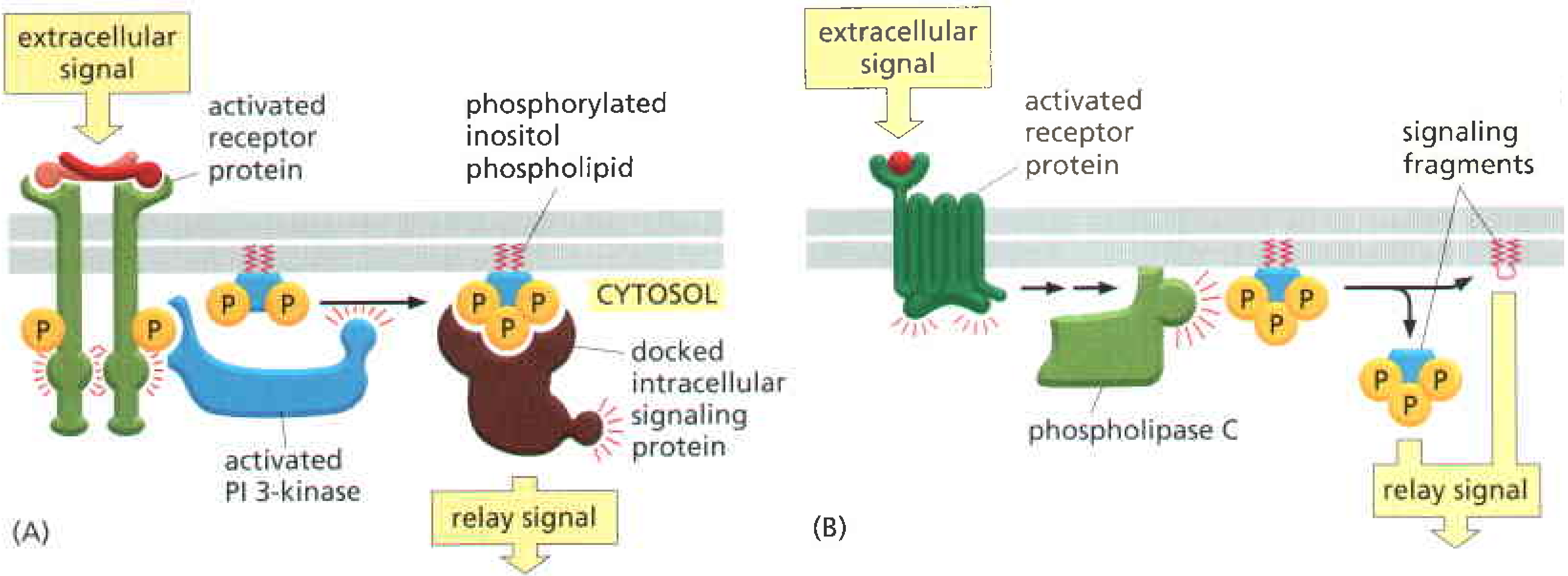
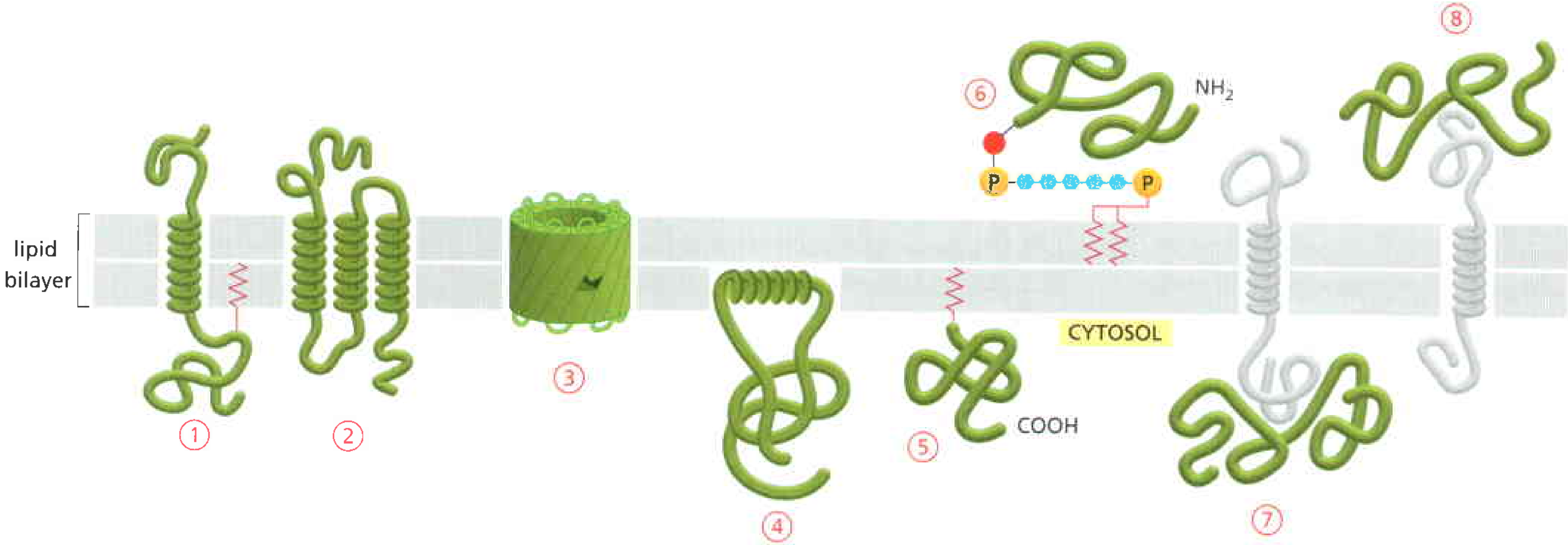


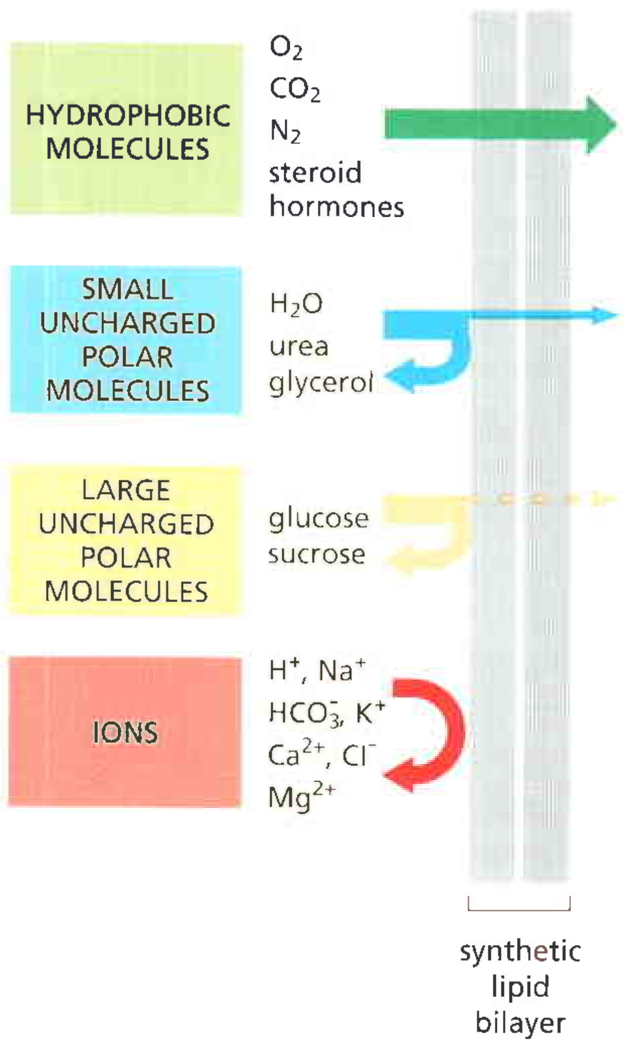
Figure 10–17 Two signaling functions of inositol phospholipids in the cytosolic leaflet of the plasma membrane. (A) Some extracellular signals activate PI 3-kinase, which phosphorylates inositol phospholipids, creating docking sites for various intracellular signaling proteins. (B) Some extracellular signals activate phospholipases that cleave inositol phospholipids, generating fragments that help relay the signal into the cell (see also Figure 15–38). (C) The sites where different classes of phospholipases cleave phospholipids. The structure of phosphatidylinositol (4,5) diphosphate is shown. Phospholipases C operate in the signaling pathways shown in (B).

Proteínas nas membranas



Transportes Celulares

Na ausência de proteínas, membranas são impermeáveis a íons devido a carga e a forte hidratação dos mesmos



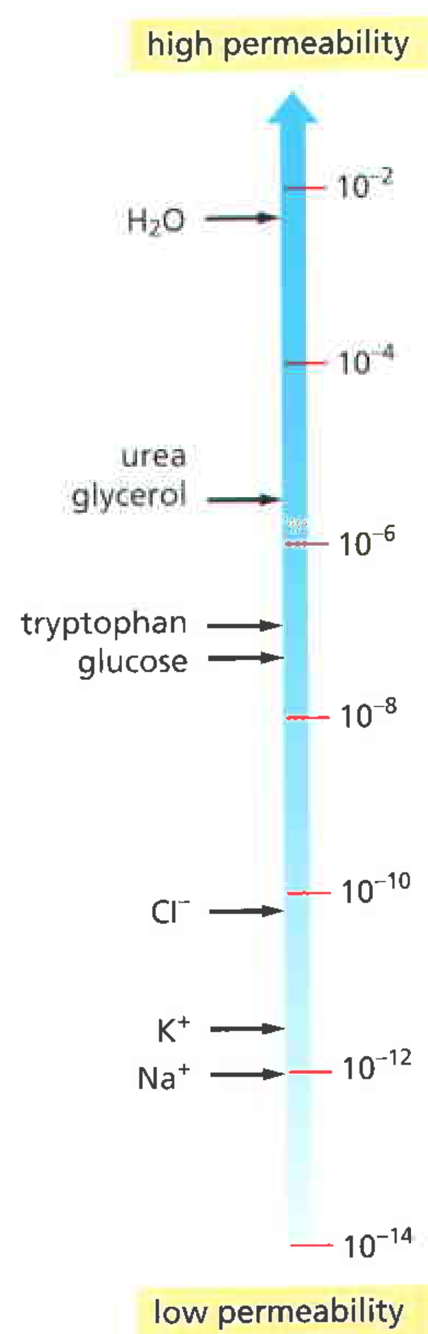
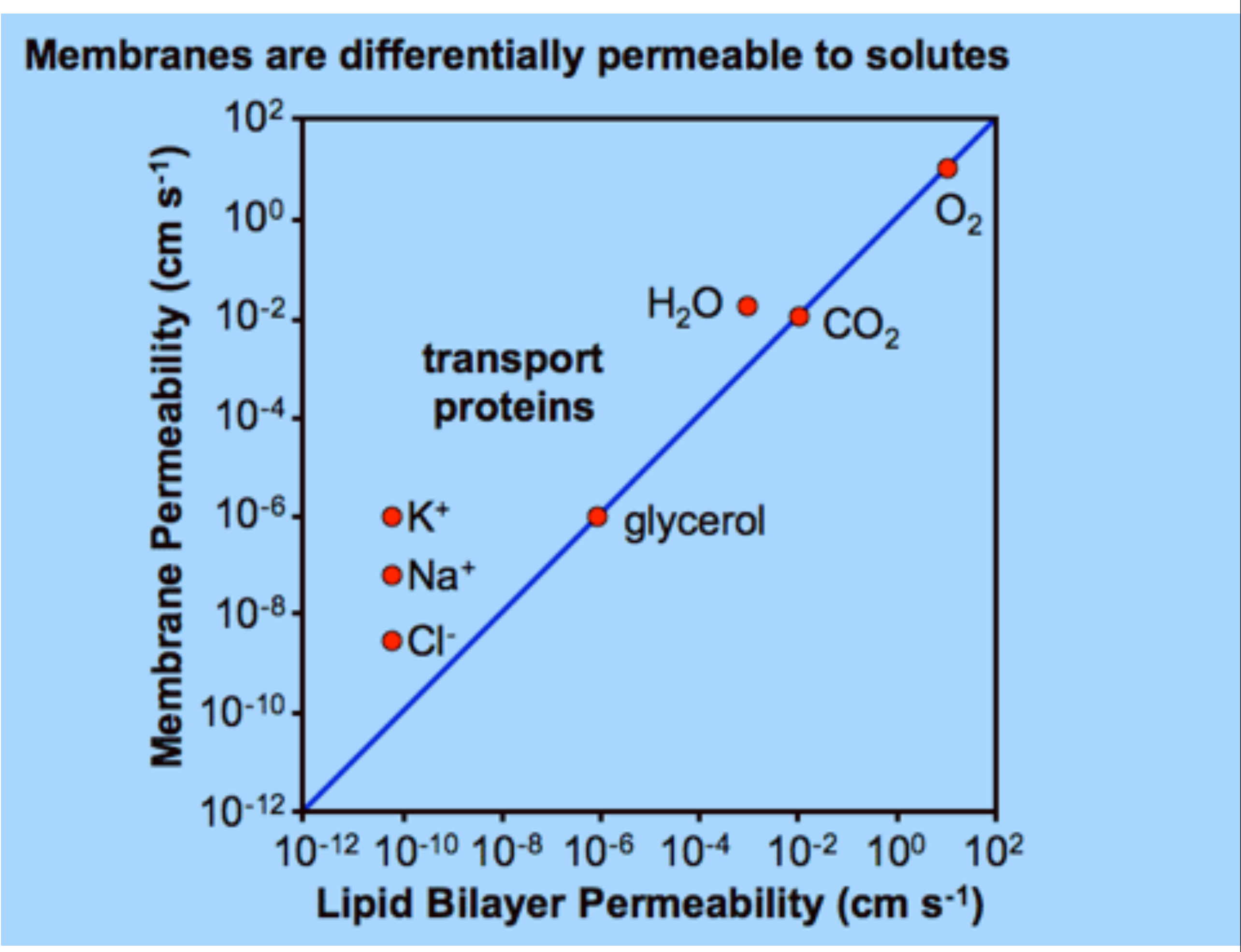


Figure 11–1 The relative permeability of a synthetic lipid bilayer to different classes of molecules. The smaller the molecule and, more importantly, the less strongly it associates with water, the more rapidly the molecule diffuses across the bilayer.



Principios

2/3 da energia metabólica total da célula é gasta com transporte

Table 11–1 A Comparison of Ion Concentrations Inside 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^+	7×10^{-5} ($10^{-7.2}$ M or pH 7.2)	4×10^{-5} ($10^{-7.4}$ M or pH 7.4)
Anions*		
Cl^-	5–15	110

*The cell must contain equal quantities of positive and negative charges (that is, it must be electrically neutral). Thus, in addition to Cl^-, the cell contains many other anions not listed in this table; in fact, most cell 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 both are mostly bound to proteins and other substances and, for Ca^{2+}, stored within various organelles.

Transporte Passivo

Todos os canais e a maioria dos transportadores permitem o soluto passar apenas passivamente, de acordo com a concentração do gradiente.

Transporte passivo ou **difusão facilitada**

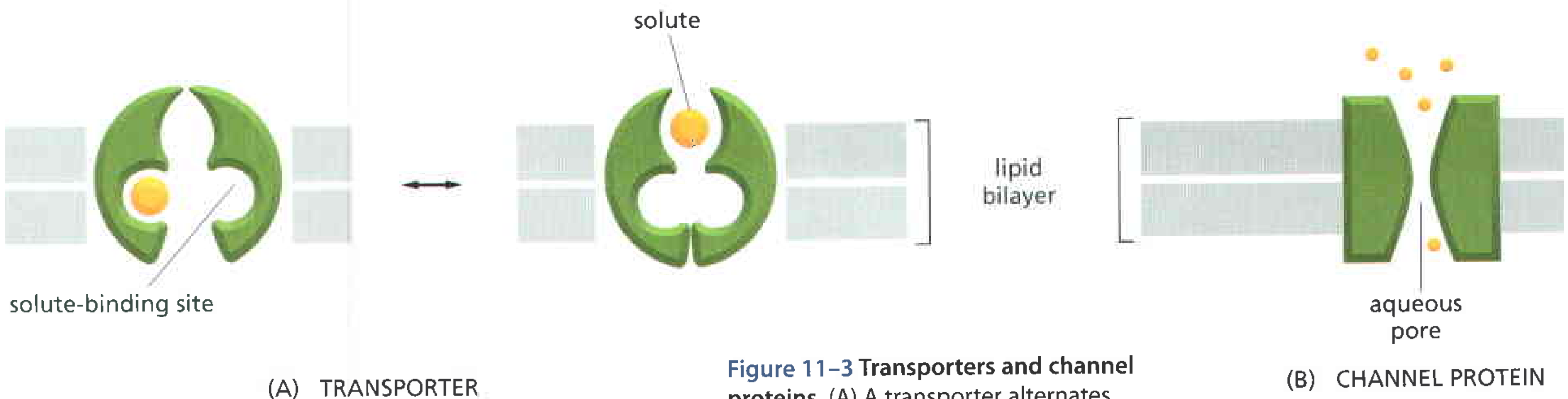


Figure 11–3 **Transporters and channel proteins.** (A) A transporter alternates between two conformations, so that the solute-binding site is sequentially accessible on one side of the bilayer and then on the other. (B) In contrast, a channel protein forms a water-filled pore across the bilayer through which specific solutes can diffuse.

Transporte Passivo

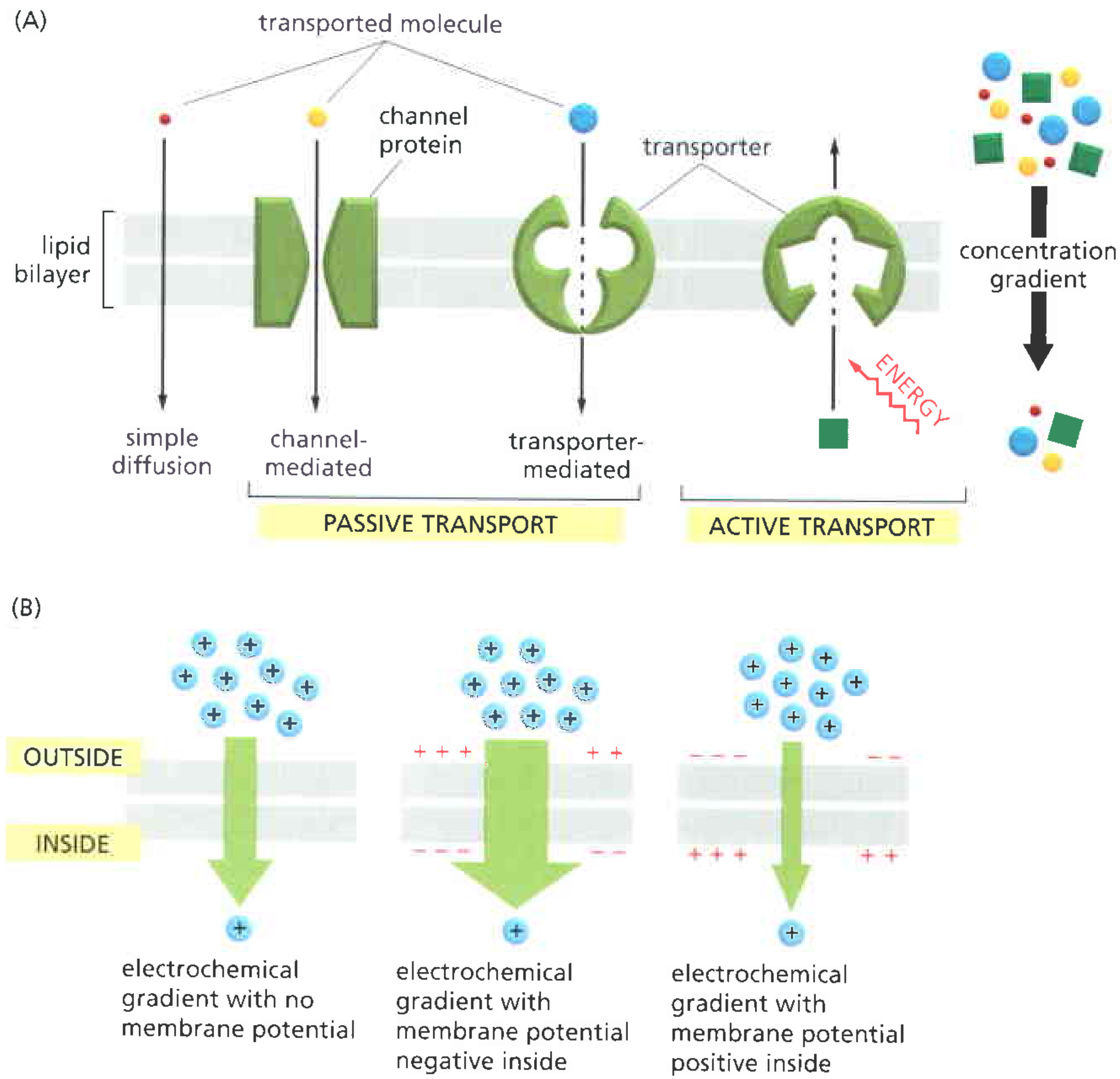
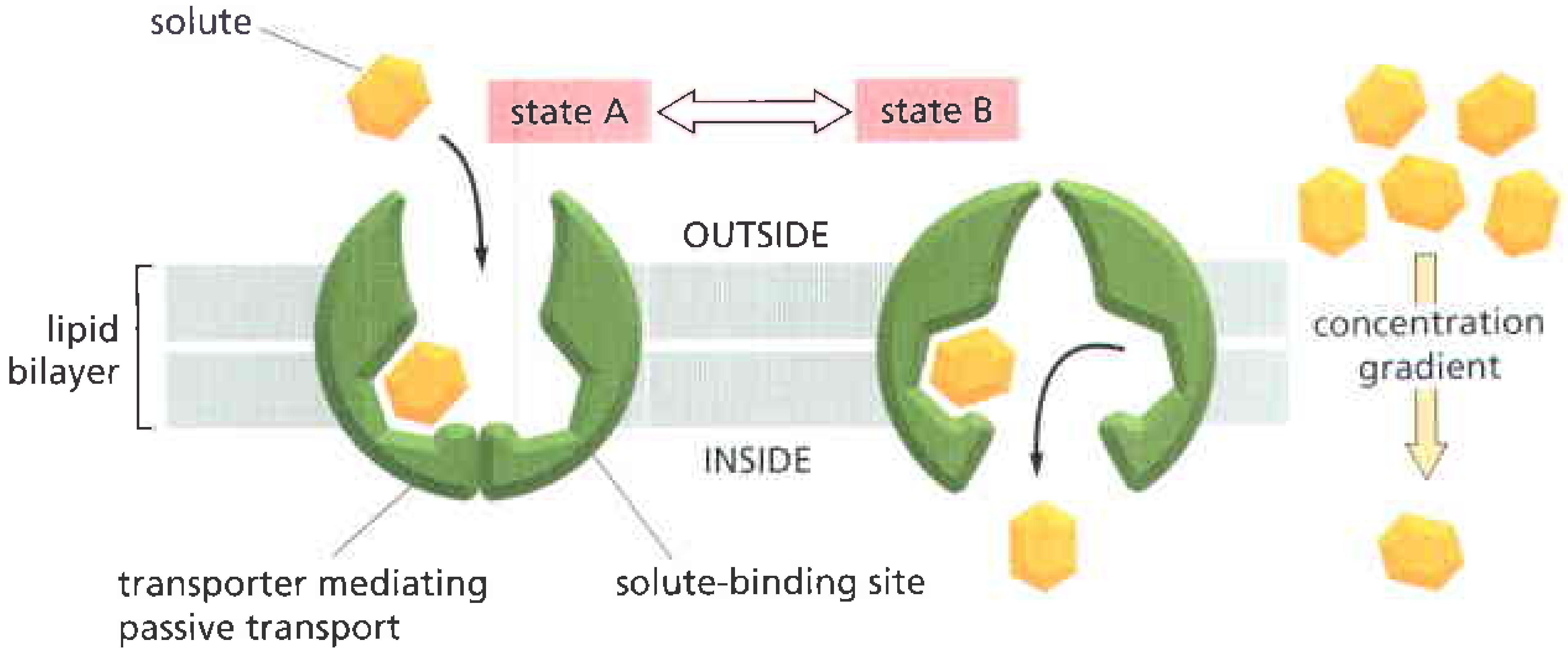


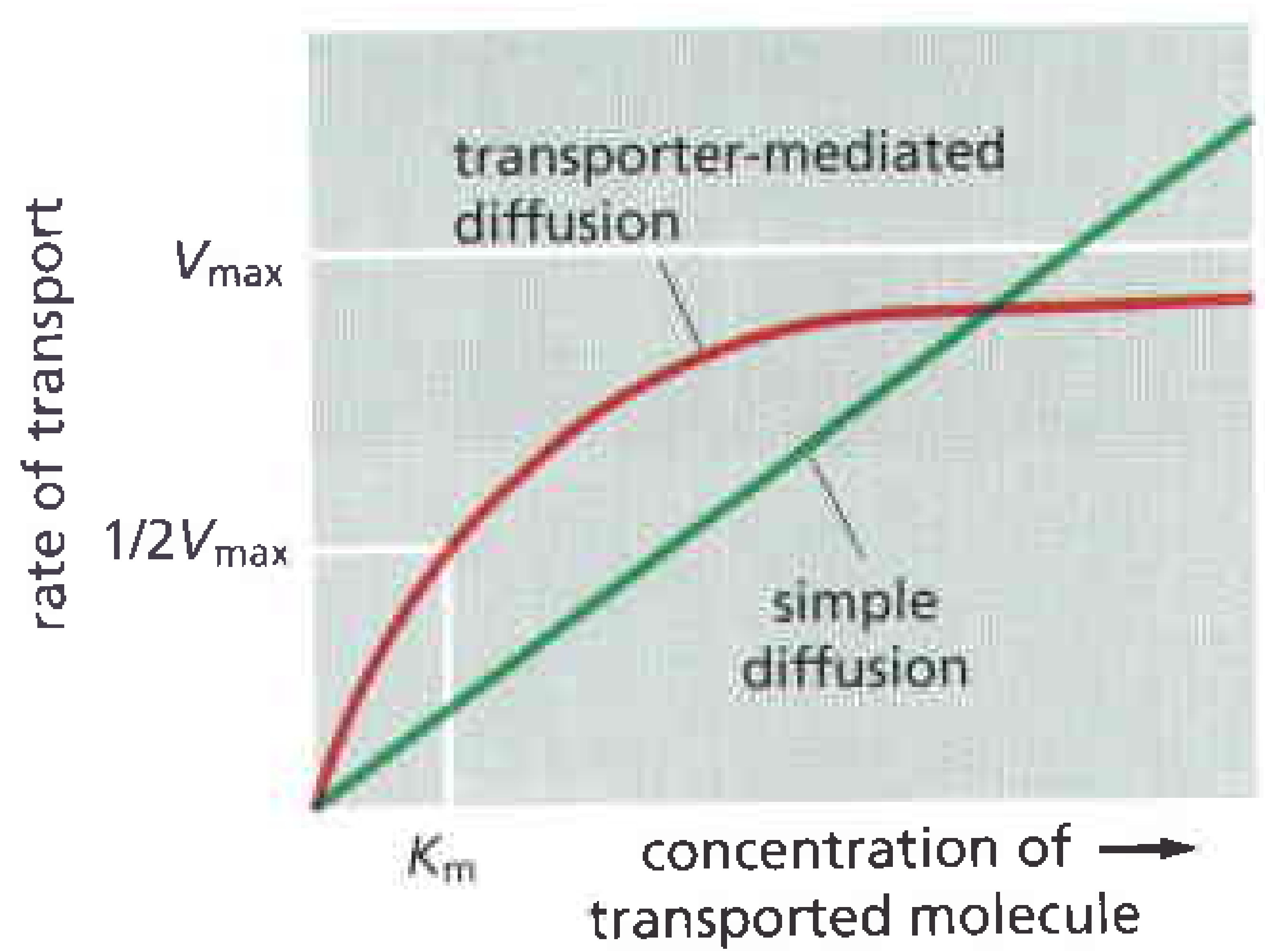
Figure 11–4 Passive and active transport compared. (A) Passive transport down an electrochemical gradient occurs spontaneously, either by simple diffusion through the lipid bilayer or by facilitated diffusion through channels and passive transporters. By contrast, active transport requires an input of metabolic energy and is always mediated by transporters that harvest metabolic energy to pump the solute against its electrochemical gradient. (B) An electrochemical gradient combines the membrane potential and the concentration gradient; they can work additively to increase the driving force on an ion across the membrane *(middle)* or can work against each other *(right)*.

Transportadores

Um transportador possui sítios com afinidade a solutos e aleatoriamente alterna de posição expondo esse sítio para a parte interna e externa da célula com **Mudanças Conformacionais Reversíveis**



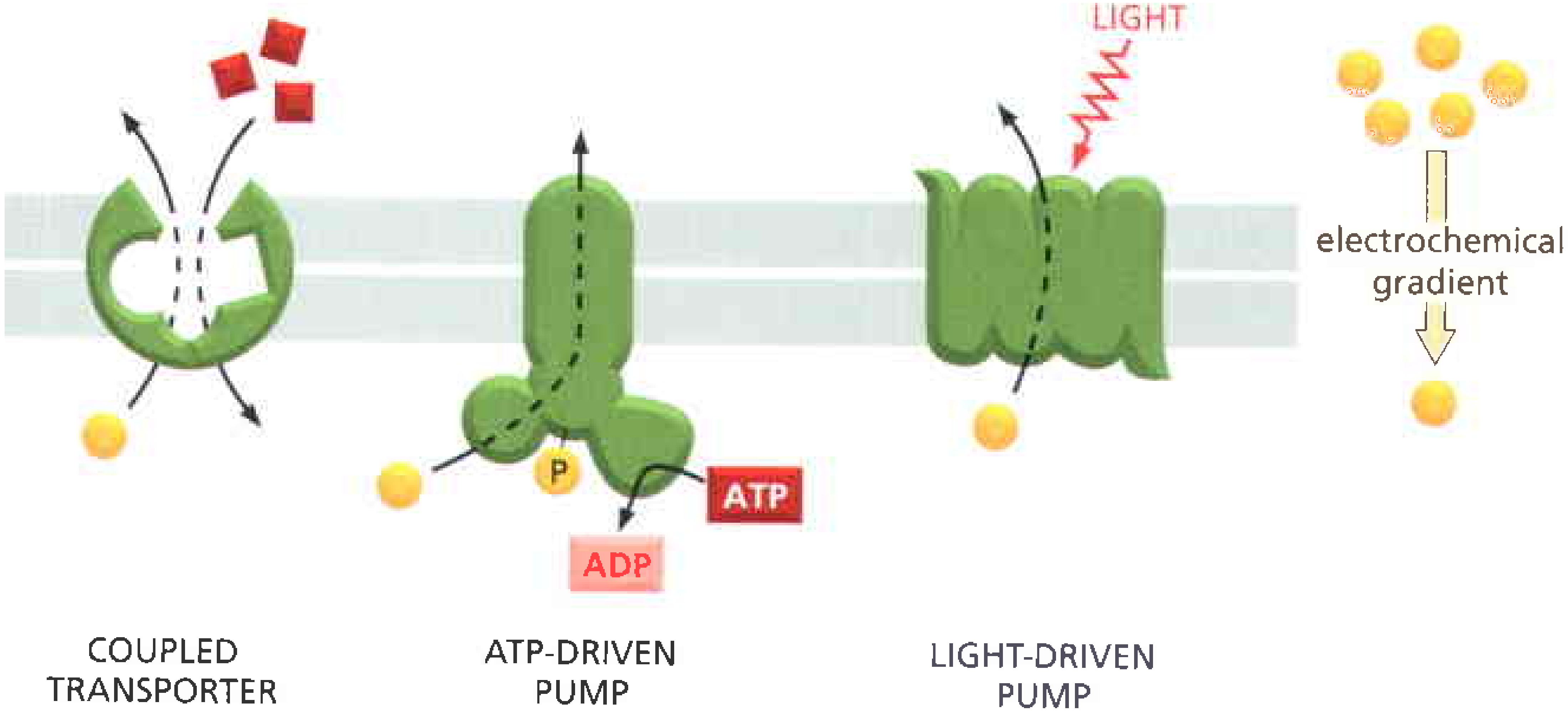
Difusão Mediada



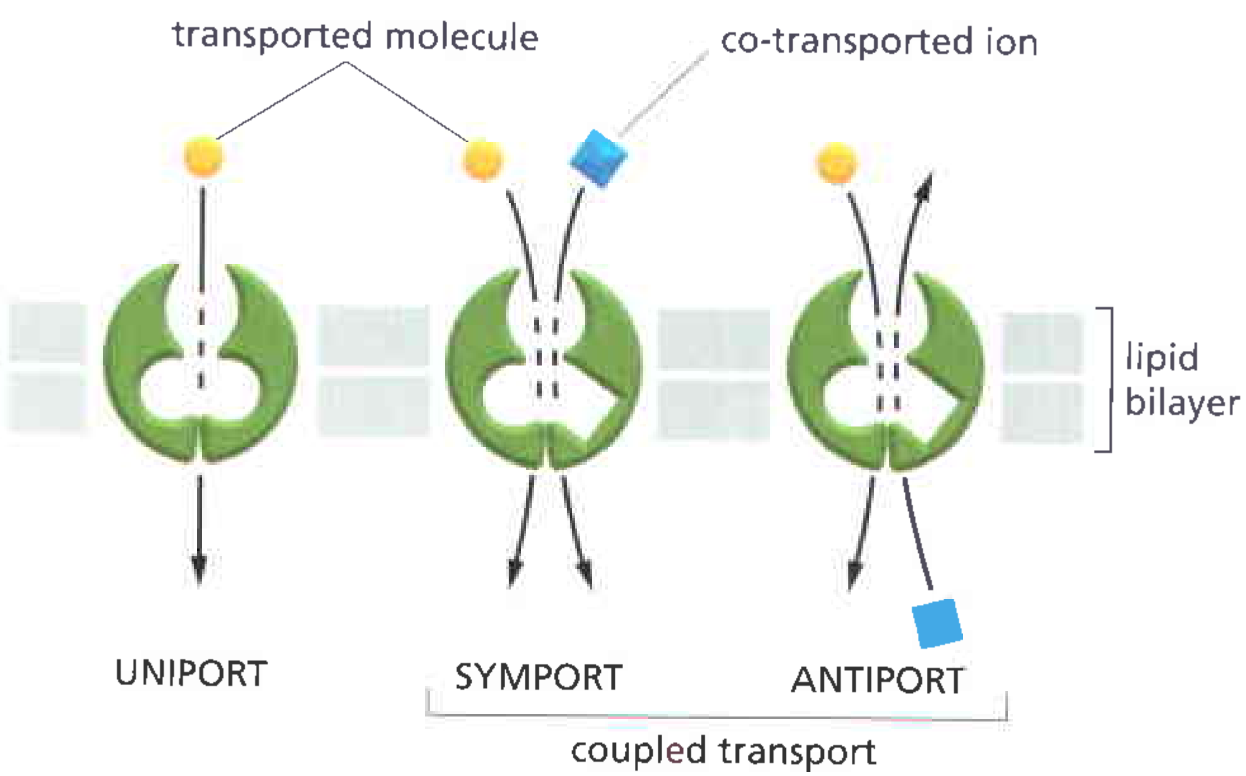
Onde V_{max} é a taxa máxima possível de transporte e K_m é a constante de acoplamento entre o soluto e o transportador.

Transporte Ativo

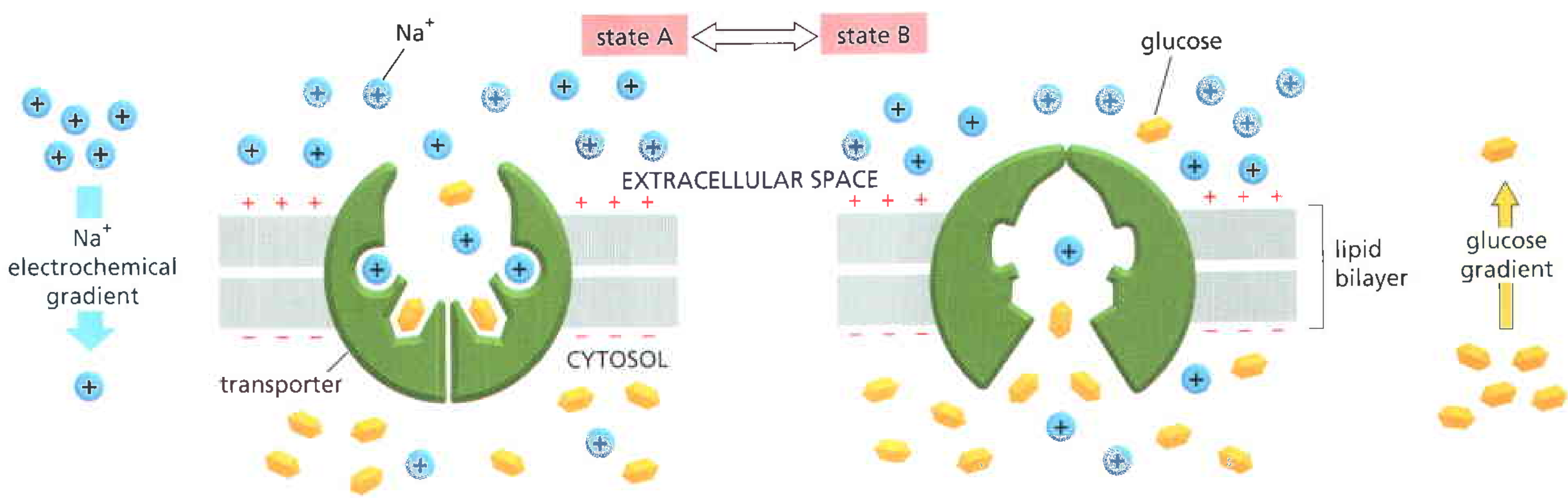
Três formas de transporte ativo. A molécula transportada esta em amarelo e a forma de energia em vermelho



Transporte Ativo (Symport)

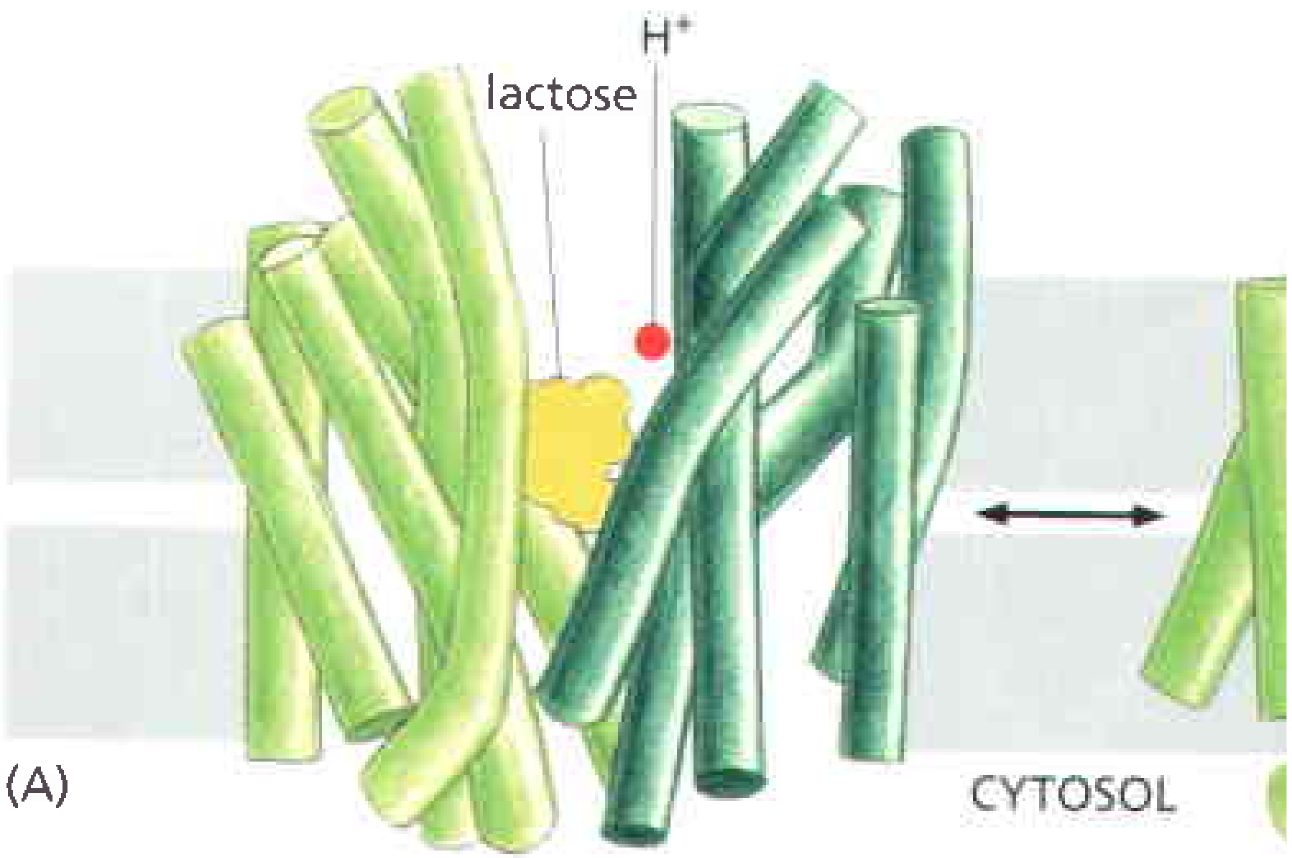


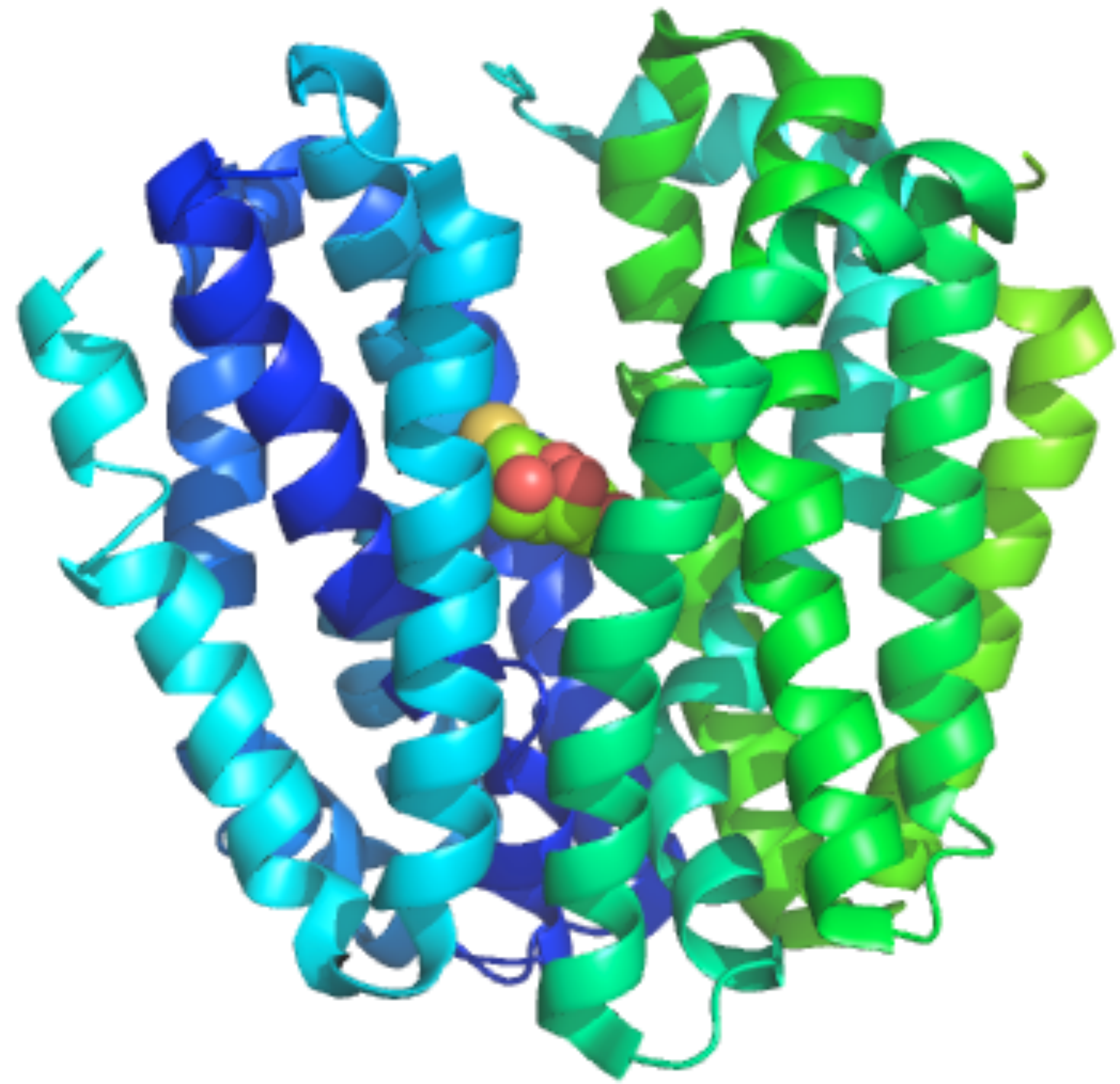
Symport usa o movimento para baixo de uma espécie de soluto de alta para baixa concentração para mover outra molécula subindo de baixa concentração de alta concentração (contra o gradiente eletroquímico). Ambas as moléculas são transportados na mesma direcção.



Transporte Ativo (Symport)

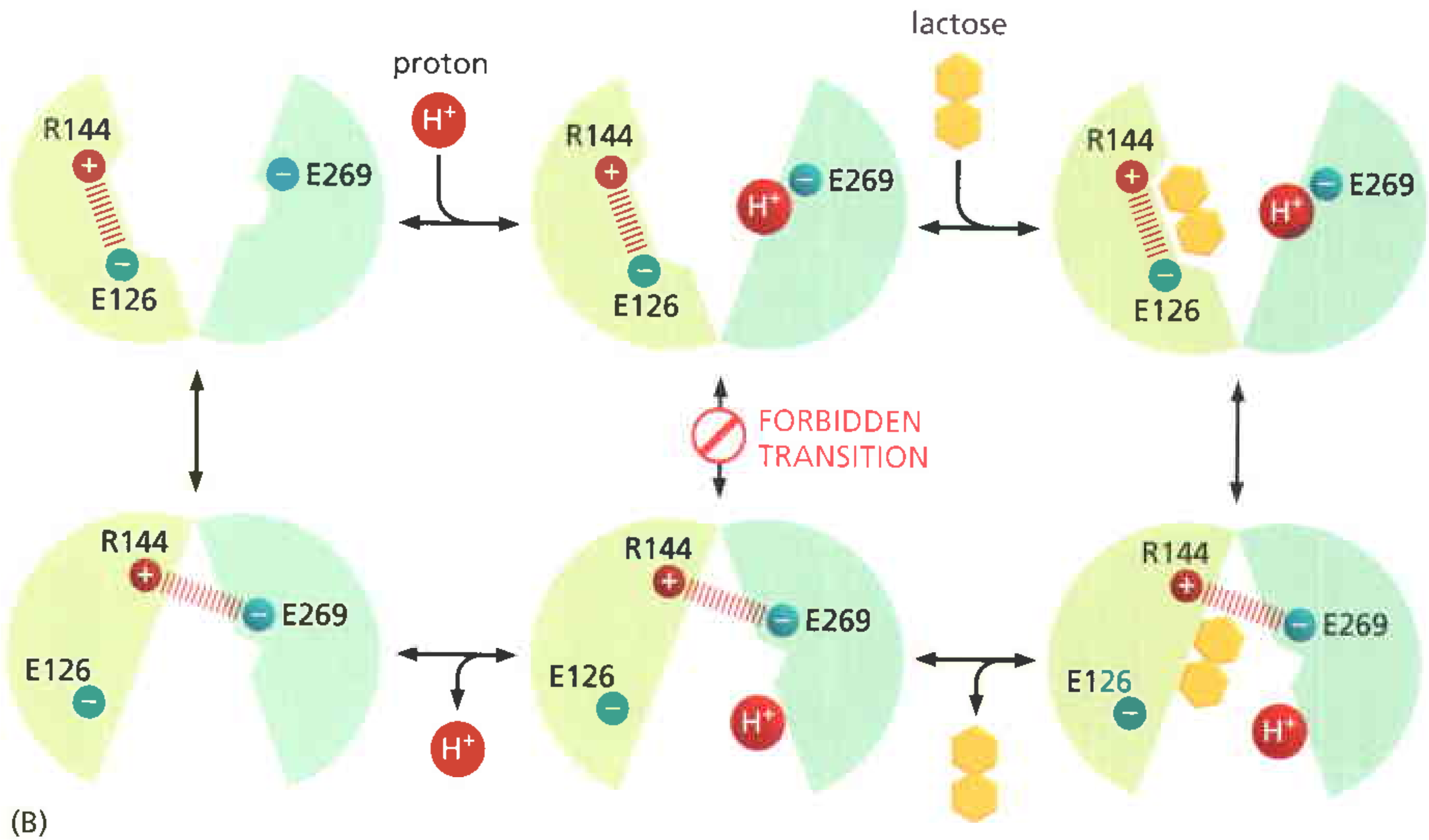
Difusão pela membrana (*permease*)
de Lactose





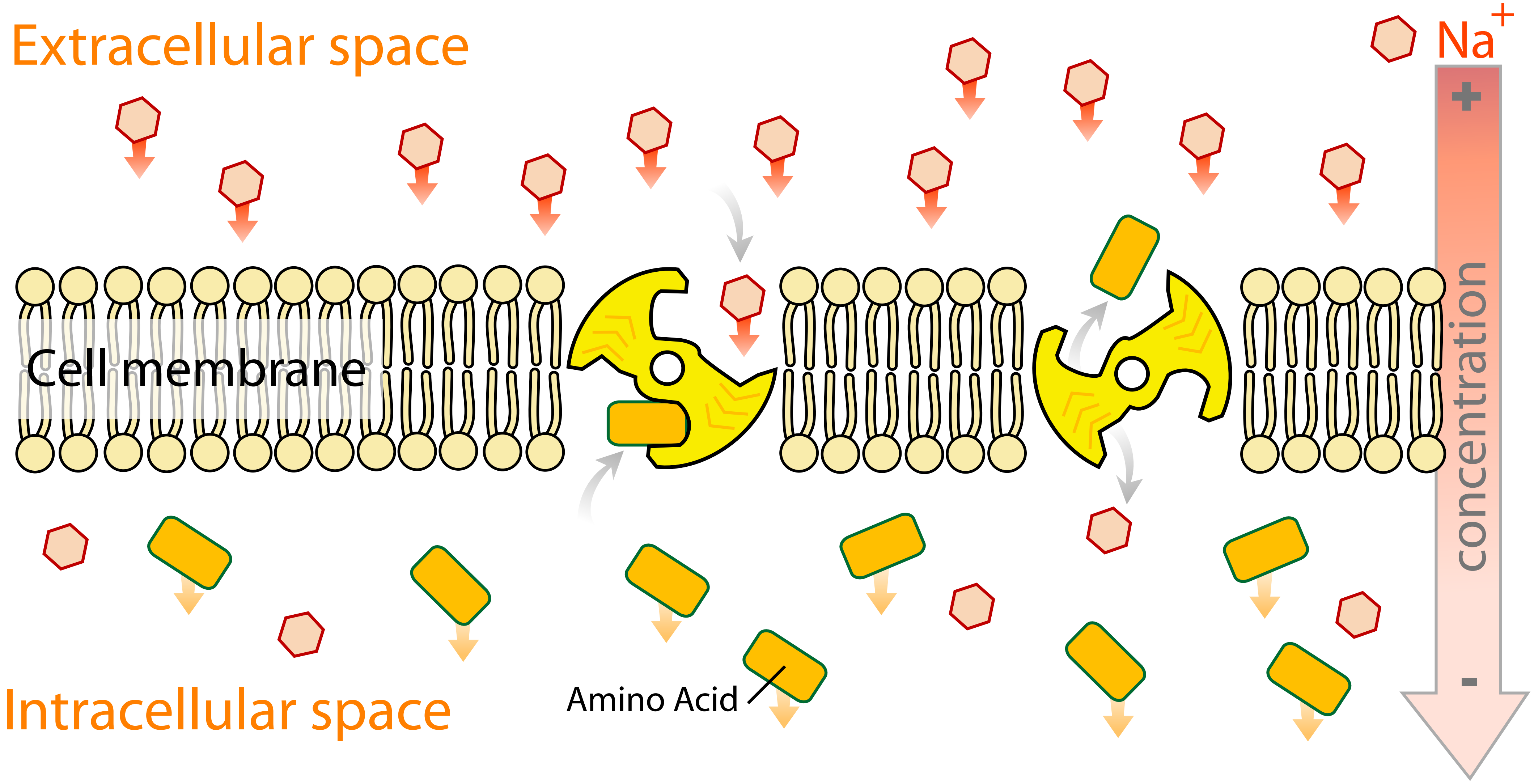
Transporte Ativo (Symport)

Difusão pela membrana (*permease*) de Lactose

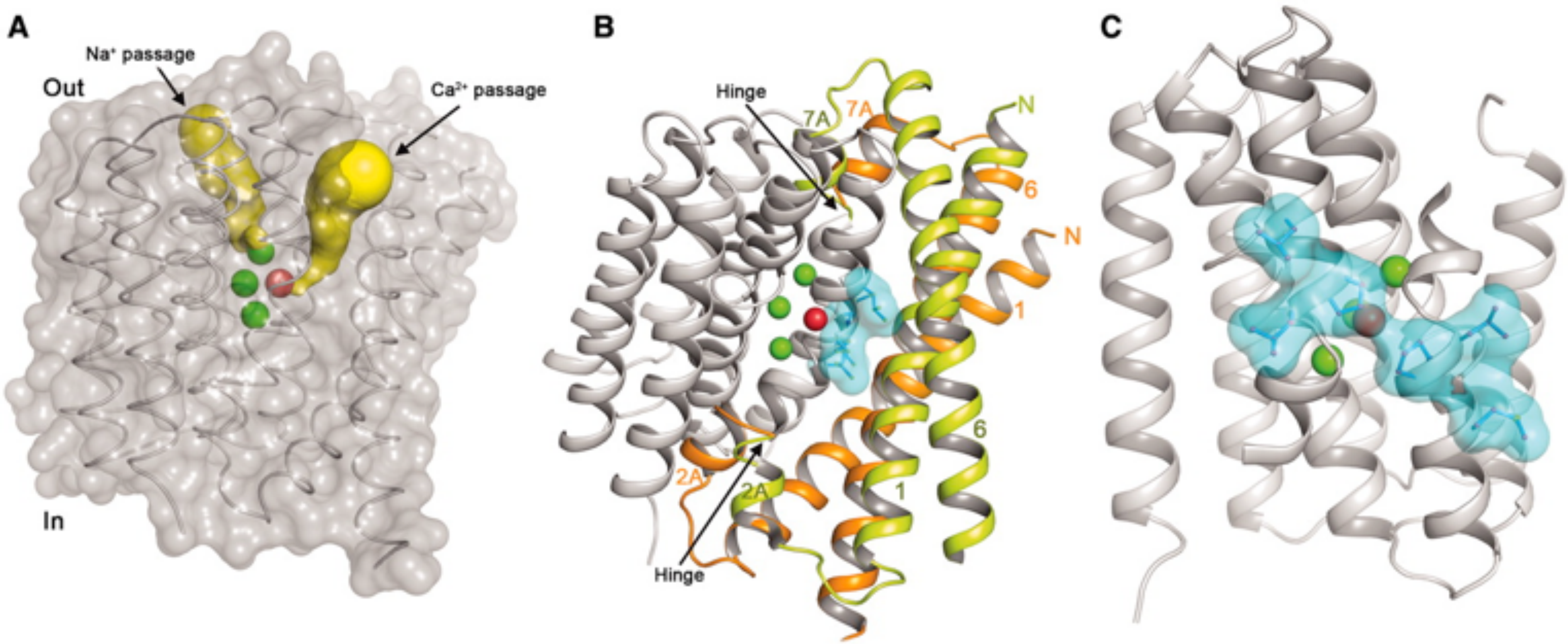


Transporte Ativo (Antiport)

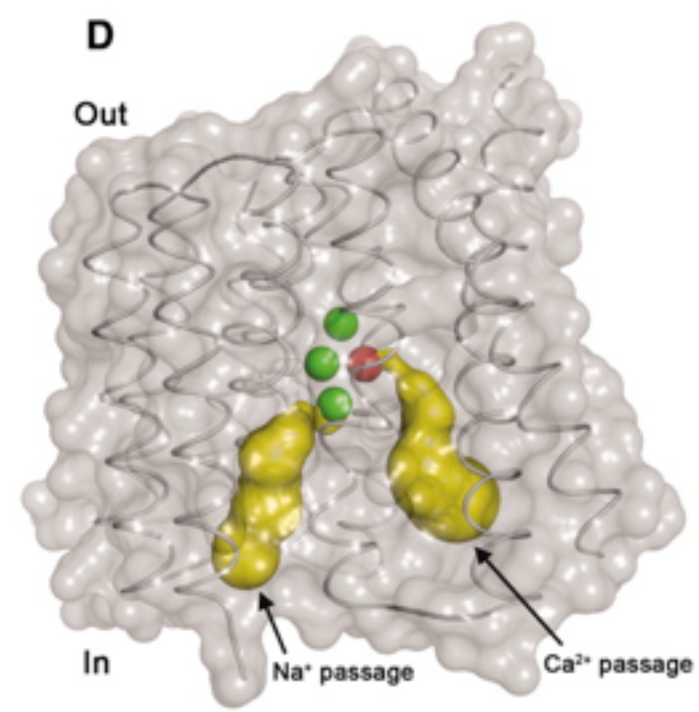
Antiporte: duas espécies de ions ou de outros solutos são bombeados em sentidos opostos através de uma membrana. Uma destas espécies é permitido fluir da alta para a baixa concentração que produz a energia entrópica para dirigir o transporte do outro soluto a partir de uma região de baixa concentração de um alto.



Transporte Ativo (Antiport)

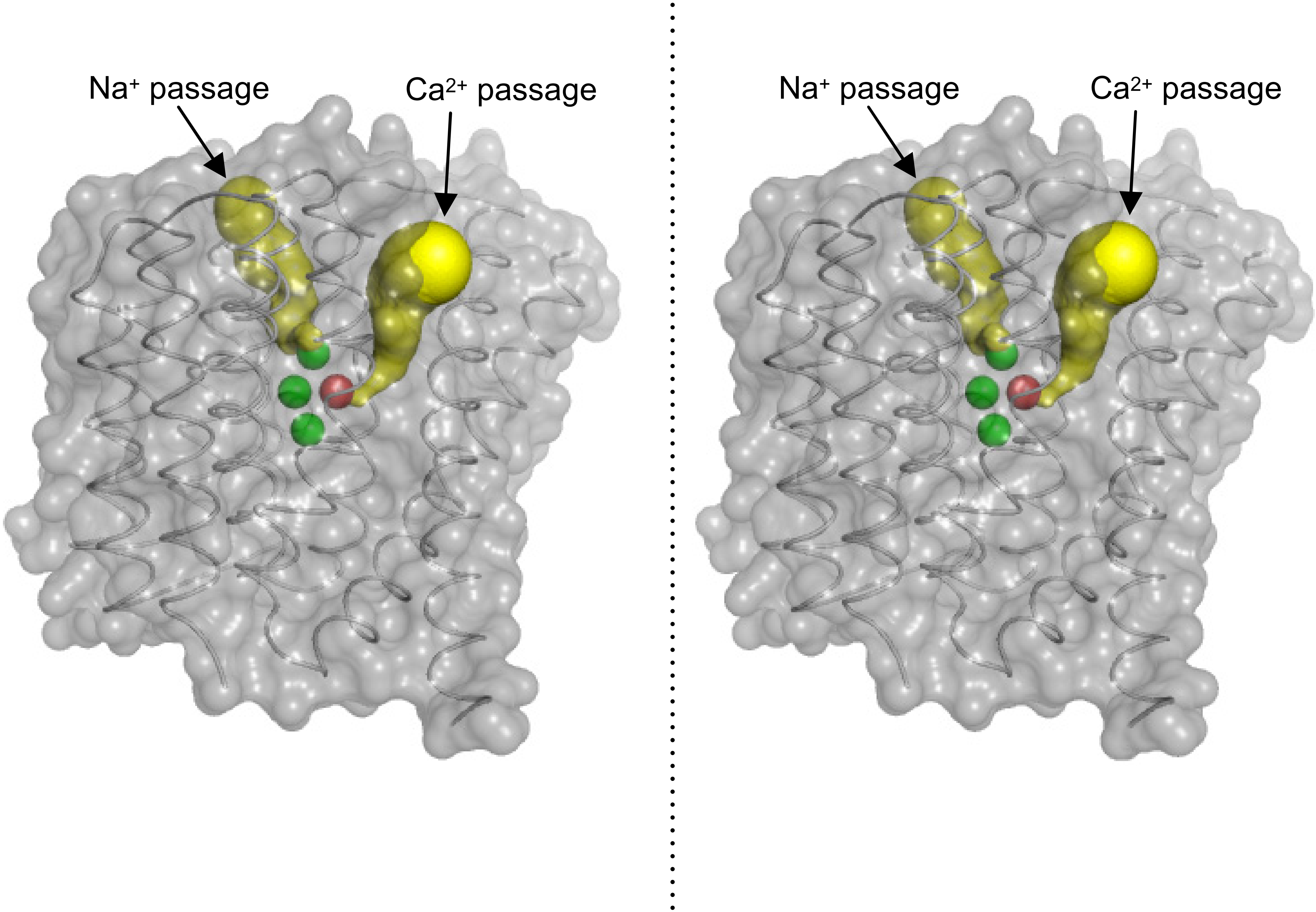


The outward-inward conformational change of NCX_Mj. (A) The surface-rendered NCX_Mj structure shows two independent external passages (yellow) for ion access to the four central ion-binding sites (colored spheres). The ion passageways are analyzed using the program CAVER (41). (B) Side view for structural comparison of the outward-facing NCX_Mj (orange) and inward-facing model (green). The core portion of the protein remains the same in both conformations and is shown in gray. The light blue surface-rendered CPK models are residues forming the central hydrophobic patch. (C) The central hydrophobic patch (light blue) with TMs 1 and 2A and 6 and 7A removed for clarity. (D) Surface-rendered inward-facing model showing two independent passageways (yellow) for intracellular ion access to the four central ion-binding sites. Stereo views of all figures shown here are also presented in figs. S5, S7, and S8.

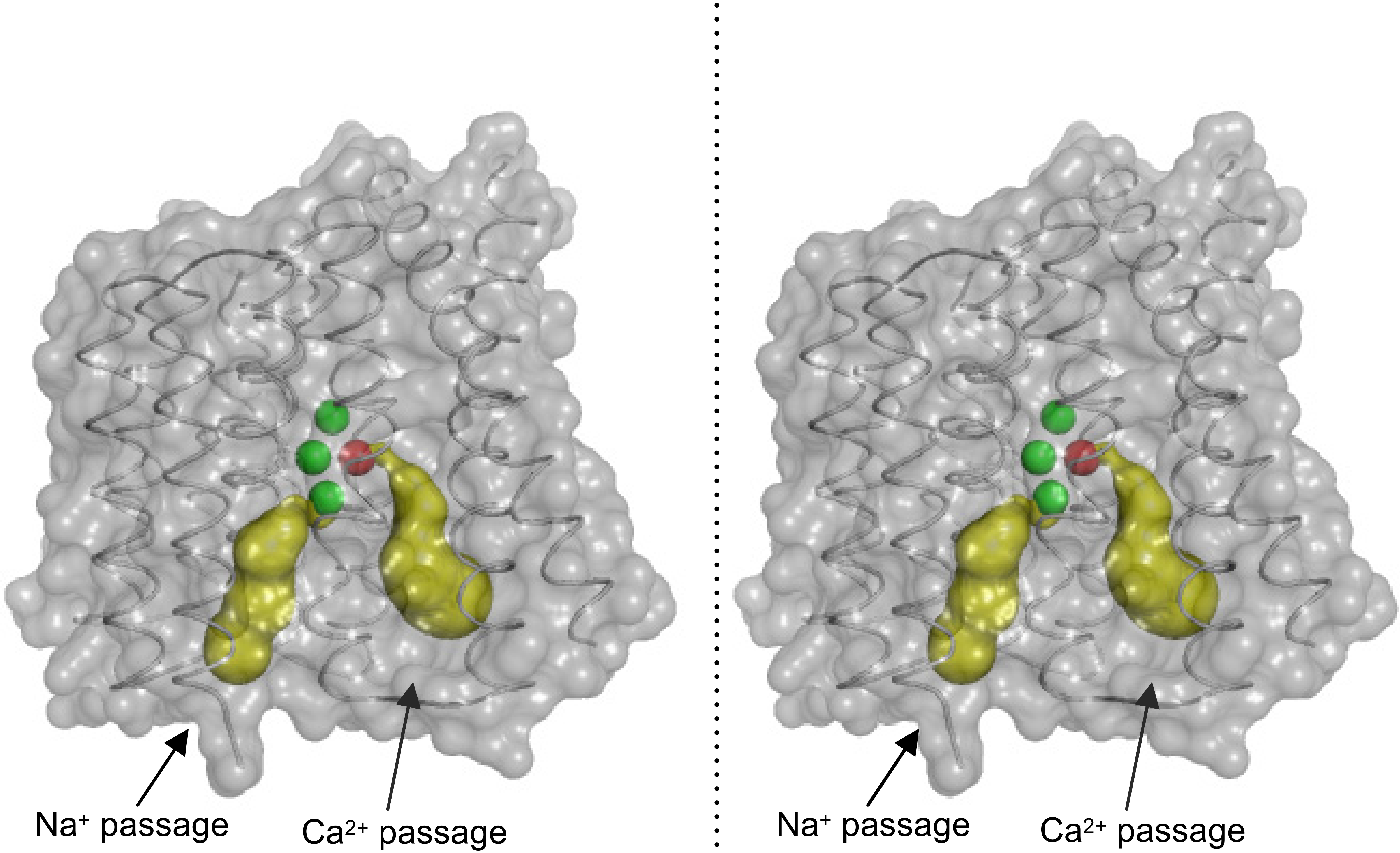


Science 10 February (2012) Vol. 335 no. 6069 pp. 686-690, DOI: 10.1126/science.1215759

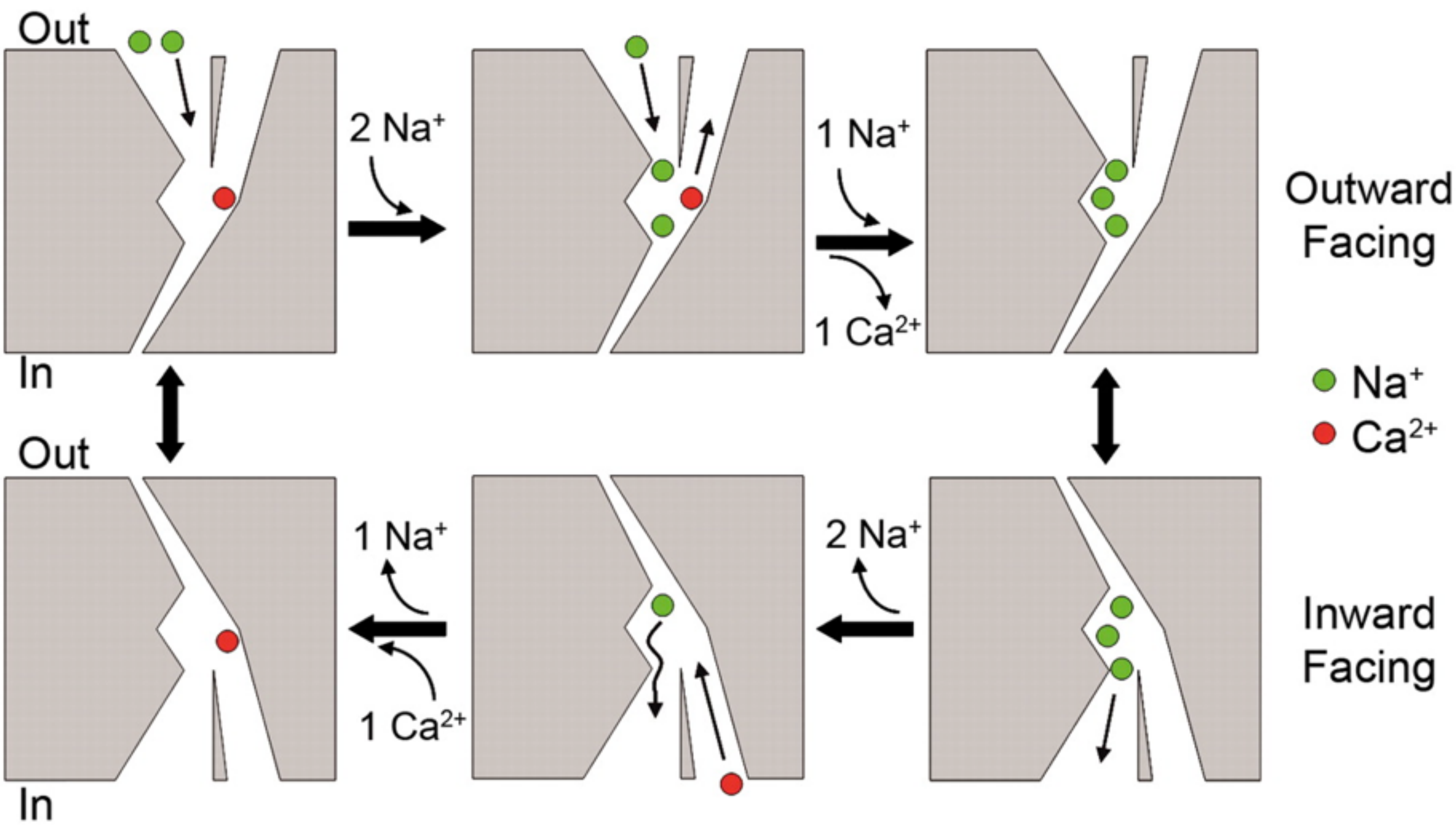
Visão Estéreo



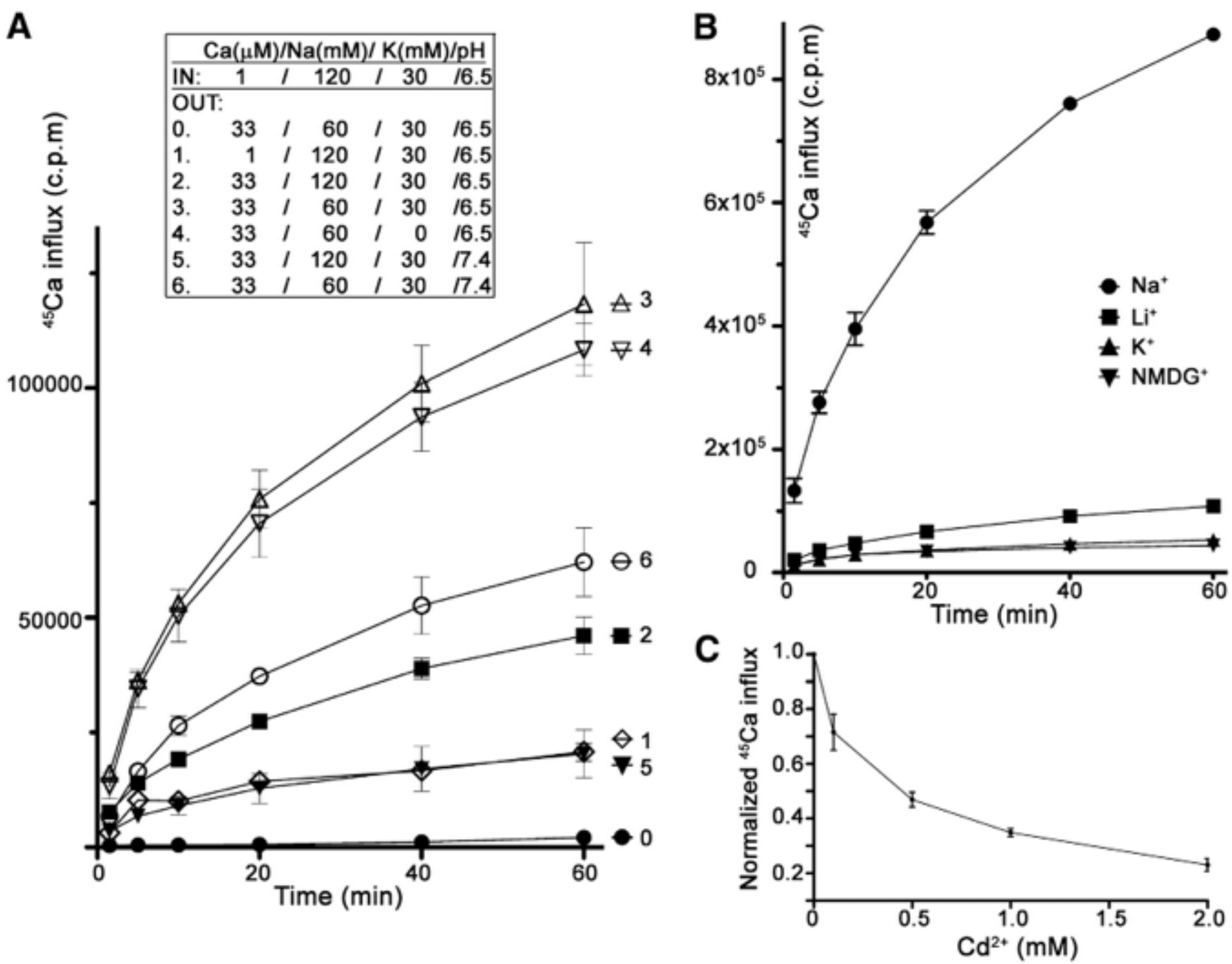
Visão Estéreo



Transporte Ativo (Antiport)



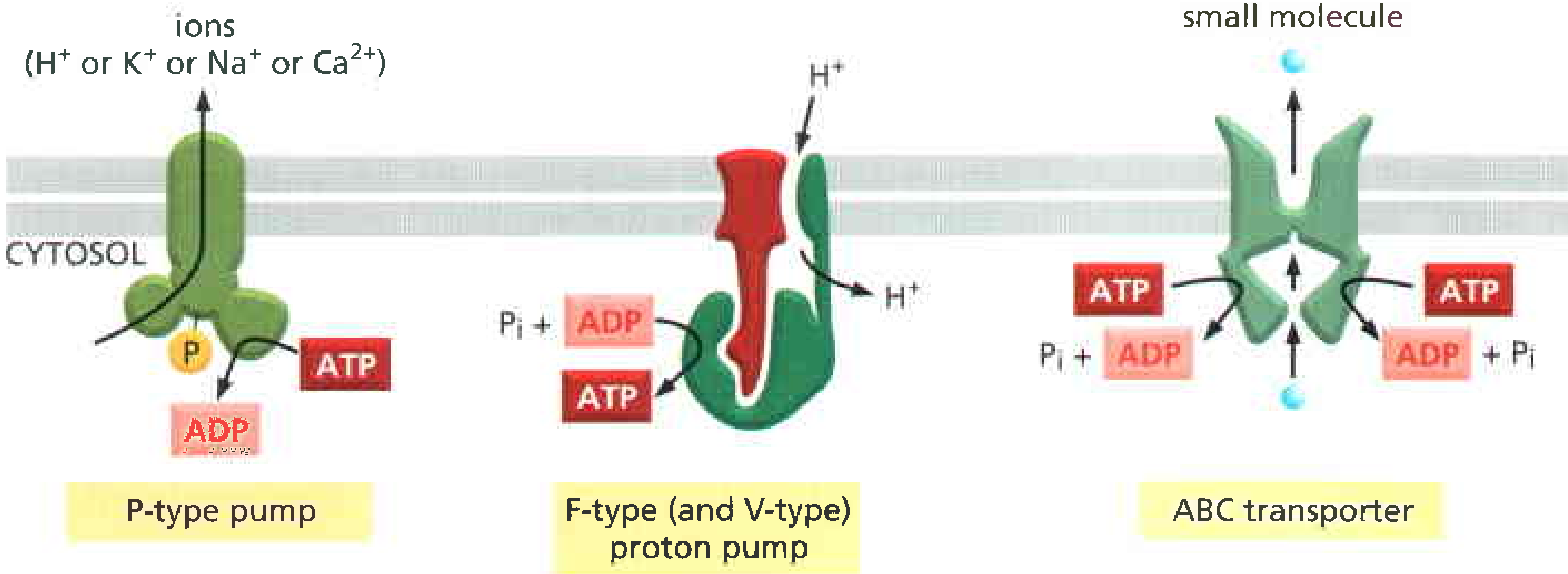
Transporte Ativo (Antiport)

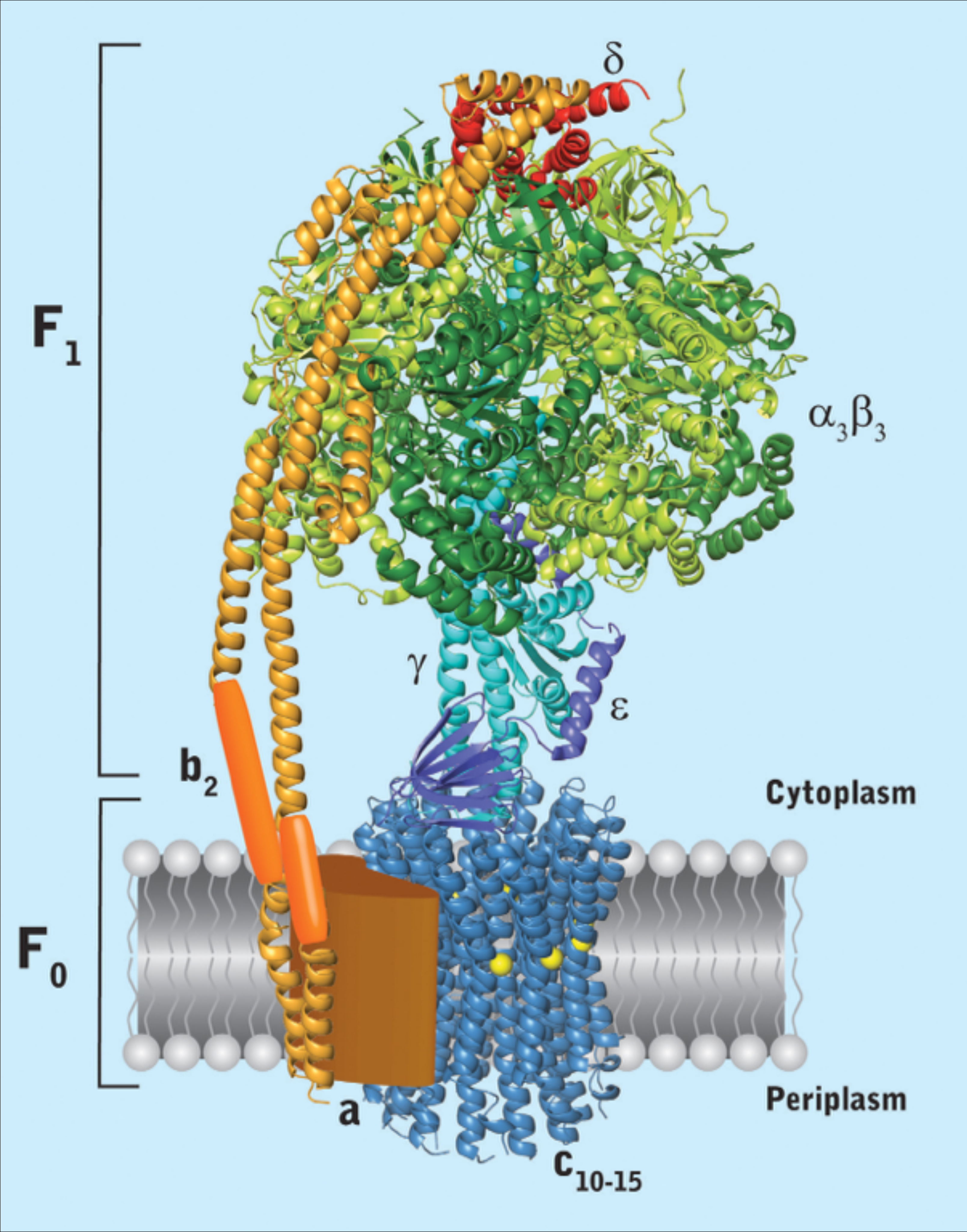


$^{45}Ca^{2+}$ flux assays of NCX_Mj reconstituted liposomes. (A) Curves 1 to 6 show the time-dependent $^{45}Ca^{2+}$ influx with various extraliposomal reaction solutions, as listed in the inset. Curve 0 is the control assay using liposomes deficient of protein. The intraliposomal solution remains the same in all measurements. c.p.m., counts per minute. (B) Selectivity of NCX_Mj. The intraliposomal solution contained 120 mM of either Na+, K+, Li+, or NMDG+ as the only monovalent cation. The extraliposomal reaction solution contained 120 mM NMDG+ and remained the same in all measurements. (C) Cd^{2+} blockage of NCX_Mj. The reaction solution is the same as that used for curve 3 in (A), except containing various concentrations of $CdCl_2$. The Ca^{2+} influx was terminated 20 min after adding $^{45}CaCl_2$. All data points are mean ± SEM of two independent experiments. Some data points shown in (B) contain error bars smaller than the representative symbols.

Bombas de ATP

Existem 3 tipos de bombas

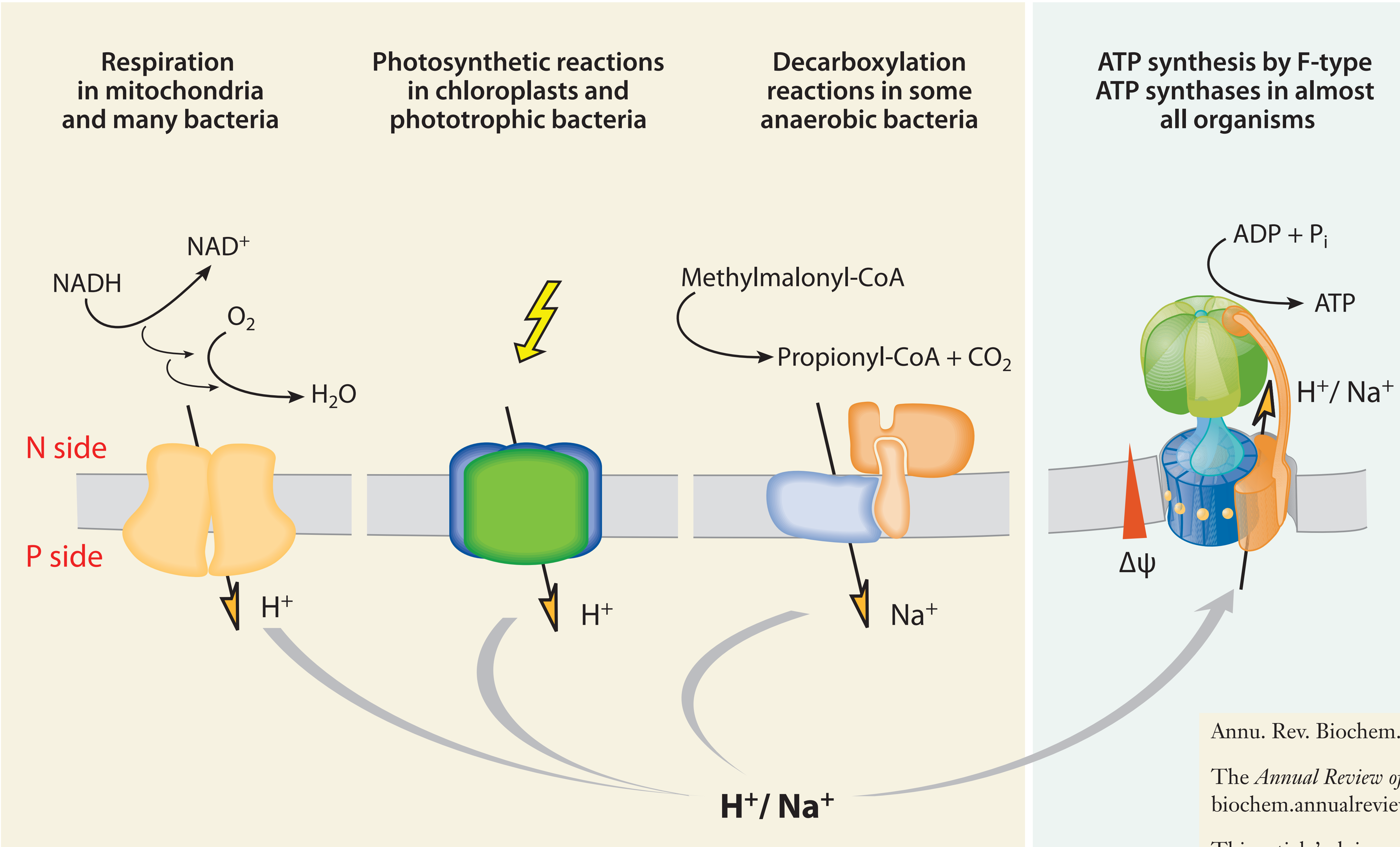




F-ATPase

O ATP sínteses é uma máquina em miniatura composta por dois motores rotativos, $\mathbf{F_1}$ e $\mathbf{F_0}$, que estão ligados mecanicamente para assegurar a troca de energia entre eles

Ciclo energético



Annu. Rev. Biochem. 2009. 78:649–72

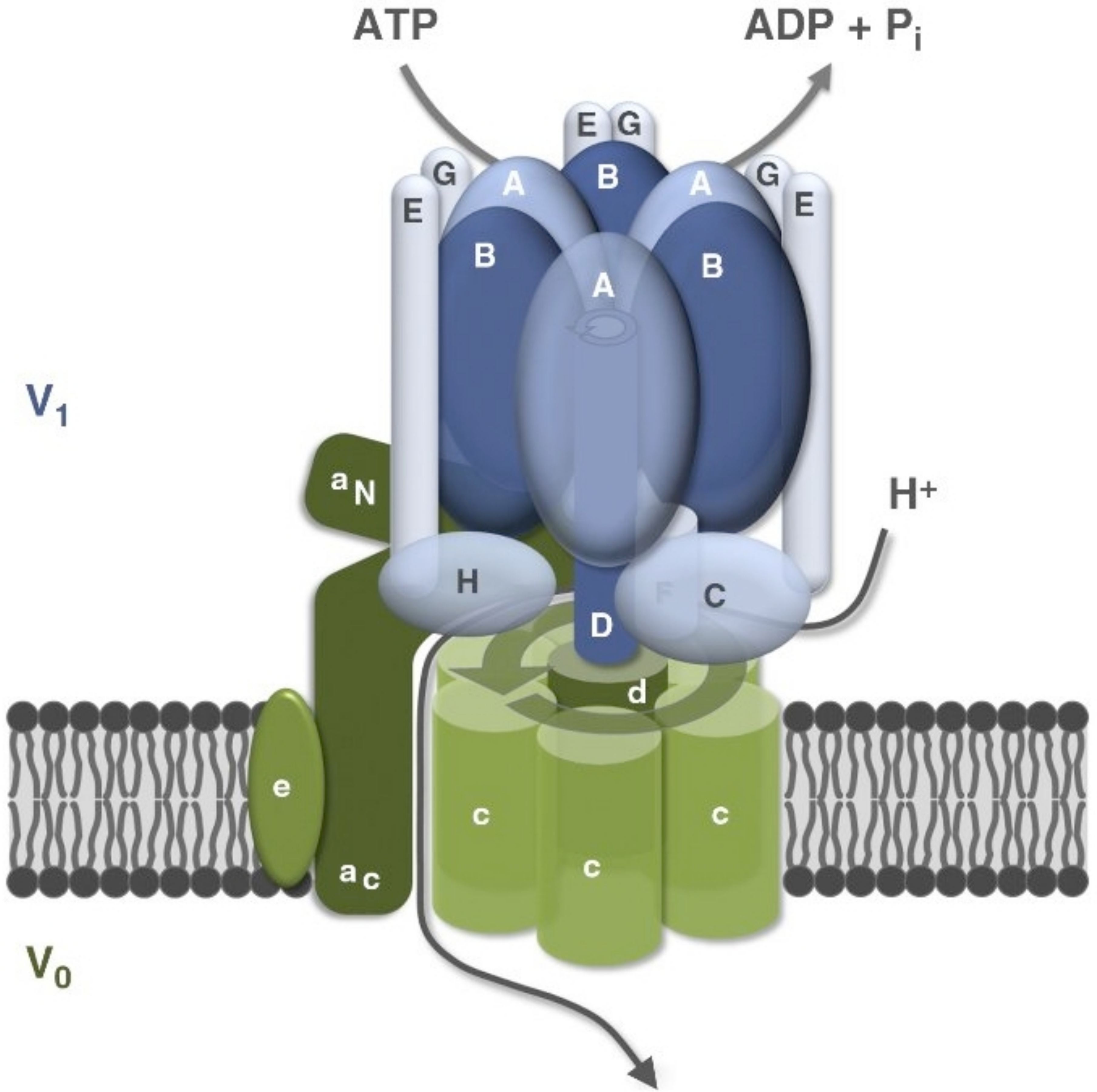
The *Annual Review of Biochemistry* is online at biochem.annualreviews.org

This article's doi: 10.1146/annurev.biochem.78.081307.104803

Figure 1

Ion cycling across biological membranes leading to ATP synthesis. In heterotrophic organisms, e.g., animals or bacteria, the metabolism of nutrients generates reducing equivalents (NADH, succinate). These are oxidized by the respiratory-chain enzymes, using oxygen as terminal electron acceptor. The free energy of the oxidation reactions is converted into an electrochemical gradient of protons ($\Delta\mu H^+$) across the membrane. Chloroplasts and phototrophic bacteria convert light energy into a $\Delta\mu H^+$ across the membrane. The anaerobic bacterium *P. modestum* couples the decarboxylation of methylmalonyl-CoA to electrogenic Na^+ transport, which results in an electrochemical sodium gradient. The electrochemical H^+ or Na^+ gradients established by these membrane-bound complexes serve as energy sources for ATP synthesis from ADP and inorganic phosphate by an F_1F_0 ATP synthase. Abbreviations: N side, the negatively charged side of a membrane; P side, the positively charged side of a membrane.

V-ATPase



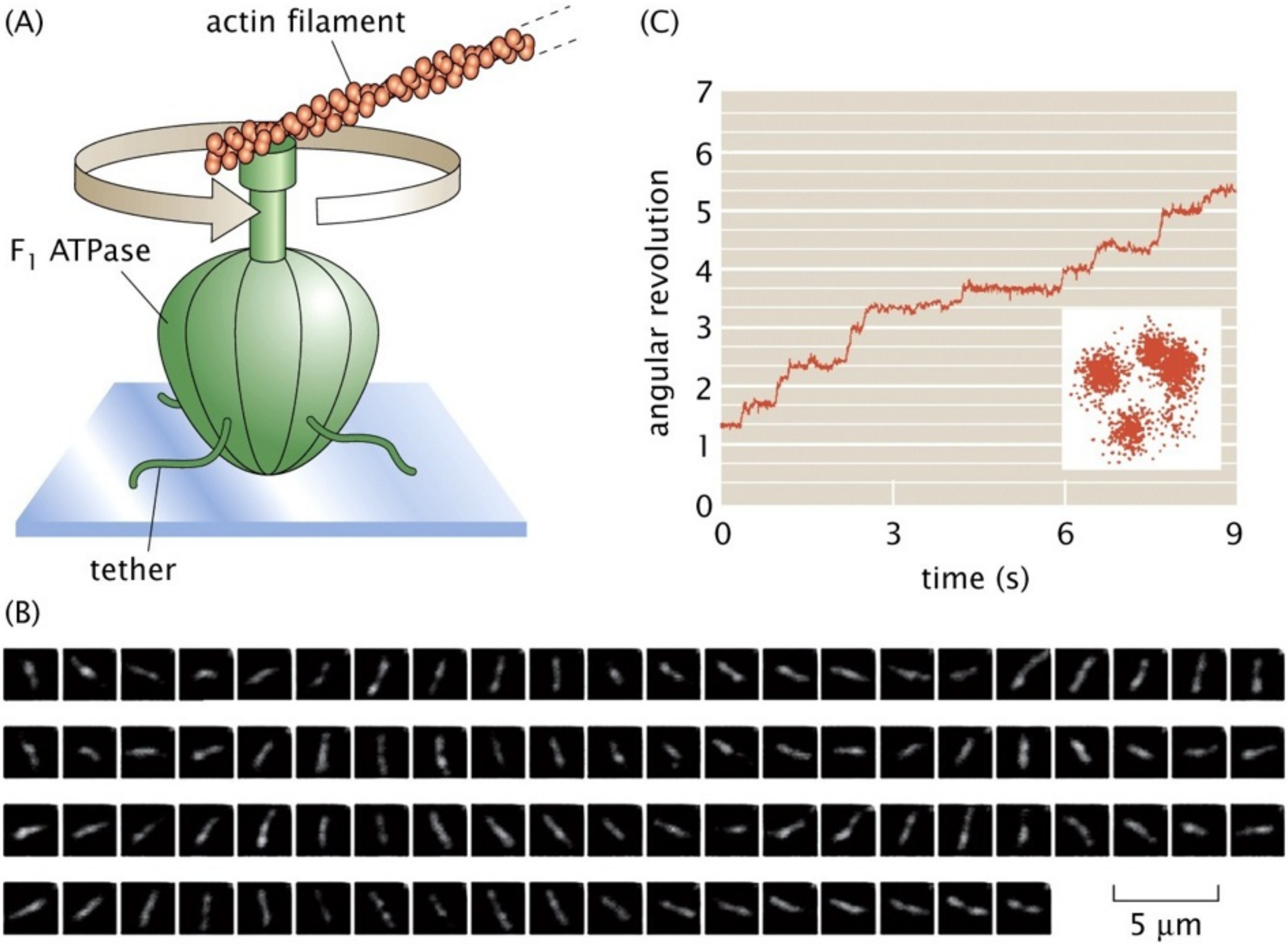


Figure 16.16 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

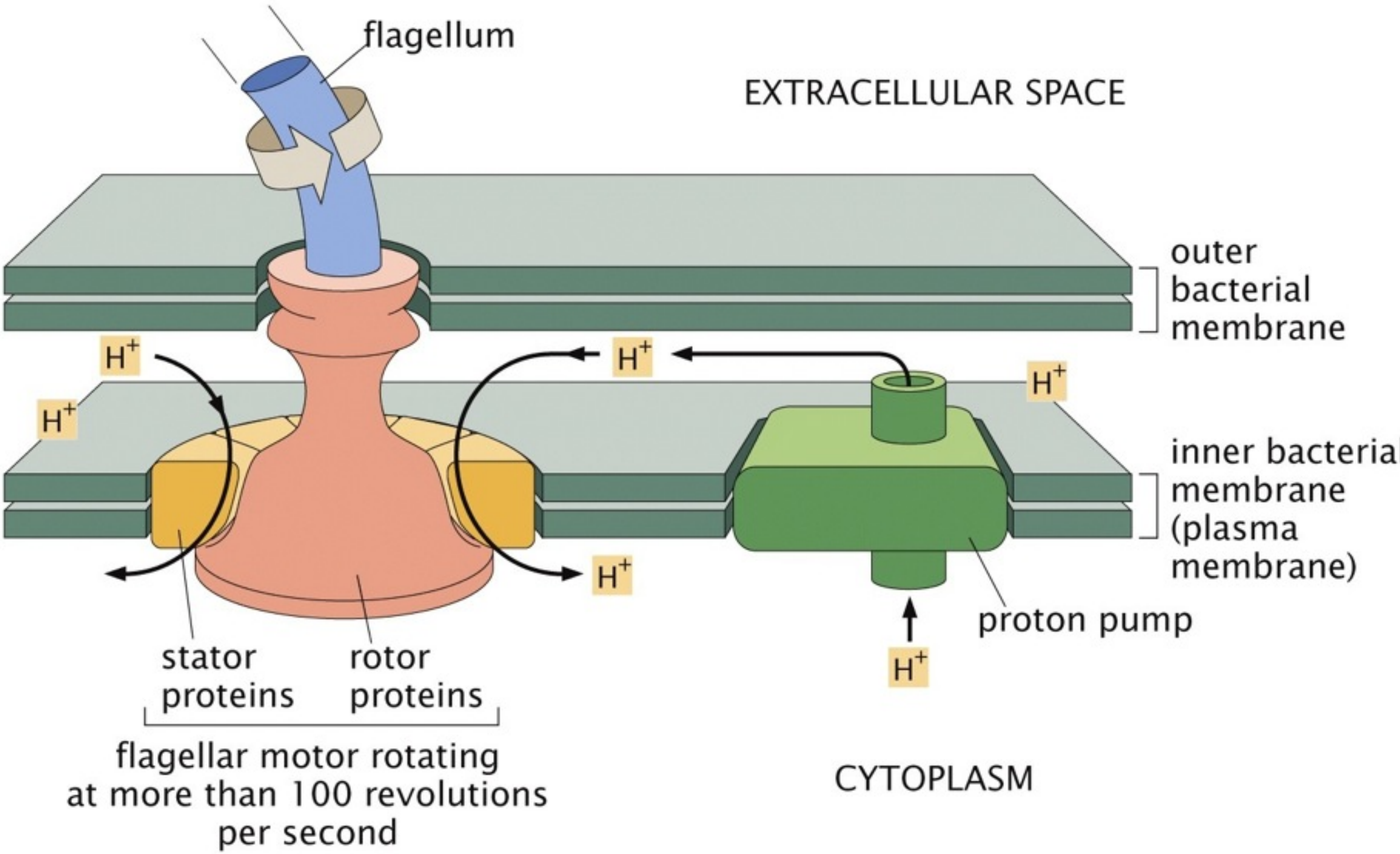


Figure 16.14a Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Figure 16.41 Operation of a Na^+ ion transporter. Diagram of the F_0 motor from the bacterium *Propionigenium modestum*. While the F_0 of most bacteria transports H^+ ions, this interesting example uses Na^+ ions instead. The movement of a single Na^+ ion through the rotor requires a turn of one step to bring the partially transported ion into registry with the charge distribution in the stator ring. At any given moment, no direct channel between the periplasm and the cytoplasm exists, but ions still move across the membrane. They enter from the periplasm when the rotor is in one position and exit into the cytoplasm when the rotor has turned by one step. This leads to rotational diffusion with drift, of the rotor. (Adapted from C. Bustamante et al., *Acc. Chem. Res.* 34:412, 2001.)

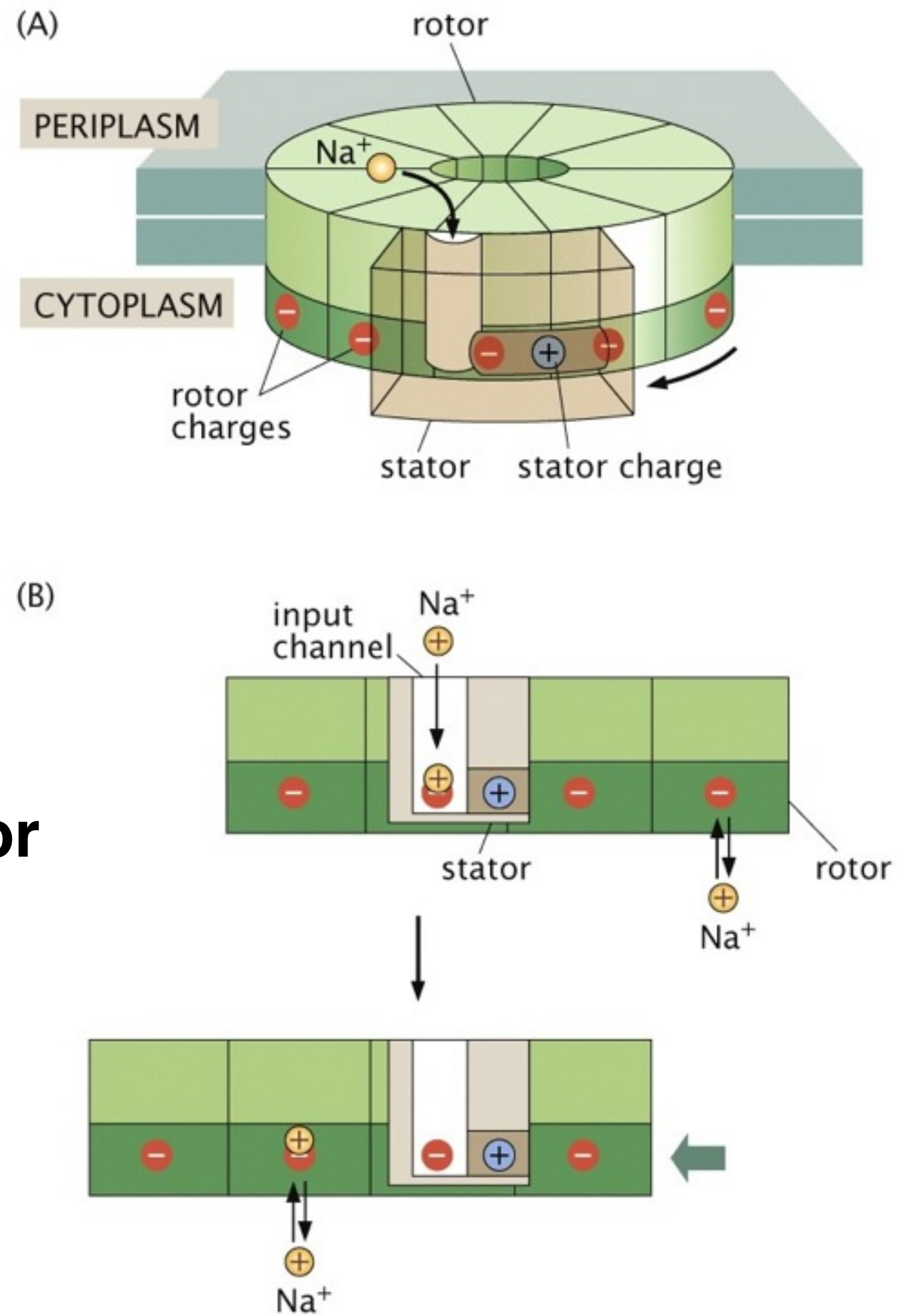


Figure 16.42 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Torque produzido pelo motor

$$\Delta G_{\text{tot}} = \Delta G_{\text{pot}} + \Delta G_{\text{conc}}$$

Energia livre associada com a movimentação dos ions entre as camadas

Energia livre associada com a mudança de entropia devido a mudança de concentração

$$\Delta G_{\rm pot} = e\Delta V, \text{ Com } \Delta V \approx 90\,{\rm mV}$$
$$\approx 4k_{\rm B}T$$

$$\Delta G_{\rm conc} = k_{\rm B}T \ln \frac{c_{\rm out}}{c_{\rm in}}$$

Assumindo que toda energia é convertida em torque

$$\tau_{F_0} \approx \frac{4k_{\rm B}T}{\pi/6} + \frac{k_{\rm B}T}{\pi/6} \ln \frac{c_{\rm out}}{c_{\rm in}}$$
$$\approx (30 + 20\Delta pH)\,{\rm pN\,nm}$$

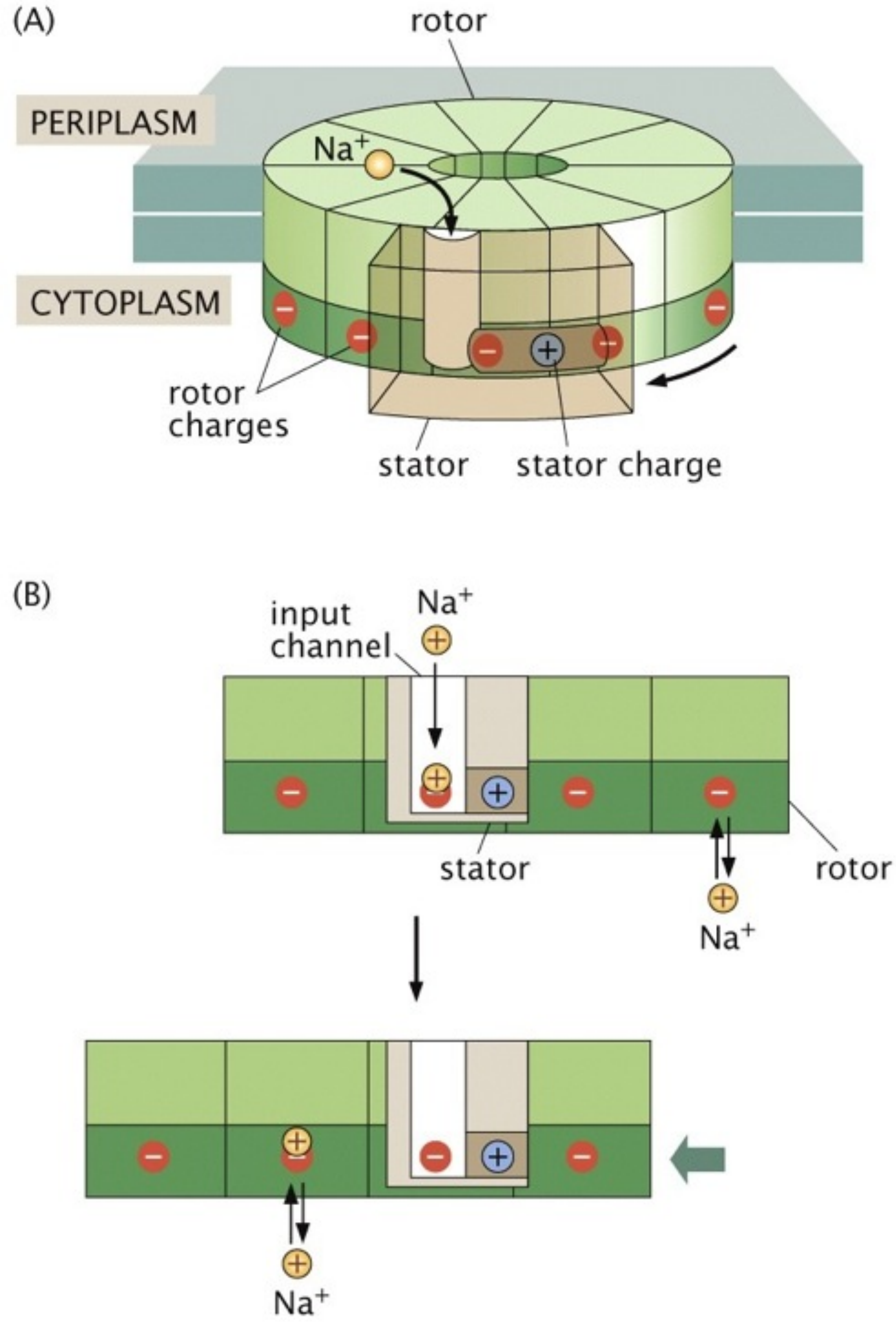
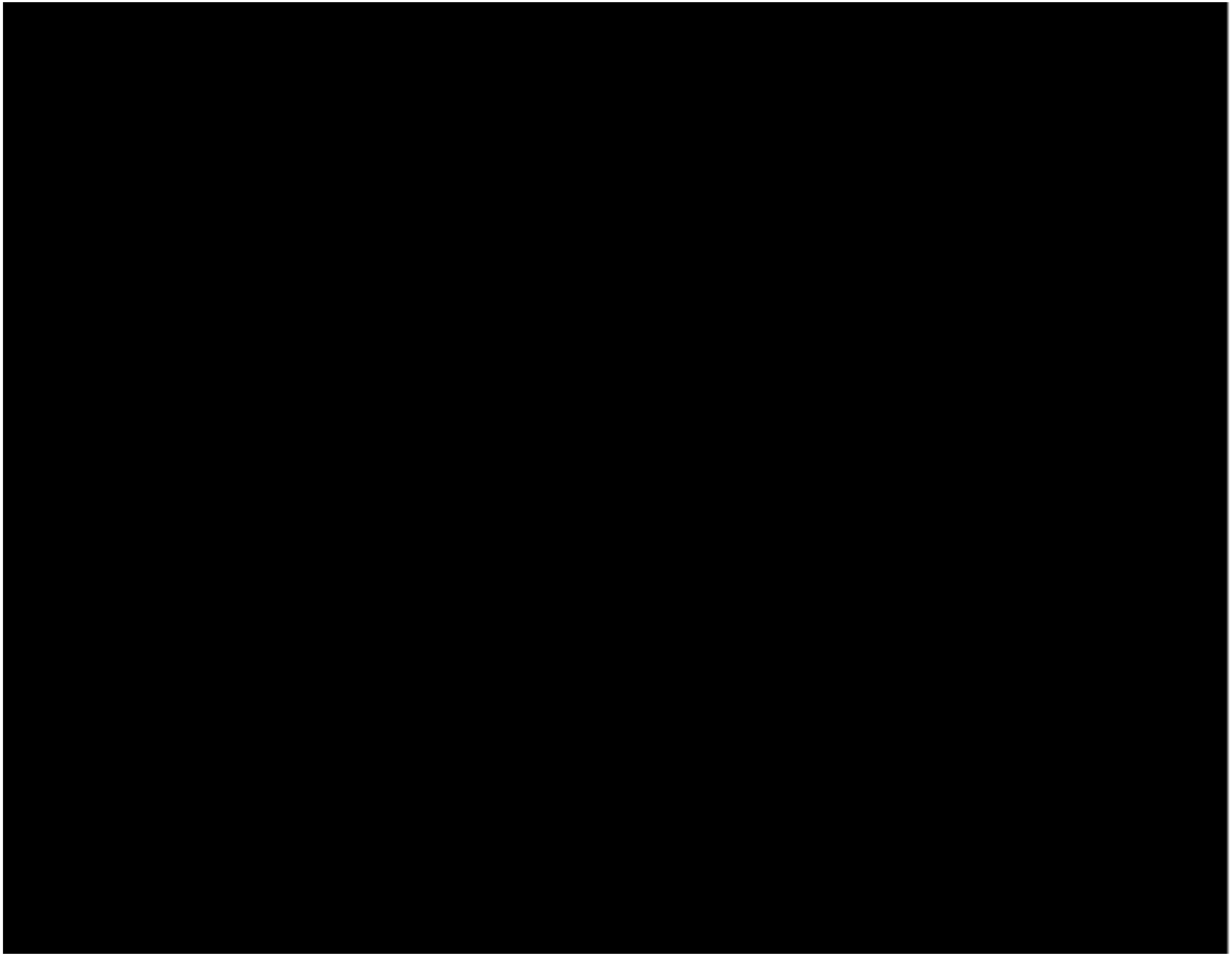


Figure 16.42 Physical Biology of the Cell, 2ed. (© Garland Science 2013)

Produção de ATP



Transporte através de células

- Na+ powered glucose symport
- Na+ pumps mantêm baixas concentrações