Chapter 4
Movement of Molecules Across Cell Membranes = Trans-Membrane Traffic

Diffusion: solute moves down its concentration gradient:

- **simple diffusion:**

  small (e.g., oxygen, carbon dioxide)

  lipid soluble (e.g., steroids)

- **facilitated diffusion:**

  requires transporter (e.g., glucose)

Chapter 4
Movement of Molecules Across Cell Membranes = Trans-Membrane Traffic (cont.)

Active transport: solute moves against its concentration gradient:

- **primary active transport:**

  ATP directly consumed (e.g., Na+ K+ATPase)

- **secondary active transport:**

  energy of ion gradient (usually Na+) used to move second solute (e.g., nutrient absorption in gut)

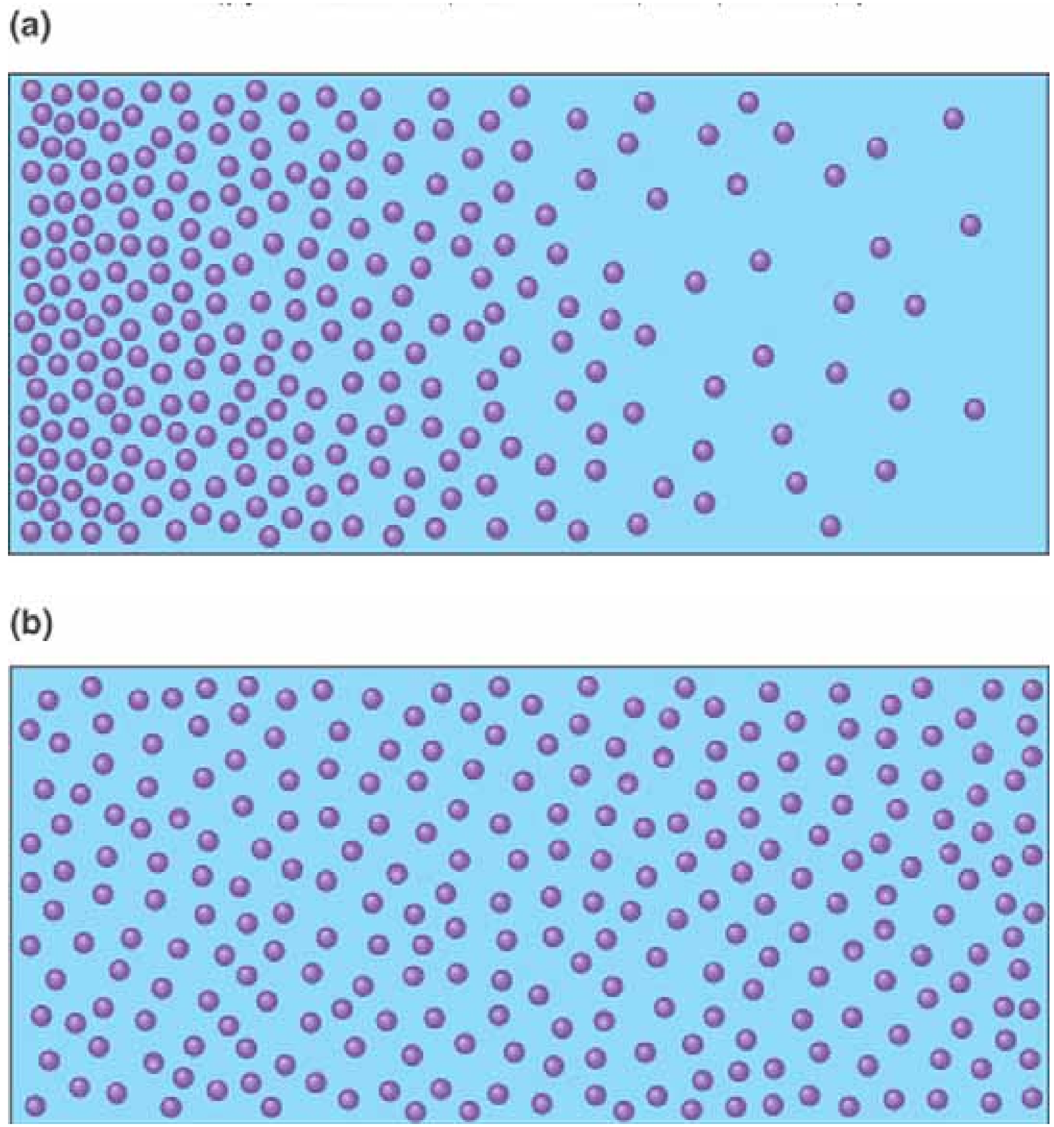
Exo- and endo- cytosis:

large scale movements of molecules

Figure 4-1

START: Initially higher concentration of molecules randomly move toward lower concentration.

Over time, solute molecules placed in a solvent will evenly distribute themselves.



Diffusional equilibrium is the result (Part b).

Figure 4-2

At time B, some glucose has crossed into side 2 as some cross into side 1.

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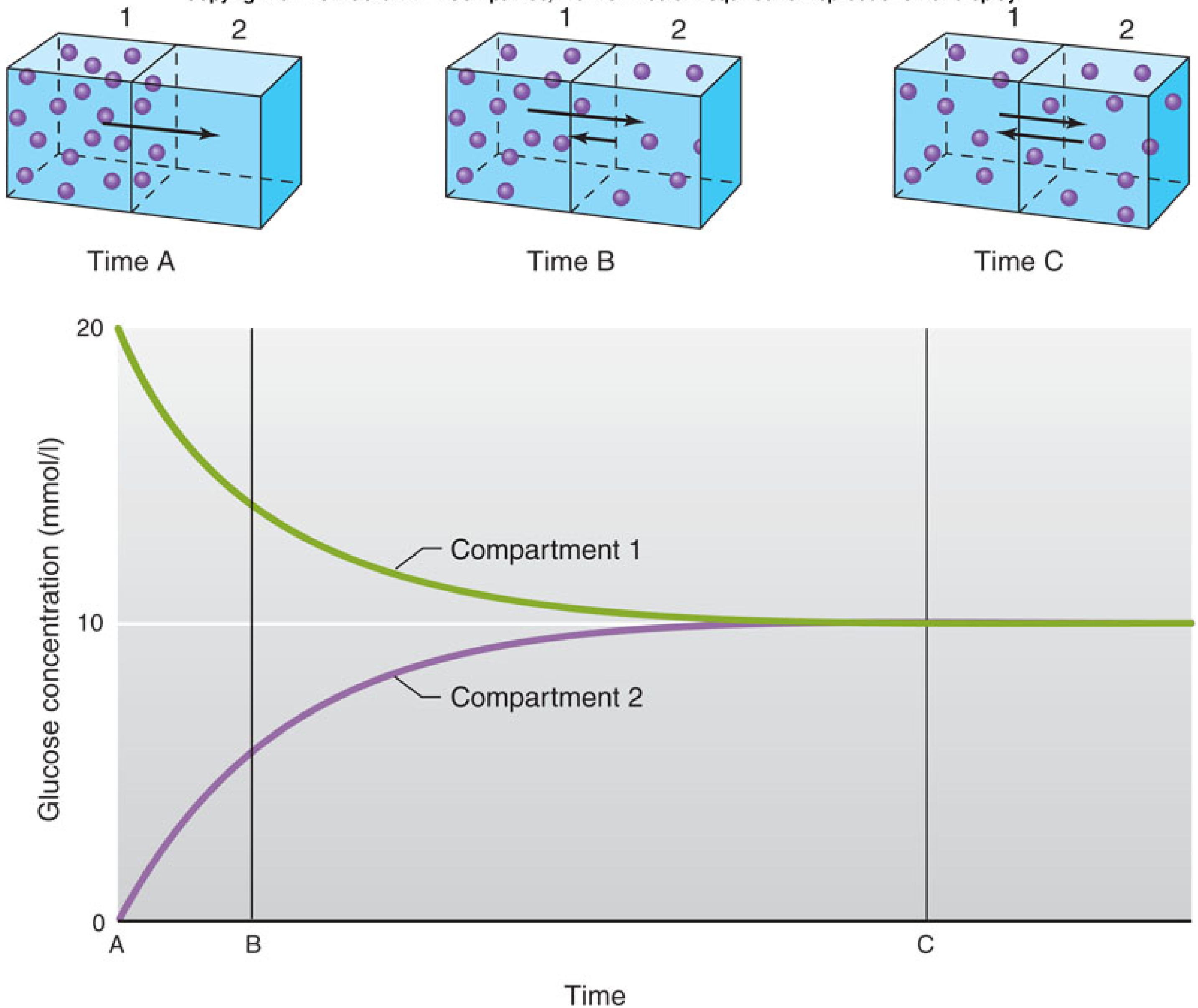
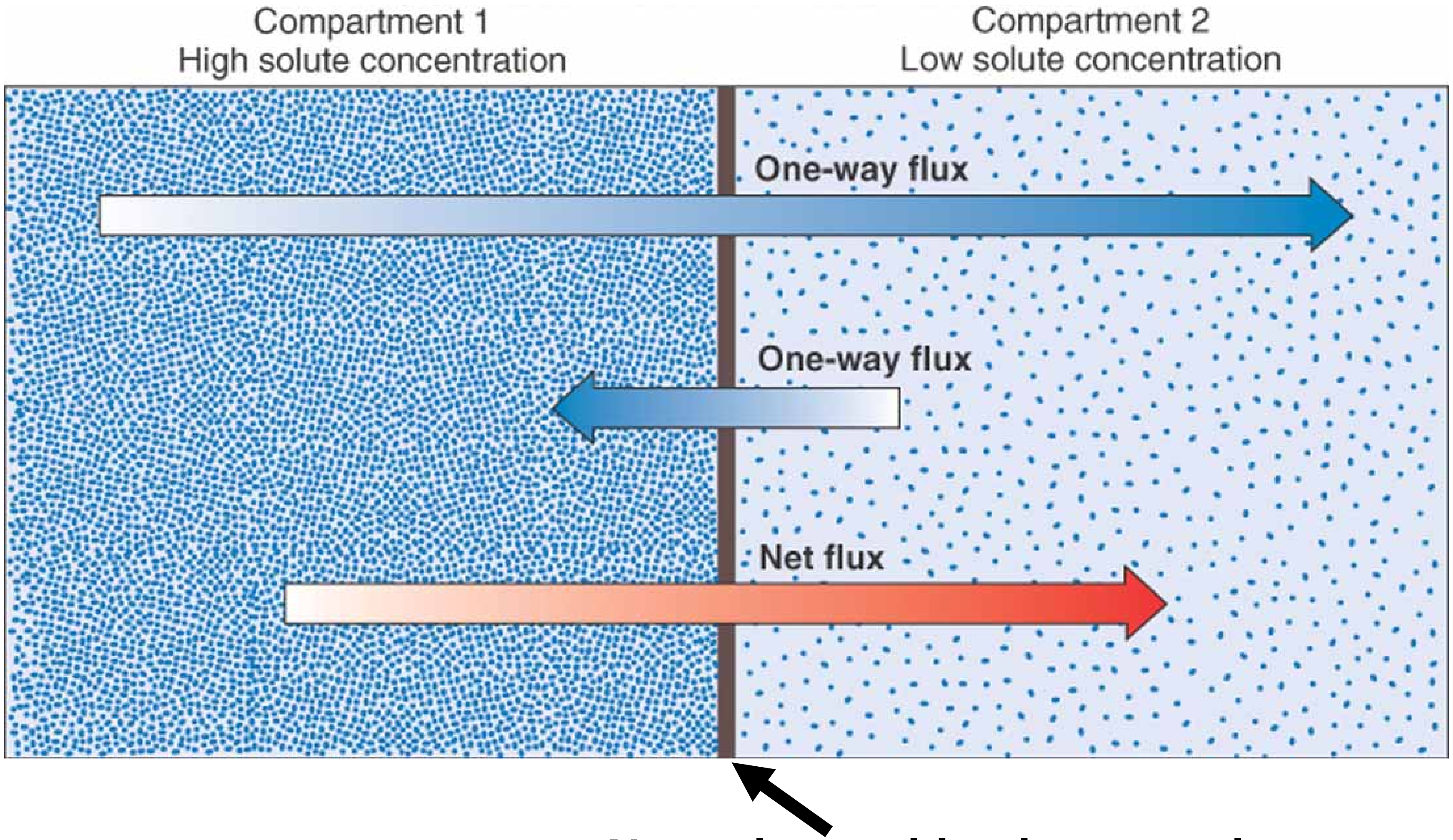
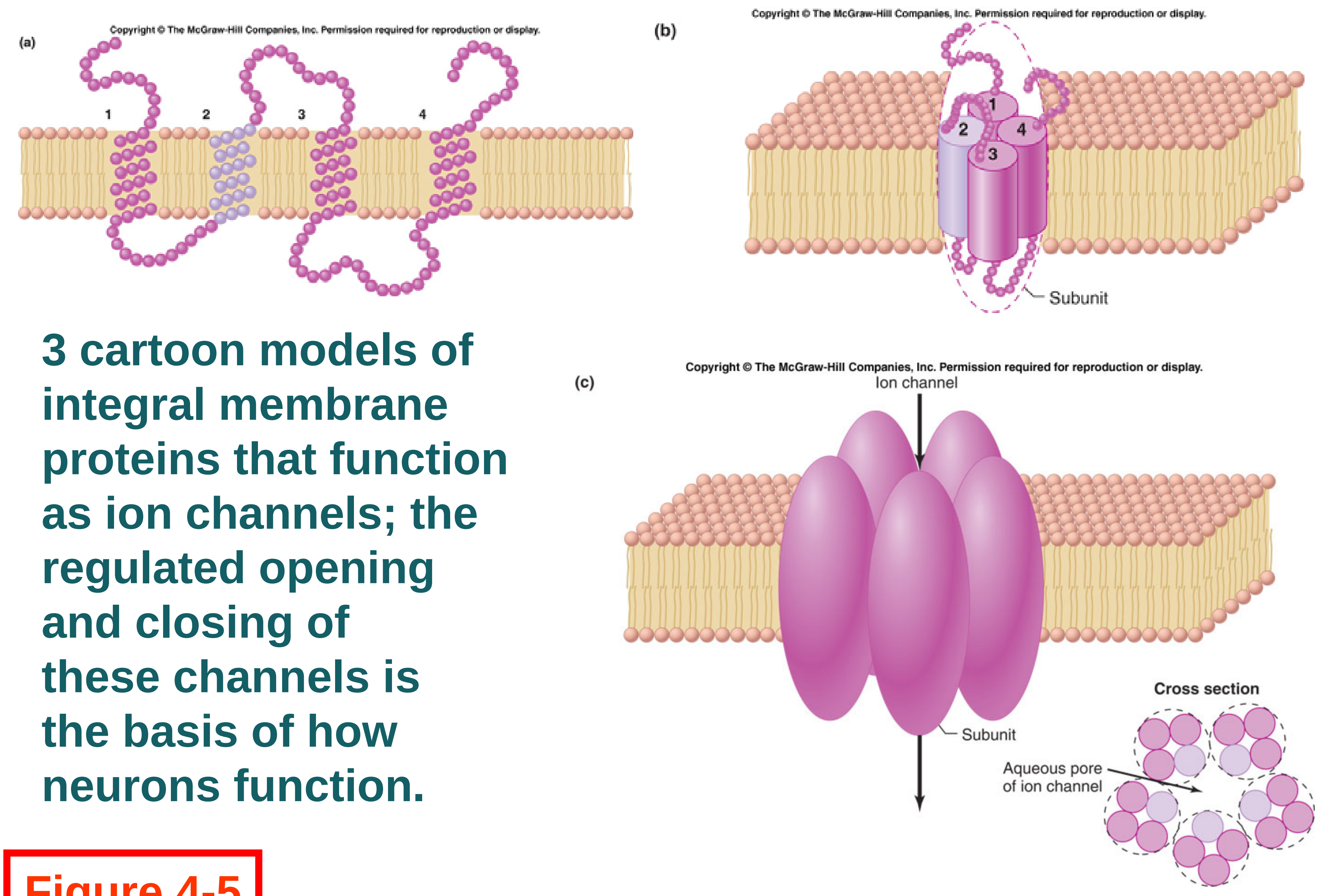




Note: the partition between the two compartments is a membrane that allows this solute to move through it.

Figure 4-3

Net flux accounts for solute movements in both directions.



3 cartoon models of integral membrane proteins that function as ion channels; the regulated opening and closing of these channels is the basis of how neurons function.

Figure 4-5

A thin shell of positive (outside) and negative (inside) charge provides the electrical gradient that drives ion movement across the membranes of excitable cells.

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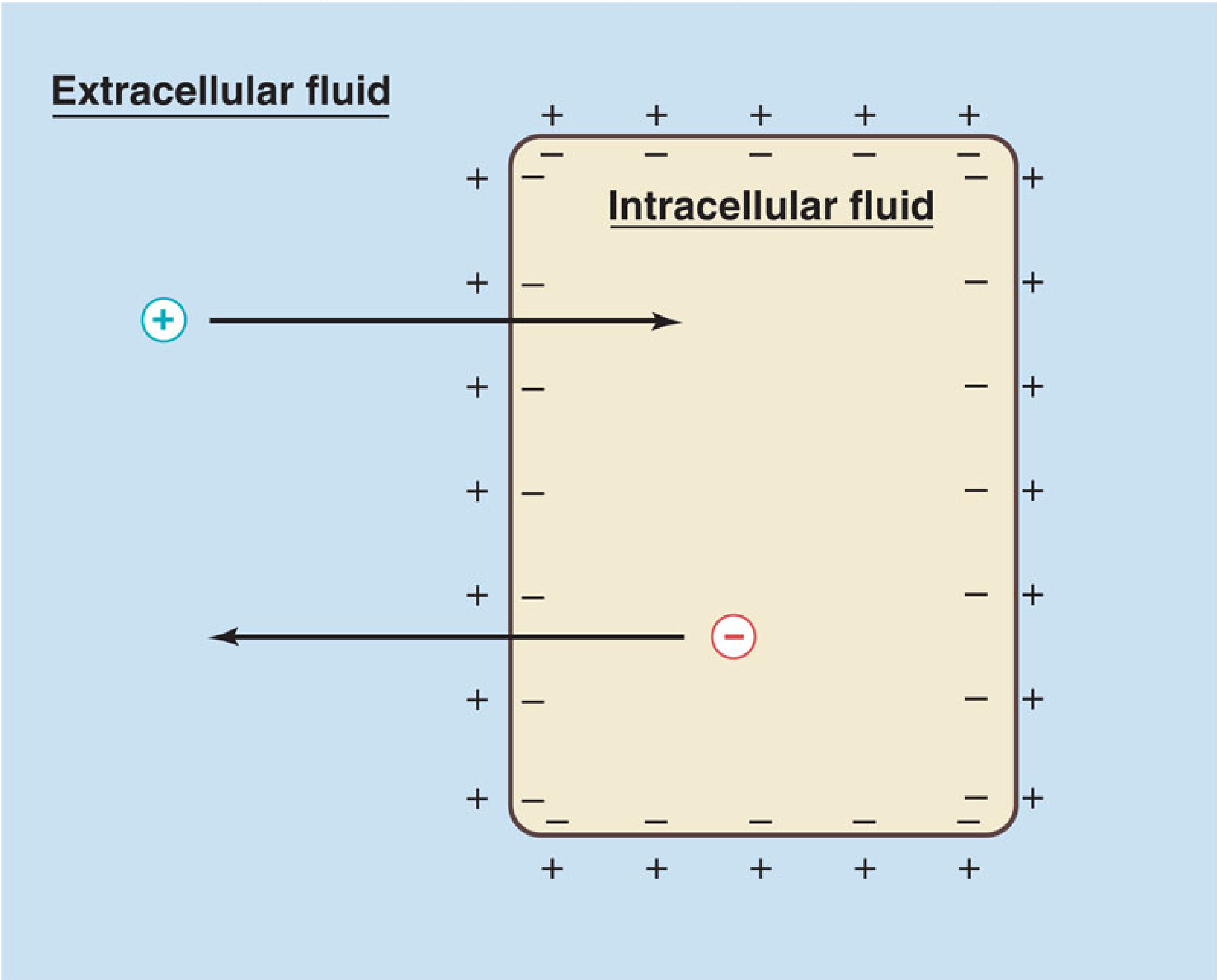
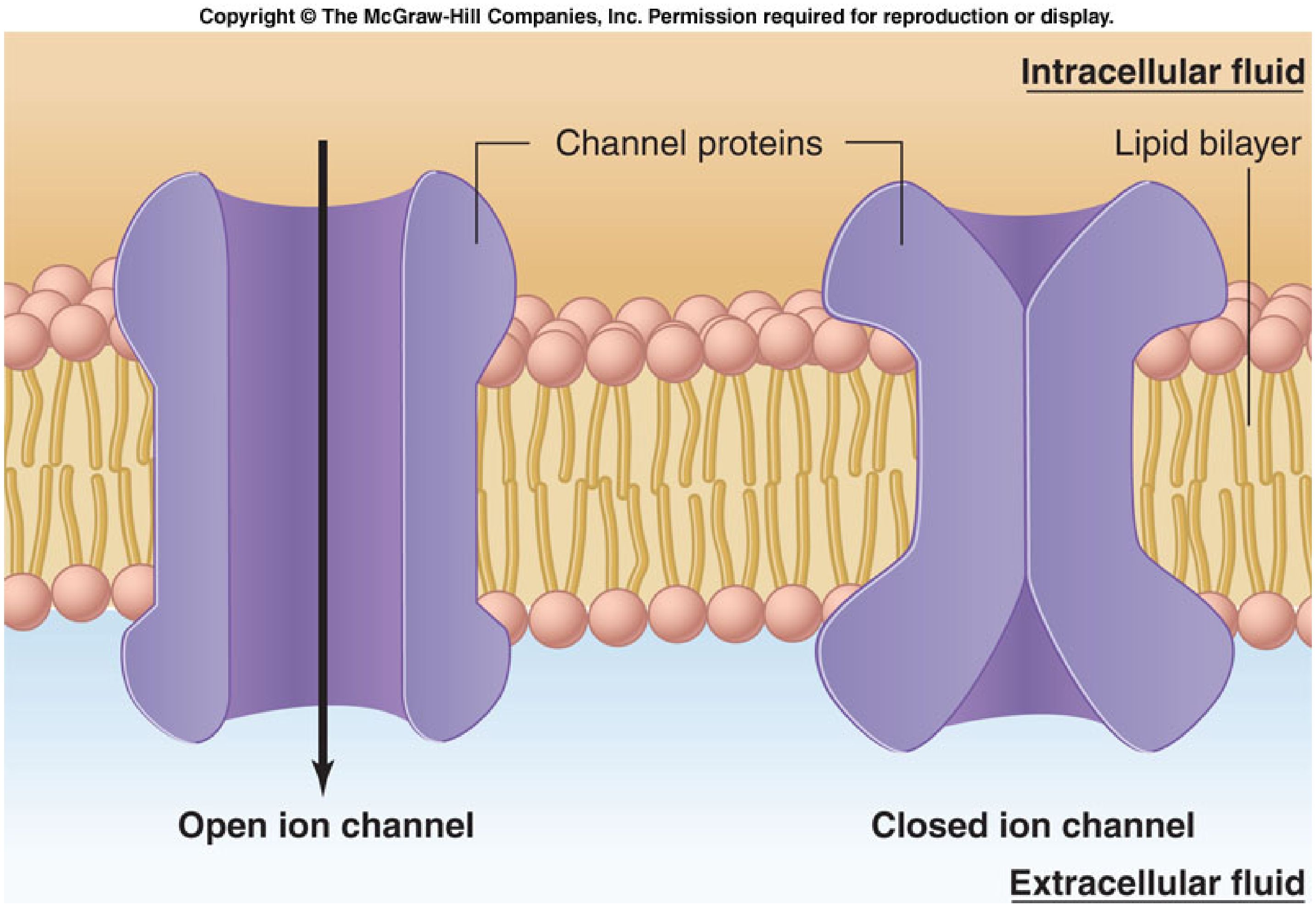


Figure 4-6

Figure 4-7



The opening and closing of ion channels results from conformational changes in integral proteins. Discovering the factors that cause these changes is key to understanding excitable cells.

A cartoon model of carrier-mediated transport.

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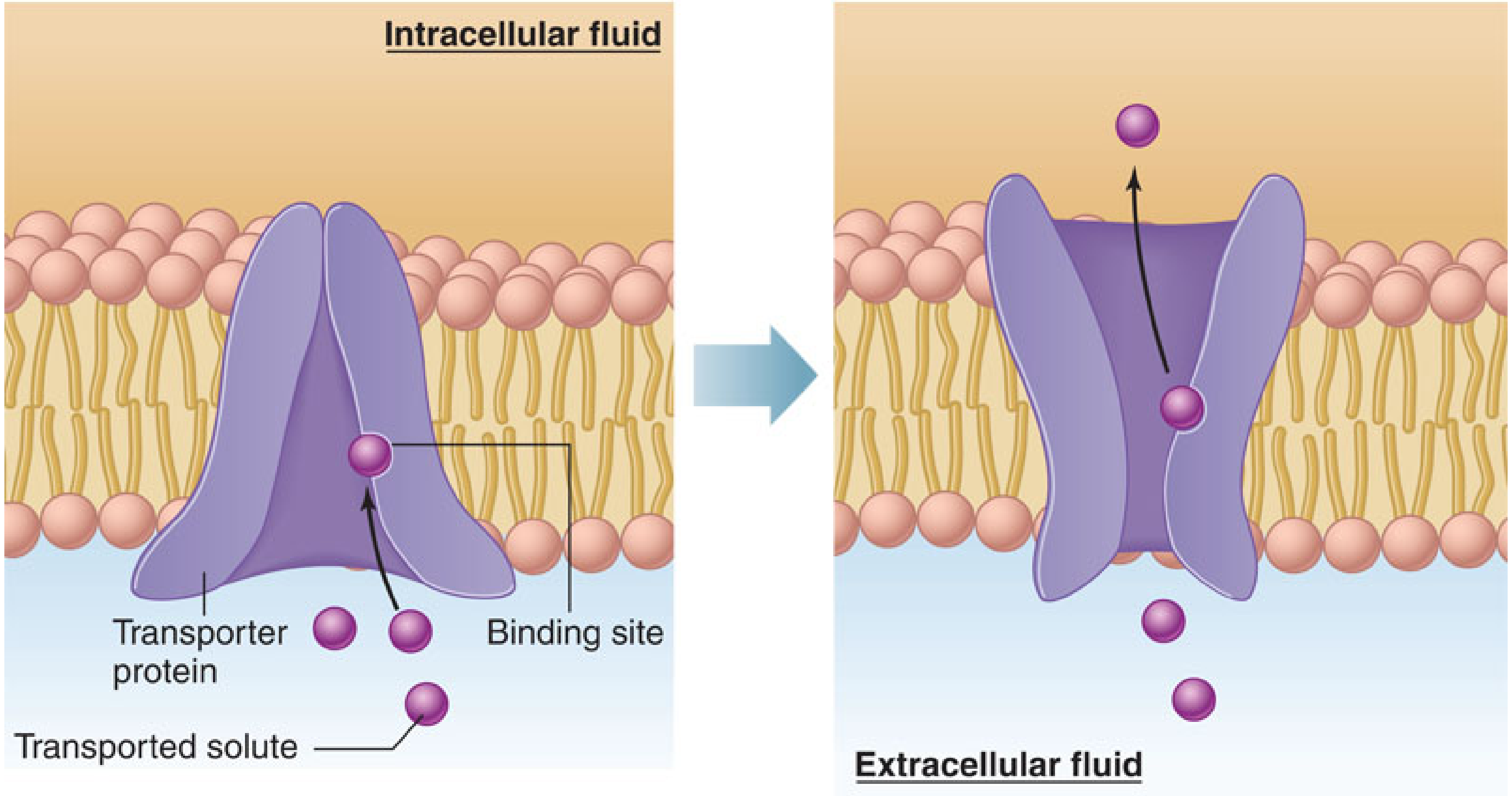
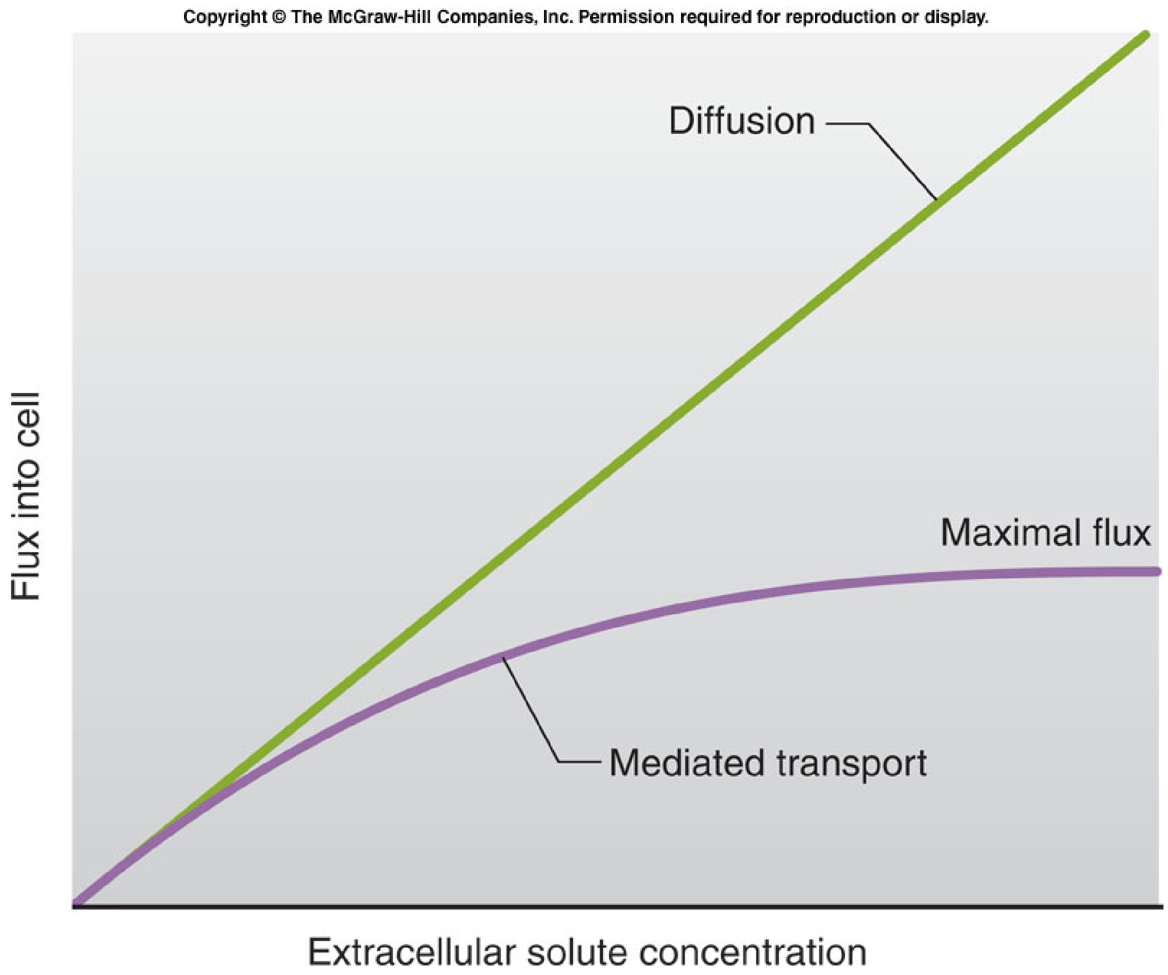


The solute acts as a ligand that binds to the transporter protein….

… and then a subsequent shape change in the protein releases the solute on the other side of the membrane.

Figure 4-8

Figure 4-9

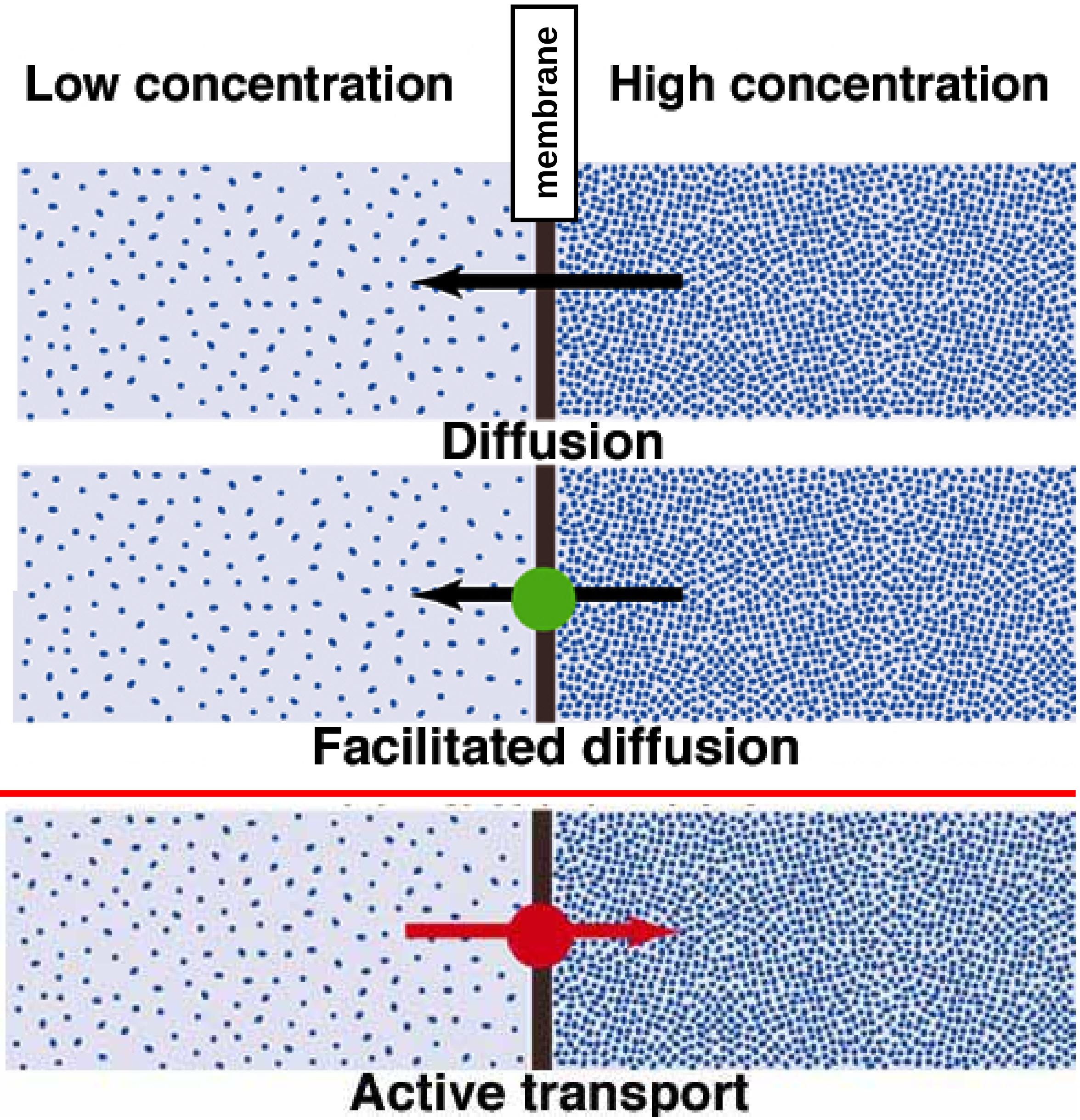


In simple diffusion, flux rate is limited only by the concentration gradient.

In carrier-mediated transport, the number of available carriers places an upper limit on the flux rate.

Figure 4-10

In both simple and facilitated diffusion, solutes move in the direction predicted by the concentration gradient.



In active transport, solutes move opposite to the direction predicted by the concentration gradient.

Models showing how active transport might operate.

The transported solute binds to the protein as it is phosphorylated (ATP expense).

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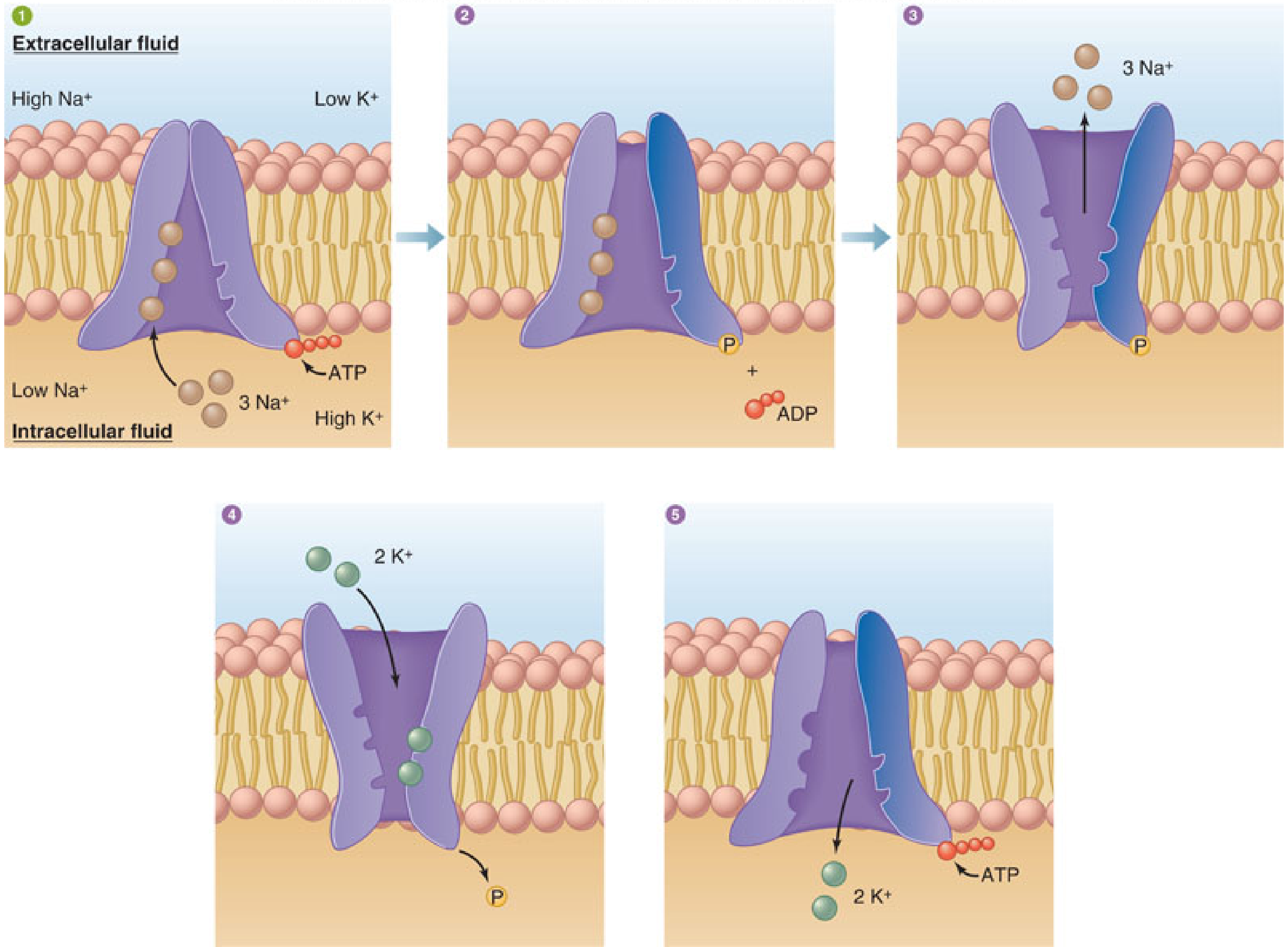

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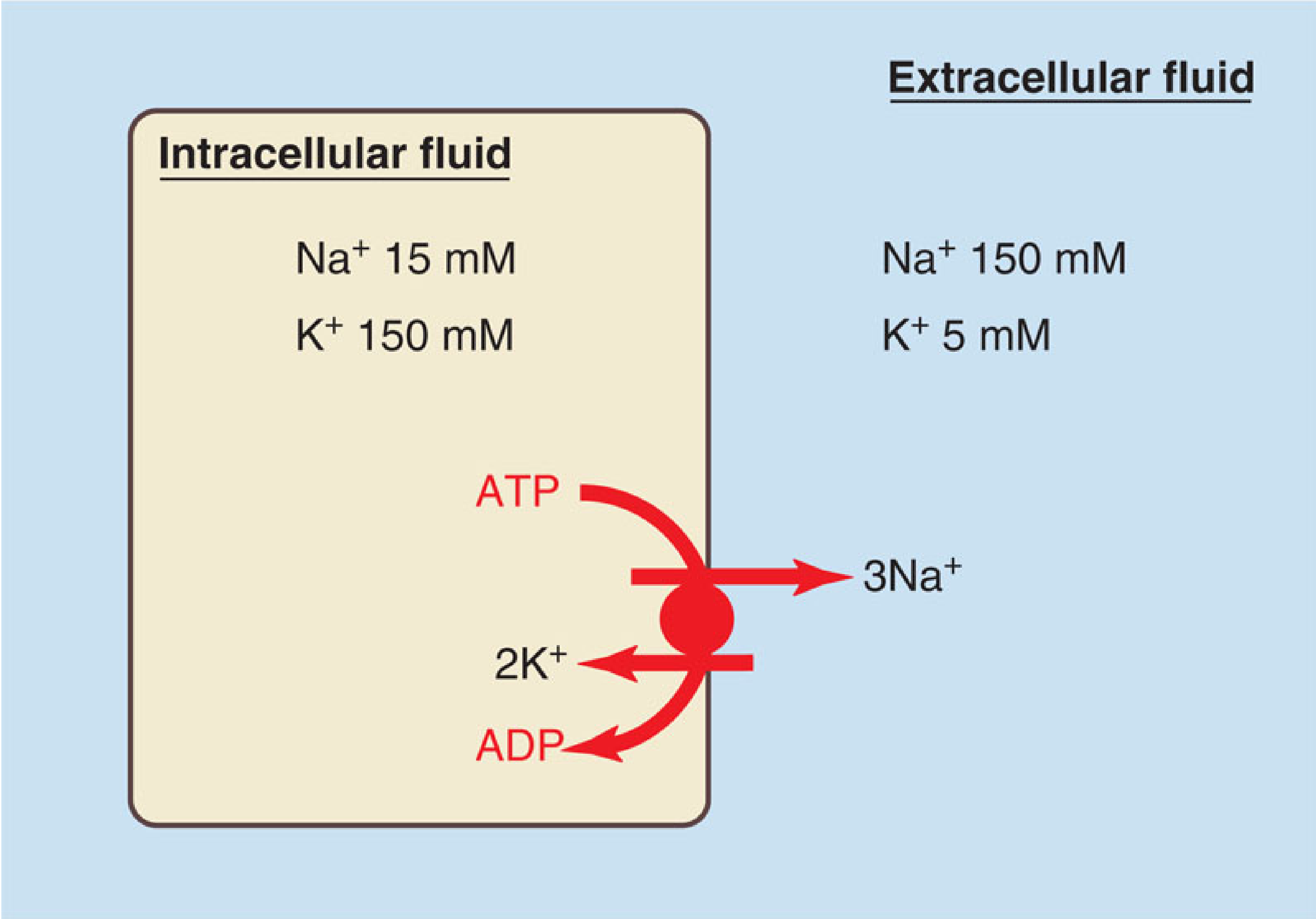

Here, in the operation of the Na^+-K^+-ATPase, also known as the "sodium pump," each ATP hydrolysis moves three sodium ions out of, and two potassium ions into, the cell.

Figure 4-12

Click here to play the Primary Active Transport Flash Animation

Figure 4-13

Secondary active transport uses the energy in an ion gradient to move a second solute.

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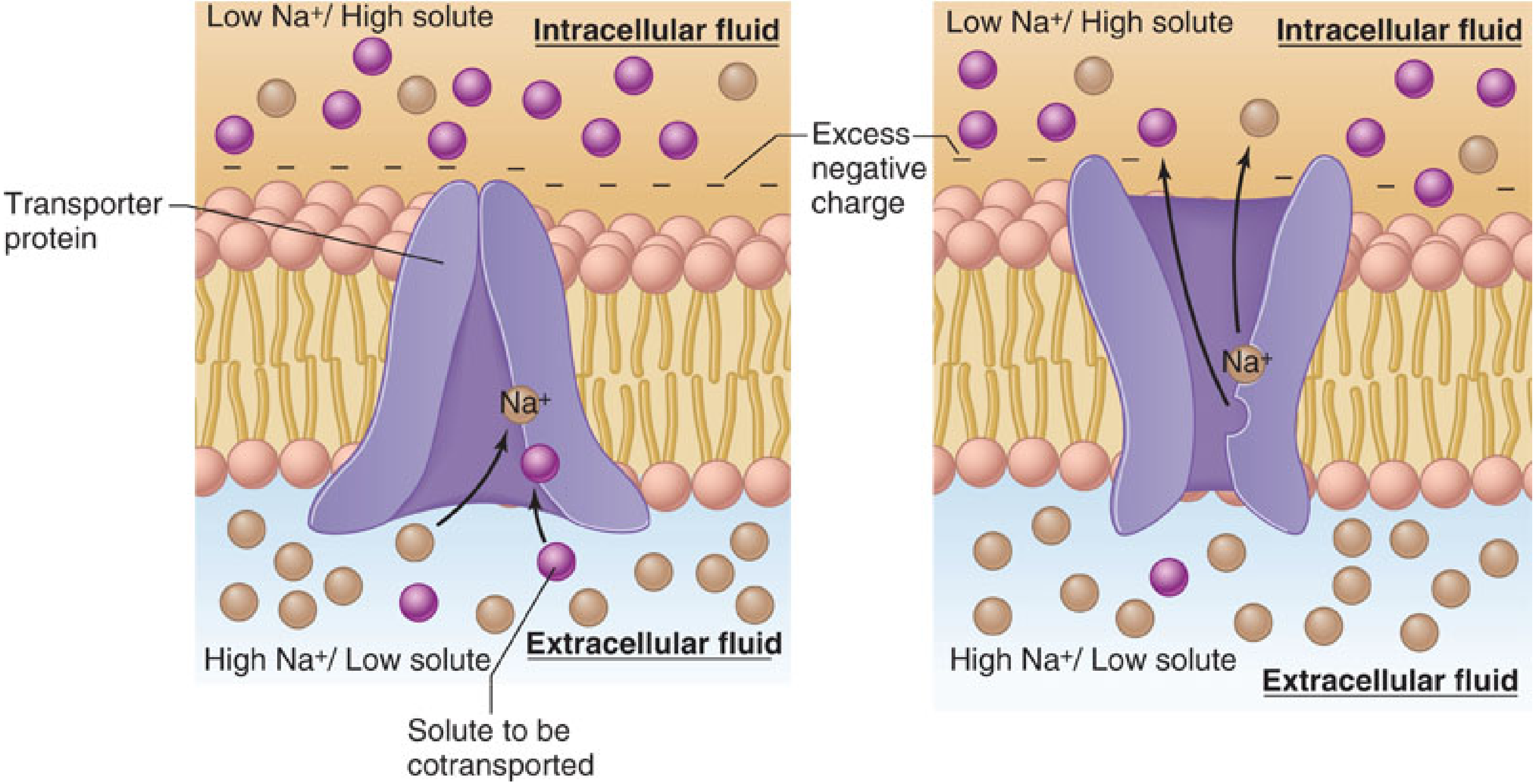

Click here to play the Secondary Active Transport Flash Animation

Figure 4-14

Cotransport:
the ion and the second solute cross the membrane in the same direction.

Countertransport:
the ion and the second solute move in opposite directions.

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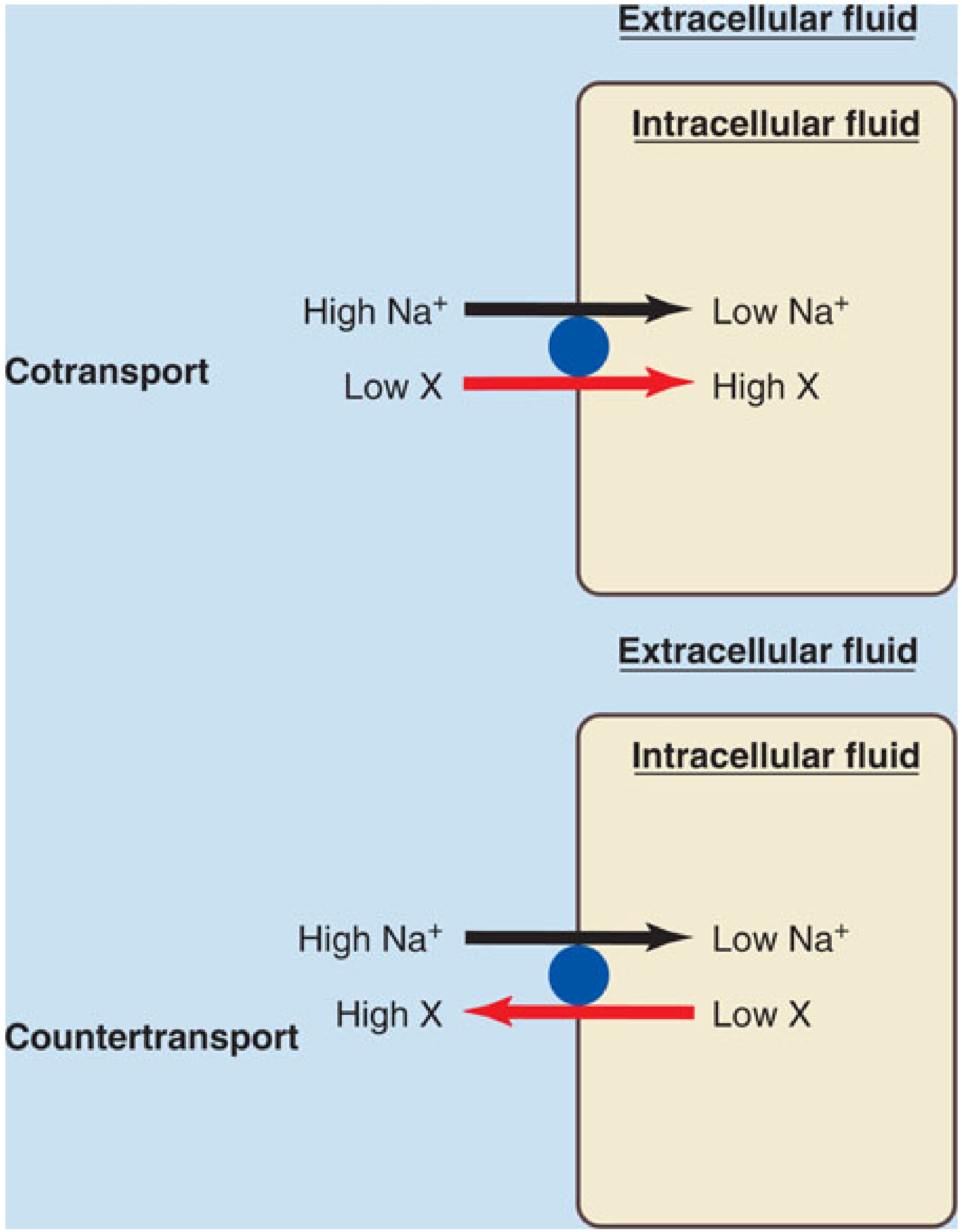


Diverse examples of carrier-mediated transport.

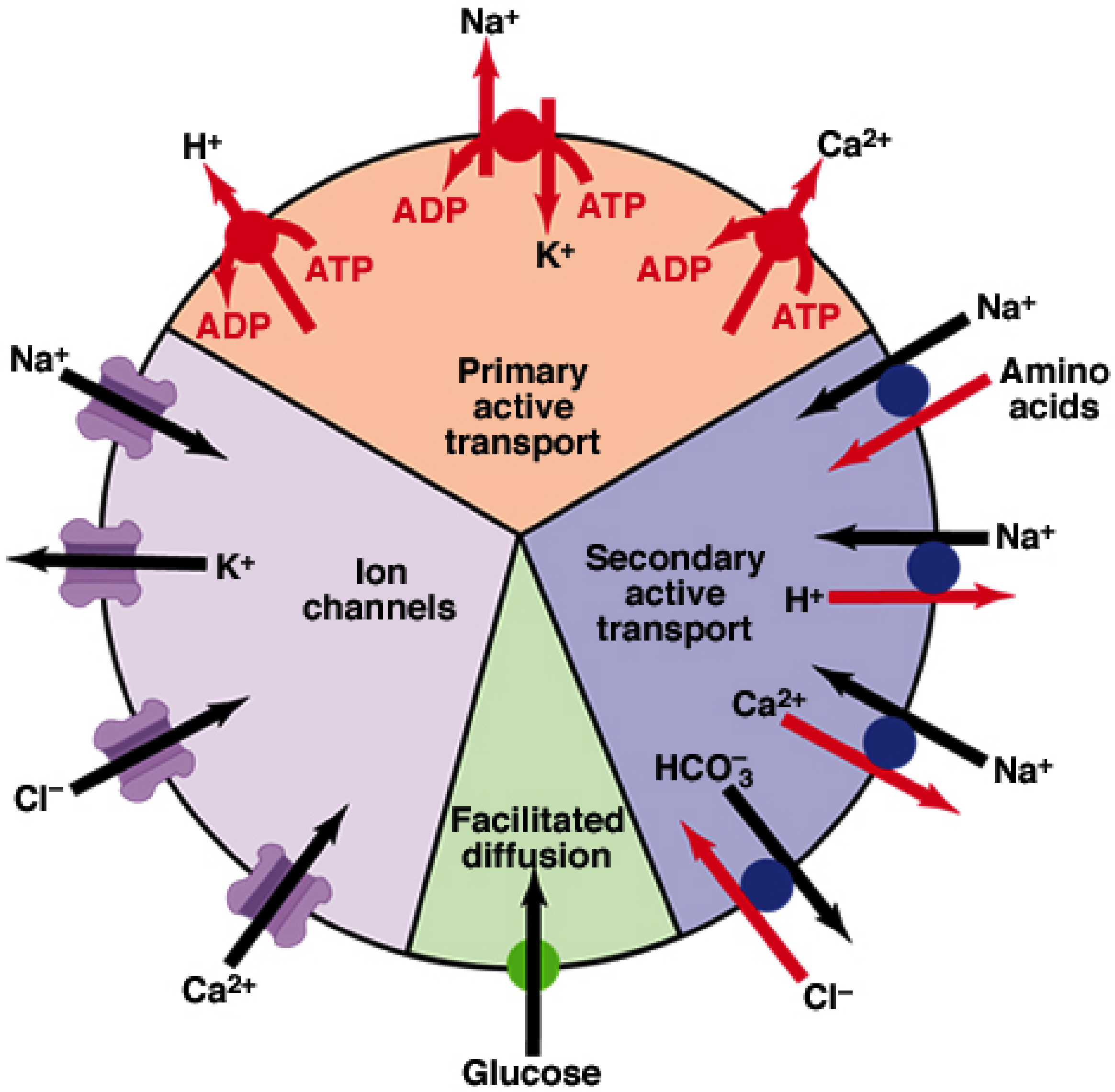


Figure 4-15

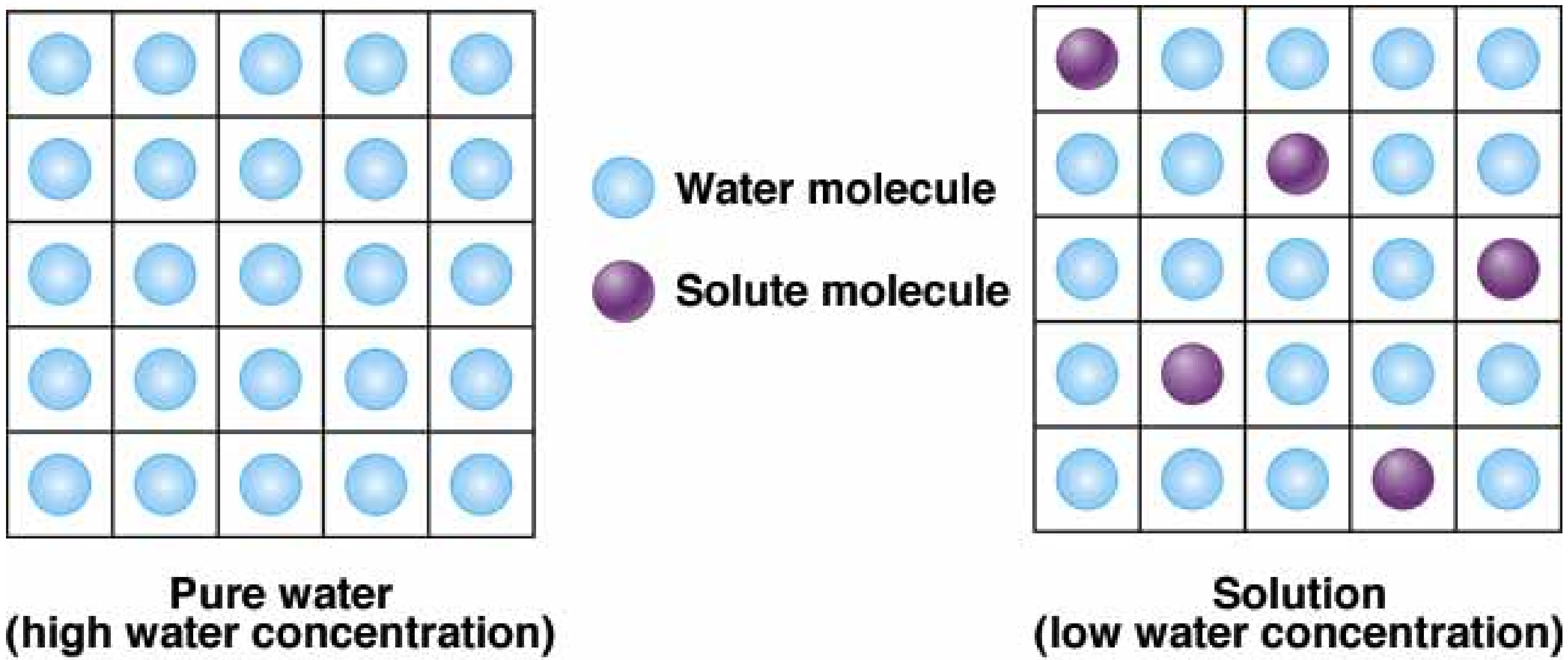
TABLE 4–2 Major Characteristics of Pathways by which Substances Cross Membranes

	Diffusion		*Mediated Transport*		
	THROUGH LIPID BILAYER	THROUGH PROTEIN CHANNEL	FACILITATED DIFFUSION	PRIMARY ACTIVE TRANSPORT	SECONDARY ACTIVE TRANSPORT
Direction of net flux	High to low concentration	High to low concentration	High to low concentration	Low to high concentration	Low to high concentration
Equilibrium or steady state	$C_o = C_i$	$C_o = C_i$*	$C_o = C_i$	$C_o \neq C_i$	$C_o \neq C_i$
Use of integral membrane protein	No	Yes	Yes	Yes	Yes
Maximal flux at high concentration (saturation)	No	No	Yes	Yes	Yes
Chemical specificity	No	Yes	Yes	Yes	Yes
Use of energy and source	No	No	No	Yes: ATP	Yes: ion gradient (often Na^+)
Typical molecules using pathway	Nonpolar: O_2, CO_2, fatty acids	Ions: Na^+, K^+, Ca^{2+}	Polar: glucose	Ions: Na^+, K^+, Ca^{2+}, H^+	Polar: amino acids, glucose, some ions

*In the presence of a membrane potential, the intracellular and extracellular ion concentrations will not be equal at equilibrium.

Figure 4-16

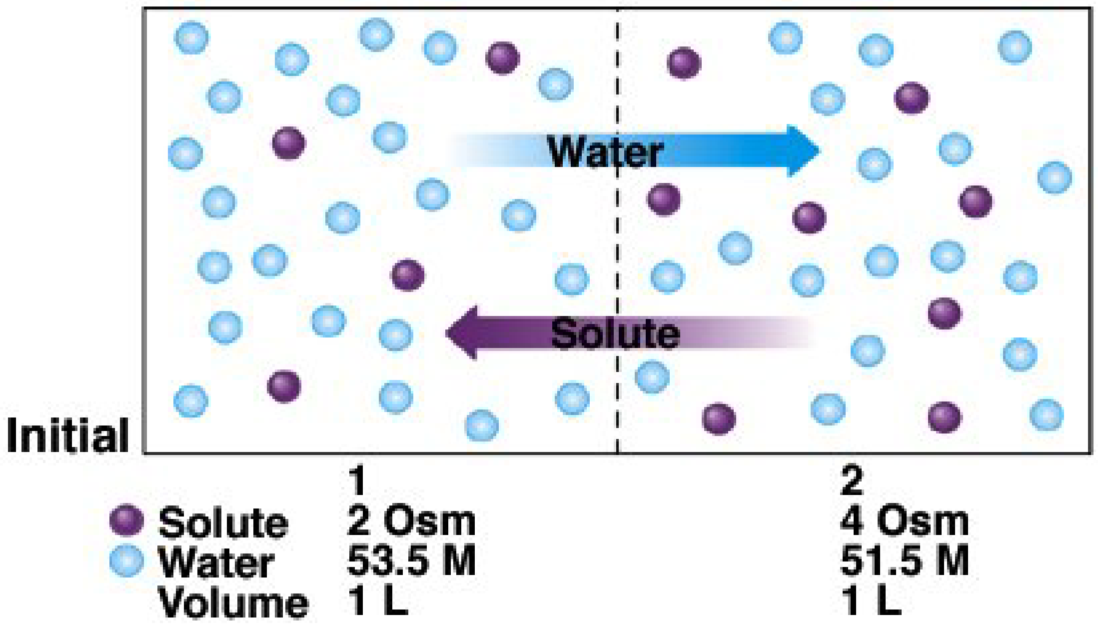
Solvent + Solute = Solution



Here, water is the solvent. The addition of solute lowers the water concentration. Addition of more solute would increase the solute concentration and further reduce the water concentration.

Figure 4-17

Begin:
The partition between the compartments is permeable to water and to the solute.



After diffusional equilibrium has occurred:
Movement of water and solutes has equalized solute and water concentrations on both sides of the partition.

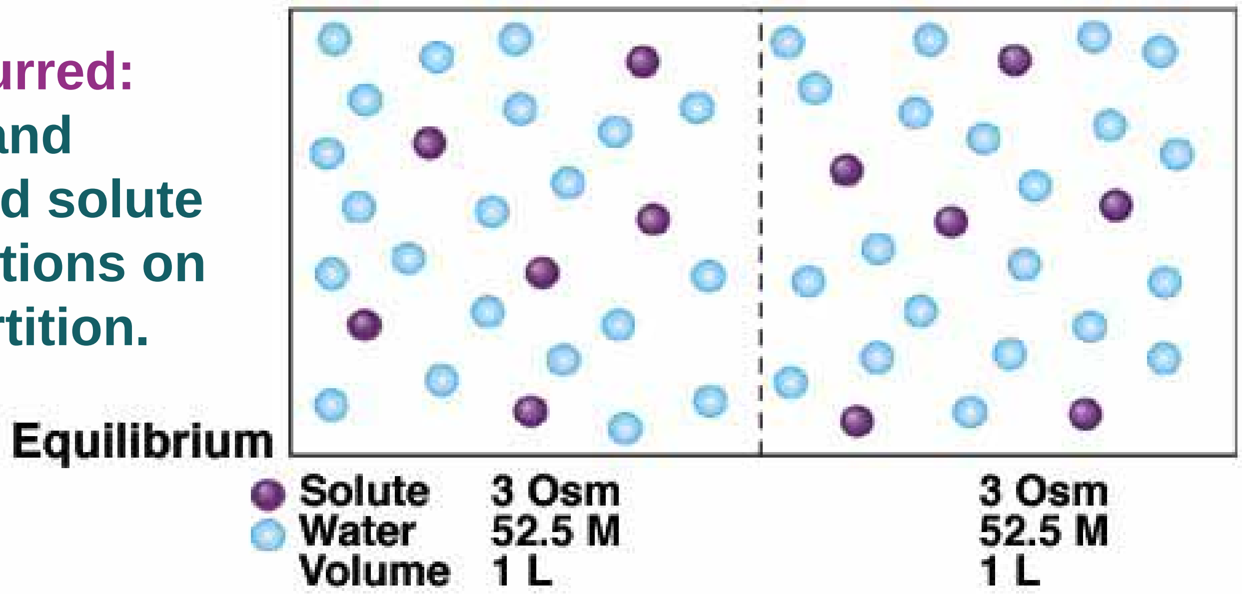
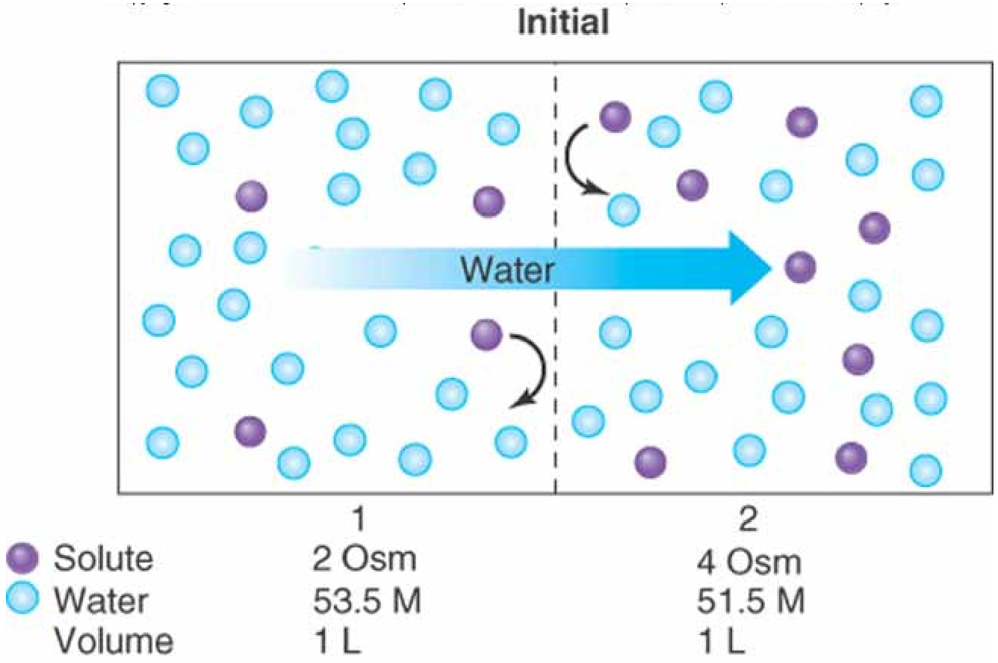
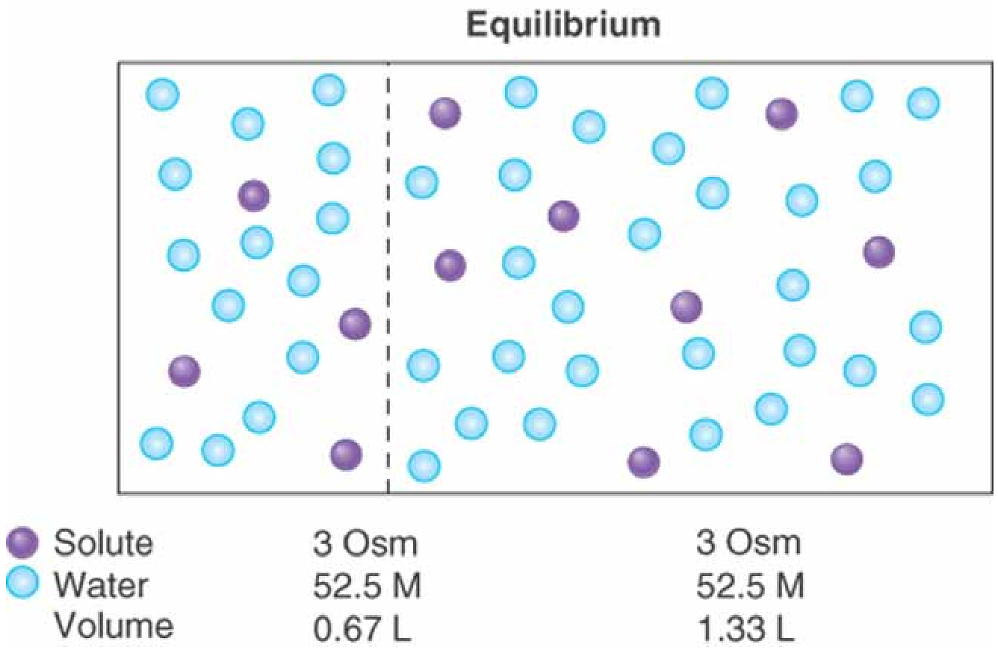


Figure 4-18

Begin:
The partition between the compartments is permeable to water only.



After diffusional equilibrium has occurred:
Movement of water only has equalized solute concentration.



Click here to play the Osmosis Flash Animation

Figure 4-19

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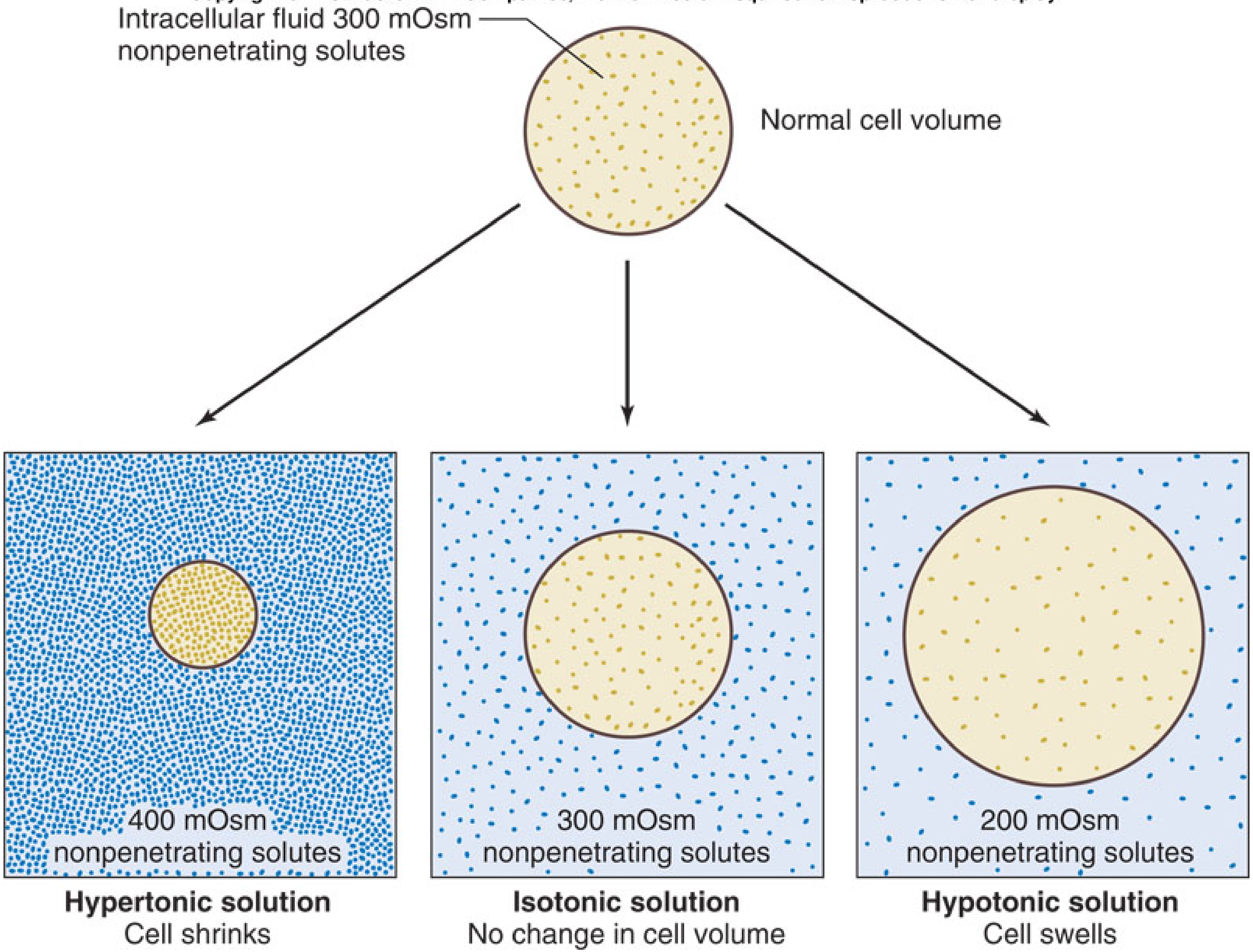

Figure 4-20

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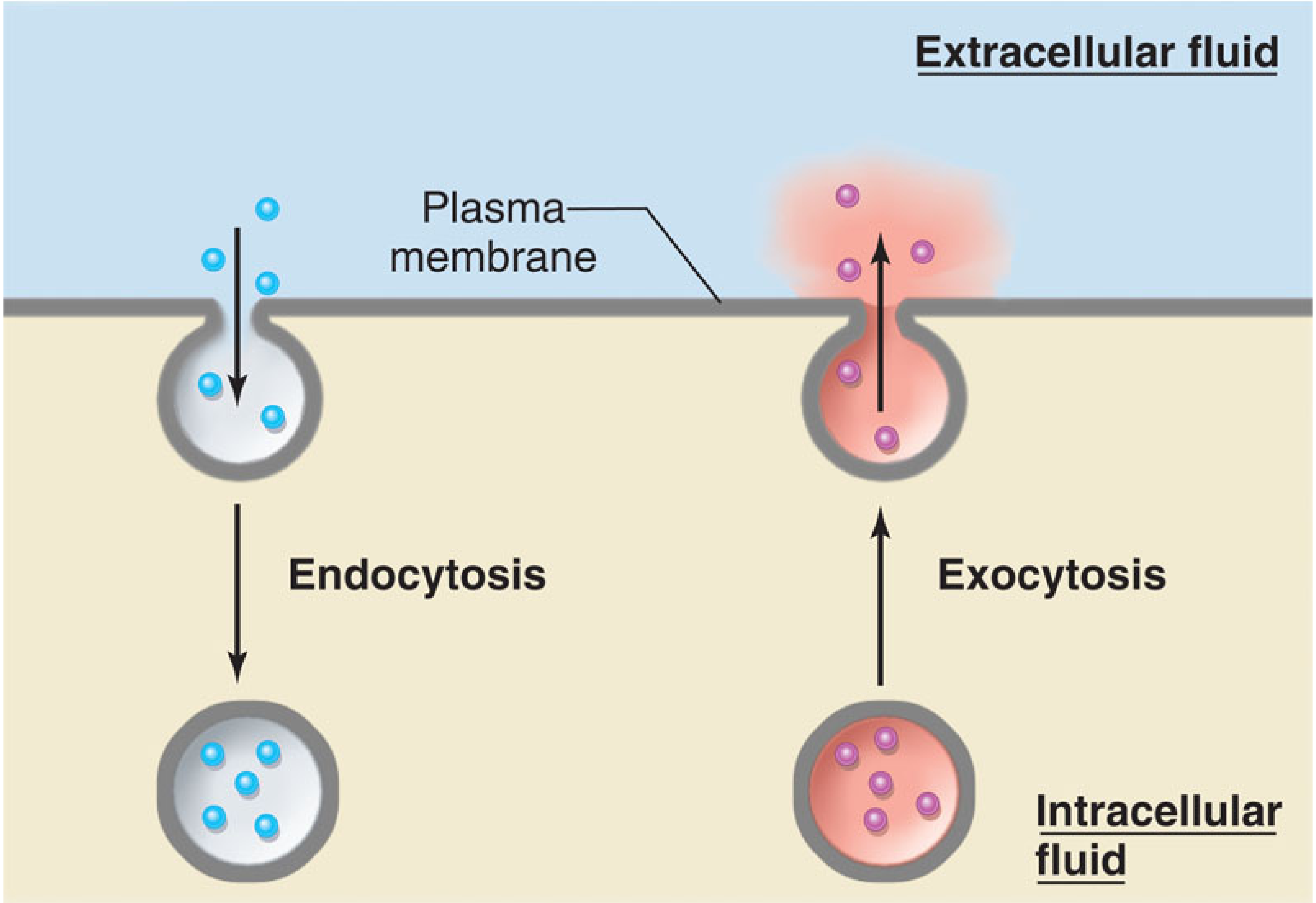
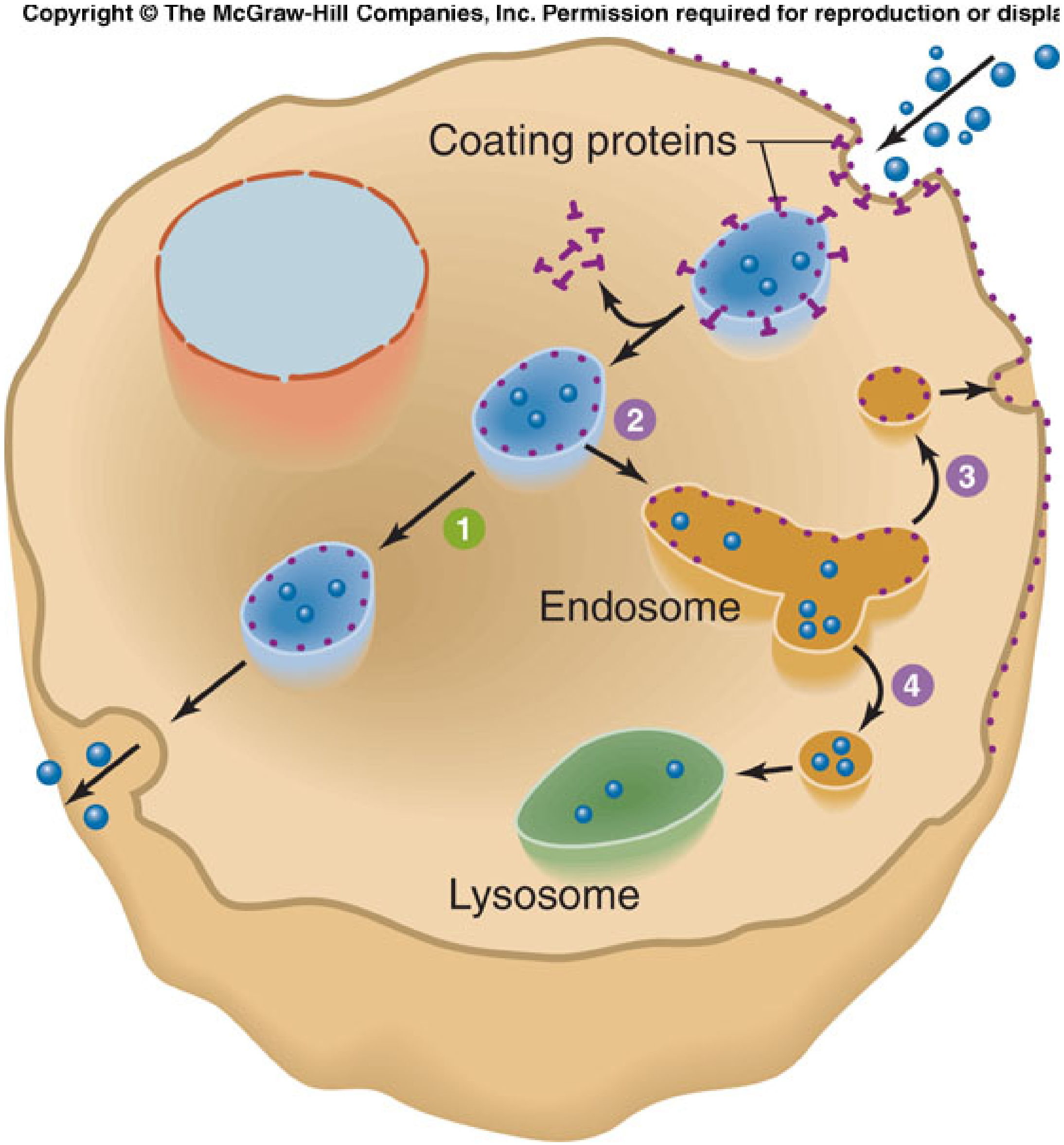


Figure 4-21

Alternative functions of endocytosis:

1. Transcellular transport
2. Endosomal processing
3. Recycling the membrane
4. Destroying engulfed materials



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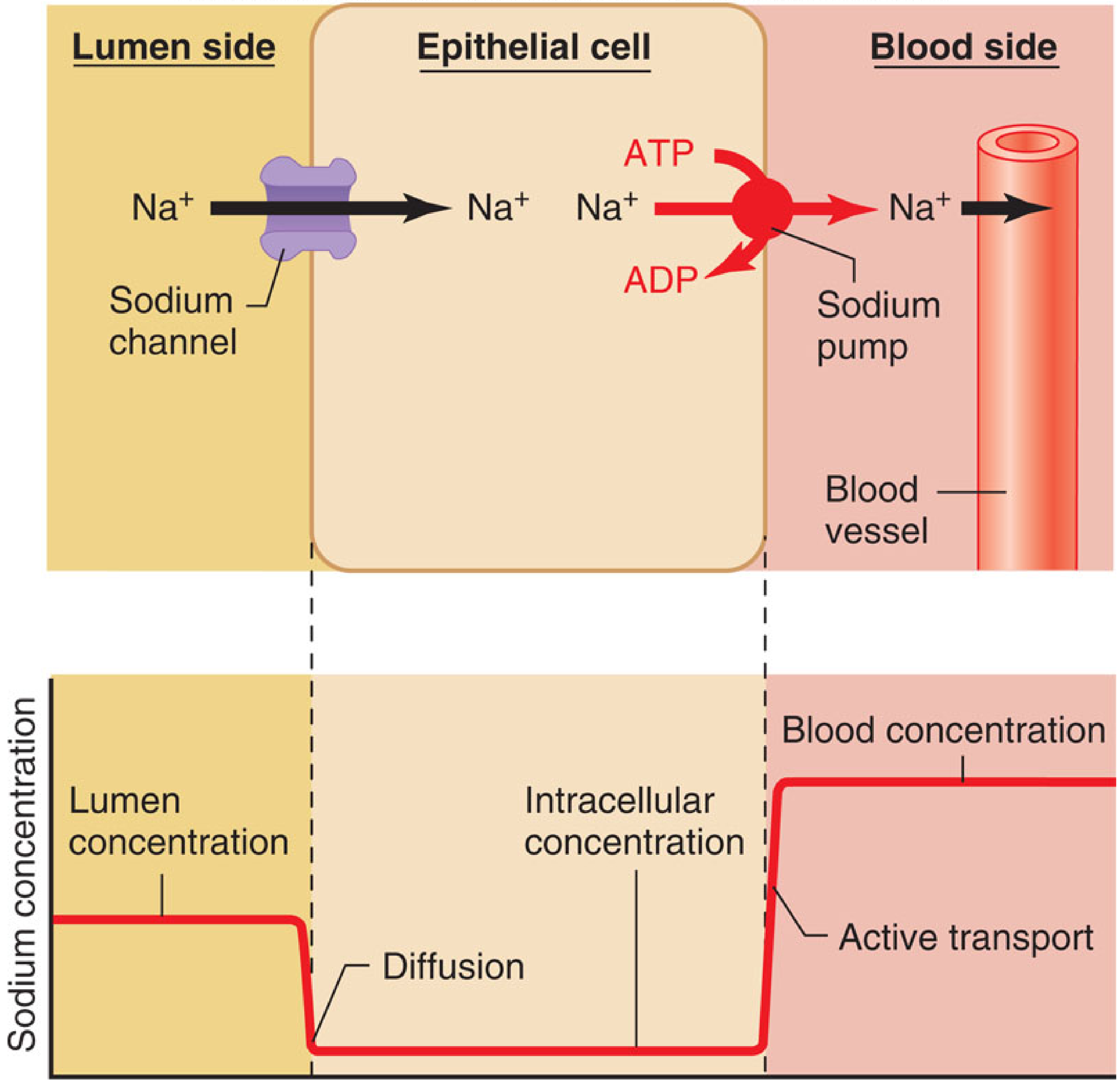

Figure 4-22

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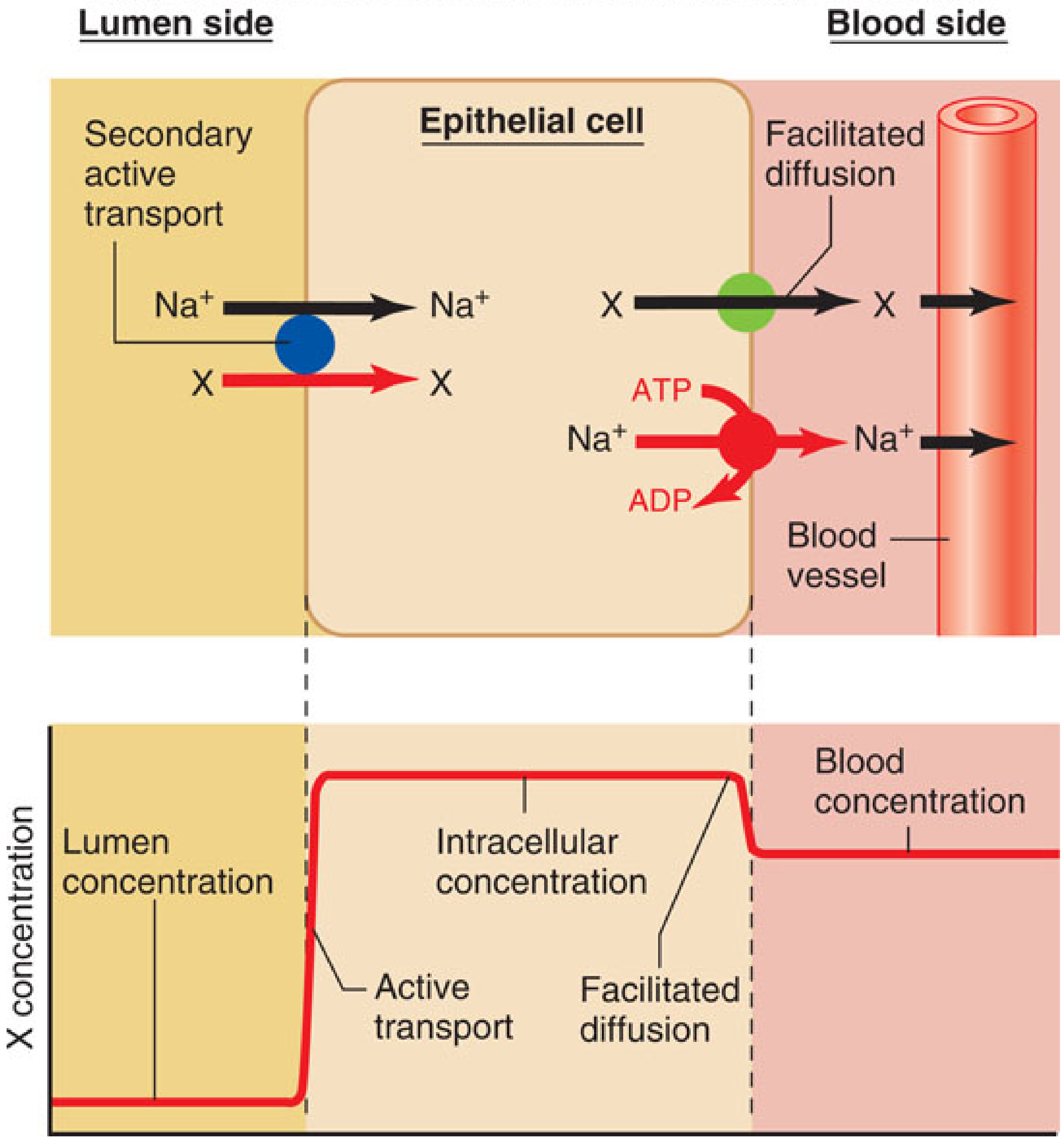

Figure 4-23

Figure 4-24

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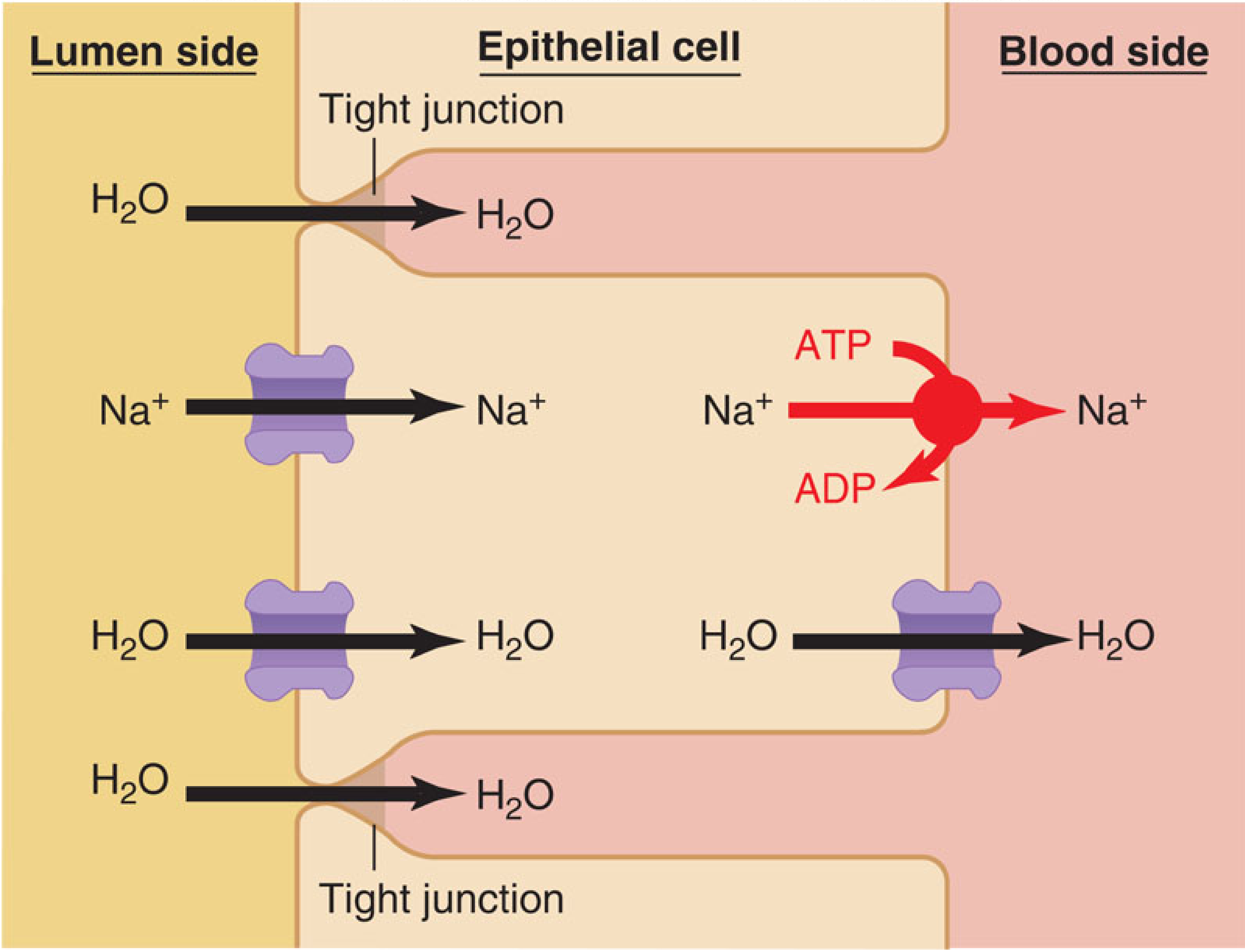

Figure 4-25

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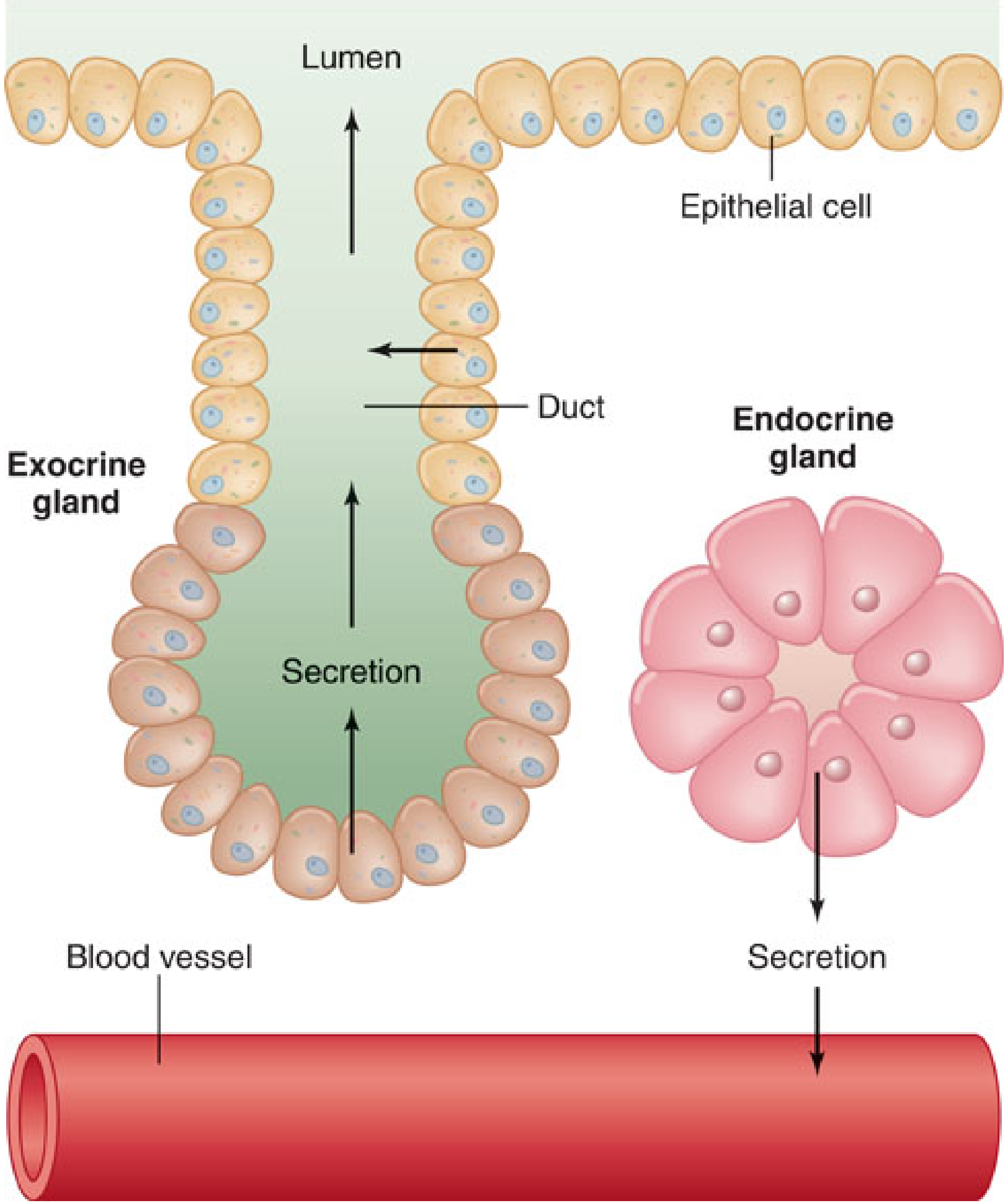

The End.