Figure 5-1

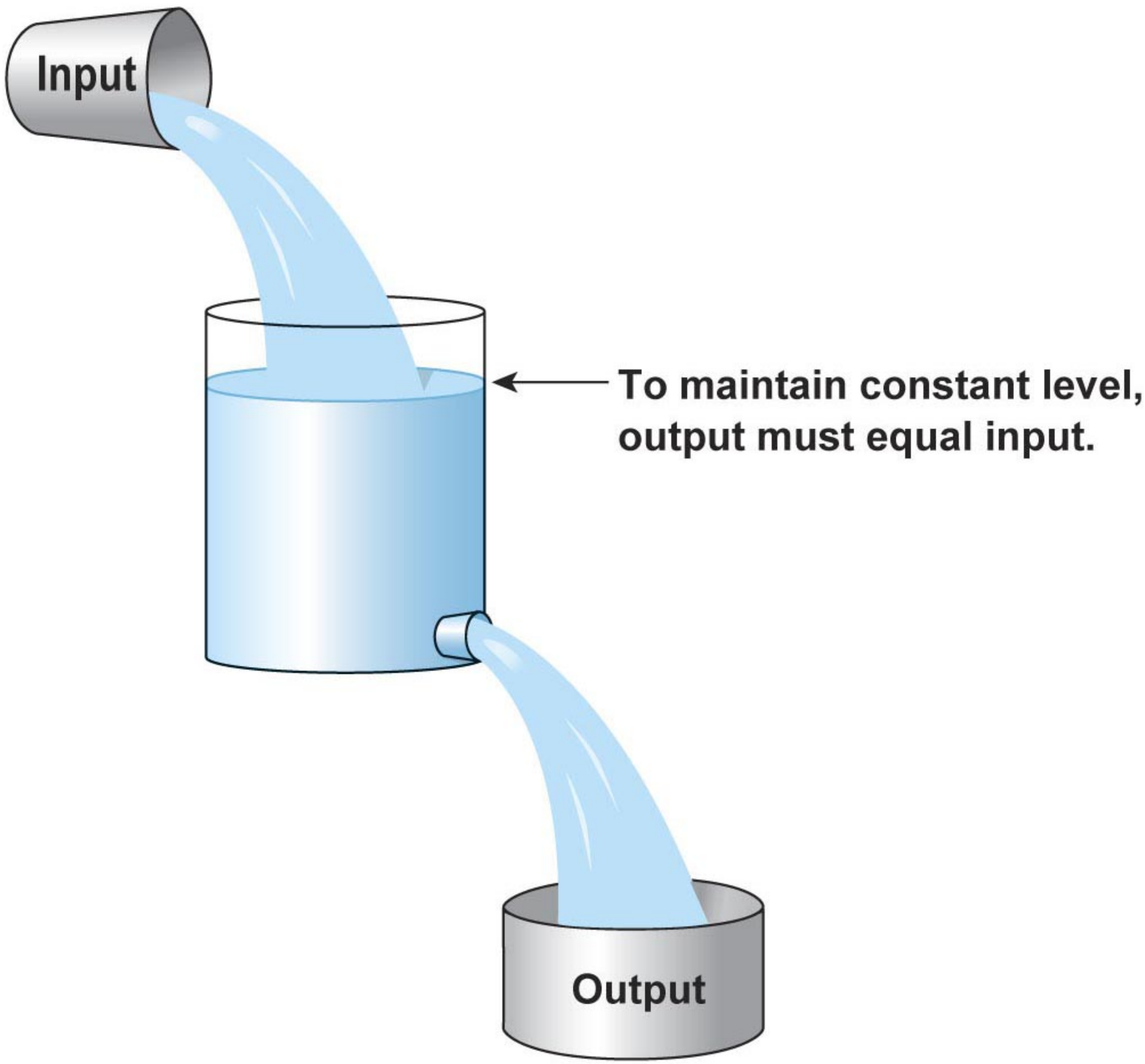

Input
To maintain constant level, output must equal input.
Output

Figure 5-2

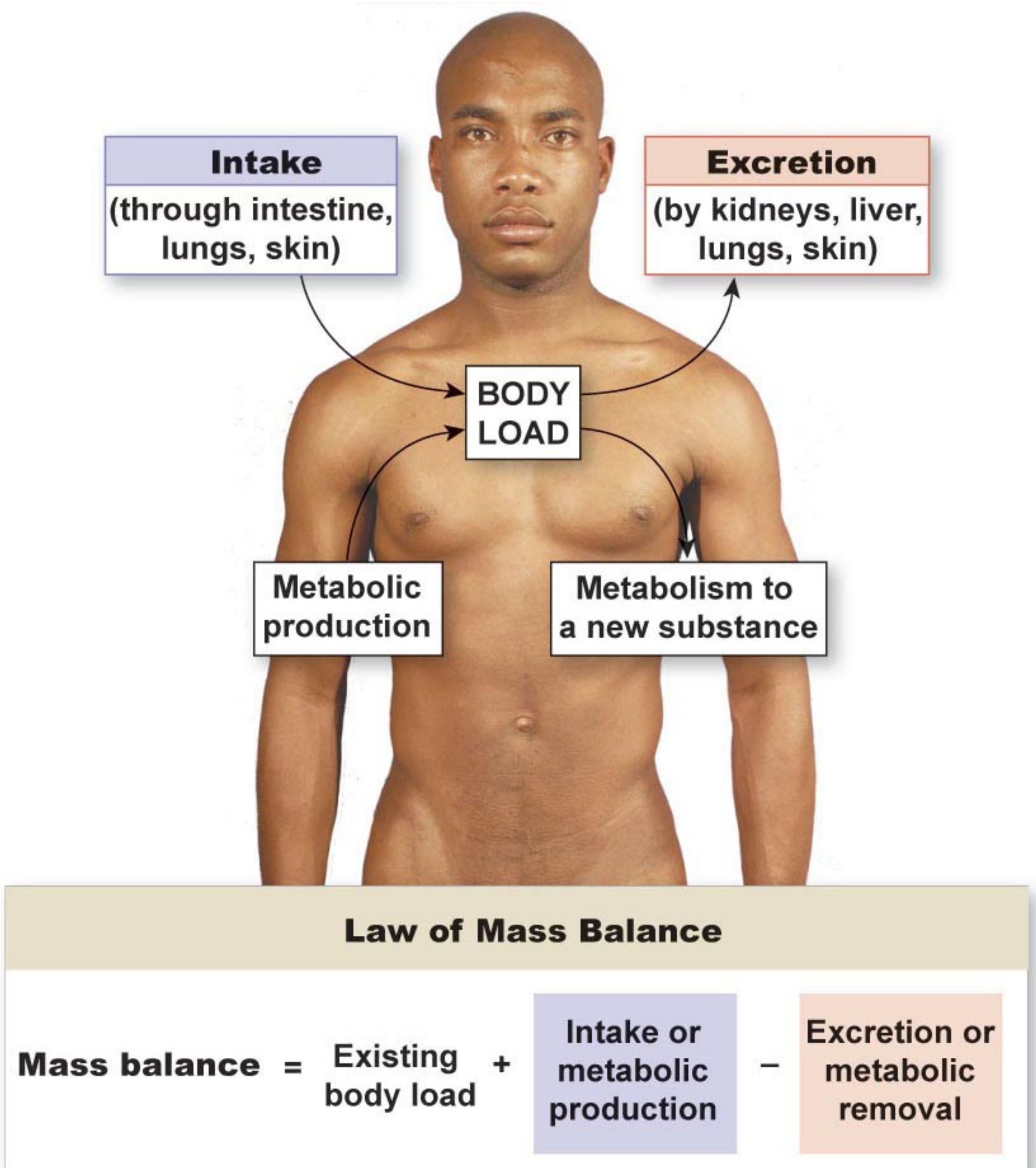
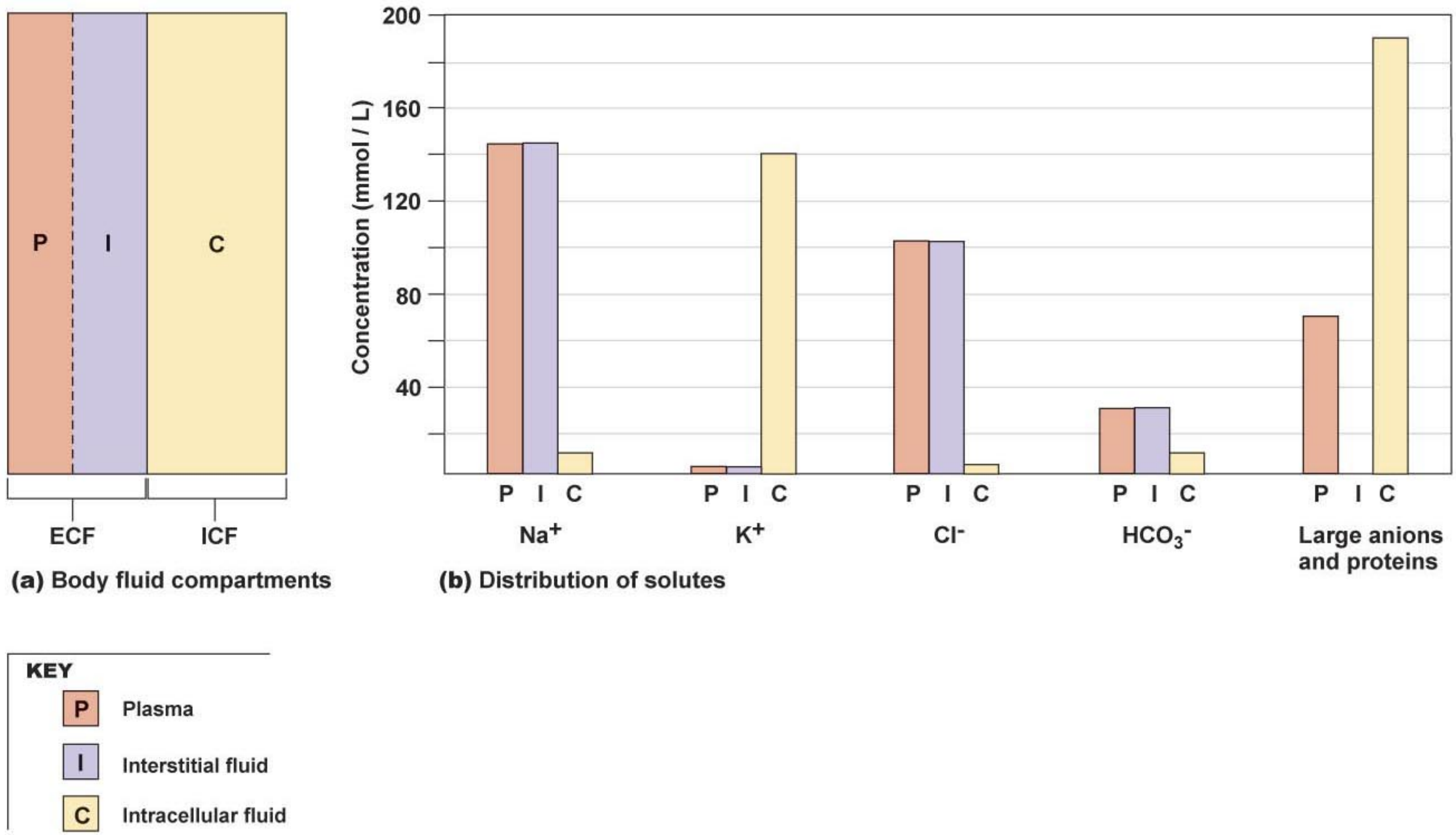

Intake
(through intestine, lungs, skin)
Excretion
(by kidneys, liver, lungs, skin)
BODY LOAD
Metabolic production
Metabolism to a new substance
Law of Mass Balance
Mass balance = Existing body load + Intake or metabolic production − Excretion or metabolic removal

Figure 5-3



(a) Body fluid compartments

(b) Distribution of solutes

Figure 5-4

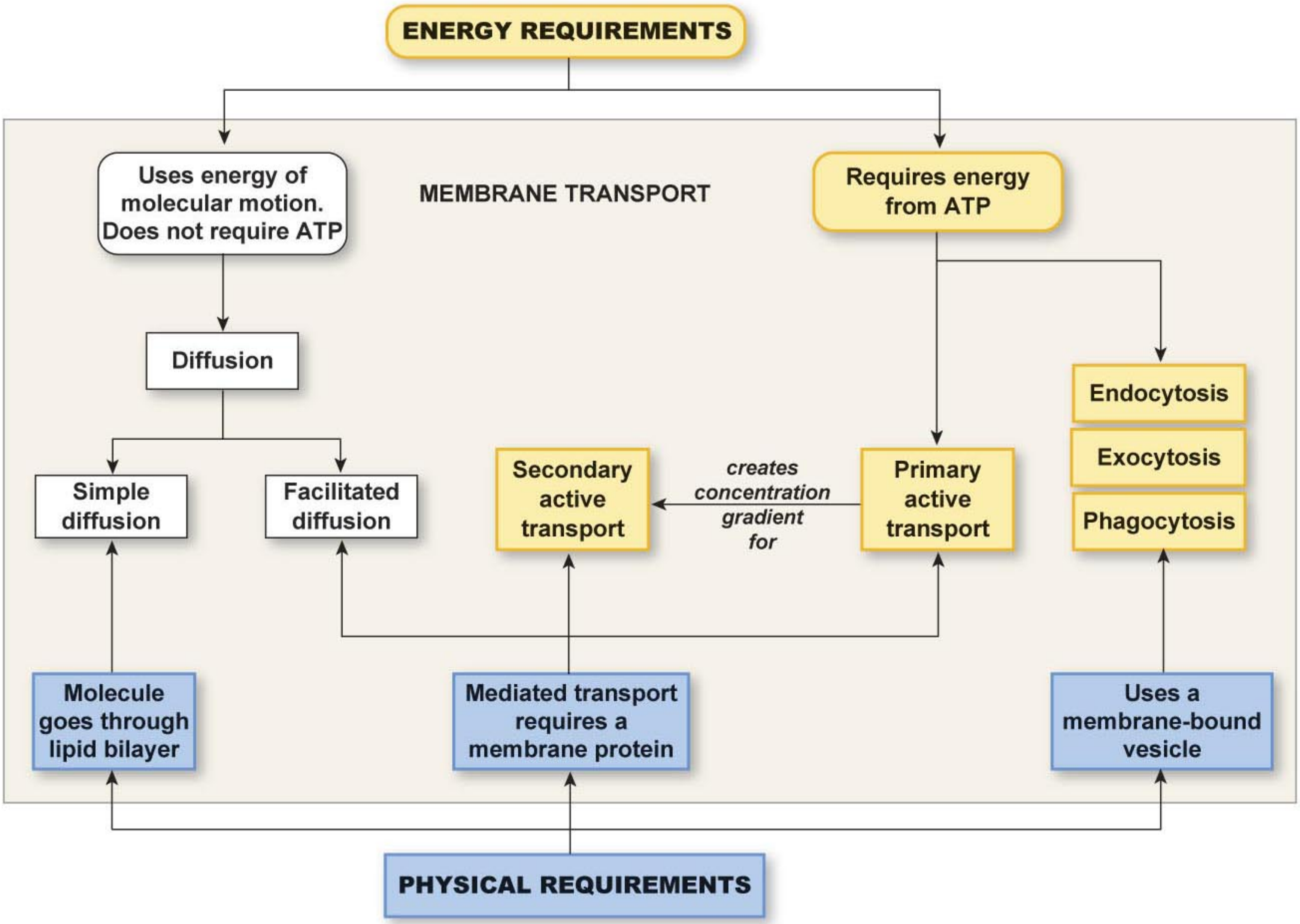

ENERGY REQUIREMENTS
MEMBRANE TRANSPORT
Uses energy of molecular motion. Does not require ATP
Requires energy from ATP
Diffusion
Endocytosis
Exocytosis
Phagocytosis
Simple diffusion
Facilitated diffusion
Secondary active transport
creates concentration gradient for
Primary active transport
Molecule goes through lipid bilayer
Mediated transport requires a membrane protein
Uses a membrane-bound vesicle
PHYSICAL REQUIREMENTS

Figure 5-5

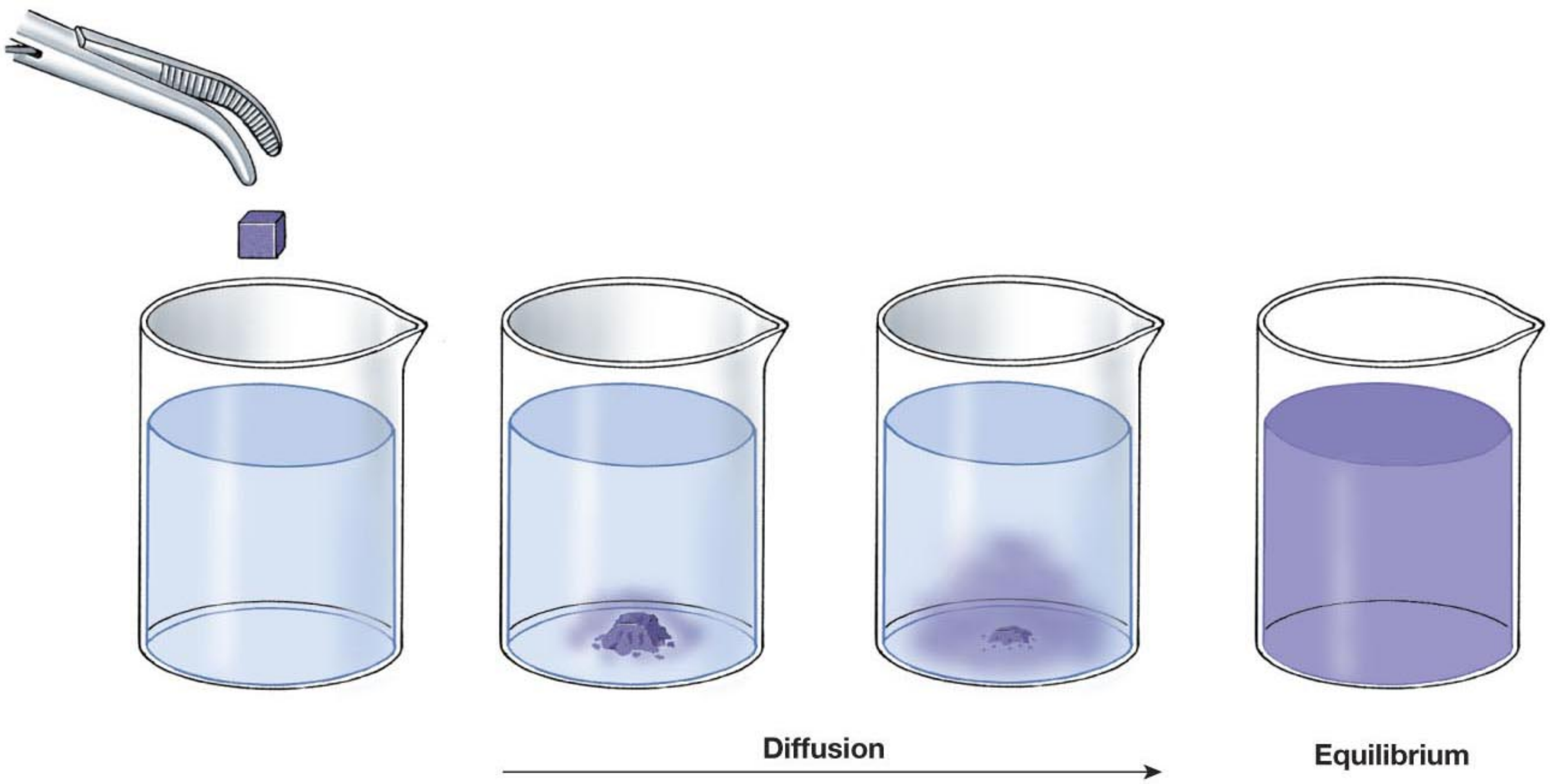
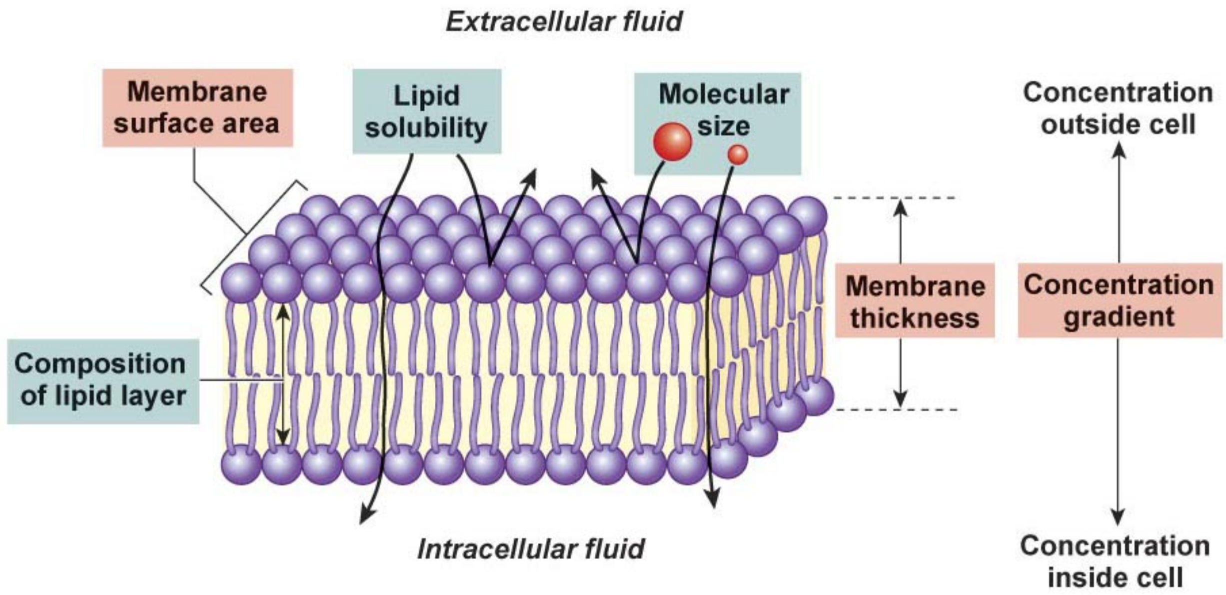


Figure 5-6, overview



Fick's Law of Diffusion says:

$$\textbf{Rate of diffusion} \propto \frac{\text{surface area} \cdot \text{concentration gradient} \cdot \text{membrane permeability}}{\text{membrane thickness}}$$

Membrane permeability

$$\text{Membrane permeability} \propto \frac{\text{lipid solubility}}{\text{molecular size}}$$

Changing the composition of the lipid layer can increase or decrease membrane permeability.

Table 5-1, part 1

TABLE 5-1	Rules for Diffusion of Uncharged Molecules
General Properties of Diffusion	
1. Diffusion uses the kinetic energy of molecular movement and does not require an outside energy source.	
2. Molecules diffuse from an area of higher concentration to an area of lower concentration.	
3. Diffusion continues until concentrations come to equilibrium. Molecular movement continues, however, after equilibrium has been reached.	
4. Diffusion is faster —along higher concentration gradients. —over shorter distances. —at higher temperatures. —for smaller molecules.	
5. Diffusion can take place in an open system or across a partition that separates two systems.	

Table 5-1, part 2

TABLE 5-1 Rules for Diffusion of Uncharged Molecules *(continued)*

Simple Diffusion Across a Membrane

6. The rate of diffusion through a membrane is faster if
   —the membrane's surface area is larger.
   —the membrane is thinner.
   —the concentration gradient is larger.
   —the membrane is more permeable to the molecule.

7. Membrane permeability to a molecule depends on
   —the molecule's lipid solubility.
   —the molecule's size.
   —the lipid composition of the membrane.

Figure 5-7, overview

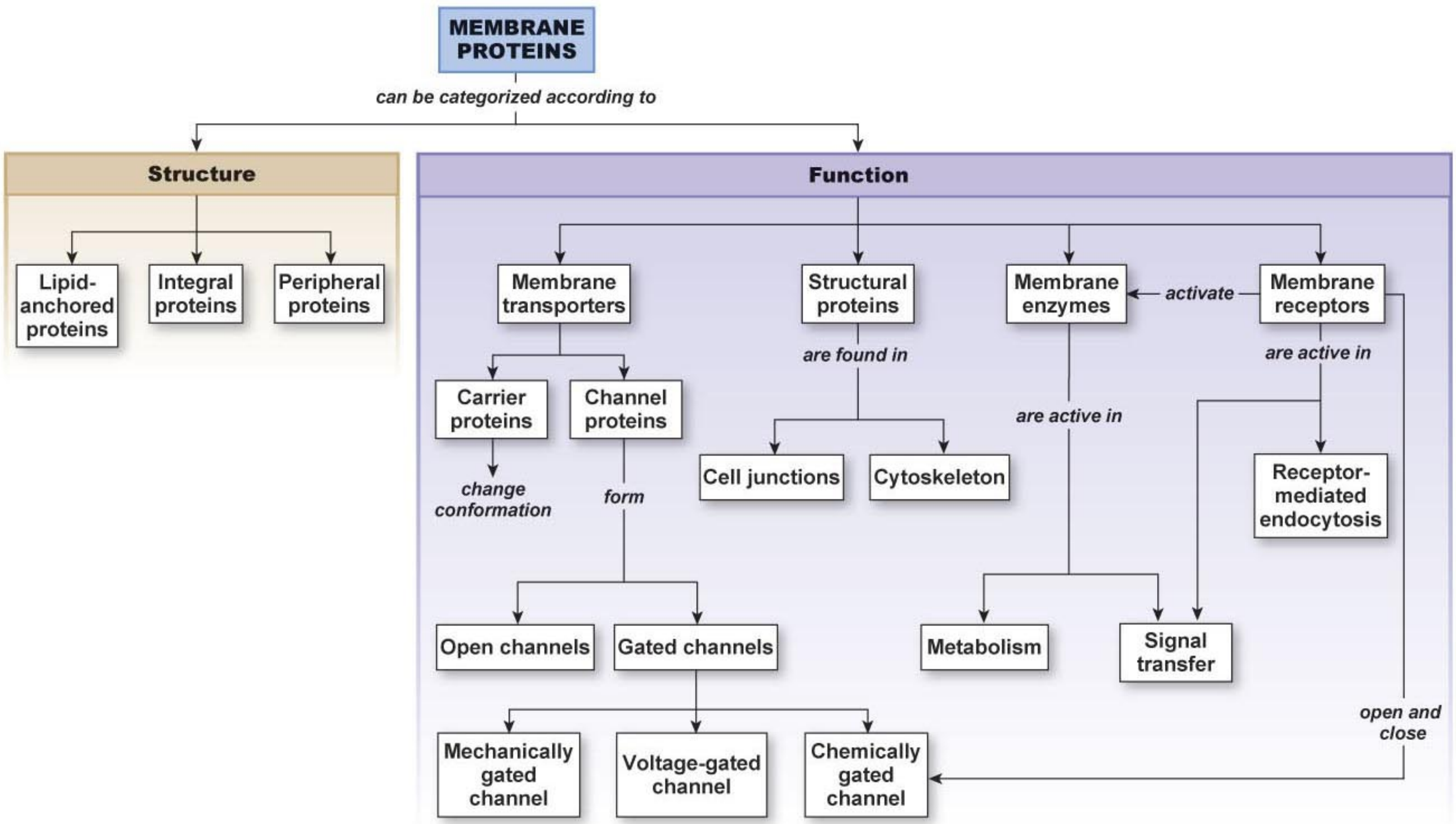


Figure 5-8

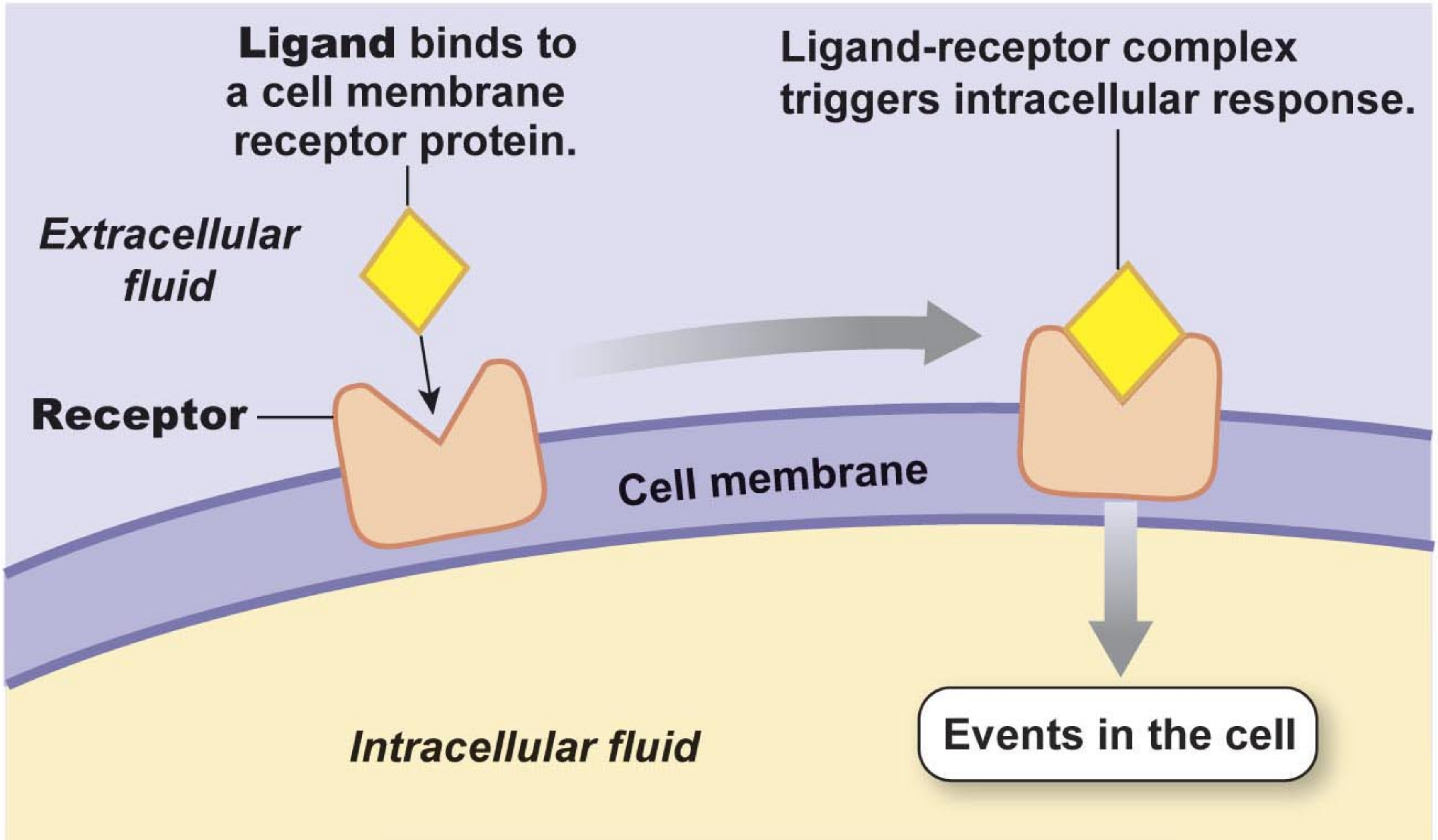

Ligand binds to a cell membrane receptor protein.
Ligand-receptor complex triggers intracellular response.
Extracellular fluid
Receptor
Cell membrane
Intracellular fluid
Events in the cell

Figure 5-9, overview

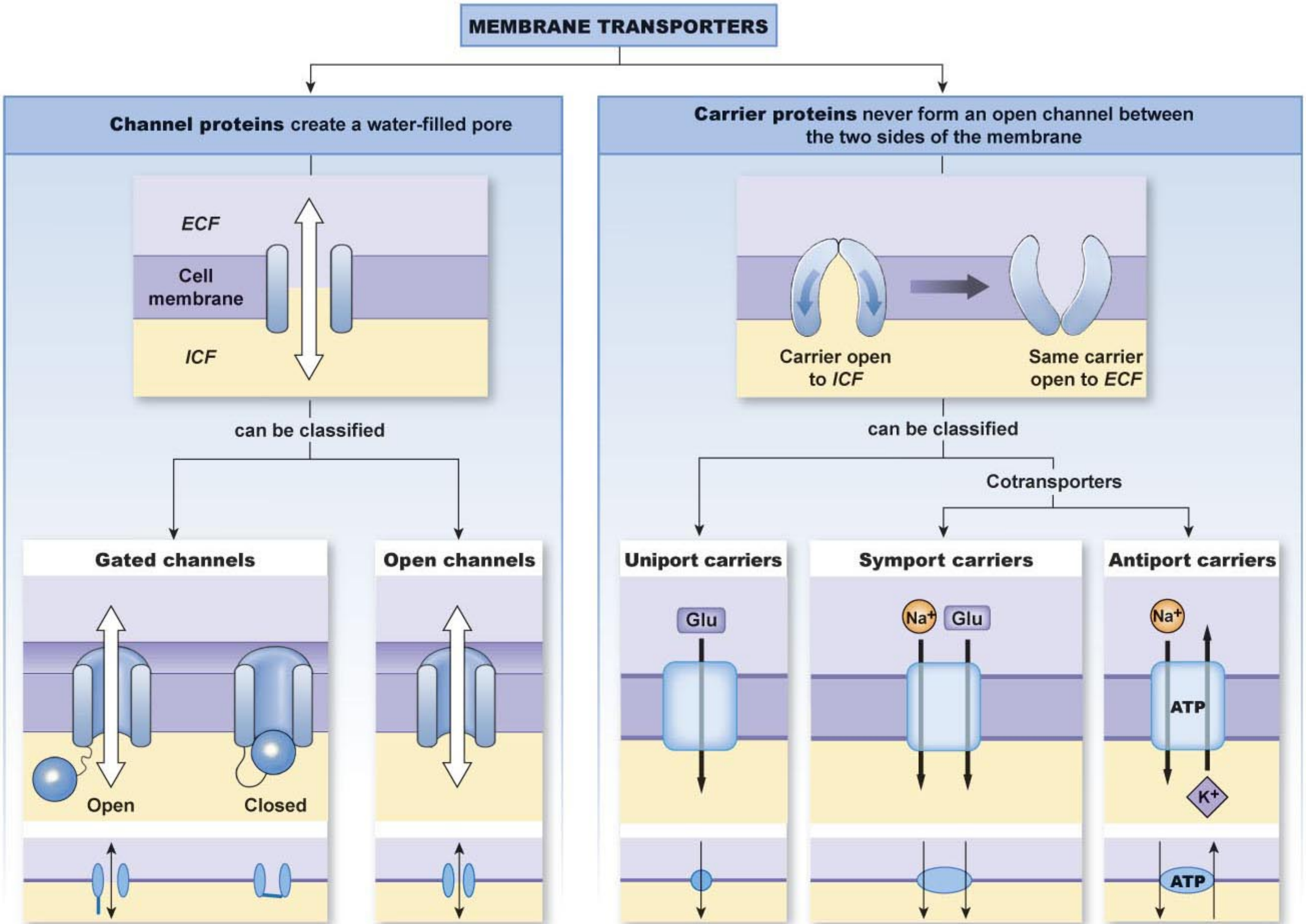
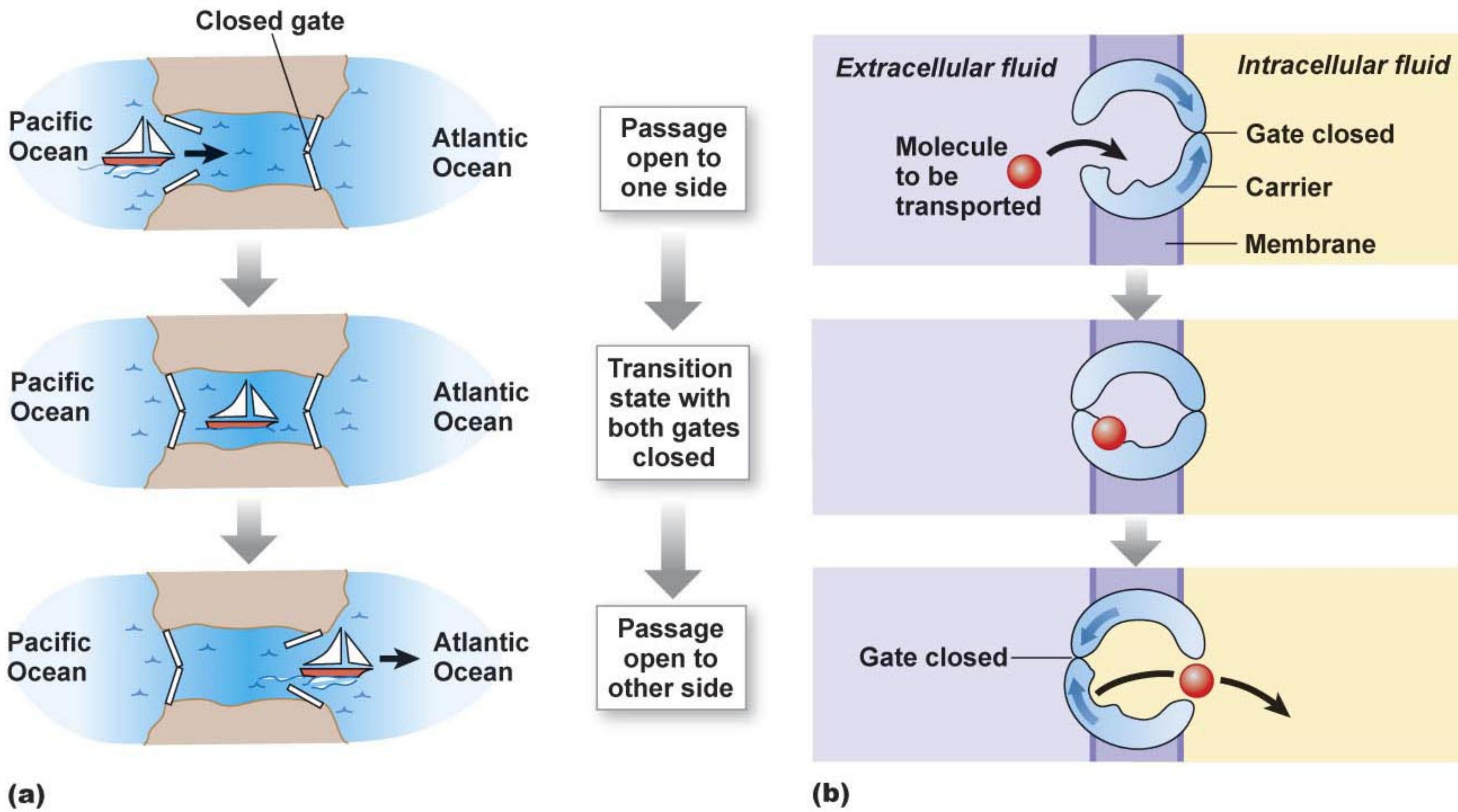
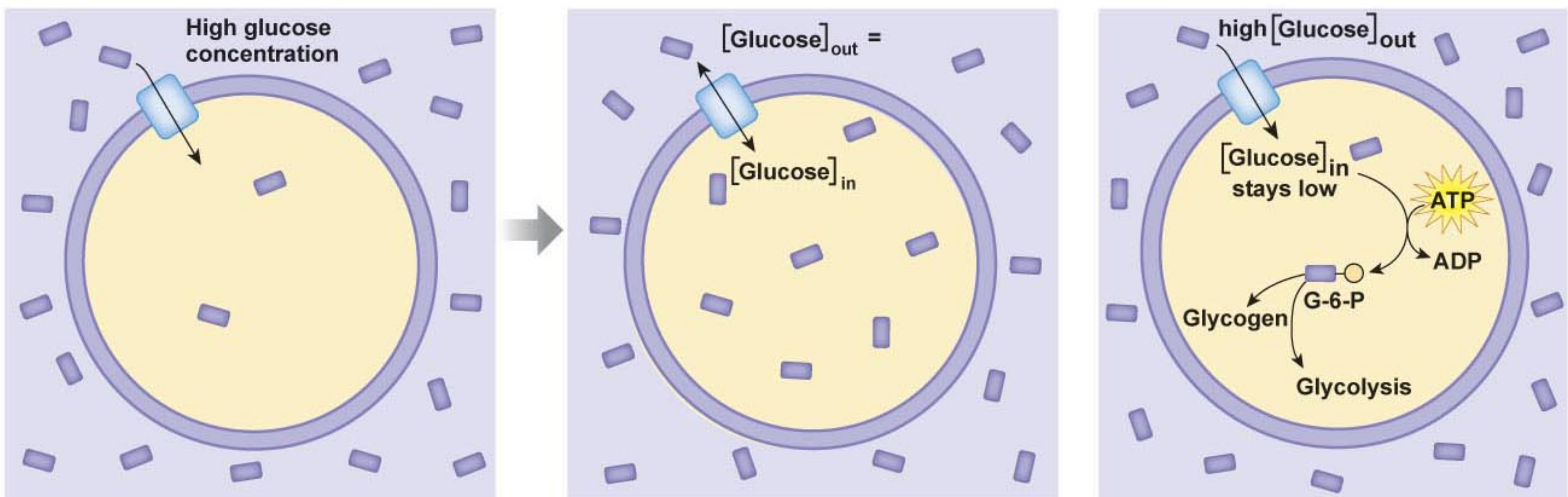


Figure 5-11



Closed gate
Pacific Ocean
Atlantic Ocean
Passage open to one side
Pacific Ocean
Atlantic Ocean
Transition state with both gates closed
Pacific Ocean
Atlantic Ocean
Passage open to other side
(a)
Extracellular fluid
Intracellular fluid
Molecule to be transported
Gate closed
Carrier
Membrane
Gate closed
(b)

Figure 5-12



(a) Facilitated diffusion **(b) Diffusion reaches equilibrium** **(c) Conversion**

Table 5-2

TABLE 5-2 Primary Active Transporters

NAMES	TYPE OF TRANSPORT
Na^+-K^+-ATPase or sodium-potassium pump	Antiport
Ca^{2+}-ATPase	Uniport
H^+-ATPase or proton pump	Uniport
H^+-K^+-ATPase	Antiport

Figure 5-13

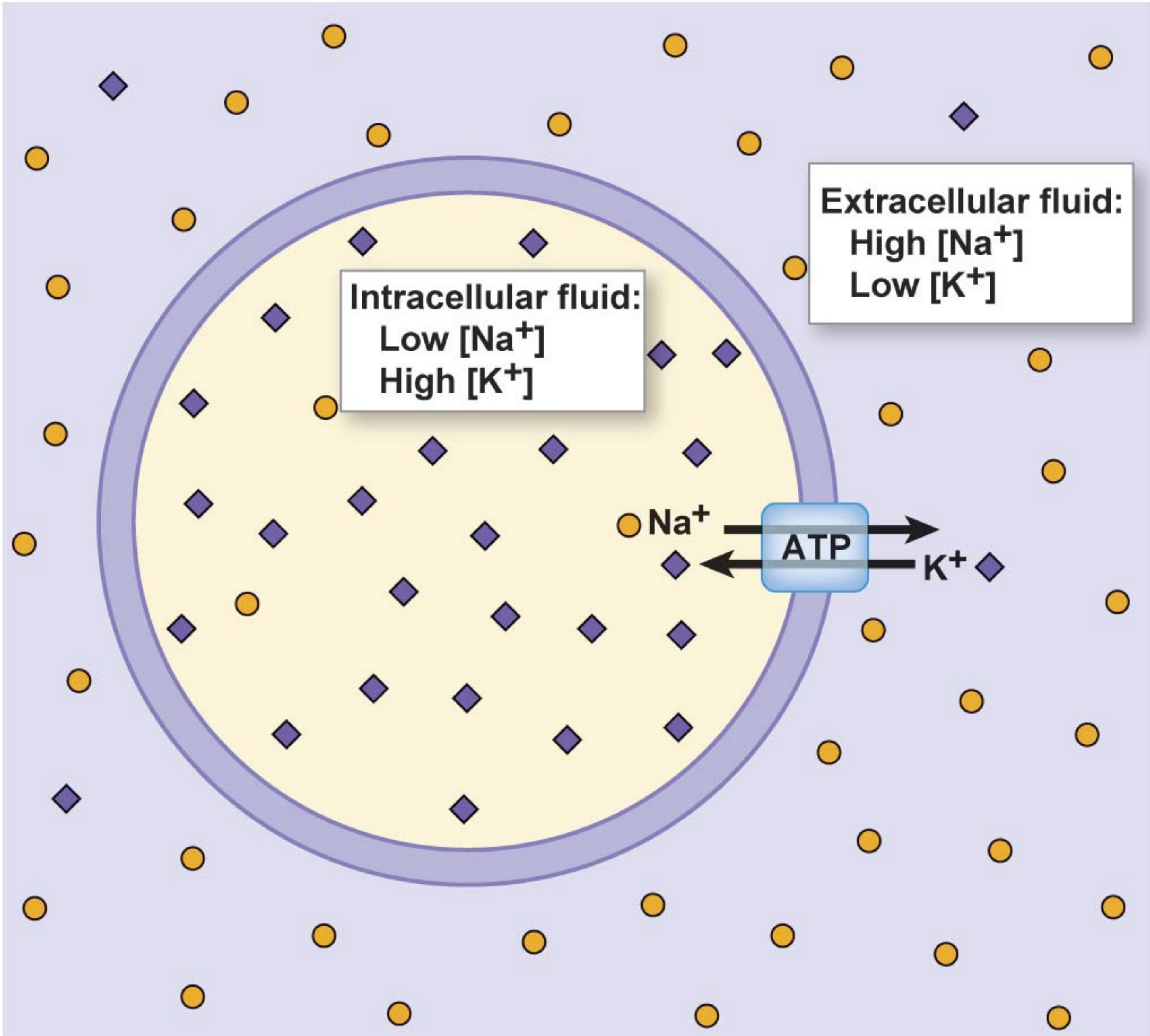

Extracellular fluid:
High [Na+]
Low [K+]
Intracellular fluid:
Low [Na+]
High [K+]
Na+
ATP
K+

Figure 5-14, overview

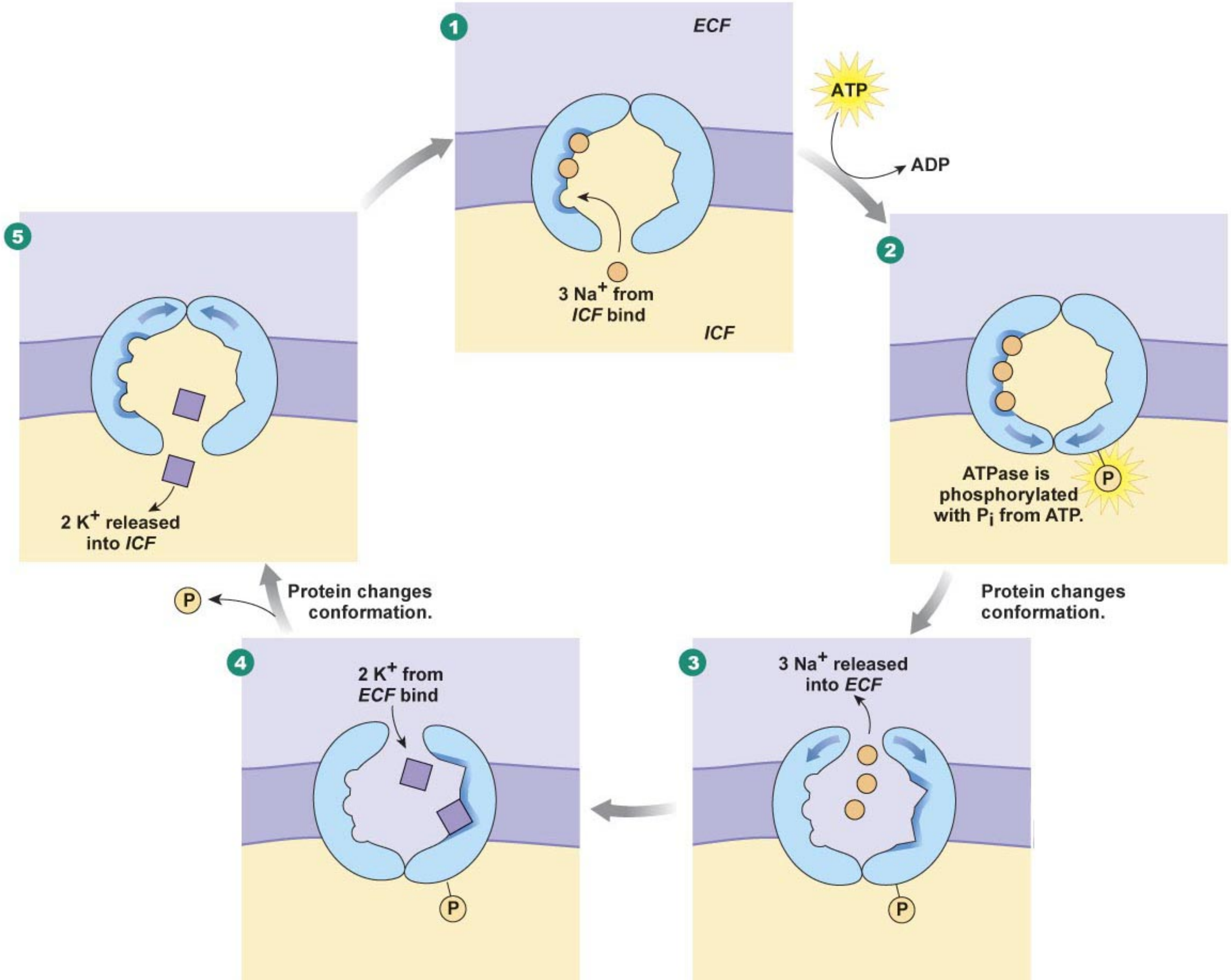


Figure 5-15, overview

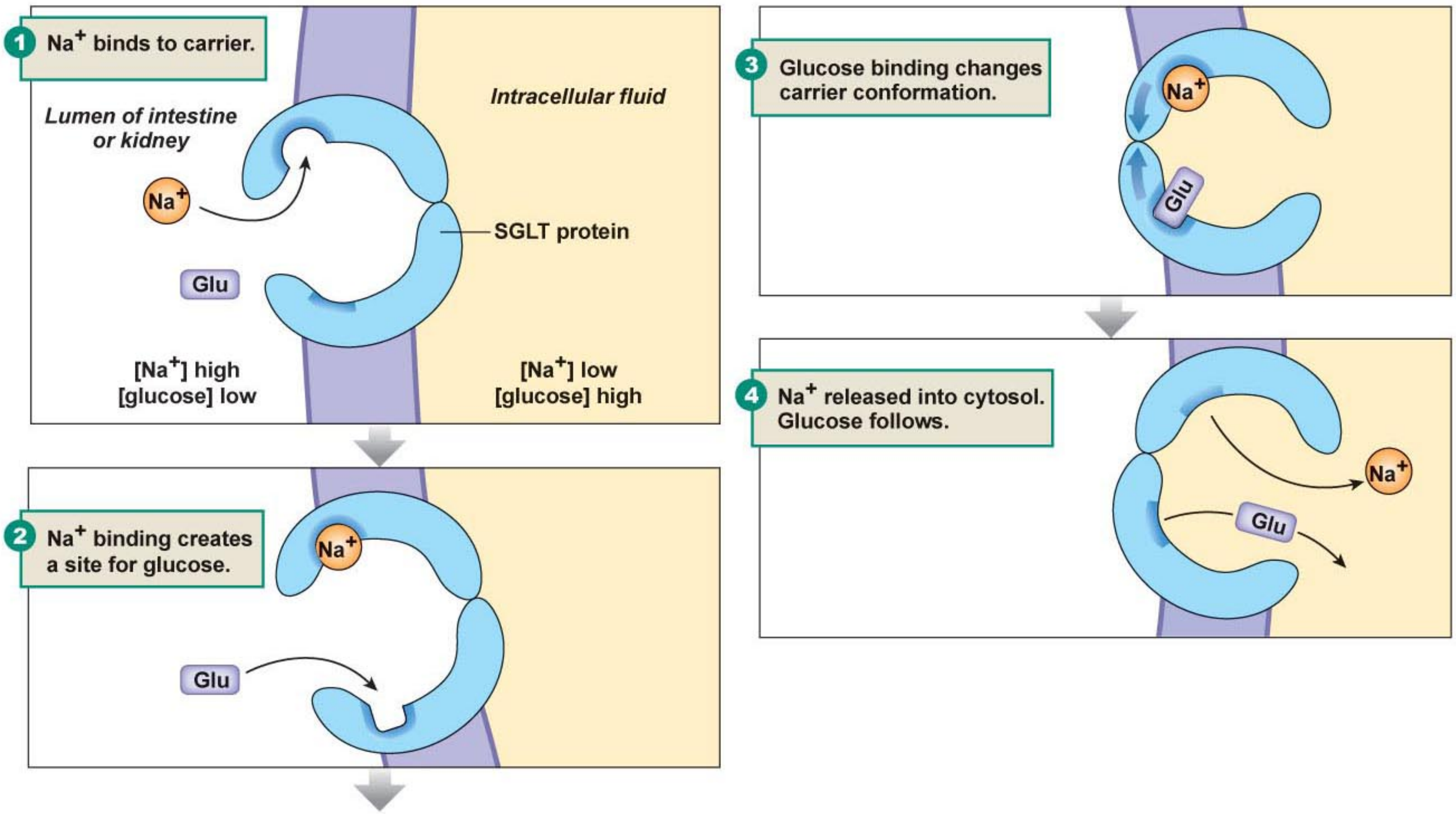
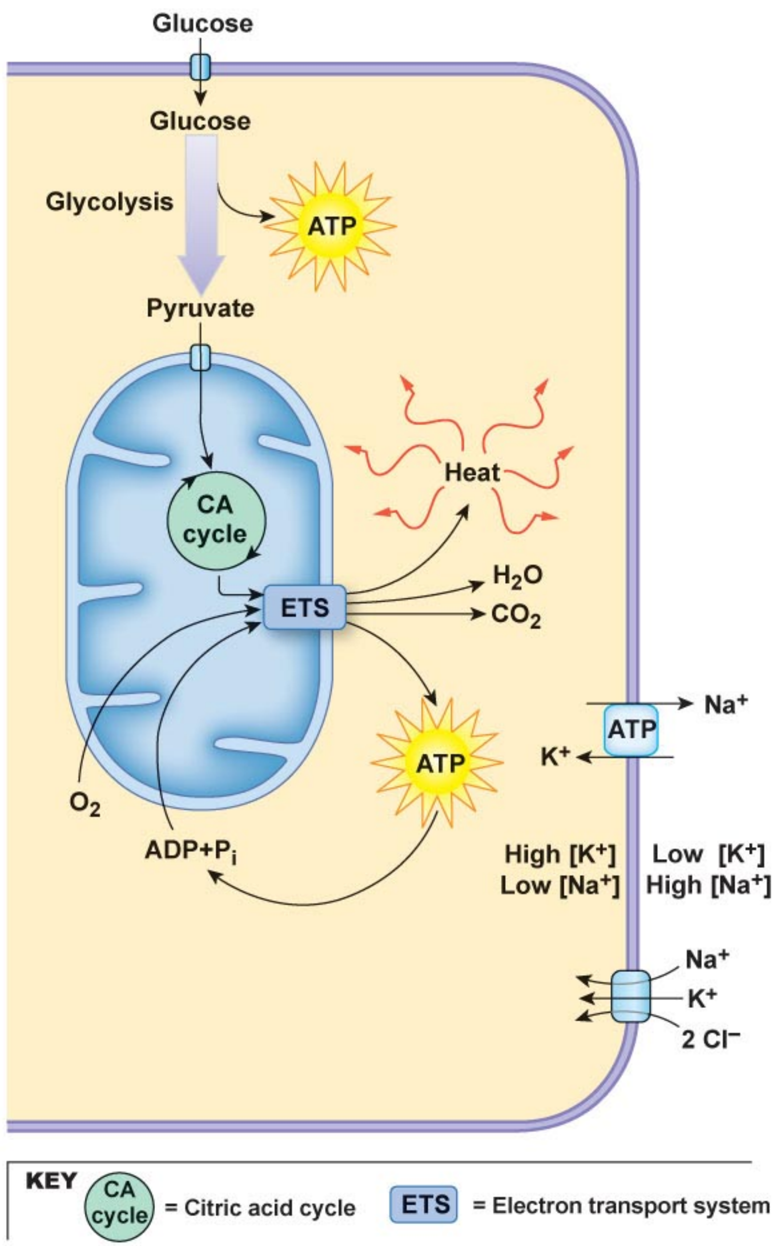


Figure 5-16, overview



Energy is imported into the cell as energy stored in chemical bonds of nutrients such as glucose.

↓

Metabolism

The chemical bond energy is converted into high-energy bonds of ATP through the process of metabolism.

↓

Primary active transport

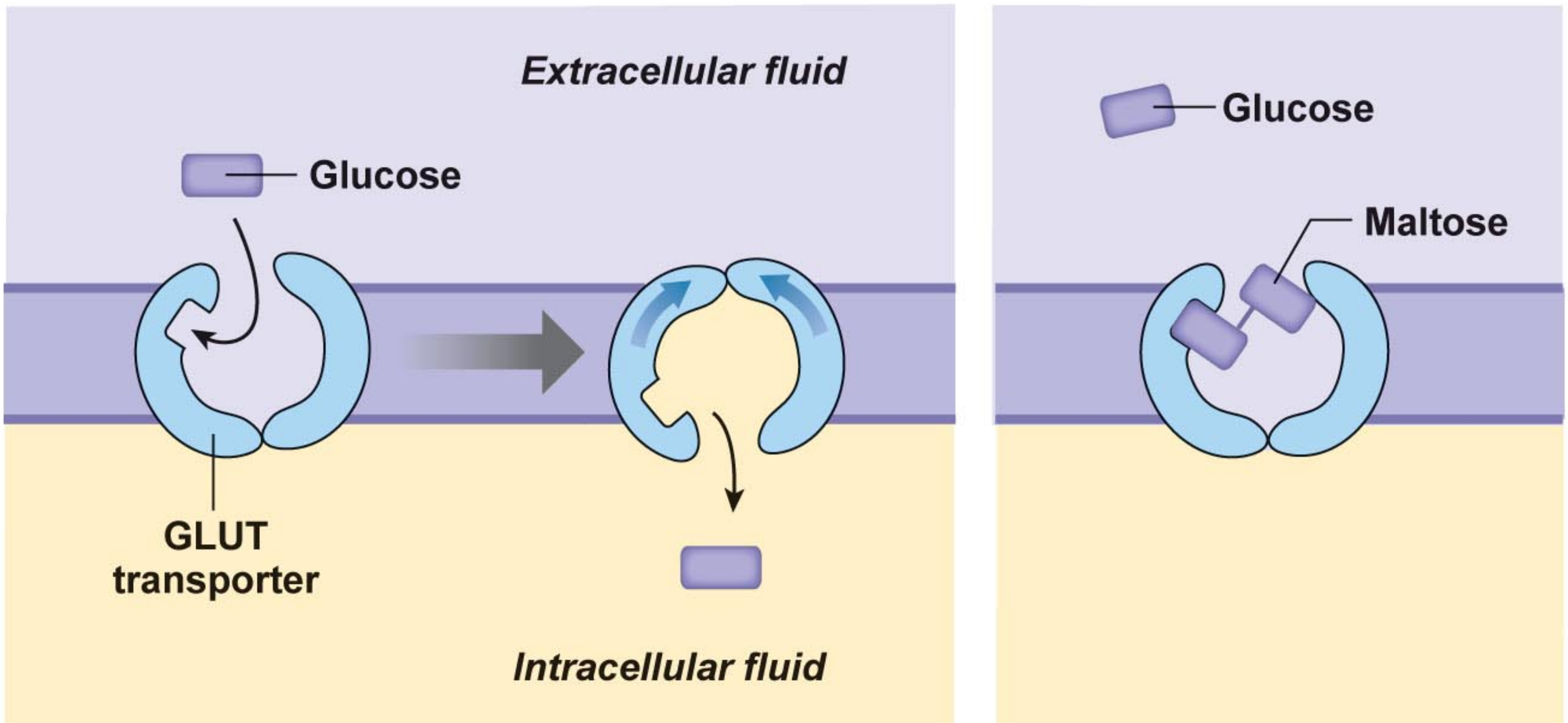
The energy in the high-energy phosphate bond of ATP is used to move K^+ and Na^+ against their concentration gradients. This creates potential energy stored in the ion concentration gradients.

↓

Secondary active transport

The energy of the Na^+ gradient can be used to move other molecules across the cell membrane against their concentration gradients.

Figure 5-18



(a) The GLUT transporter

(b) Maltose

Figure 5-17

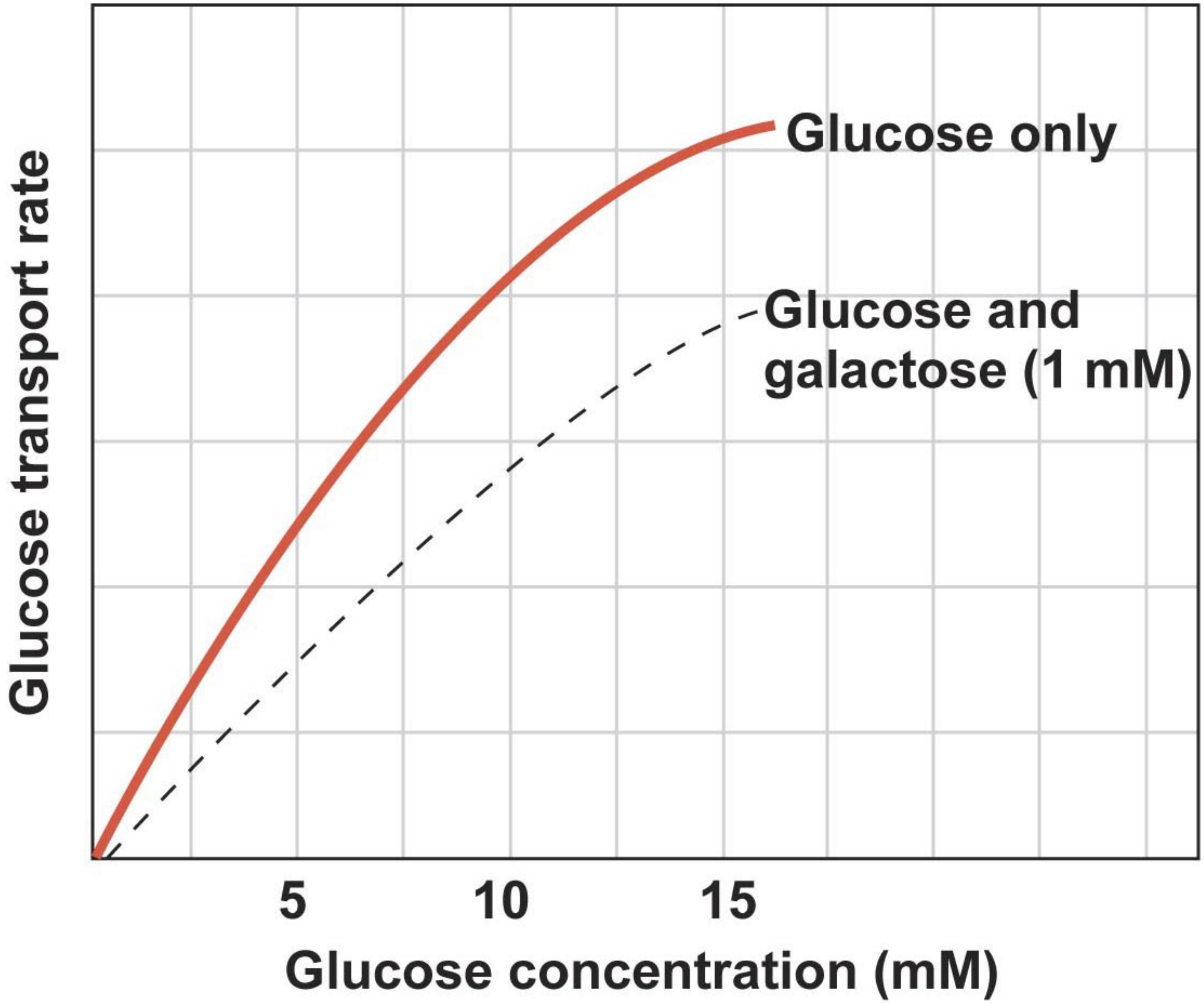
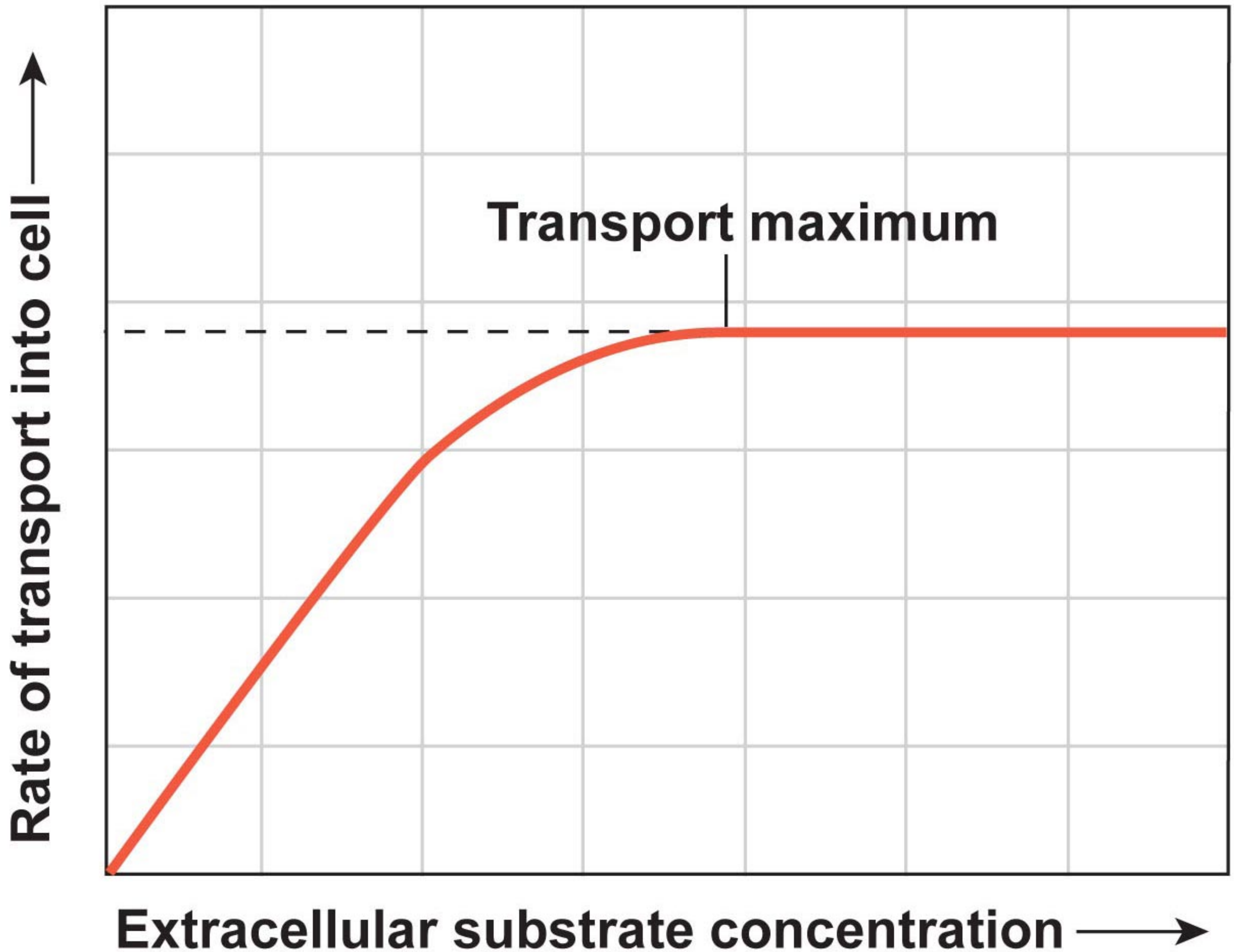

Glucose only
Glucose and galactose (1 mM)
Glucose transport rate
5
10
15
Glucose concentration (mM)

Figure 5-19



Transport maximum
Rate of transport into cell
Extracellular substrate concentration

Figure 5-20, overview

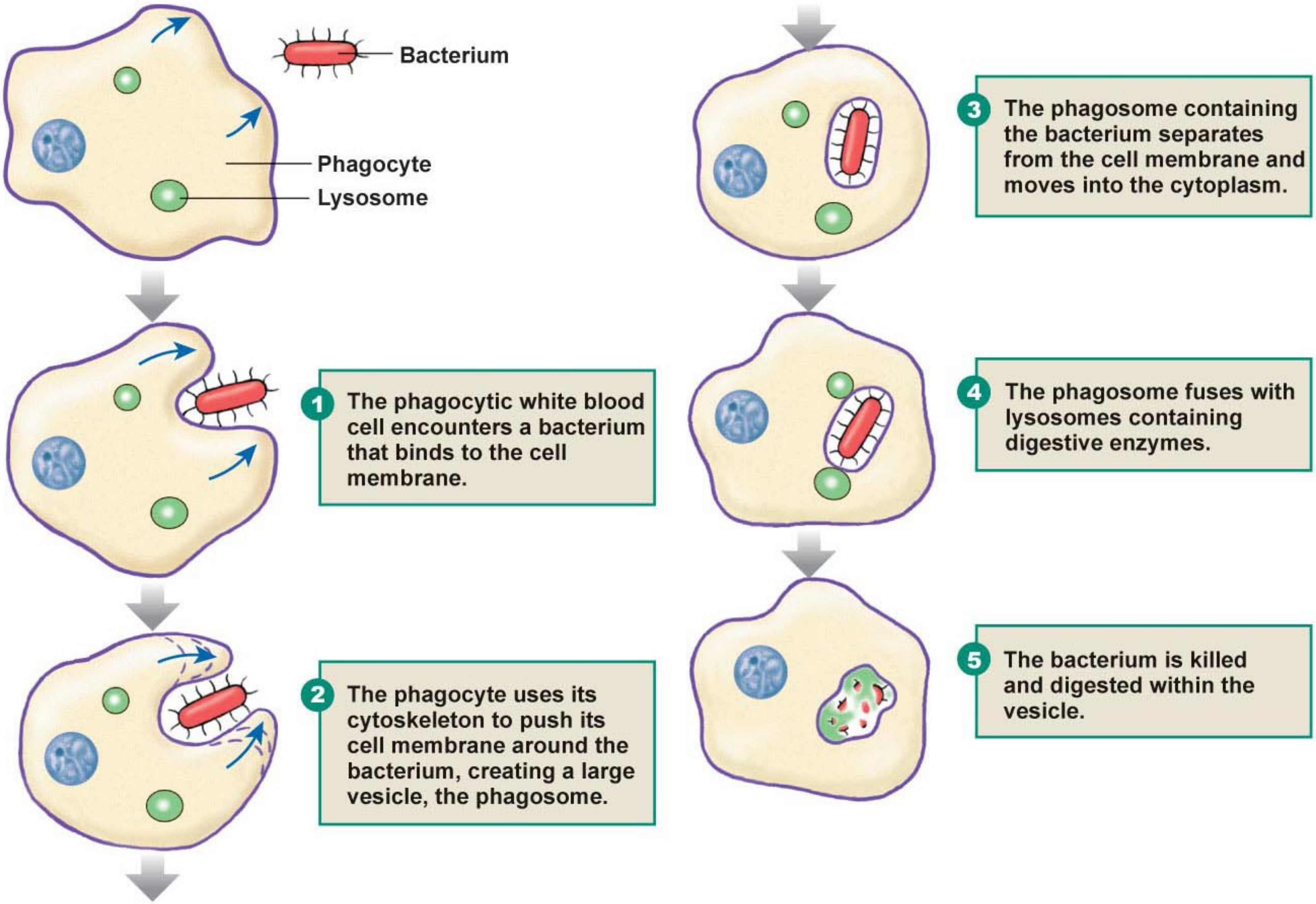


Figure 5-21, overview

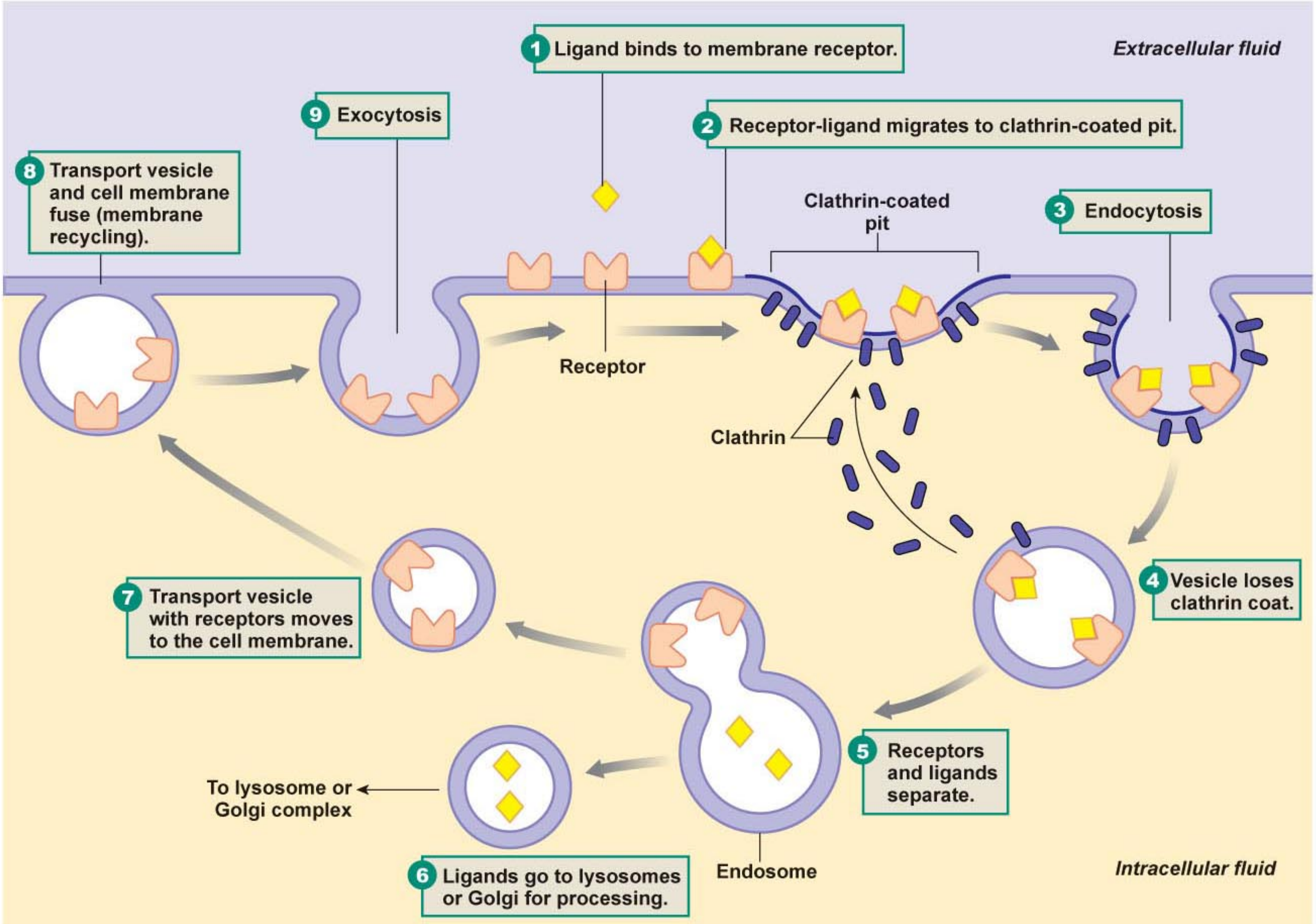
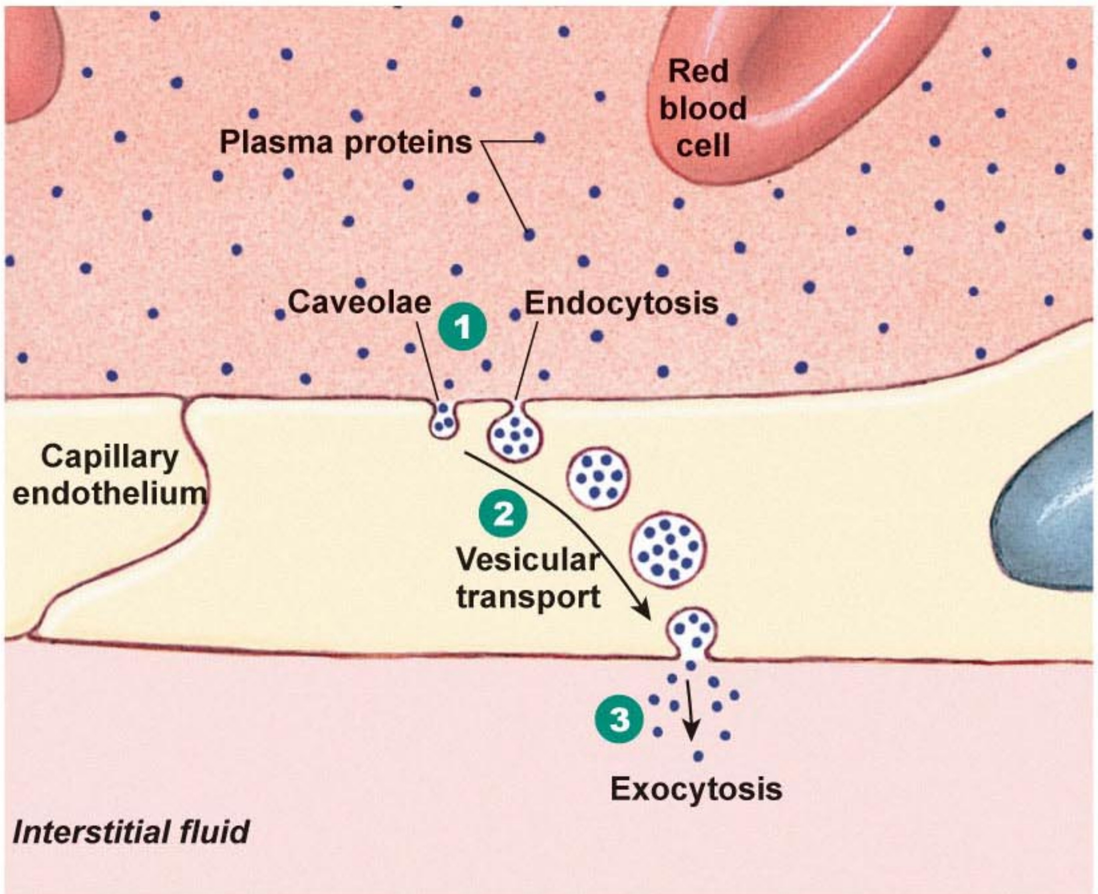


Figure 5-24



1. Plasma proteins are concentrated in caveolae, which then undergo endocytosis and form vesicles.

2. Vesicles cross the cell with help from the cytoskeleton.

3. Vesicle contents are released into interstitial fluid by exocytosis.

Figure 5-25

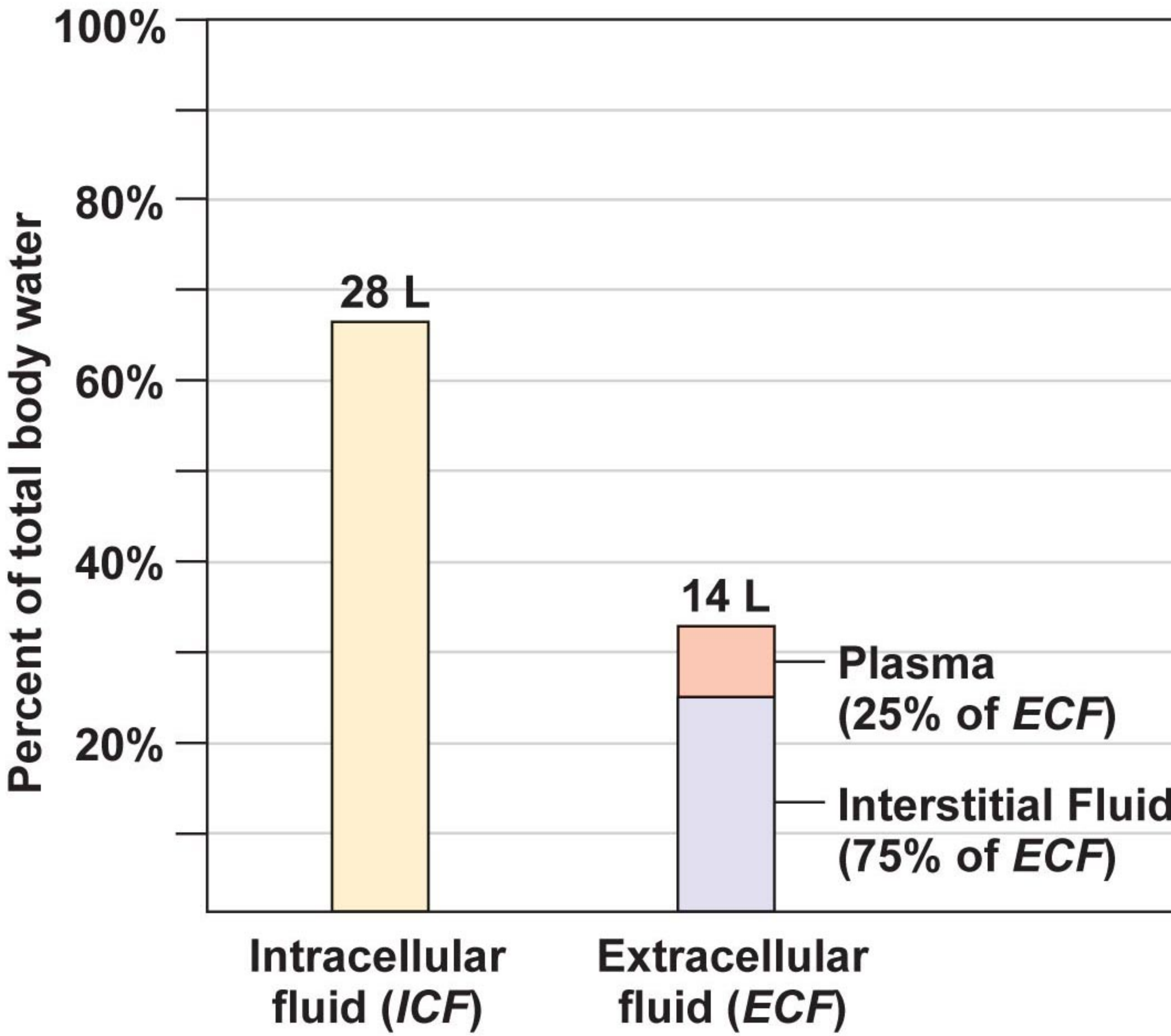

100%
80%
60%
40%
20%
Percent of total body water
28 L
14 L
Plasma
(25% of *ECF*)
Interstitial Fluid
(75% of *ECF*)
Intracellular
fluid (*ICF*)
Extracellular
fluid (*ECF*)

Figure 5-26, overview

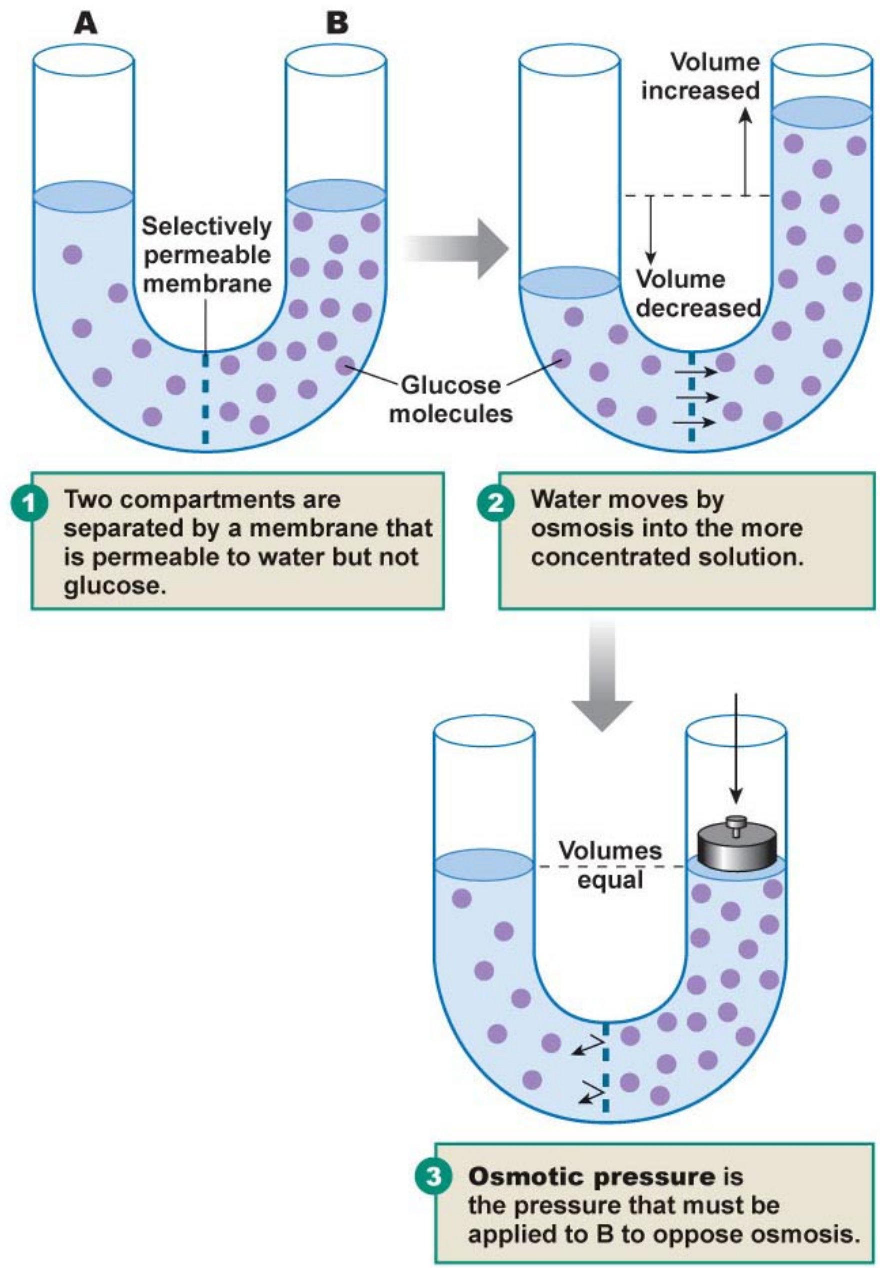


Figure 5-27

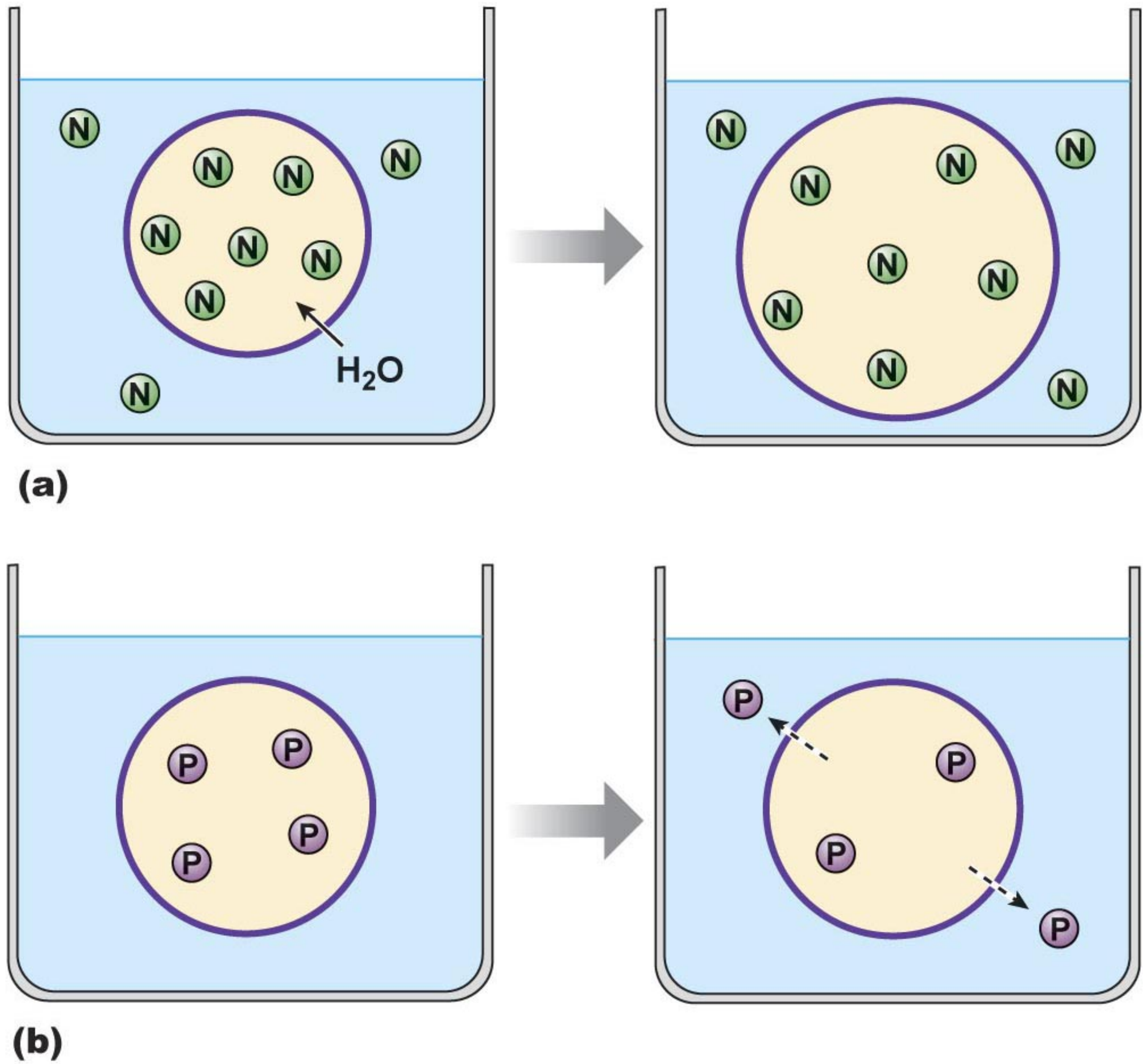


Figure 5-28

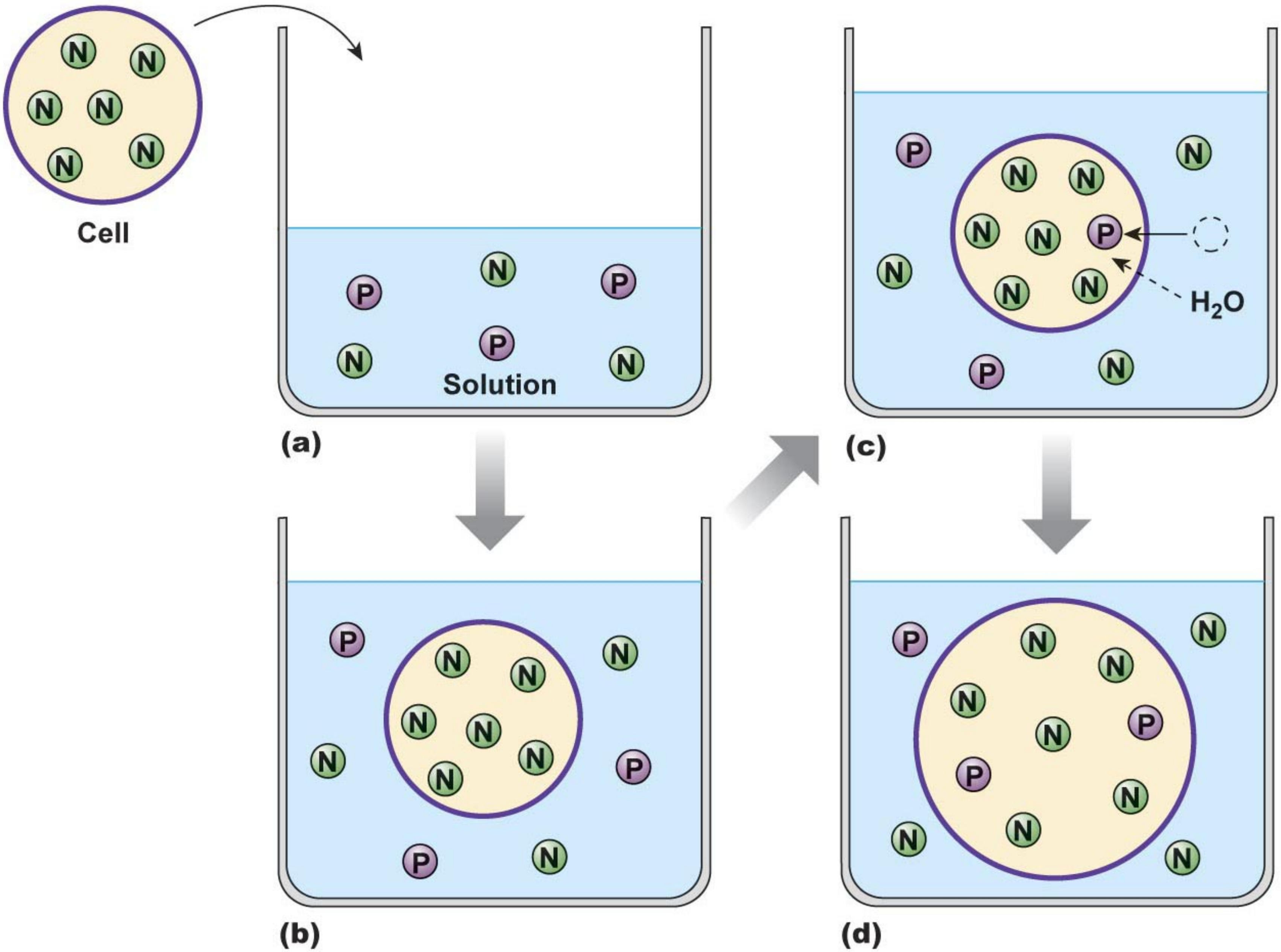

N
N
N
N
N
N
Cell
P
N
P
P
N
Solution
N
(a)
P
N
N
N
N
N
N
N
P
P
N
(b)
P
N
N
N
N
N
P
N
N
N
H_2O
P
N
(c)
P
N
N
N
N
P
N
P
N
N
N
N
(d)

Table 5-5

TABLE 5-5 Comparing Osmolarities

SOLUTION A = 1 OsM GLUCOSE	SOLUTION B = 2 OsM GLUCOSE	SOLUTION C = 1 OsM NACL
A is hyposmotic to B	B is hyperosmotic to A	C is isosmotic to A
A is isosmotic to C	B is hyperosmotic to C	C is hyposmotic to B

Table 5-6

TABLE 5-6 Tonicity of Solutions

SOLUTION	CELL BEHAVIOR WHEN PLACED IN THE SOLUTION	DESCRIPTION OF THE SOLUTION RELATIVE TO THE CELL
A	Cell swells	Solution A is hypotonic
B	Cell doesn't change size	Solution B is isotonic
C	Cell shrinks	Solution C is hypertonic

Figure 5-29

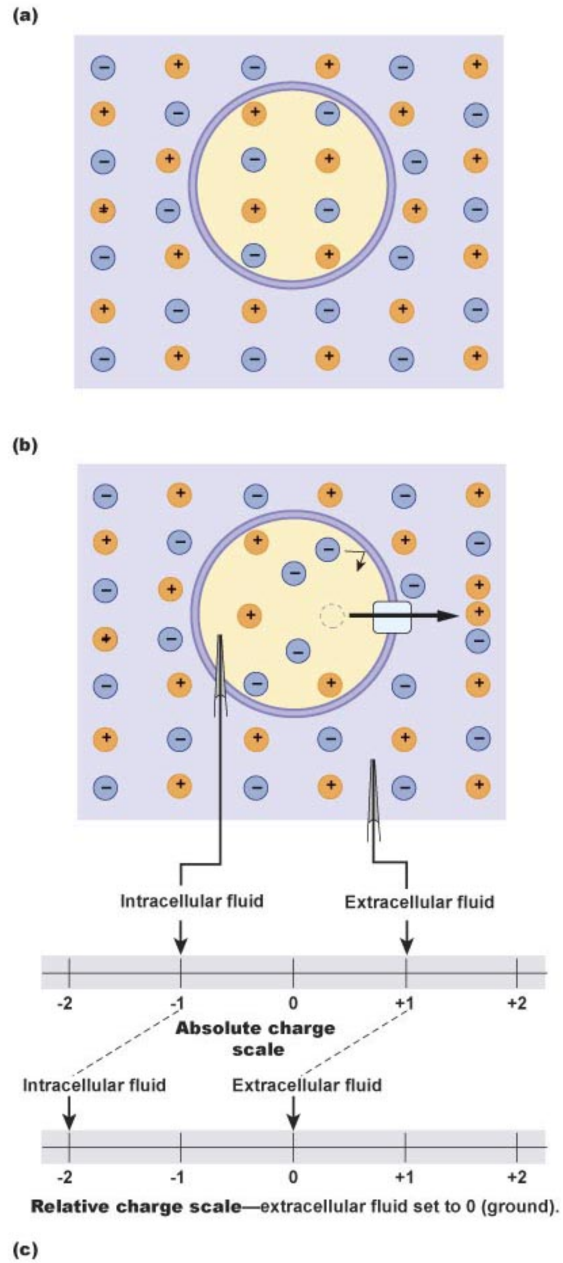

(a)
(b)
Intracellular fluid
Extracellular fluid
-2
-1
0
+1
+2
Absolute charge scale
Intracellular fluid
Extracellular fluid
-2
-1
0
+1
+2
Relative charge scale—extracellular fluid set to 0 (ground).
(c)

Figure 5-29a

(a) Cell and solution are electrically and chemically at equilibrium.

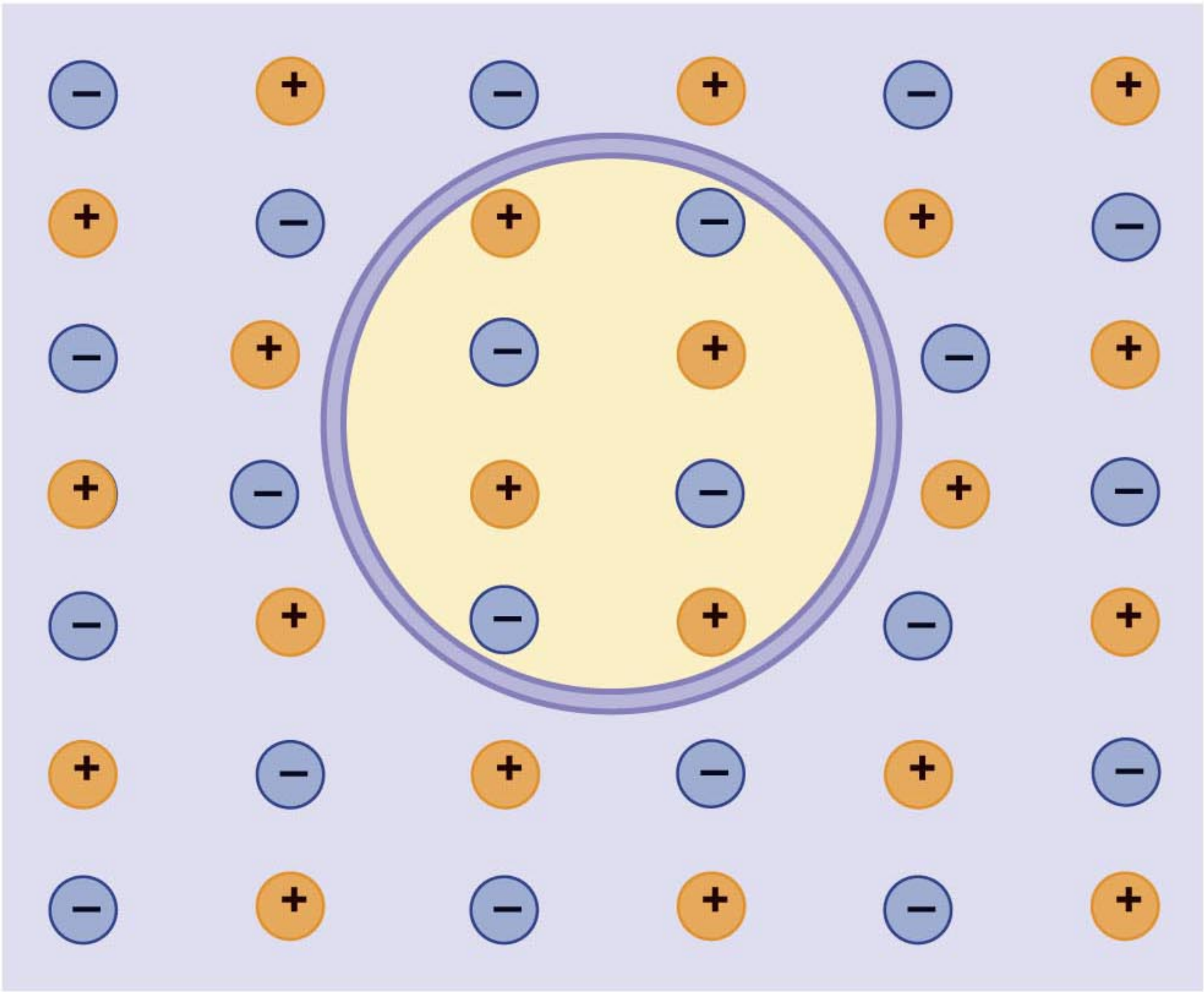


Figure 5-29b

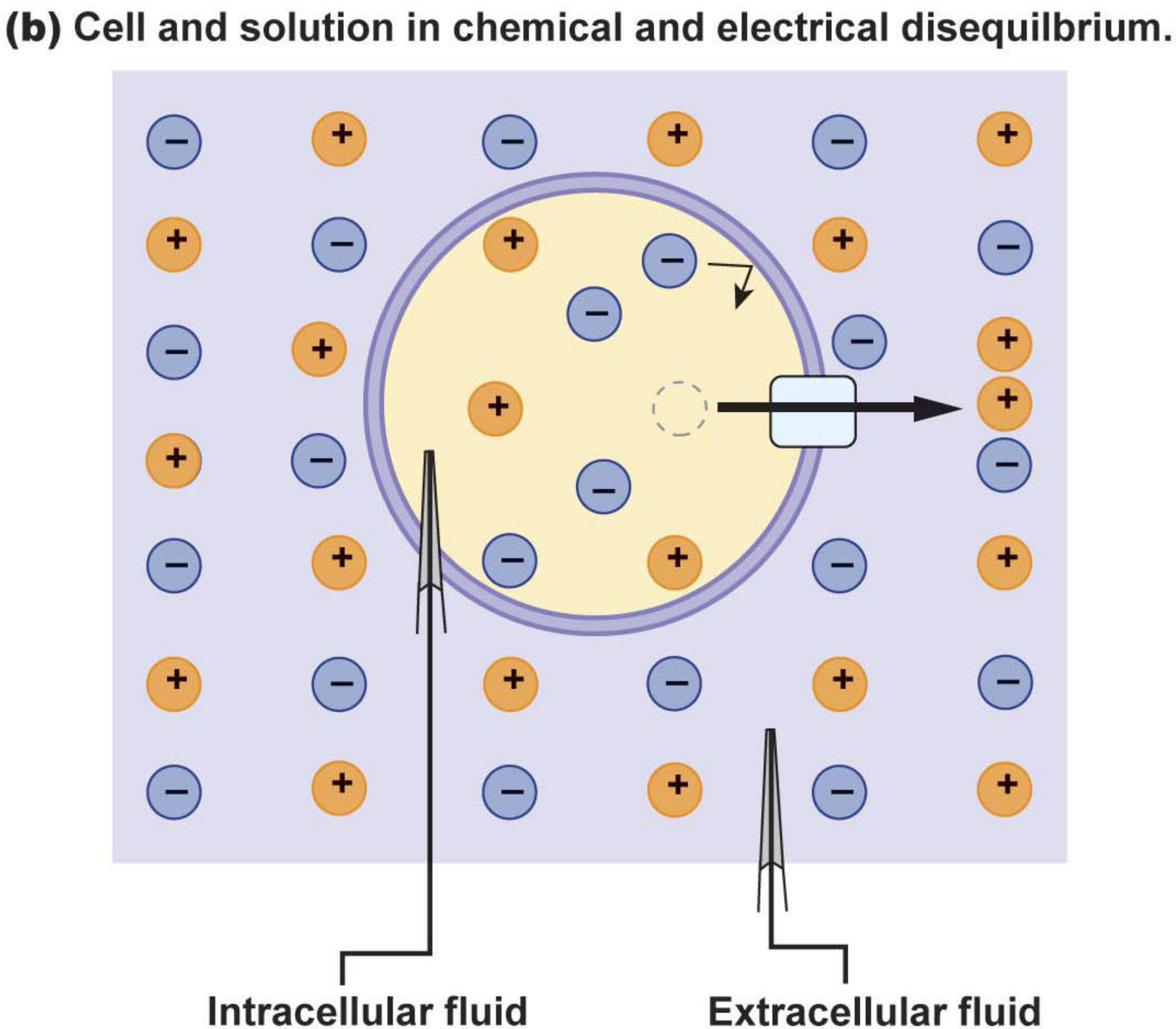
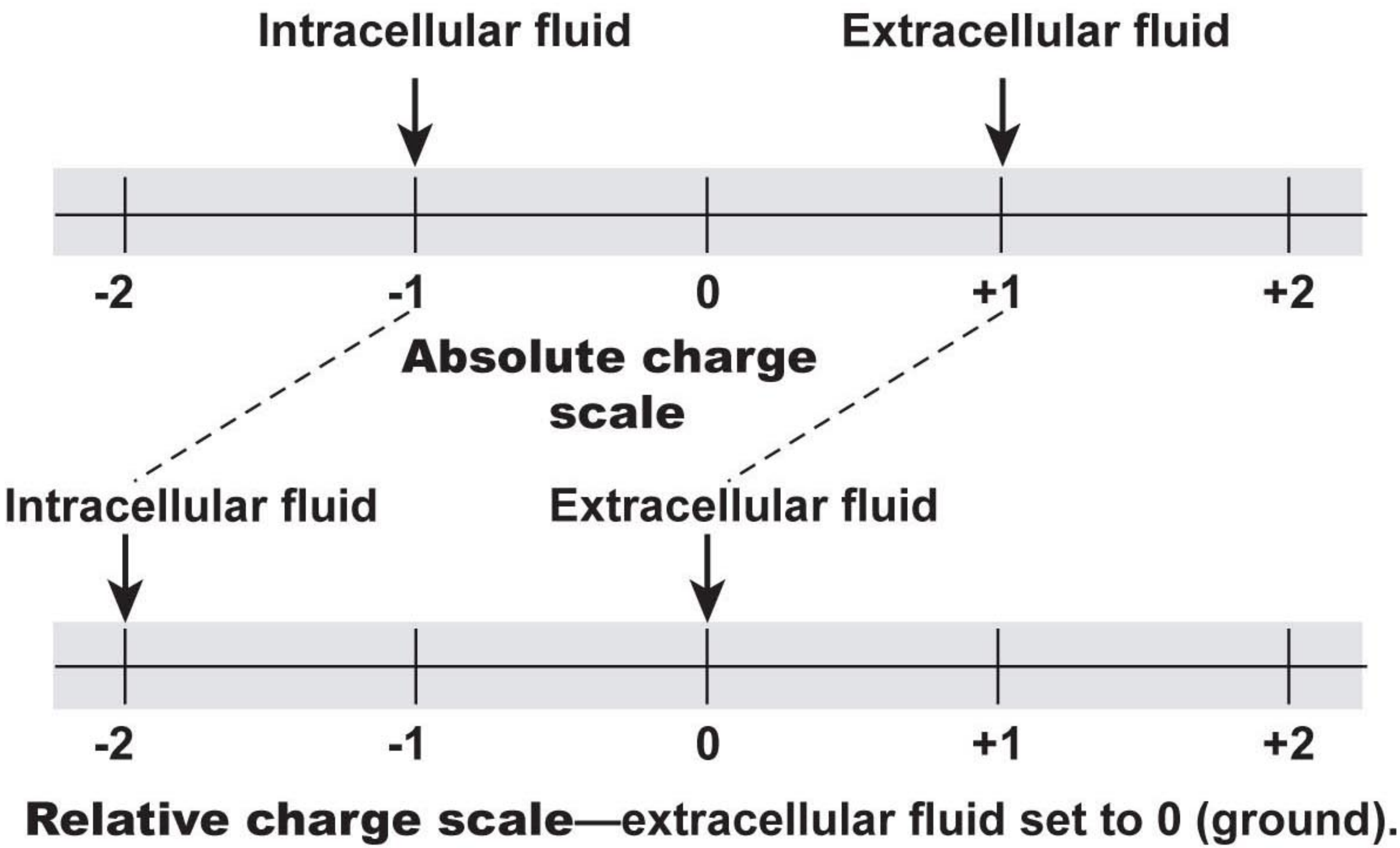
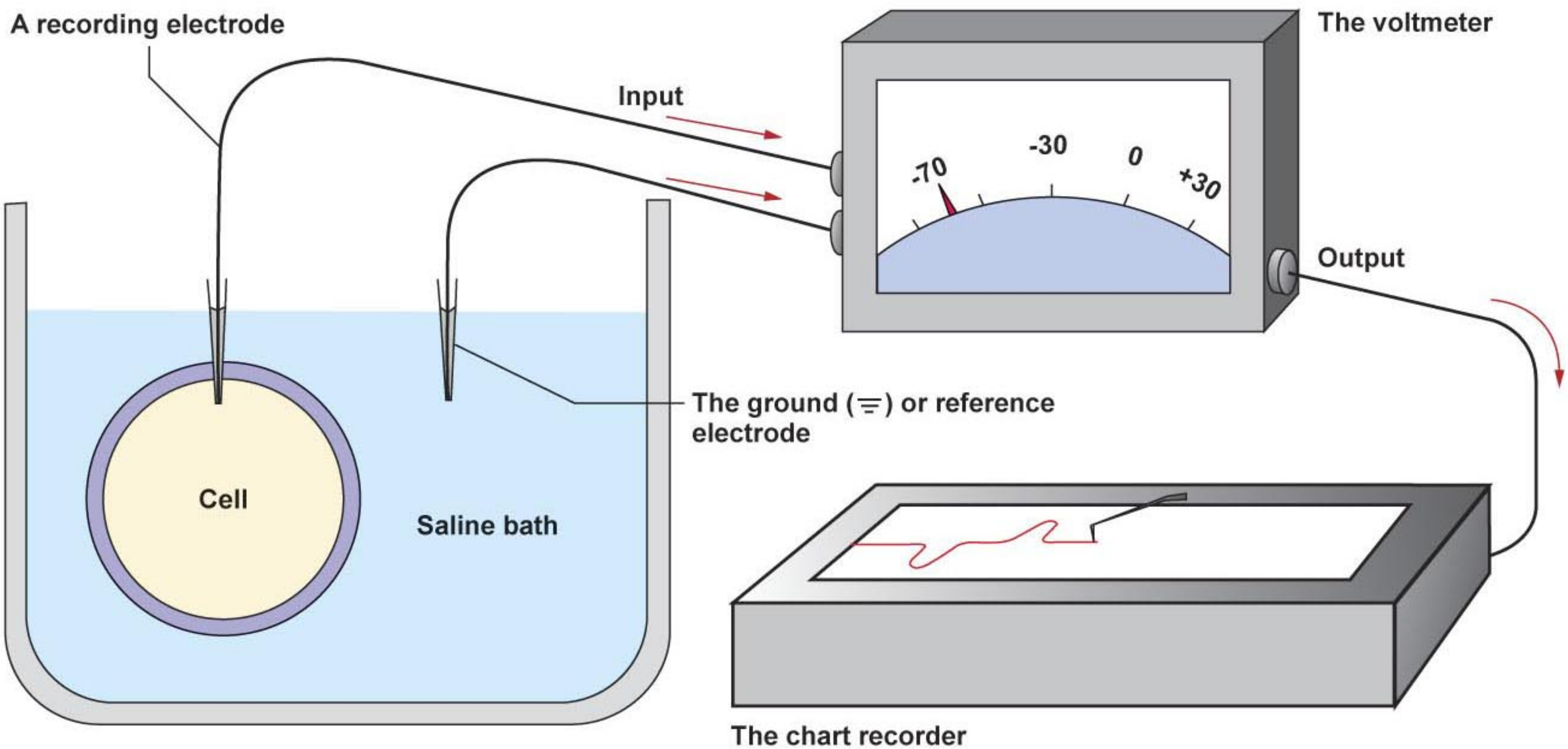

(b) Cell and solution in chemical and electrical disequilbrium.
Intracellular fluid
Extracellular fluid

Figure 5-29c



(c) On an absolute charge scale, the extracellular fluid *(ECF)* would be at +1 and the intracellular fluid *(ICF)* at -1.

Figure 5-30



A recording electrode
Input
The voltmeter
-70
-30
0
+30
Output
The ground (=) or reference electrode
Cell
Saline bath
The chart recorder

Figure 5-33

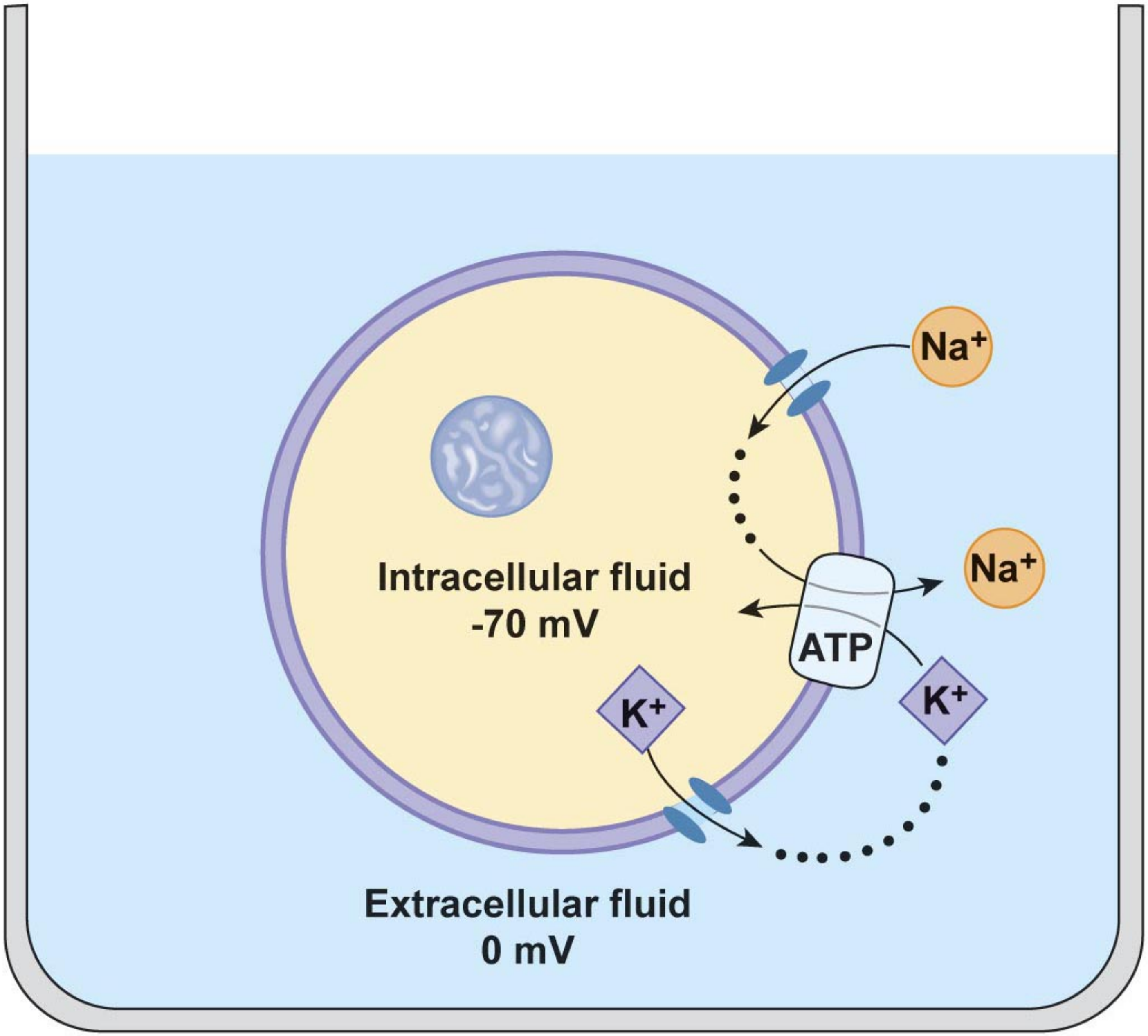

Na+
Na+
Intracellular fluid
-70 mV
ATP
K+
K+
Extracellular fluid
0 mV

Figure 5-34

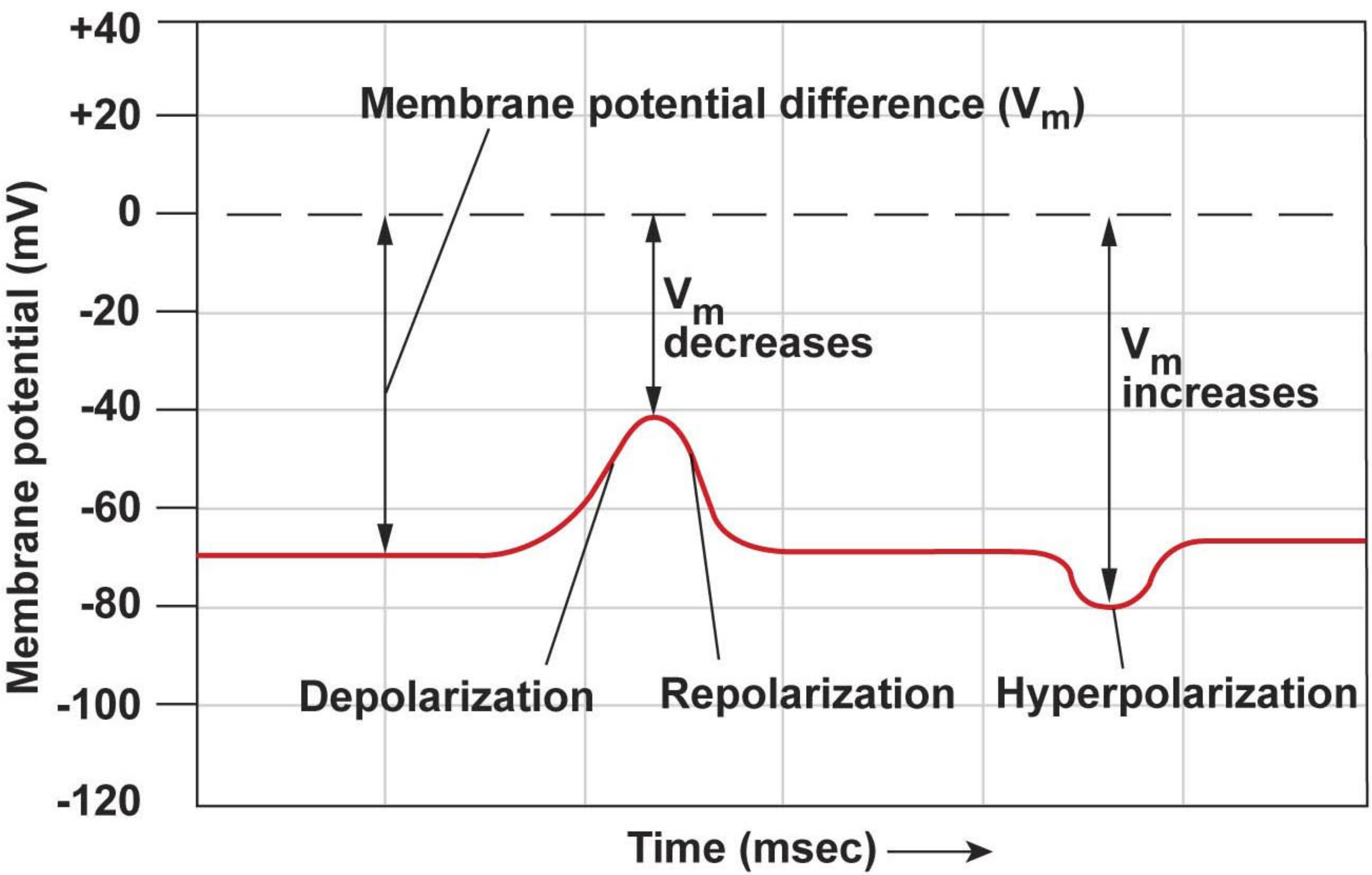
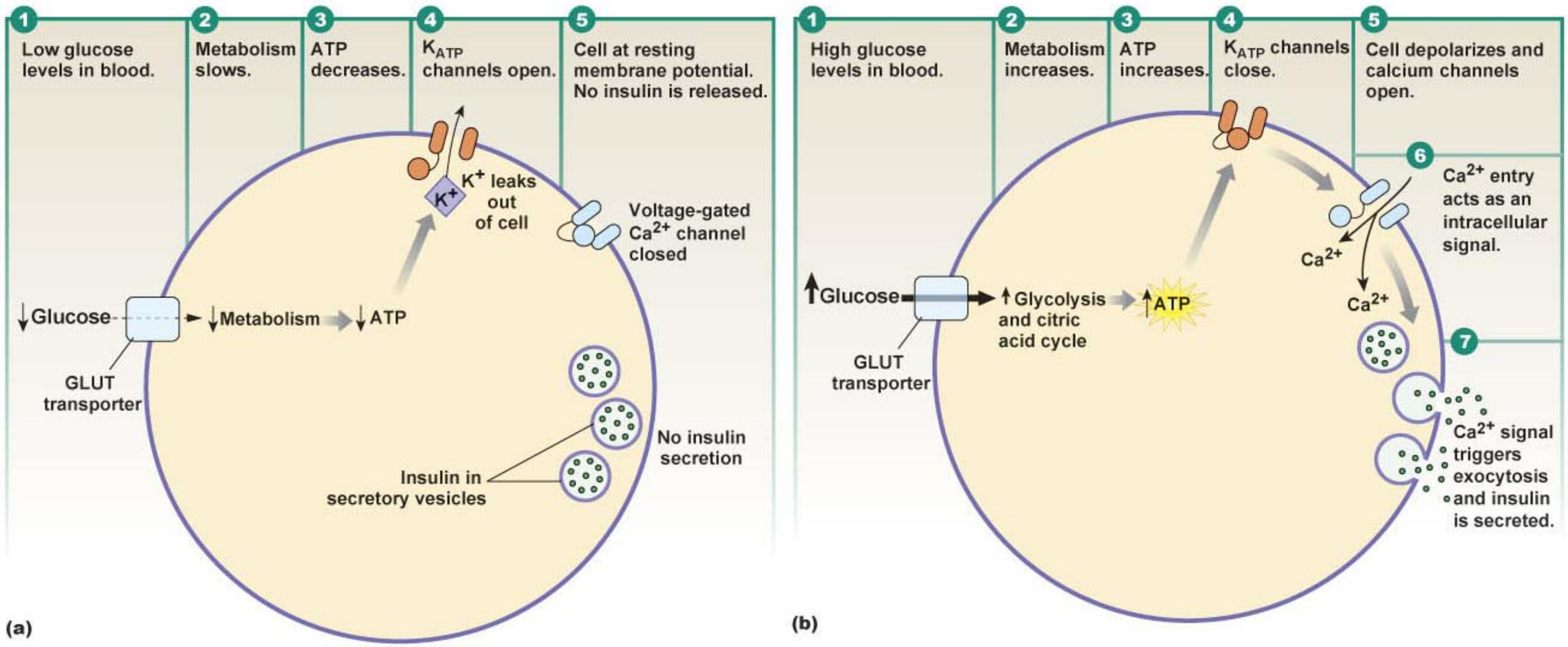

+40
+20
0
-20
-40
-60
-80
-100
-120
Membrane potential (mV)
Membrane potential difference (V_m)
V_m decreases
V_m increases
Depolarization
Repolarization
Hyperpolarization
Time (msec)

Figure 5-35



1 Low glucose levels in blood.
2 Metabolism slows.
3 ATP decreases.
4 K$_{ATP}$ channels open.
5 Cell at resting membrane potential. No insulin is released.
↓Glucose
GLUT transporter
↓Metabolism
↓ATP
K+
K+ leaks out of cell
Voltage-gated Ca2+ channel closed
No insulin secretion
Insulin in secretory vesicles
(a)
1 High glucose levels in blood.
2 Metabolism increases.
3 ATP increases.
4 K$_{ATP}$ channels close.
5 Cell depolarizes and calcium channels open.
6 Ca2+ entry acts as an intracellular signal.
7 Ca2+ signal triggers exocytosis and insulin is secreted.
↑Glucose
GLUT transporter
↑Glycolysis and citric acid cycle
↑ATP
Ca2+
Ca2+
(b)