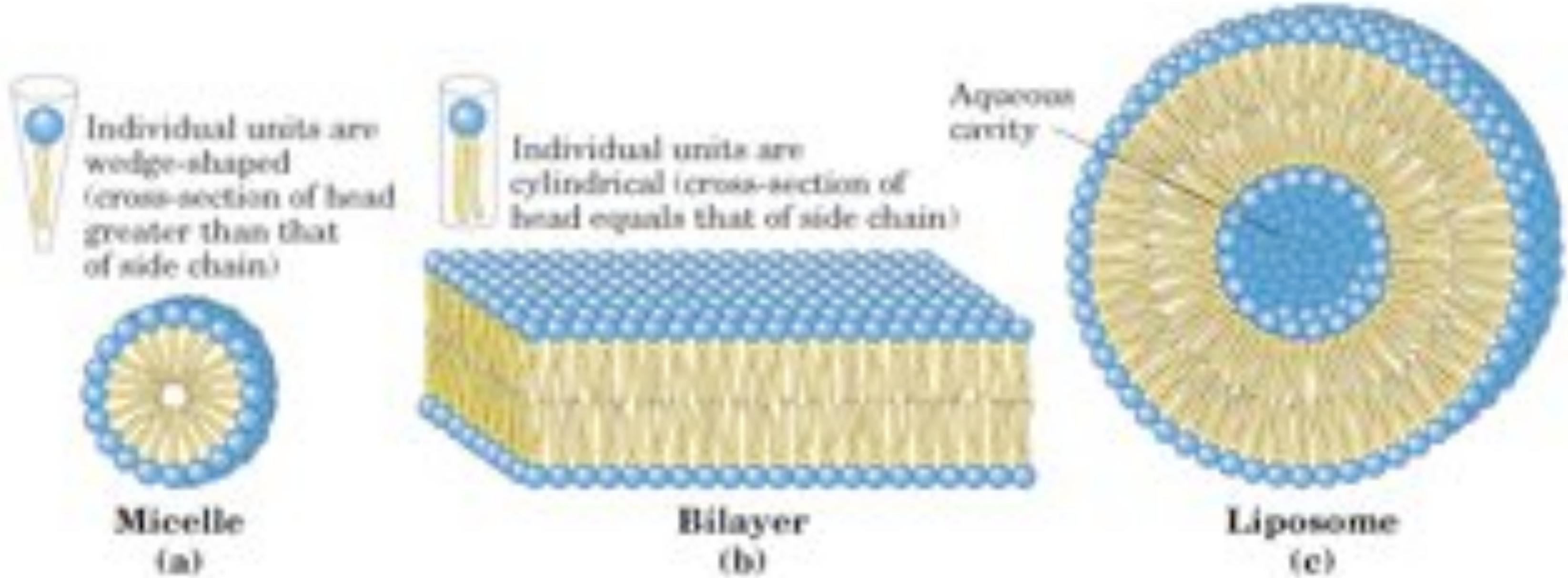


Individual units are wedge-shaped (cross-section of head greater than that of side chain)
Individual units are cylindrical (cross-section of head equals that of side chain)
Aqueous cavity
Micelle
(a)
Bilayer
(b)
Liposome
(c)

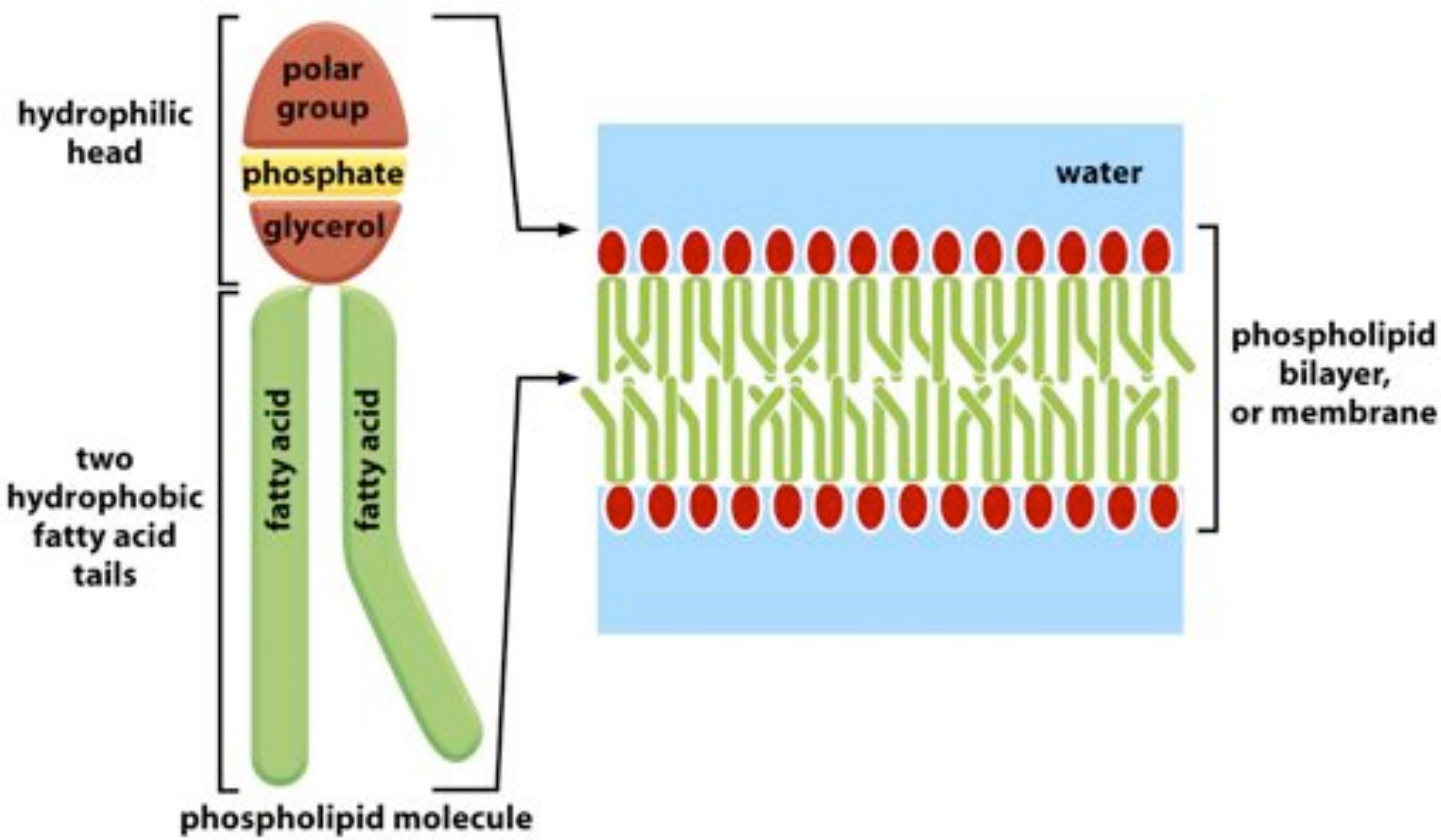


Figure 2-22 *Molecular Biology of the Cell* (© Garland Science 2008)

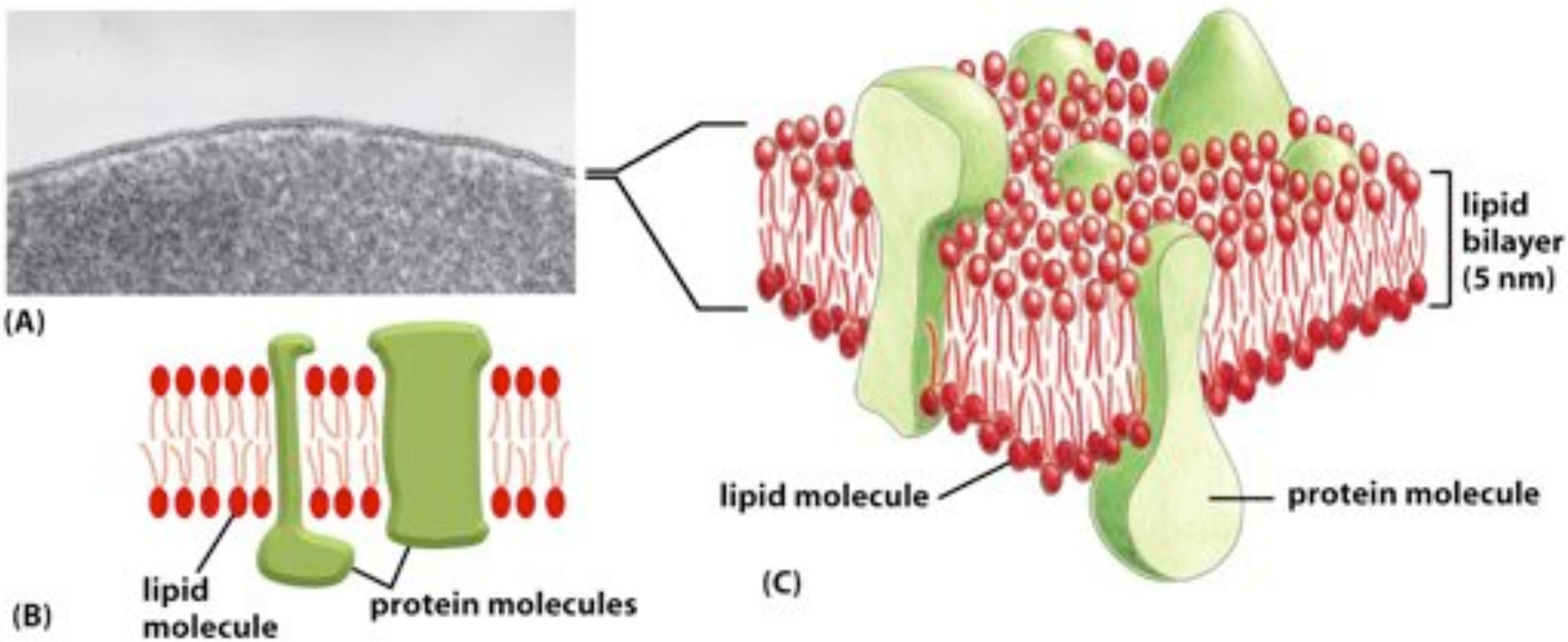


Figure 10-1 *Molecular Biology of the Cell* (© Garland Science 2008)

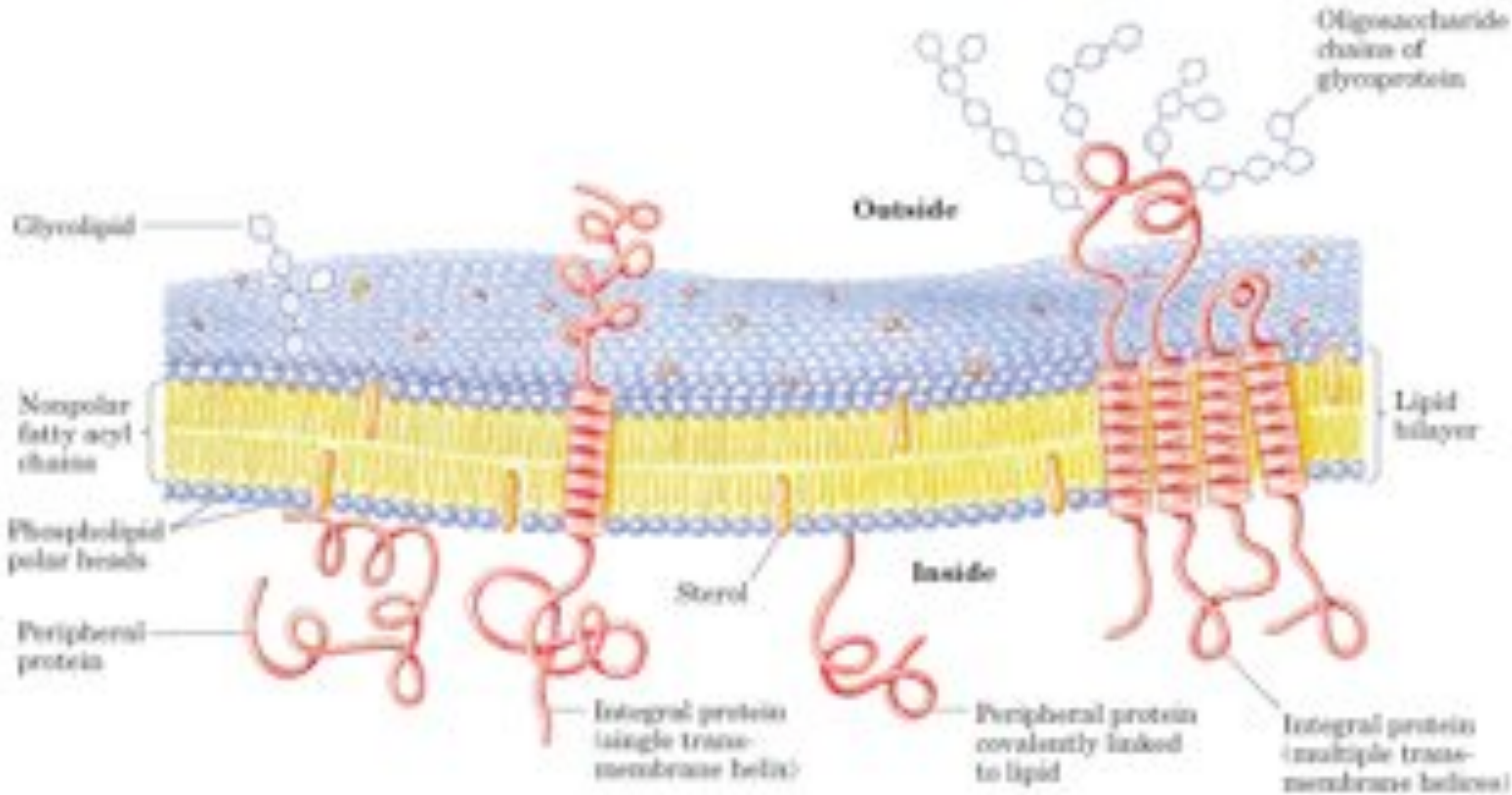
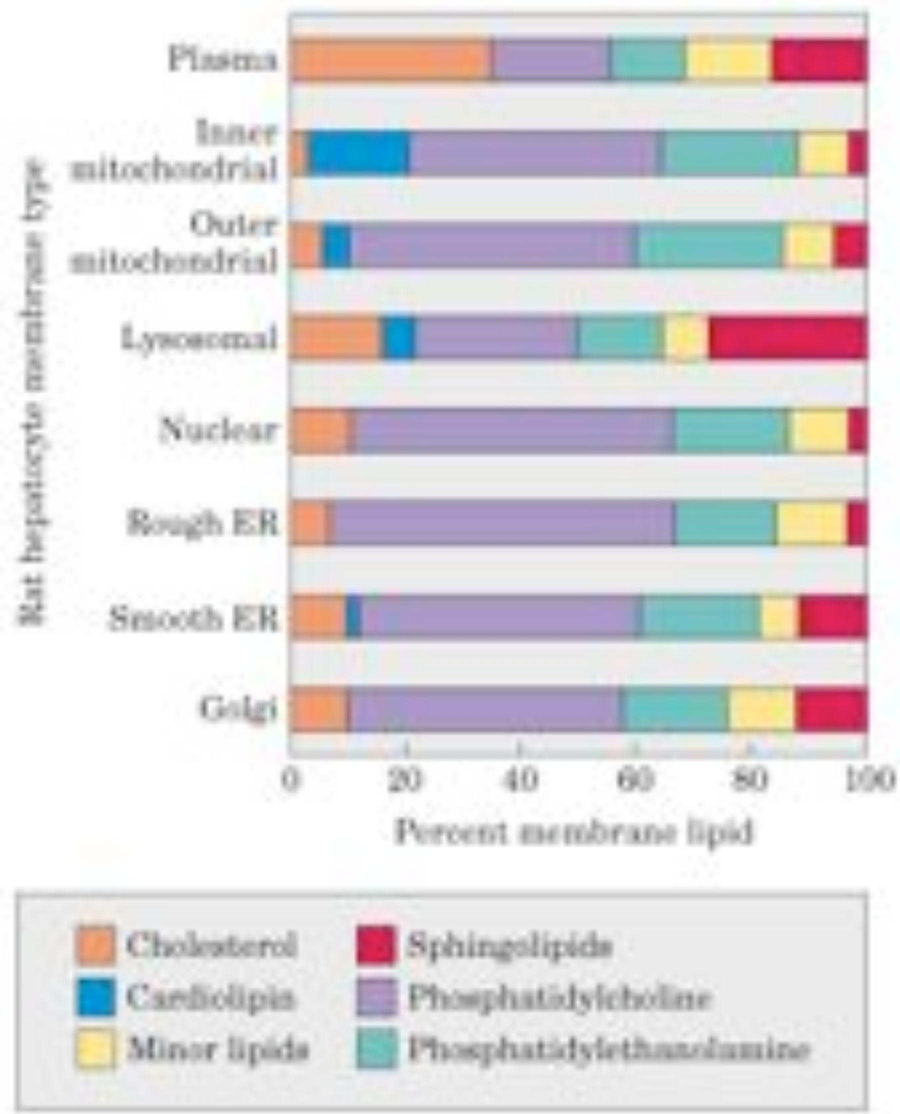

Oligosaccharide chains of glycoprotein
Outside
Glycolipid
Nonpolar fatty acyl chains
Lipid bilayer
Phospholipid polar heads
Inside
Sterol
Peripheral protein
Integral protein (single trans-membrane helix)
Peripheral protein covalently linked to lipid
Integral protein (multiple trans-membrane helices)

table 12–1

Major Components of Plasma Membranes in Various Organisms

	Components (% by weight)				
	Protein	Phospholipid	Sterol	Sterol type	Other lipids
Human myelin sheath	30	30	19	Cholesterol	Galactolipids, plasmalogens
Mouse liver	45	27	25	Cholesterol	—
Maize leaf	47	26	7	Sitosterol	Galactolipids
Yeast	52	7	4	Ergosterol	Triacylglycerols, steryl esters
Paramecium (ciliated protist)	56	40	4	Stigmasterol	—
E. coli	75	25	0	—	—


Plasma
Inner mitochondrial
Outer mitochondrial
Lysosomal
Nuclear
Rough ER
Smooth ER
Golgi
Rat hepatocyte membrane type
0
20
40
60
80
100
Percent membrane lipid
Cholesterol
Cardiolipin
Minor lipids
Sphingolipids
Phosphatidylcholine
Phosphatidylethanolamine

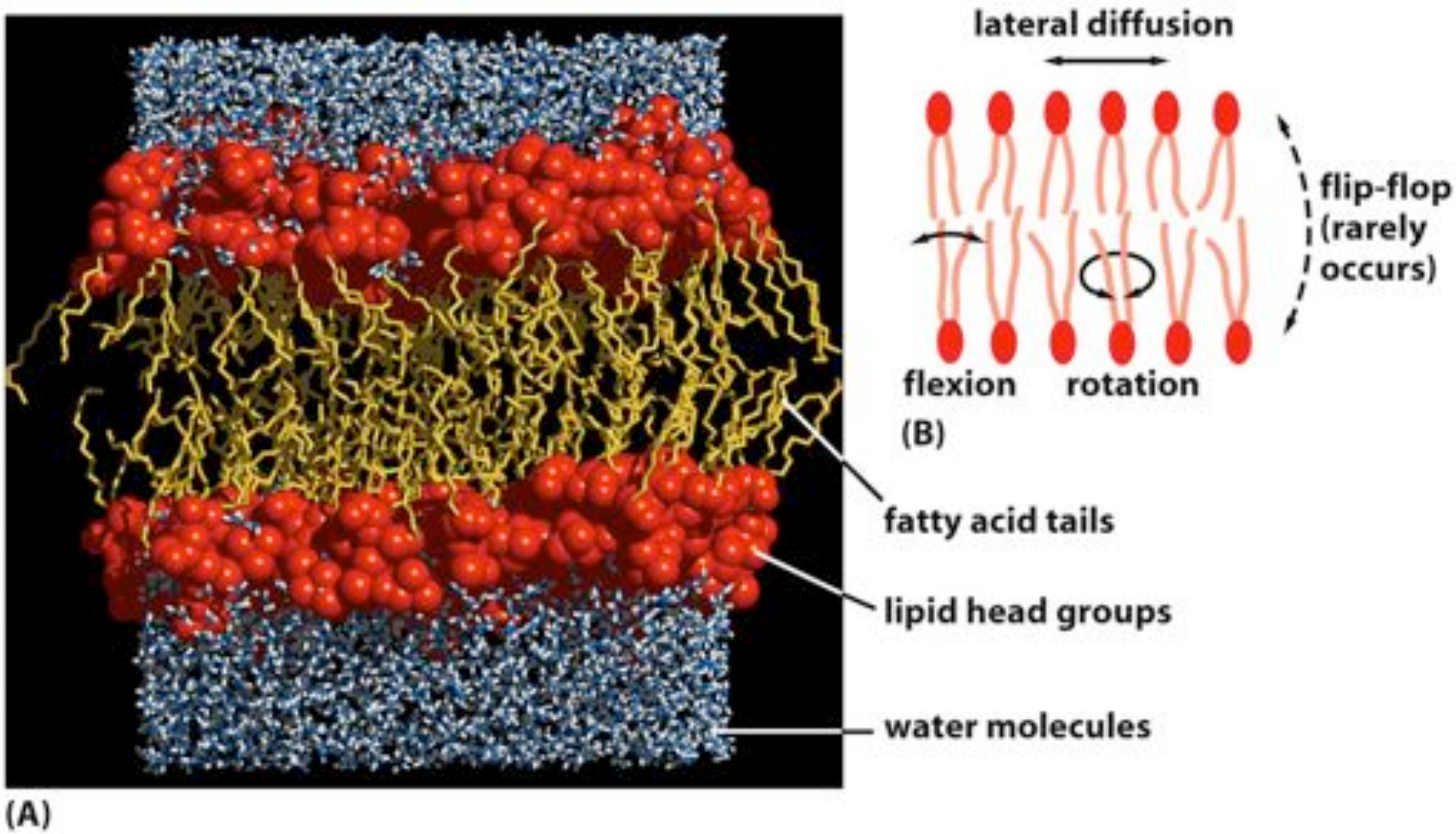


Figure 10-11 *Molecular Biology of the Cell* (© Garland Science 2008)

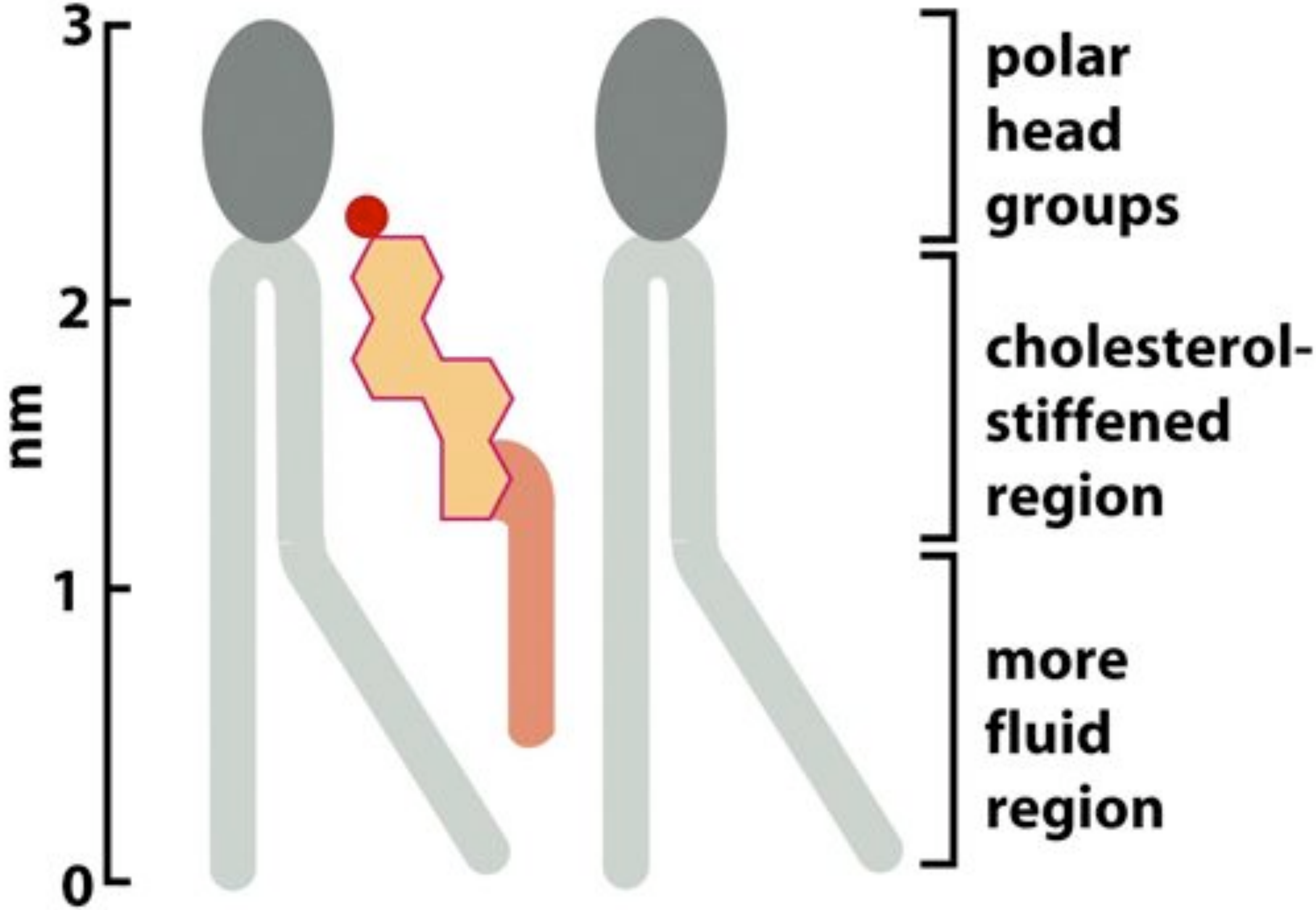


Figure 10-5 *Molecular Biology of the Cell* (© Garland Science 2008)

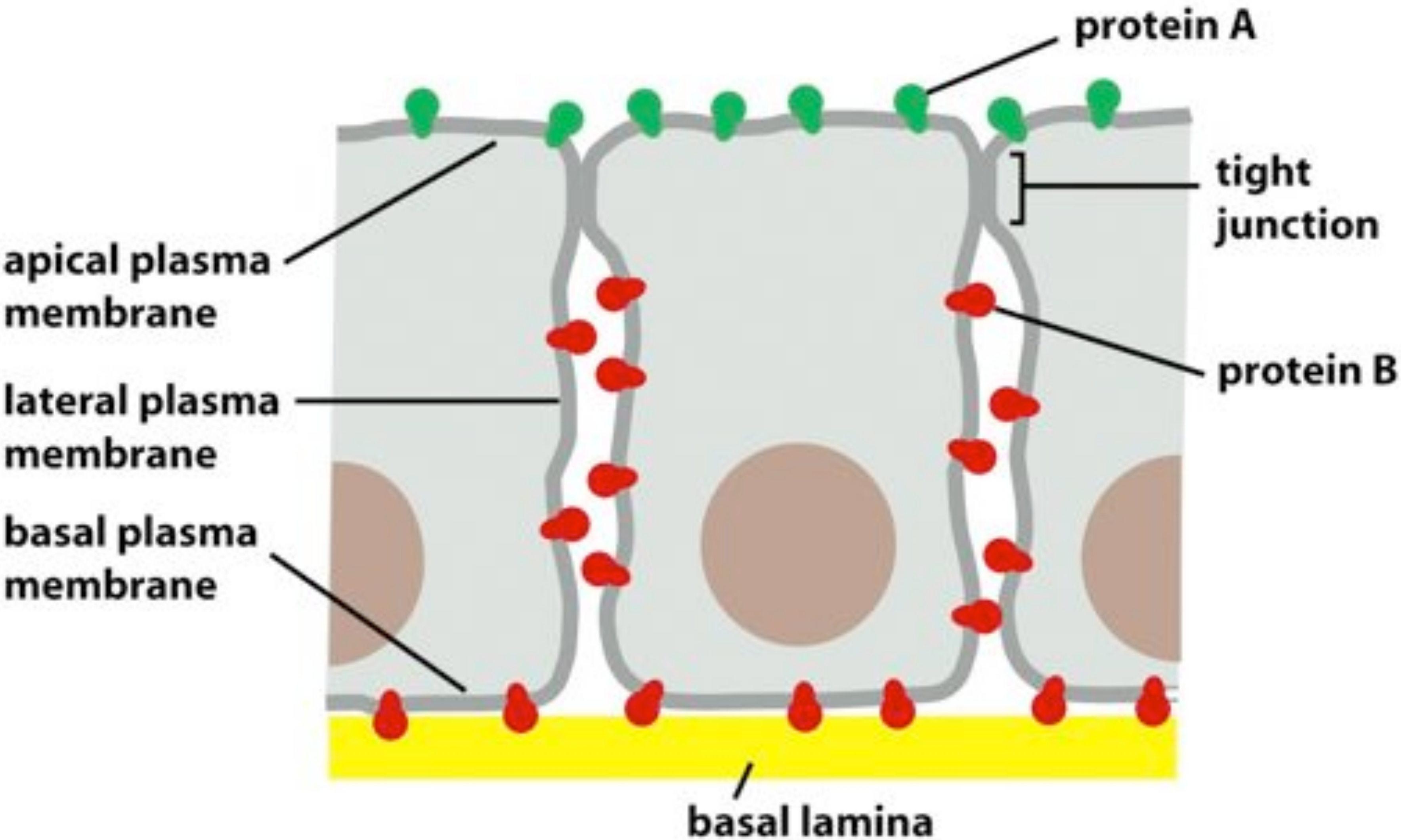


Figure 10-37 *Molecular Biology of the Cell* (© Garland Science 2008)

table 12–2

Fatty Acid Composition of *E. coli* Cells Cultured at Different Temperatures

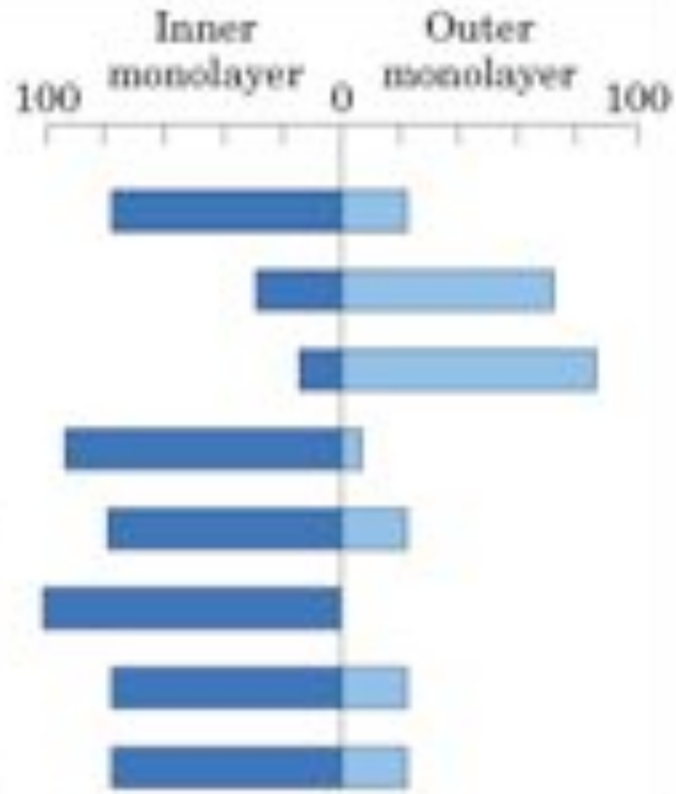
	Percentage of total fatty acids*			
	10 °C	20 °C	30 °C	40 °C
Myristic acid (14:0)	4	4	4	8
Palmitic acid (16:0)	18	25	29	48
Palmitoleic acid (16:1)	26	24	23	9
Oleic acid (18:1)	38	34	30	12
Hydroxymyristic acid	13	10	10	8
Ratio of unsaturated to saturated†	2.9	2.0	1.6	0.38

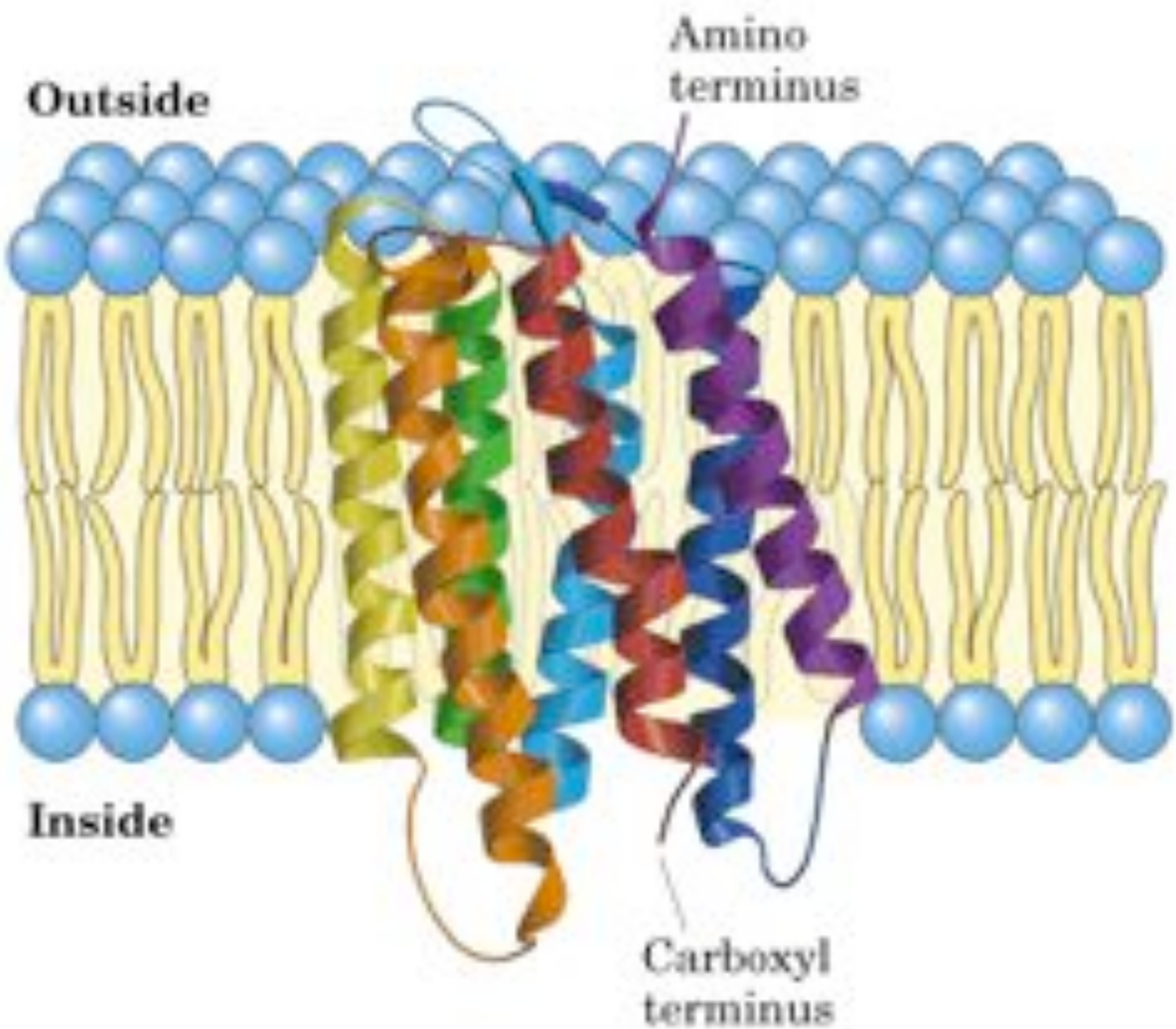
Source: Data from Marr, A.G. & Ingraham, J.L. (1962) Effect of temperature on the composition of fatty acids in *Escherichia coli*. *J. Bacteriol.* **84,** 1260.

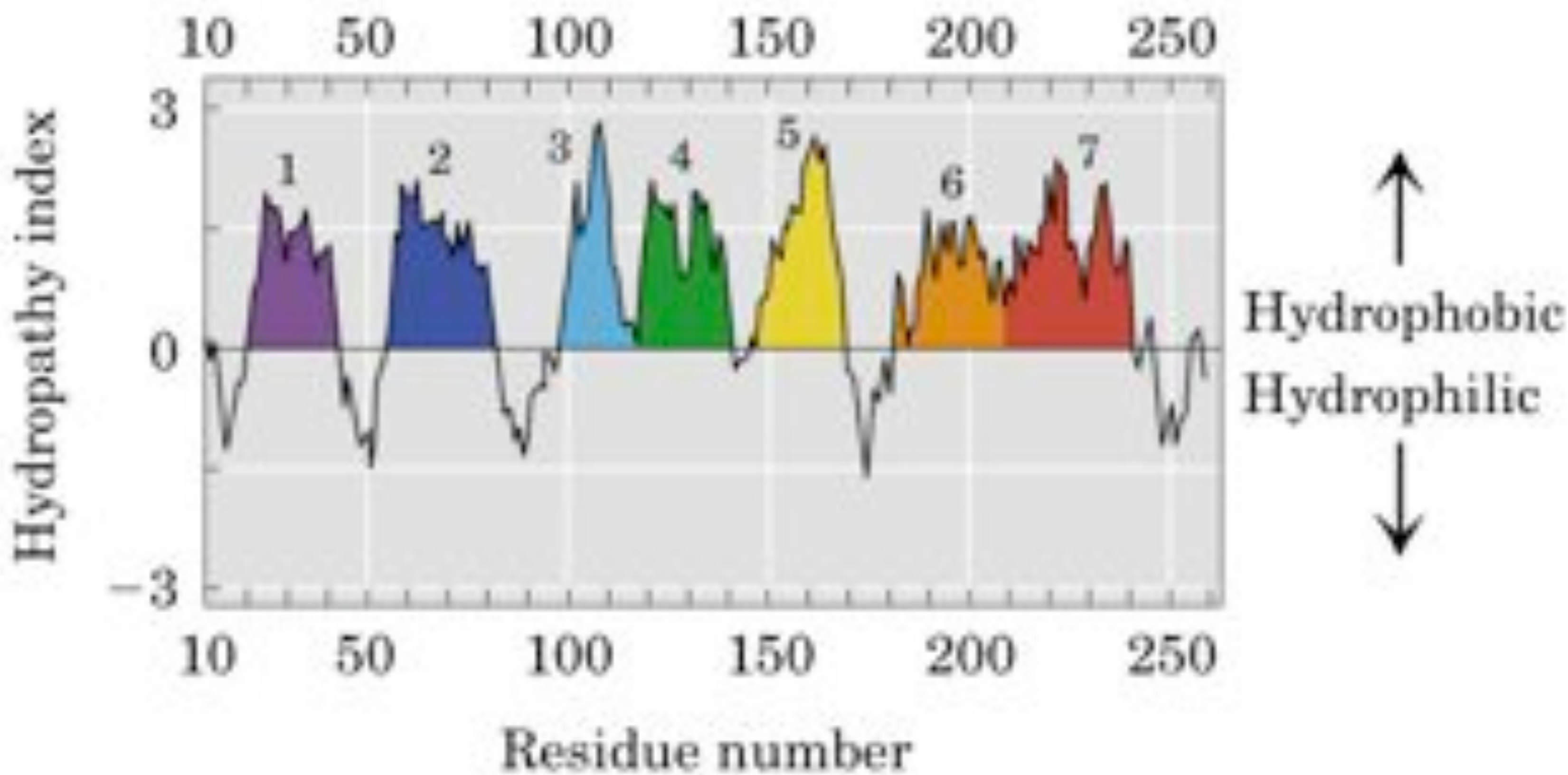
*The exact fatty acid composition depends not only on growth temperature but on growth stage and growth medium composition.

†Calculated as the total percentage of 16:1 plus 18:1 divided by the total percentage of 14:0 plus 16:0. Hydroxymyristic acid was omitted from this calculation.

Membrane phospholipid	Percent of total membrane phospholipid	Distribution in membrane
Phosphatidylethanolamine	30	
Phosphatidylcholine	27	
Sphingomyelin	23	
Phosphatidylserine	15	
Phosphatidylinositol		
Phosphatidylinositol 4-phosphate	5	
Phosphatidylinositol 4,5-bisphosphate		
Phosphatidic acid		

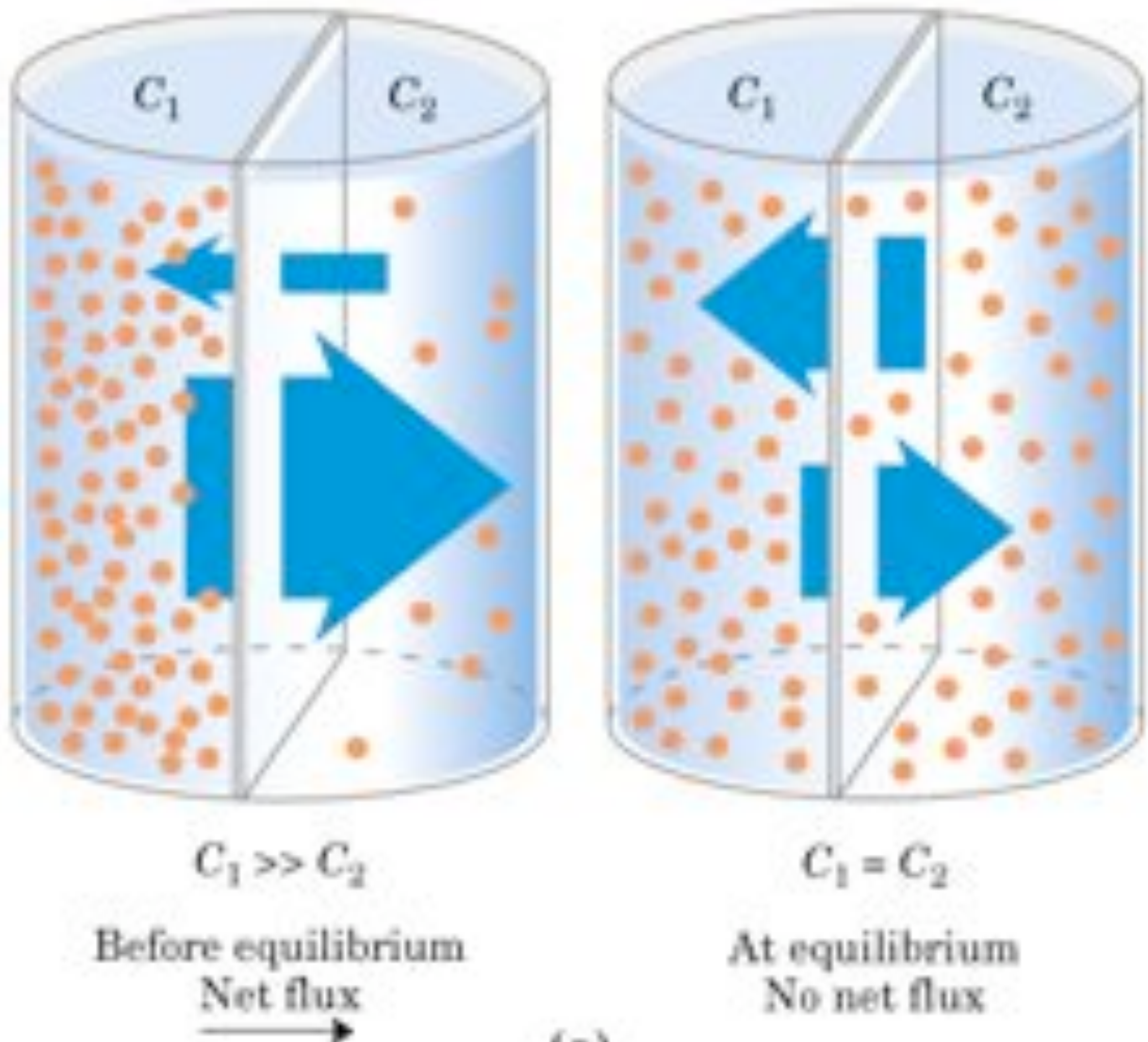



Outside
Amino
terminus
Inside
Carboxyl
terminus



Bacteriorhodopsin

(b)


C_1
C_2
C_1
C_2
$C_1 >> C_2$
Before equilibrium
Net flux
$C_1 = C_2$
At equilibrium
No net flux

(a)

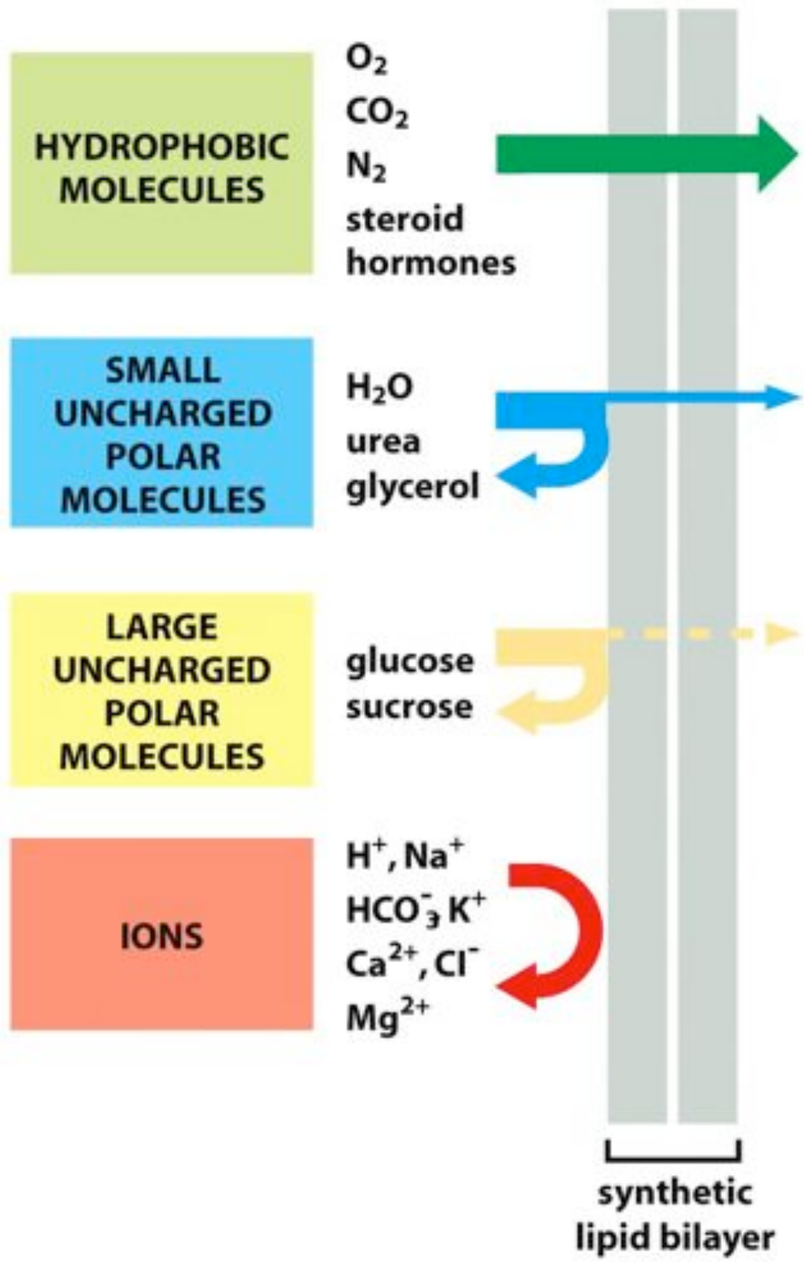


Figure 11-1 *Molecular Biology of the Cell* (© Garland Science 2008)

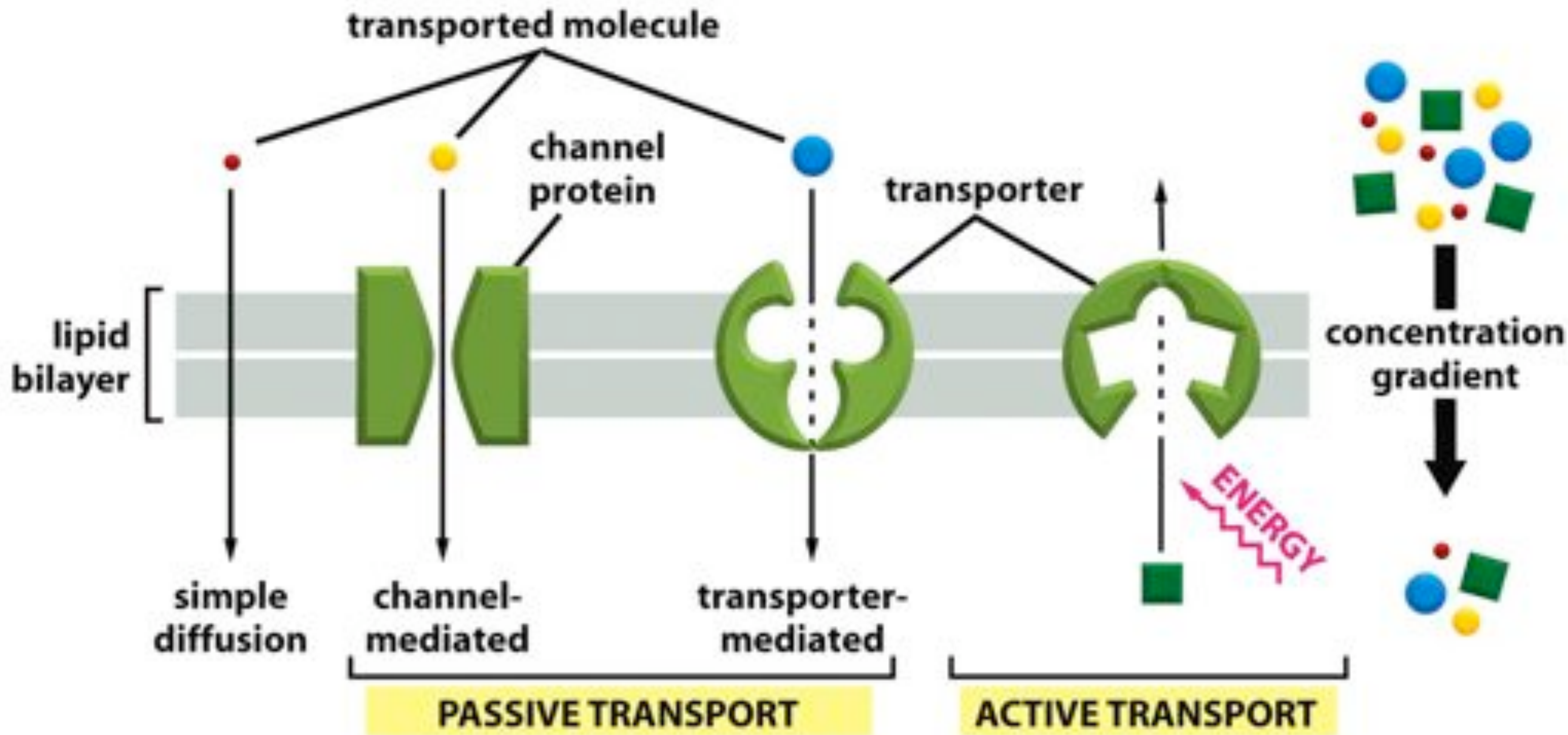


Figure 11-4a *Molecular Biology of the Cell* (© Garland Science 2008)

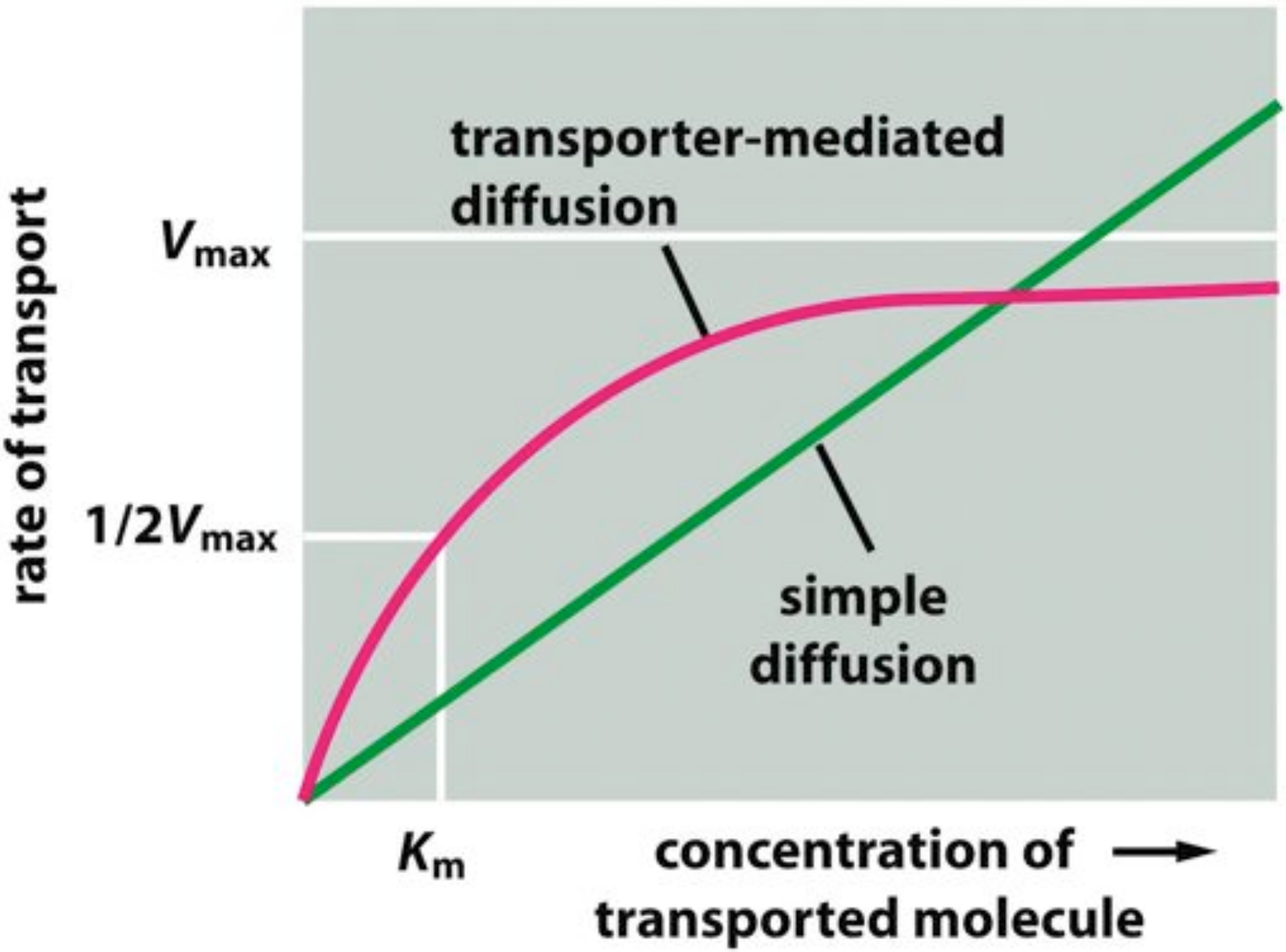
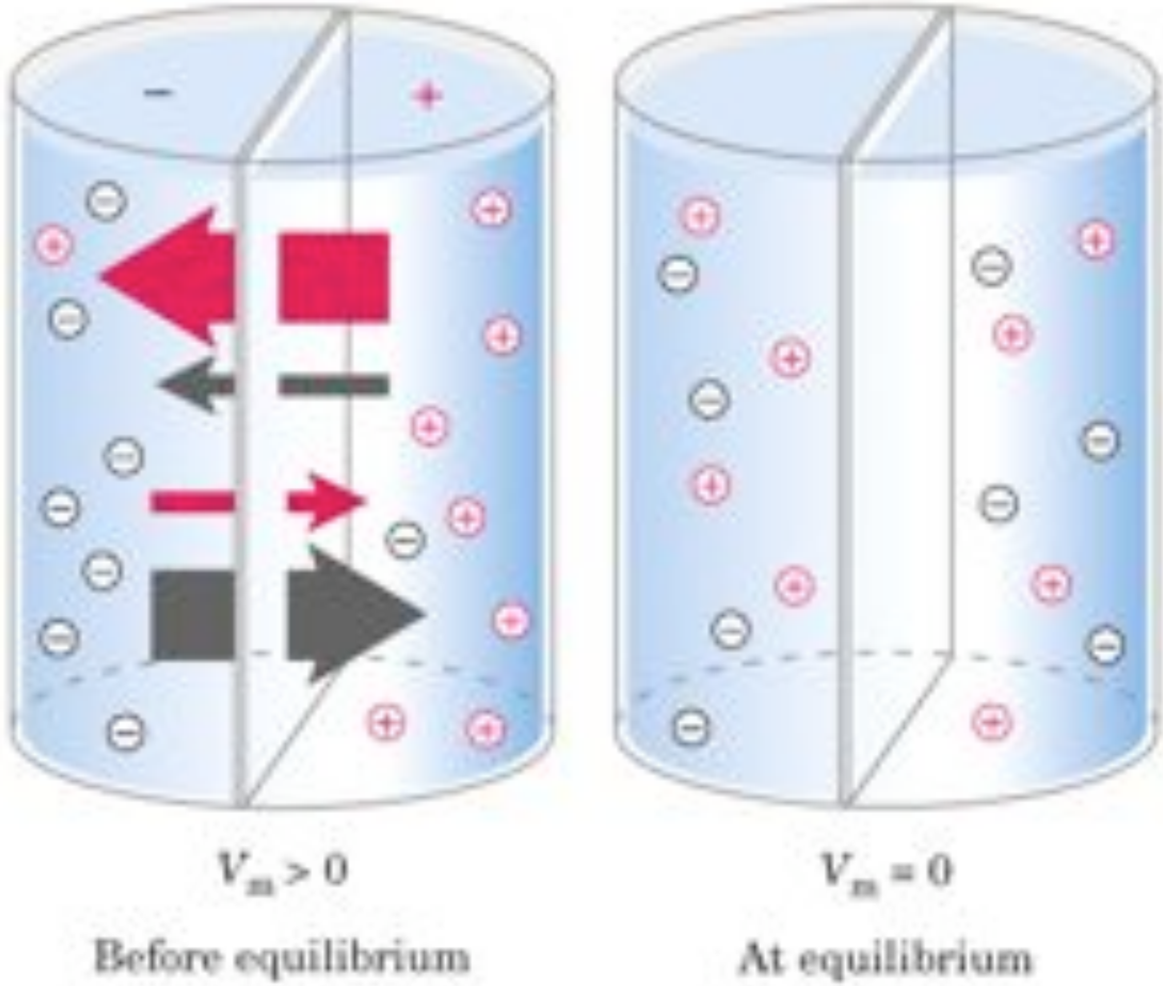


Figure 11-6 *Molecular Biology of the Cell* (© Garland Science 2008)



(b)

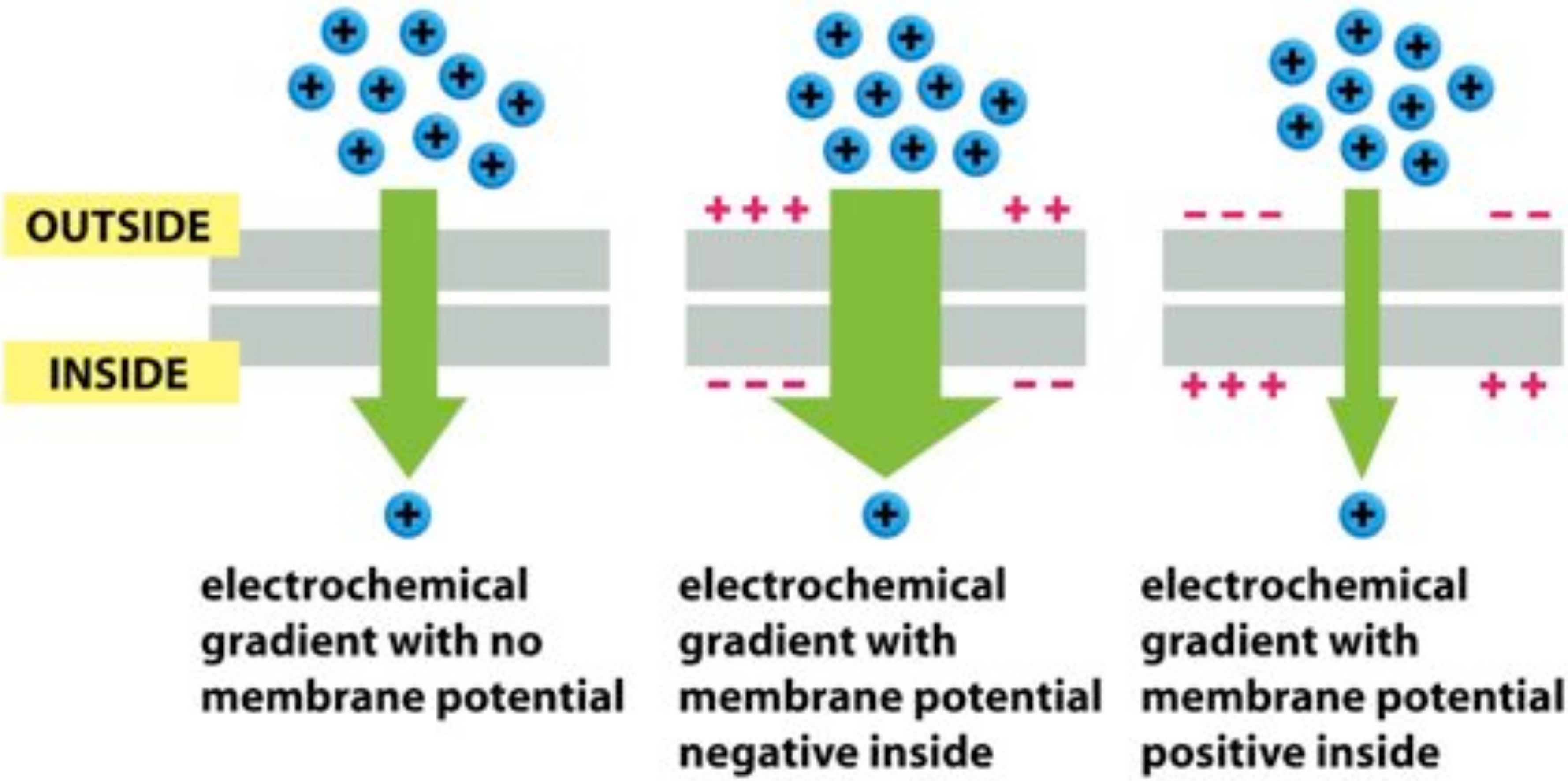


Figure 11-4b *Molecular Biology of the Cell* (© Garland Science 2008)

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*

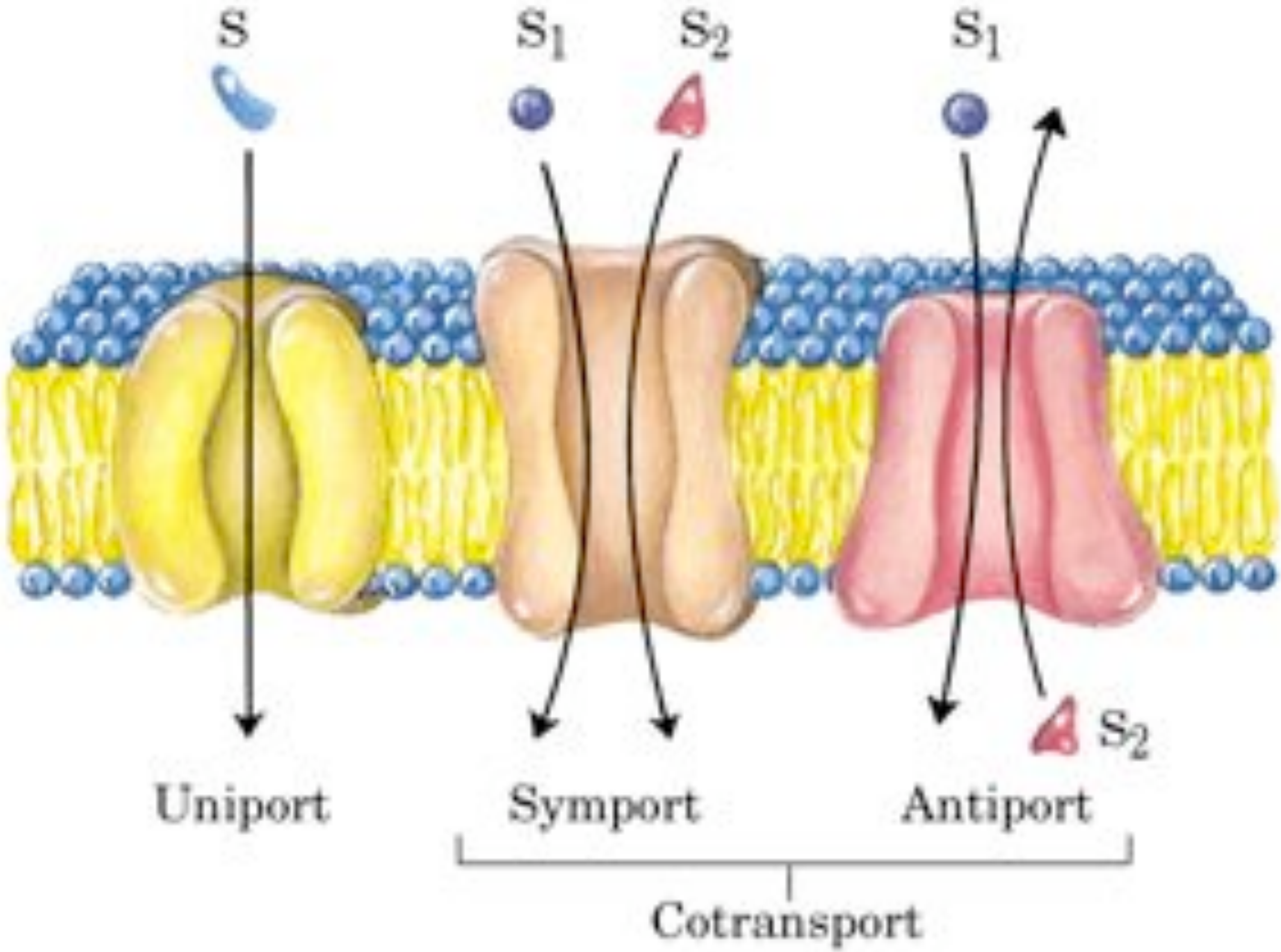
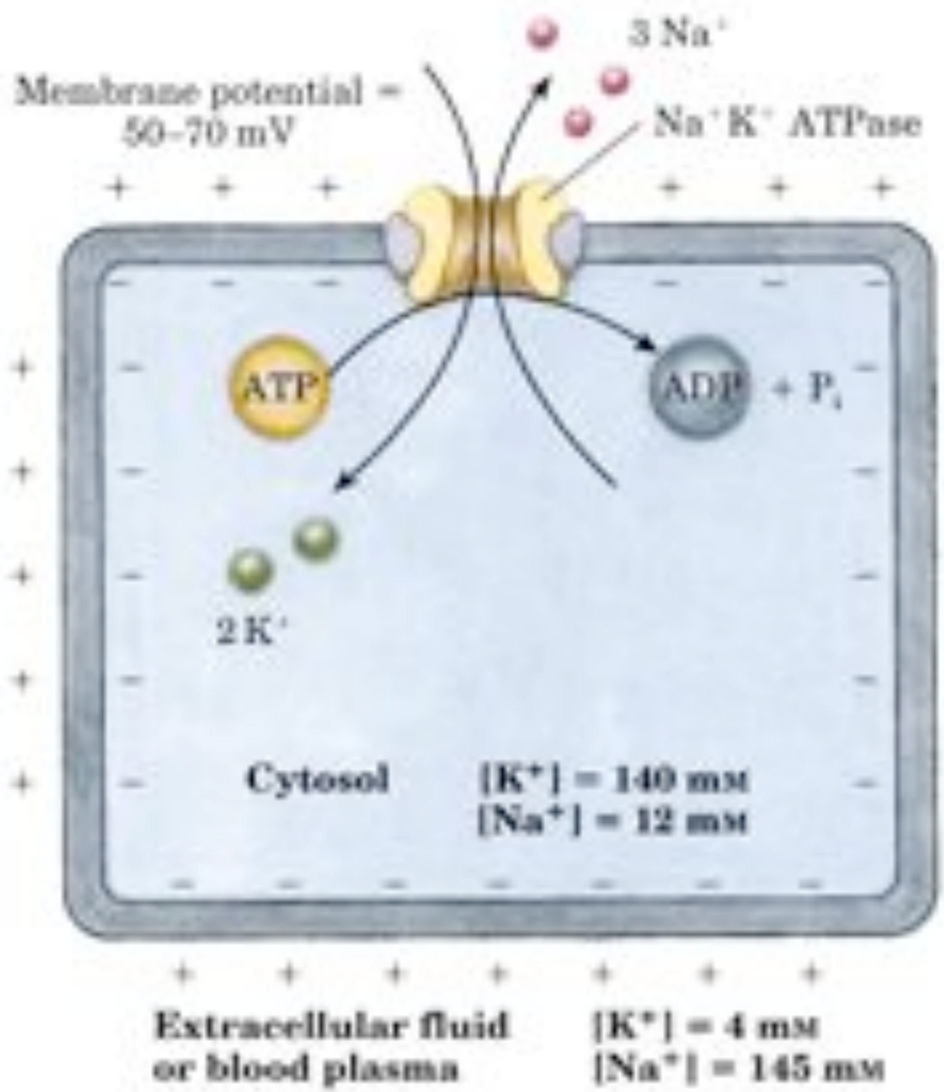
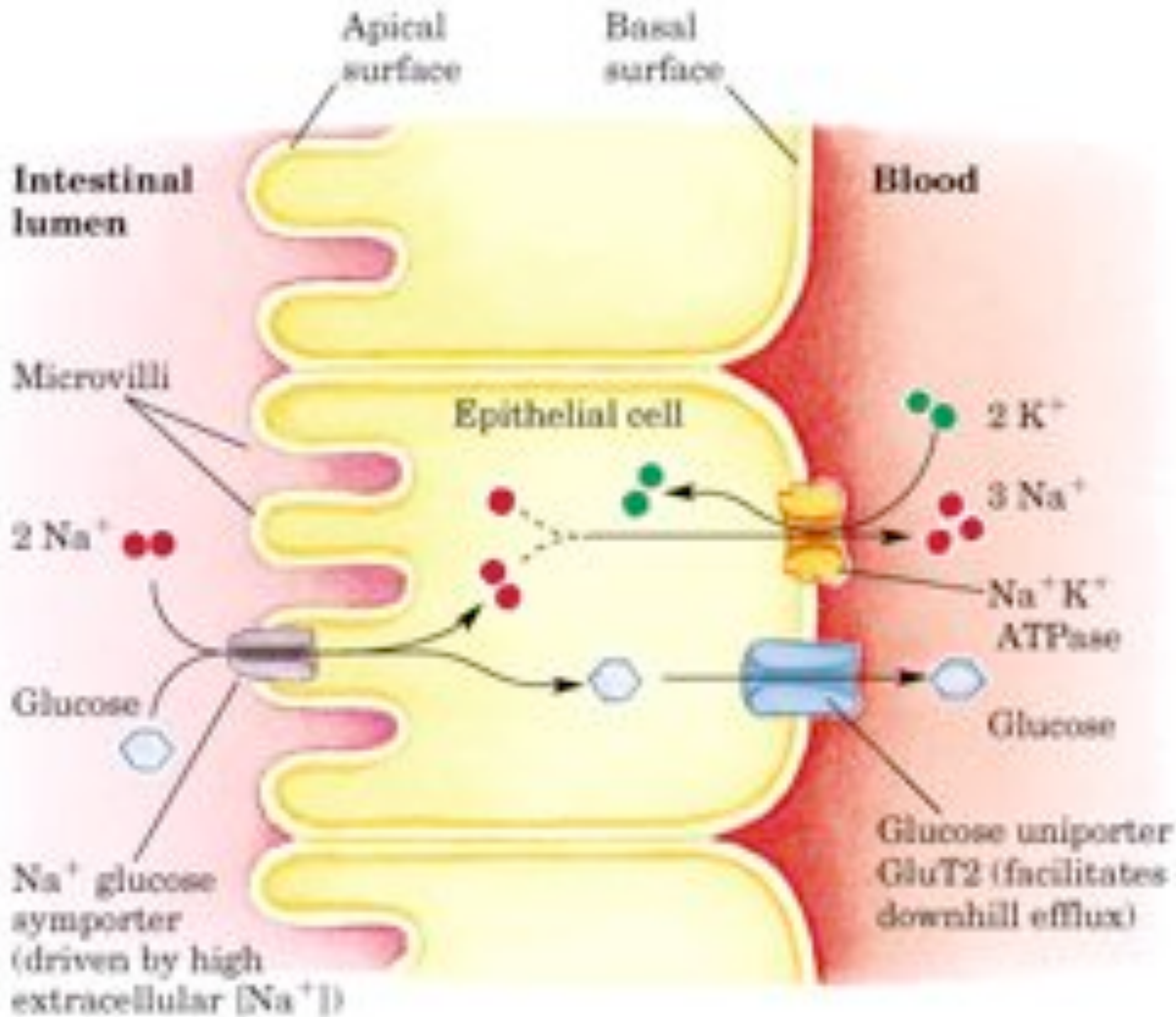

S
S1
S2
S1
S2
Uniport
Symport
Antiport
Cotransport

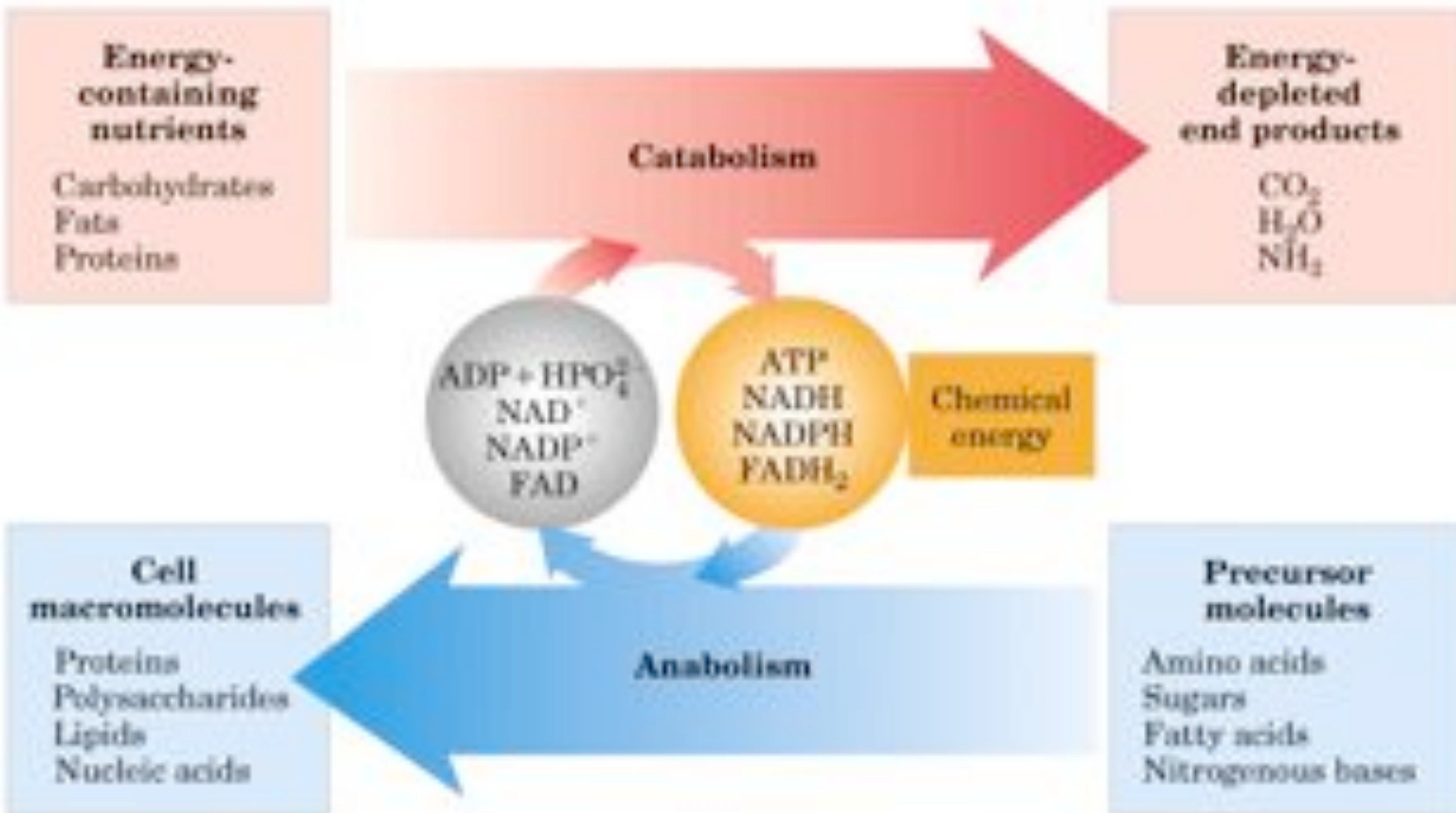
table 12–5

Cotransport Systems Driven by Gradients of Na^+ or H^+

Organism or tissue	Transported solute (moving against its gradient)	Cotransported solute (moving down its gradient)	Type of transport
E. coli	Lactose	H^+	Symport
	Proline	H^+	Symport
	Dicarboxylic acids	H^+	Symport
Intestine, kidney of vertebrates	Glucose	Na^+	Symport
	Amino acids	Na^+	Symport
Vertebrate cells (many types)	Ca^{2+}	Na^+	Antiport
Higher plants	K^+	H^+	Antiport
Fungi (*Neurospora*)	K^+	H^+	Antiport

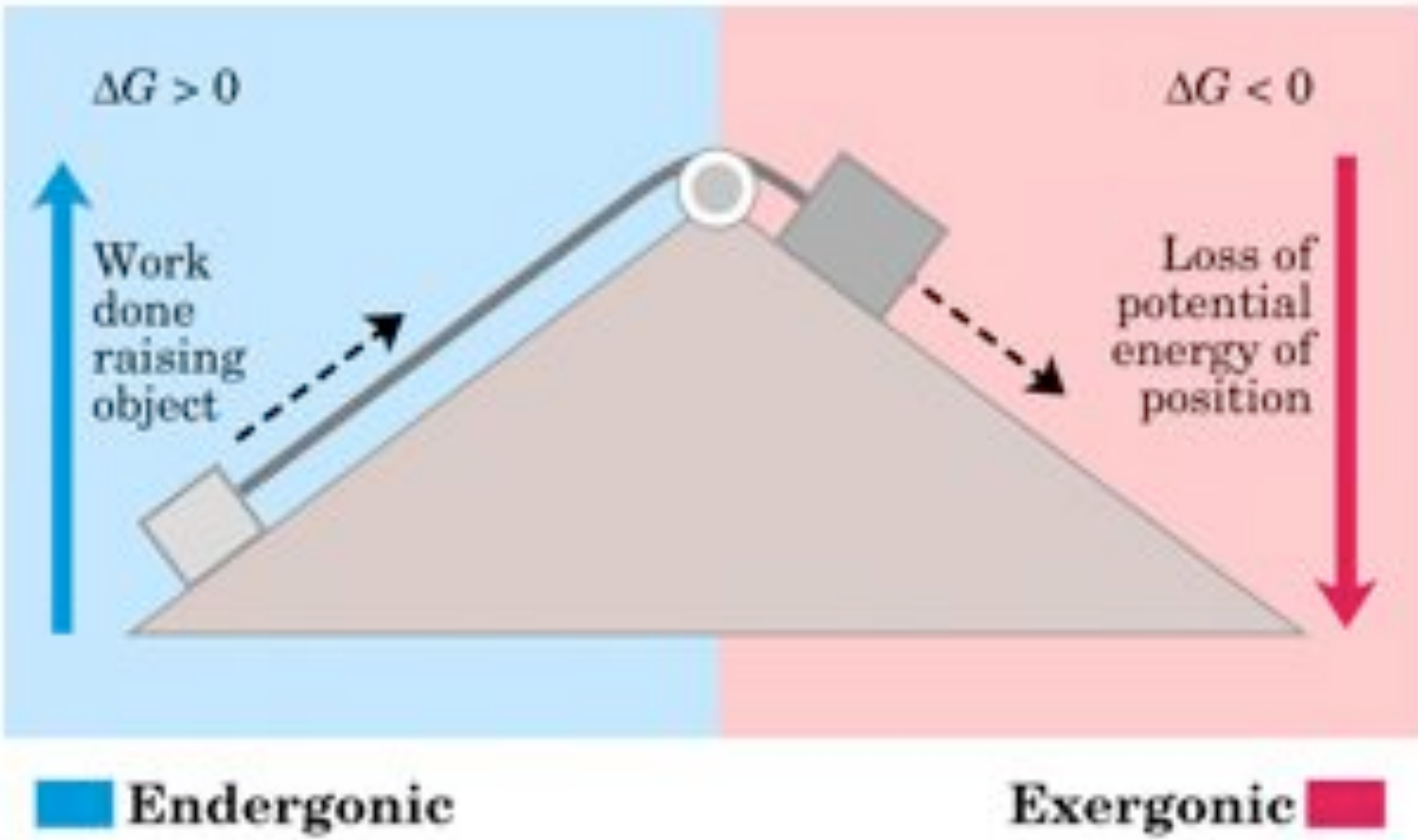

3 Na+
Membrane potential = 50–70 mV
Na+K+ ATPase
ATP
ADP + Pi
2 K+
Cytosol
[K+] = 140 mM
[Na+] = 12 mM
Extracellular fluid or blood plasma
[K+] = 4 mM
[Na+] = 145 mM


Apical surface
Basal surface
Intestinal lumen
Blood
Microvilli
Epithelial cell
2 K⁺
3 Na⁺
2 Na⁺
Na⁺K⁺ ATPase
Glucose
Glucose
Na⁺ glucose symporter (driven by high extracellular [Na⁺])
Glucose uniporter GluT2 (facilitates downhill efflux)



Energy-containing nutrients
Carbohydrates
Fats
Proteins
Catabolism
Energy-depleted end products
CO_2
H_2O
NH_3
$ADP + HPO_4^{2-}$
NAD^+
$NADP^+$
FAD
ATP
NADH
NADPH
$FADH_2$
Chemical energy
Cell macromolecules
Proteins
Polysaccharides
Lipids
Nucleic acids
Anabolism
Precursor molecules
Amino acids
Sugars
Fatty acids
Nitrogenous bases

(a) Mechanical example



$$\Delta G'^{\circ} = -RT \ln K'_{\mathrm{eq}}$$

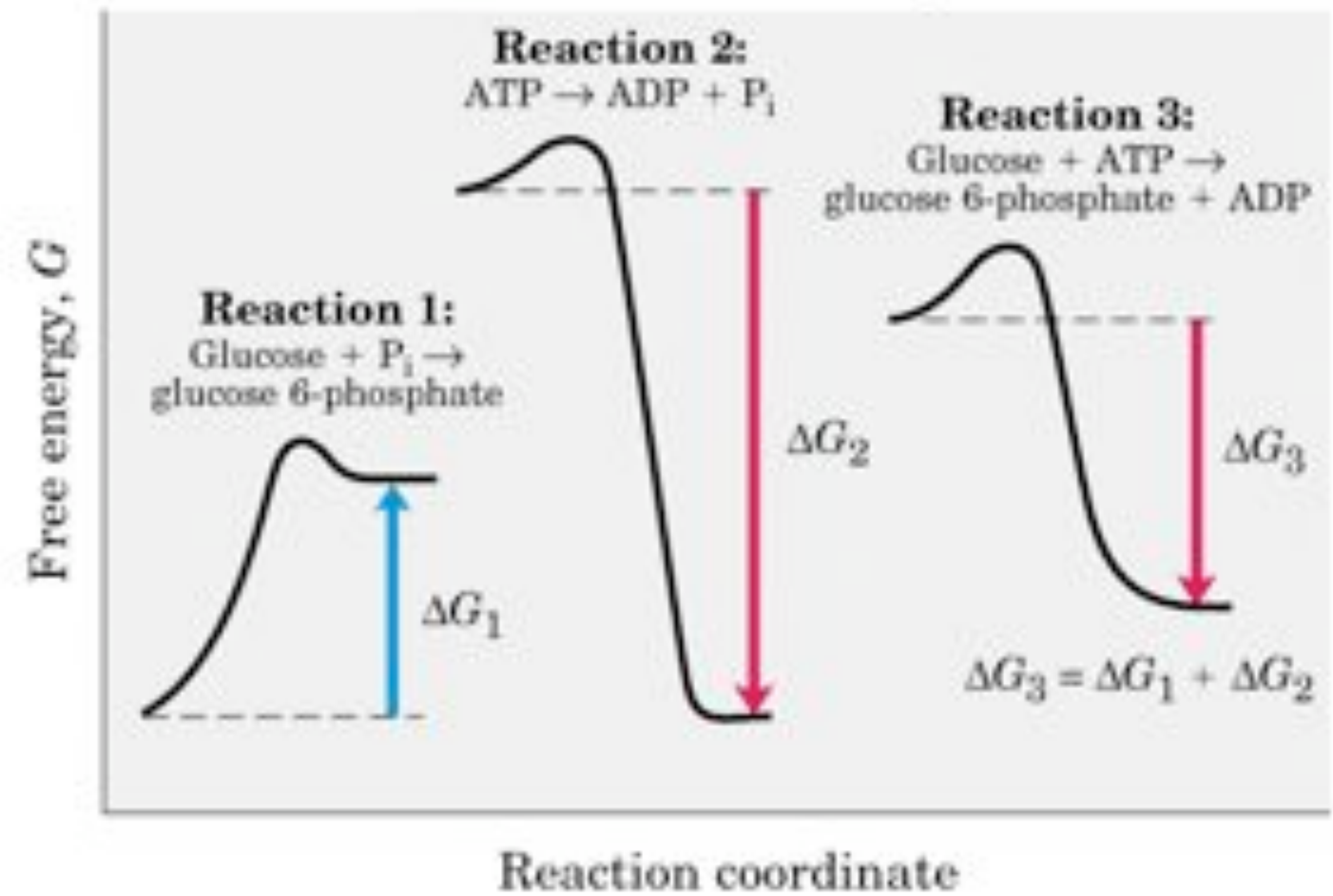
table 14–3

Relationships among K'_{eq}, $\Delta G'^{\circ}$, and the Direction of Chemical Reactions under Standard Conditions

When K'_{eq} is	$\Delta G'^{\circ}$ is	Starting with 1 M components the reaction
>1.0	Negative	Proceeds forward
1.0	Zero	Is at equilibrium
<1.0	Positive	Proceeds in reverse

$$
\begin{array}{llll}
(1) & A \longrightarrow B & \Delta G_1^{'\circ} & \\
(2) & B \longrightarrow C & \Delta G_2^{'\circ} & \\
\hline
\textit{Sum:} & A \longrightarrow C & \Delta G_1^{'\circ} & + \quad \Delta G_2^{'\circ}
\end{array}
$$

(b) Chemical example



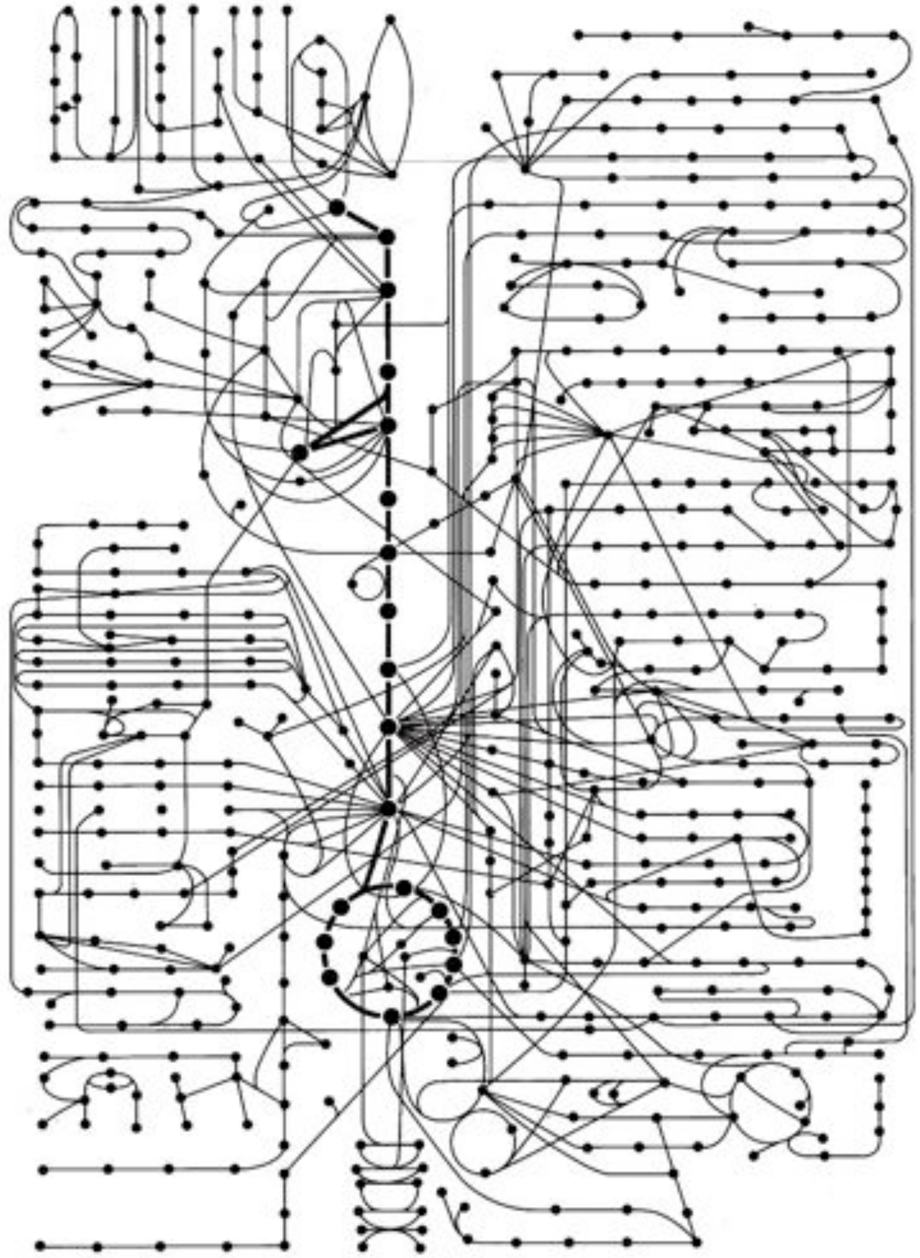
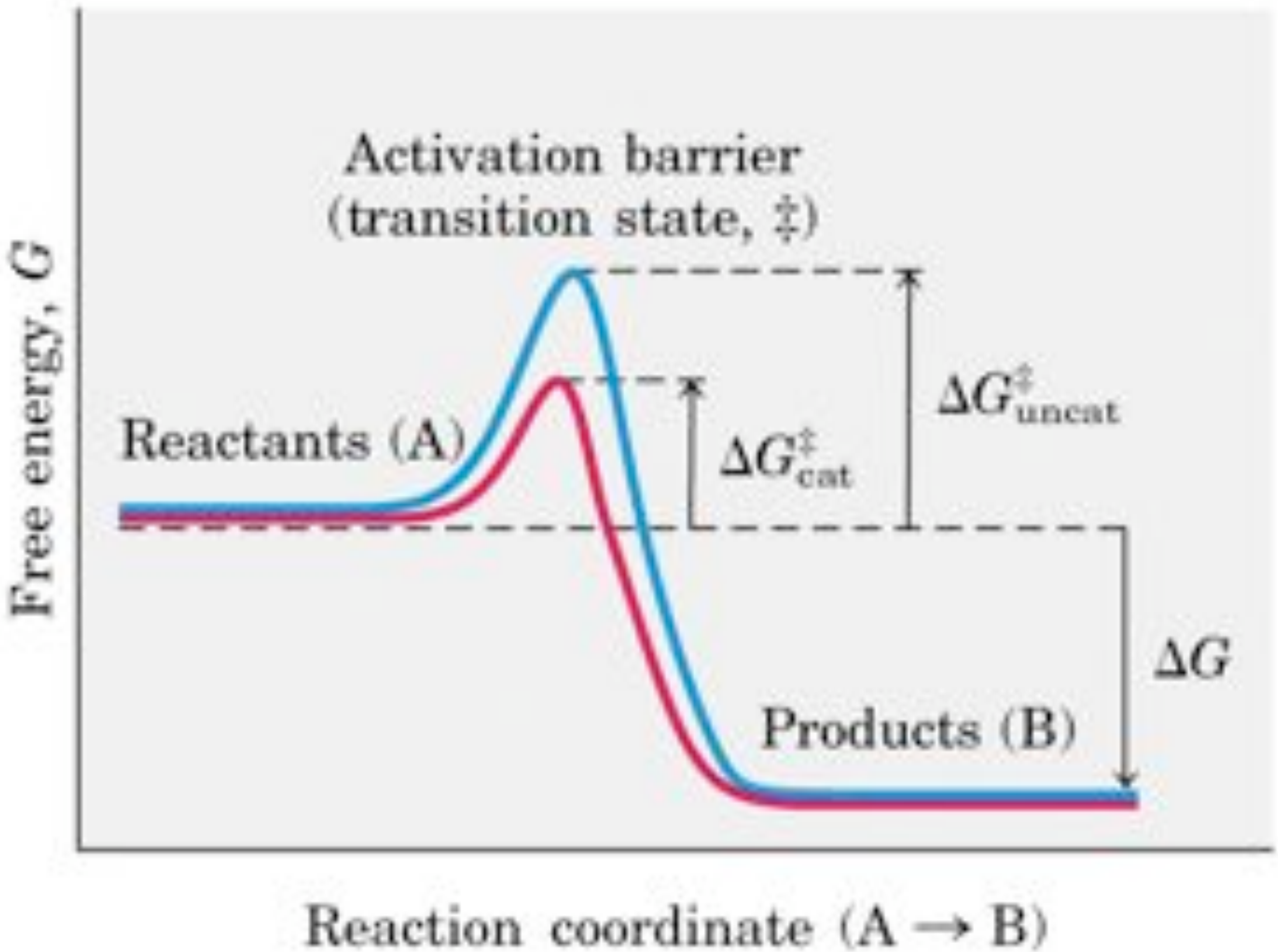


Figure 2-35 *Molecular Biology of the Cell* (© Garland Science 2008)



Activation barrier
(transition state, ‡)
Free energy, G
Reactants (A)
$\Delta G^{\ddagger}_{cat}$
$\Delta G^{\ddagger}_{uncat}$
ΔG
Products (B)
Reaction coordinate (A → B)

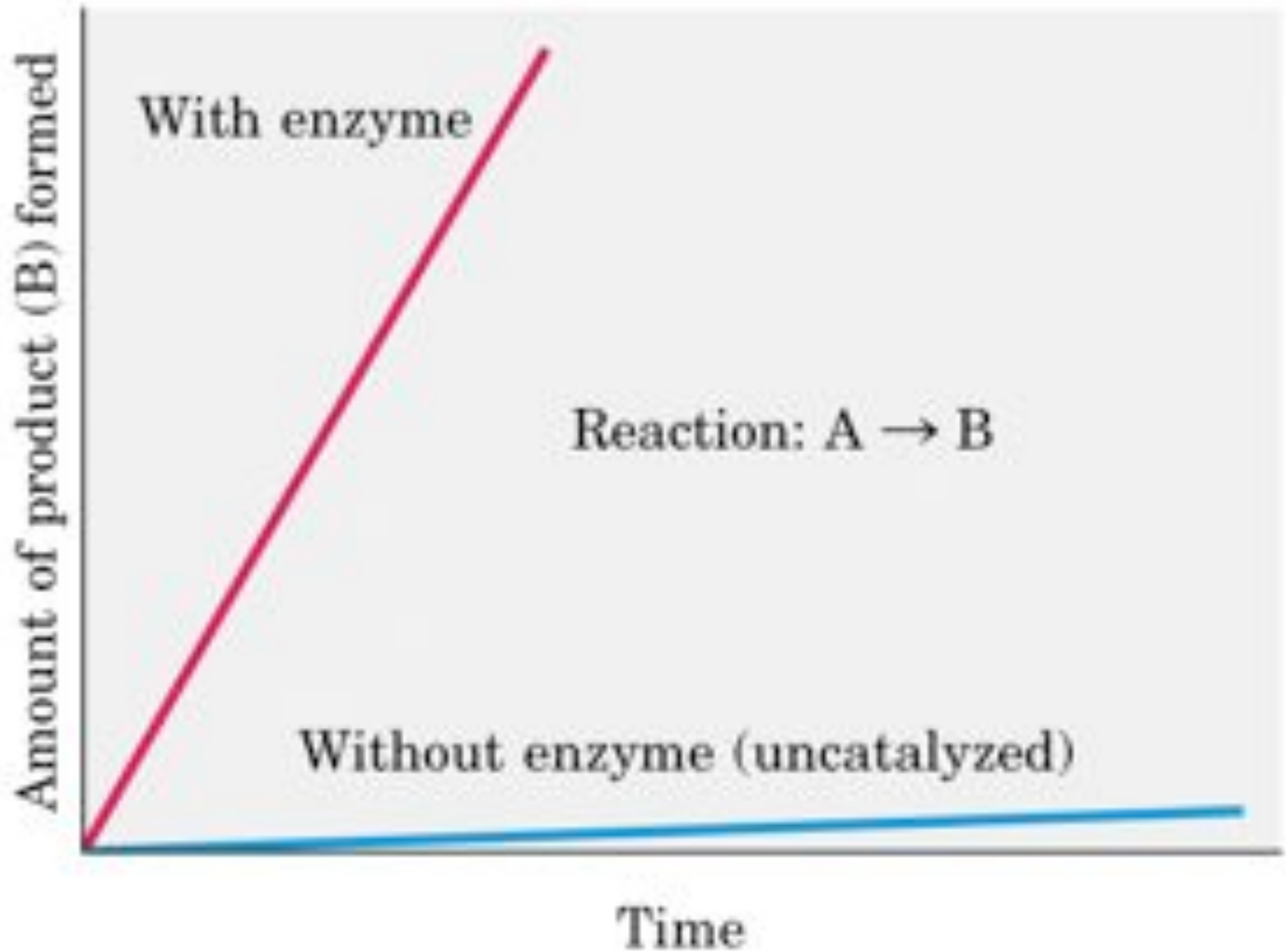
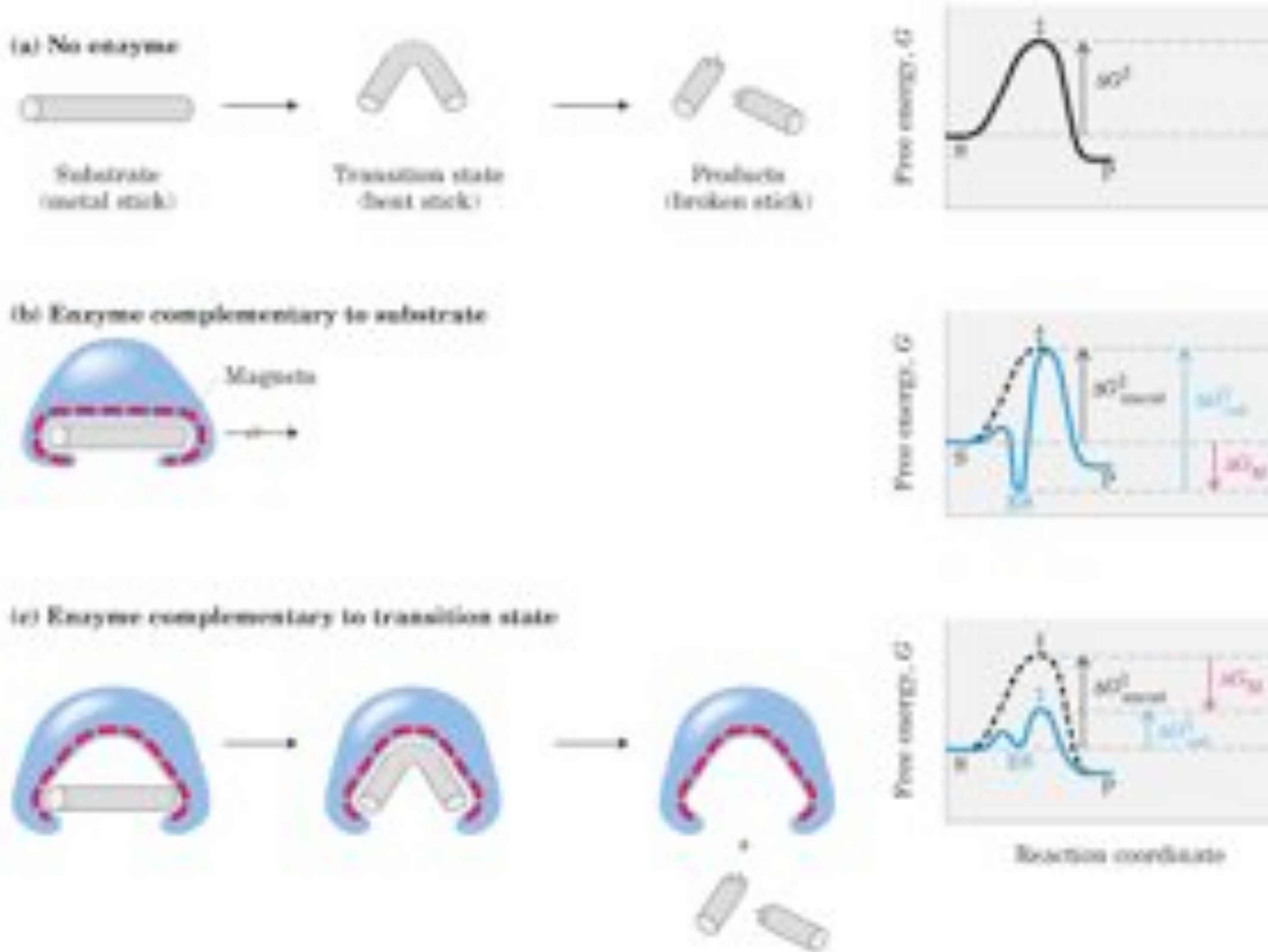

Amount of product (B) formed
With enzyme
Reaction: A → B
Without enzyme (uncatalyzed)
Time

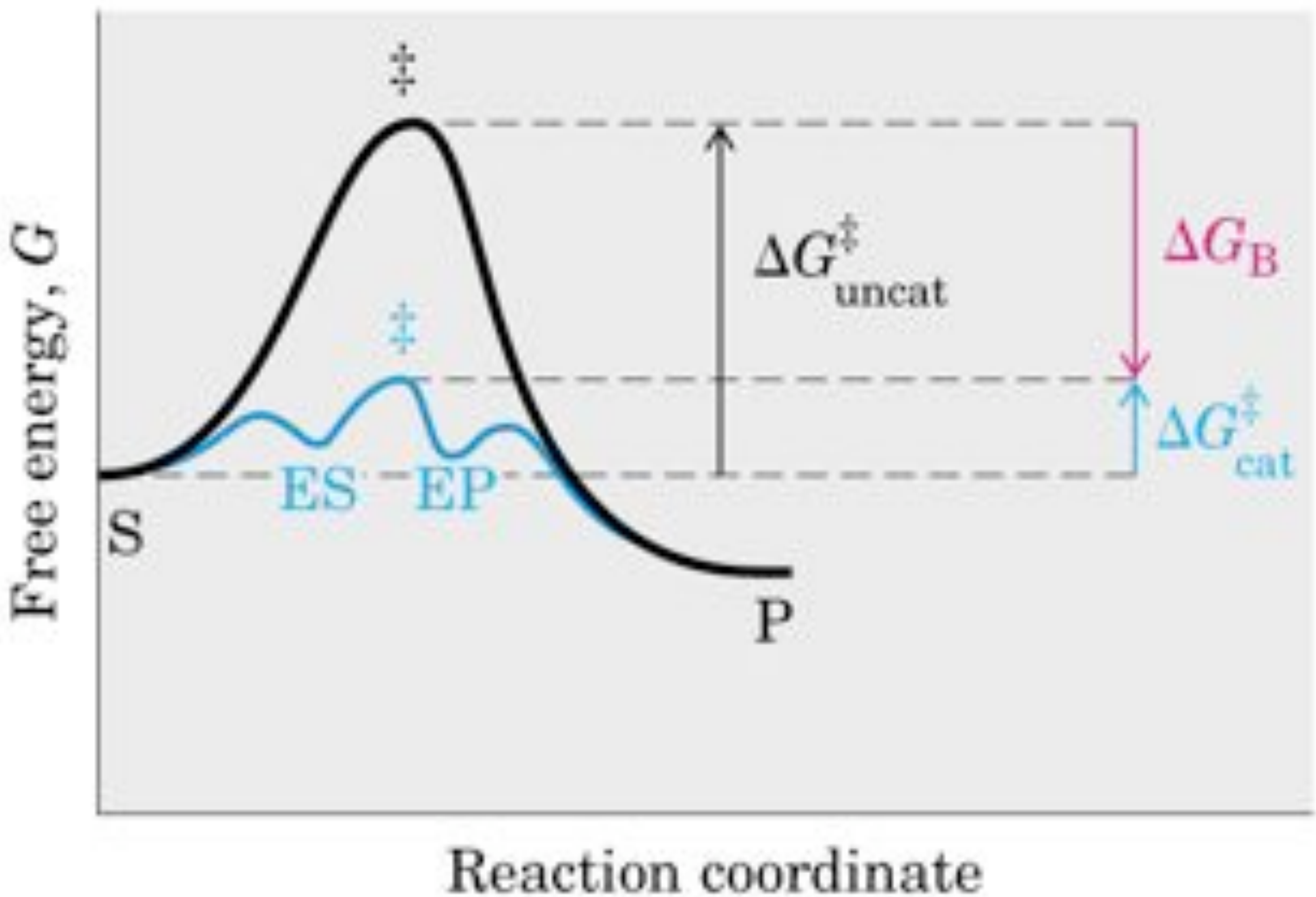
Table 3–1 Some Common Types of Enzymes

ENZYME	REACTION CATALYZED
Hydrolases	general term for enzymes that catalyze a hydrolytic cleavage reaction; *nucleases* and *proteases* are more specific names for subclasses of these enzymes.
Nucleases	break down nucleic acids by hydrolyzing bonds between nucleotides.
Proteases	break down proteins by hydrolyzing bonds between amino acids.
Synthases	synthesize molecules in anabolic reactions by condensing two smaller molecules together.
Isomerases	catalyze the rearrangement of bonds within a single molecule.
Polymerases	catalyze polymerization reactions such as the synthesis of DNA and RNA.
Kinases	catalyze the addition of phosphate groups to molecules. Protein kinases are an important group of kinases that attach phosphate groups to proteins.
Phosphatases	catalyze the hydrolytic removal of a phosphate group from a molecule.
Oxido-Reductases	general name for enzymes that catalyze reactions in which one molecule is oxidized while the other is reduced. Enzymes of this type are often more specifically named either *oxidases*, *reductases*, or *dehydrogenases*.
ATPases	hydrolyze ATP. Many proteins with a wide range of roles have an energy-harnessing ATPase activity as part of their function, for example, motor proteins such as *myosin* and membrane transport proteins such as the *sodium–potassium pump*.

Enzyme names typically end in "-ase," with the exception of some enzymes, such as pepsin, trypsin, thrombin and lysozyme that were discovered and named before the convention became generally accepted at the end of the nineteenth century. The common name of an enzyme usually indicates the substrate and the nature of the reaction catalyzed. For example, citrate synthase catalyzes the synthesis of citrate by a reaction between acetyl CoA and oxaloacetate.

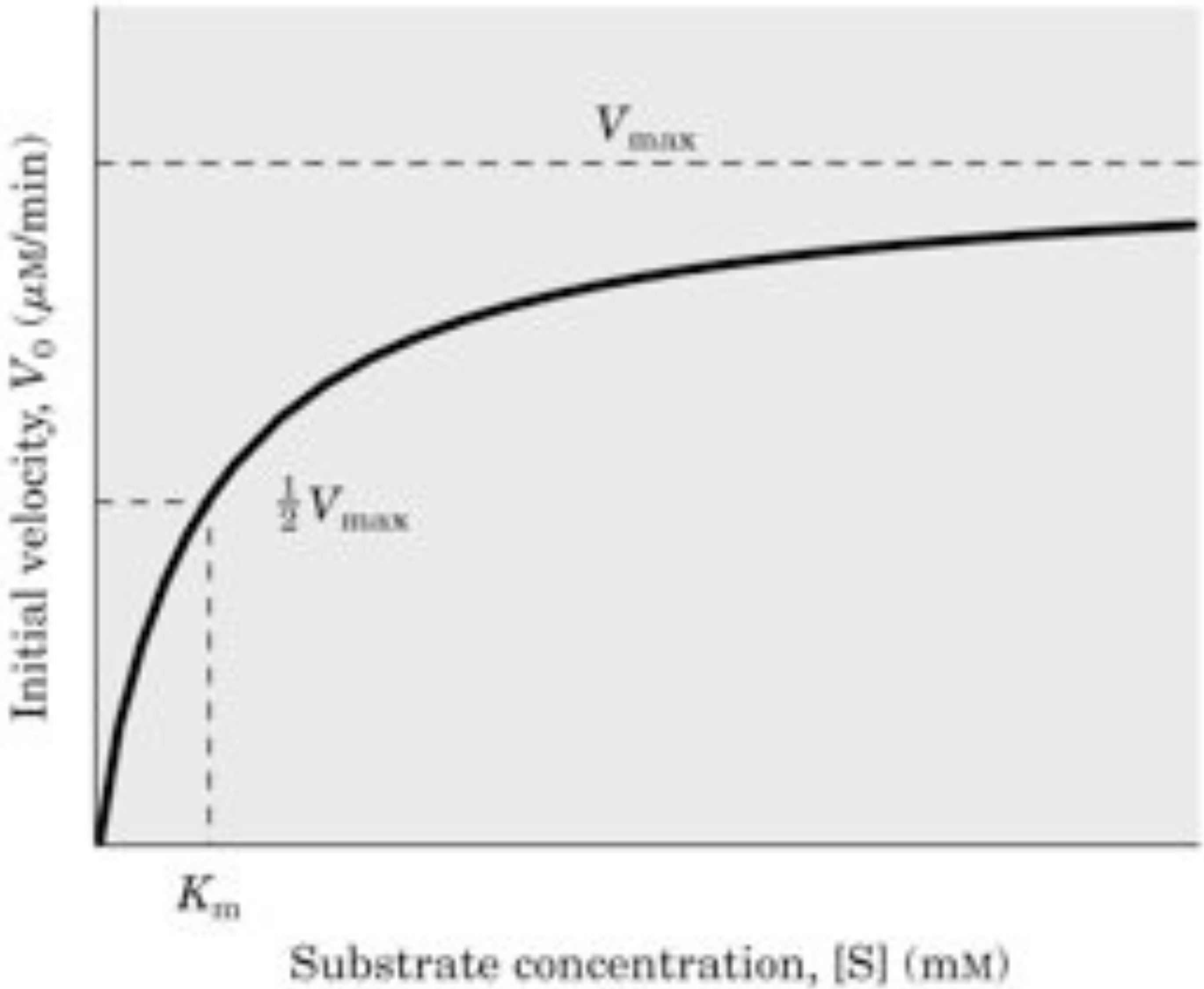
Table 3-1 *Molecular Biology of the Cell*


(a) No enzyme
Substrate (metal stick)
Transition state (bent stick)
Products (broken stick)
Free energy, G
(b) Enzyme complementary to substrate
Magnets
Free energy, G
(c) Enzyme complementary to transition state
Free energy, G
Reaction coordinate



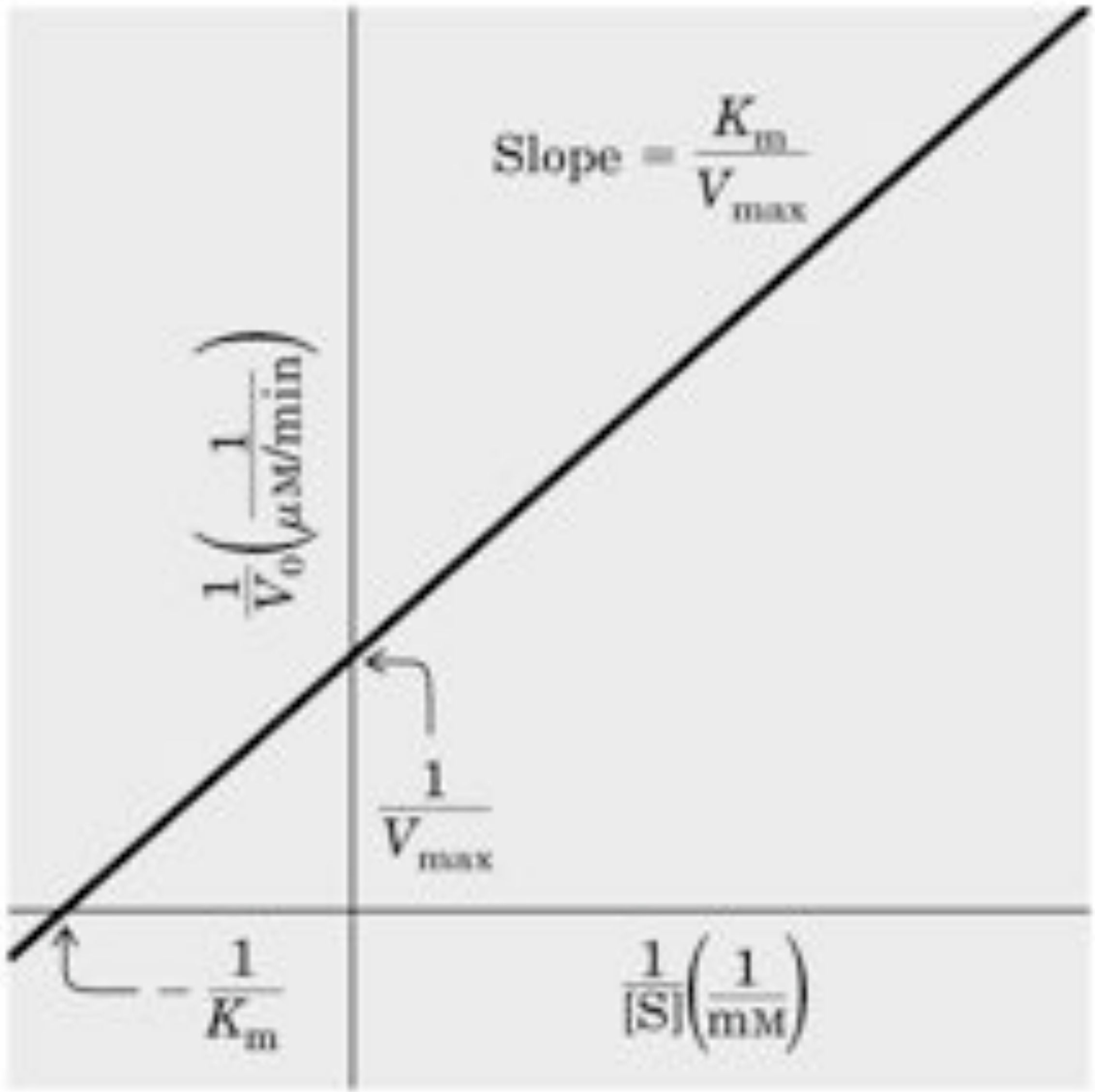
‡
$\Delta G^{\ddagger}_{uncat}$
ΔG_B
‡
$\Delta G^{\ddagger}_{cat}$
ES
EP
S
P
Free energy, G
Reaction coordinate

$$V_0 = \frac{V_{max}[S]}{K_m + [S]}$$



V_{max}
$\frac{1}{2}V_{max}$
K_m
Initial velocity, V_0 (μM/min)
Substrate concentration, [S] (mM)

$$\frac{1}{V_0} = \frac{K_\mathrm{m}}{V_\mathrm{max}[\mathrm{S}]} + \frac{1}{V_\mathrm{max}}$$



Slope = $\frac{K_m}{V_{max}}$
$\frac{1}{V_0}\left(\frac{1}{\mu M/min}\right)$
$\frac{1}{V_{max}}$
$-\frac{1}{K_m}$
$\frac{1}{[S]}\left(\frac{1}{mM}\right)$

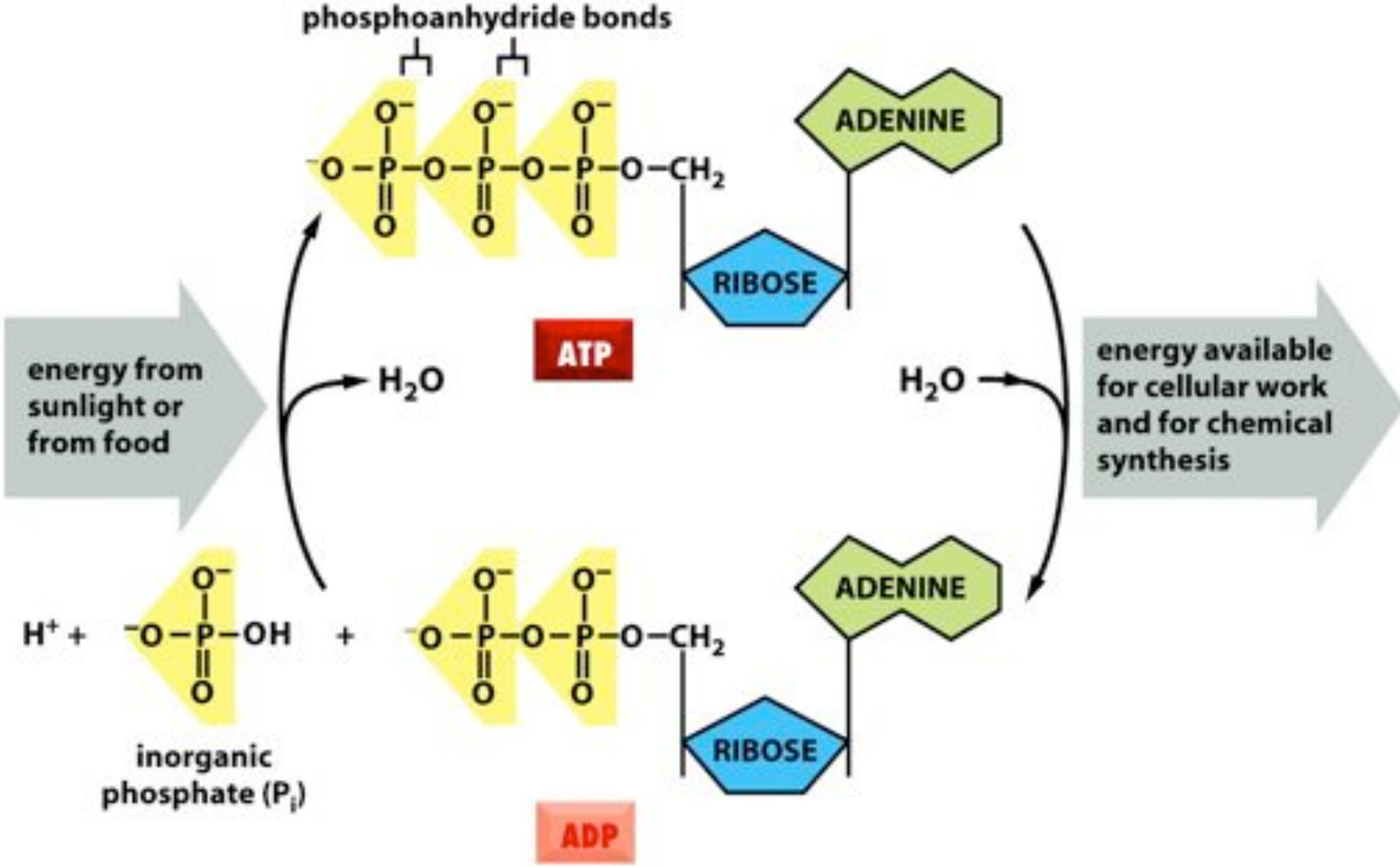
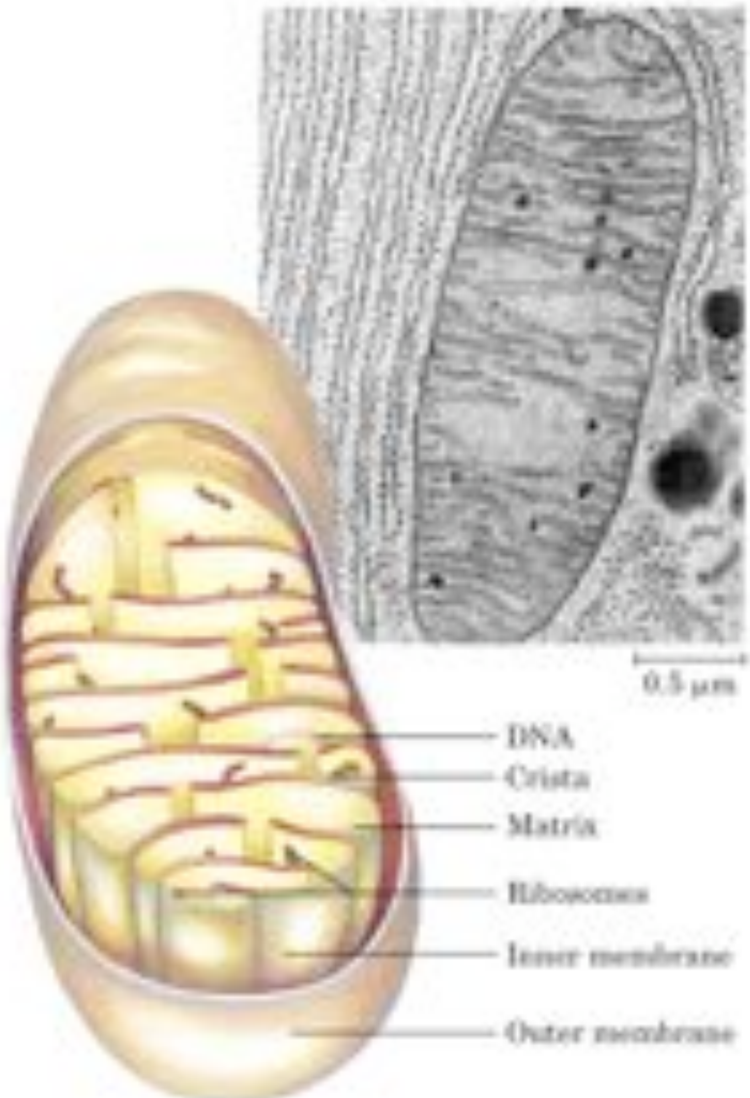


Figure 2-27 *Molecular Biology of the Cell* (© Garland Science 2008)


0.5 μm
DNA
Crista
Matrix
Ribosomes
Inner membrane
Outer membrane

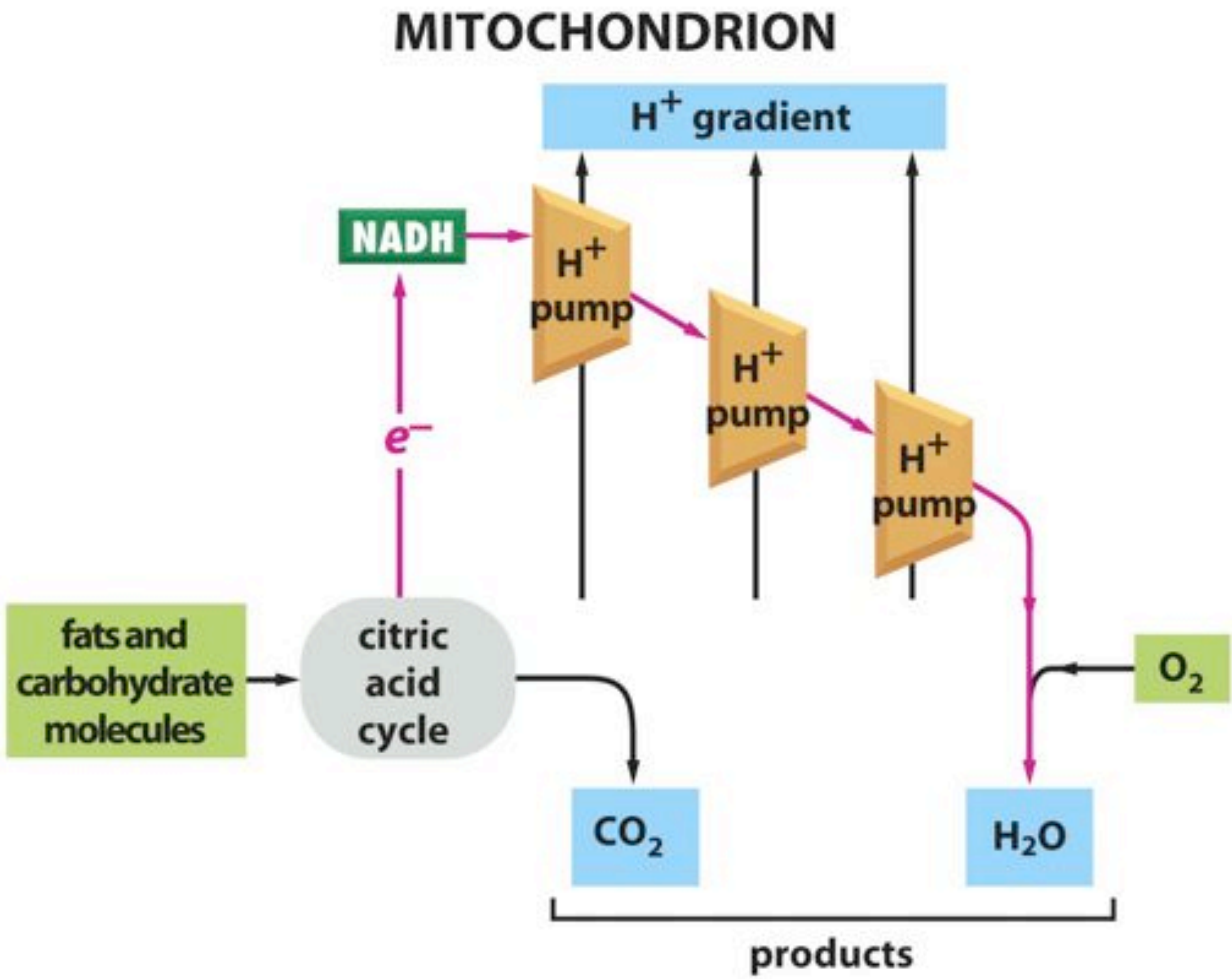


Figure 14-3a *Molecular Biology of the Cell* (© Garland Science 2008)

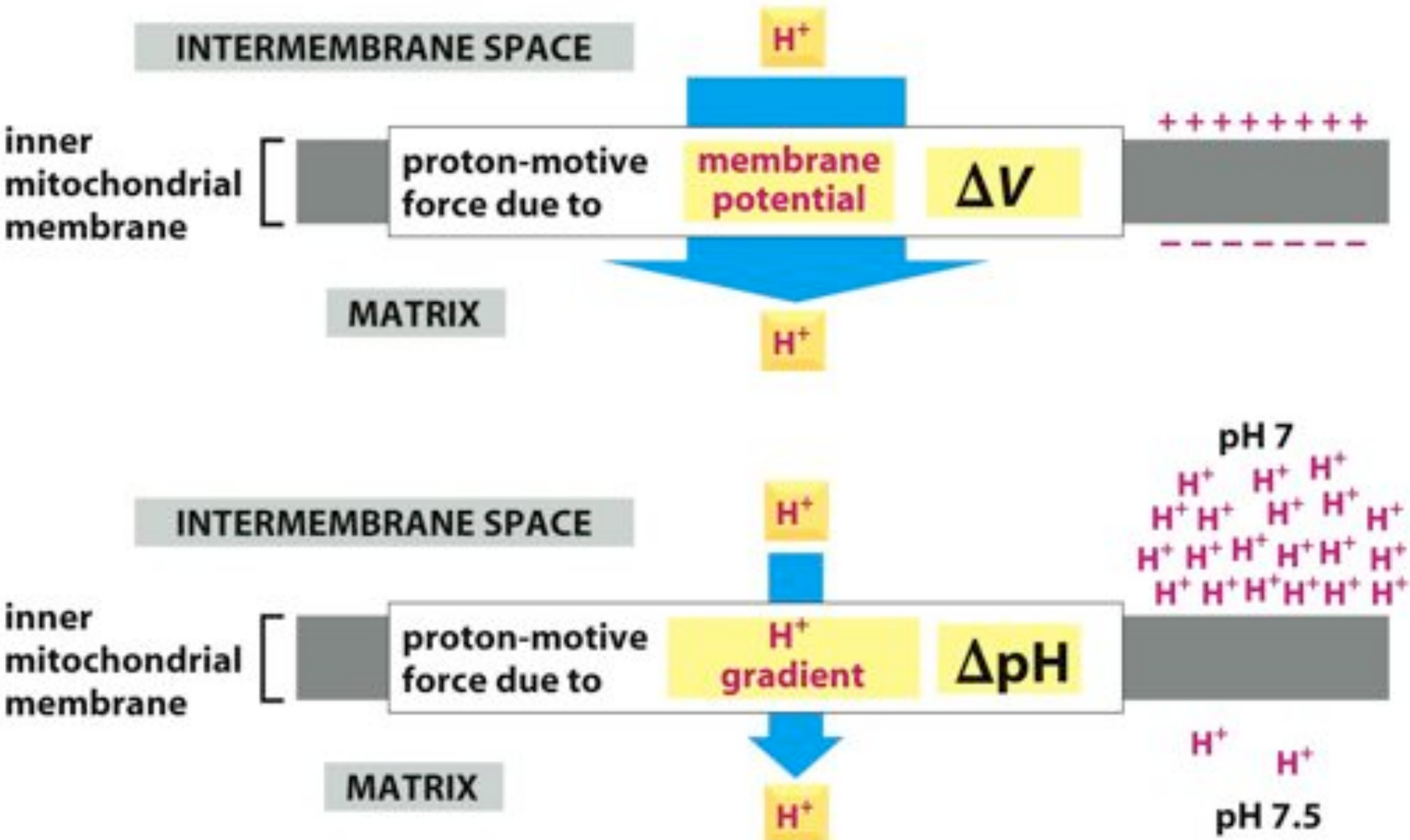


Figure 14-13 *Molecular Biology of the Cell* (© Garland Science 2008)

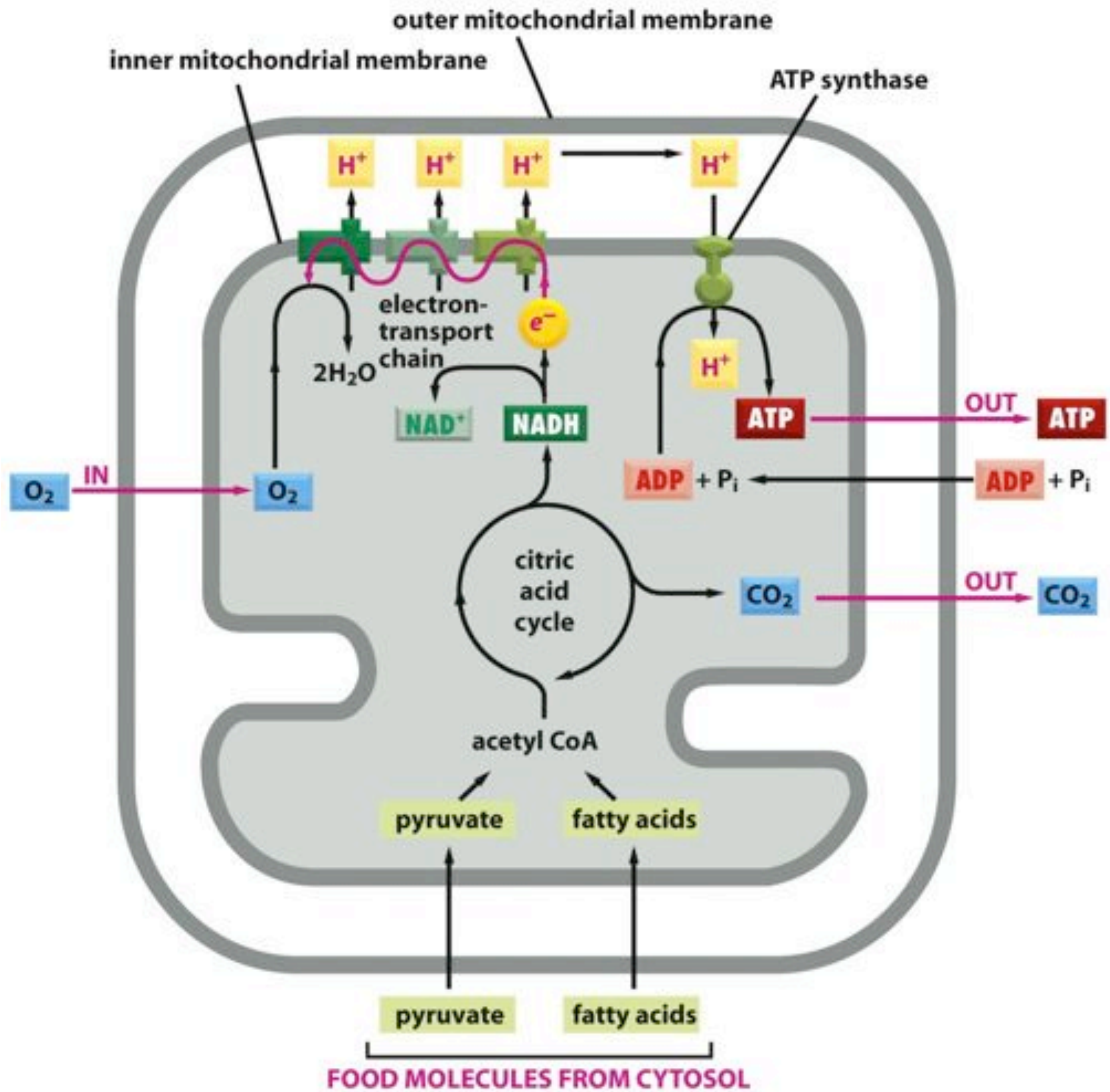
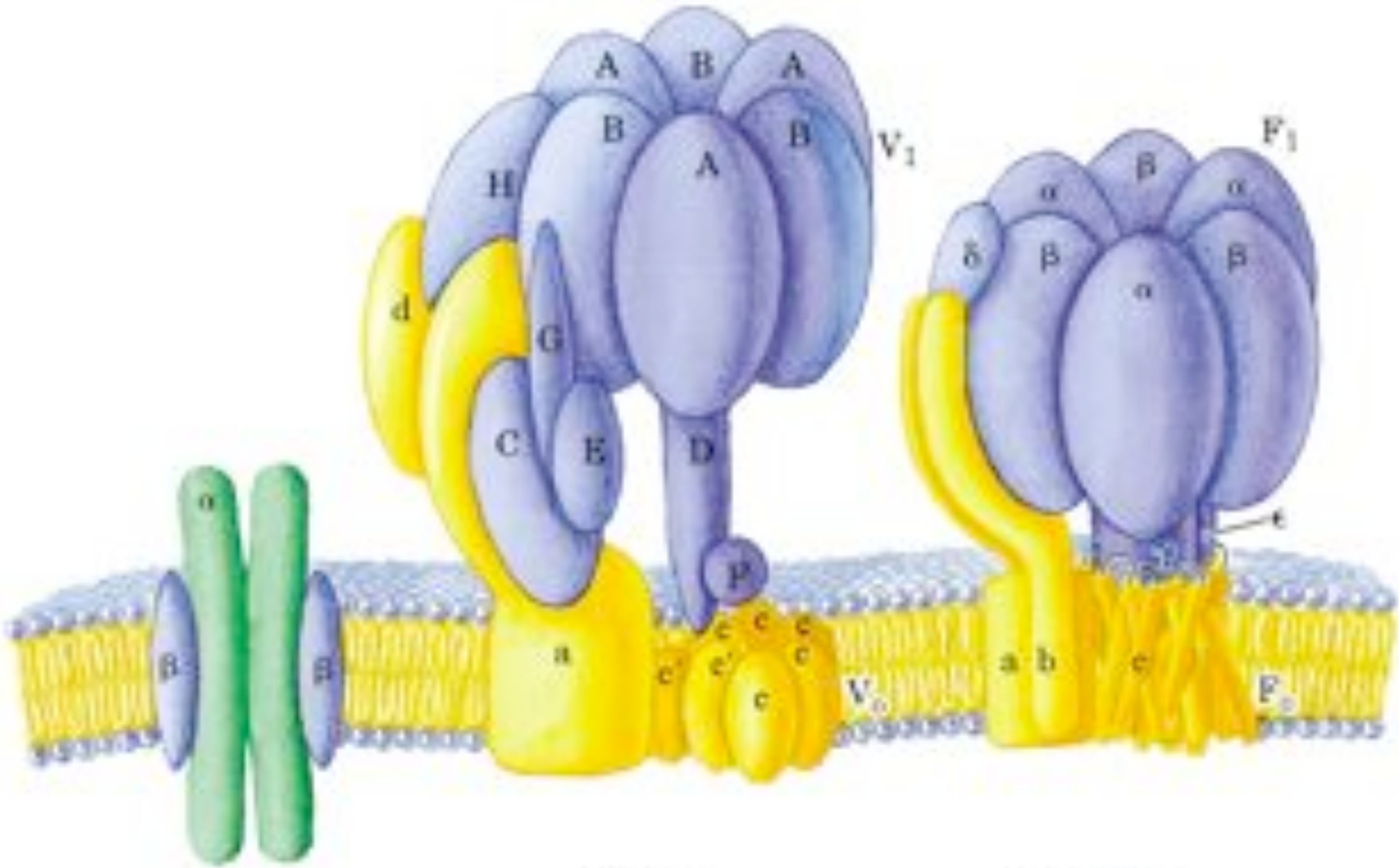


Figure 14-10 *Molecular Biology of the Cell* (© Garland Science 2008)



P-type
(a)

V-type
(b)

F-type
(c)

table 12–4

Four Classes of Transport ATPases

	Organism or tissue	Type of membrane	Role of ATPase
P-type ATPases			
Na^+K^+	Animal tissues	Plasma	Maintains low $[Na^+]$, high $[K^+]$ inside cell; creates transmembrane electrical potential
H^+K^+	Acid-secreting (parietal) cells of mammals	Plasma	Acidifies contents of stomach
H^+	Fungi (Neurospora)	Plasma	Create H^+ gradient to drive secondary transport of extracellular solutes into cell
H^+	Higher plants	Plasma	
Ca^{2+}	Animal tissues	Plasma	Maintains low $[Ca^{2+}]$ in cytosol
Ca^{2+}	Myocytes of animals	Sarcoplasmic reticulum (endoplasmic reticulum)	Sequesters intracellular Ca^{2+}, keeping cytosolic $[Ca^{2+}]$ low
Cd^{2+}, Hg^{2+}, Cu^{2+}	Bacteria	Plasma	Pumps heavy metal ions out of cell
V-type ATPases			
H^+	Animals	Lysosomal, endosomal, secretory vesicles	Create low pH in compartment, activating proteases and other hydrolytic enzymes
H^+	Higher plants	Vacuolar	
H^+	Fungi	Vacuolar	
F-type ATPases			
H^+	Eukaryotes	Inner mitochondrial	Catalyze formation of ATP from ADP + P_i
H^+	Higher plants	Thylakoid	
H^+	Prokaryotes	Plasma	
Multidrug transporter			
	Animal tumor cells	Plasma	Removes a wide variety of hydrophobic natural products and synthetic drugs from cytosol, including vinblastine, doxorubicin, actinomycin D, mitomycin, taxol, colchicine, and puromycin

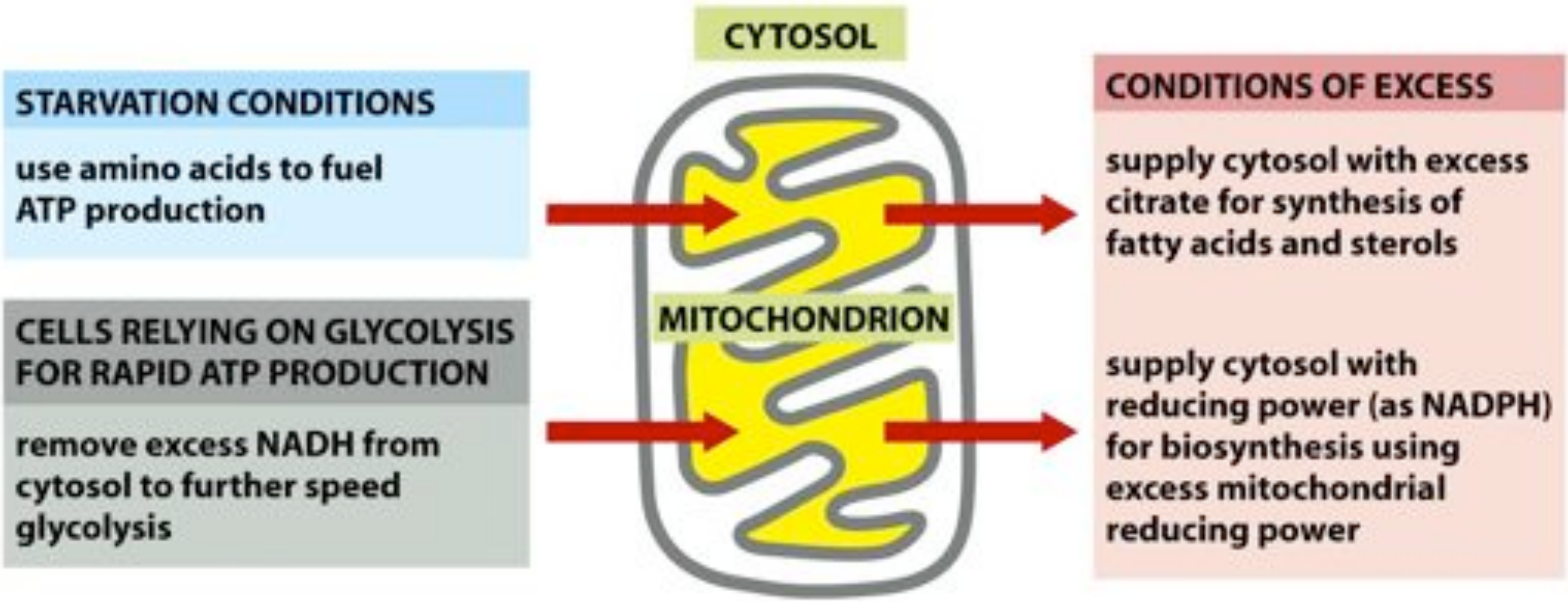
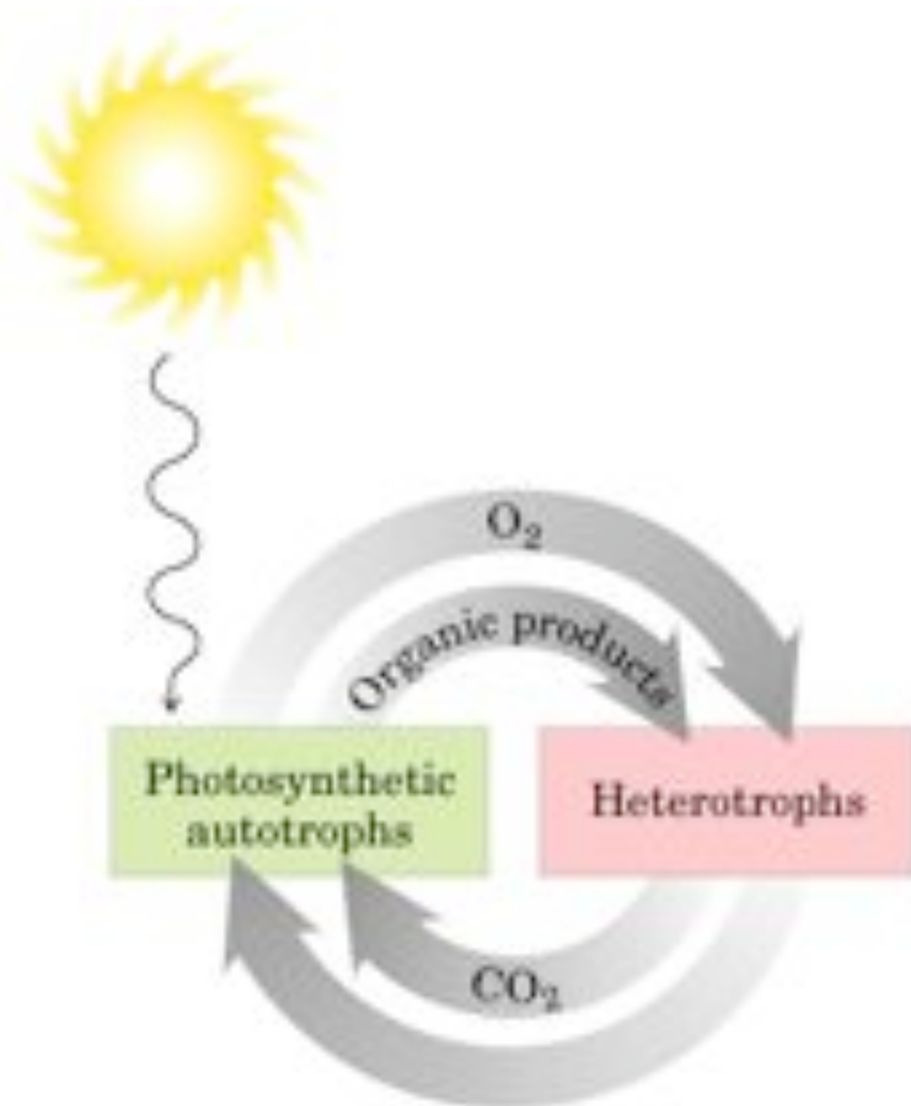


Figure 14-32 *Molecular Biology of the Cell* (© Garland Science 2008)



O_2
Organic products
Photosynthetic autotrophs
Heterotrophs
CO_2

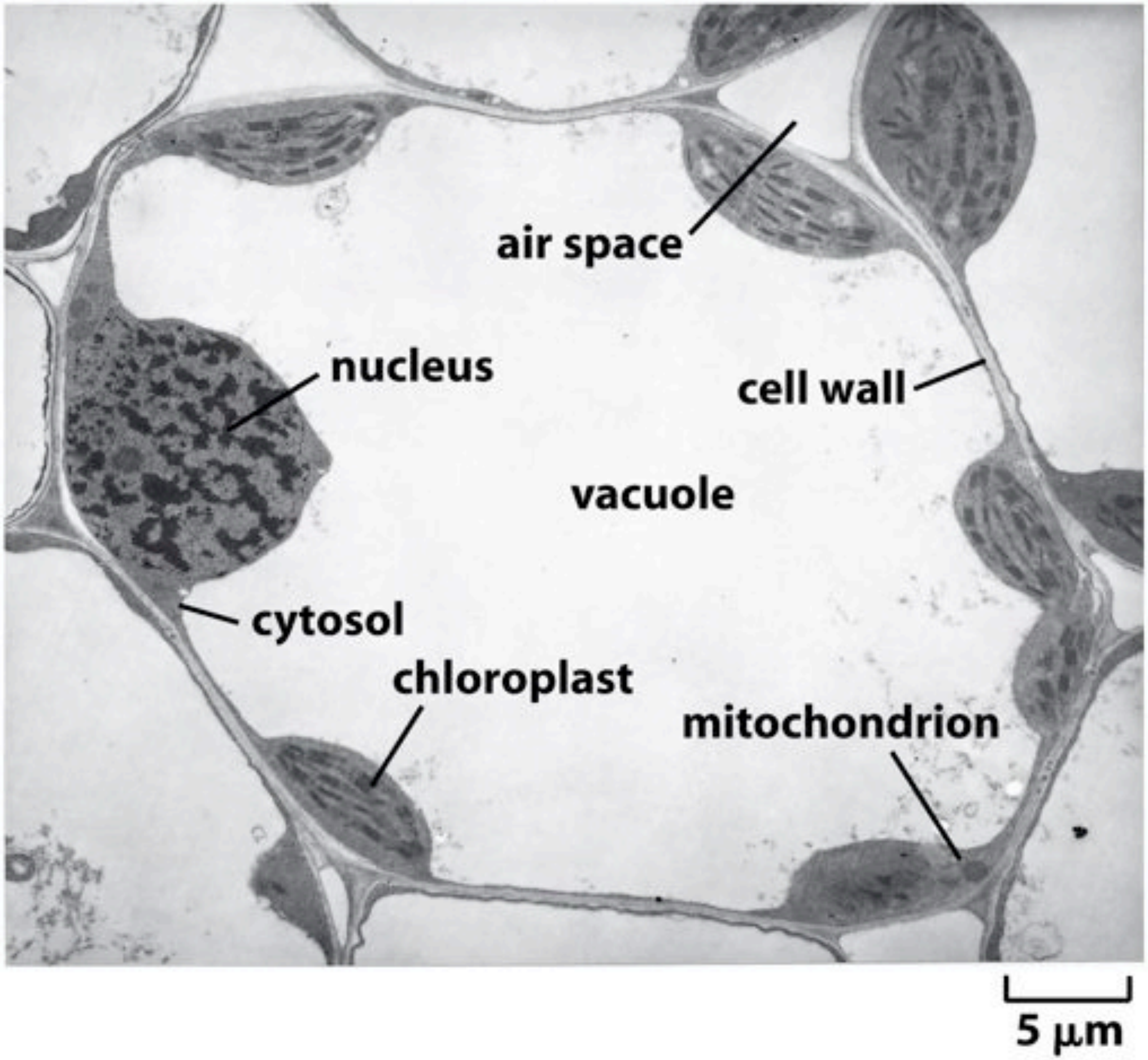


Figure 14-35a *Molecular Biology of the Cell* (© Garland Science 2008)

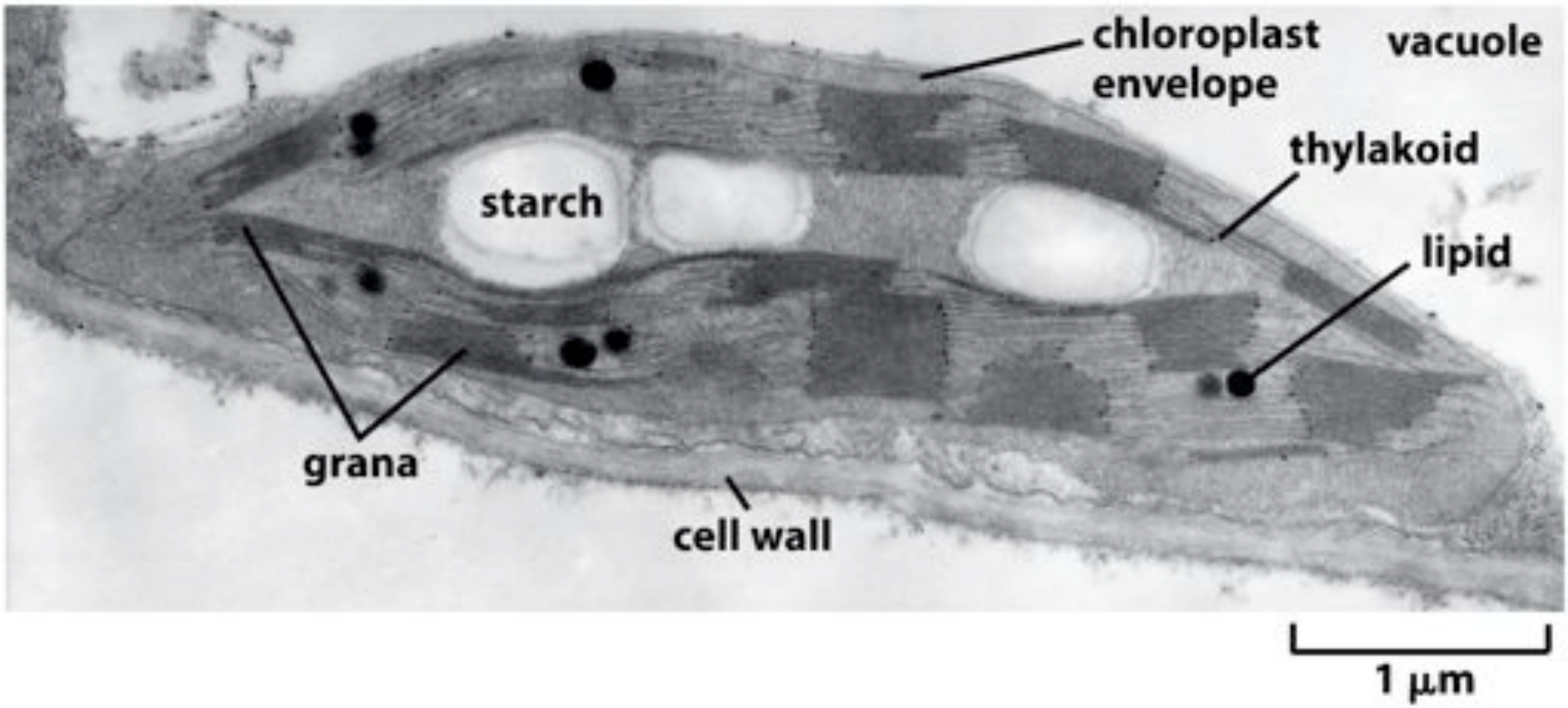


Figure 14-35b *Molecular Biology of the Cell* (© Garland Science 2008)

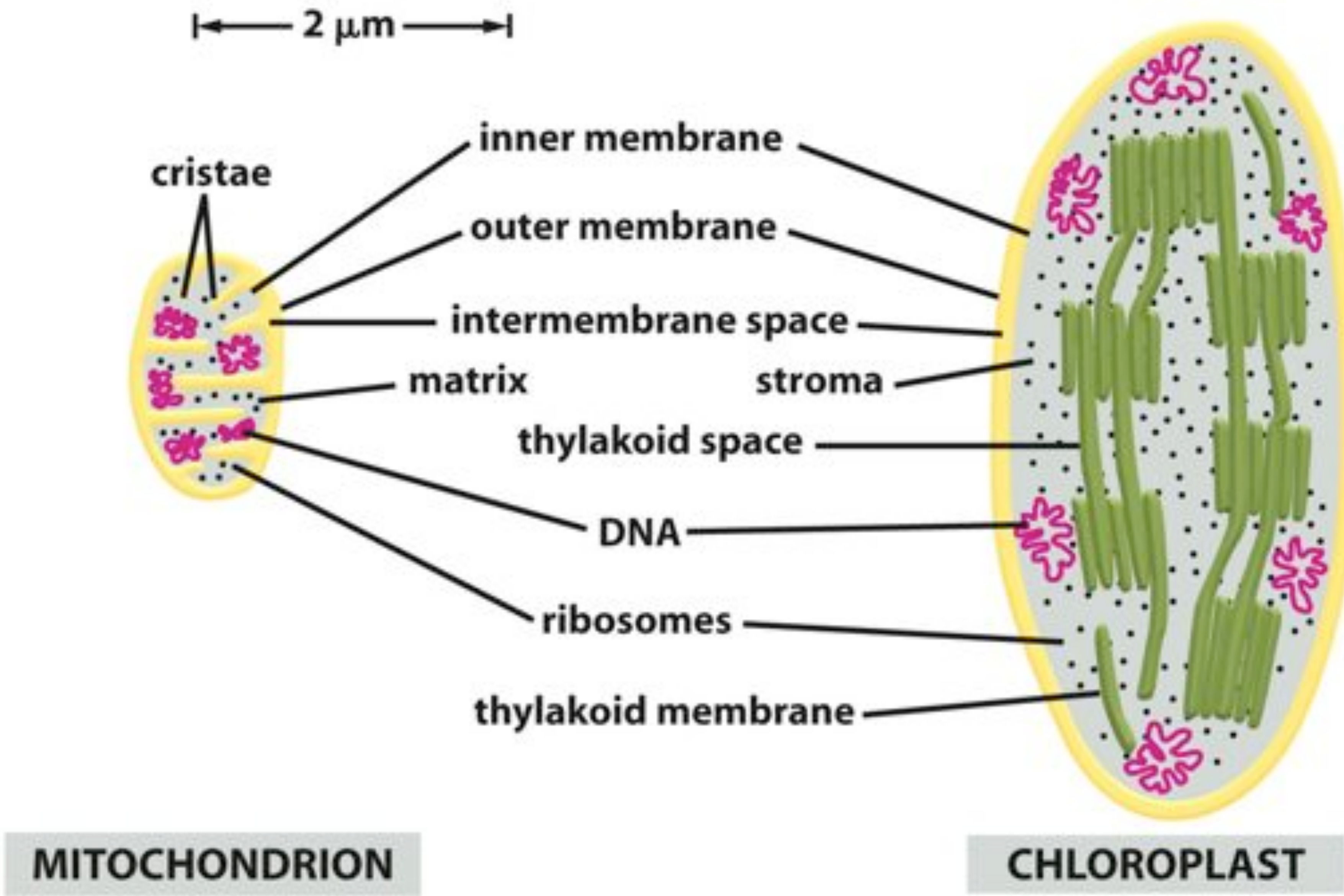


Figure 14-37 *Molecular Biology of the Cell* (© Garland Science 2008)

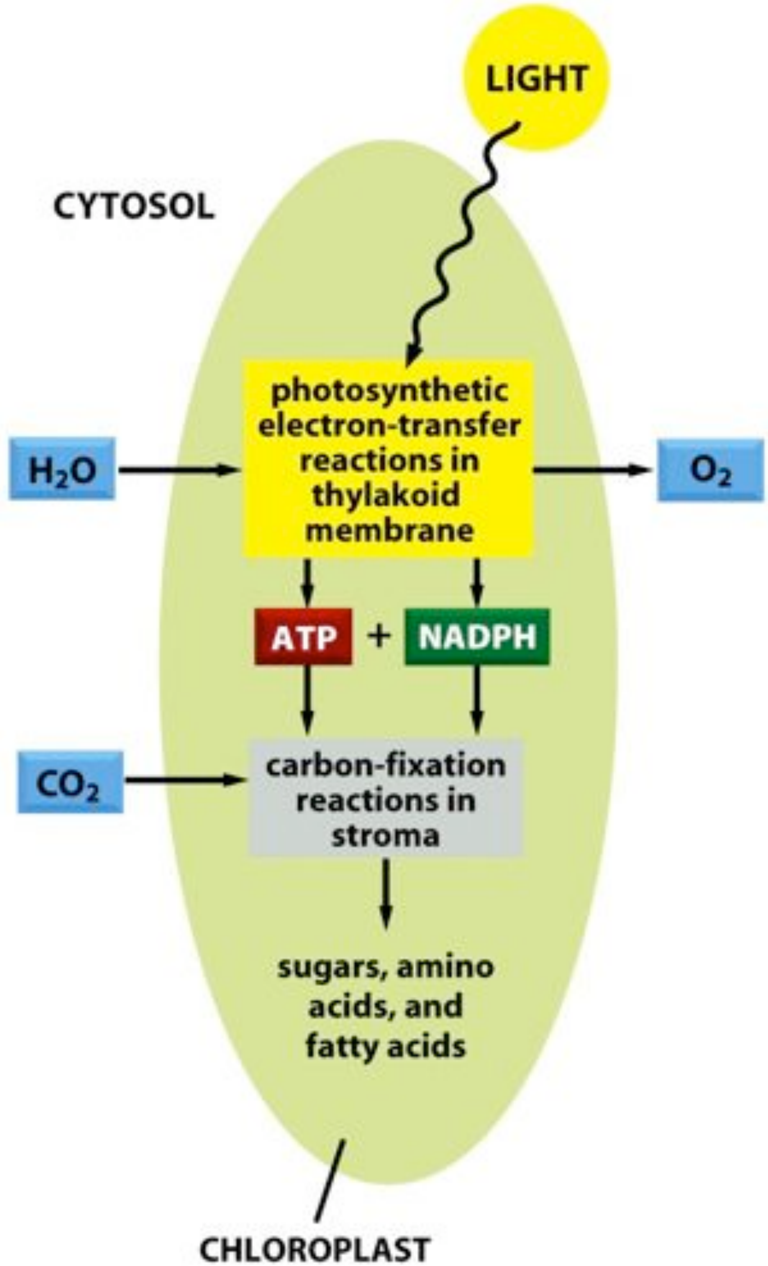


Figure 14-38 *Molecular Biology of the Cell* (© Garland Science 2008)

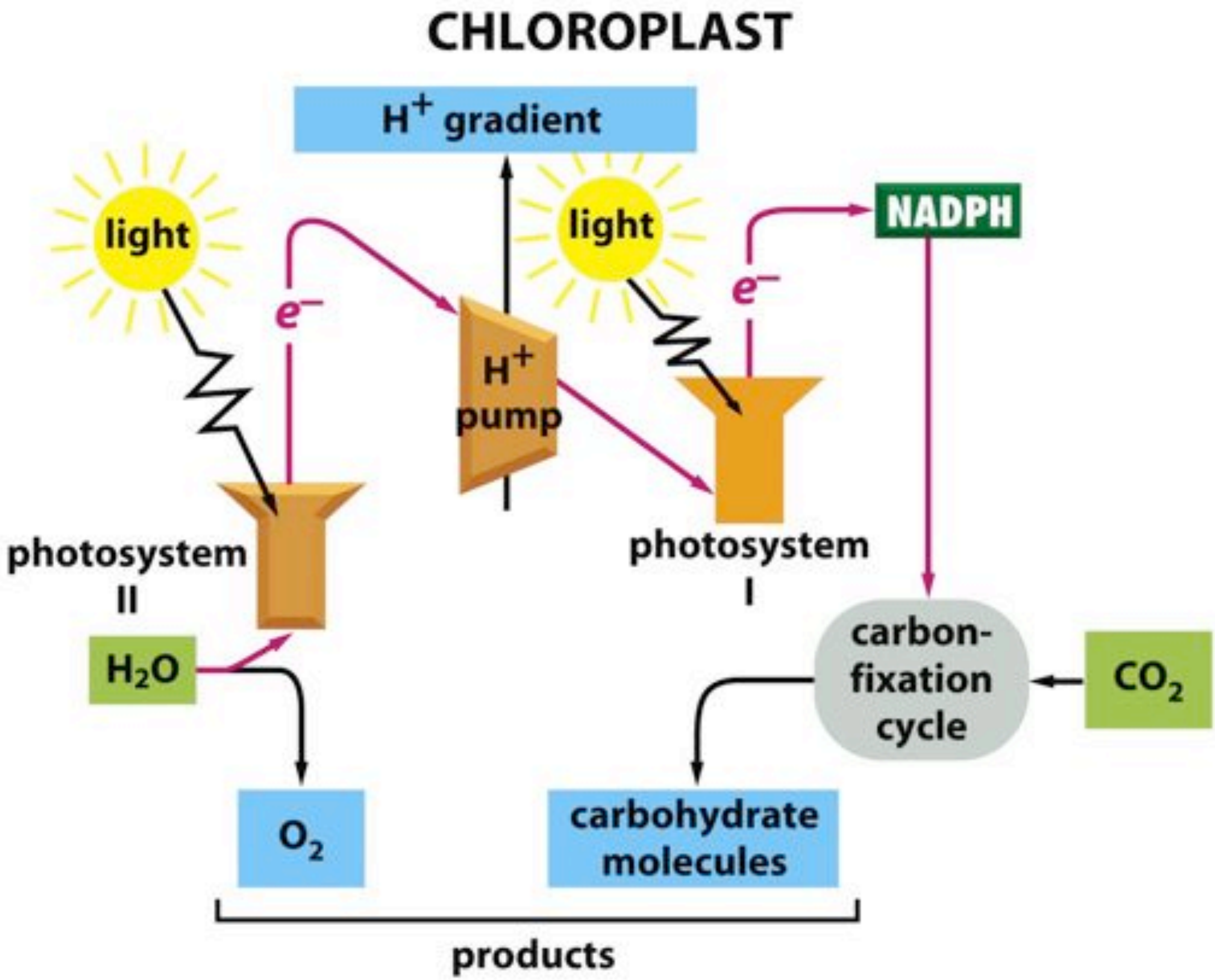


Figure 14-3b *Molecular Biology of the Cell* (© Garland Science 2008)

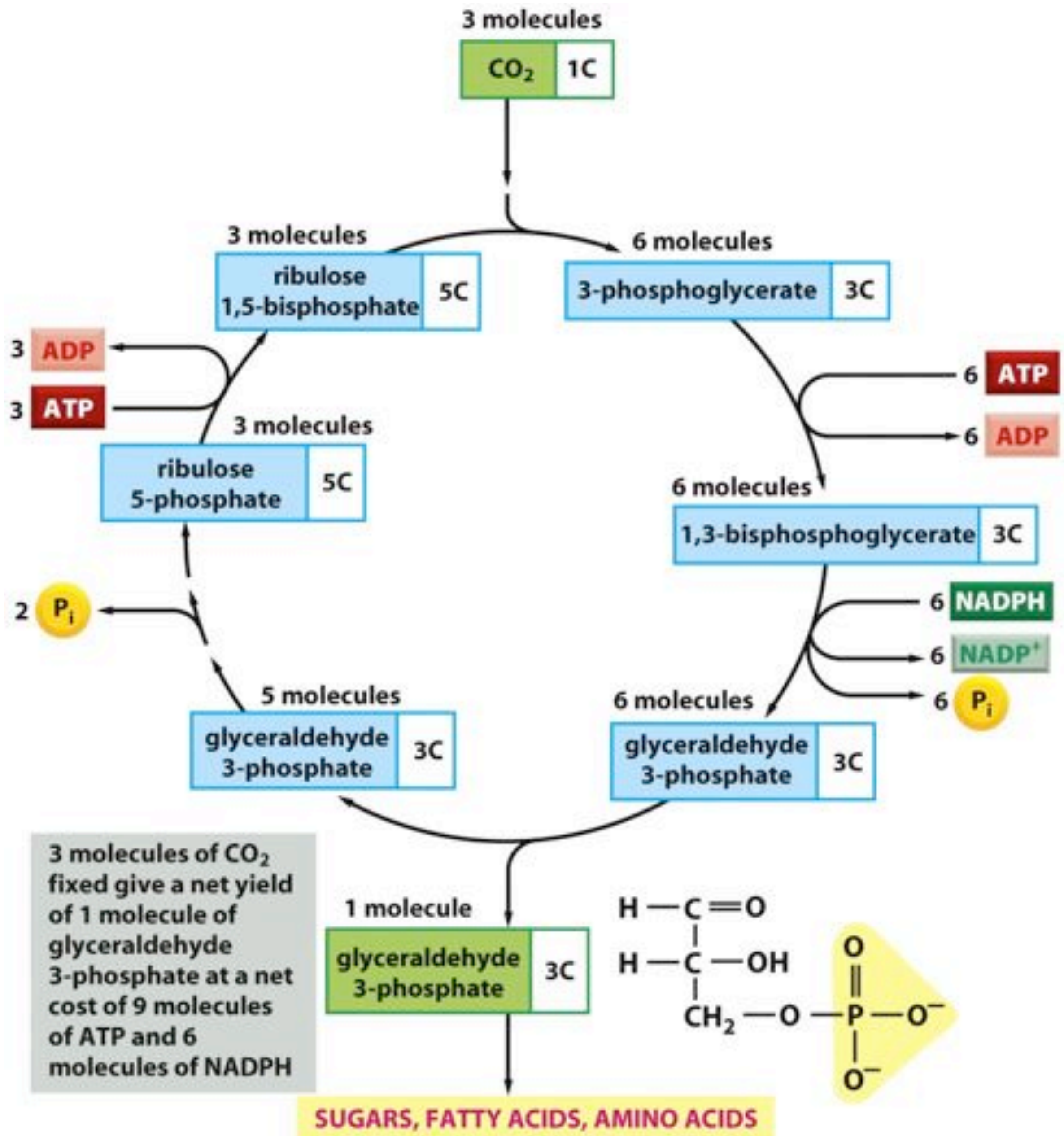


Figure 14-40 *Molecular Biology of the Cell* (© Garland Science 2008)

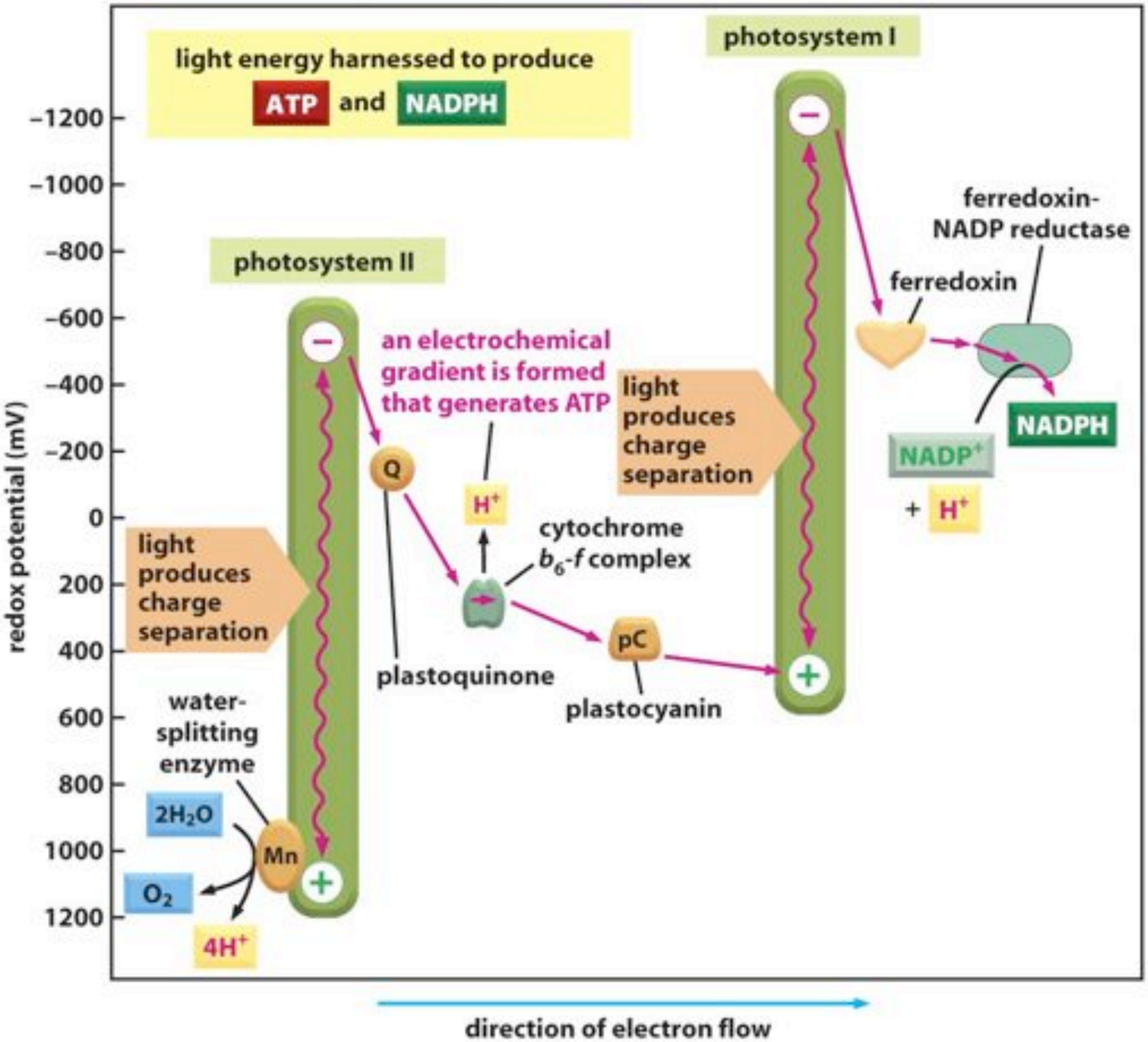


Figure 14-49 *Molecular Biology of the Cell* (© Garland Science 2008)