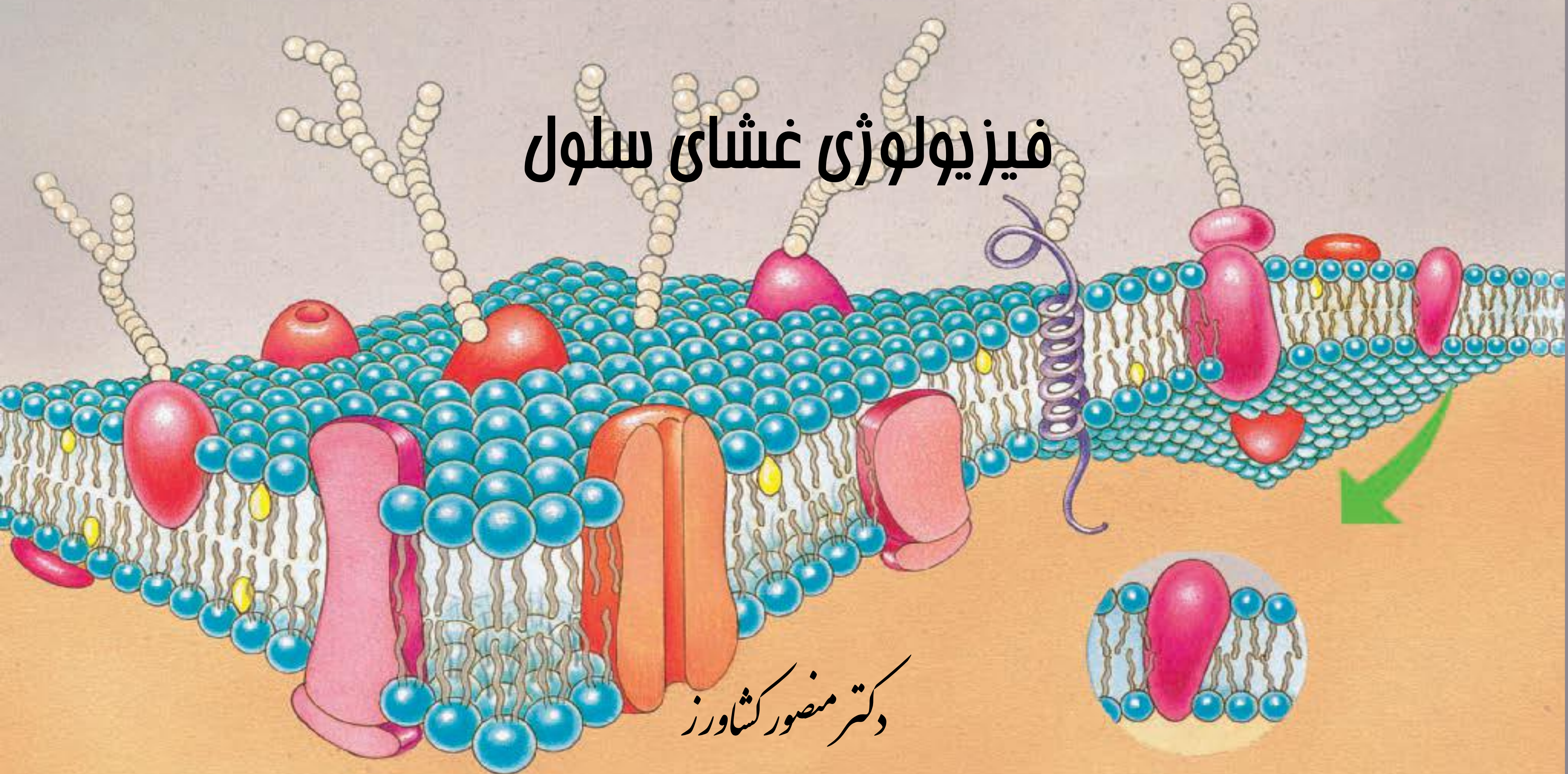
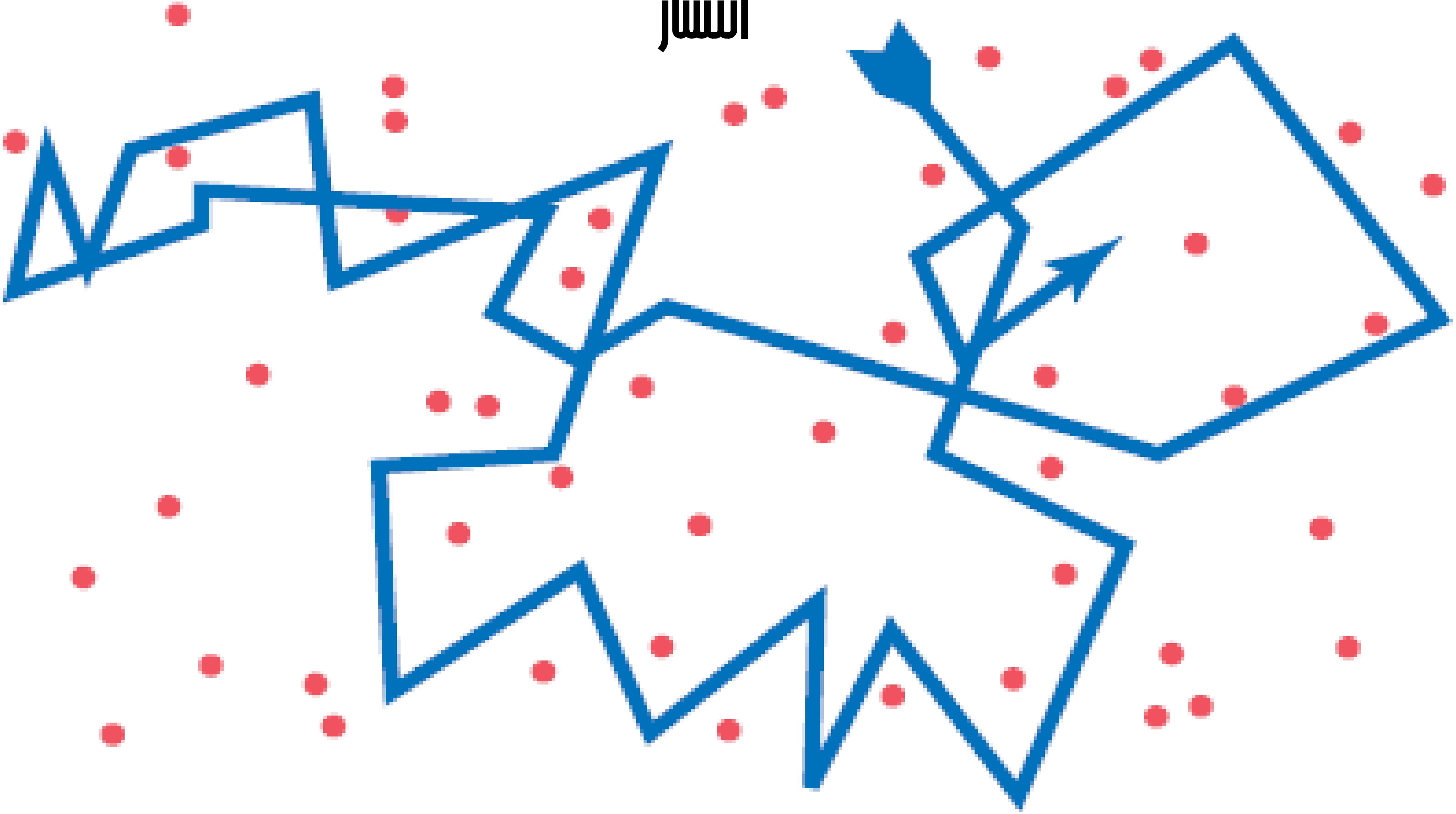
فیزیولوژی غشای سلول

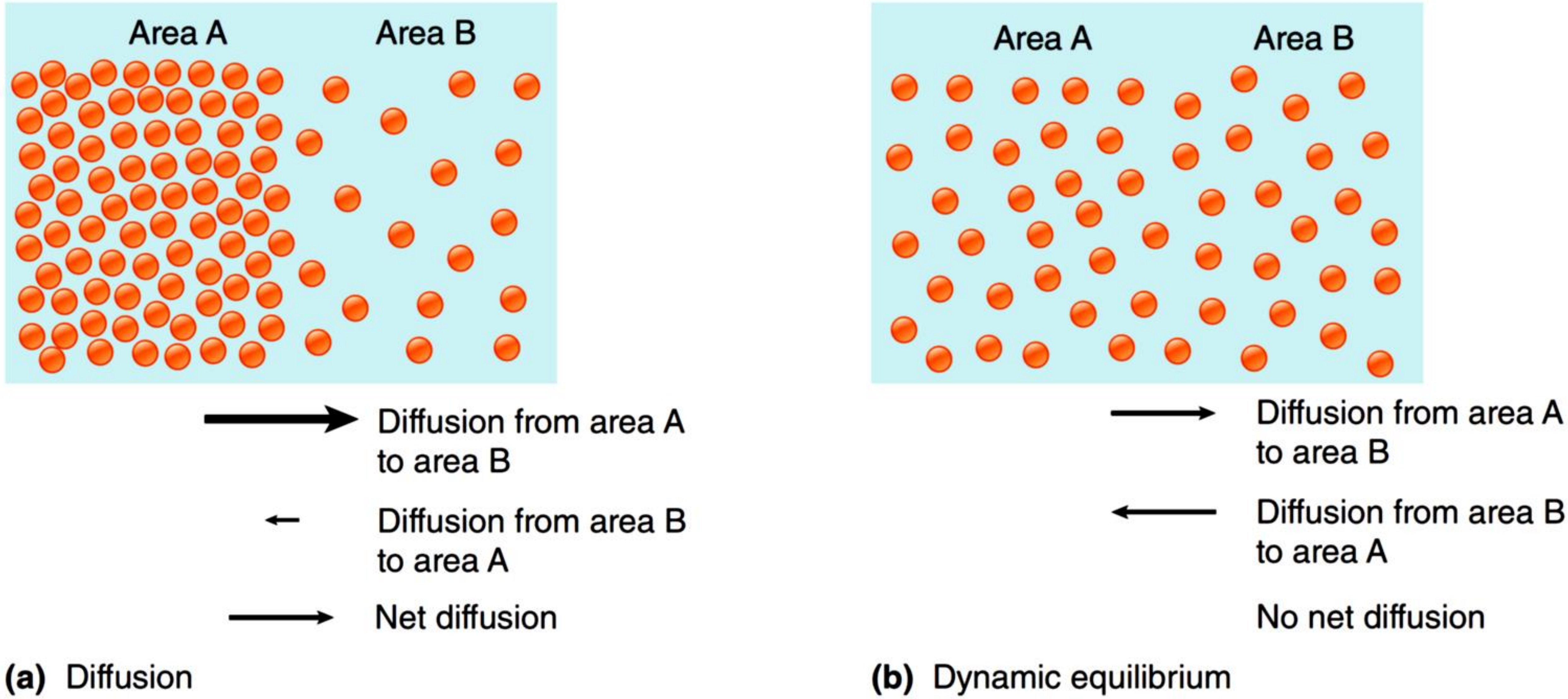


دکتر منصور کشاورز

انتشار



انتشار خالص


Area A
Area B
Diffusion from area A to area B
Diffusion from area B to area A
Net diffusion
(a) Diffusion
Area A
Area B
Diffusion from area A to area B
Diffusion from area B to area A
No net diffusion
(b) Dynamic equilibrium

انتقال مواد از غشاء

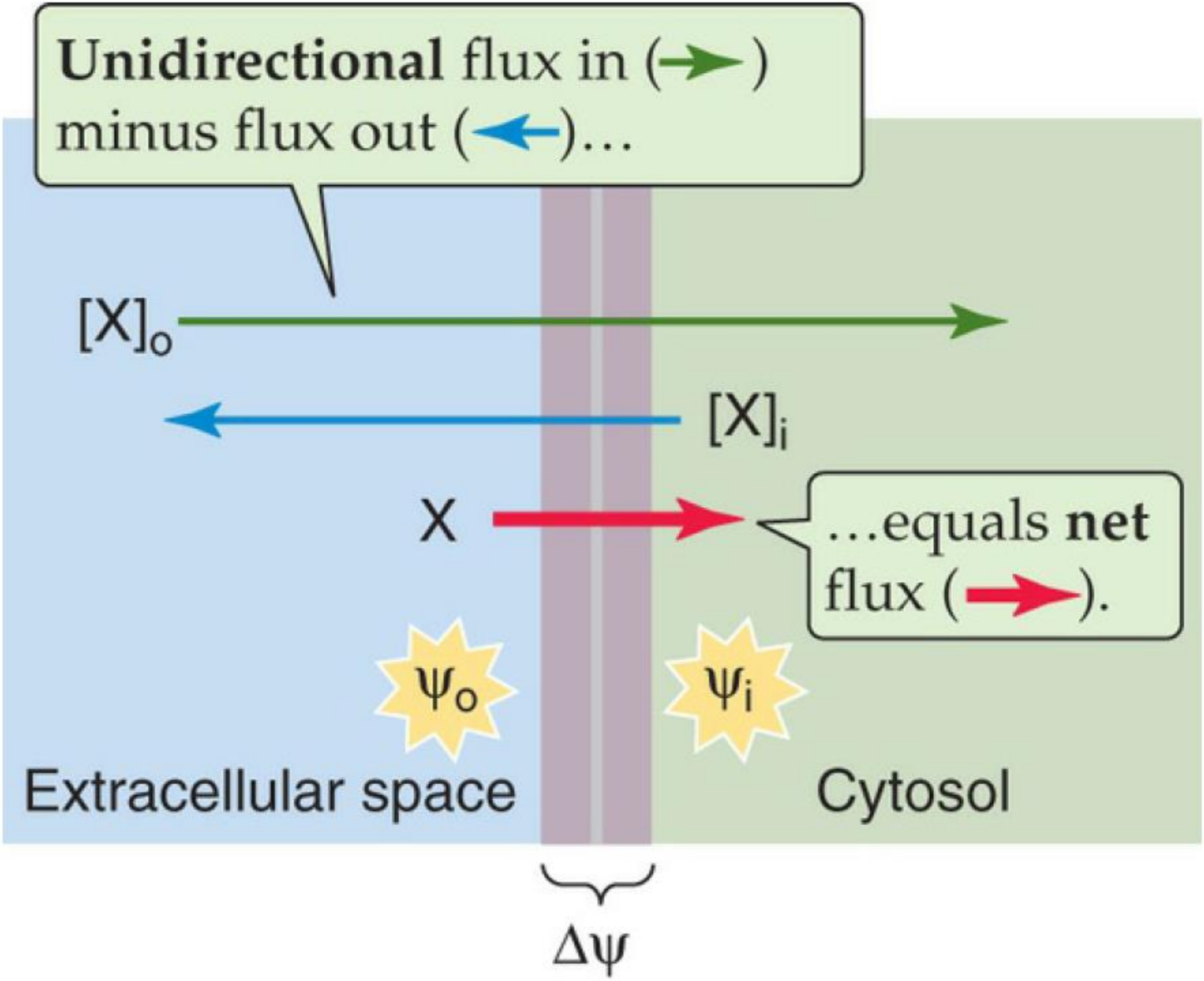


TABLE 3-1 Factors Influencing the Rate of Net Diffusion of a Substance across a Membrane (Fick's Law of Diffusion)

Factor	Effect on Rate of Net Diffusion
↑ Concentration gradient of substance (ΔC)	↑
↑ Surface area of membrane (A)	↑
↑ Lipid solubility (β)	↑
↑ Molecular weight of substance (MW)	↓
↑ Distance (thickness) (ΔX)	↓

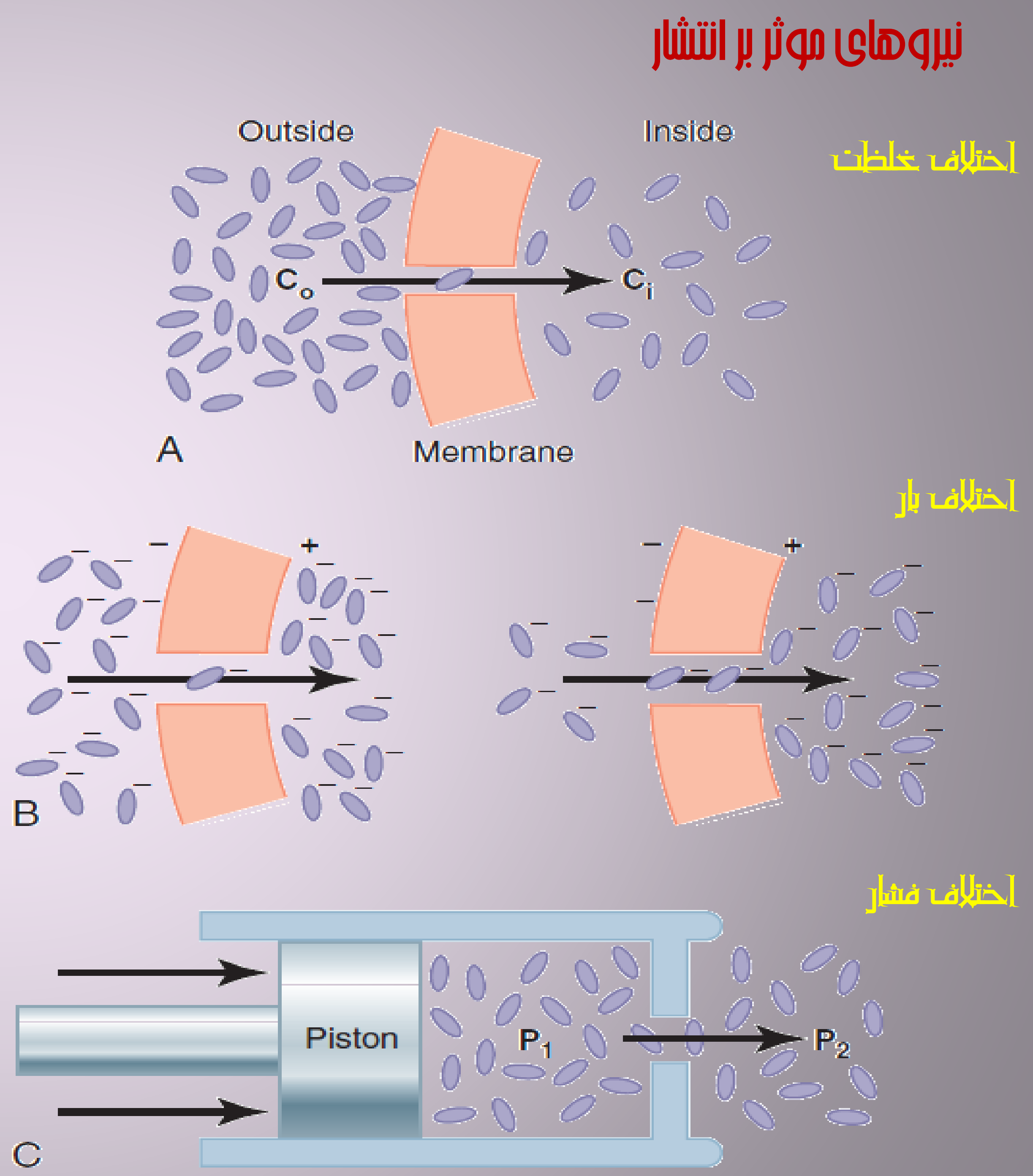
Modified Fick's equation:

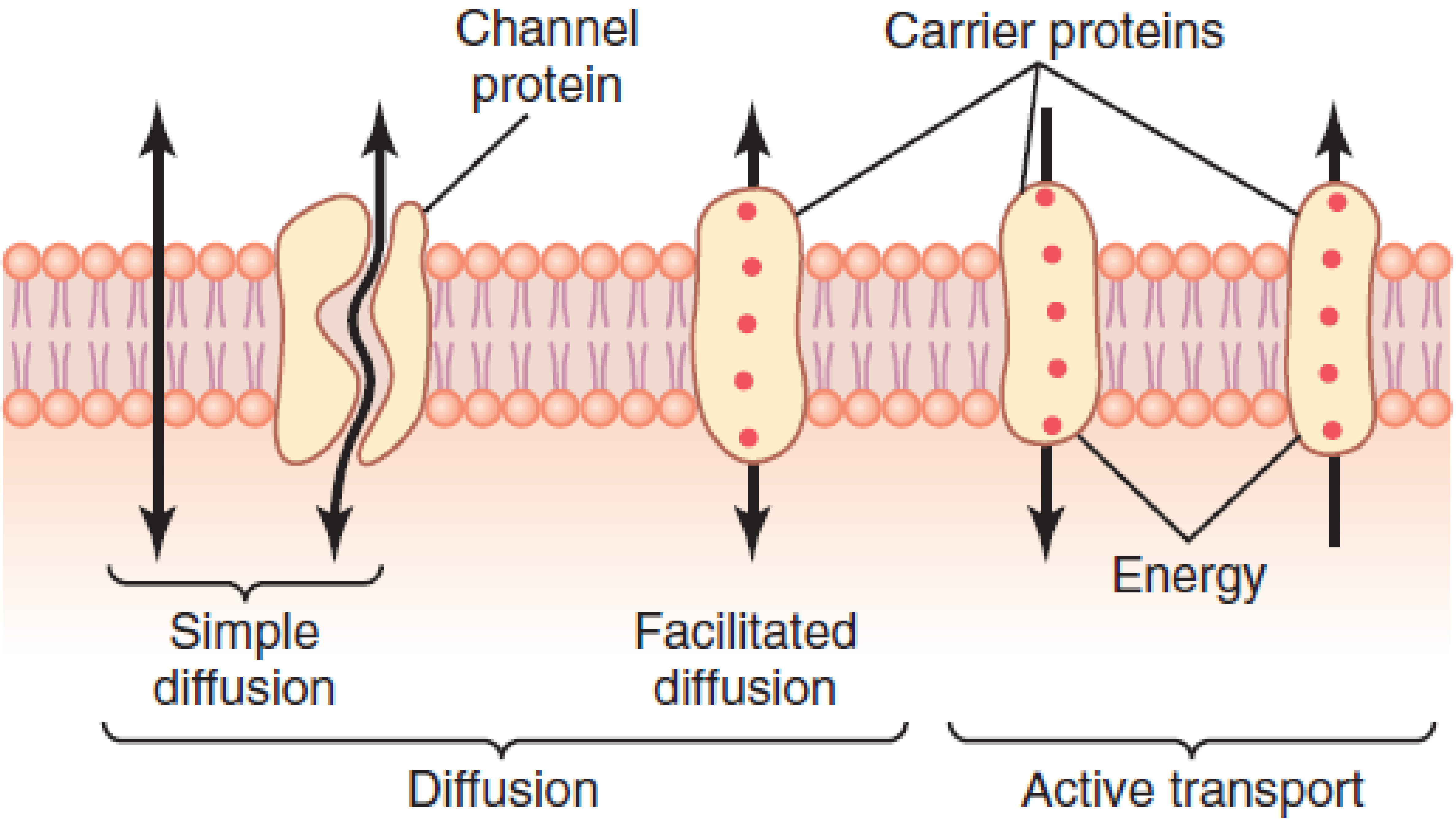
$$\text{Net rate of diffusion } (Q) = \frac{\Delta C \cdot A \cdot \beta}{\sqrt{MW} \cdot \Delta X}$$

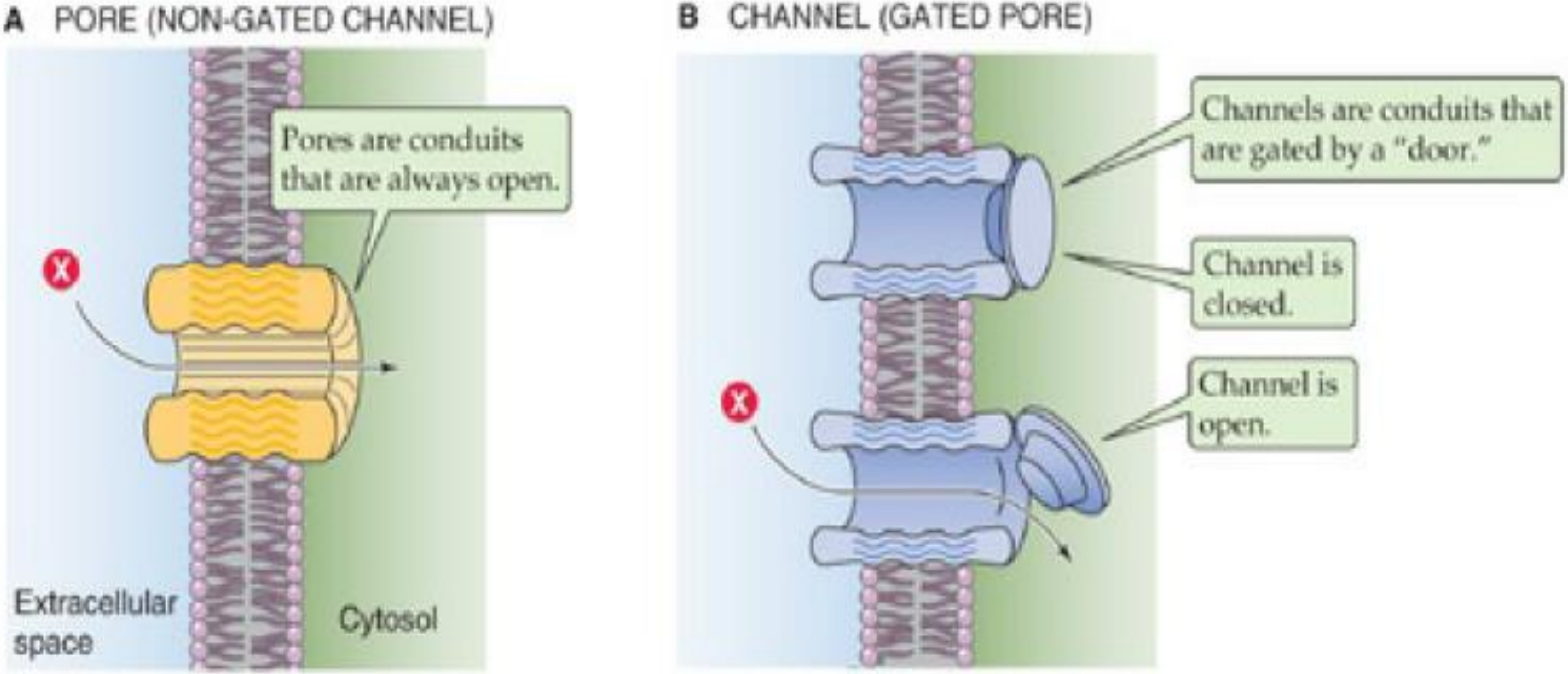
$$\left[\text{diffusion constant } (D) \propto \frac{\beta}{\sqrt{MW}}\right]$$

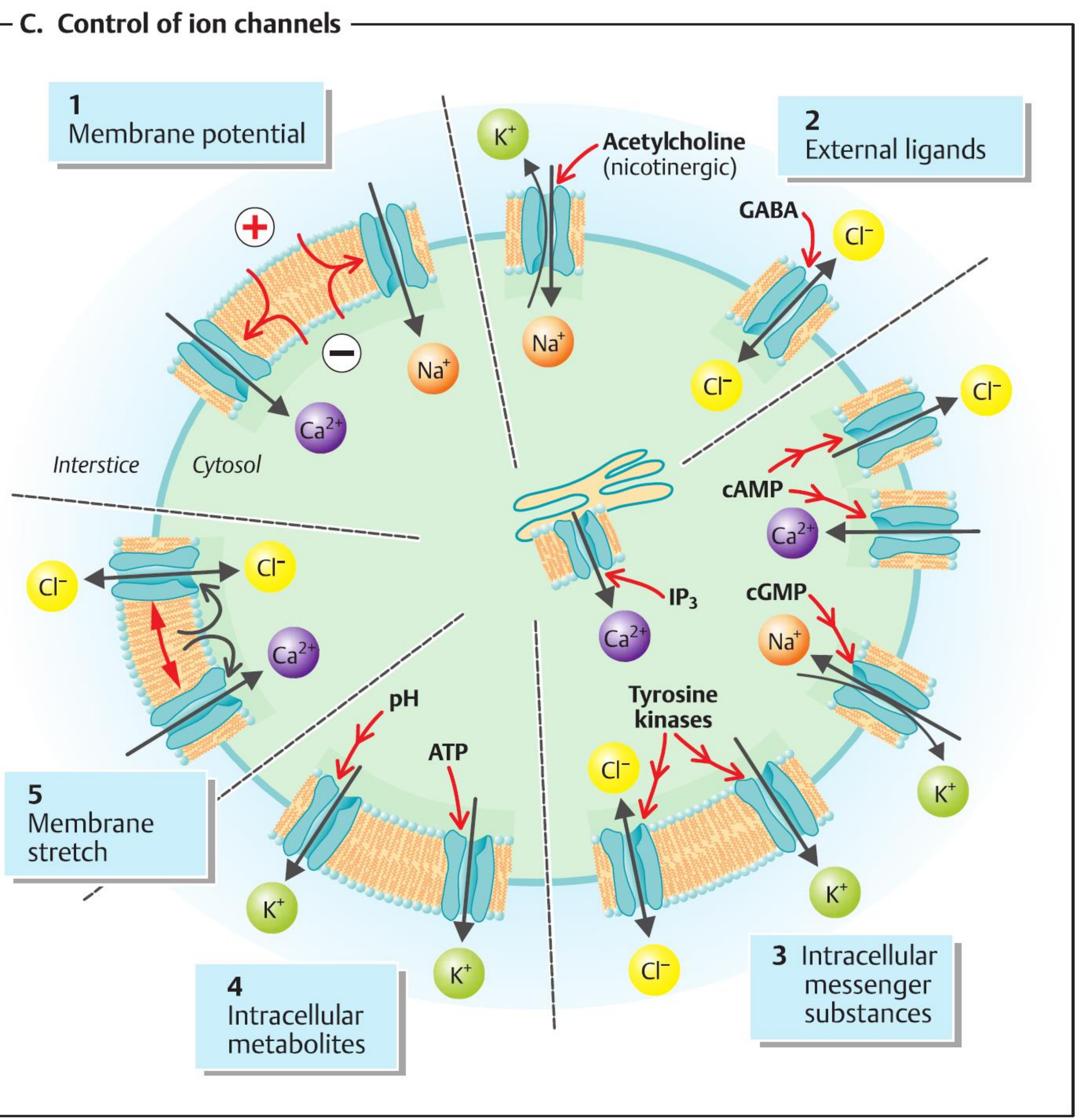
$$\left[\text{permeability } (P) = \frac{D}{\Delta X}\right]$$

$$\text{Restated } Q \propto \Delta C \cdot A \cdot P$$



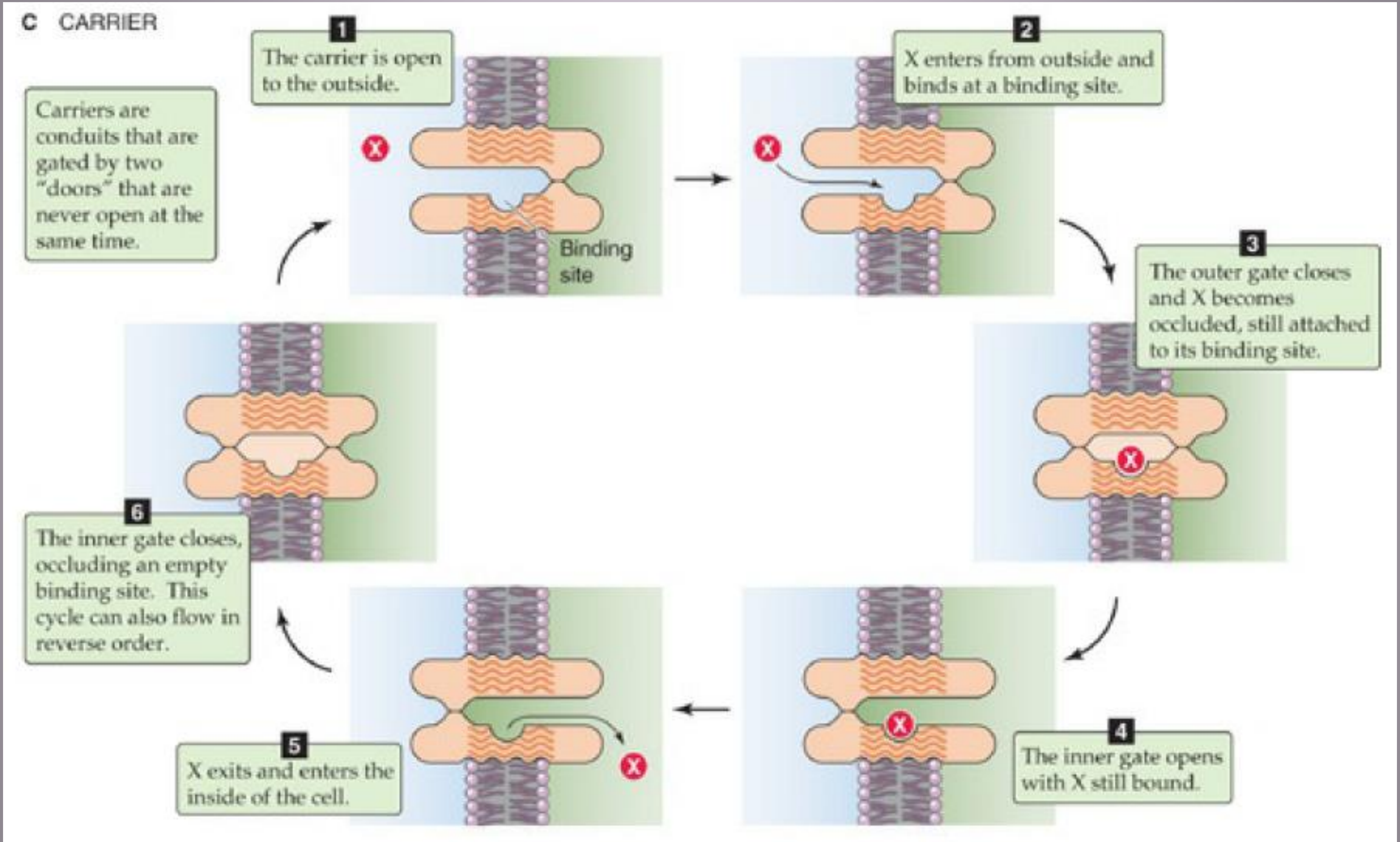

Channel protein
Carrier proteins
Energy
Simple diffusion
Facilitated diffusion
Diffusion
Active transport

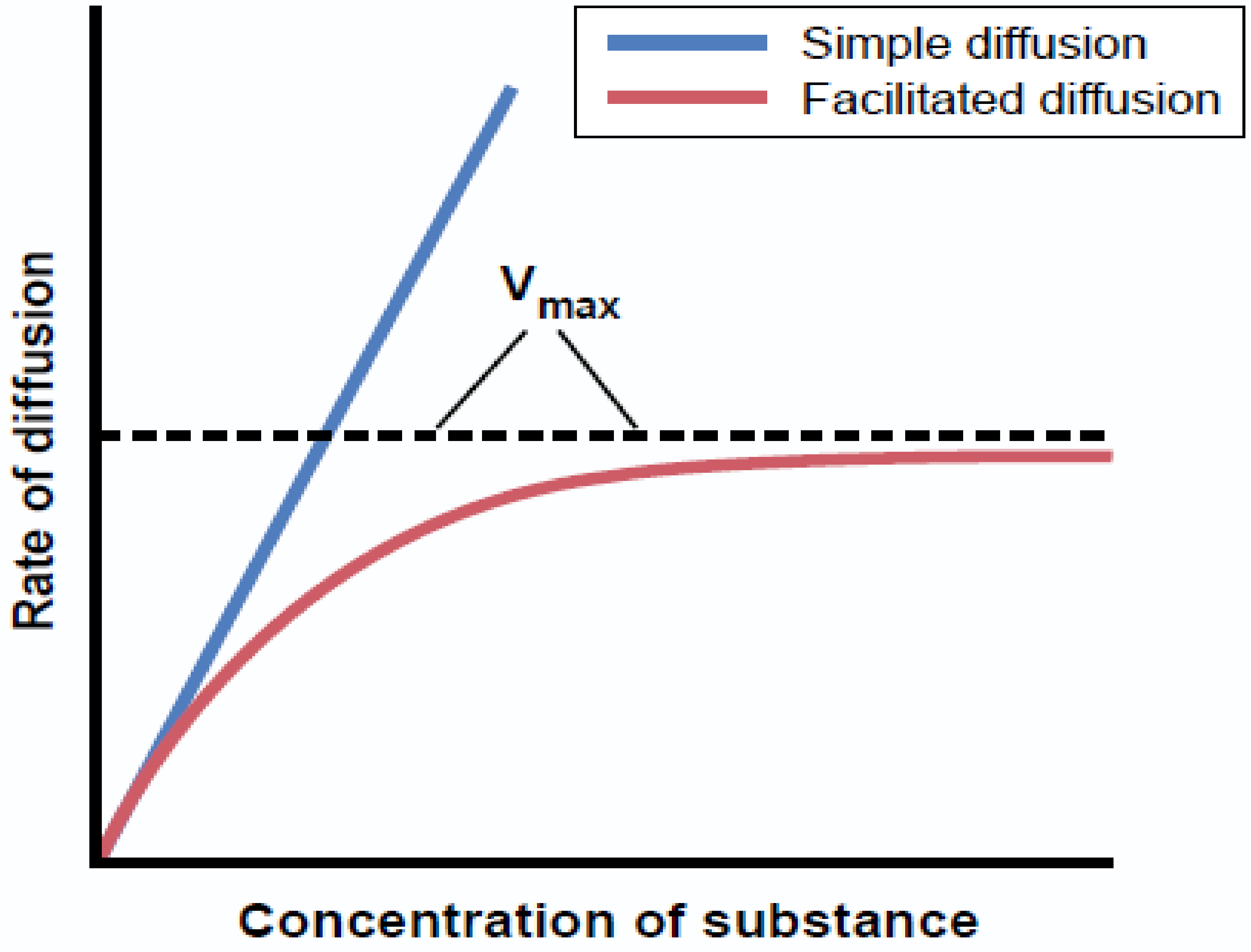

A PORE (NON-GATED CHANNEL)
Pores are conduits that are always open.
X
Extracellular space
Cytosol
B CHANNEL (GATED PORE)
Channels are conduits that are gated by a "door."
Channel is closed.
Channel is open.
X



انواع کانال دریچه دار

- ولتاژی
- لیگاندی
- مکانیکی
- ....

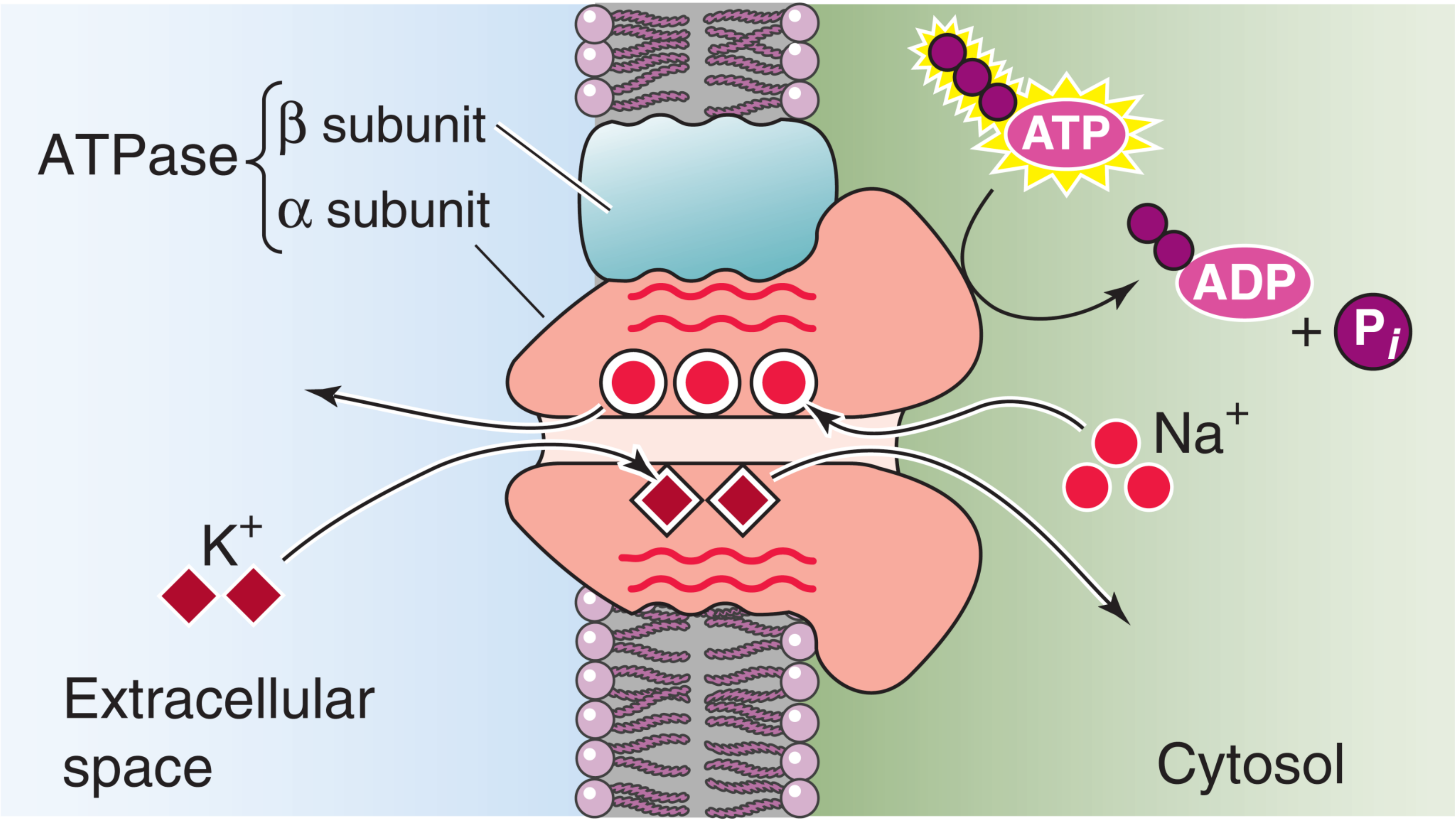

C CARRIER
Carriers are conduits that are gated by two "doors" that are never open at the same time.
1
The carrier is open to the outside.
X
Binding site
2
X enters from outside and binds at a binding site.
X
3
The outer gate closes and X becomes occluded, still attached to its binding site.
X
4
The inner gate opens with X still bound.
X
5
X exits and enters the inside of the cell.
X
6
The inner gate closes, occluding an empty binding site. This cycle can also flow in reverse order.



ویژگی های ناقل

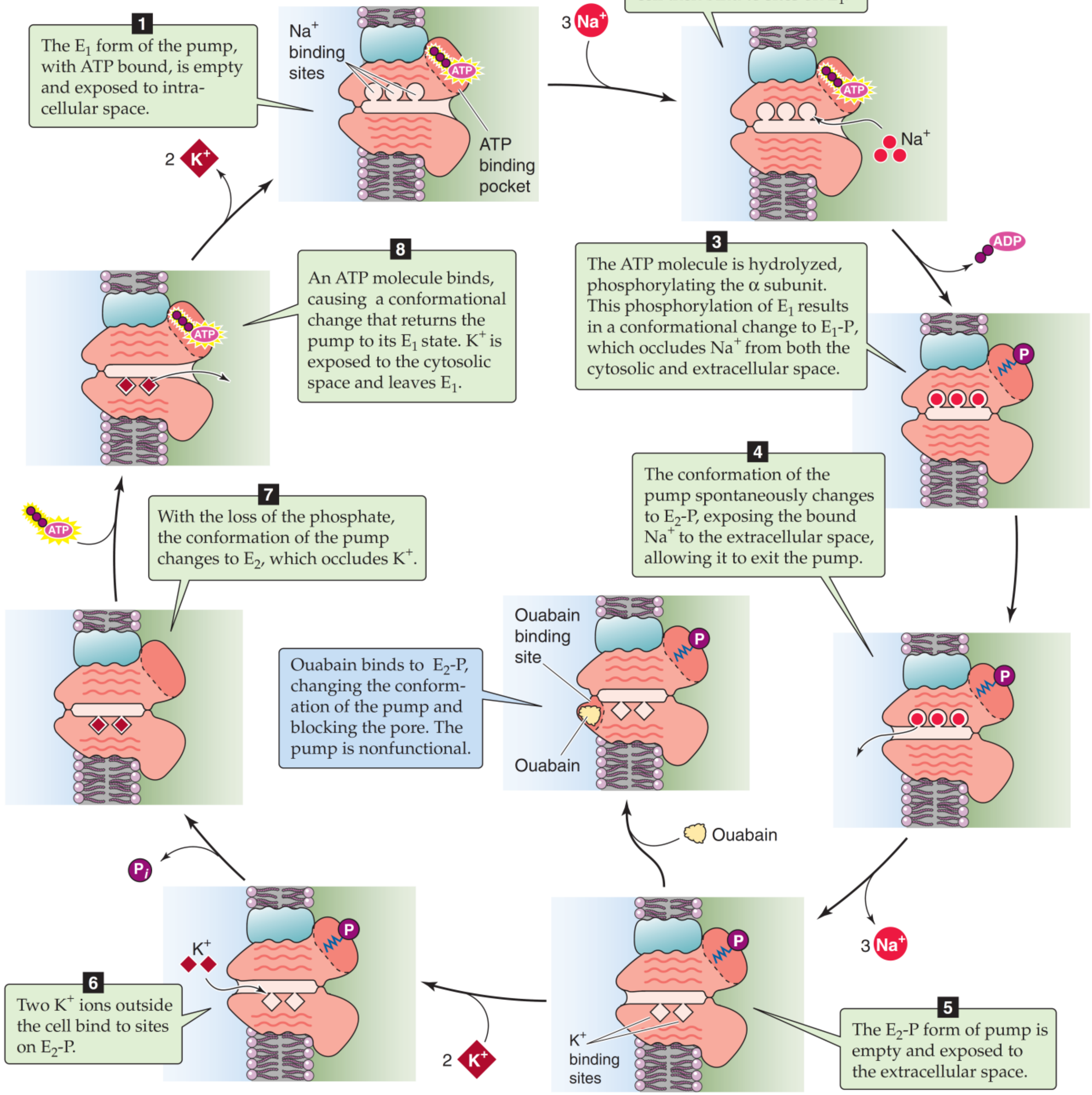
- اشباع پذیری
- اختصاص
- رقابت

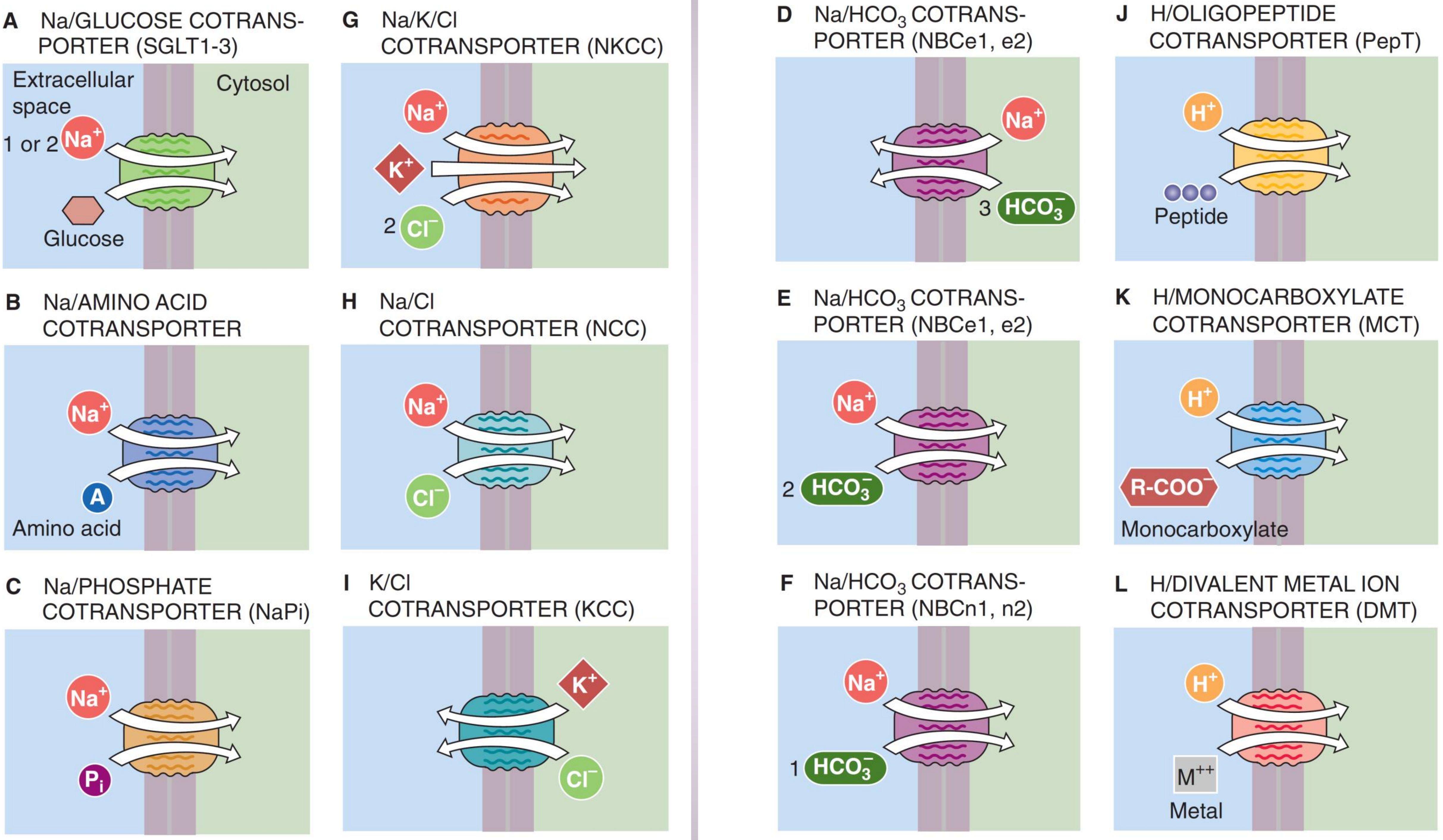
A Na–K PUMP



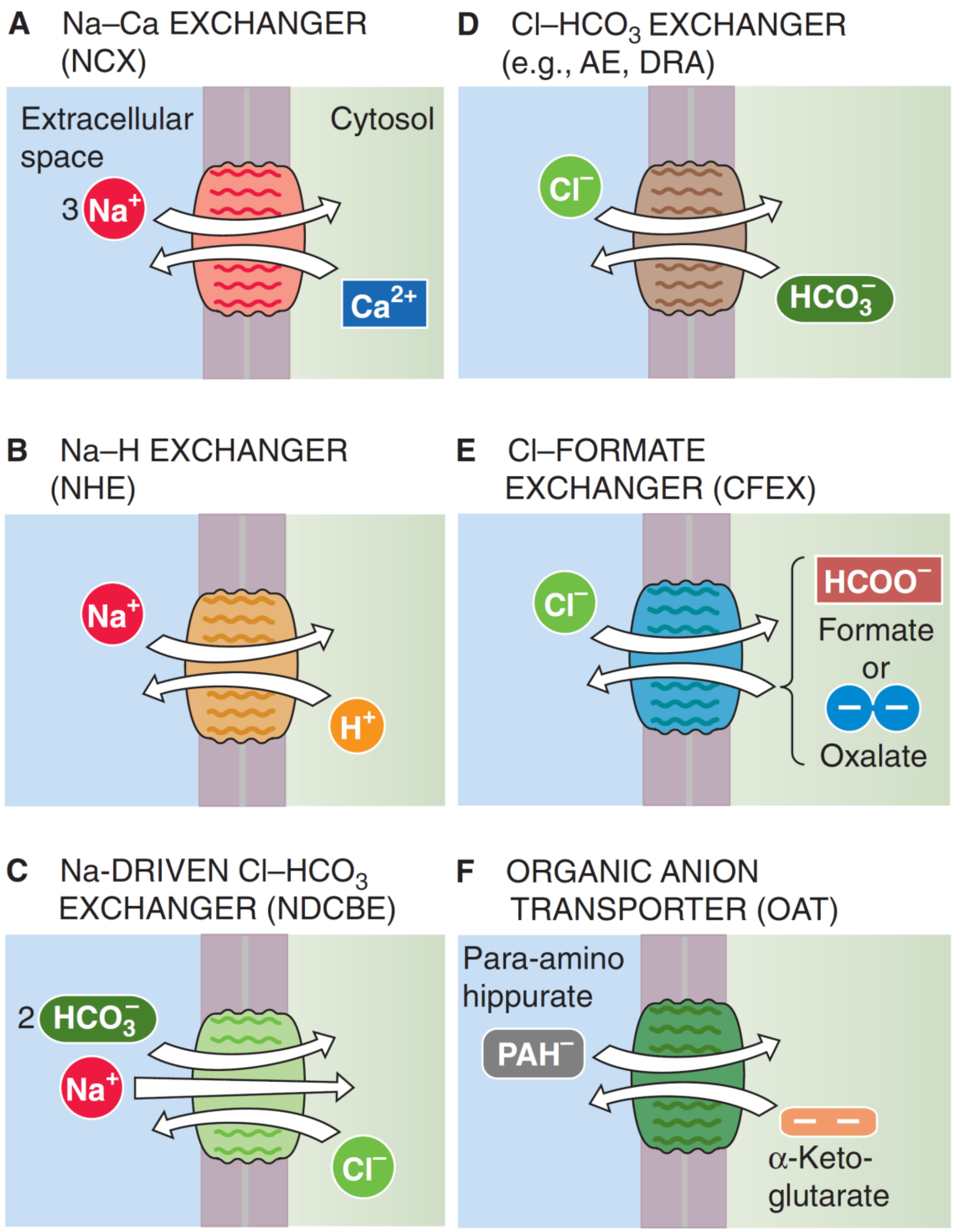
ATPase
β subunit
α subunit
ATP
ADP
+ Pi
Na+
K+
Extracellular space
Cytosol

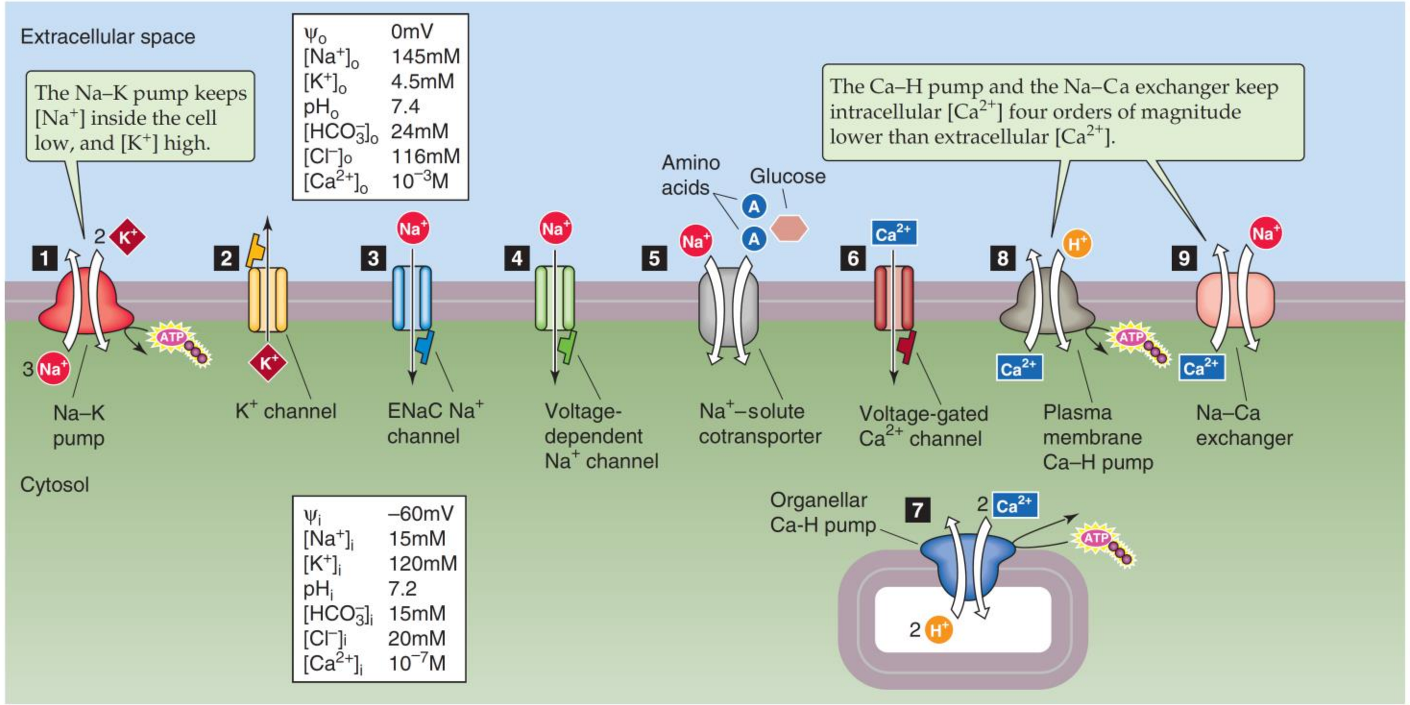
B ENZYMATIC CYCLE OF THE Na–K PUMP



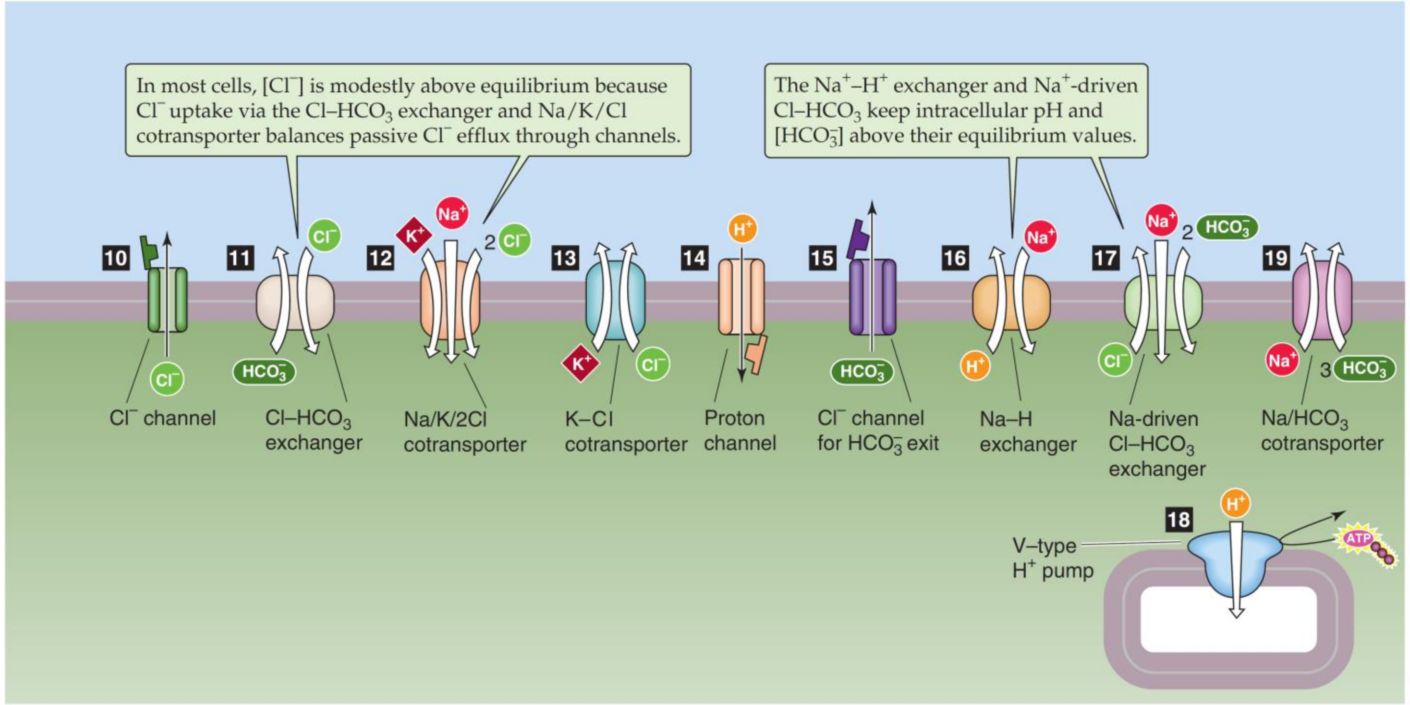


A Na/GLUCOSE COTRANSPORTER (SGLT1-3)
Extracellular space
Cytosol
1 or 2 Na+
Glucose
B Na/AMINO ACID COTRANSPORTER
Na+
A
Amino acid
C Na/PHOSPHATE COTRANSPORTER (NaPi)
Na+
Pi
D Na/HCO3 COTRANSPORTER (NBCe1, e2)
Na+
3 HCO3−
E Na/HCO3 COTRANSPORTER (NBCe1, e2)
Na+
2 HCO3−
F Na/HCO3 COTRANSPORTER (NBCn1, n2)
Na+
1 HCO3−
G Na/K/Cl COTRANSPORTER (NKCC)
Na+
K+
2 Cl−
H Na/Cl COTRANSPORTER (NCC)
Na+
Cl−
I K/Cl COTRANSPORTER (KCC)
K+
Cl−
J H/OLIGOPEPTIDE COTRANSPORTER (PepT)
H+
Peptide
K H/MONOCARBOXYLATE COTRANSPORTER (MCT)
H+
R-COO−
Monocarboxylate
L H/DIVALENT METAL ION COTRANSPORTER (DMT)
H+
M++
Metal


A Na–Ca EXCHANGER (NCX)
Extracellular space
Cytosol
3 Na^+
Ca^{2+}
B Na–H EXCHANGER (NHE)
Na^+
H^+
C Na-DRIVEN Cl–HCO_3 EXCHANGER (NDCBE)
2 HCO_3^-
Na^+
Cl^-
D Cl–HCO_3 EXCHANGER (e.g., AE, DRA)
Cl^-
HCO_3^-
E Cl–FORMATE EXCHANGER (CFEX)
Cl^-
$HCOO^-$
Formate
or
Oxalate
F ORGANIC ANION TRANSPORTER (OAT)
Para-amino hippurate
PAH^-
α-Keto-glutarate



Extracellular space
ψo 0mV
[Na+]o 145mM
[K+]o 4.5mM
pHo 7.4
[HCO3-]o 24mM
[Cl-]o 116mM
[Ca2+]o 10-3M
The Na–K pump keeps [Na+] inside the cell low, and [K+] high.
The Ca–H pump and the Na–Ca exchanger keep intracellular [Ca2+] four orders of magnitude lower than extracellular [Ca2+].
Amino acids
Glucose
1 Na–K pump
2 K+ channel
3 ENaC Na+ channel
4 Voltage-dependent Na+ channel
5 Na+–solute cotransporter
6 Voltage-gated Ca2+ channel
8 Plasma membrane Ca–H pump
9 Na–Ca exchanger
Cytosol
ψi –60mV
[Na+]i 15mM
[K+]i 120mM
pHi 7.2
[HCO3-]i 15mM
[Cl-]i 20mM
[Ca2+]i 10-7M
7 Organellar Ca-H pump
ATP



In most cells, [Cl-] is modestly above equilibrium because Cl- uptake via the Cl–HCO3 exchanger and Na/K/Cl cotransporter balances passive Cl- efflux through channels.
The Na+–H+ exchanger and Na+-driven Cl–HCO3 keep intracellular pH and [HCO3-] above their equilibrium values.
10 Cl- channel
11 Cl–HCO3 exchanger
12 Na/K/2Cl cotransporter
13 K–Cl cotransporter
14 Proton channel
15 Cl- channel for HCO3- exit
16 Na–H exchanger
17 Na-driven Cl–HCO3 exchanger
19 Na/HCO3 cotransporter
18 V–type H+ pump
ATP

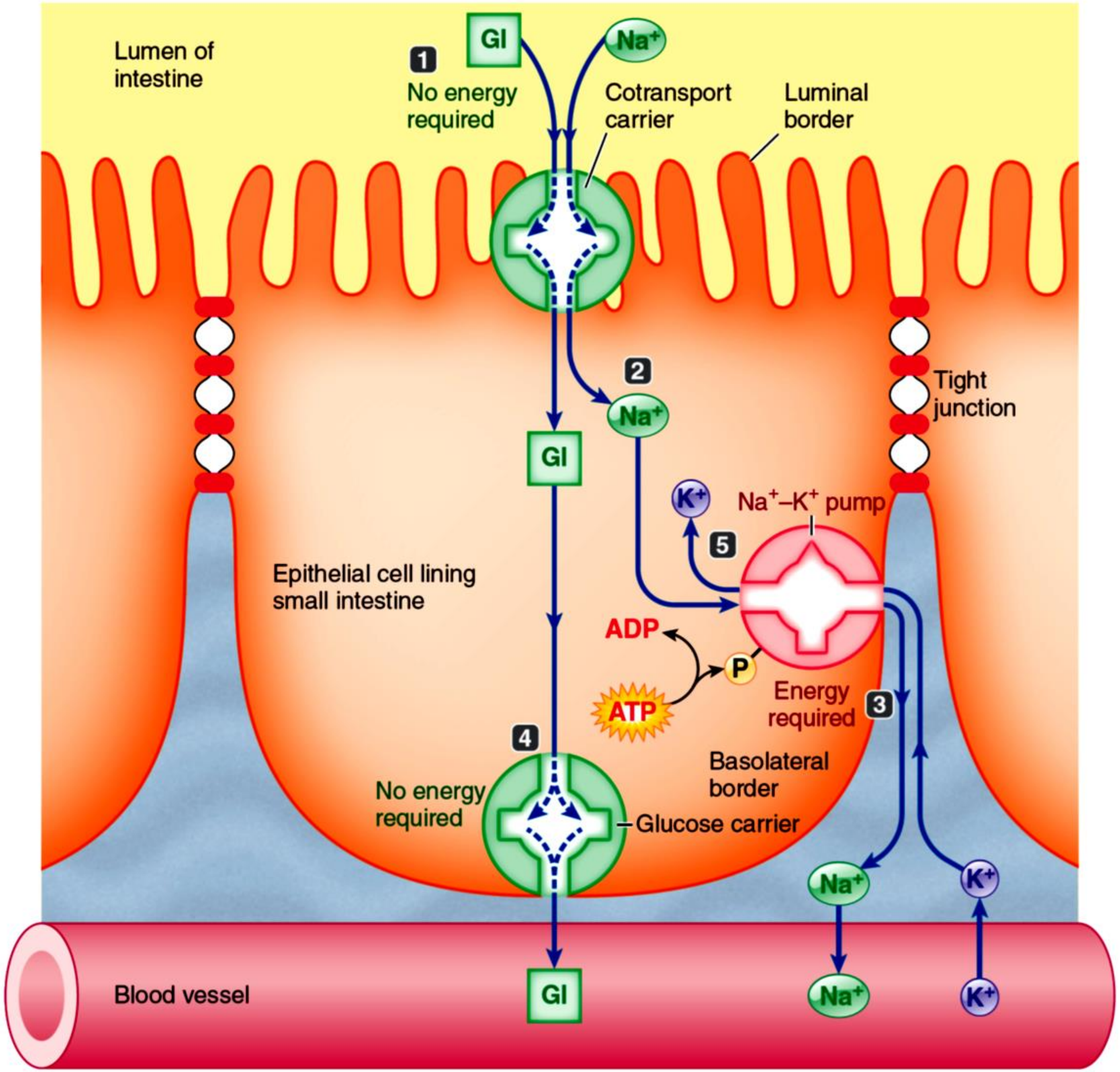
1 A cotransport carrier at the luminal border simultaneously transfers glucose against a concentration gradient and Na^+ down a concentration gradient from the lumen into the cell.

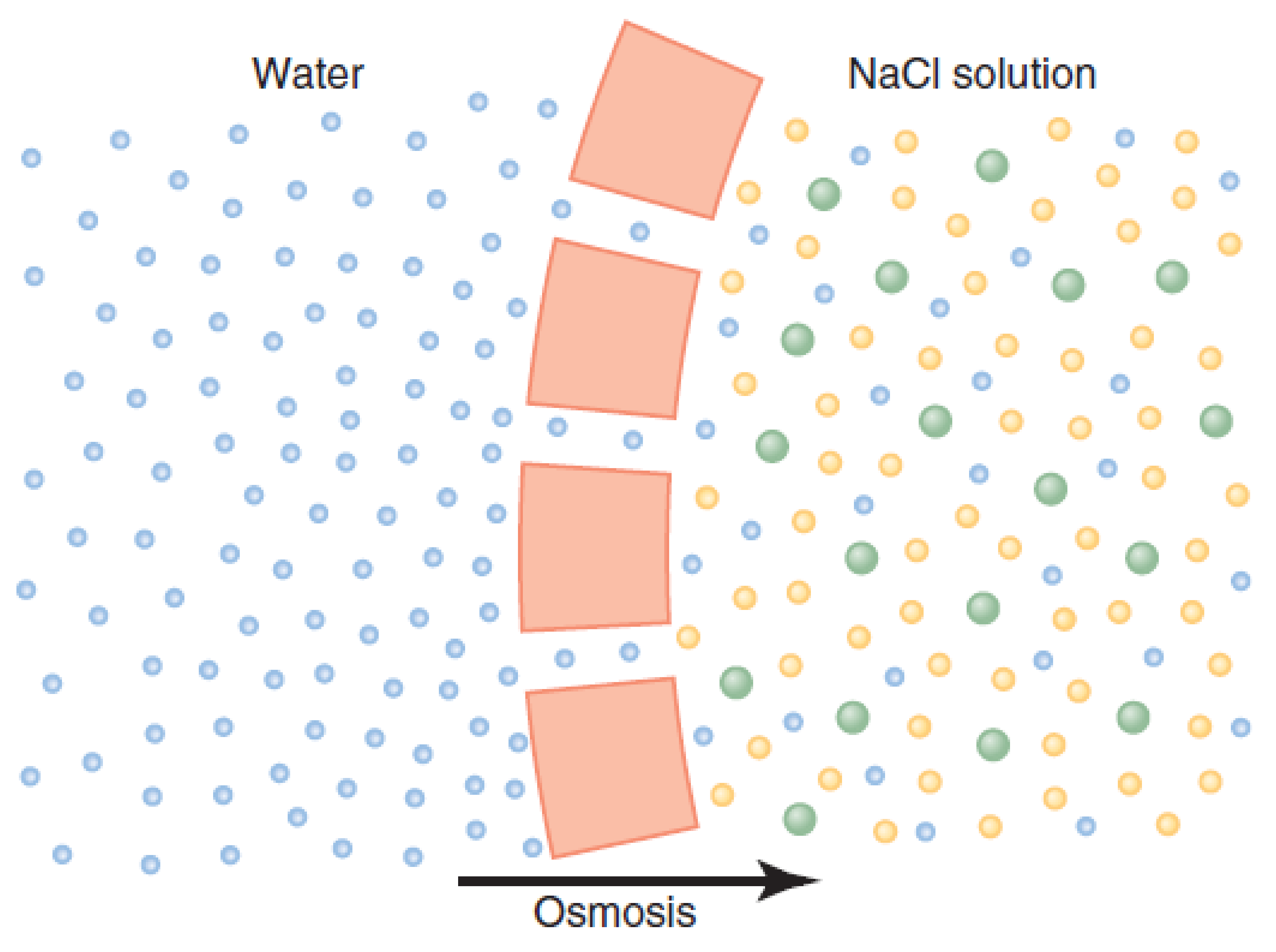
2 No energy is directly used by the cotransport carrier to move glucose uphill. Instead operation of the cotransport carrier is driven by the Na^+ concentration gradient (low Na^+ in ICF compared with lumen) established by the energy-using Na^+–K^+ pump.

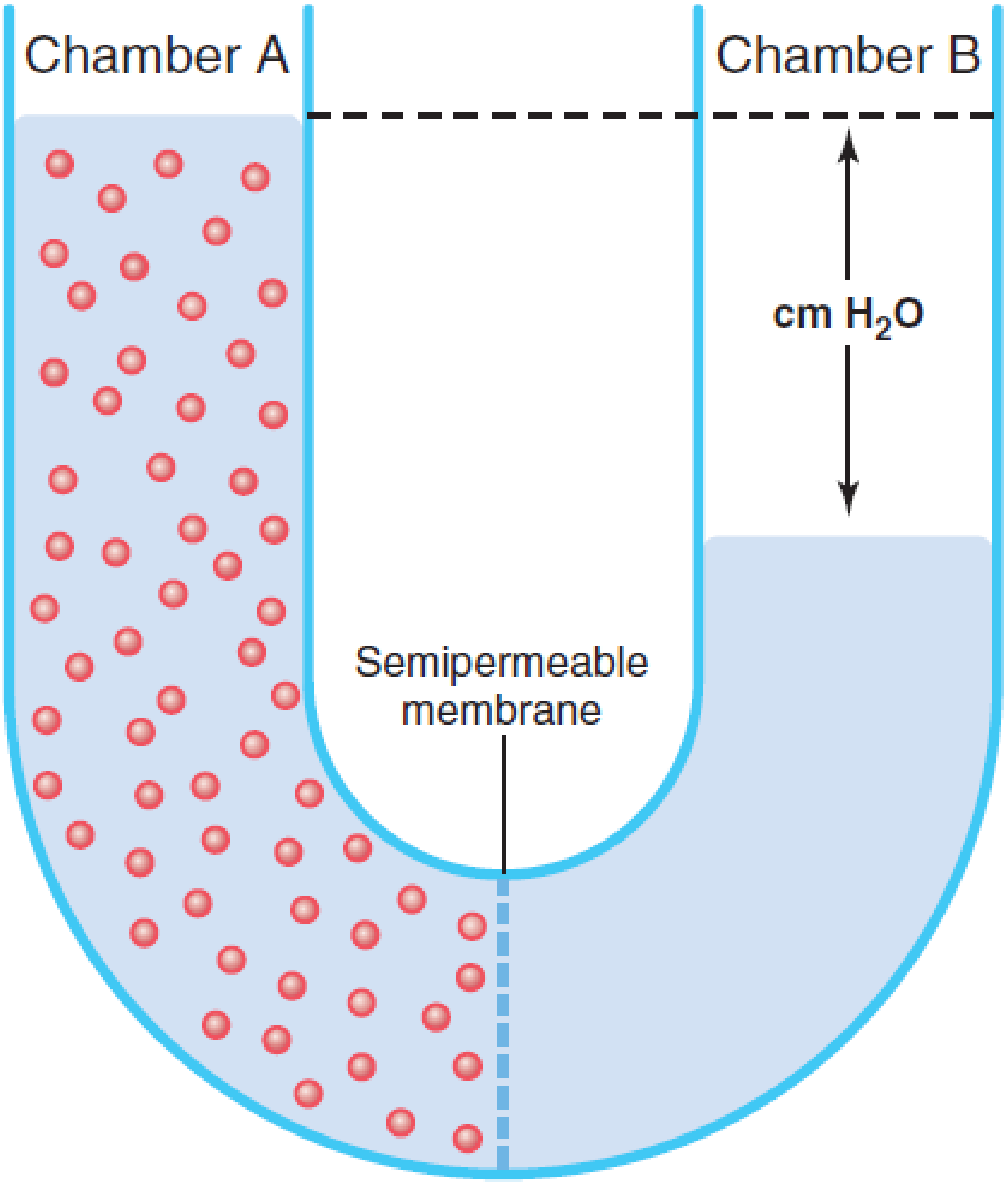
3 The Na^+–K^+ pump actively transports Na^+ out of the cell at the basolateral border keeping the ICF Na^+ concentration lower than the luminal concentration.

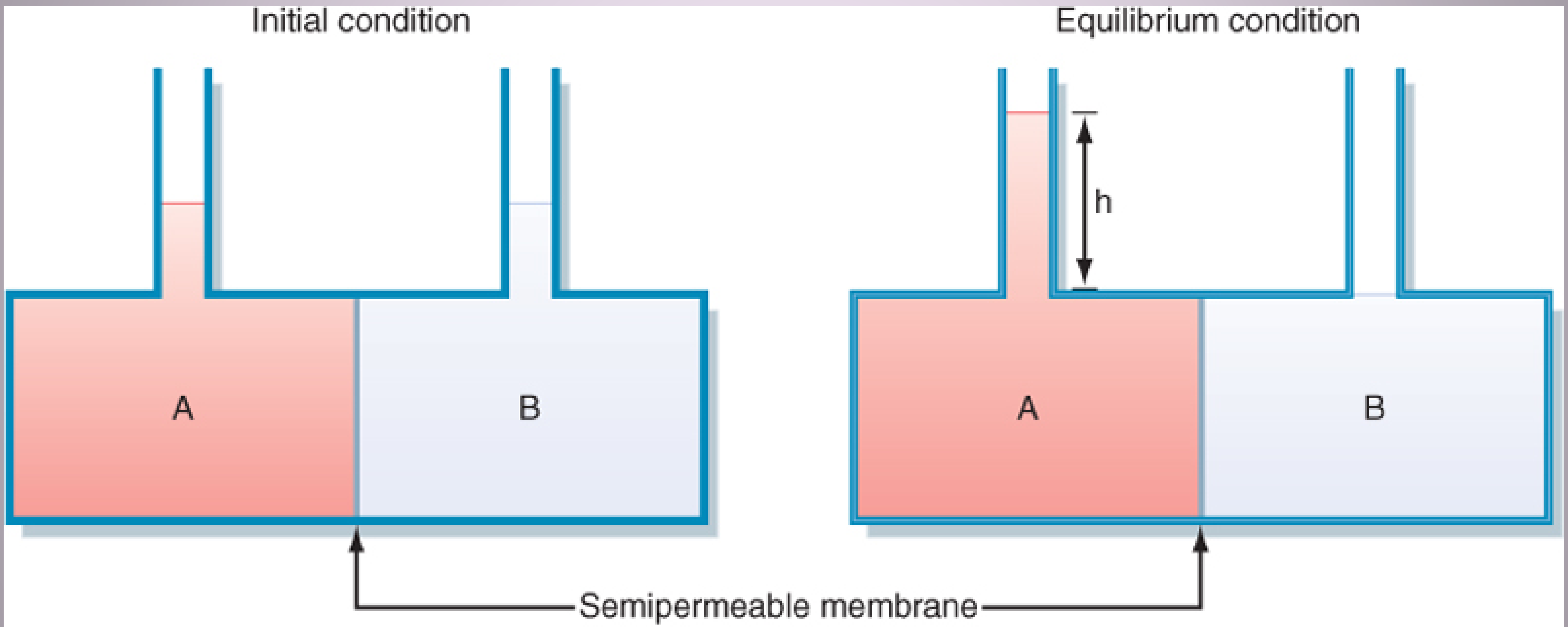
4 After entering the cell by secondary active transport, glucose is transported down its concentration gradient from the cell into the blood by facilitated diffusion, mediated by a passive glucose carrier at the basal border.

5 The Na^+–K^+ pump also actively transports K^+ into the cell, maintaining a high intracellular K^+ concentration.

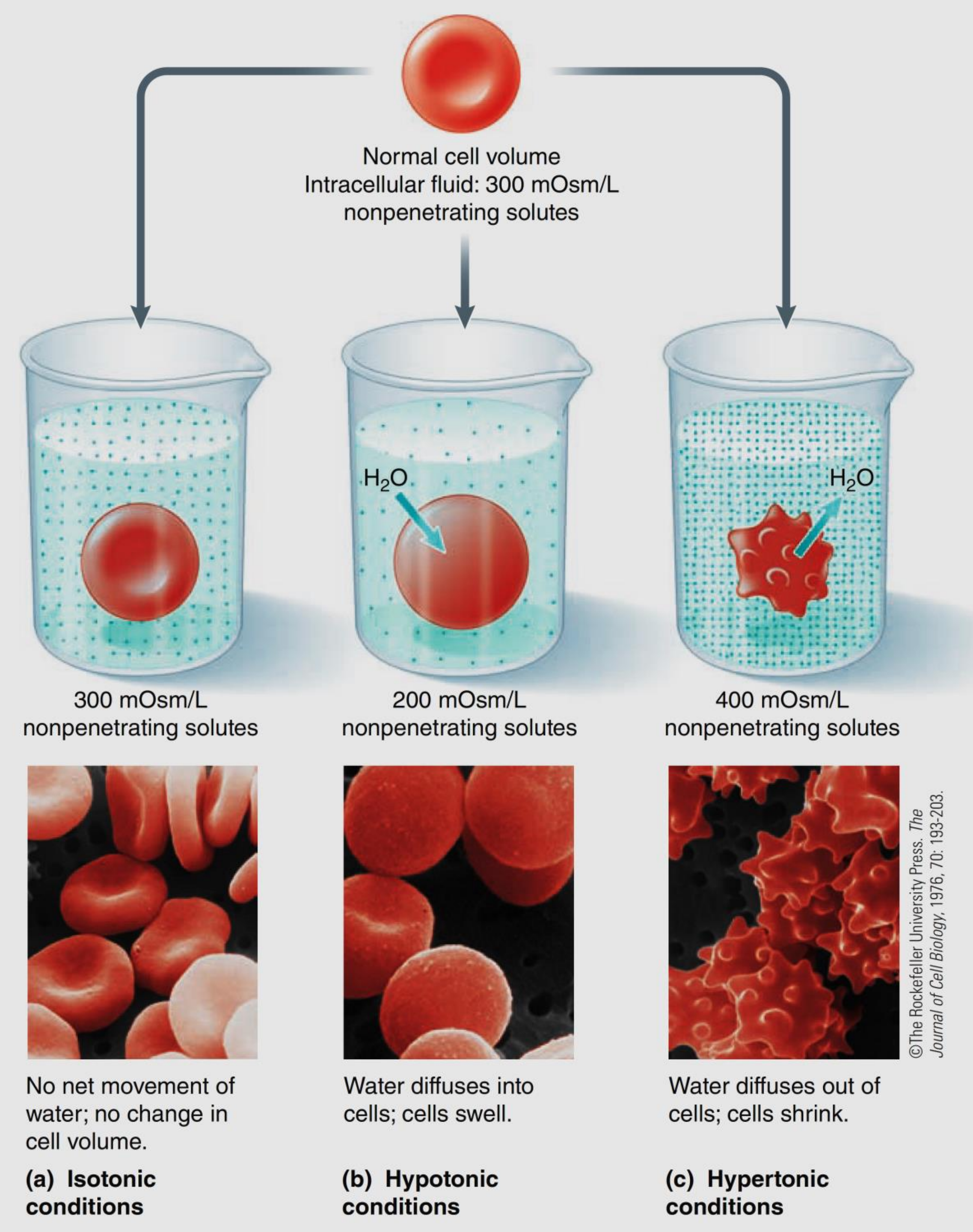



Water
NaCl solution
Osmosis


Chamber A
Chamber B
cm H_2O
Semipermeable membrane



Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.



Normal cell volume
Intracellular fluid: 300 mOsm/L
nonpenetrating solutes
H_2O
H_2O
300 mOsm/L
nonpenetrating solutes
200 mOsm/L
nonpenetrating solutes
400 mOsm/L
nonpenetrating solutes
©The Rockefeller University Press. The Journal of Cell Biology, 1976, 70: 193-203.
No net movement of water; no change in cell volume.
(a) Isotonic conditions
Water diffuses into cells; cells swell.
(b) Hypotonic conditions
Water diffuses out of cells; cells shrink.
(c) Hypertonic conditions