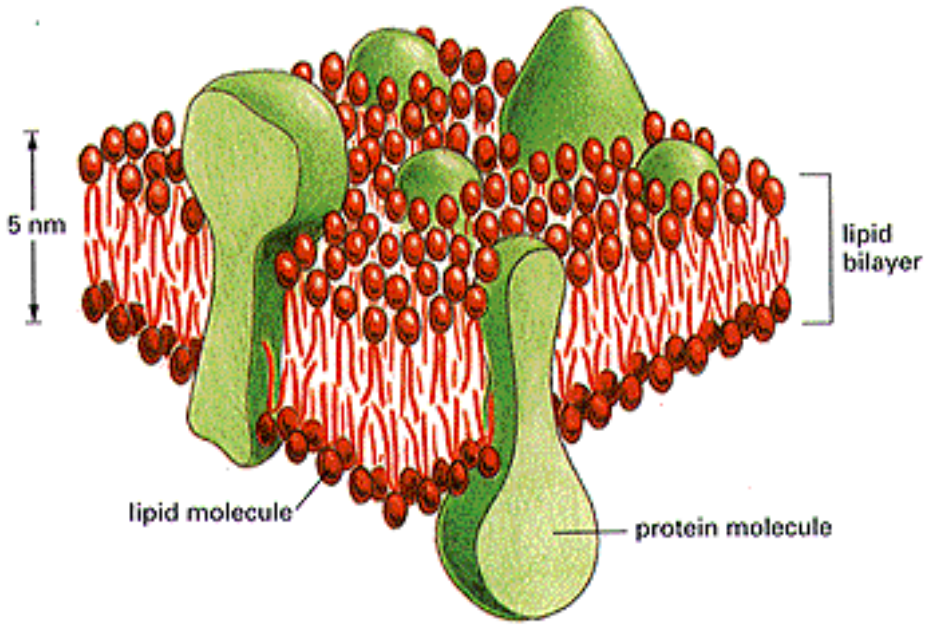
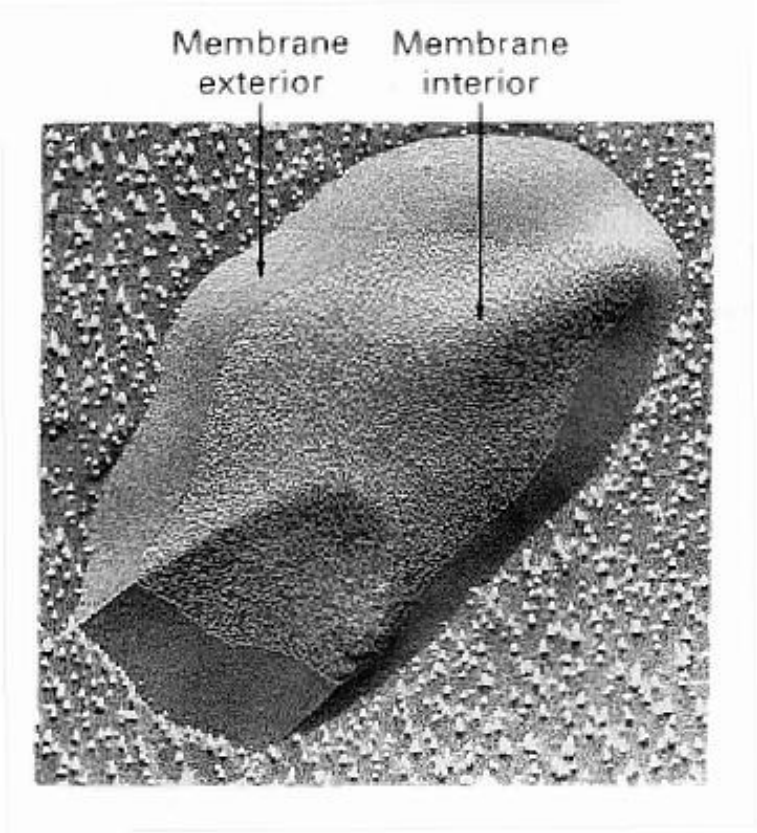
Structure, fonctions
et composition des membranes

Fonctions des membranes

- Compartimentation
  - Séparation de réactions chimiques incompatibles
  - Gradients de concentration
  - Energétique cellulaire et mitochondries
- Echanges
  - Endocytose, exocytose
  - Transport: pompes et canaux
  - Membrane plasmique
- Communication intercellulaire
  - Récepteurs, hormones et neurotransmetteurs
  - Electrophysiologie

Les membranes biologiques sont constituées de lipides et de protéines





- *70% des protéines sont associées aux membranes*
- *Les protéines membranaires constituent 20% de la masse protéique des cellules*
- *Les protéines membranaires constituent 50% de la masse protéique des membranes*

Rôles des lipides

- Rôle structural : les membranes biologiques sont constituées de lipides et de protéines
- Rôle énergétique : stockage et échanges
- Rôle de signalisation : à la surface des membranes

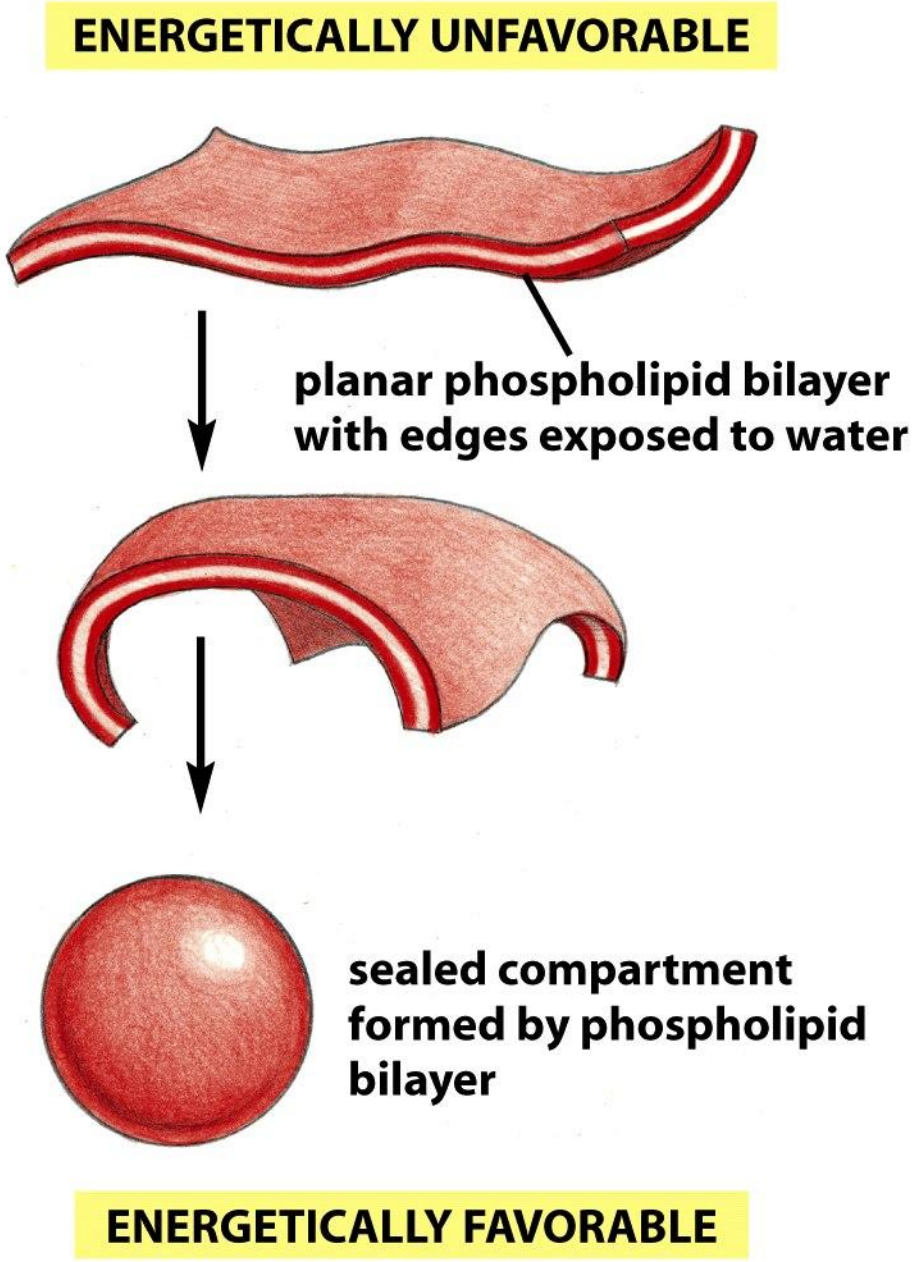


Figure 10-8 *Molecular Biology of the Cell* (© Garland Science 2008)

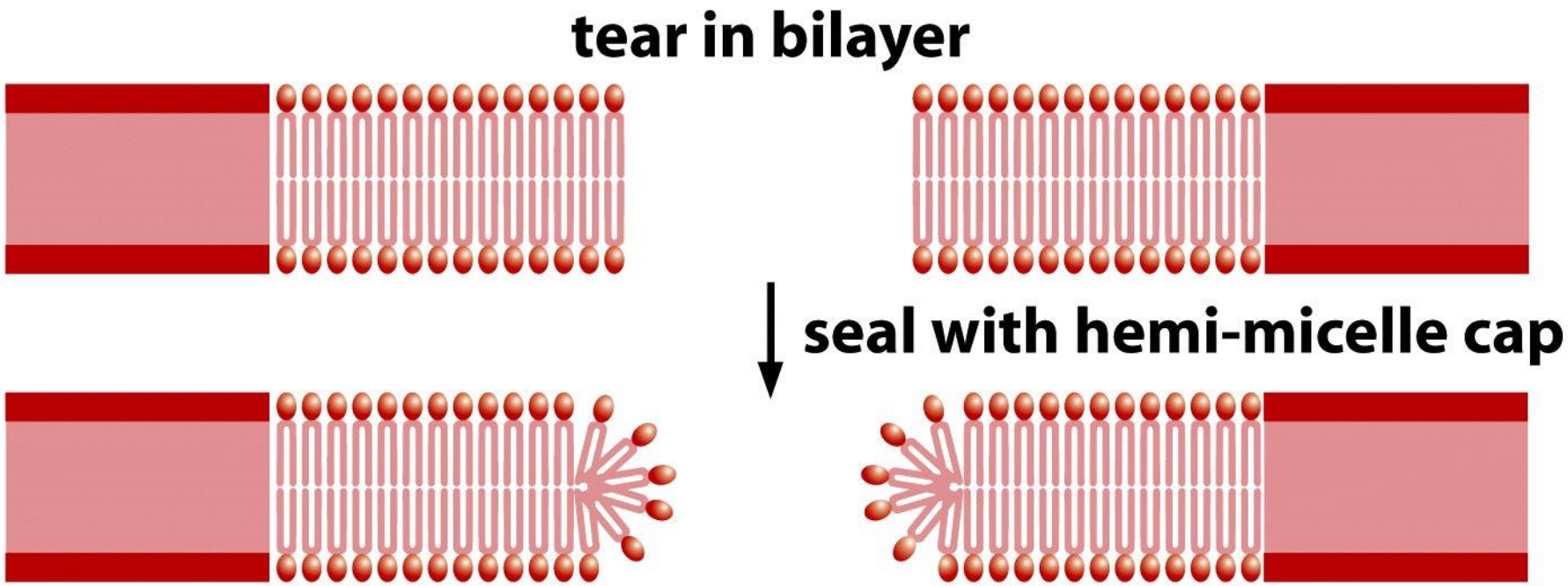


Figure Q10-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Structure des phospholipides

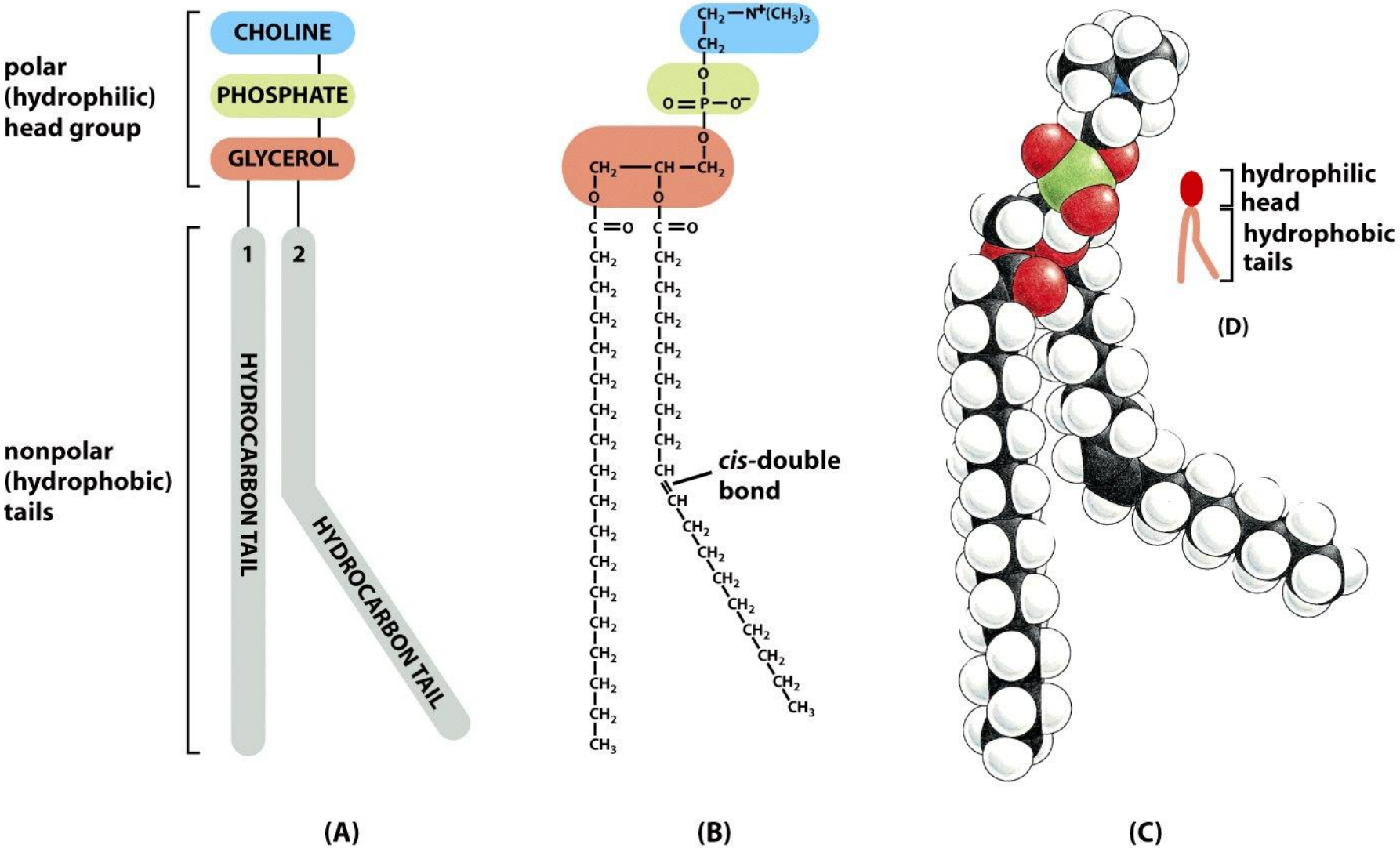


Figure 10-2 *Molecular Biology of the Cell* (© Garland Science 2008)

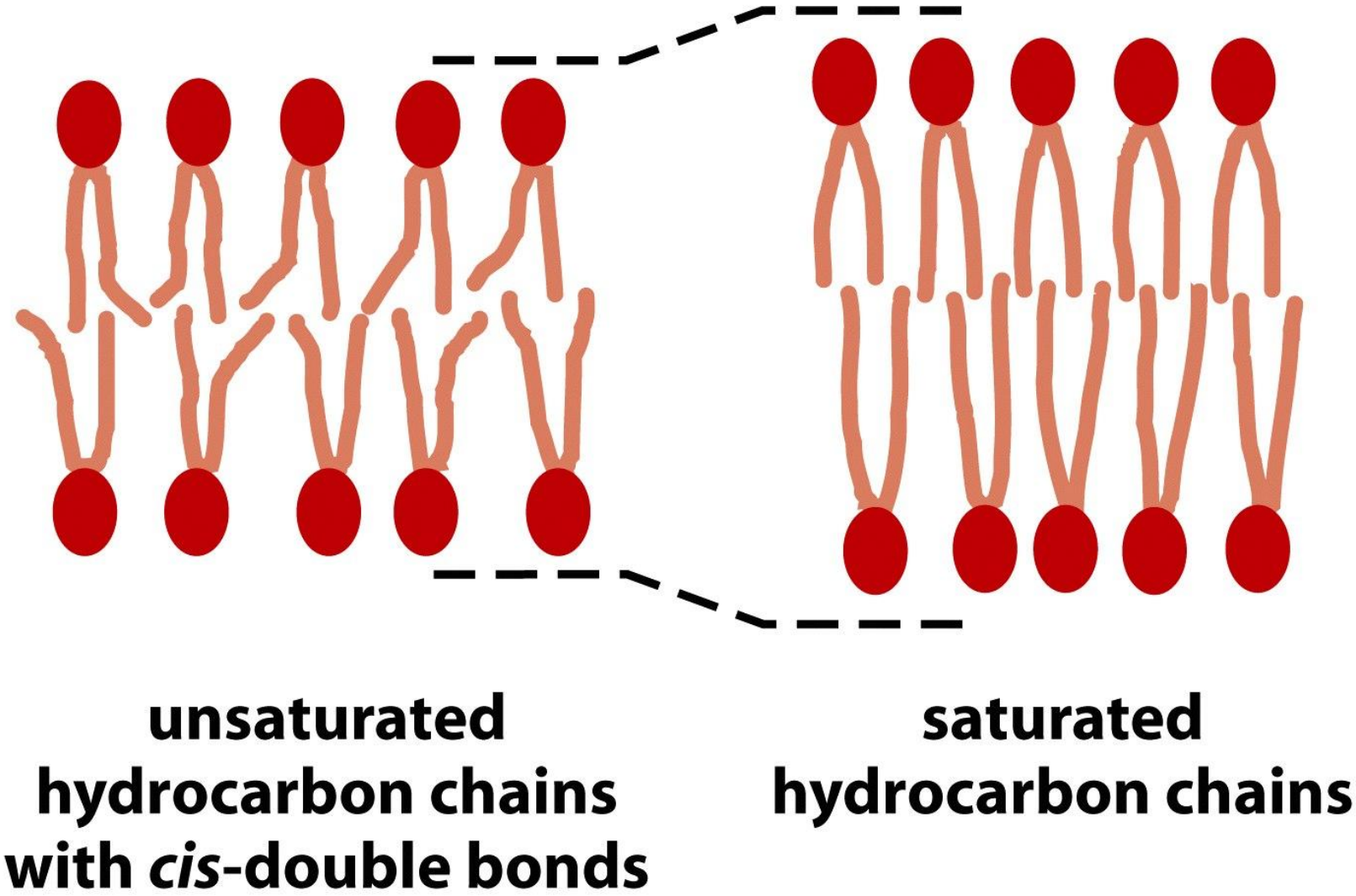
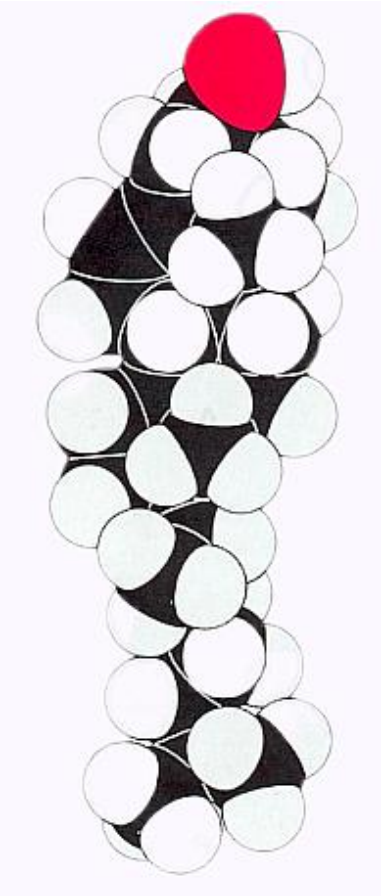
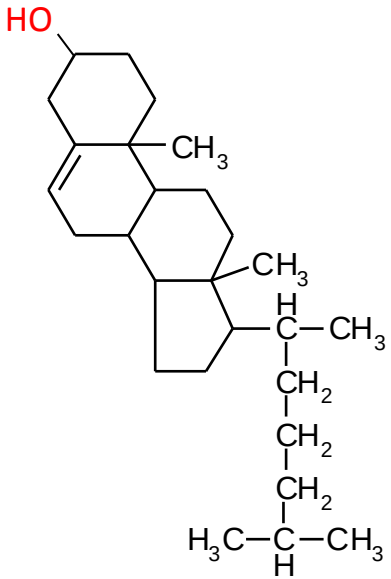


Figure 10-12 *Molecular Biology of the Cell* (© Garland Science 2008)

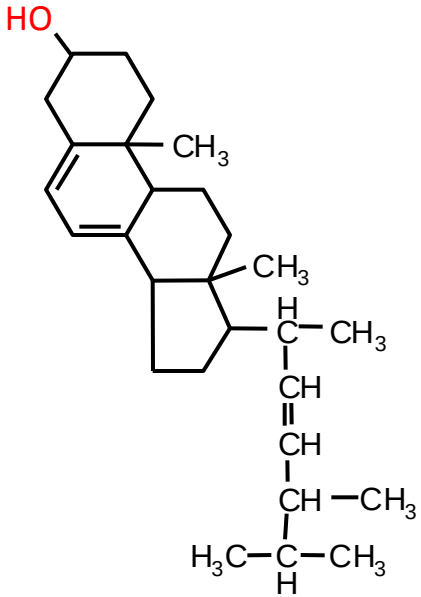
Les membranes des cellules eucaryotes contiennent du cholestérol





cholestérol

cellules animales



ergostérol

cellules végétales

Le cholestérol influence la fluidité membranaire

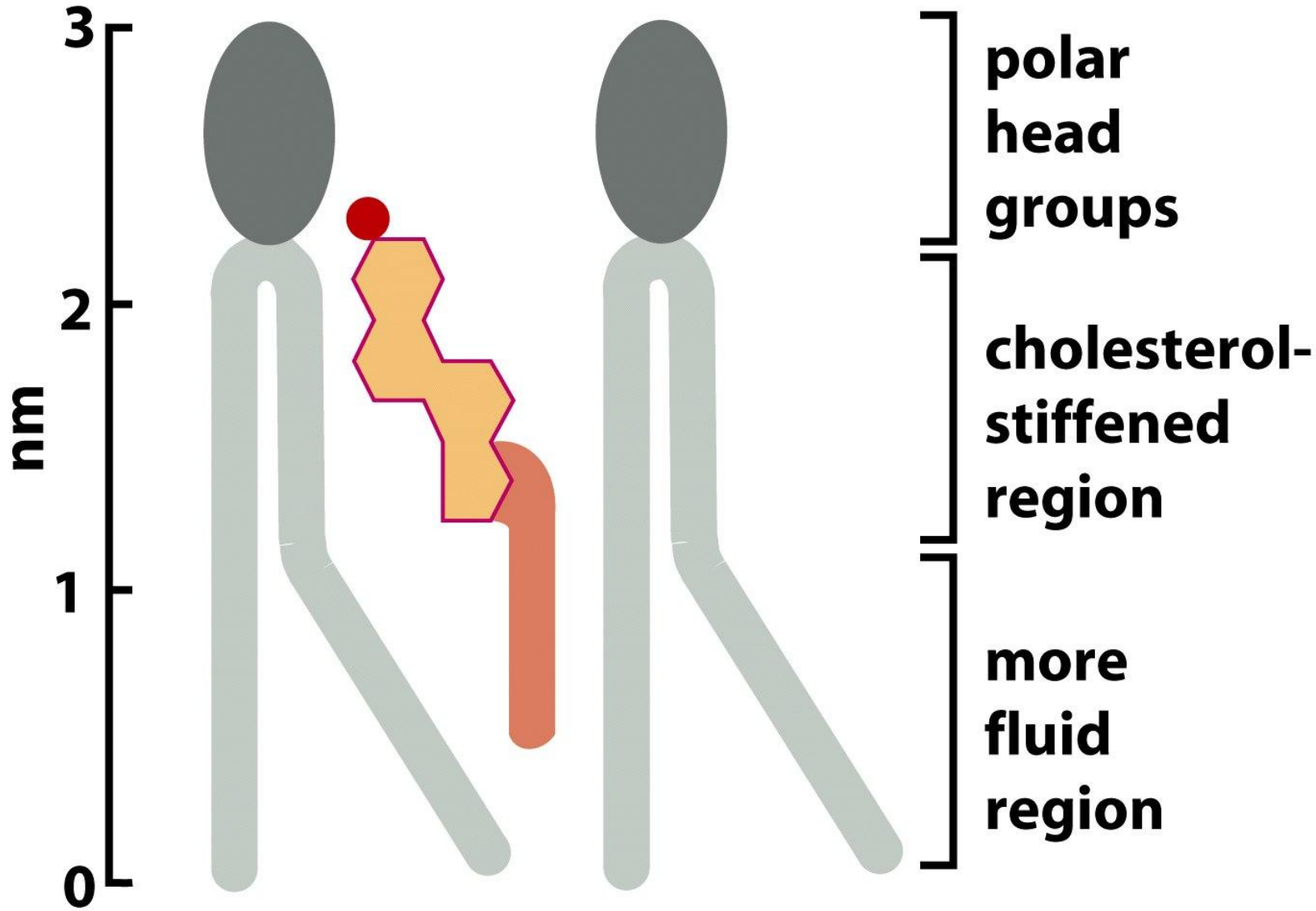
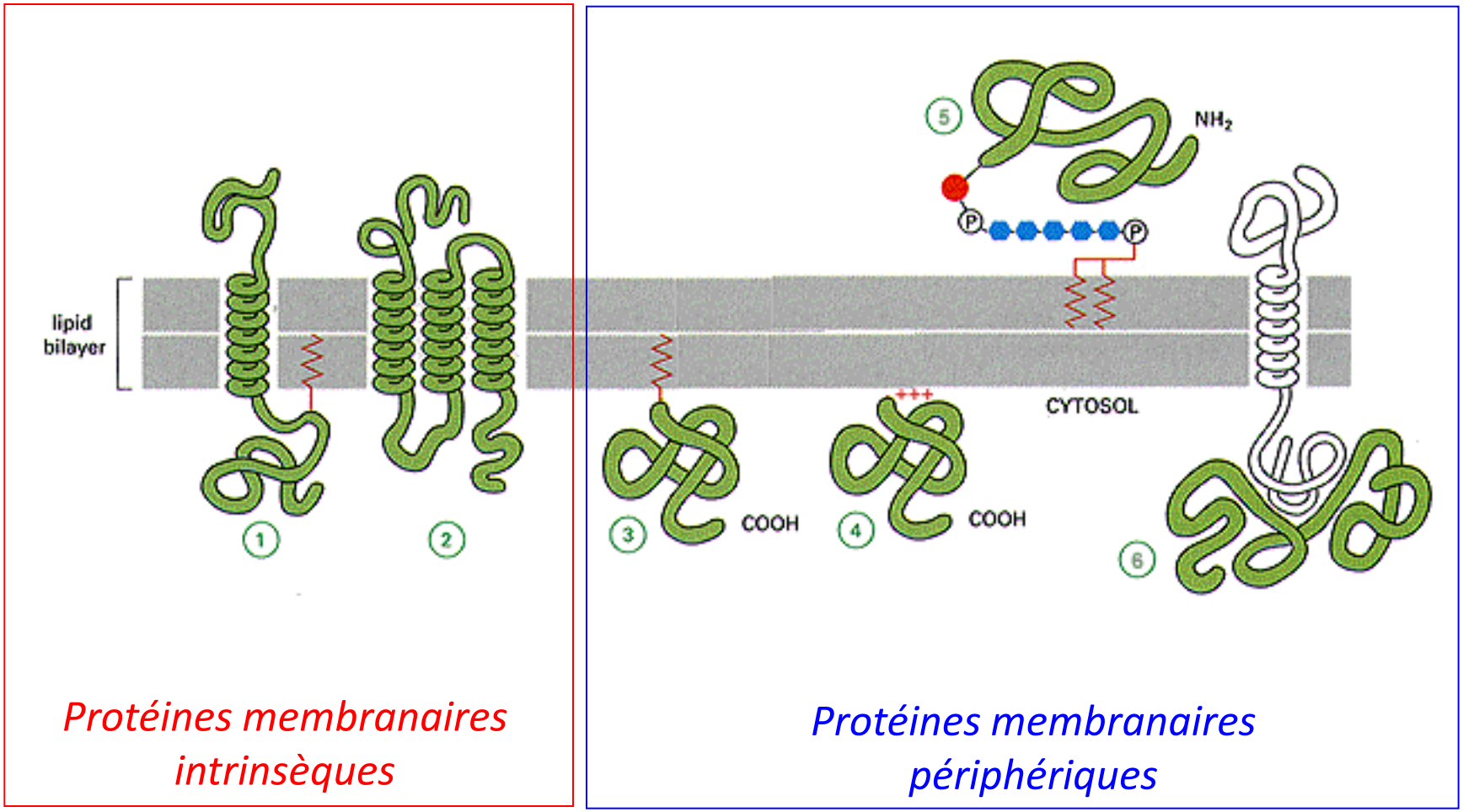


Figure 10-5 *Molecular Biology of the Cell* (© Garland Science 2008)

Interaction des protéines avec les membranes



Solubilisables après destruction de la membrane par des détergents

Solubilisables par des moyens physico-chimiques doux (pH, concentration de sel)

Les divers types de protéines membranaires

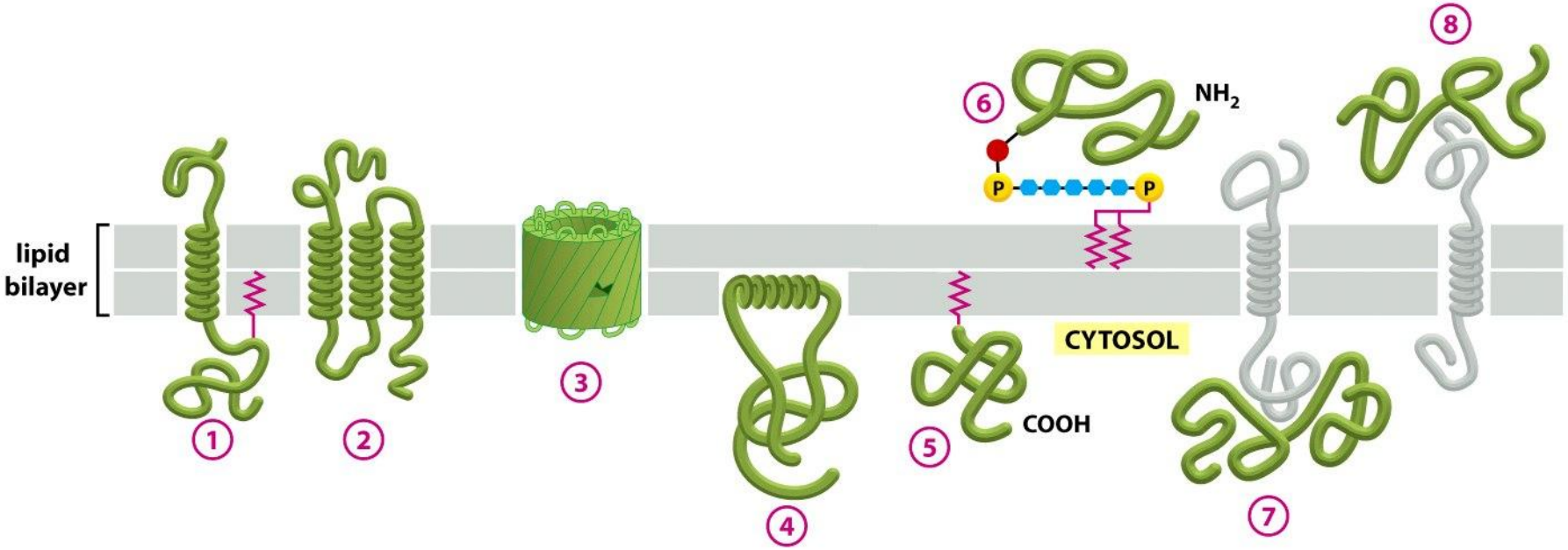
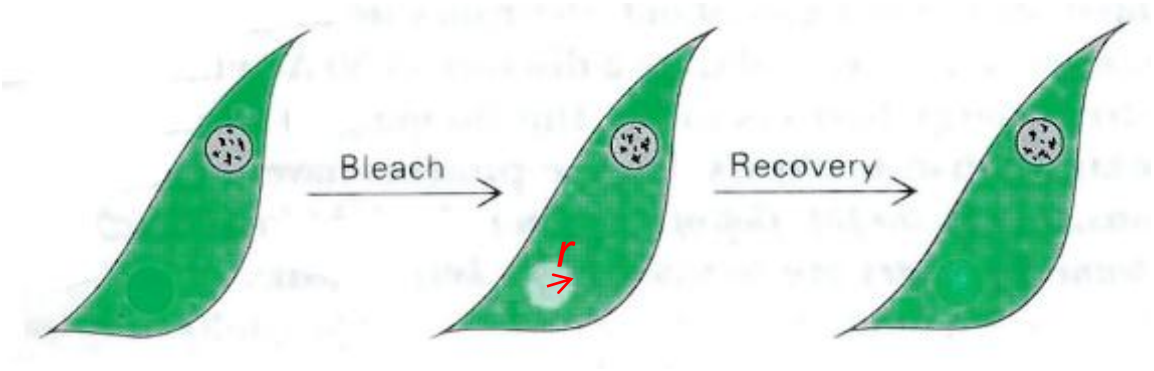
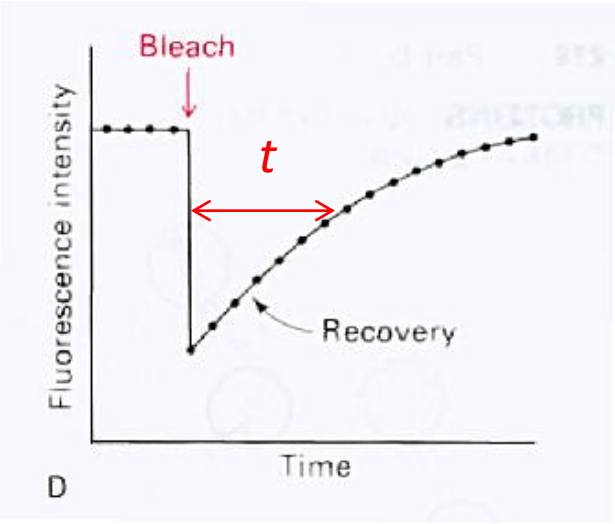


Figure 10-19 *Molecular Biology of the Cell* (© Garland Science 2008)

Les lipides et les protéines peuvent diffuser rapidement dans le plan de la membrane

Fluorescence Recovery After Photobleaching (FRAP)





Coefficients de diffusion latérale:

Lipides	1-2 $\mu m^2/s$
Protéines membranaires périphériques	1 $\mu m^2/s$
Protéines membranaires intrinsèques	0.1-0.5 $\mu m^2/s$
Attachement au cytosquelette	10^{-4} $\mu m^2/s$

$$t = r^2/D$$

La membrane est renforcée par son association au cytosquelette (ex : réseau de spectrine/actine dans les hématies)

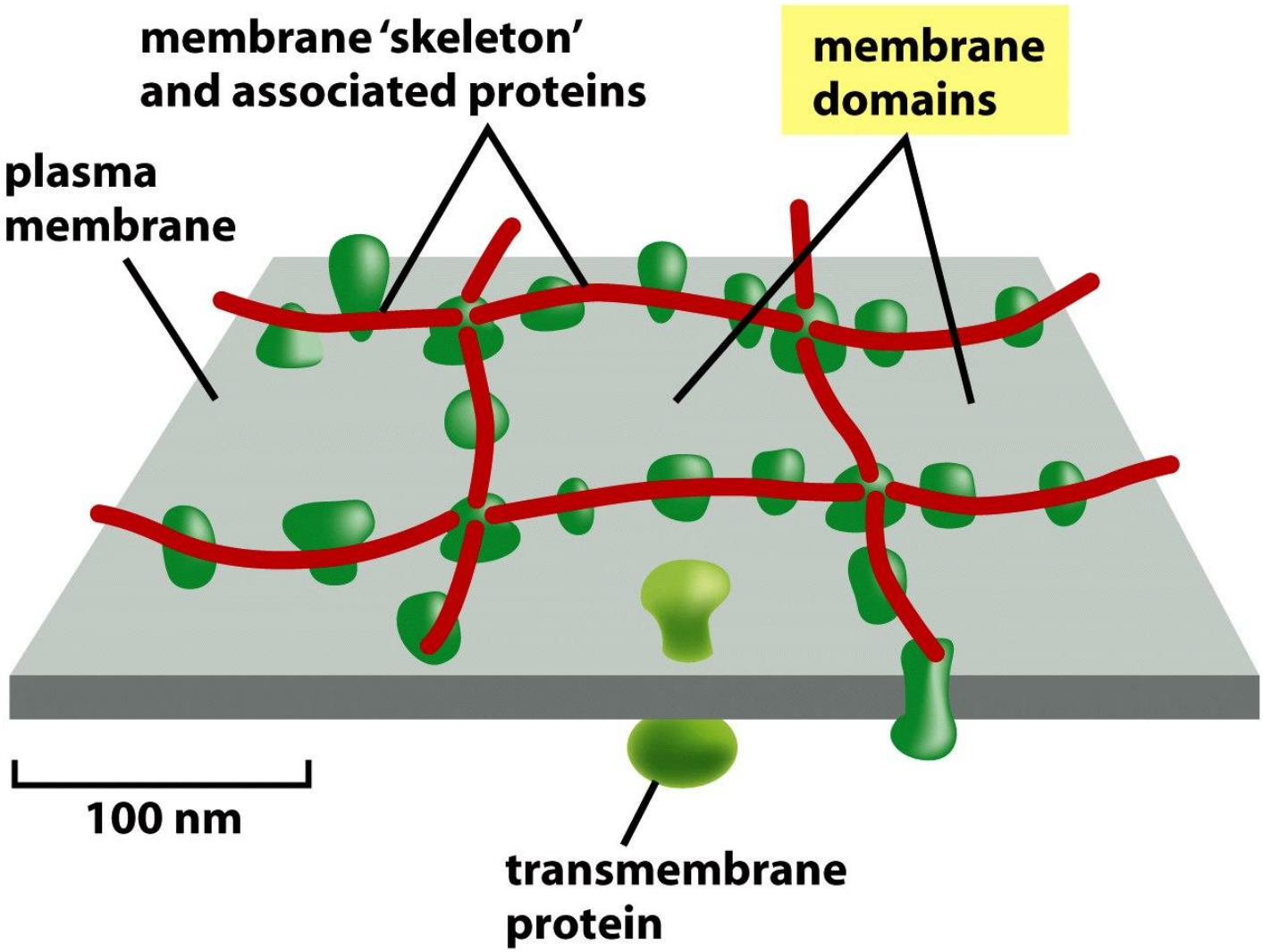
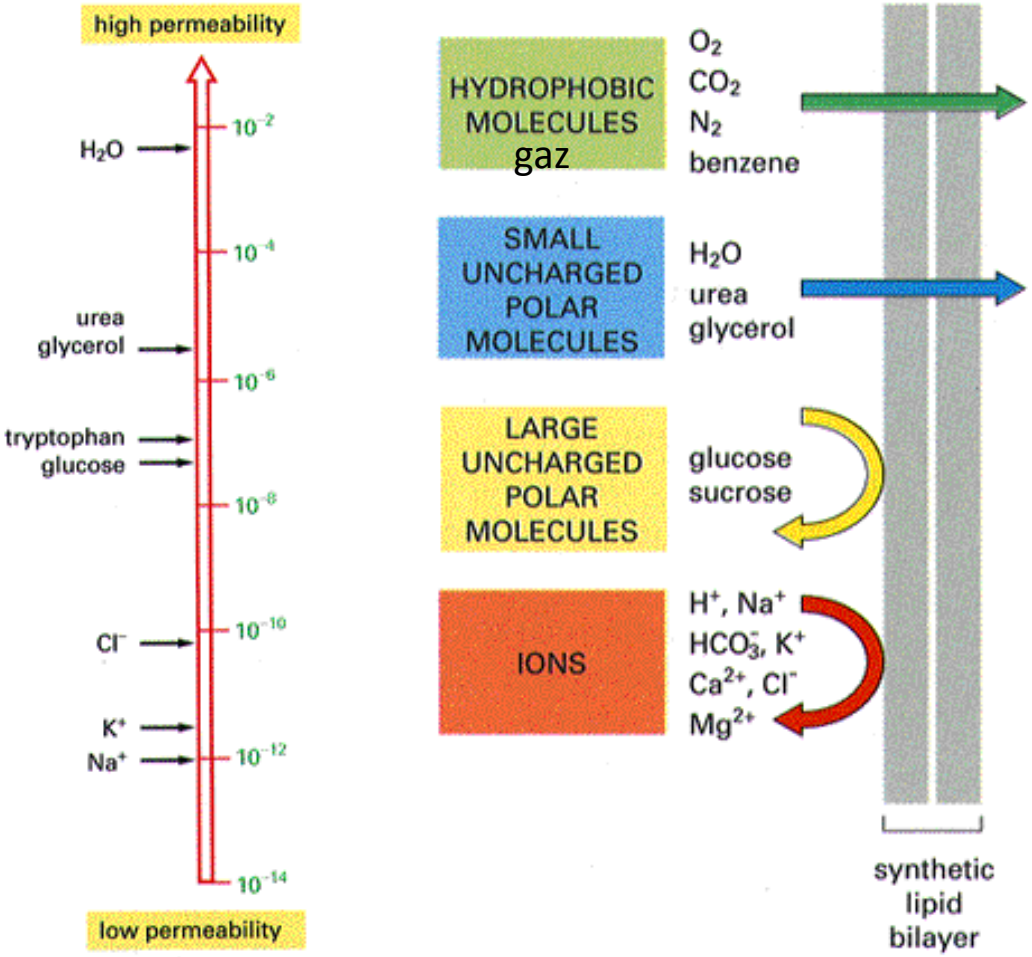


Figure 10-42a *Molecular Biology of the Cell* (© Garland Science 2008)

Les bicouches lipidiques sont imperméables aux molécules polaires



Les protéines membranaires sont indispensables pour le transport des

- *molécules polaires*
- *ions*

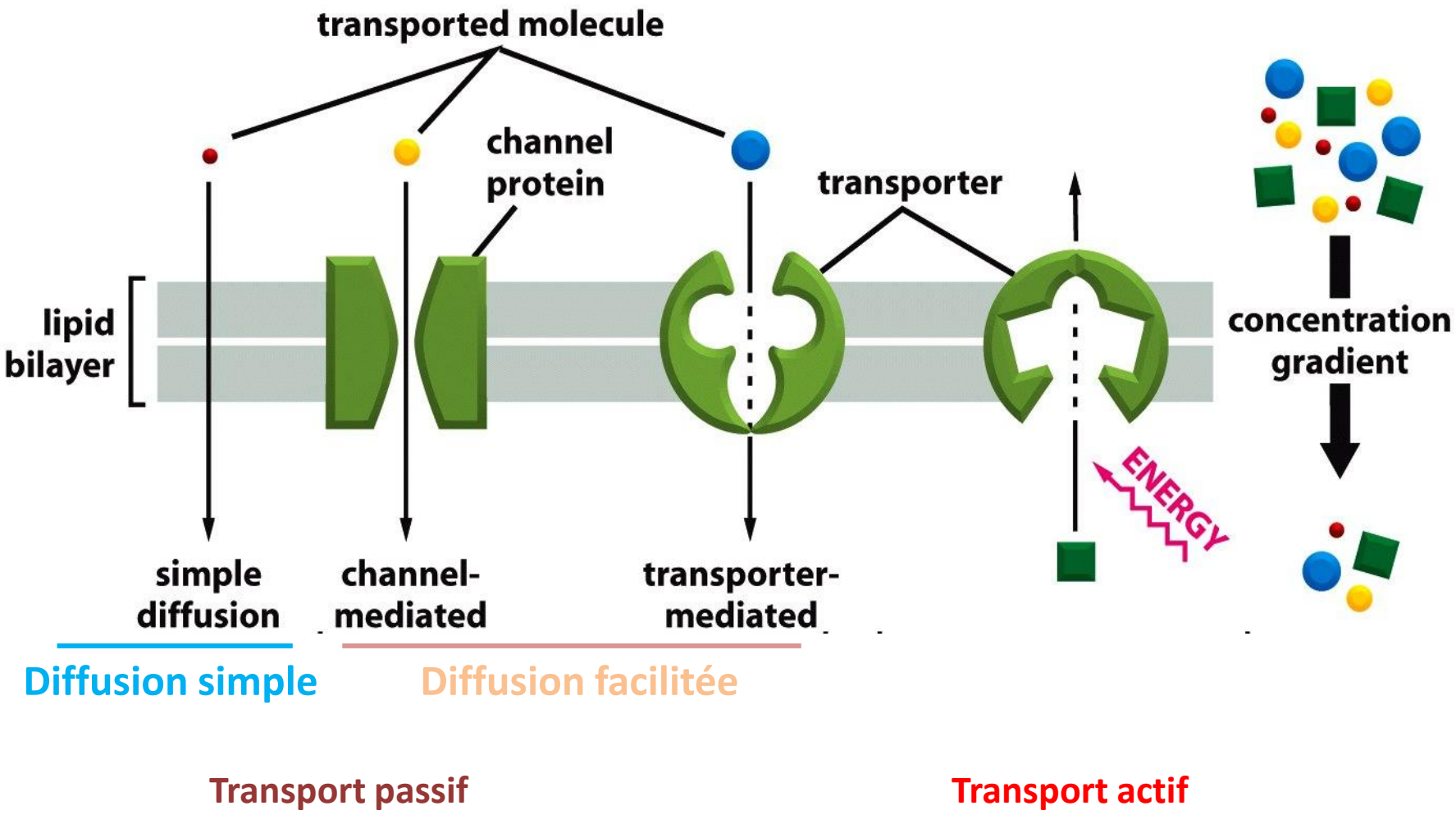


Figure 11-4a *Molecular Biology of the Cell* (© Garland Science 2008)

Co-Transporteurs: exemple du symporteur Na/glucose,
qui permet l'absorption du glucose par la membrane apicale des cellules intestinales

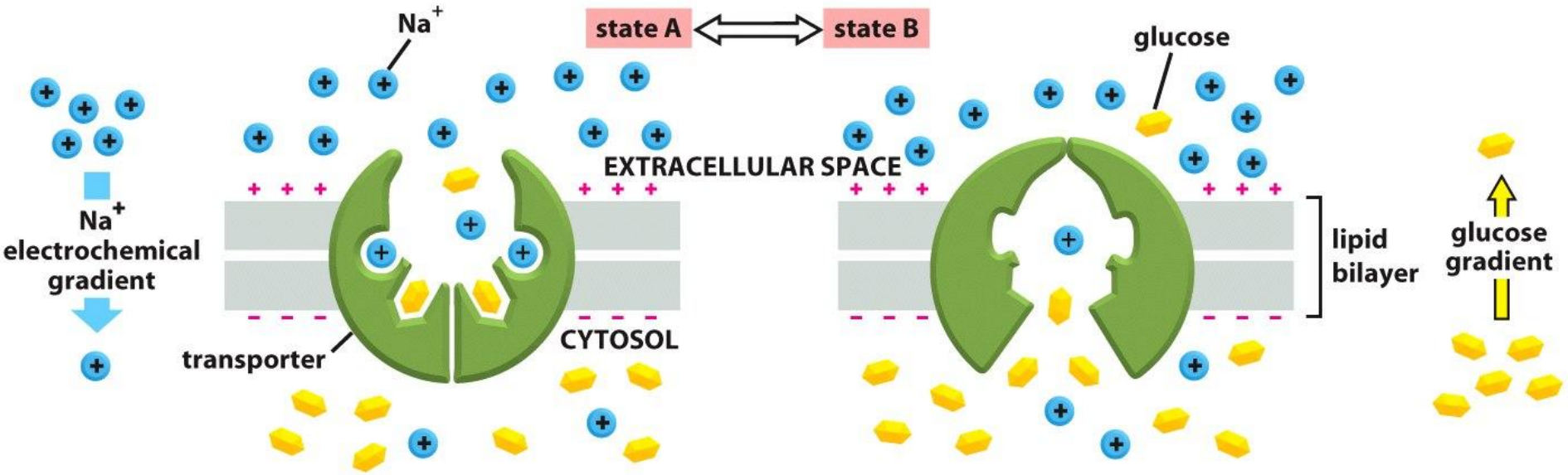
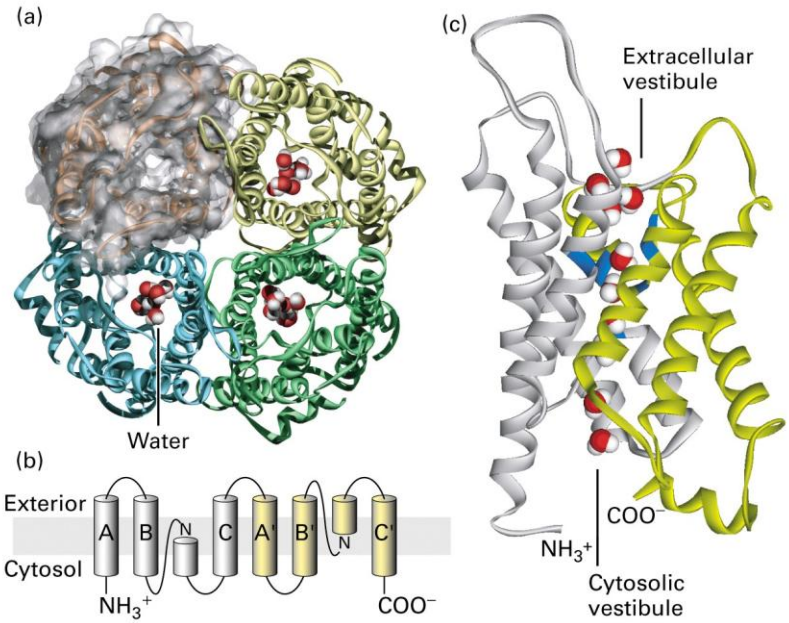
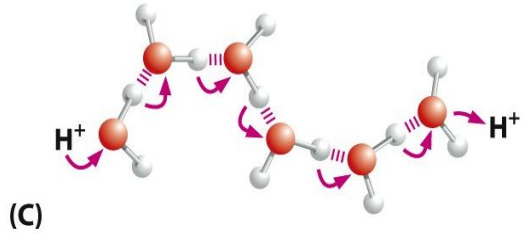
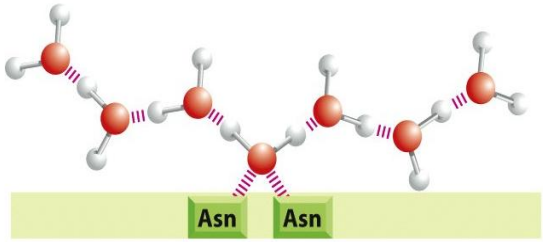


Figure 11-9 *Molecular Biology of the Cell* (© Garland Science 2008)

Les aquaporines régulent le transport hydrique







Canal imperméable aux ions: les groupes COO^- des Asn empêchent le passage des cations et maintiennent la structure des molécules d'eau; le pore, chargé positivement s'oppose au passage des anions.

10 molécules d'eau s'alignent ds un pore de 0,3nm de diamètre.

Les canaux répondent à différents stimuli en fonction de leur nature

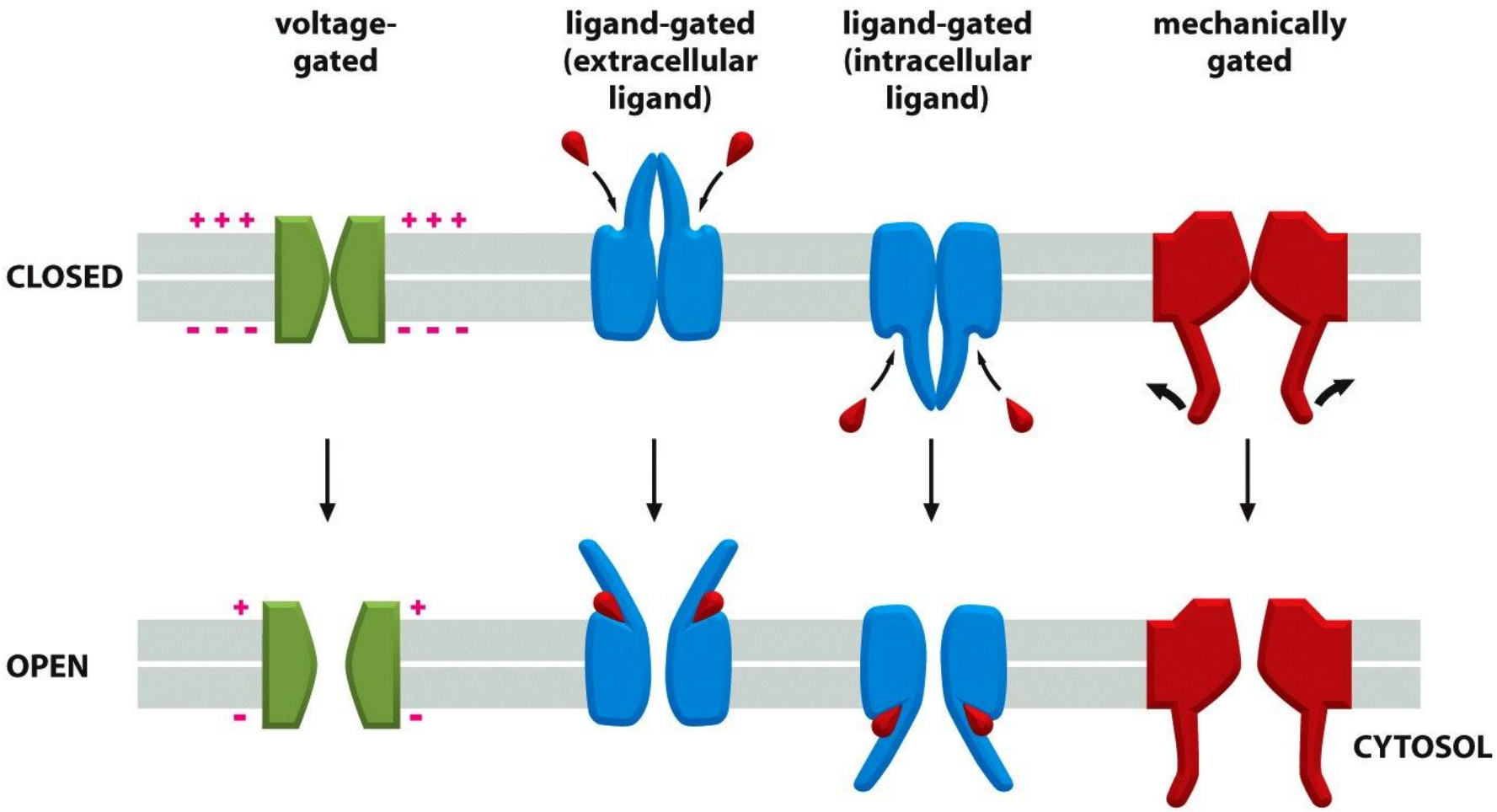


Figure 11-21 *Molecular Biology of the Cell* (© Garland Science 2008)

Transport actif: contre le gradient électrochimique

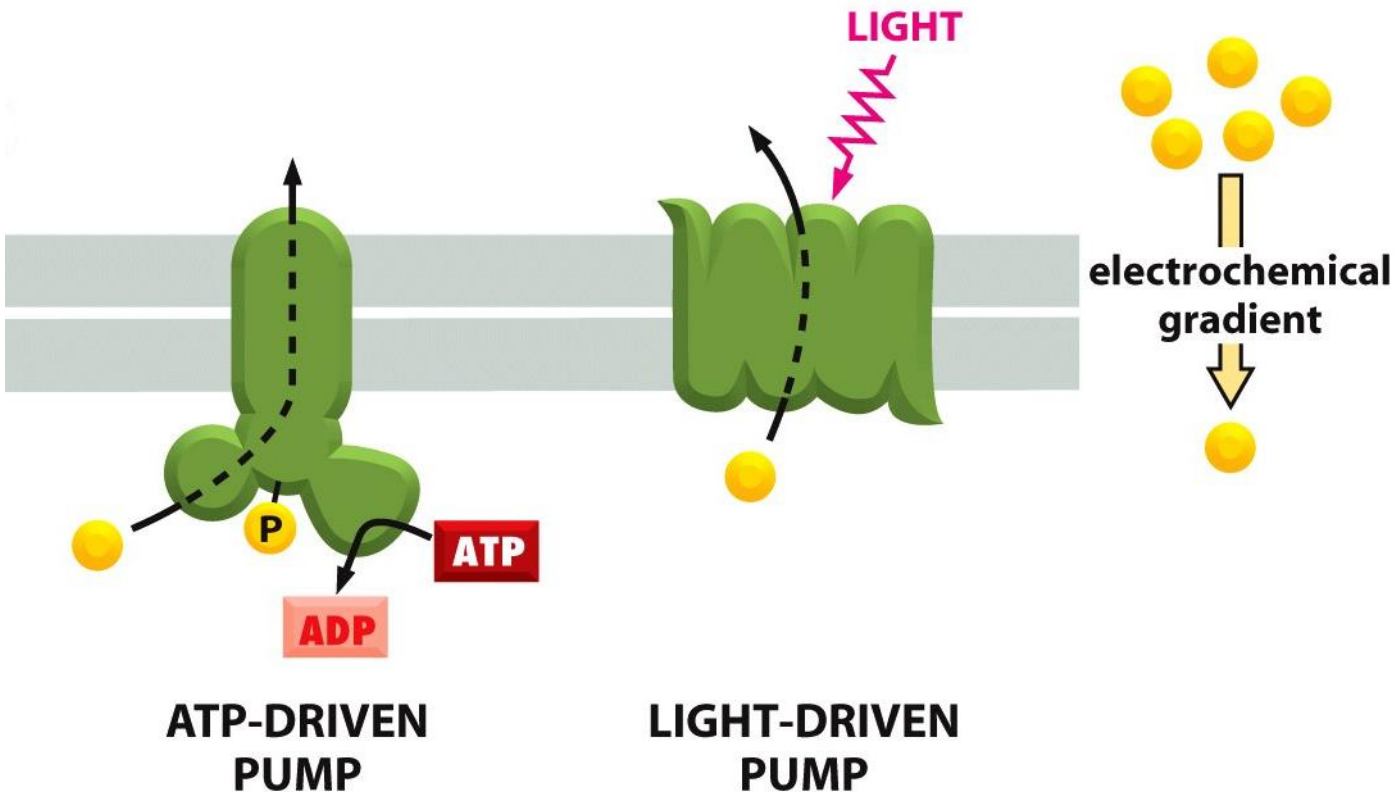


Figure 11-7 *Molecular Biology of the Cell* (© Garland Science 2008)

Les 3 types d'ATPases

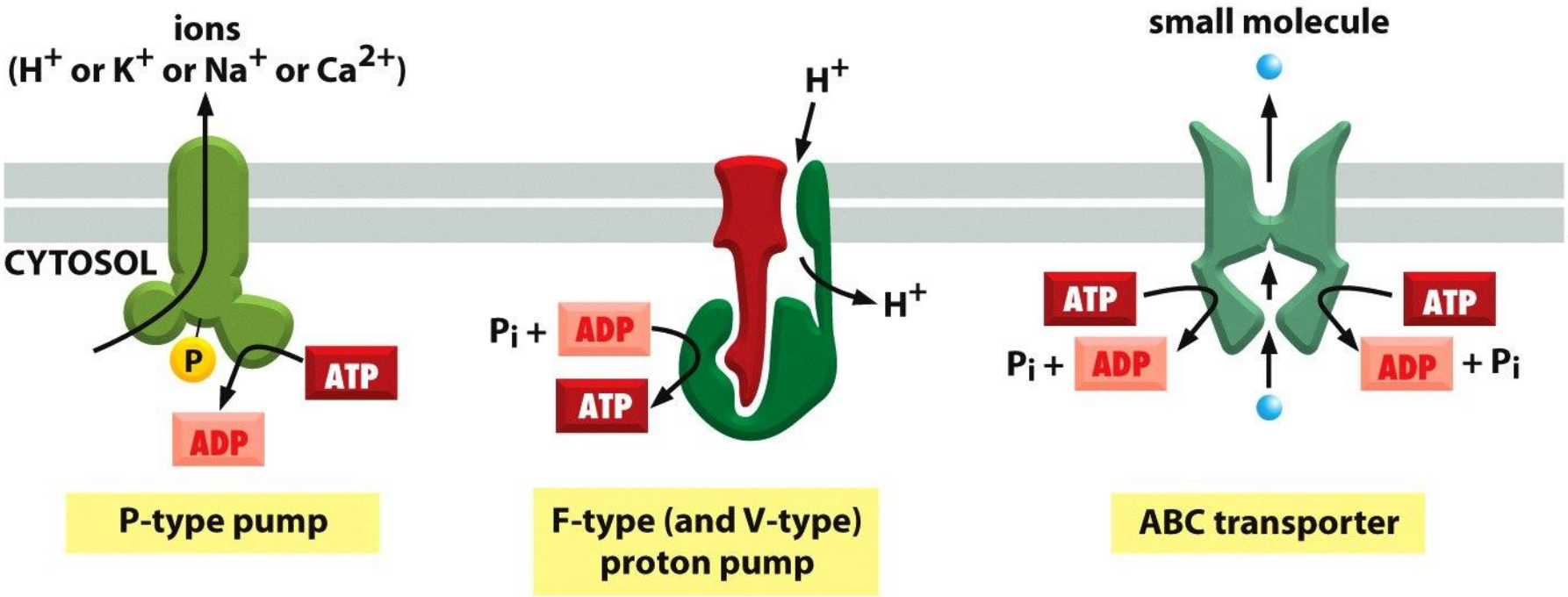
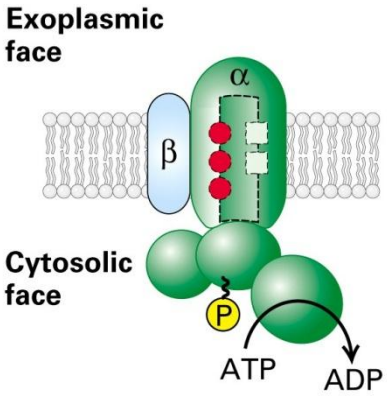


Figure 11-12 *Molecular Biology of the Cell* (© Garland Science 2008)



P-class pumps

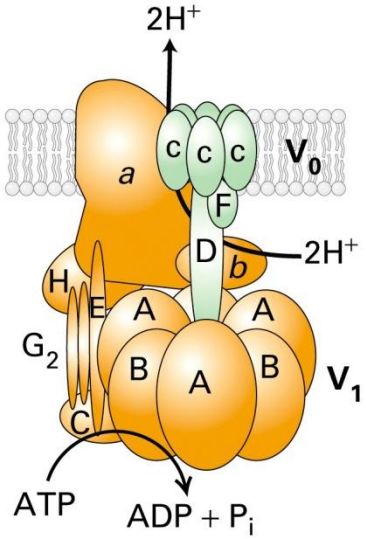
Plasma membrane of plants, fungi, bacteria (H^+ pump)

Plasma membrane of higher eukaryotes (Na^+/K^+ pump)

Apical plasma membrane of mammalian stomach (H^+/K^+ pump)

Plasma membrane of all eukaryotic cells (Ca^{2+} pump)

Sarcoplasmic reticulum membrane in muscle cells (Ca^{2+} pump)

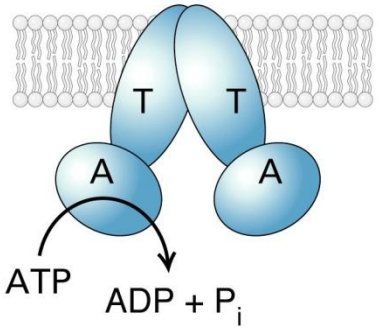


V-class proton pumps

Vacuolar membranes in plants, yeast, other fungi

Endosomal and lysosmal membranes in animal cells

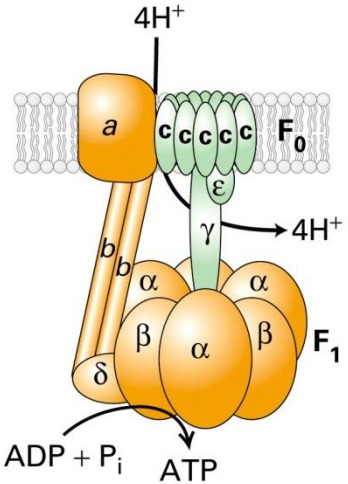
Plasma membrane of osteoclasts and some kidney tubule cells



ABC superfamily

Bacterial plasma membranes (amino acid, sugar, and peptide transporters)

Mammalian plasma membranes (transporters of phospholipids, small lipophilic drugs, cholesterol, other small molecules)



F-class proton pumps

Bacterial plasma membrane

Inner mitochondrial membrane

Thylakoid membrane of chloroplast

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.

Table 11-1 *Molecular Biology of the Cell* (© Garland Science 2008)

L'ATPase Na/K

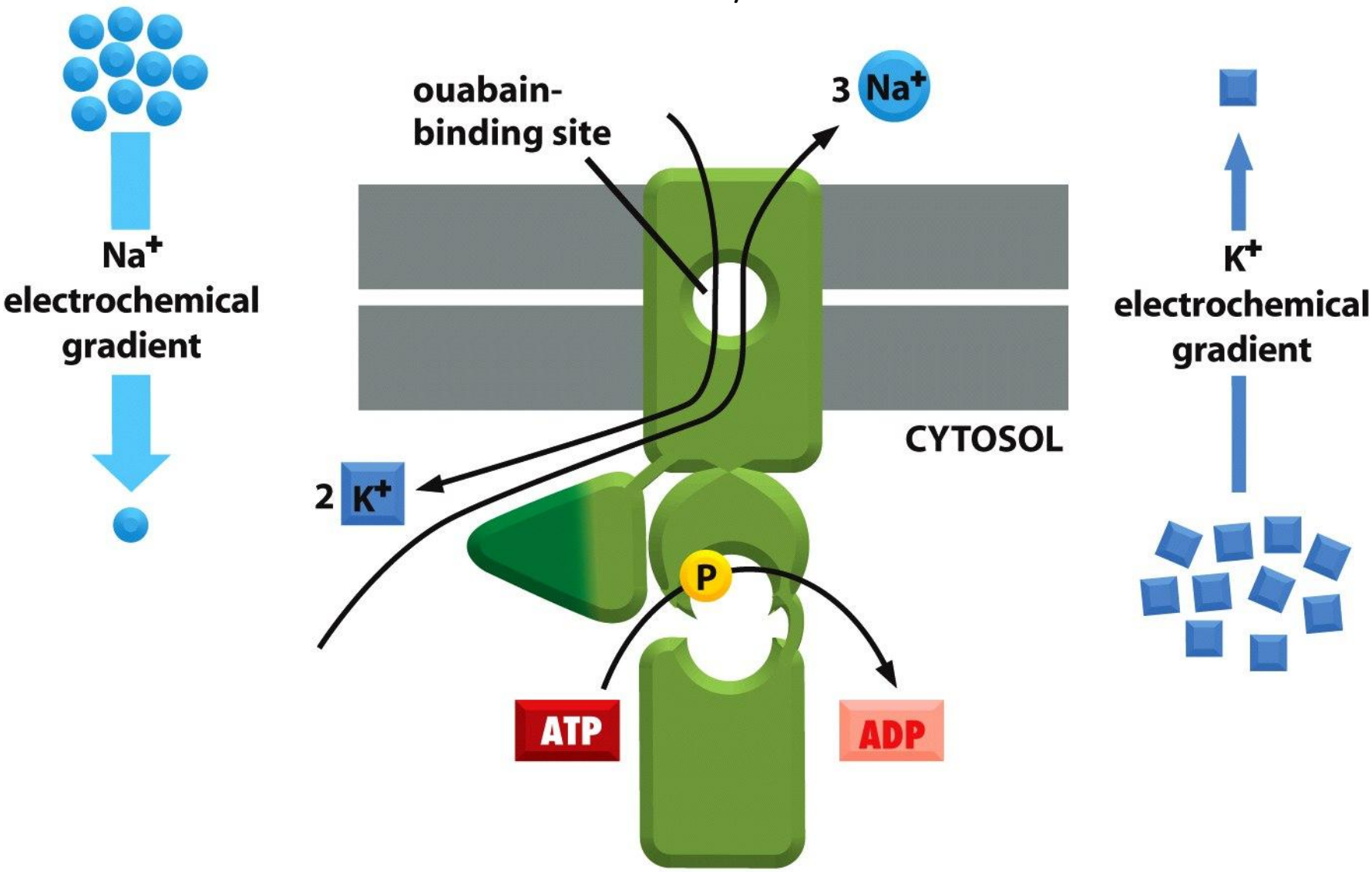


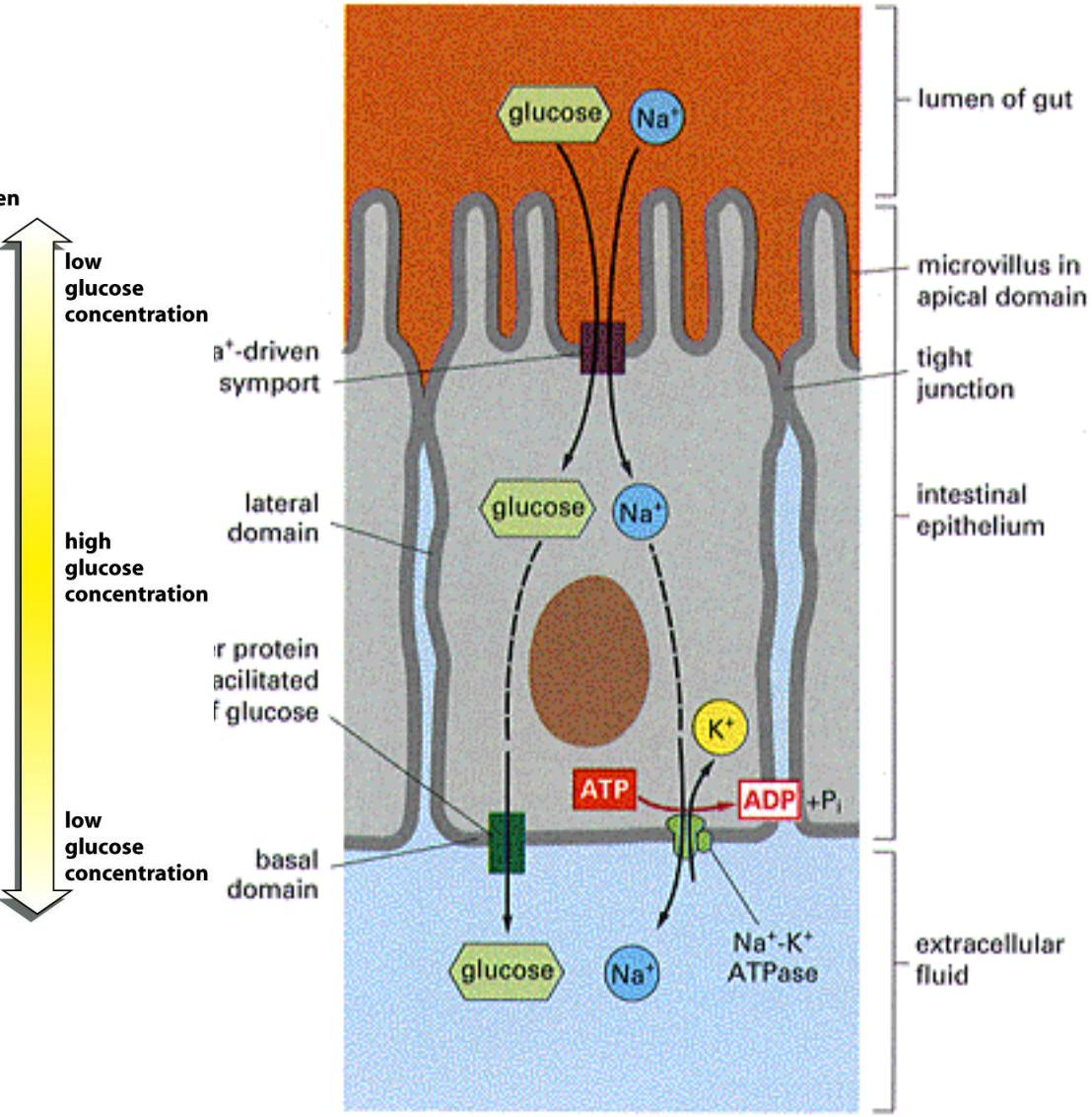
Figure 11-14 *Molecular Biology of the Cell* (© Garland Science 2008)

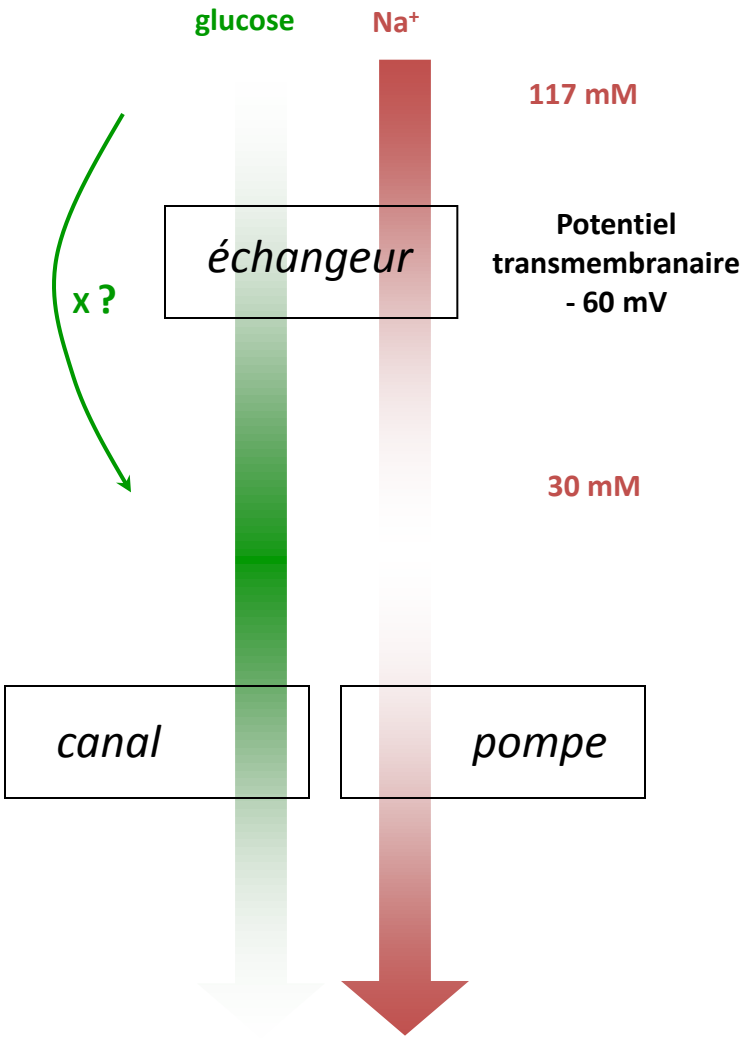
Rôle de la pompe Na/K dans le fonctionnement du muscle cardiaque

Dans les cellules du muscle cardiaque, la concentration faible de Ca est maintenue par un antiporteur 3Na/Ca.

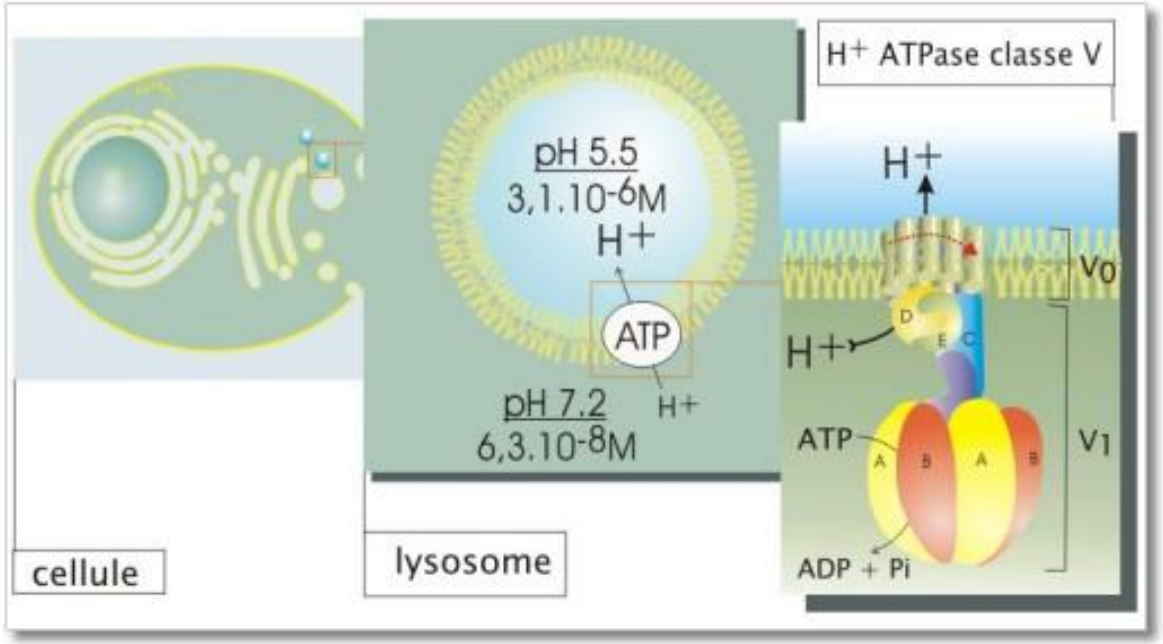
L'ouabaine et la digoxine, qui réduisent l'activité de la pompe Na/K, augmentent la concentration de Ca intracellulaire, provoquant la contraction du muscle cardiaque. Ces drogues sont largement employées dans le traitement des crises cardiaques.

Transport de métabolites dans l'intestin



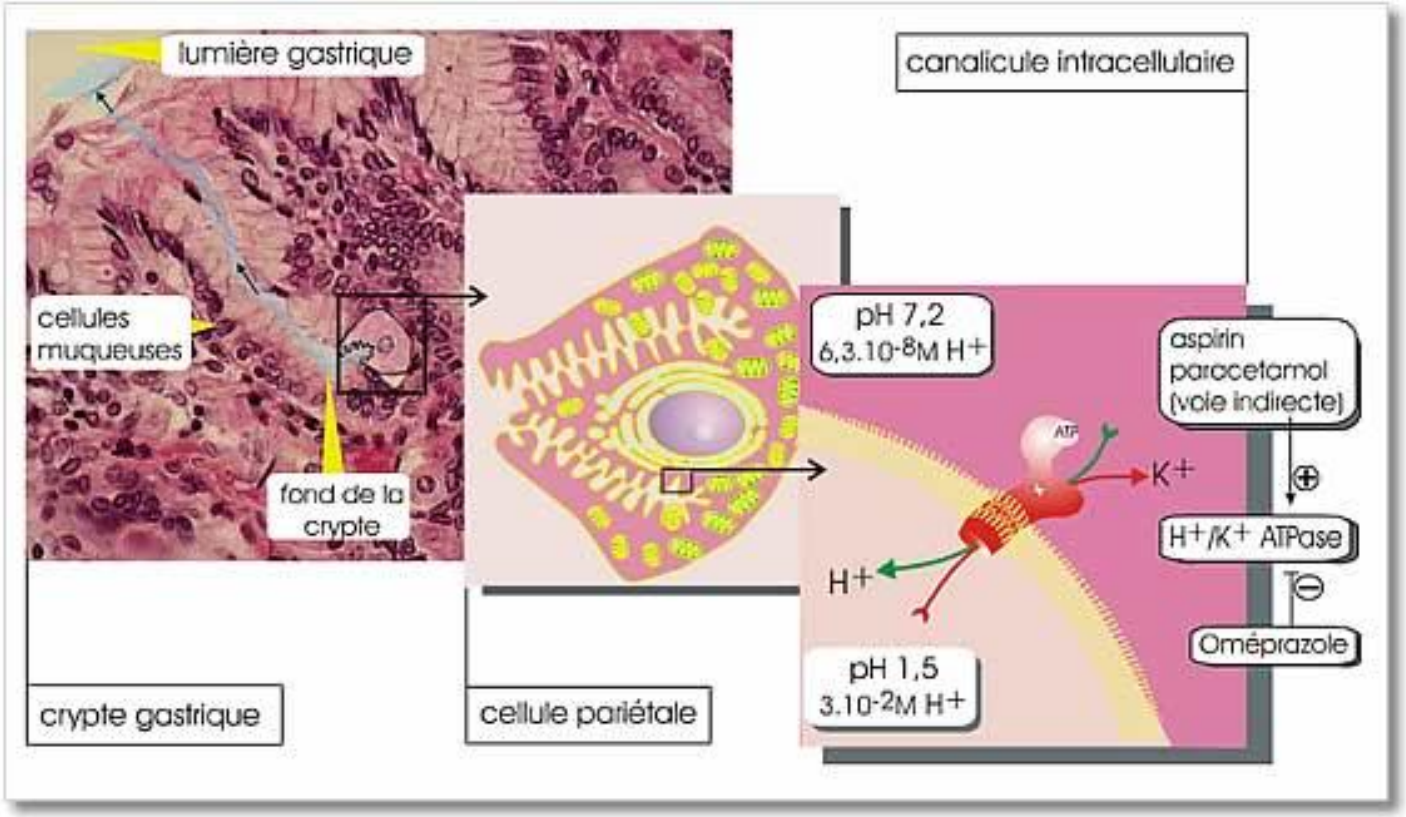


Régulation du pH des lysosomes
(pompes à protons de type V-class)



Le lysosome est un compartiment qui a pour fonction la dégradation des déchets intracellulaires ou provenant de l'extérieur (endosomes)
Il contient une cinquantaine de protéases qui fonctionnent à pH 5,5

Régulation du pH extracellulaire dans l'estomac



La pompe H^+/K^+ génère un puissant gradient de protons $[H^+]$ est 10^6 plus élevée dans la lumière de l'estomac que dans le cytoplasme des cellules (pH 1,5). L'oméprazole ,drogue utilisée pour guérir les ulcères a un effet inhibiteur sur l'ATPase, conduisant à une augmentation du pH (4) favorable à la cicatrisation