تَنوير

BIOLOGY

Lec no : 9 + 10

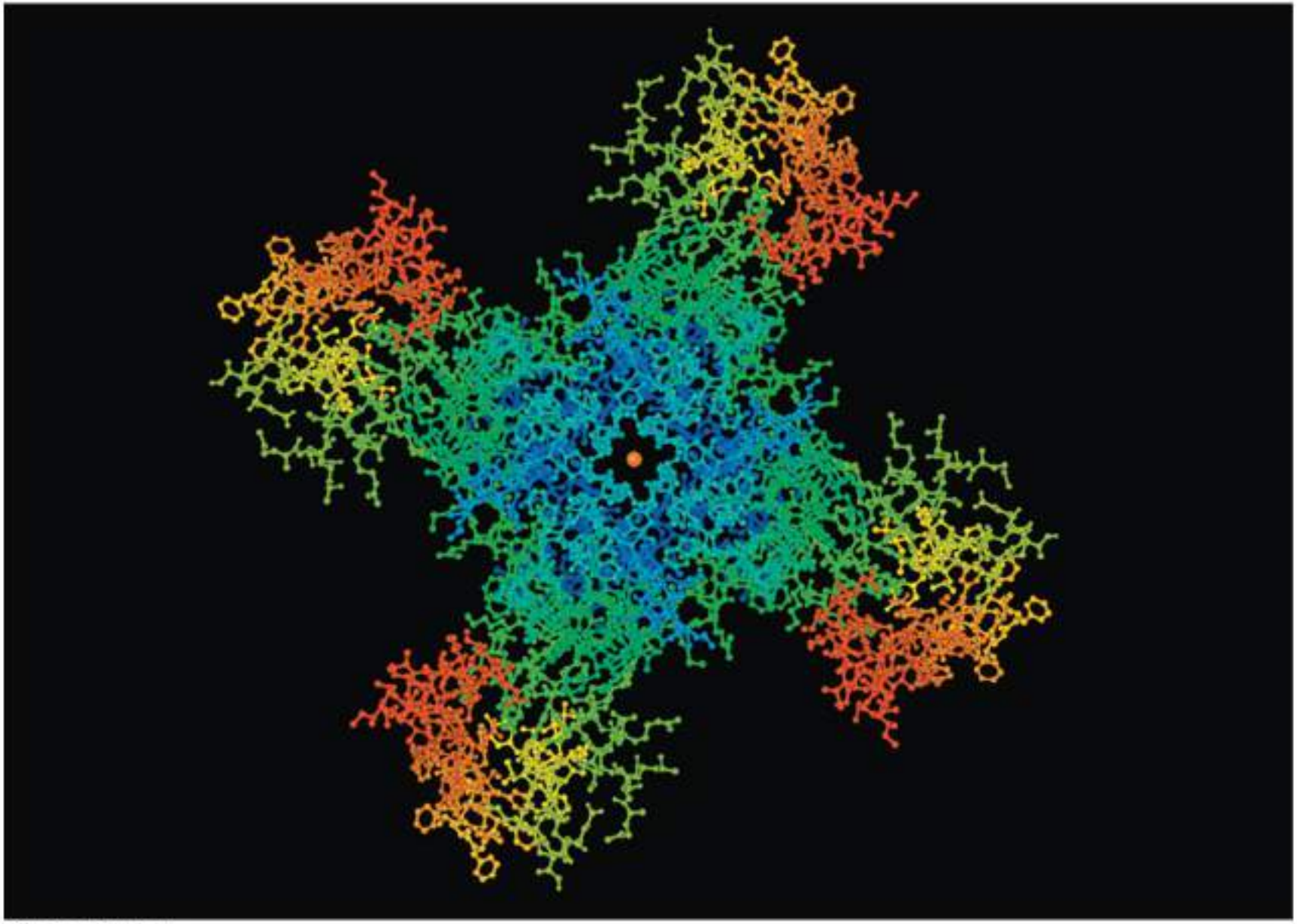
File Title : Chapter 8

Done By : Anas Malek

Overview: Life at the Edge

- The plasma membrane is the boundary that separates the living cell from its surroundings
- The plasma membrane exhibits **selective permeability**, allowing some substances to cross it more easily than others

Figure 7.1



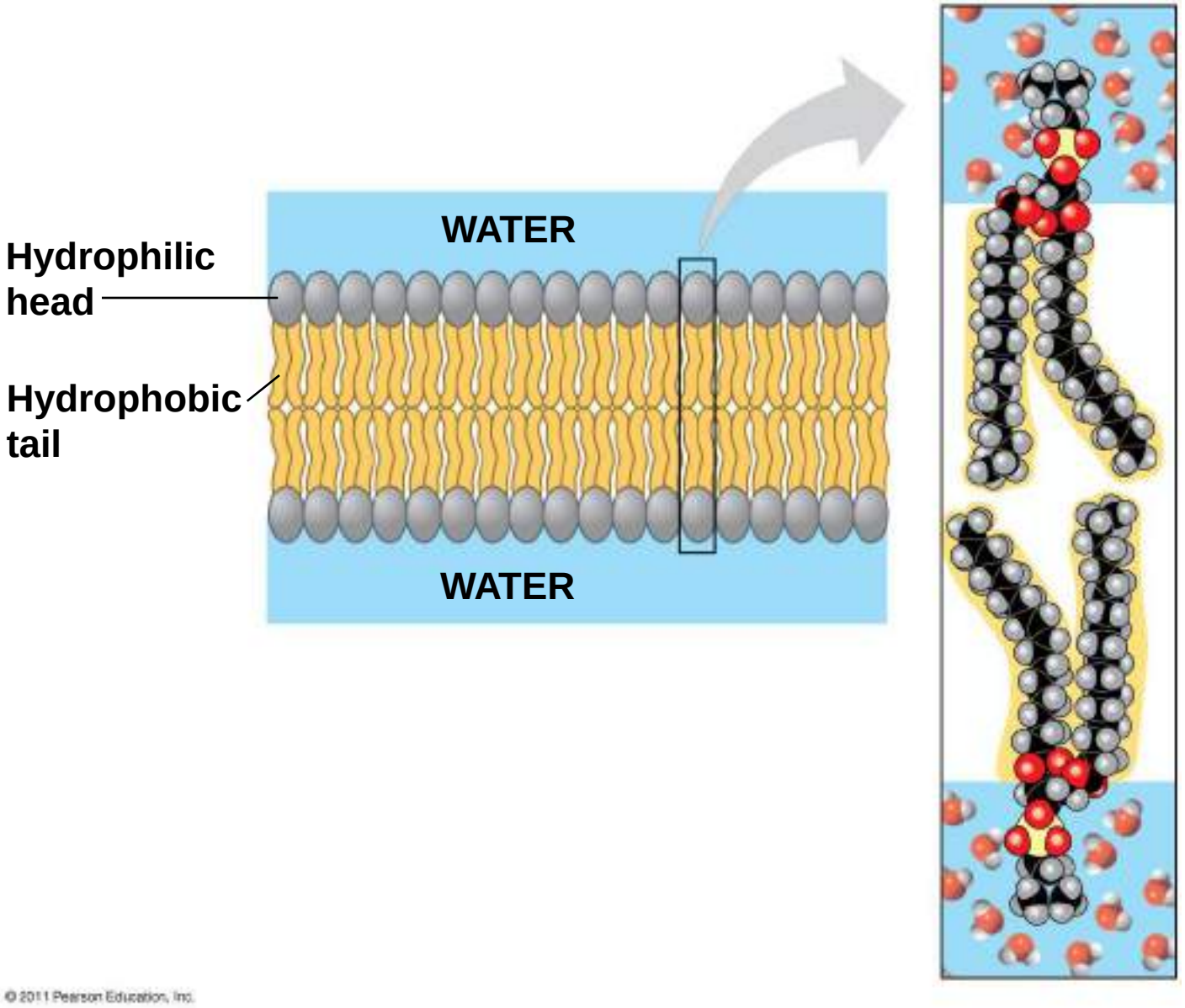
Concept 7.1: Cellular membranes are fluid mosaics of lipids and proteins

- Phospholipids are the most abundant lipid in the plasma membrane
- Phospholipids are **amphipathic molecules**, containing hydrophobic and hydrophilic regions
- The **fluid mosaic model** states that a membrane is a fluid structure with a "mosaic" of various proteins embedded in it

Membrane Models: *Scientific Inquiry*

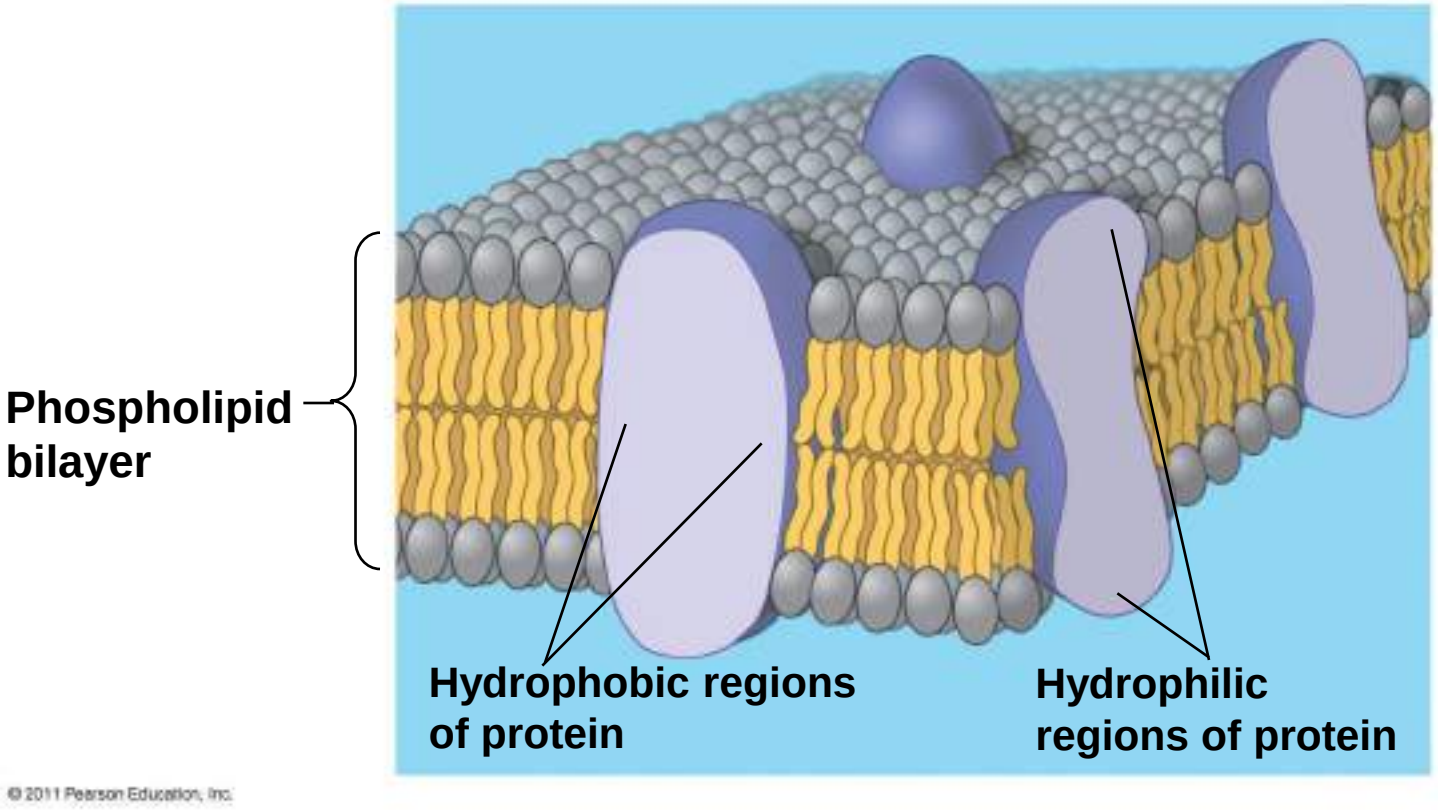
- Membranes have been chemically analyzed and found to be made of proteins and lipids
- Scientists studying the plasma membrane reasoned that it must be a phospholipid bilayer

Figure 7.2



- In 1935, Hugh Davson and James Danielli proposed a sandwich model in which the phospholipid bilayer lies between two layers of globular proteins
- Later studies found problems with this model, particularly the placement of membrane proteins, which have hydrophilic and hydrophobic regions
- In 1972, S. J. Singer and G. Nicolson proposed that the membrane is a mosaic of proteins dispersed within the bilayer, with only the hydrophilic regions exposed to water

Figure 7.3

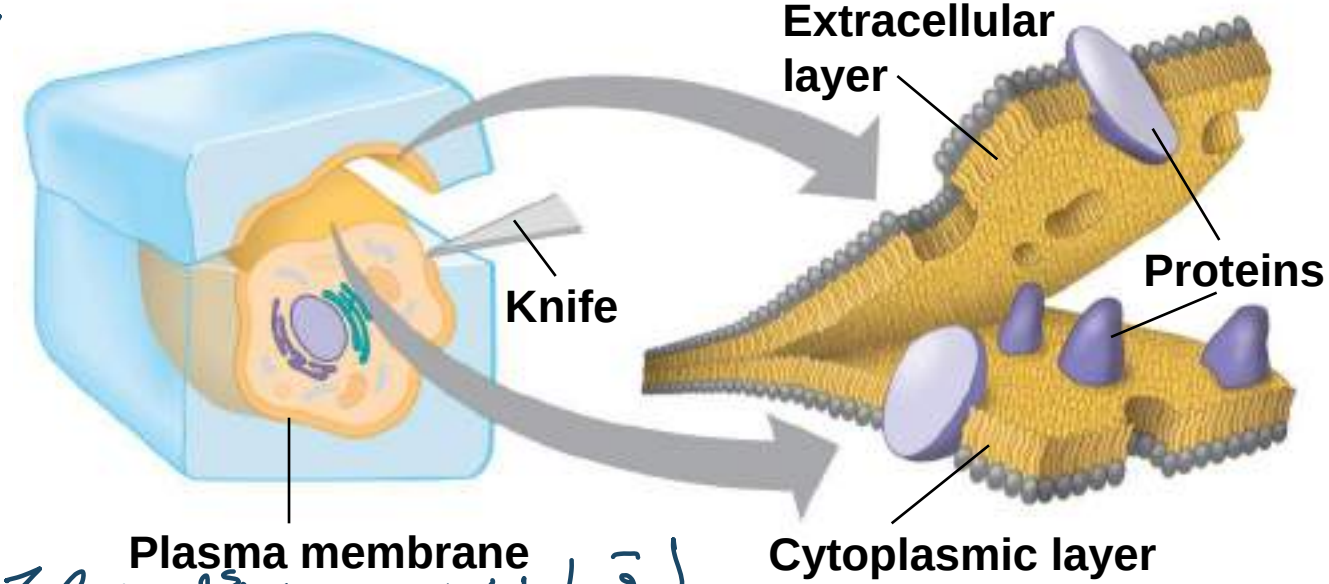


فعل بسی

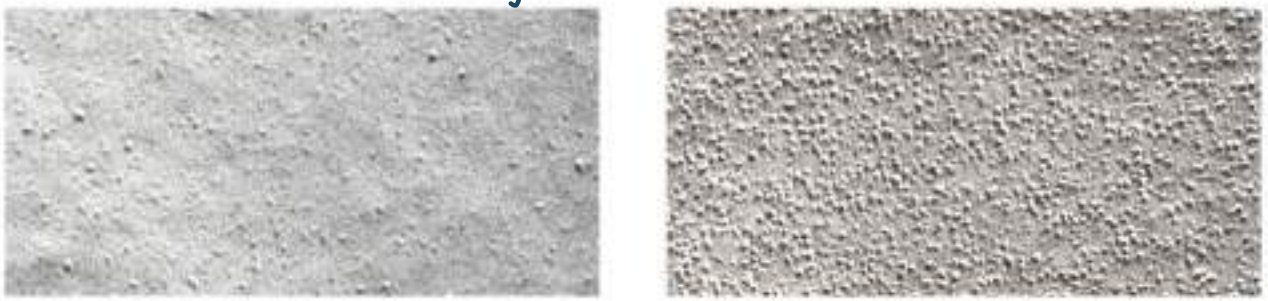
- Freeze-fracture studies of the plasma membrane supported the fluid mosaic model
- Freeze-fracture is a specialized preparation technique that splits a membrane along the middle of the phospholipid bilayer

Figure 7.4

TECHNIQUE



RESULTS



Inside of extracellular layer

Inside of cytoplasmic layer

Figure 7.4a

Inside of extracellular layer

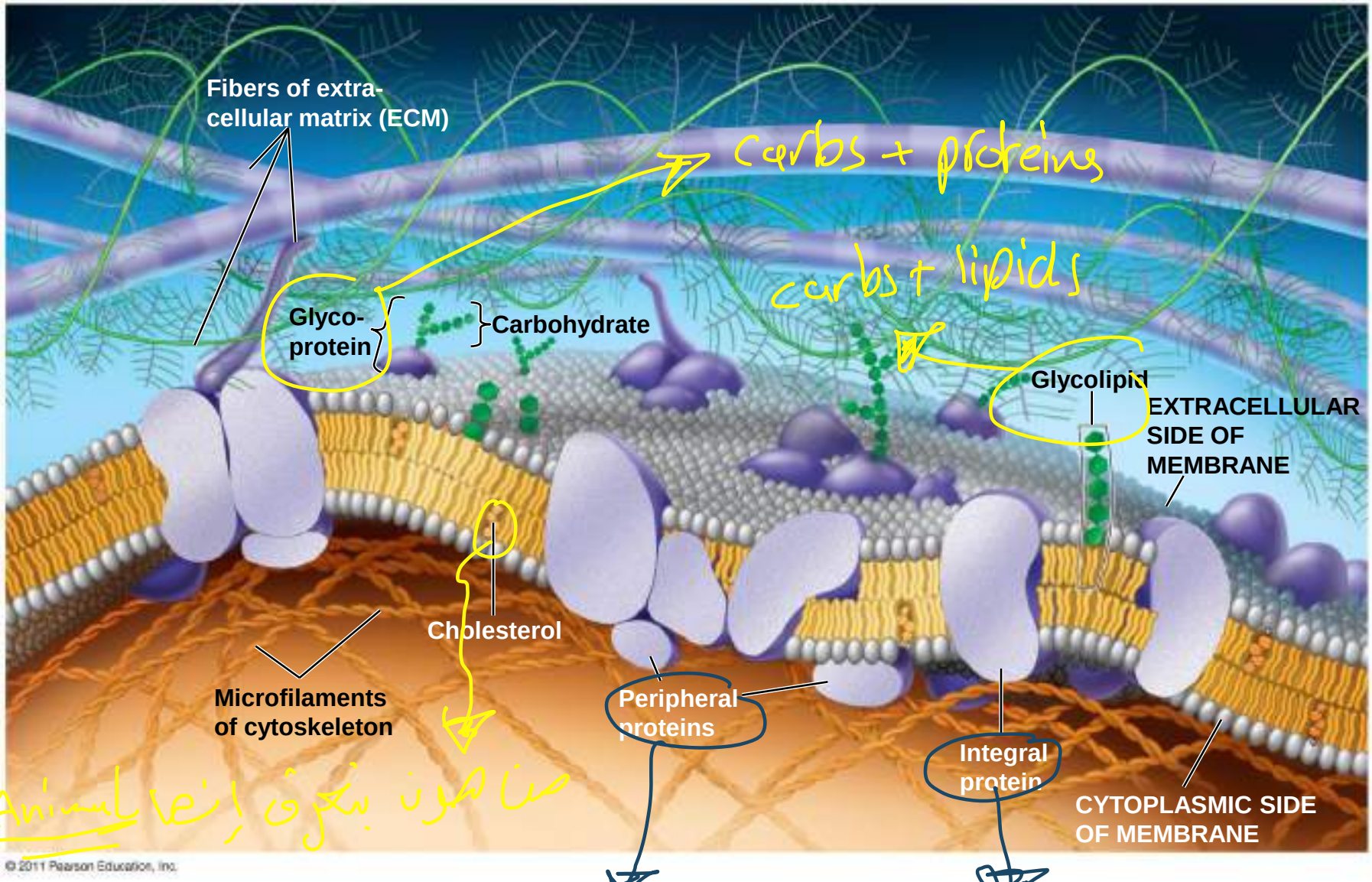
Figure 7.4b

Inside of cytoplasmic layer

The Fluidity of Membranes

- Phospholipids in the plasma membrane can move within the bilayer
- Most of the lipids, and some proteins, drift laterally
- Rarely does a molecule flip-flop transversely across the membrane

Figure 7.5


Fibers of extra-cellular matrix (ECM)
Glyco-protein
Carbohydrate
Glycolipid
EXTRACELLULAR SIDE OF MEMBRANE
Cholesterol
Microfilaments of cytoskeleton
Peripheral proteins
Integral protein
CYTOPLASMIC SIDE OF MEMBRANE
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∝ factors of fluidity of plasma membrane

(fluid مائع)

(1) Movement of phospholipids

(2) " " proteins

(3) Type of Fatty acids in phospholipids

(4) cholesterol (Temprature buffer)

High → fluidity الكوليسترول بقلل ال

low → fluidity الكوليسترول بزيد ال

Figure 7.6

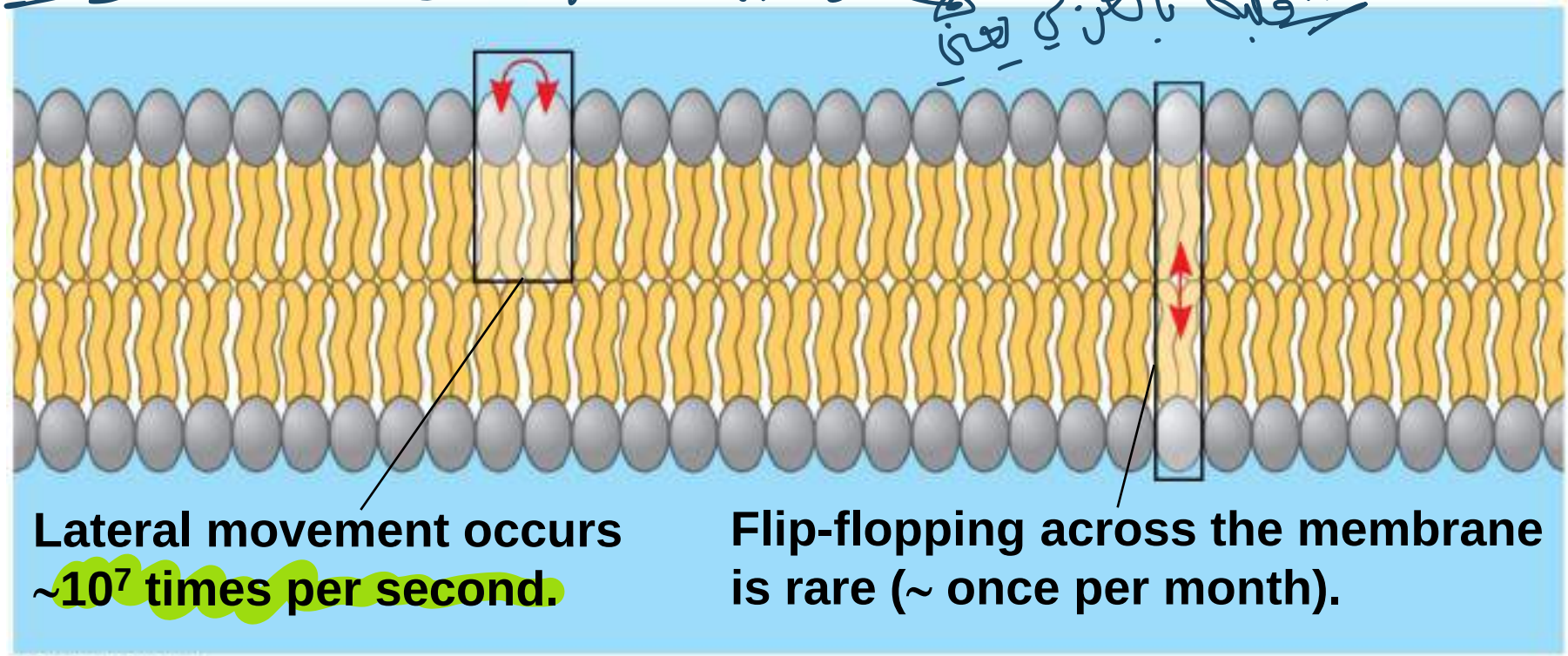
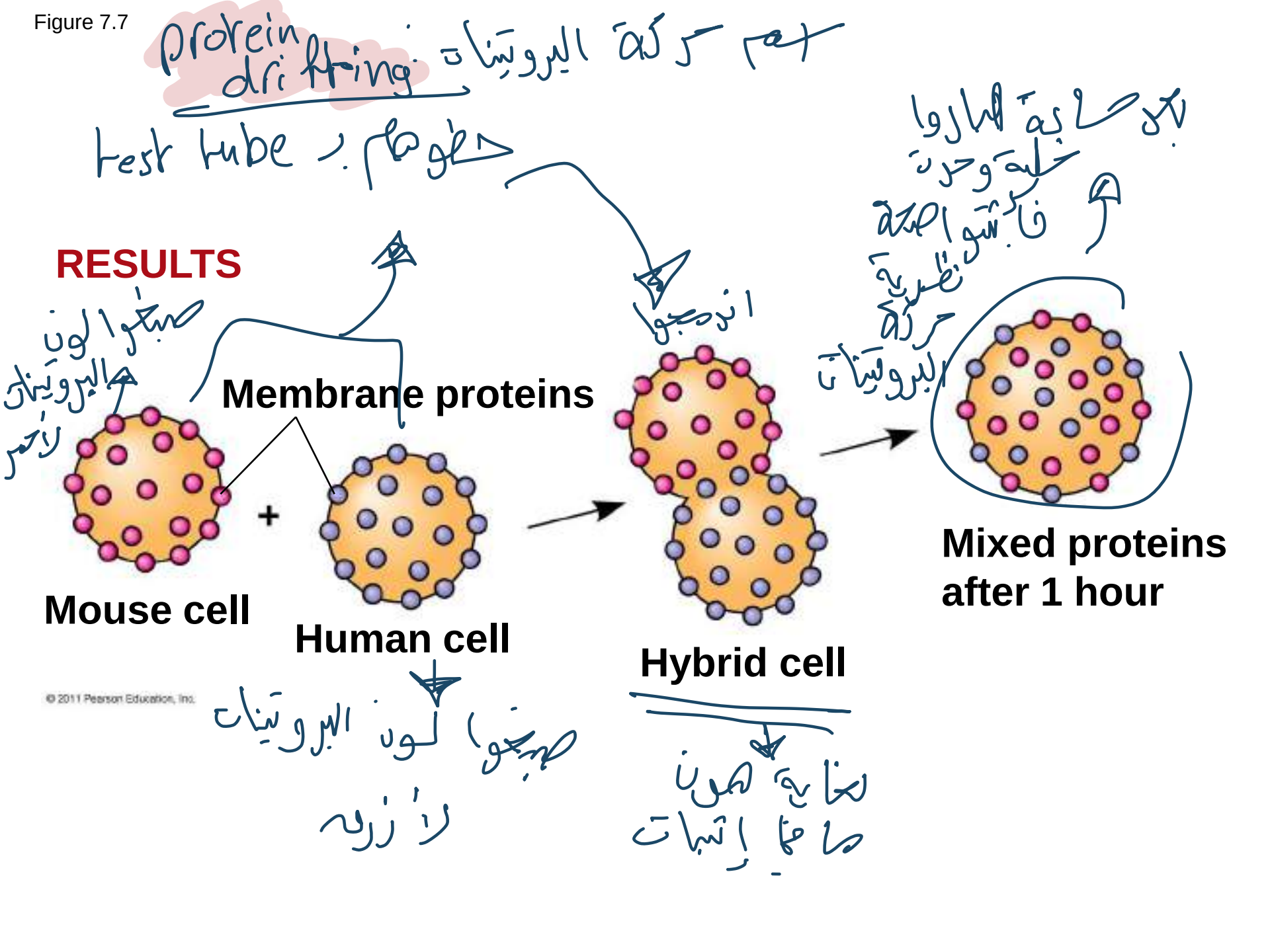


Figure 7.7


RESULTS
Membrane proteins
Mouse cell
Human cell
Hybrid cell
Mixed proteins after 1 hour
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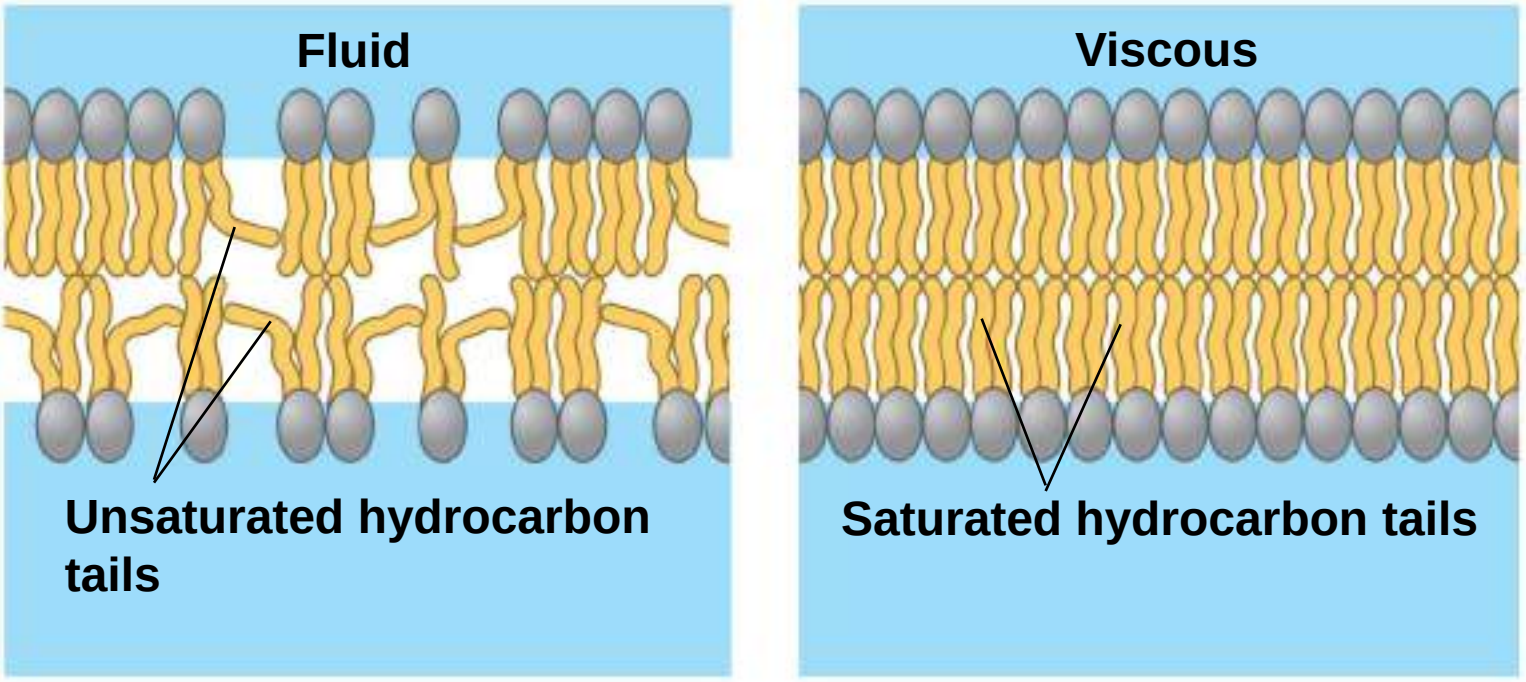
- As temperatures cool, membranes switch from a fluid state to a solid state
- The temperature at which a membrane solidifies depends on the types of lipids
- Membranes rich in unsaturated fatty acids are more fluid than those rich in saturated fatty acids
- Membranes must be fluid to work properly; they are usually about as fluid as salad oil

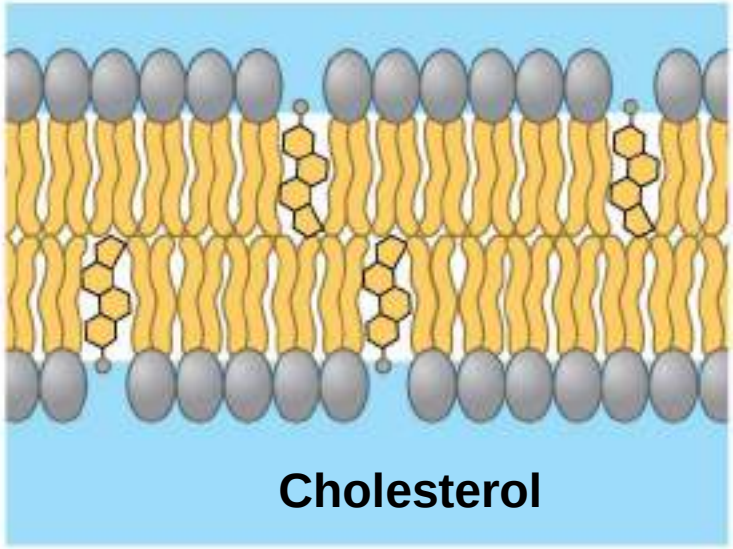
- The steroid cholesterol has different effects on membrane fluidity at different temperatures
- At warm temperatures (such as 37°C), cholesterol restrains movement of phospholipids
- At cool temperatures, it maintains fluidity by preventing tight packing

Figure 7.8



(a) Unsaturated versus saturated hydrocarbon tails

(b) Cholesterol within the animal cell membrane



Evolution of Differences in Membrane Lipid Composition

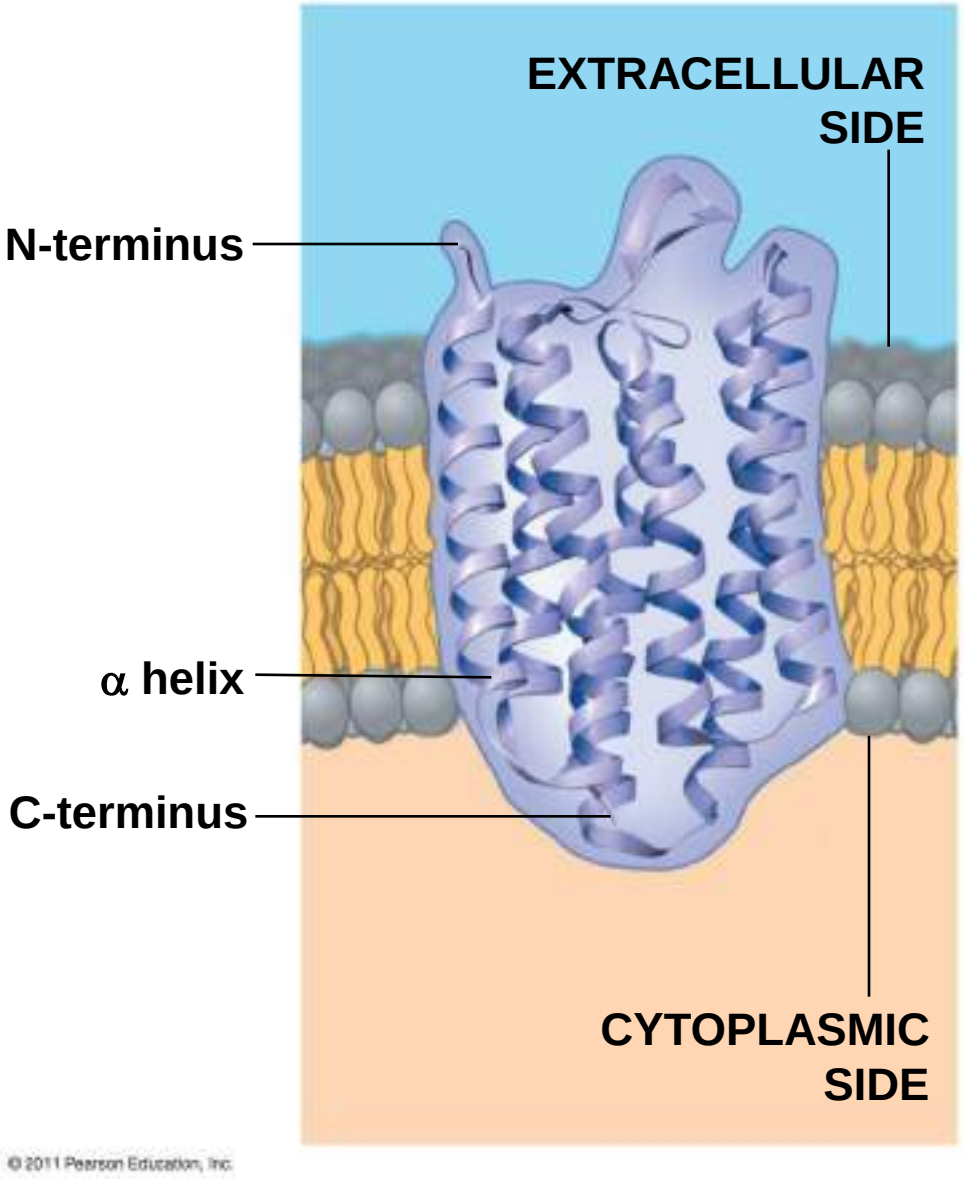
- Variations in lipid composition of cell membranes of many species appear to be adaptations to specific environmental conditions
- Ability to change the lipid compositions in response to temperature changes has evolved in organisms that live where temperatures vary

Membrane Proteins and Their Functions

- A membrane is a collage of different proteins, often grouped together, embedded in the fluid matrix of the lipid bilayer
- Proteins determine most of the membrane's specific functions

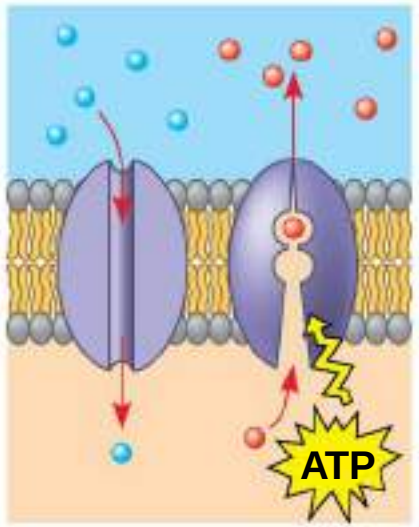
- **Peripheral proteins** are bound to the surface of the membrane
- **Integral proteins** penetrate the hydrophobic core
- Integral proteins that span the membrane are called transmembrane proteins
- The hydrophobic regions of an integral protein consist of one or more stretches of nonpolar amino acids, often coiled into alpha helices

Figure 7.9

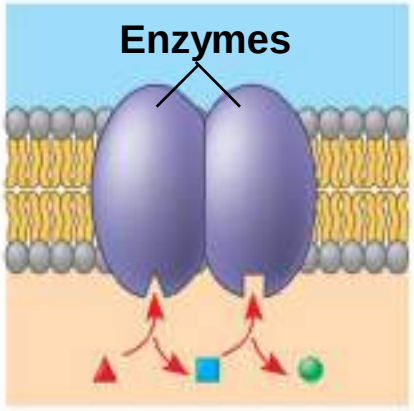

EXTRACELLULAR SIDE
N-terminus
α helix
C-terminus
CYTOPLASMIC SIDE
© 2011 Pearson Education, Inc.

- Six major functions of membrane proteins
  - (1) – Transport
  - (2) – Enzymatic activity
  - (3) – Signal transduction
  - (4) – Cell-cell recognition
  - (5) – Intercellular joining
  - (6) – Attachment to the cytoskeleton and extracellular matrix (ECM)

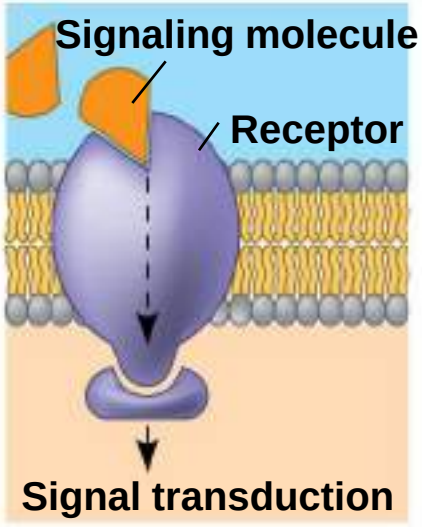
Figure 7.10



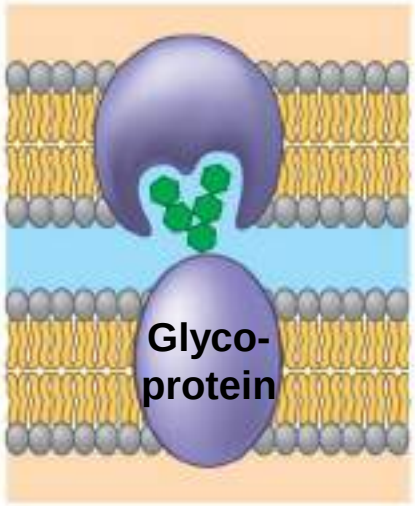
(a) Transport



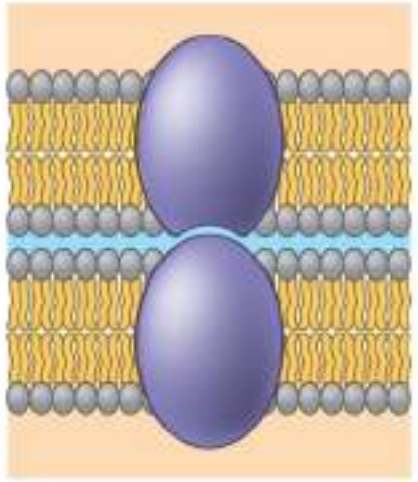
(b) Enzymatic activity



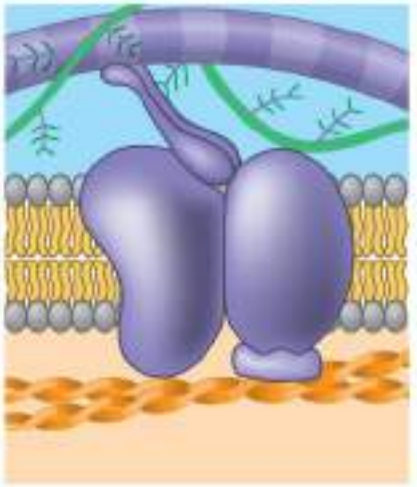
(c) Signal transduction



(d) Cell-cell recognition



(e) Intercellular joining



(f) Attachment to the cytoskeleton and extracellular matrix (ECM)

Figure 7.10a

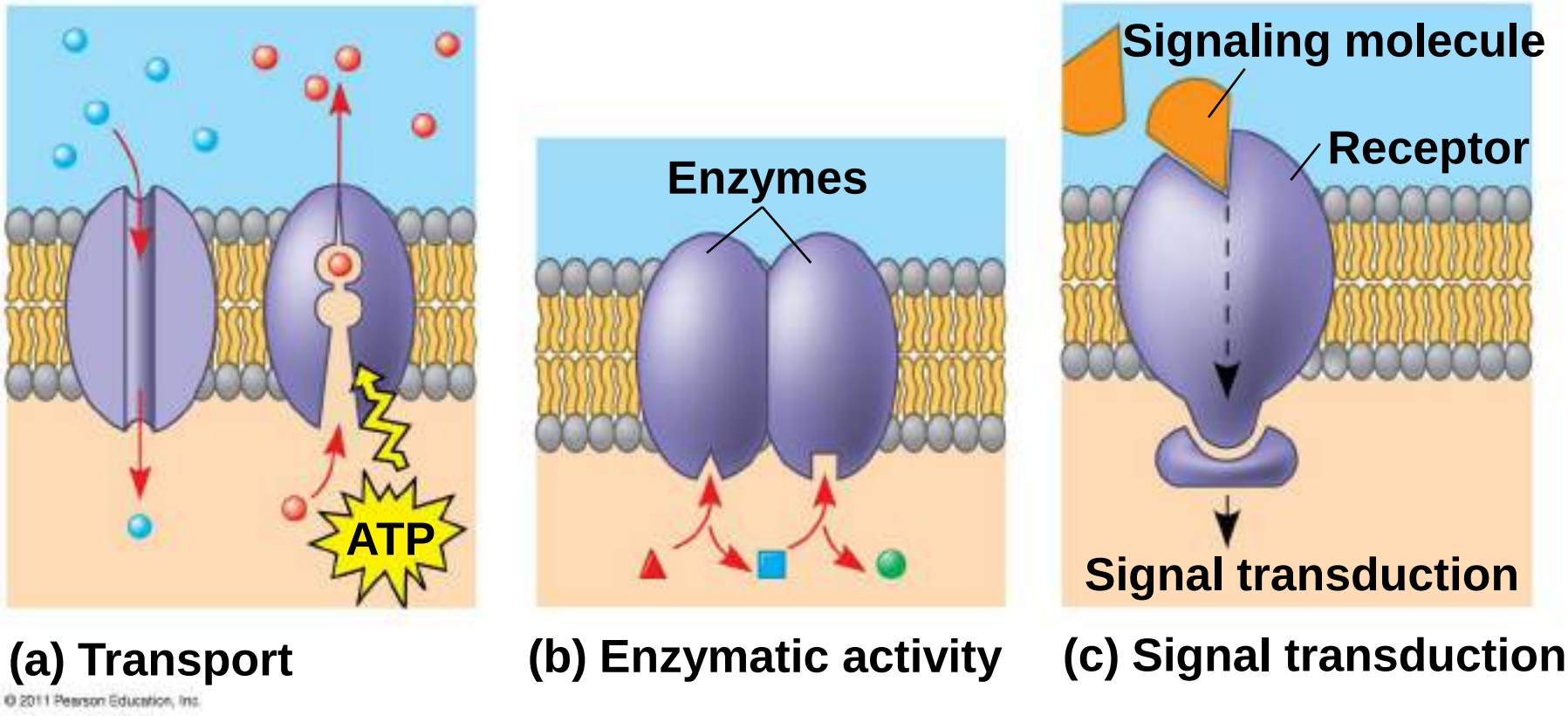
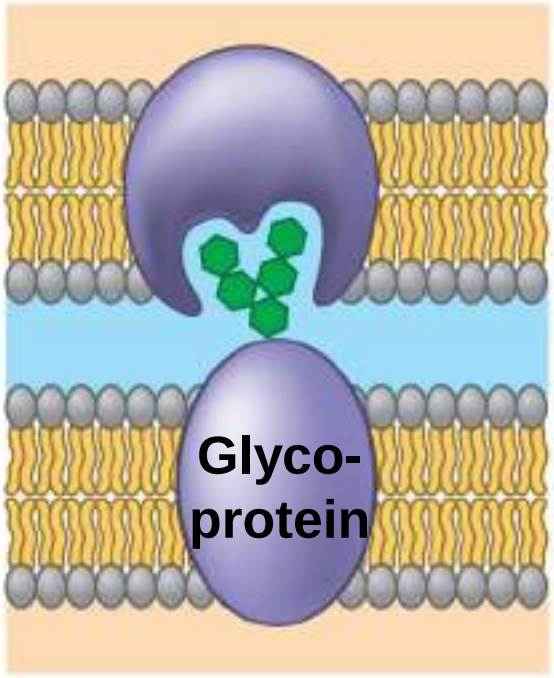
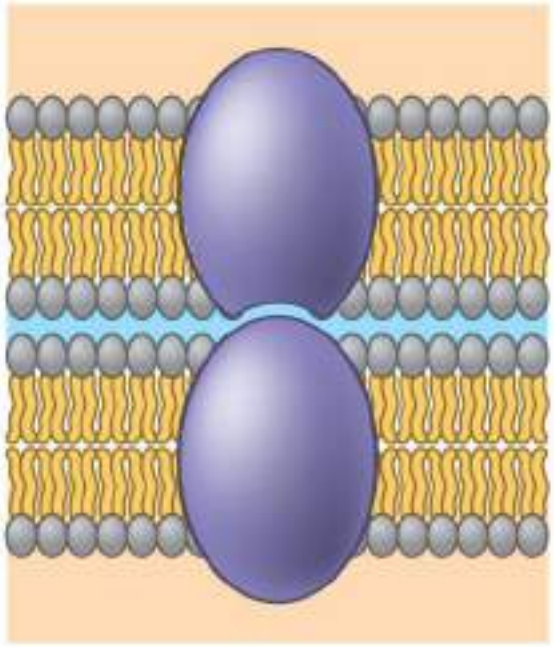


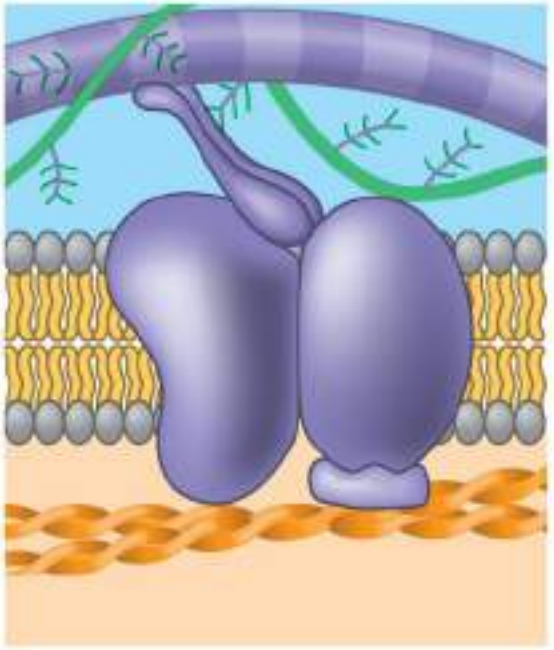
Figure 7.10b



(d) Cell-cell recognition



(e) Intercellular joining

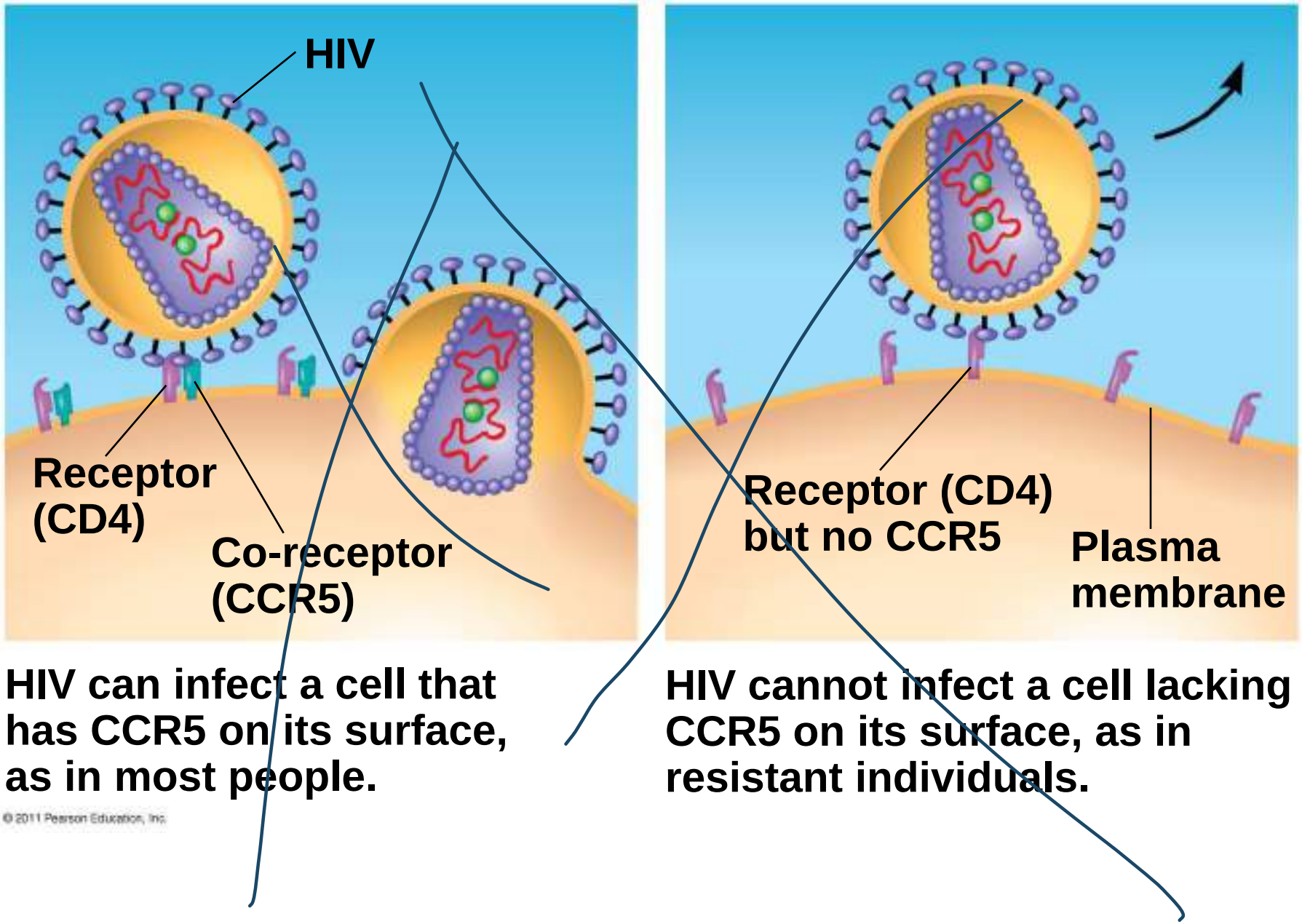


(f) Attachment to the cytoskeleton and extracellular matrix (ECM)

The Role of Membrane Carbohydrates in Cell-Cell Recognition

- Cells recognize each other by binding to surface molecules, often containing carbohydrates, on the extracellular surface of the plasma membrane
- Membrane carbohydrates may be covalently bonded to lipids (forming **glycolipids**) or more commonly to proteins (forming **glycoproteins**)
- Carbohydrates on the external side of the plasma membrane vary among species, individuals, and even cell types in an individual

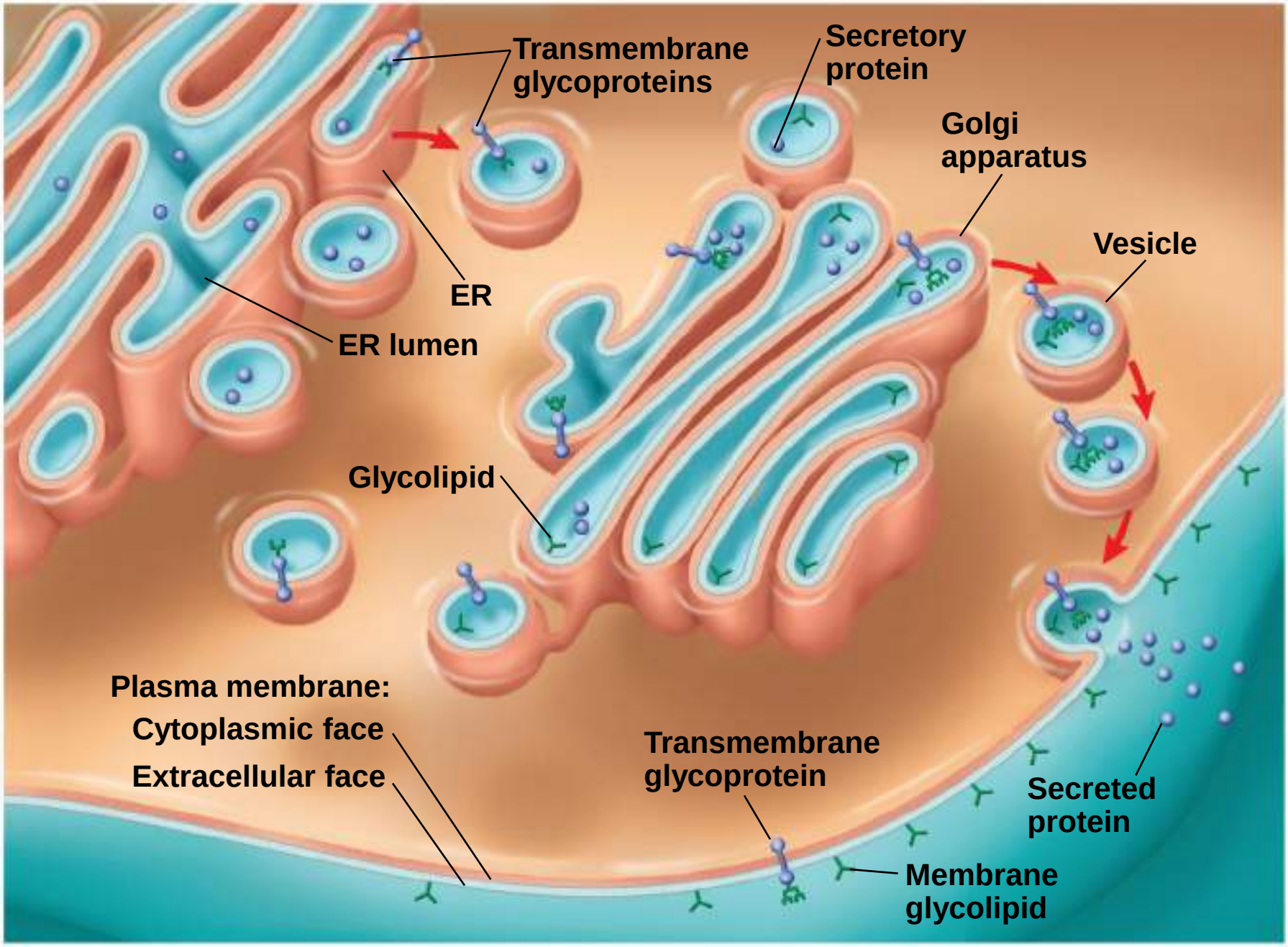
Figure 7.11



Synthesis and Sidedness of Membranes

- Membranes have distinct inside and outside faces
- The asymmetrical distribution of proteins, lipids, and associated carbohydrates in the plasma membrane is determined when the membrane is built by the ER and Golgi apparatus

Figure 7.12



Concept 7.2: Membrane structure results in selective permeability

- A cell must exchange materials with its surroundings, a process controlled by the plasma membrane
- Plasma membranes are selectively permeable, regulating the cell's molecular traffic

المواد اللي بتدخل عن طريق الـ membrane وكيف بتدخل:

① small, non polar (hydrophobic) or gas → phospho عن طريق الـ lipid bilayer

② small, polar (ion) → protein عن طريق

③ water → transport proteins (channels) او aquaporins

④ macromolecules → bulk transport (exocytosis)

The Permeability of the Lipid Bilayer

- Hydrophobic (nonpolar) molecules, such as hydrocarbons, can dissolve in the lipid bilayer and pass through the membrane rapidly
- Polar molecules, such as sugars, do not cross the membrane easily

Transport Proteins

- **Transport proteins** allow passage of hydrophilic substances across the membrane
- Some transport proteins, called channel proteins, have a hydrophilic channel that certain molecules or ions can use as a tunnel
- Channel proteins called **aquaporins** facilitate the passage of water

- Other transport proteins, called carrier proteins, bind to molecules and change shape to shuttle them across the membrane
- A transport protein is specific for the substance it moves

∞ Transport across plasma membrane :

- Passive → No ATP
  - Diffusion (الانتشار)
    - osmosise
    - Facciletated diffusion
- active → ATP
  - (Animal cells) Na^+/K^+ pump
  - proton pump

∞ الى بحدد اتجاه حركة المادة :

: concentration gradient (فرق التركيز)

① Down :
Higher to lower concentration (No energy needs)
(passive)

② Against :
Lower to Higher concentration (Needs energy)
(active)

concentration (تركيز)

Concept 7.3: Passive transport is diffusion of a substance across a membrane with no energy investment

- **Diffusion** is the tendency for molecules to spread out evenly into the available space
- Although each molecule moves randomly, diffusion of a population of molecules may be directional
- At dynamic equilibrium, as many molecules cross the membrane in one direction as in the other

PLAY Animation: Membrane Selectivity

PLAY Animation: Diffusion

Figure 7.13

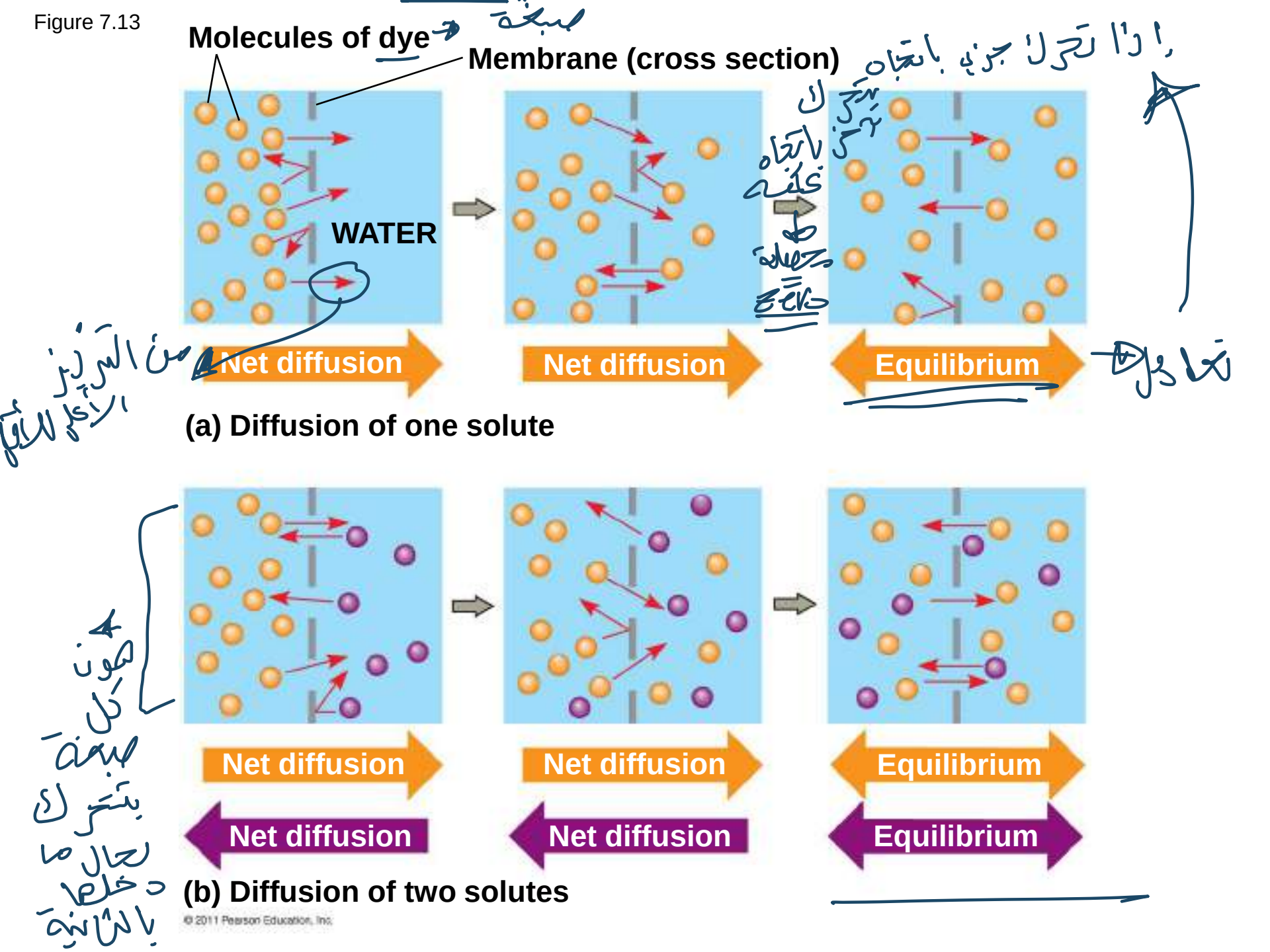
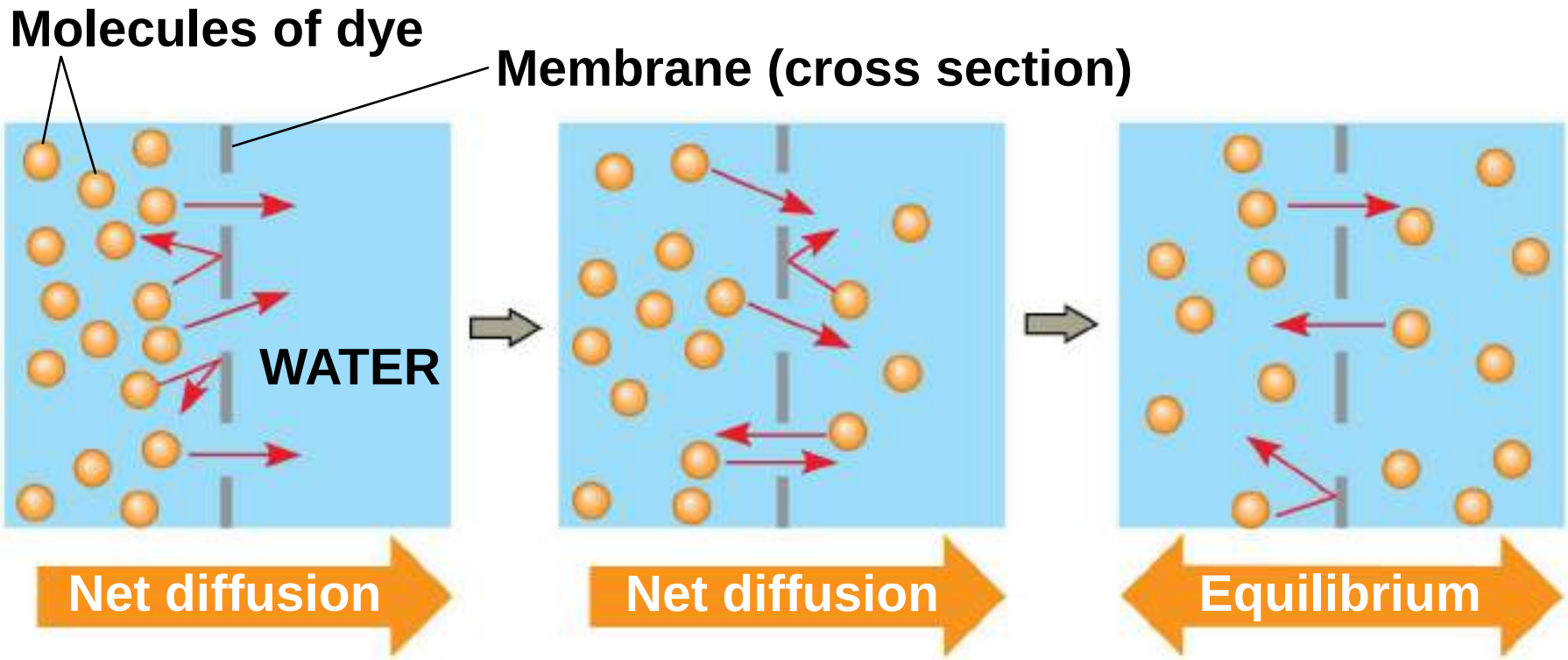
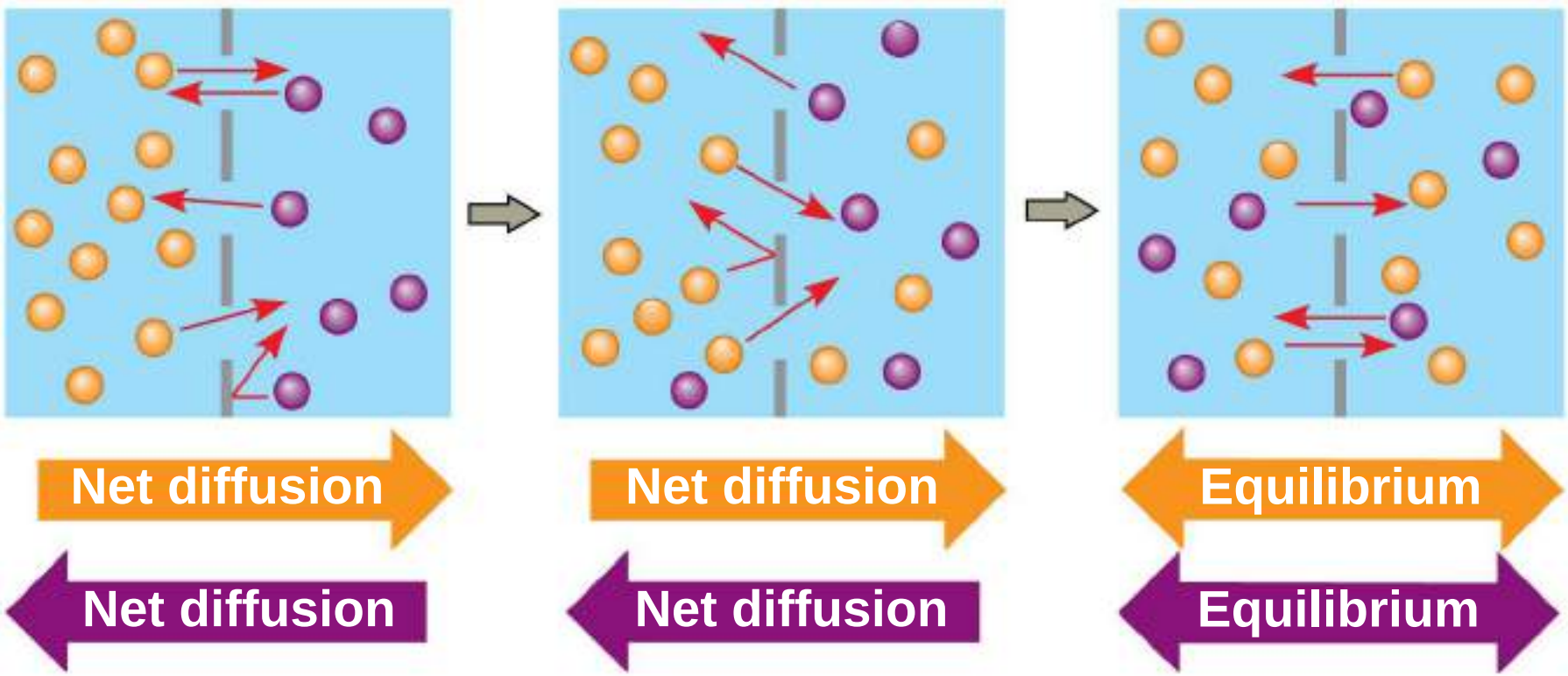


Figure 7.13a



(a) Diffusion of one solute

Figure 7.13b



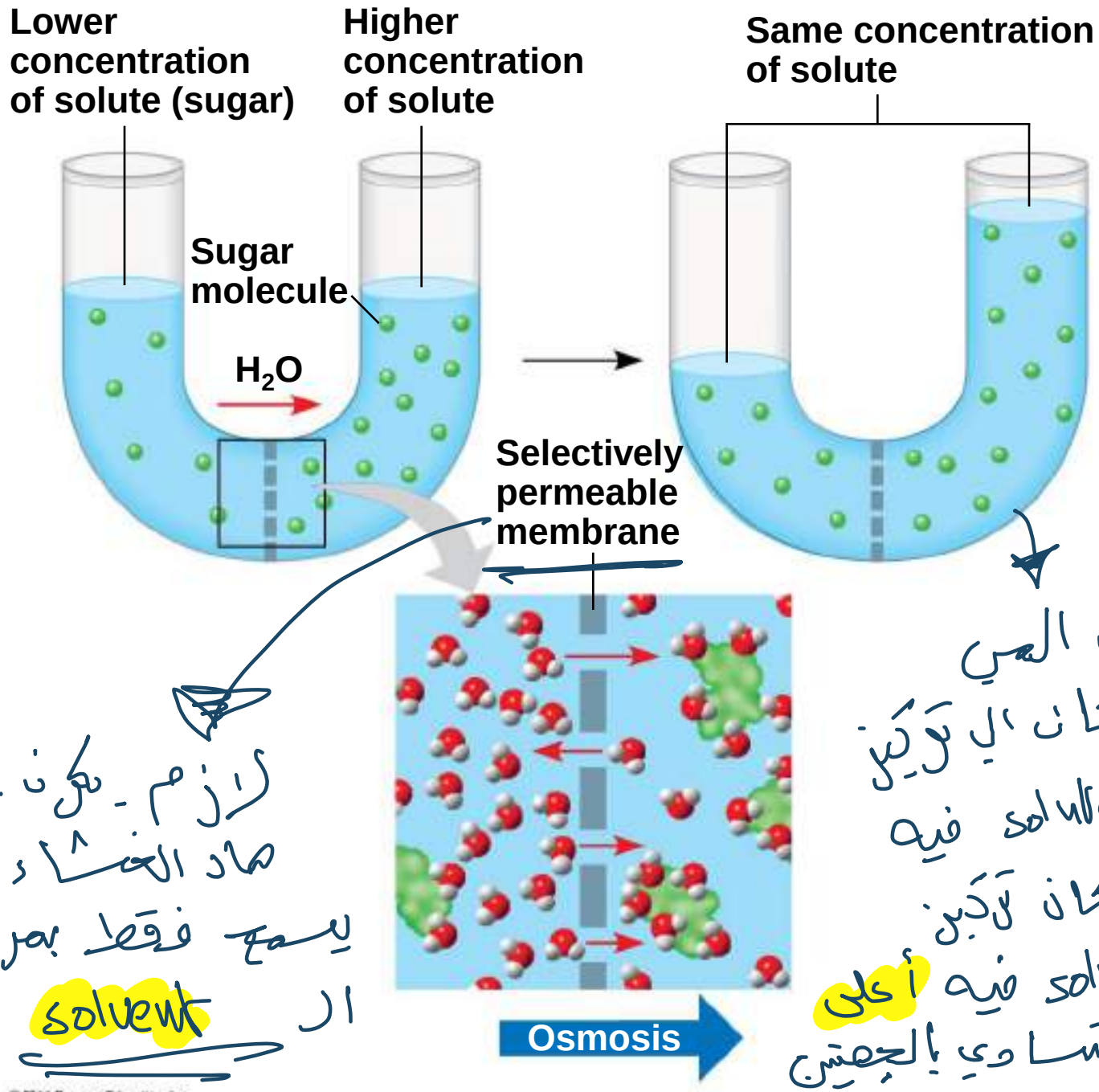
(b) Diffusion of two solutes

- Substances diffuse down their **concentration gradient**, the region along which the density of a chemical substance increases or decreases
- No work must be done to move substances down the concentration gradient
- The diffusion of a substance across a biological membrane is **passive transport** because no energy is expended by the cell to make it happen

Effects of Osmosis on Water Balance

- **Osmosis** is the diffusion of water across a selectively permeable membrane
- Water diffuses across a membrane from the region of lower solute concentration to the region of higher solute concentration until the solute concentration is equal on both sides

Figure 7.14



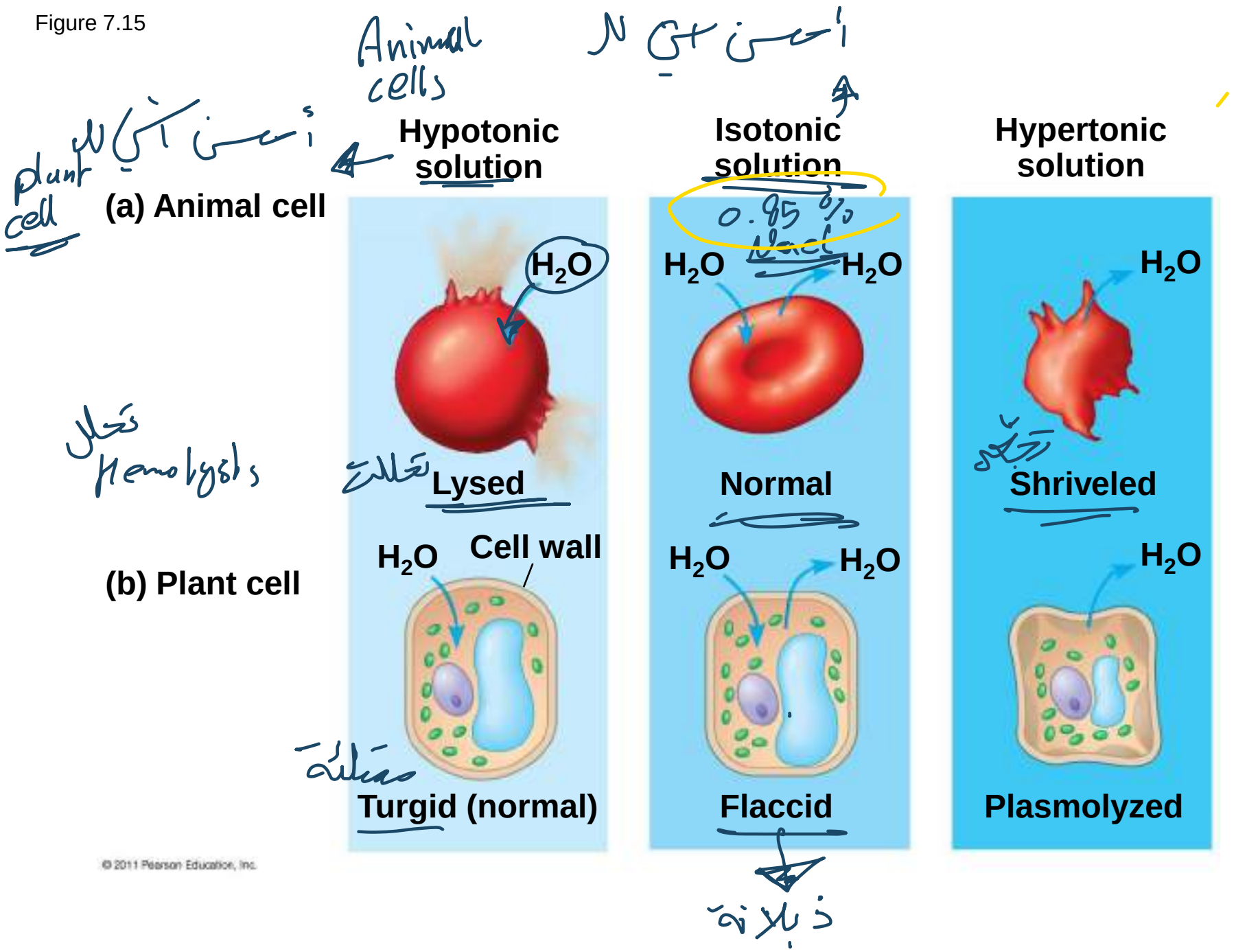
لازم يكون بيغطي
ضاد الخشاء وهو
يسمح فقط بمرور
ال solvent

تحركت الميه
صنا المكان اللي تركيز
ال solute فيه
أقل لمكان تركيز
ال solute فيه أعلى
فبيصير متساوي بالجهتين

Water Balance of Cells Without Walls

- **Tonicity** is the ability of a surrounding solution to cause a cell to gain or lose water
- **Isotonic** solution: Solute concentration is the same as that inside the cell; no net water movement across the plasma membrane
- **Hypertonic** solution: Solute concentration is greater than that inside the cell; cell loses water
- **Hypotonic** solution: Solute concentration is less than that inside the cell; cell gains water

Figure 7.15

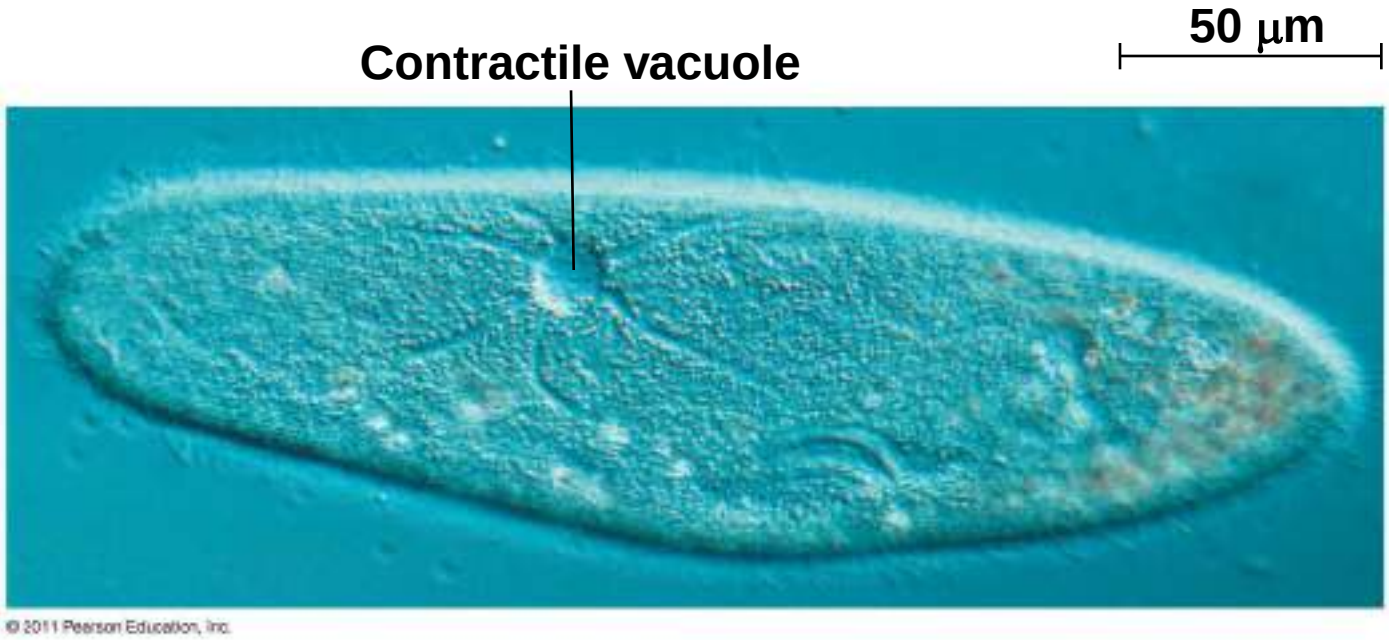


- Hypertonic or hypotonic environments create osmotic problems for organisms
- **Osmoregulation**, the control of solute concentrations and water balance, is a necessary adaptation for life in such environments
- The protist *Paramecium*, which is hypertonic to its pond water environment, has a contractile vacuole that acts as a pump

PLAY Video: *Chlamydomonas*

PLAY Video: *Paramecium* Vacuole

Figure 7.16



Water Balance of Cells with Walls

- Cell walls help maintain water balance
- A plant cell in a hypotonic solution swells until the wall opposes uptake; the cell is now **turgid** (firm)
- If a plant cell and its surroundings are isotonic, there is no net movement of water into the cell; the cell becomes **flaccid** (limp), and the plant may wilt

- In a hypertonic environment, plant cells lose water; eventually, the membrane pulls away from the wall, a usually lethal effect called **plasmolysis**

PLAY Video: Plasmolysis

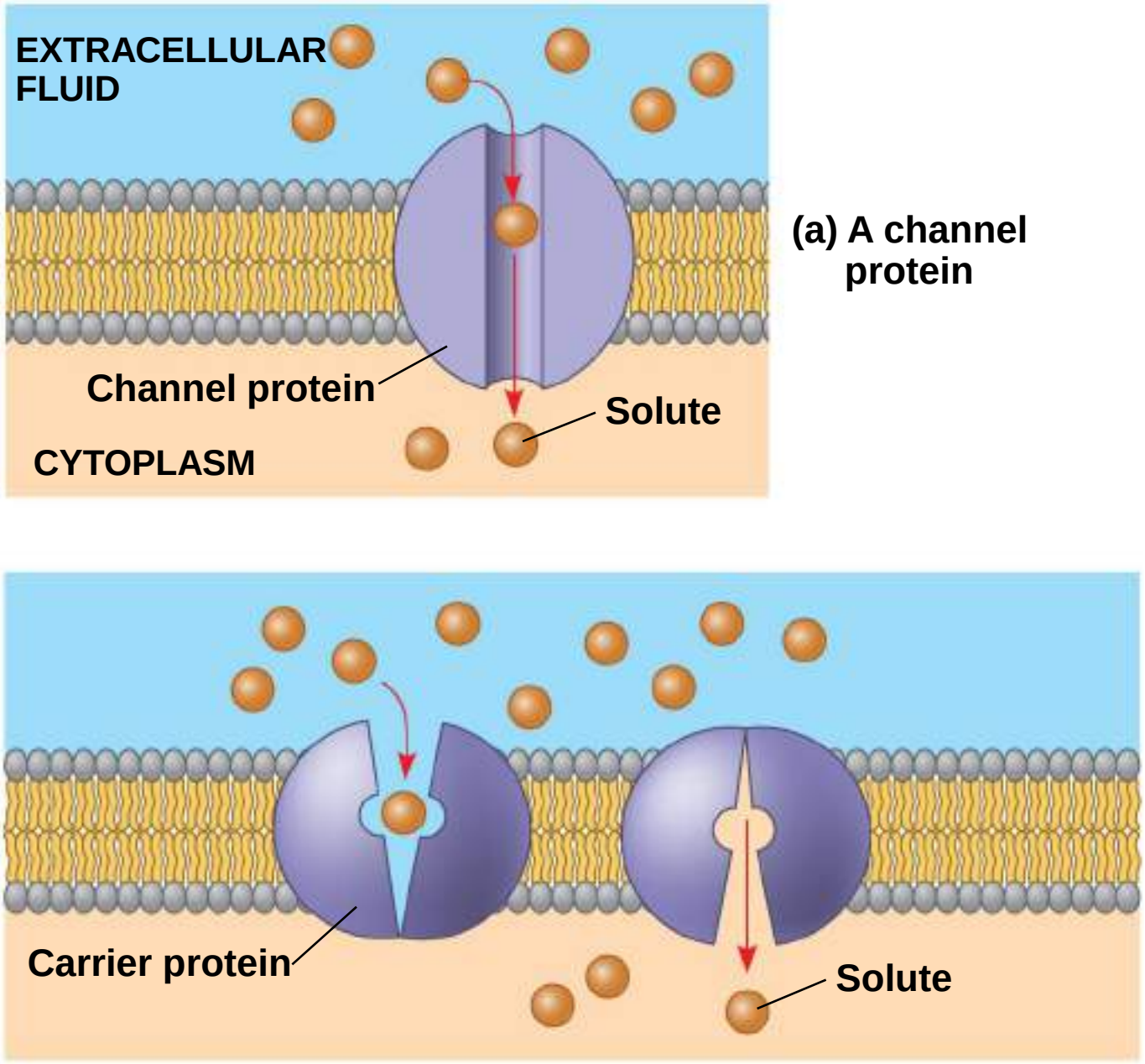
PLAY Video: Turgid *Elodea*

PLAY Animation: Osmosis

Facilitated Diffusion: Passive Transport Aided by Proteins

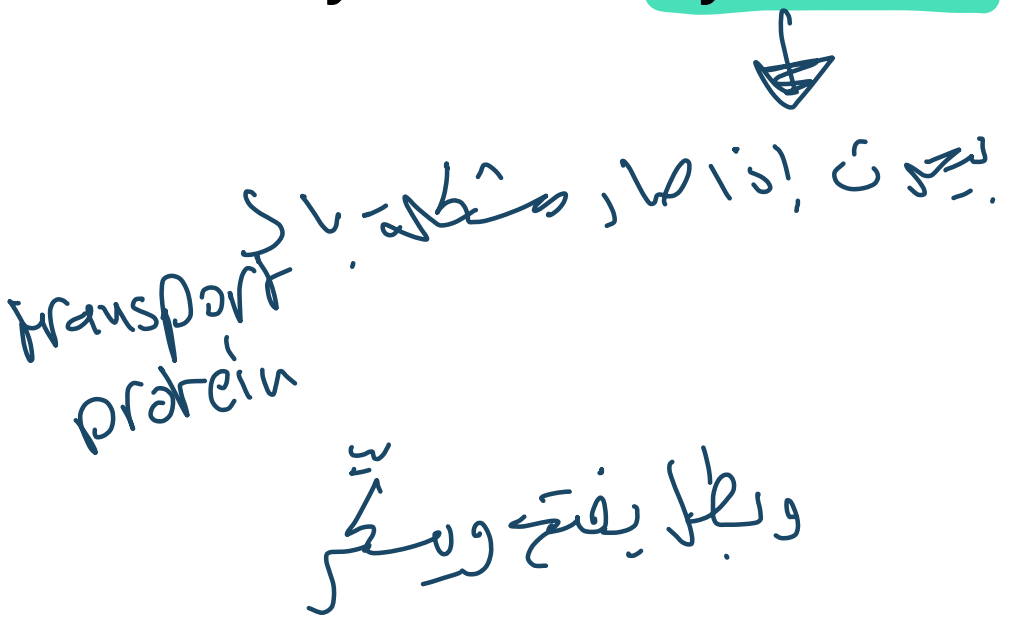
- In **facilitated diffusion**, transport proteins speed the passive movement of molecules across the plasma membrane
- Channel proteins provide corridors that allow a specific molecule or ion to cross the membrane
- Channel proteins include
  - Aquaporins, for facilitated diffusion of water
  - **Ion channels** that open or close in response to a stimulus (**gated channels**)

Figure 7.17



- Carrier proteins undergo a subtle change in shape that translocates the solute-binding site across the membrane

- Some diseases are caused by malfunctions in specific transport systems, for example the kidney disease cystinuria



Concept 7.4: Active transport uses energy to move solutes against their gradients

- Facilitated diffusion is still passive because the solute moves down its concentration gradient, and the transport requires no energy
- Some transport proteins, however, can move solutes against their concentration gradients

ما ان فقدر نحكي ان Active transport لازم يتوفر 3 شروط:

1. Low to High concentration
2. Needs ATP
3. Transport protein

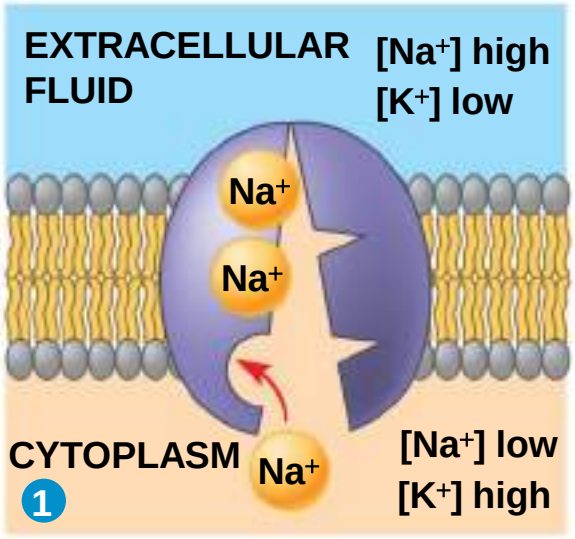
The Need for Energy in Active Transport

- **Active transport** moves substances against their concentration gradients
- Active transport requires energy, usually in the form of ATP
- Active transport is performed by specific proteins embedded in the membranes

Animation: Active Transport

- Active transport allows cells to maintain concentration gradients that differ from their surroundings
- The **sodium-potassium pump** is one type of active transport system

Figure 7.18-1



خارج الـ membrane
[Na+] High
[K+] low

داخل الخلية
[Na+] low
[K+] High

Figure 7.18-2

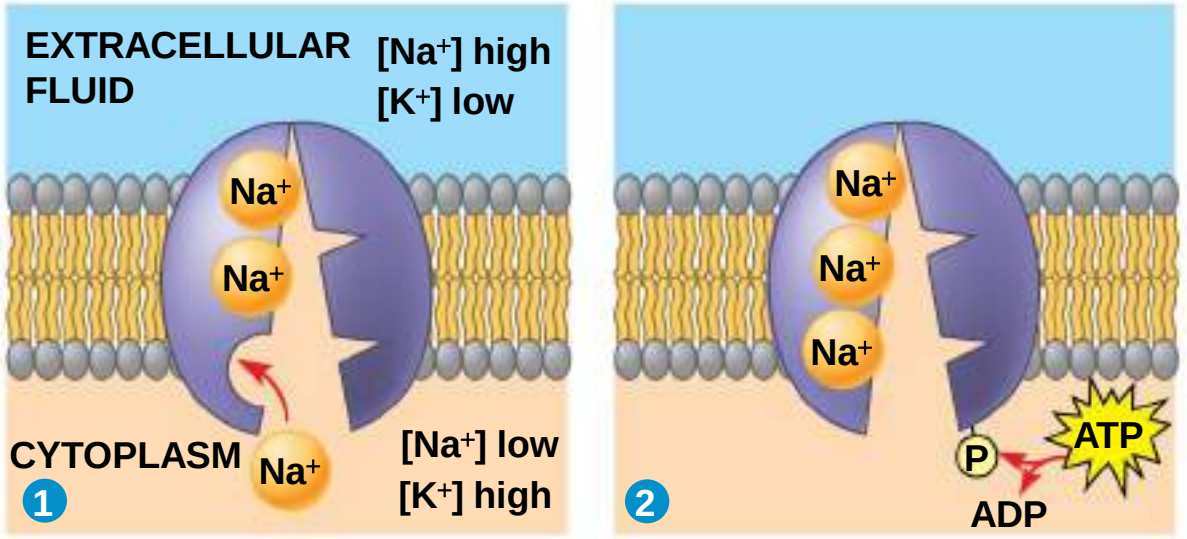


Figure 7.18-3

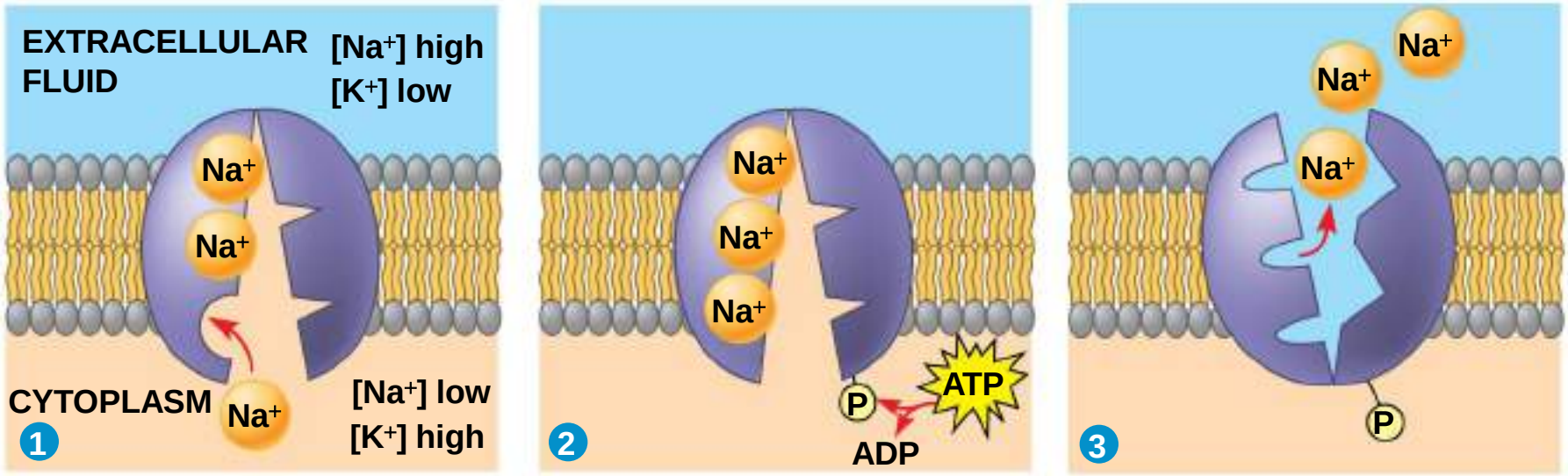
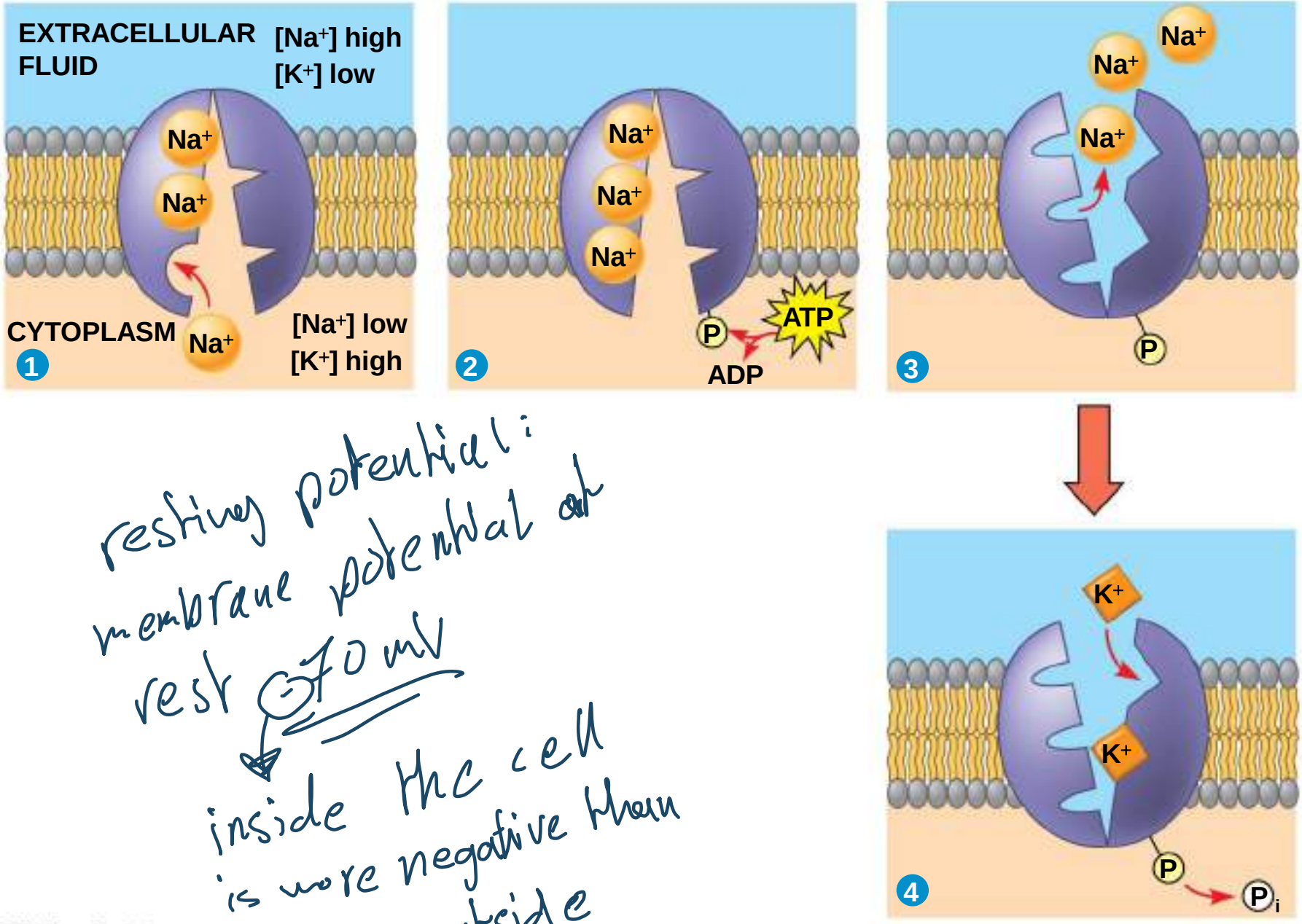


Figure 7.18-4



resting potential: membrane potential at rest -70 mV

inside the cell is more negative than outside

Figure 7.18-5

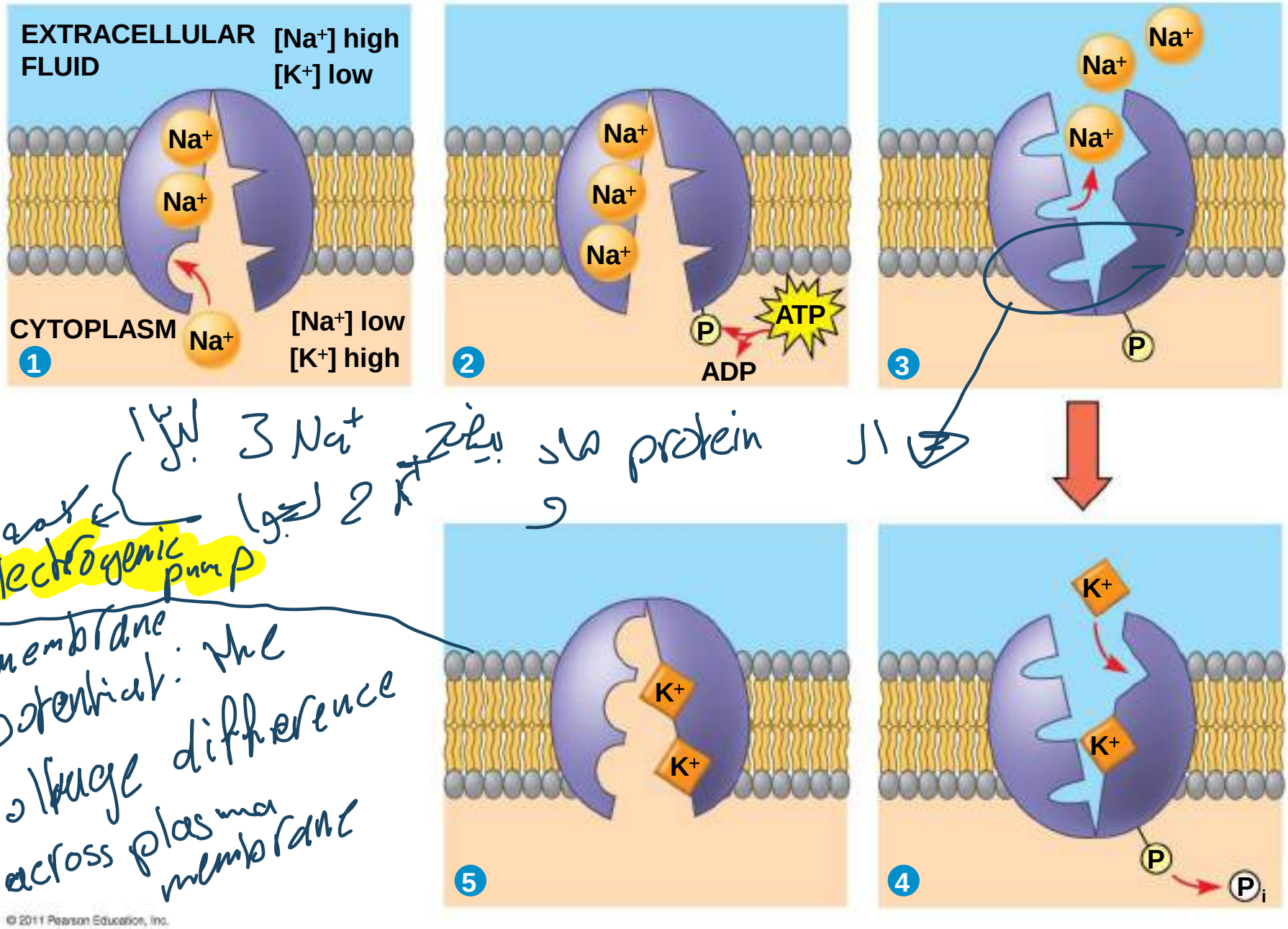


Figure 7.18-6

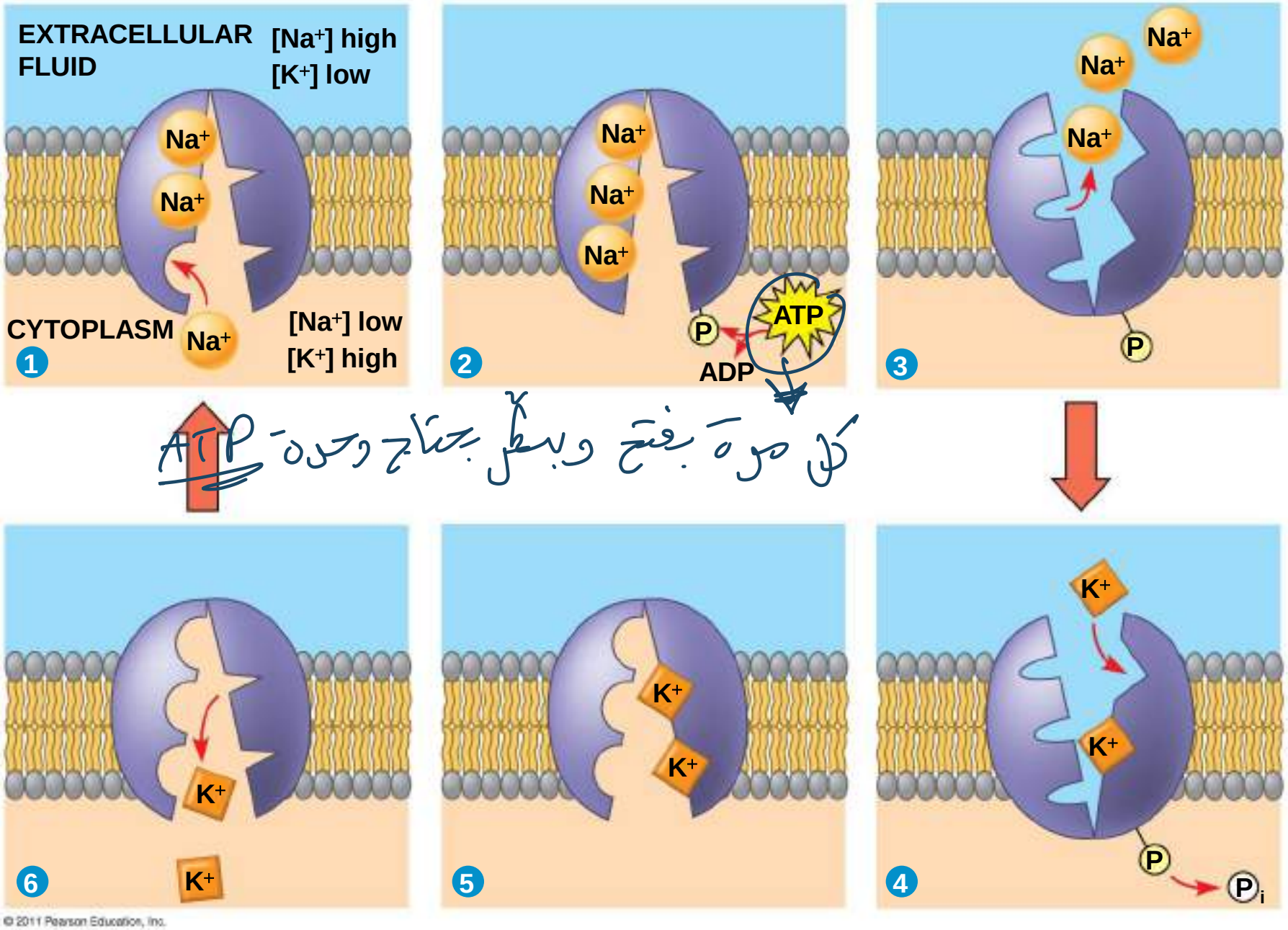

EXTRACELLULAR FLUID
[Na+] high
[K+] low
Na+
Na+
CYTOPLASM
Na+
[Na+] low
[K+] high
1
Na+
Na+
Na+
P
ATP
ADP
2
Na+
Na+
Na+
P
3
ATP كل مرة بفتح وبطلع بحتاج وحدة
K+
K+
4
K+
K+
5
K+
K+
6
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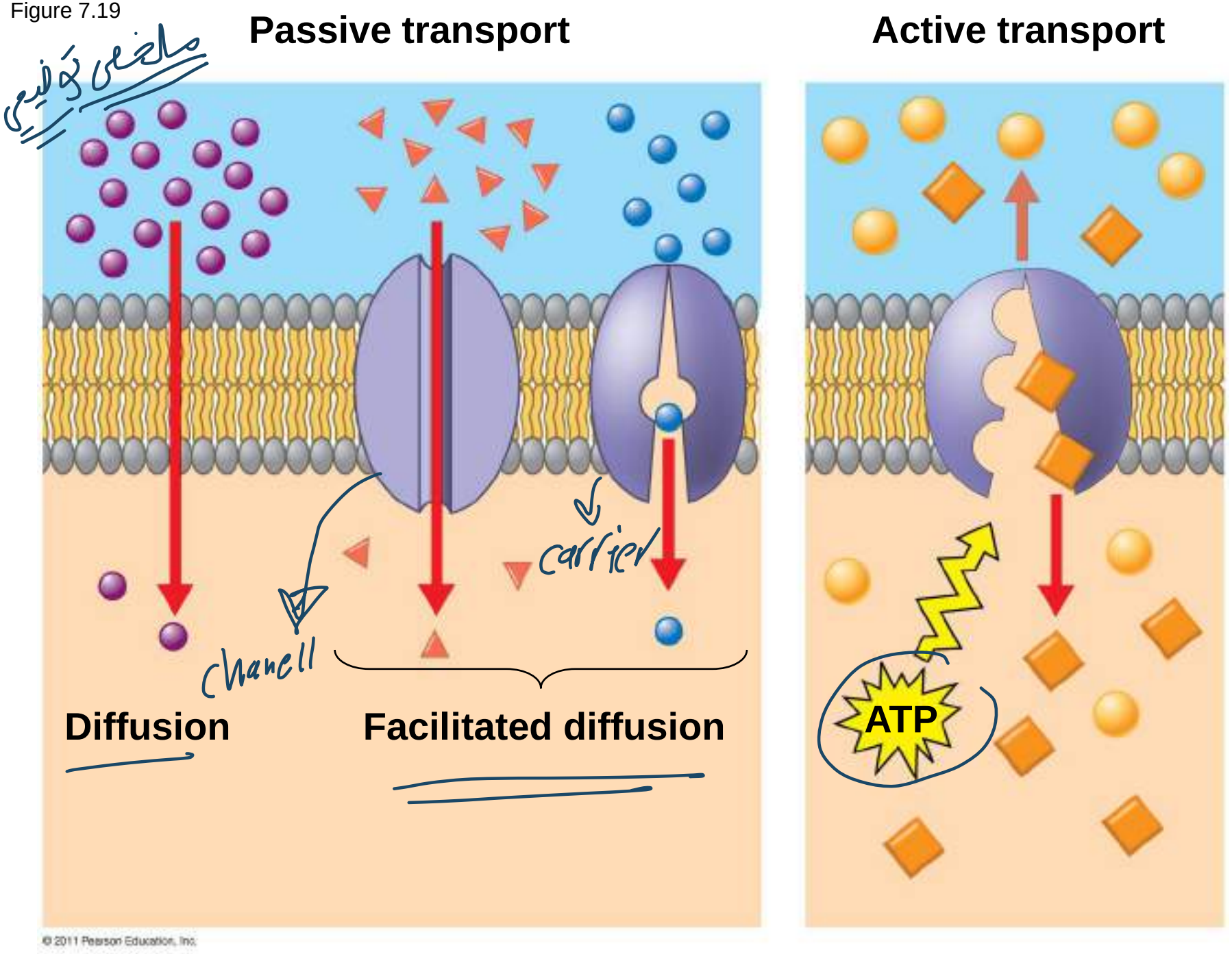
Figure 7.19


Passive transport
Active transport
carrier
Channel
Diffusion
Facilitated diffusion
ATP
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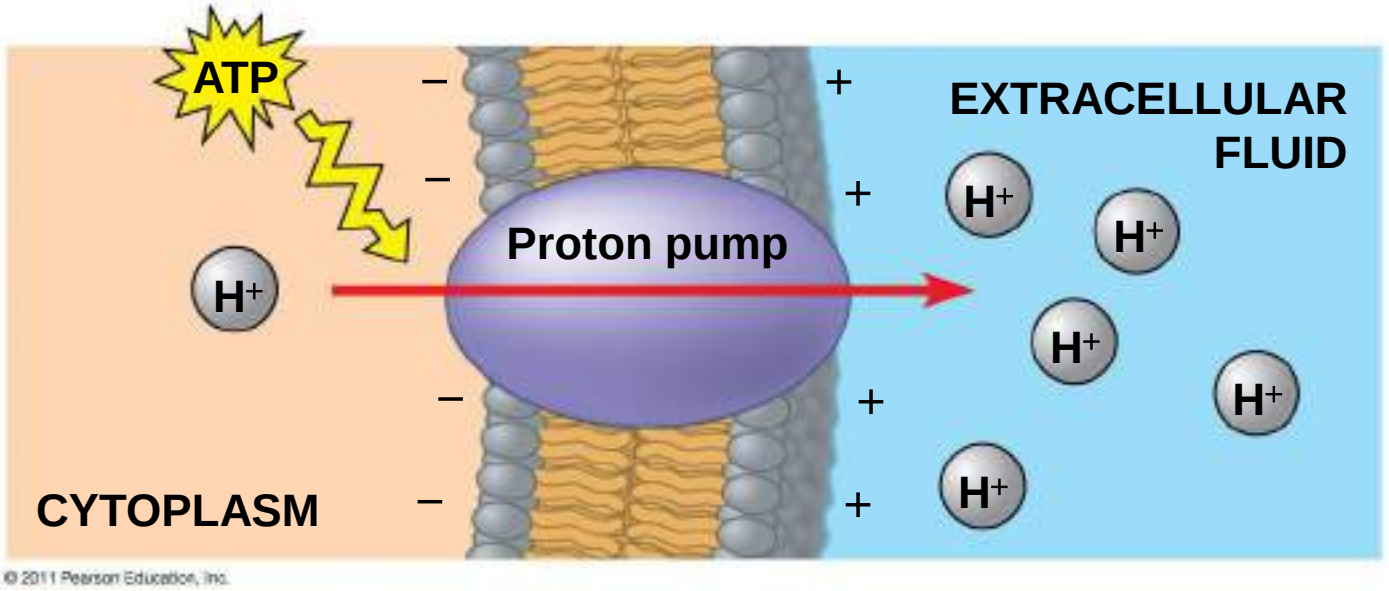
How Ion Pumps Maintain Membrane Potential

- **Membrane potential** is the voltage difference across a membrane
- Voltage is created by differences in the distribution of positive and negative ions across a membrane

- Two combined forces, collectively called the **electrochemical gradient**, drive the diffusion of ions across a membrane
  - A chemical force (the ion's concentration gradient)
  - An electrical force (the effect of the membrane potential on the ion's movement)

- An **electrogenic pump** is a transport protein that generates voltage across a membrane
- The sodium-potassium pump is the major electrogenic pump of animal cells
- The main electrogenic pump of plants, fungi, and bacteria is a **proton pump**
- Electrogenic pumps help store energy that can be used for cellular work

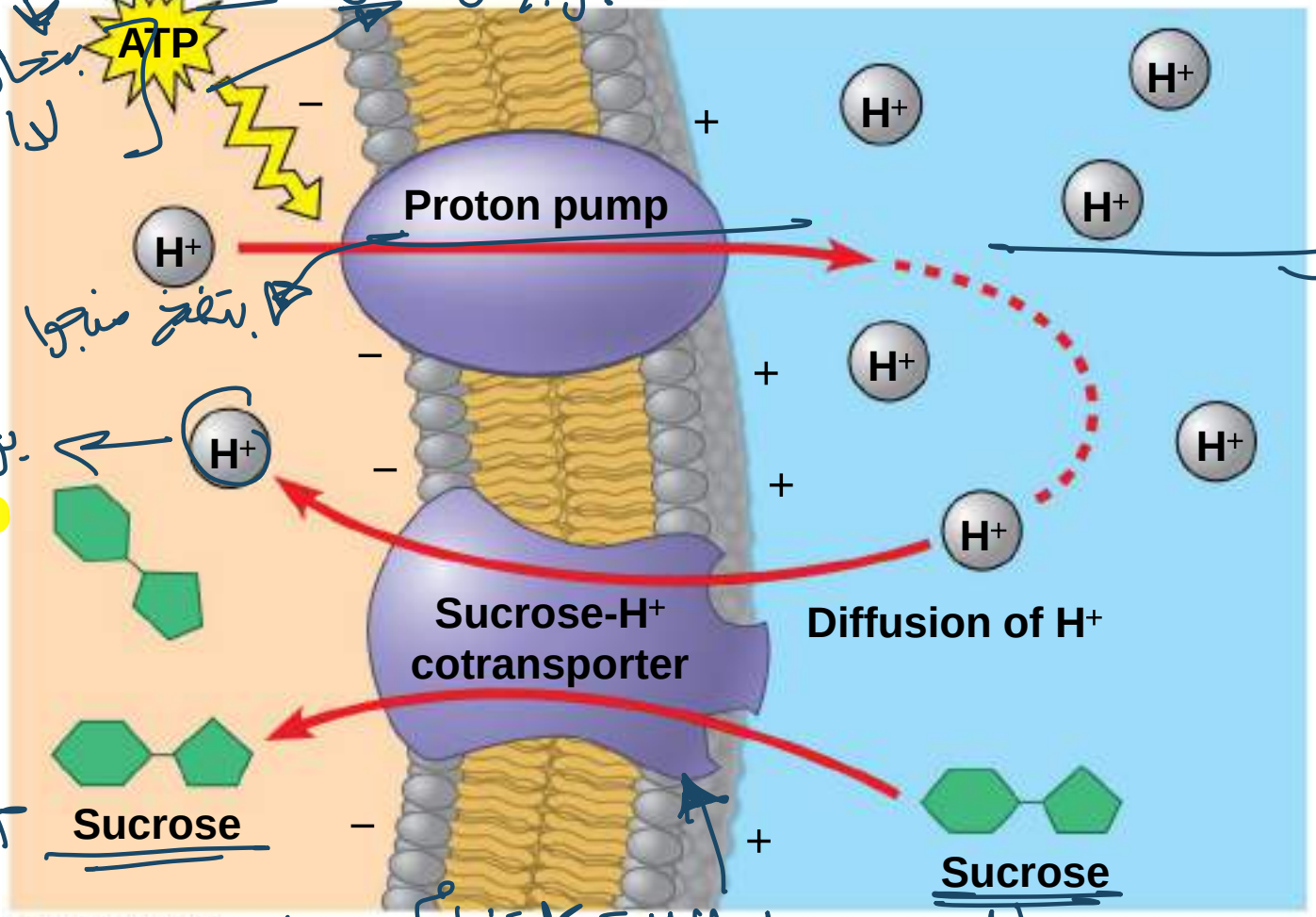
Figure 7.20



Cotransport: Coupled Transport by a Membrane Protein

- **Cotransport** occurs when active transport of a solute indirectly drives transport of other solutes
- Plants commonly use the gradient of hydrogen ions generated by proton pumps to drive active transport of nutrients into the cell

Figure 7.21


ATP
Proton pump
H+
Sucrose-H+ cotransporter
Diffusion of H+
Sucrose
Sucrose
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Concept 7.5: Bulk transport across the plasma membrane occurs by exocytosis and endocytosis

- Small molecules and water enter or leave the cell through the lipid bilayer or via transport proteins
- Large molecules, such as polysaccharides and proteins, cross the membrane in bulk via vesicles
- Bulk transport requires energy

Exocytosis

- In **exocytosis**, transport vesicles migrate to the membrane, fuse with it, and release their contents
- Many secretory cells use exocytosis to export their products

PLAY Animation: Exocytosis

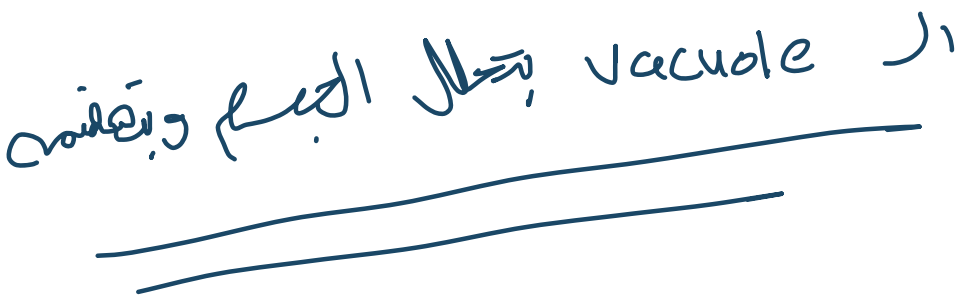
Endocytosis

- In **endocytosis**, the cell takes in macromolecules by forming vesicles from the plasma membrane
- Endocytosis is a reversal of exocytosis, involving different proteins
- There are three types of endocytosis
  1. – Phagocytosis ("cellular eating")
  2. – Pinocytosis ("cellular drinking")
  3. – Receptor-mediated endocytosis

Pinocytosis حالة خاصة من ال

Animation: Exocytosis and Endocytosis Introduction

- In **phagocytosis** a cell engulfs a particle in a vacuole
- The vacuole fuses with a lysosome to digest the particle



PLAY Animation: Phagocytosis

- In **pinocytosis**, molecules are taken up when extracellular fluid is “gulped” into tiny vesicles

Animation: Pinocytosis

- In **receptor-mediated endocytosis**, binding of ligands to receptors triggers vesicle formation
  - A **ligand** is any molecule that binds specifically to a receptor site of another molecule

LDL → proteins carry coleshrol

Animation: Receptor-Mediated Endocytosis

Figure 7.22

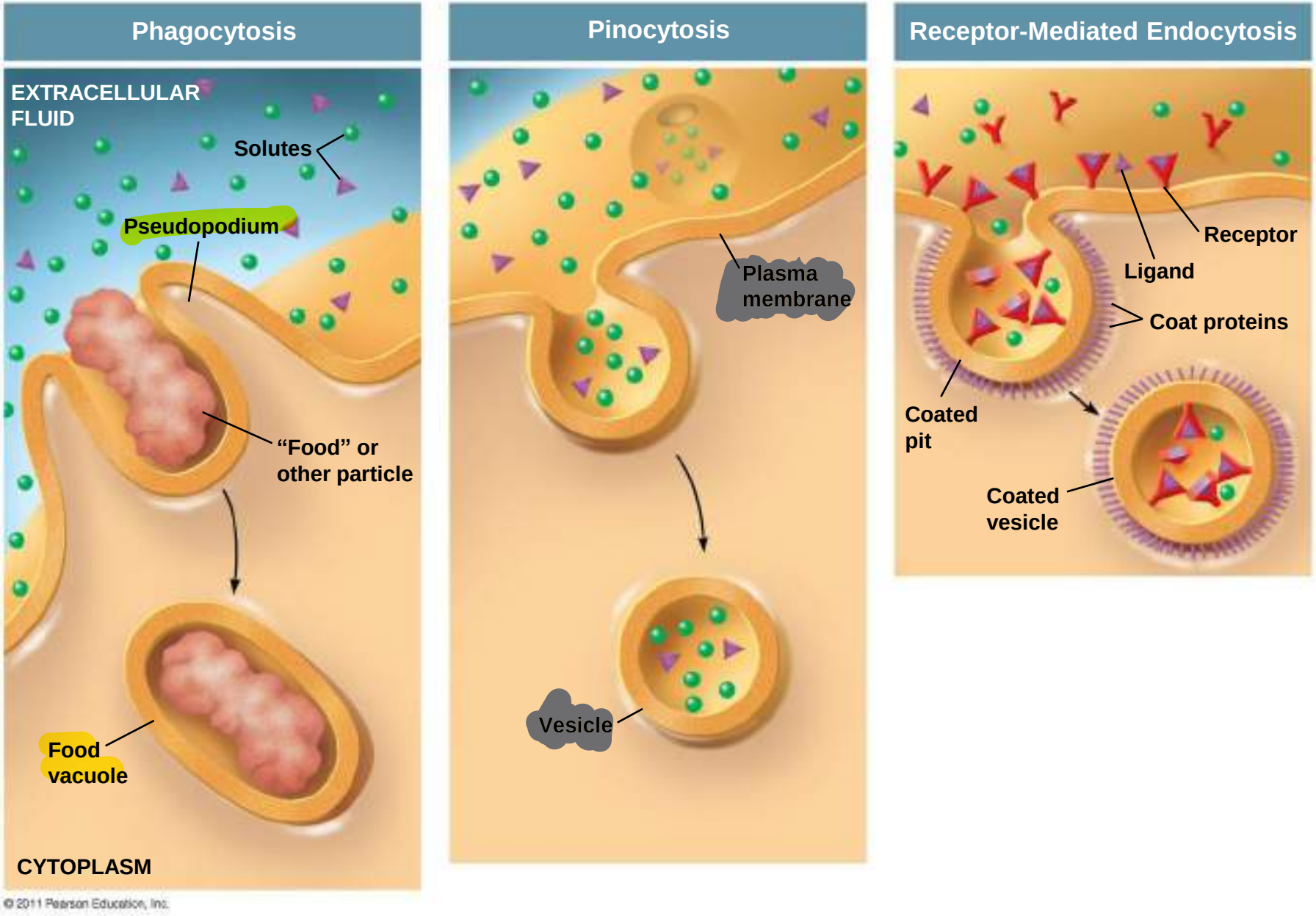
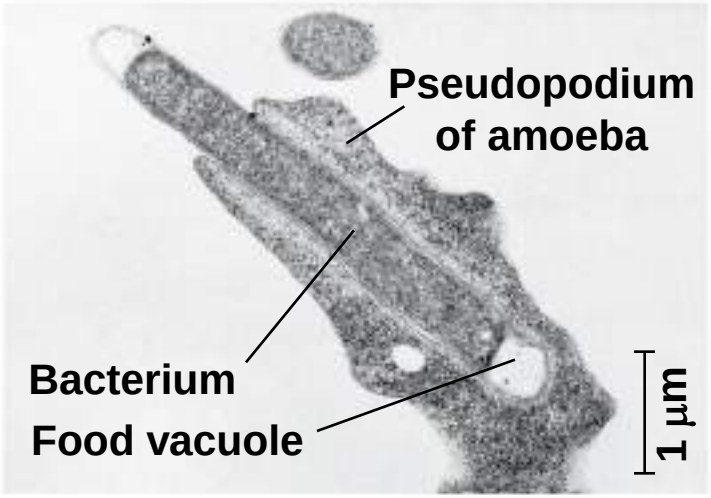


Figure 7.22a

Phagocytosis



An amoeba engulfing a bacterium via phagocytosis (TEM).

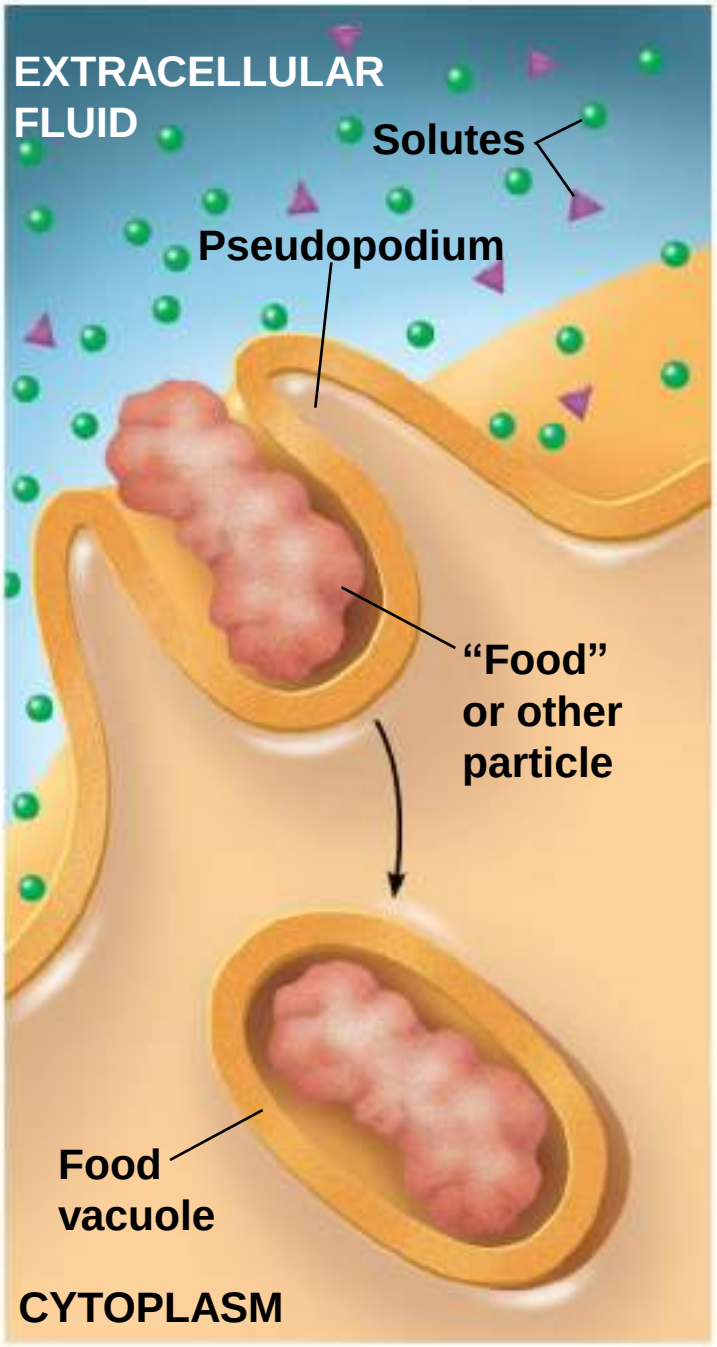
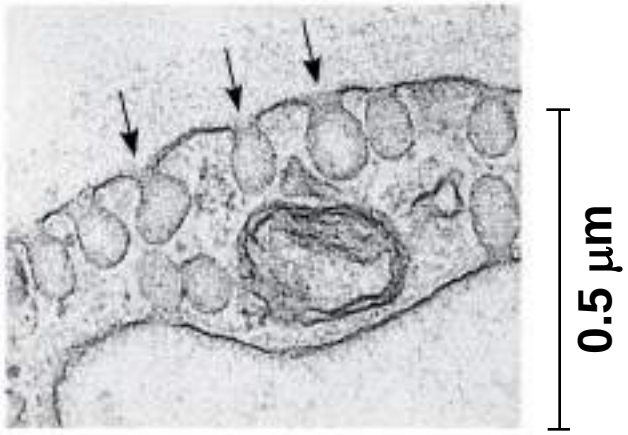


Figure 7.22b

Pinocytosis



Pinocytosis vesicles forming in a cell lining a small blood vessel (TEM).

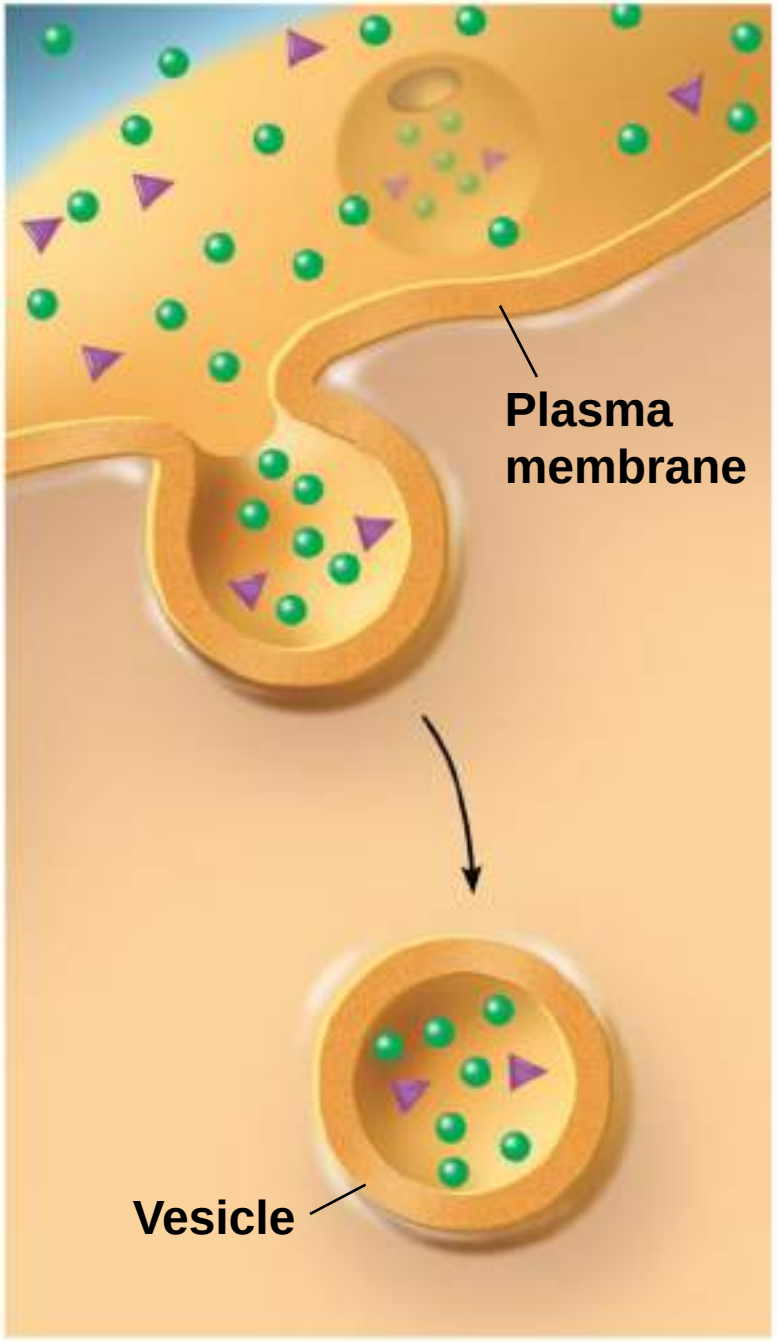
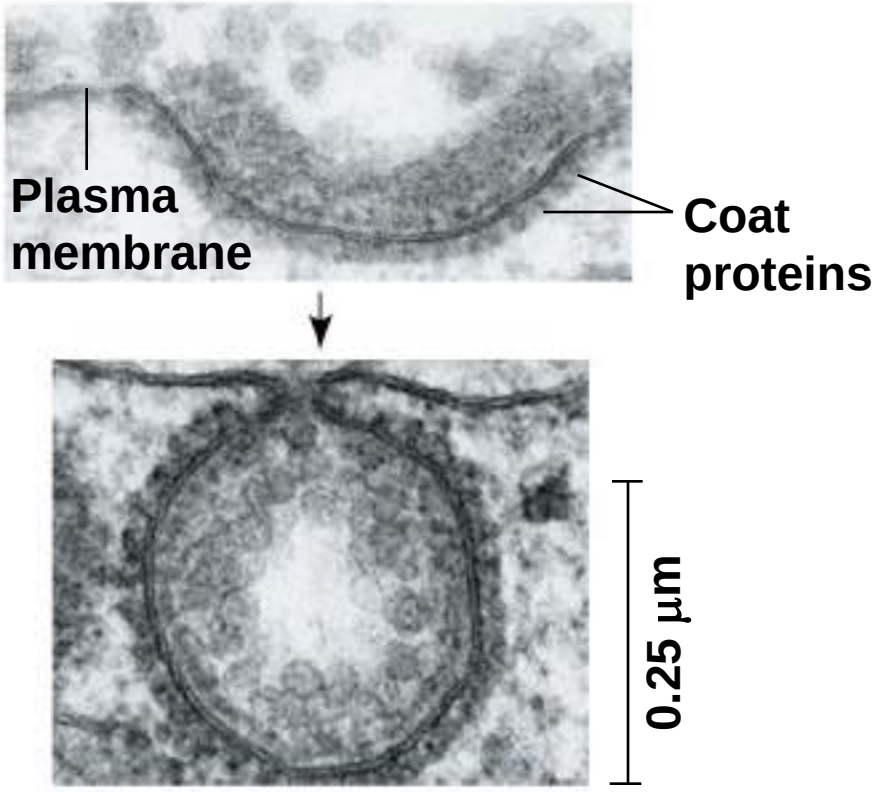
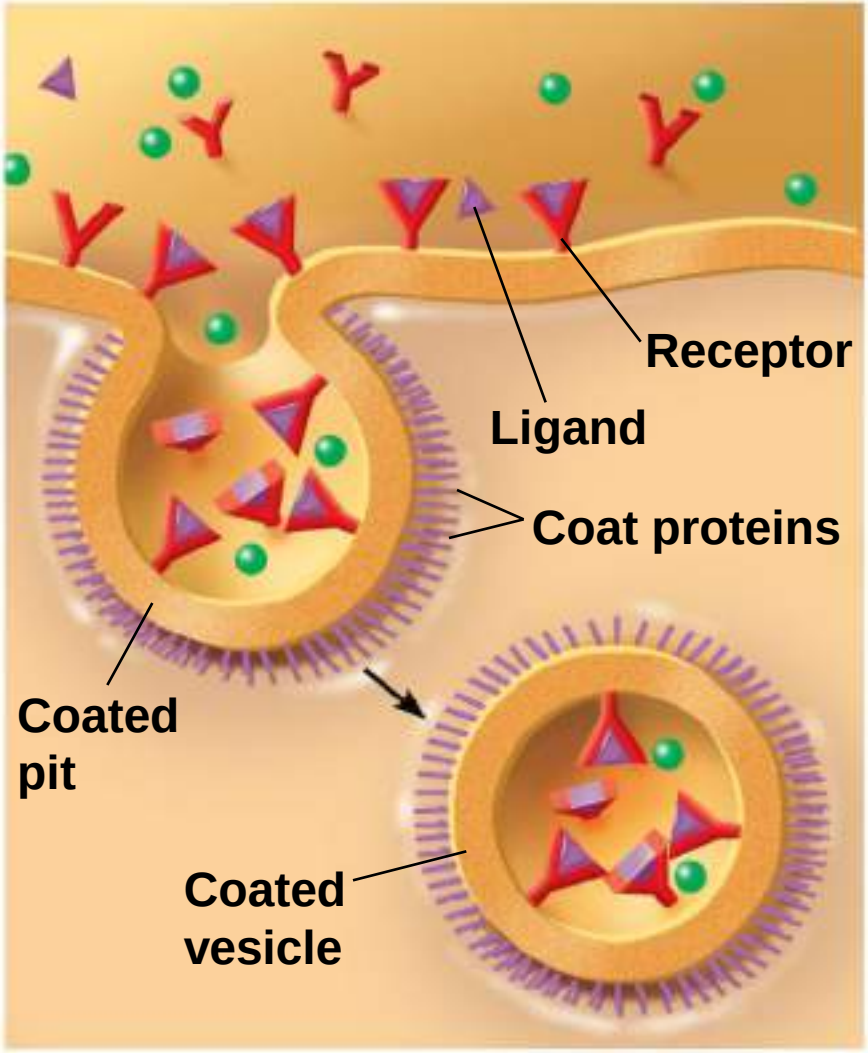


Figure 7.22c

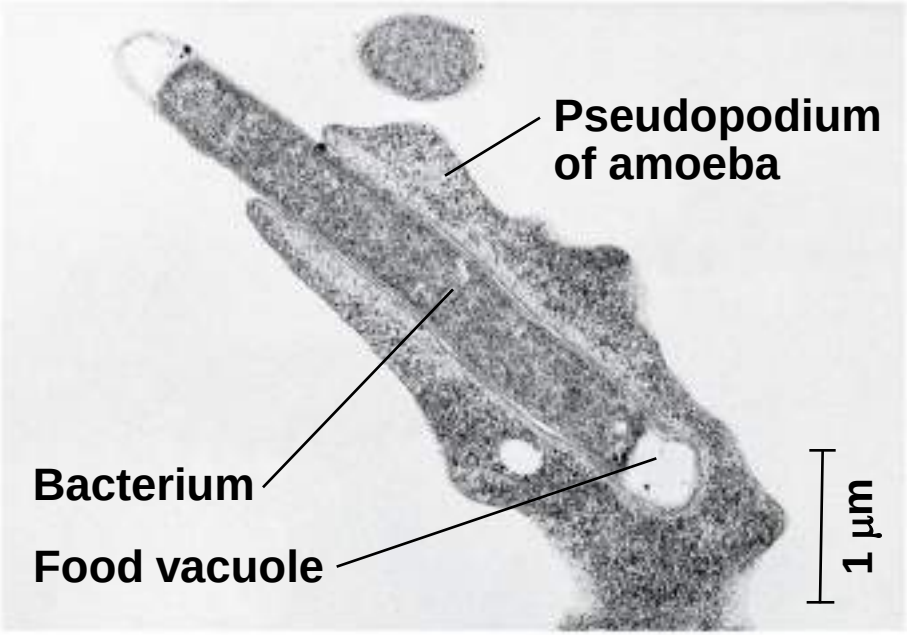
Receptor-Mediated Endocytosis





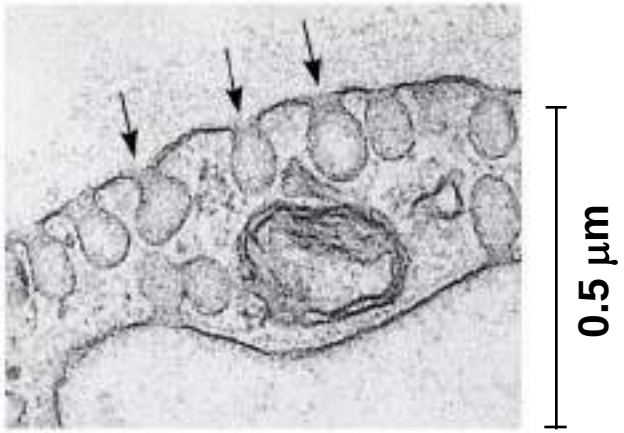
Top: **A coated pit.** ***Bottom:*** **A coated vesicle forming during receptor-mediated endocytosis (TEMs).**

Figure 7.22d



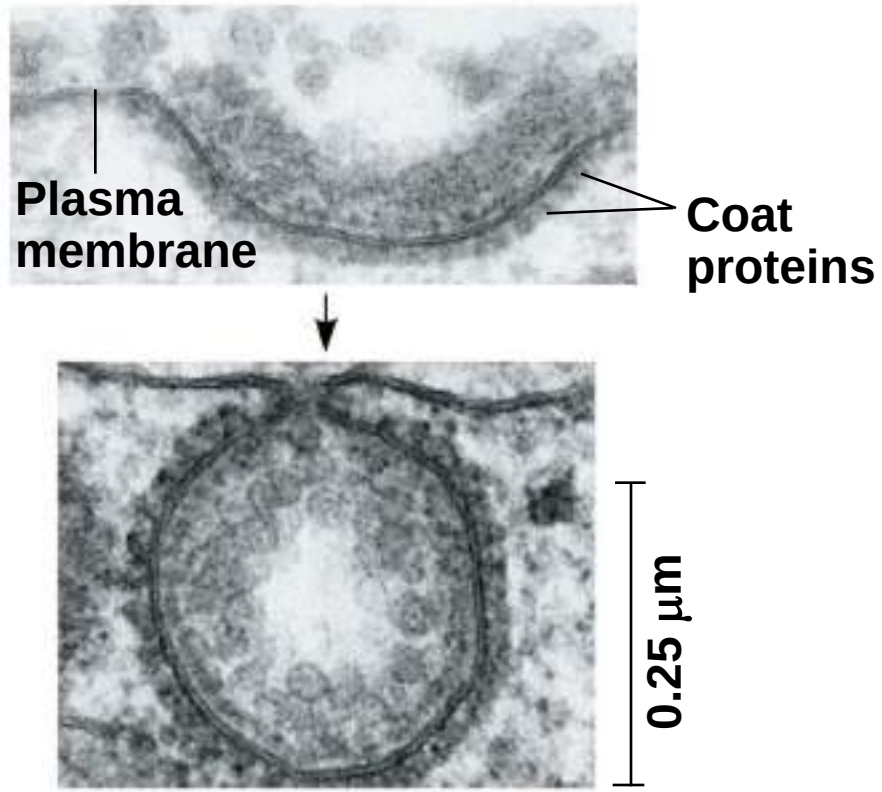
An amoeba engulfing a bacterium via phagocytosis (TEM).

Figure 7.22e



Pinocytosis vesicles forming (indicated by arrows) in a cell lining a small blood vessel (TEM).

Figure 7.22f



Top: **A coated pit.** ***Bottom:*** **A coated vesicle forming during receptor-mediated endocytosis (TEMs).**

Figure 7.UN01

Passive transport: Facilitated diffusion

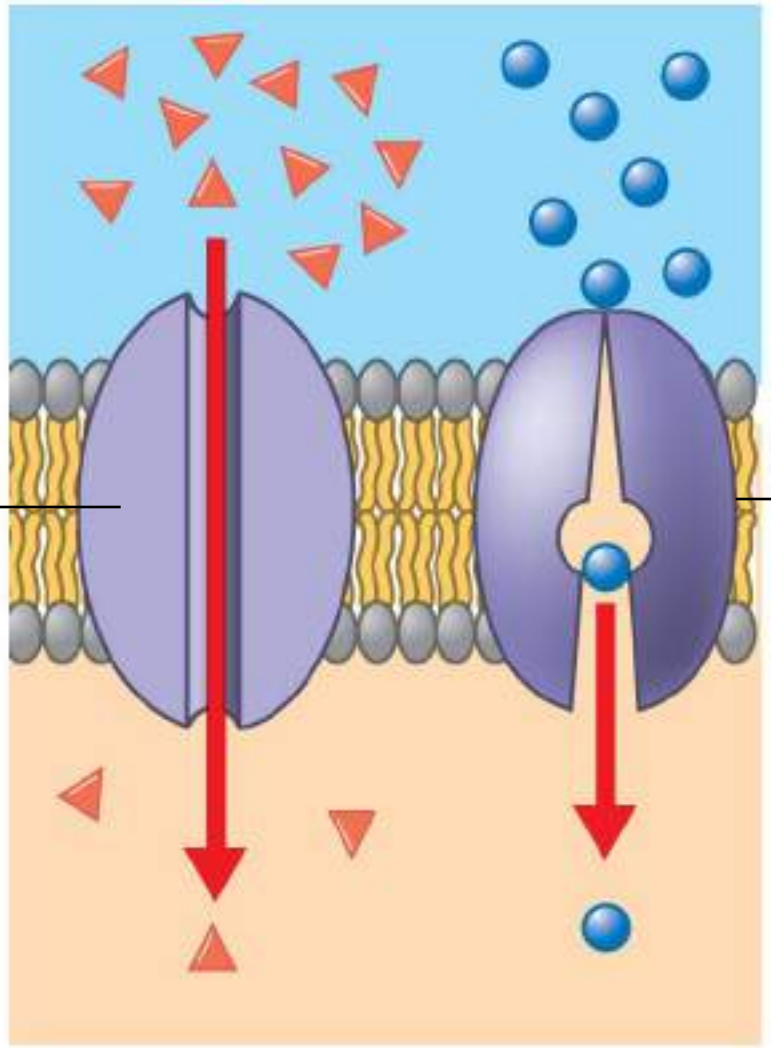


Figure 7.UN02

Active transport

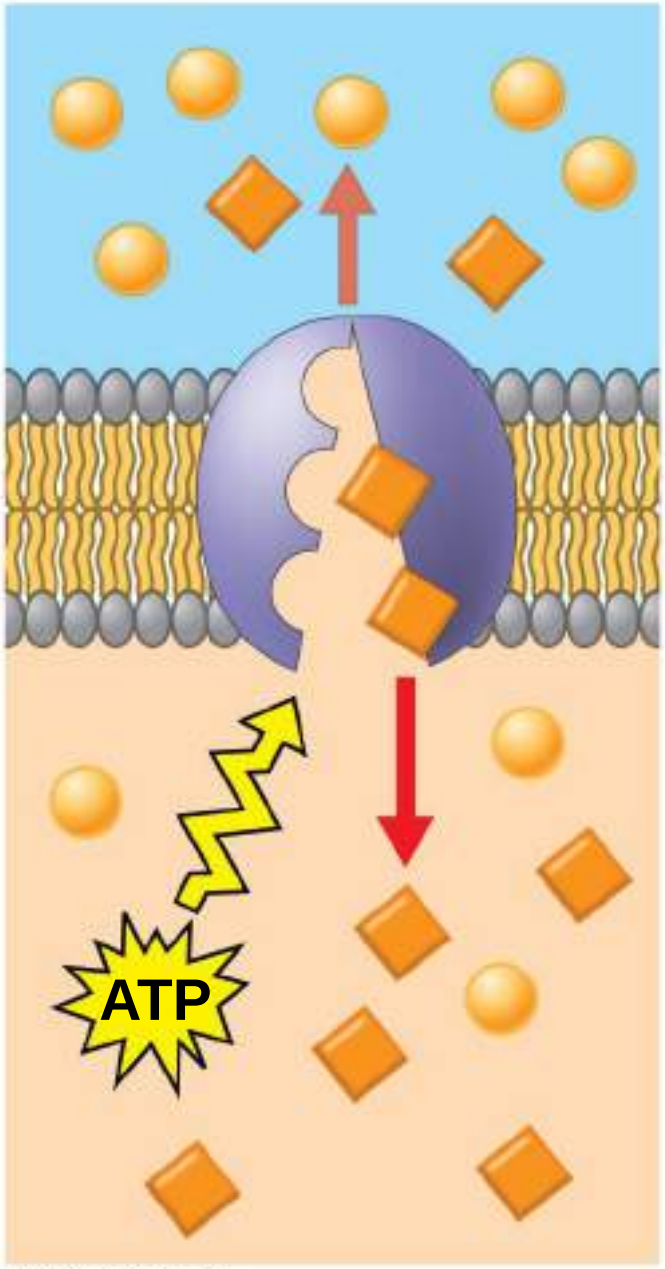


Figure 7.UN03

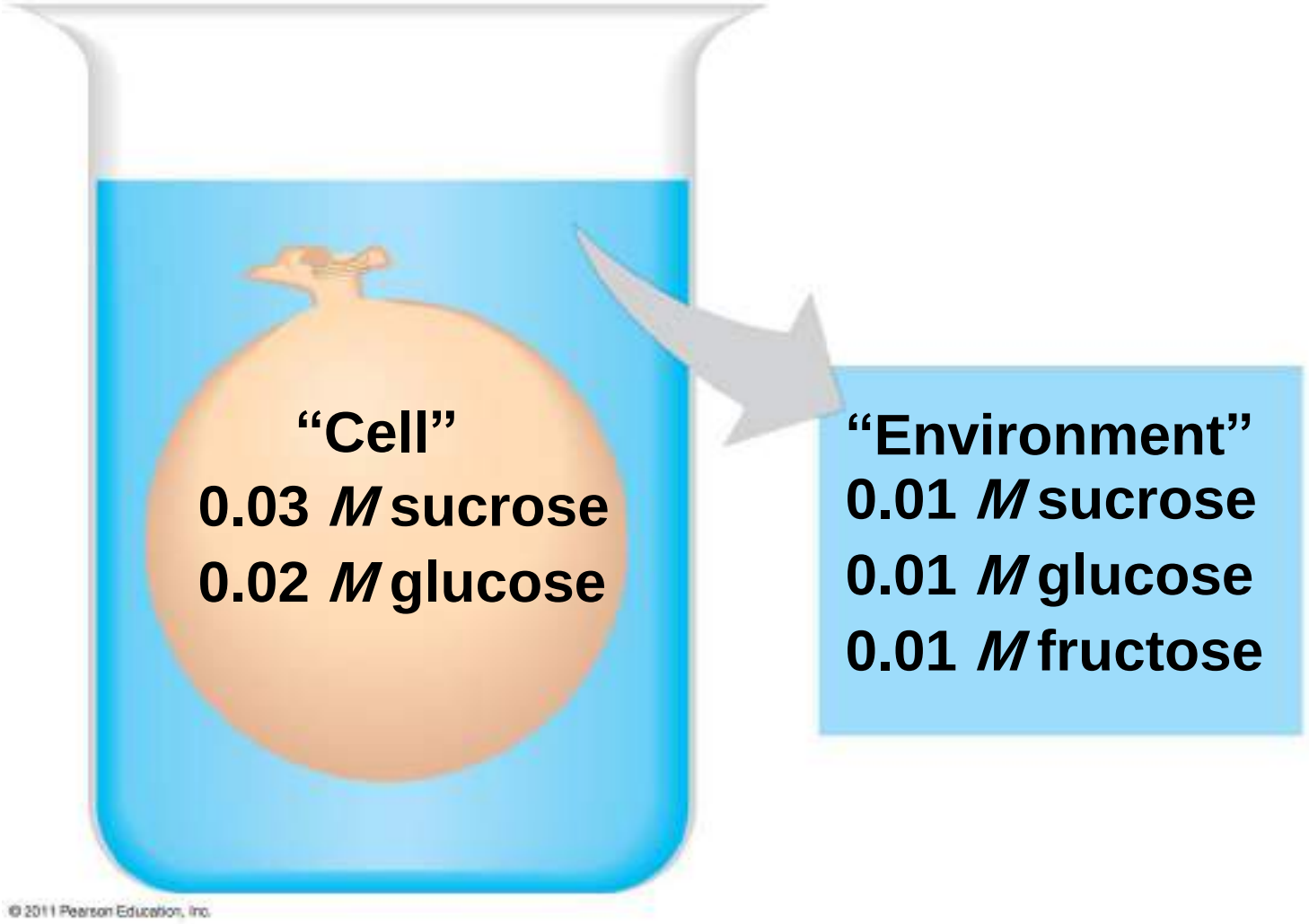


Figure 7.UN04