Essentials of Biology

Sylvia S. Mader

Chapter 5
Lecture Outline

Prepared by: Dr. Stephen Ebbs
Southern Illinois University Carbondale

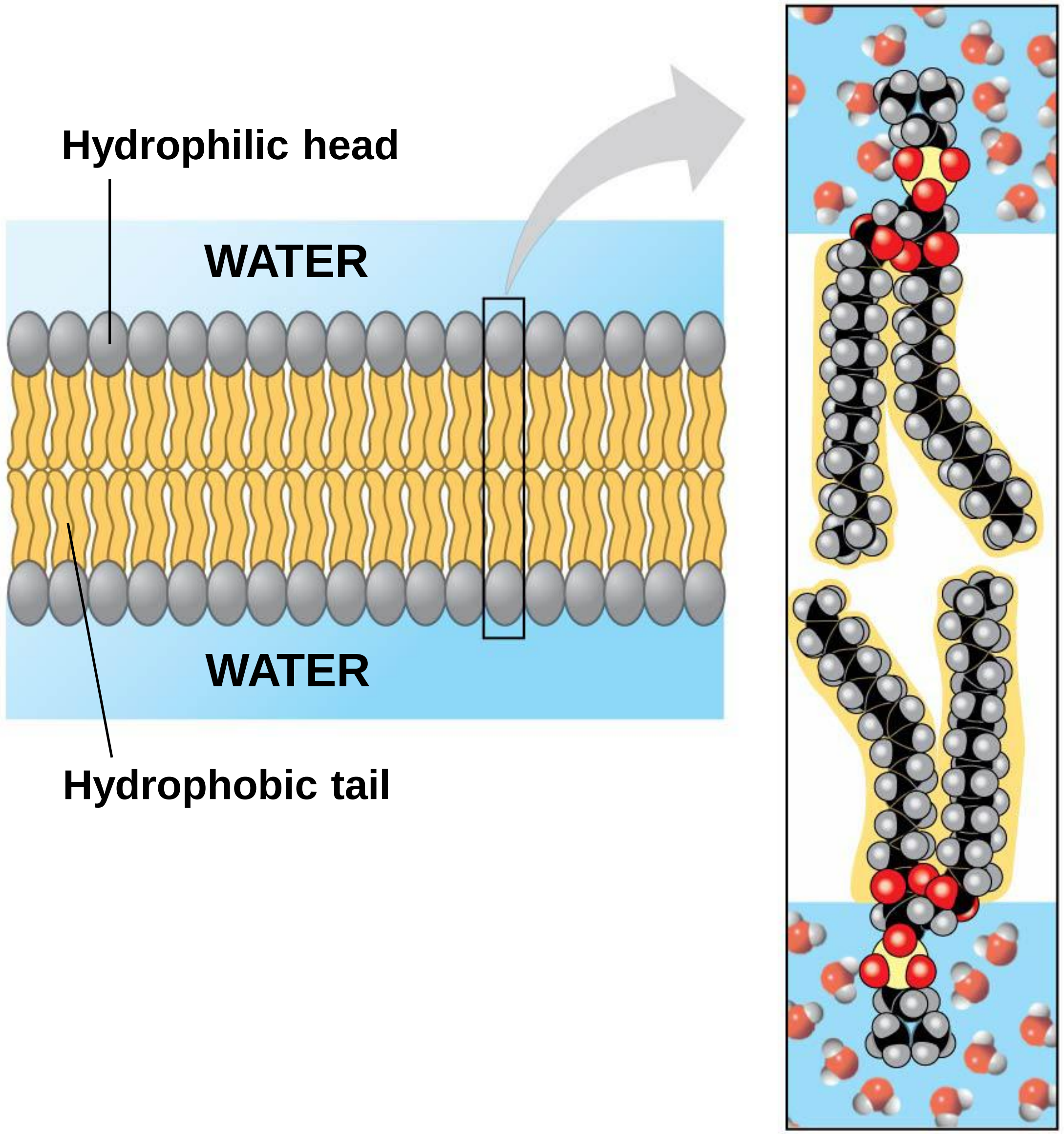
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

4.3 The Plasma Membrane

- The plasma membrane is the boundary that separates the inside of the cell from the outside environment.
- The plasma membrane is a phospholipid bilayer in which proteins are embedded.

- Phospholipids are **amphipathic** molecules, containing hydrophobic and hydrophilic regions
- The polar heads face toward the inside and outside of the cell.
- The nonpolar tails face inward toward each other
- Cholesterol if present (in animal cells) adds structural support and help modify fluidity of the membrane.

Figure 7.2



4.3 The Plasma Membrane (cont.)

- The fluid mosaic model describes the plasma membrane as a phospholipid bilayer in which proteins are imbedded either partially (peripheral proteins) or completely (integral proteins).
- The pattern of the proteins varies according to the type of membrane and its function.
- Proteins are held in place by attachment to protein fibers inside the cell (cytoskeleton) and protein fibers outside the cell (extracellular matrix).

4.3 The Plasma Membrane (cont.)

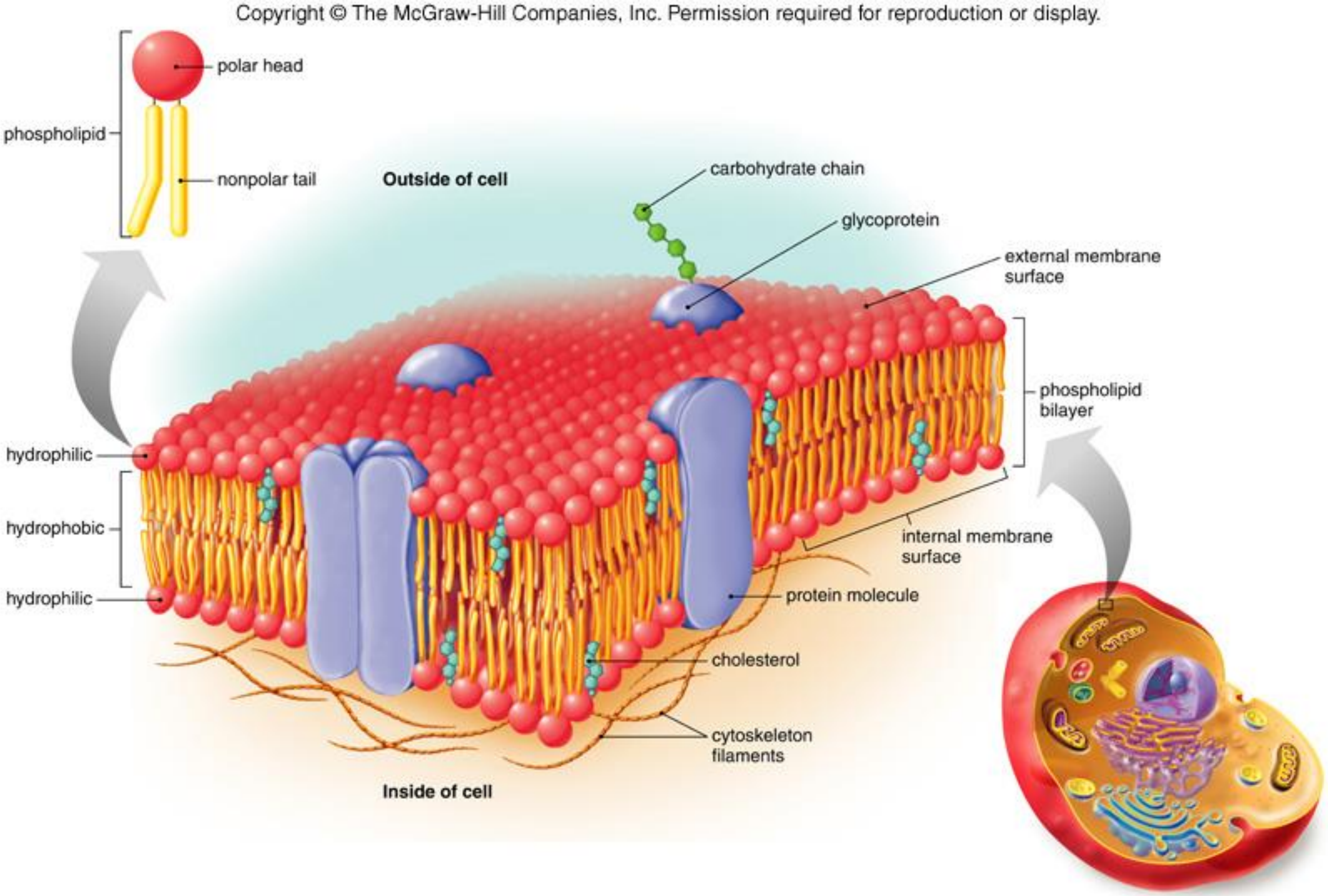
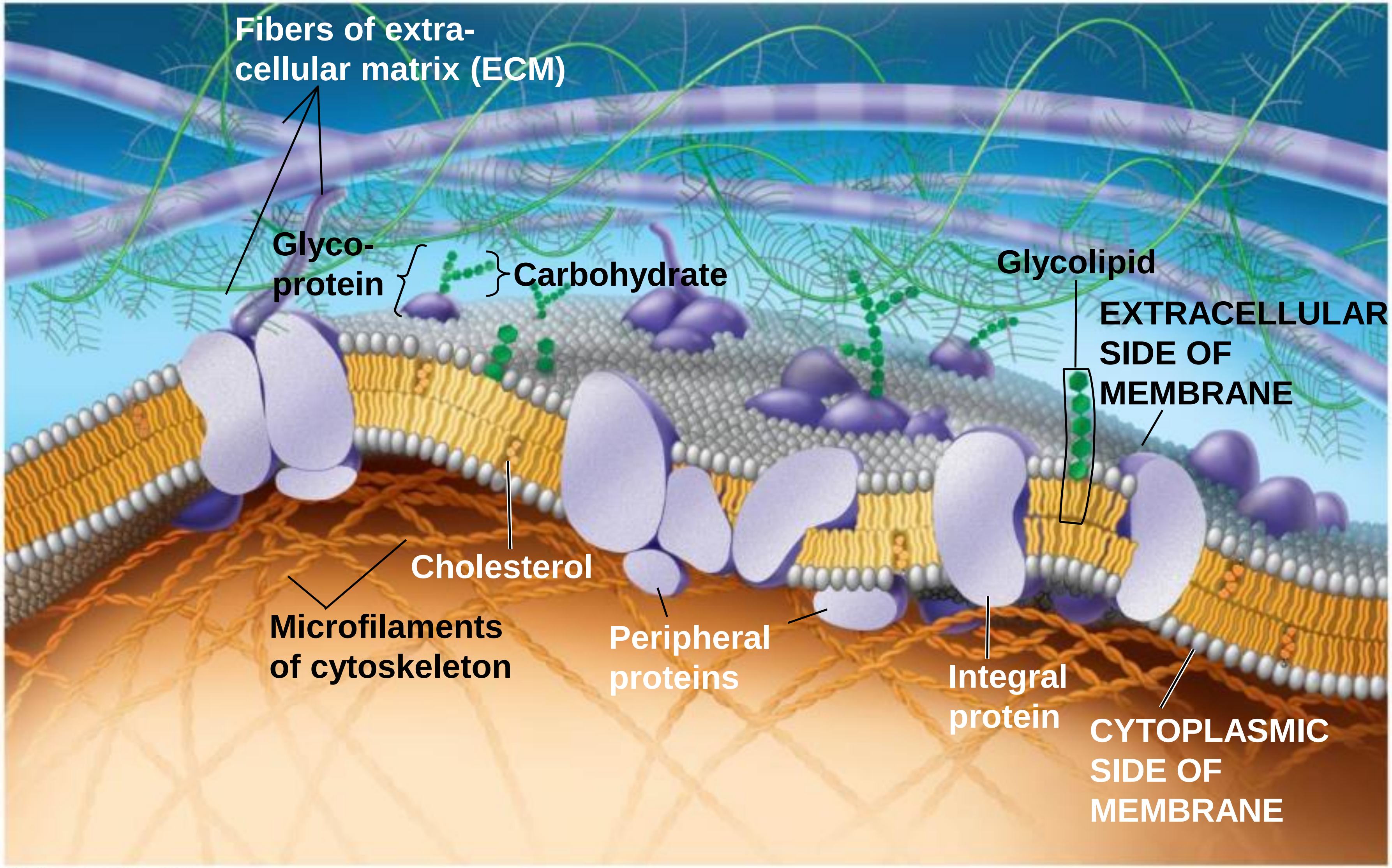


Figure 7.3



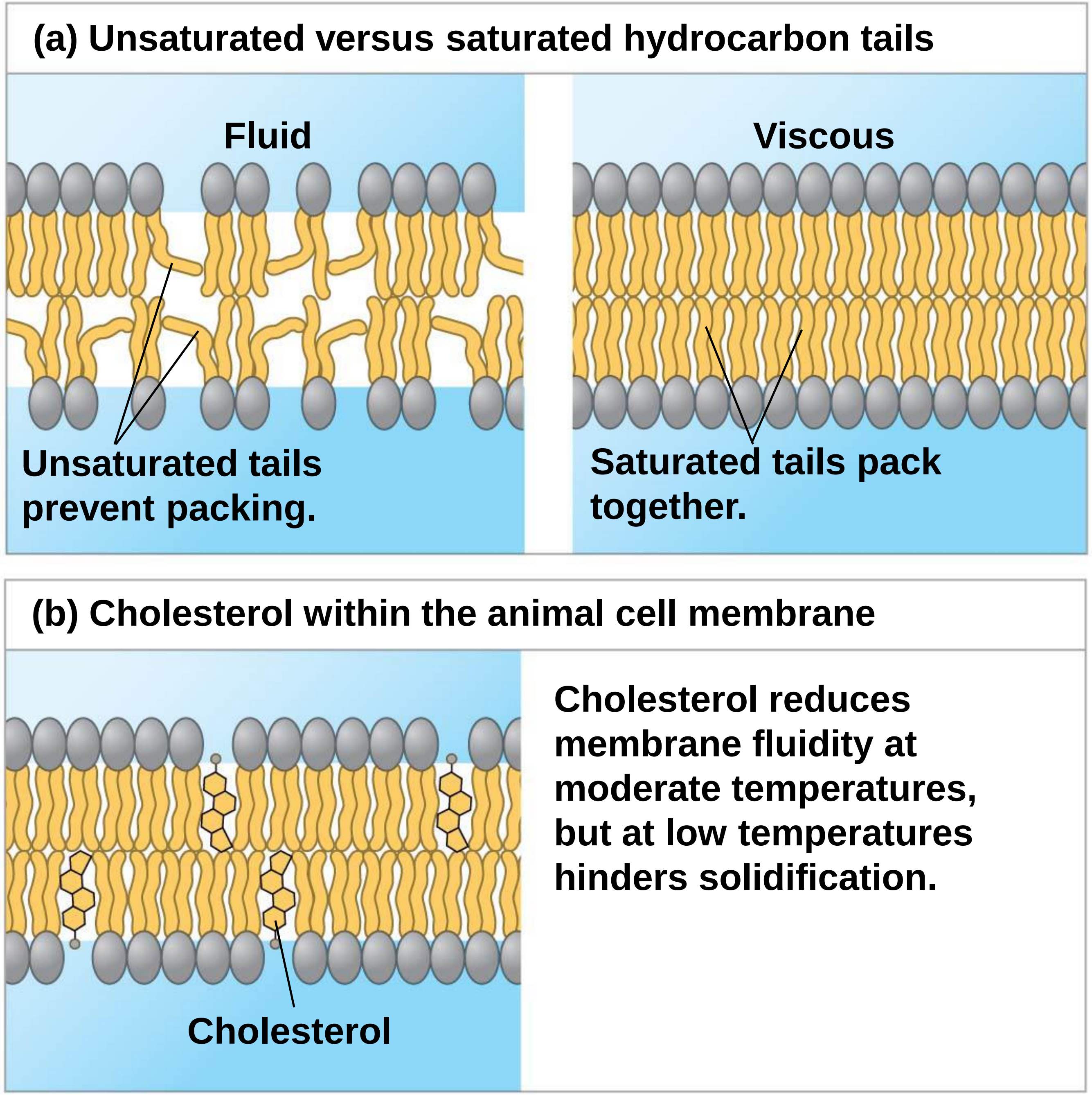
Fibers of extra-
cellular matrix (ECM)
Glyco-
protein
Carbohydrate
Glycolipid
EXTRACELLULAR
SIDE OF
MEMBRANE
Cholesterol
Microfilaments
of cytoskeleton
Peripheral
proteins
Integral
protein
CYTOPLASMIC
SIDE OF
MEMBRANE

The Fluidity of The Membrane

- Phospholipids in the plasma membrane can move within the bilayer
- Most of the lipids, and some proteins, drift laterally
- Rarely, a lipid may flip-flop transversely across the membrane
- As temperatures cool, membranes switch from a fluid state to a solid state. But 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 7.5


(a) Unsaturated versus saturated hydrocarbon tails
Fluid
Viscous
Unsaturated tails prevent packing.
Saturated tails pack together.
(b) Cholesterol within the animal cell membrane
Cholesterol
Cholesterol reduces membrane fluidity at moderate temperatures, but at low temperatures hinders solidification.

Functions of Membrane Proteins

- The wide variety of proteins that are present in membranes have different functions.
- Channel proteins are simple protein pores that allow substances to move across the membrane.
- Carrier proteins combine with substances to assist their movement across membranes.
- Cell recognition proteins are glycoproteins that have several functions, such as recognition of pathogens.

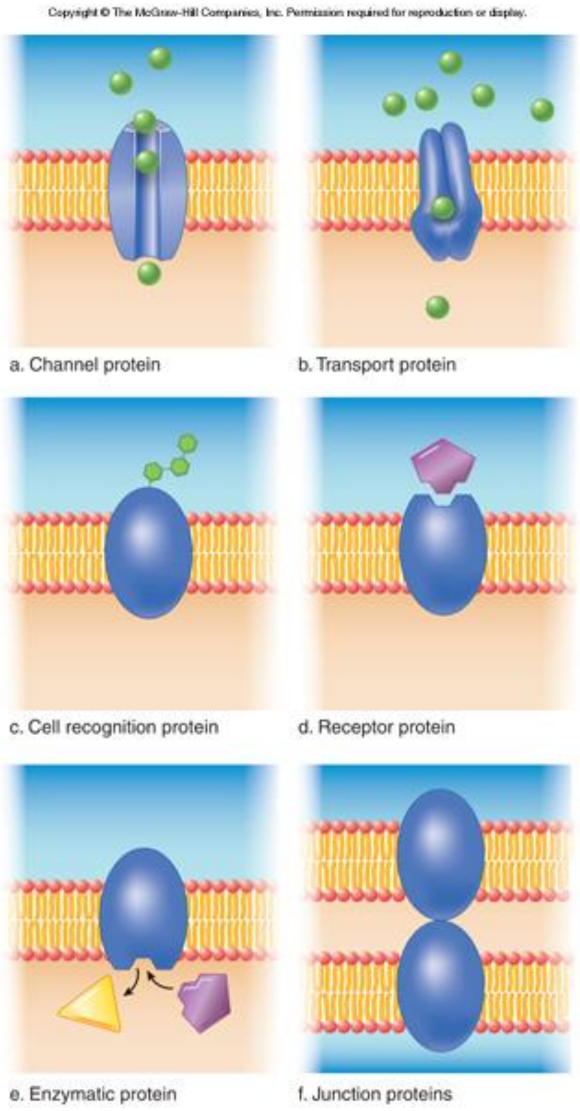
Functions of Membrane Proteins (cont.)

- Receptor proteins have a shape that can only bind specific signal molecules.

- Enzymatic proteins are membrane proteins that carry out chemical reactions.

- Junction proteins connect cells to each other and allow them to communicate.

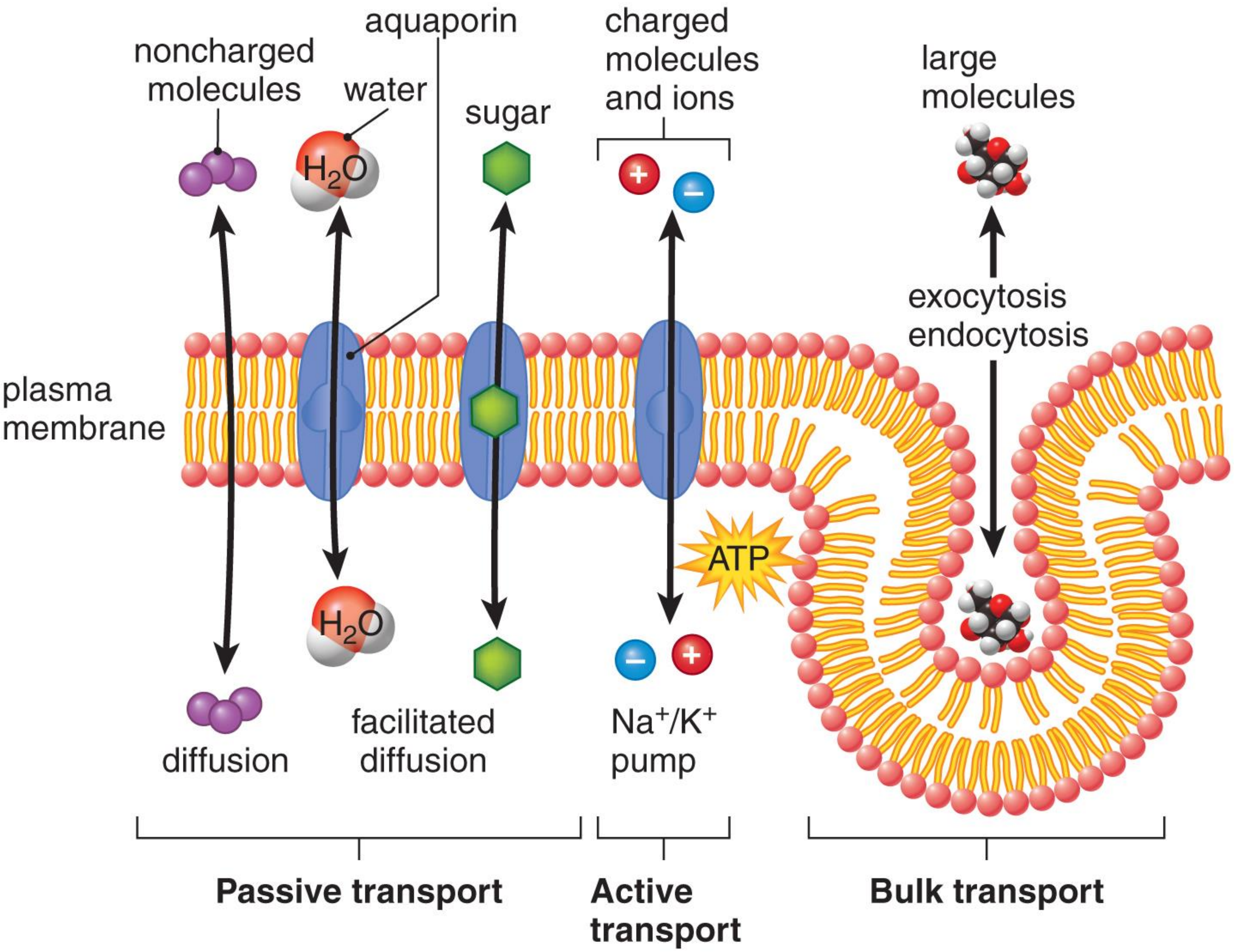
Functions of Membrane Proteins (cont.)



Cell Transport

- The plasma membrane regulates the transport of molecules into and out of the cell.

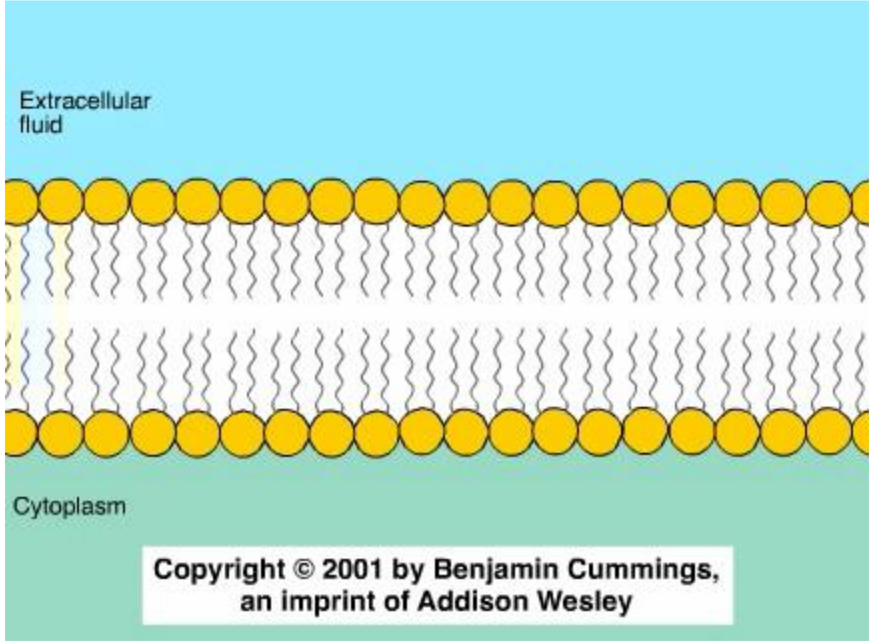
- The plasma membrane is differentially (selectively) permeable, which means that some substances move freely across the membrane but others are restricted.


noncharged molecules
water
aquaporin
sugar
charged molecules and ions
large molecules
exocytosis
endocytosis
plasma membrane
H_2O
H_2O
ATP
diffusion
facilitated diffusion
Na^+/K^+ pump
Passive transport
Active transport
Bulk transport

Cell Transport (cont.)

- Substances can enter cells in three ways.
  - Passive transport
  - Active transport
  - Bulk transport

Animation: Membrane Selectivity



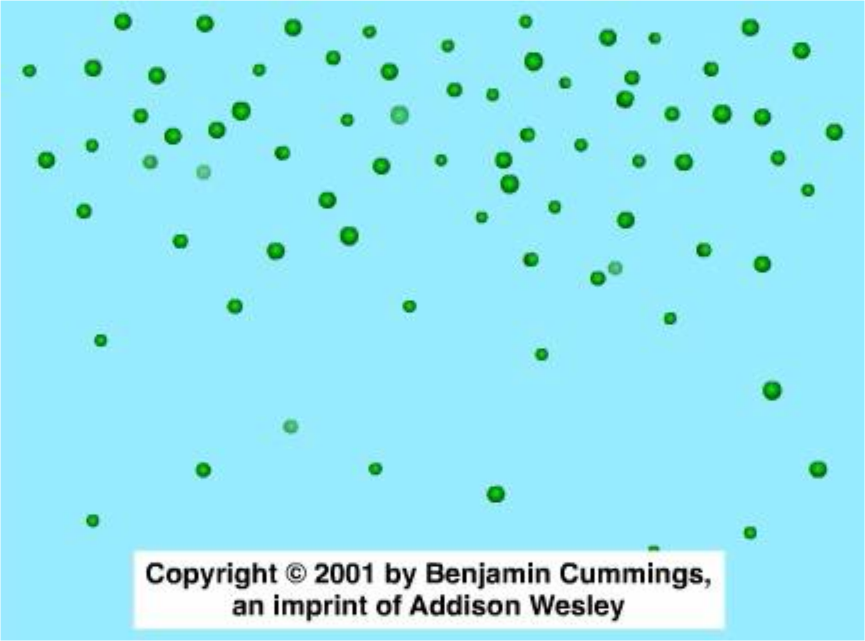
Passive Transport: No Energy Required

- Simple diffusion occurs when the solute (a substance dissolved in a liquid solvent) moves from a higher concentration to a lower concentration (down their concentration gradient).

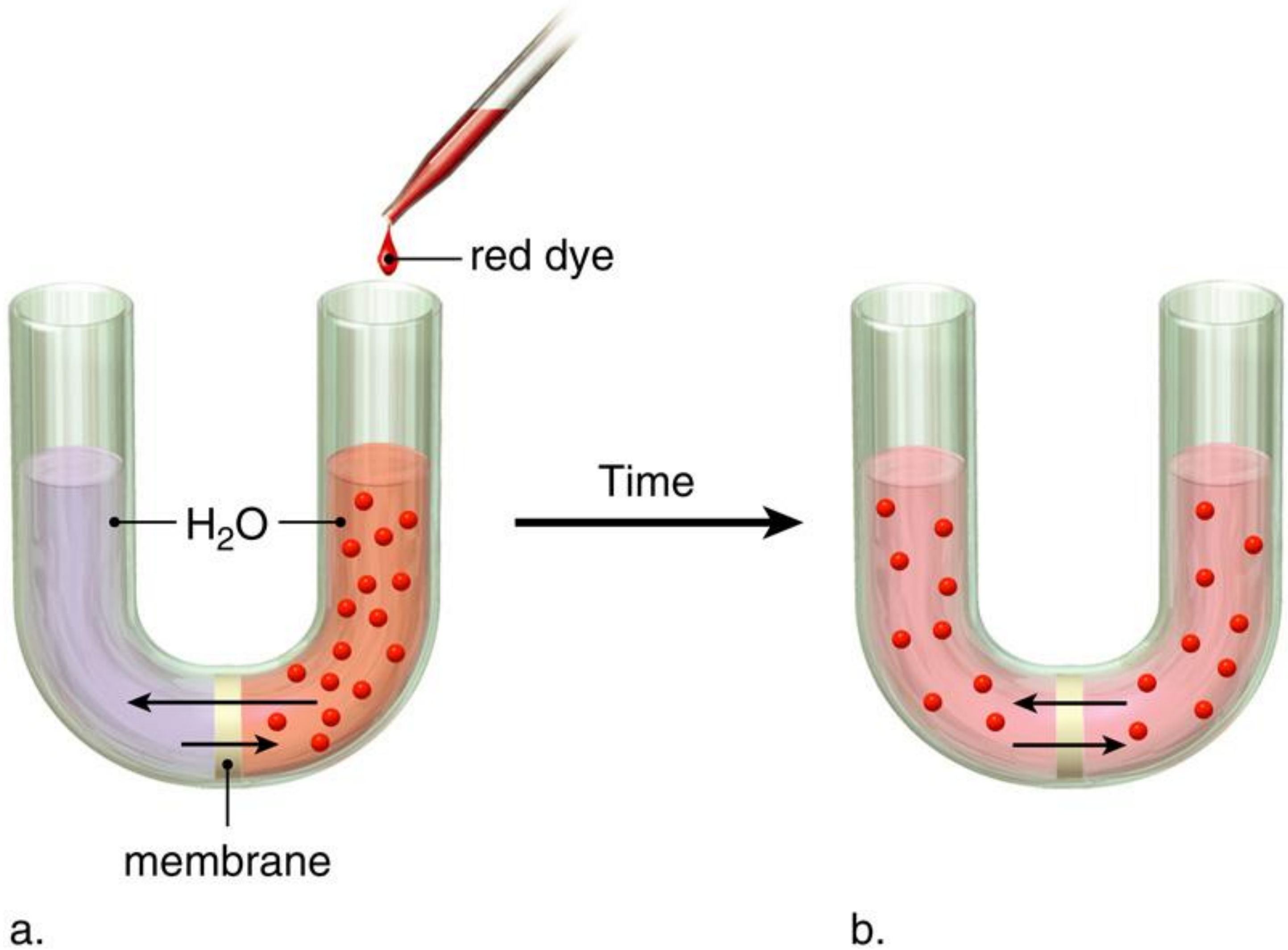
- Simple diffusion occurs until equilibrium is reached.

- Simple diffusion is passive because it does not require energy.

Animation: Diffusion



Passive Transport: No Energy Required (cont.)



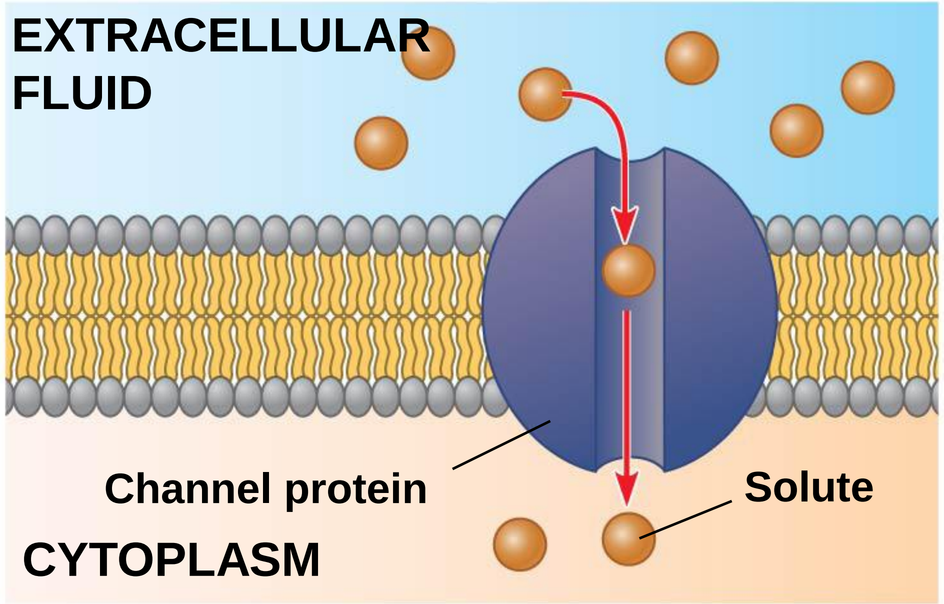
Passive Transport: No Energy Required

- Small, uncharged molecules (non-polar) such as oxygen, carbon dioxide, and water cross membranes by simple diffusion.
- Its important in transport of oxygen from alveoli in lungs (high oxygen concentration) to blood (low oxygen concentration), and from blood (high oxygen concentration) to tissues (low oxygen concentration).
- Rate of diffusion depends on several factors such as: temperature, pressure, electrical currents and molecular size.

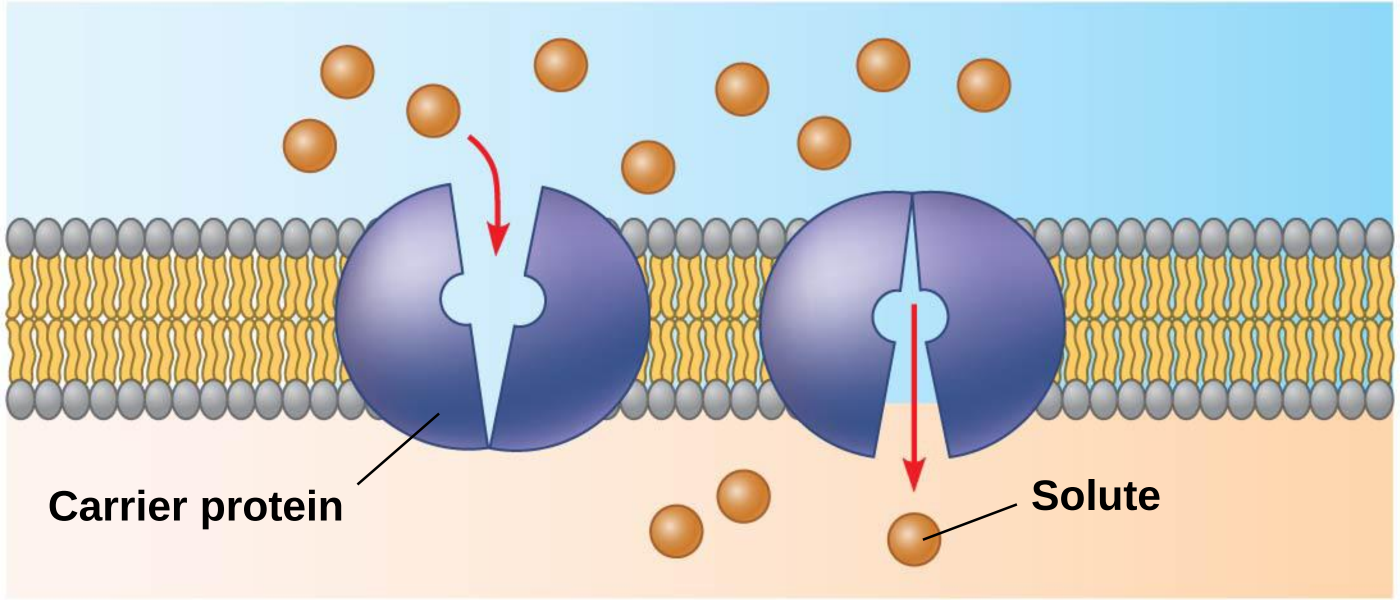
Facilitated Diffusion

- Ions and polar molecules cross membranes by facilitated diffusion.
  - Facilitated diffusion is also passive transport.
  - Membrane proteins (carriers and channels) assist the movement of the molecule across the membrane.

Figure 7.14



(a) A channel protein



(b) A carrier protein

Osmosis

- Diffusion of water across a differentially permeable membrane is called osmosis.
- Osmosis is a type of passive diffusion where the solvent (water) moves across the membrane, rather than the solute.
- Water moves down its own concentration gradient; from free water high concentration (therefore salt is in low concentration), to free water low concentration (therefore salt is in high concentration).
- In this case, the membrane is not permeable to the solute.

Osmosis (cont.)

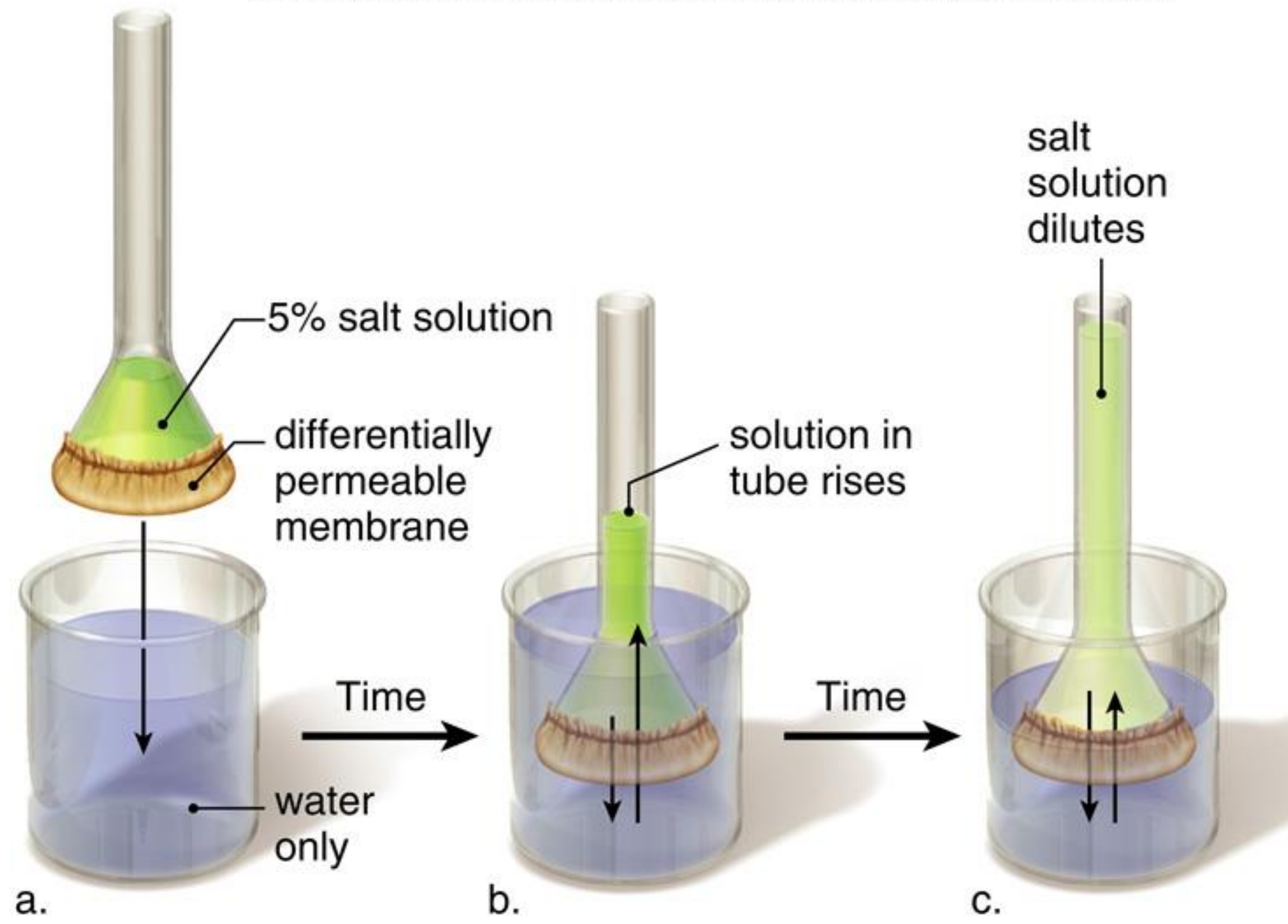


Figure 7.11

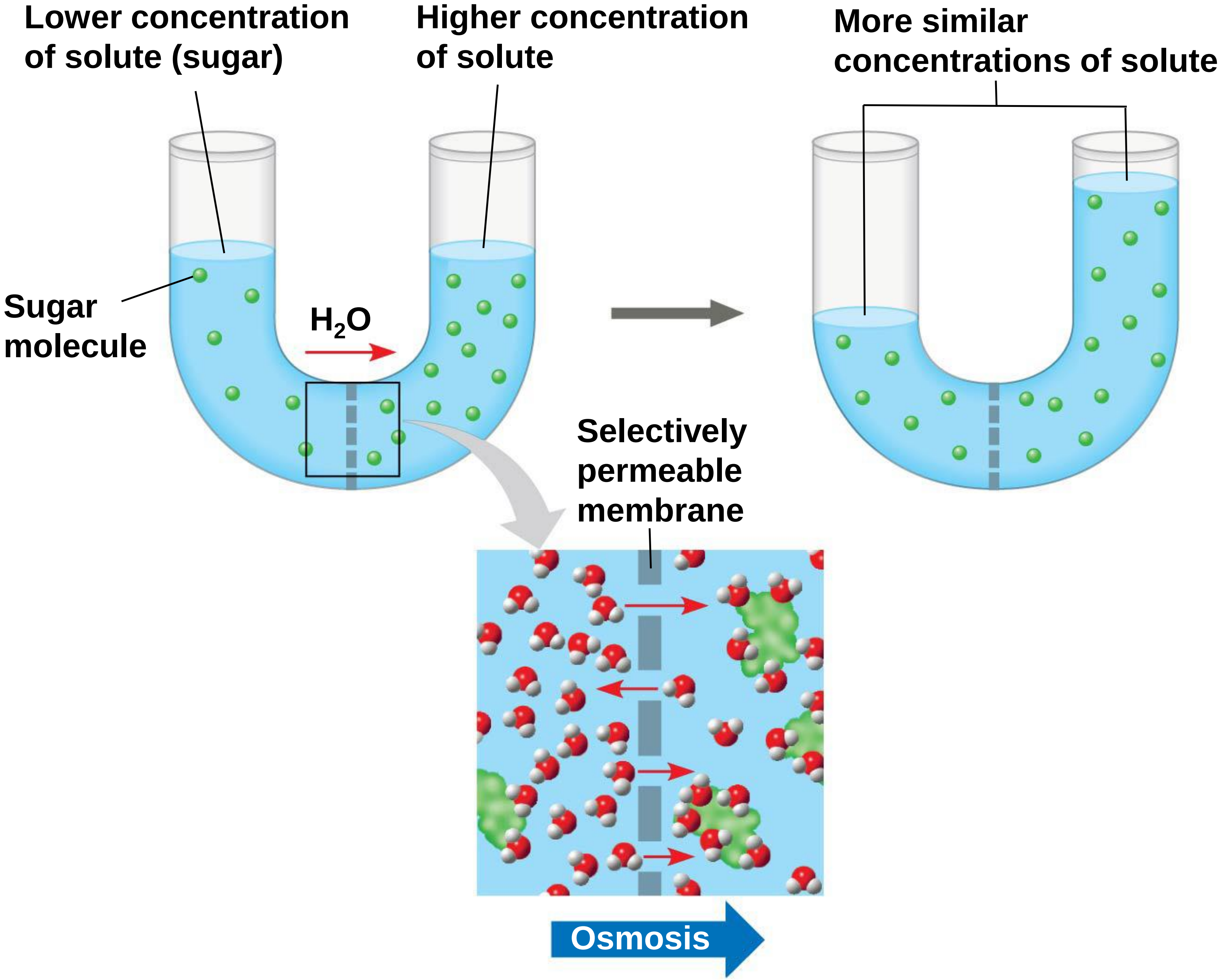
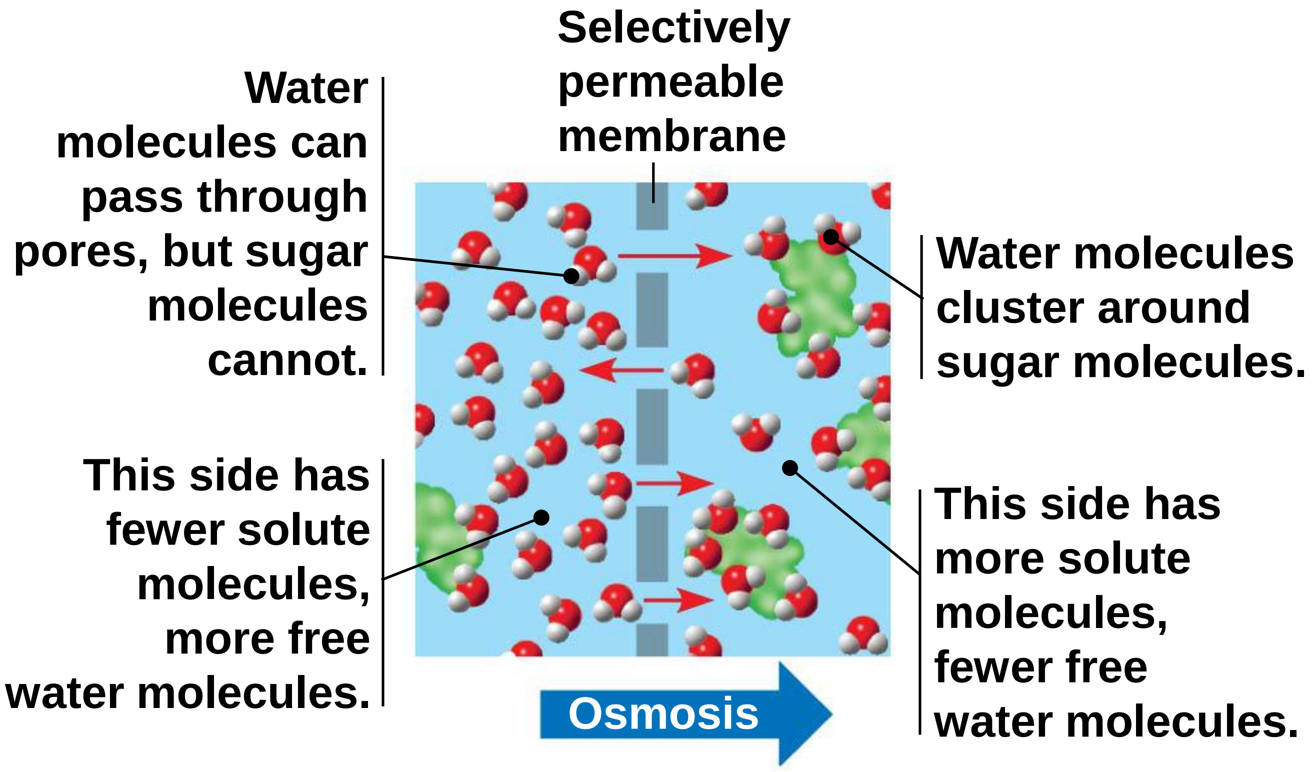
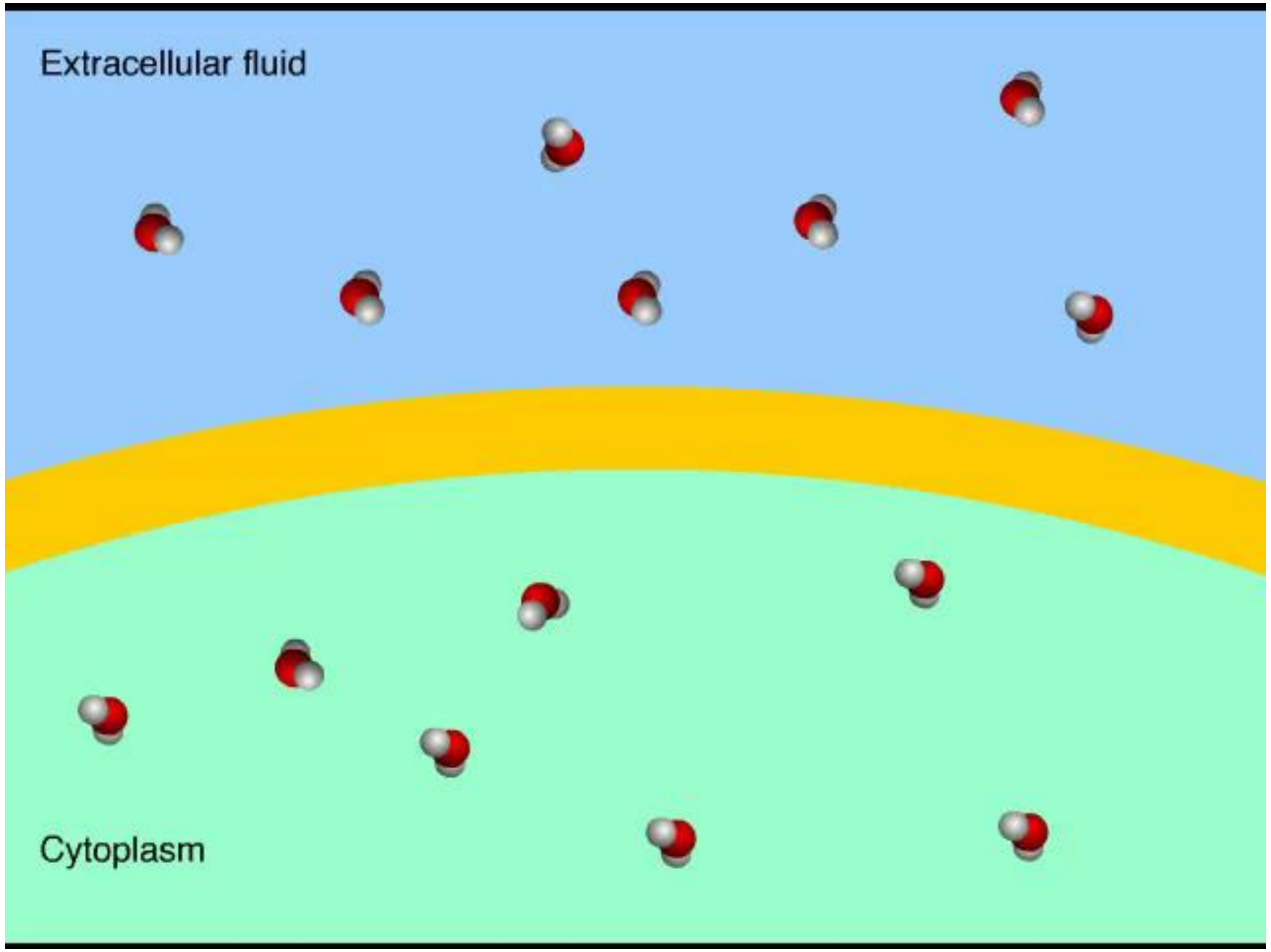

Lower concentration of solute (sugar)
Higher concentration of solute
More similar concentrations of solute
Sugar molecule
H_2O
Selectively permeable membrane
Osmosis

Figure 7.11a


Selectively permeable membrane
Water molecules can pass through pores, but sugar molecules cannot.
Water molecules cluster around sugar molecules.
This side has fewer solute molecules, more free water molecules.
This side has more solute molecules, fewer free water molecules.
Osmosis

Animation: Osmosis



The Effect of Osmosis on Cells

- Osmosis can affect the size and shape of cells, depending on differences in water concentration across the membrane.
- Three types of solutions:

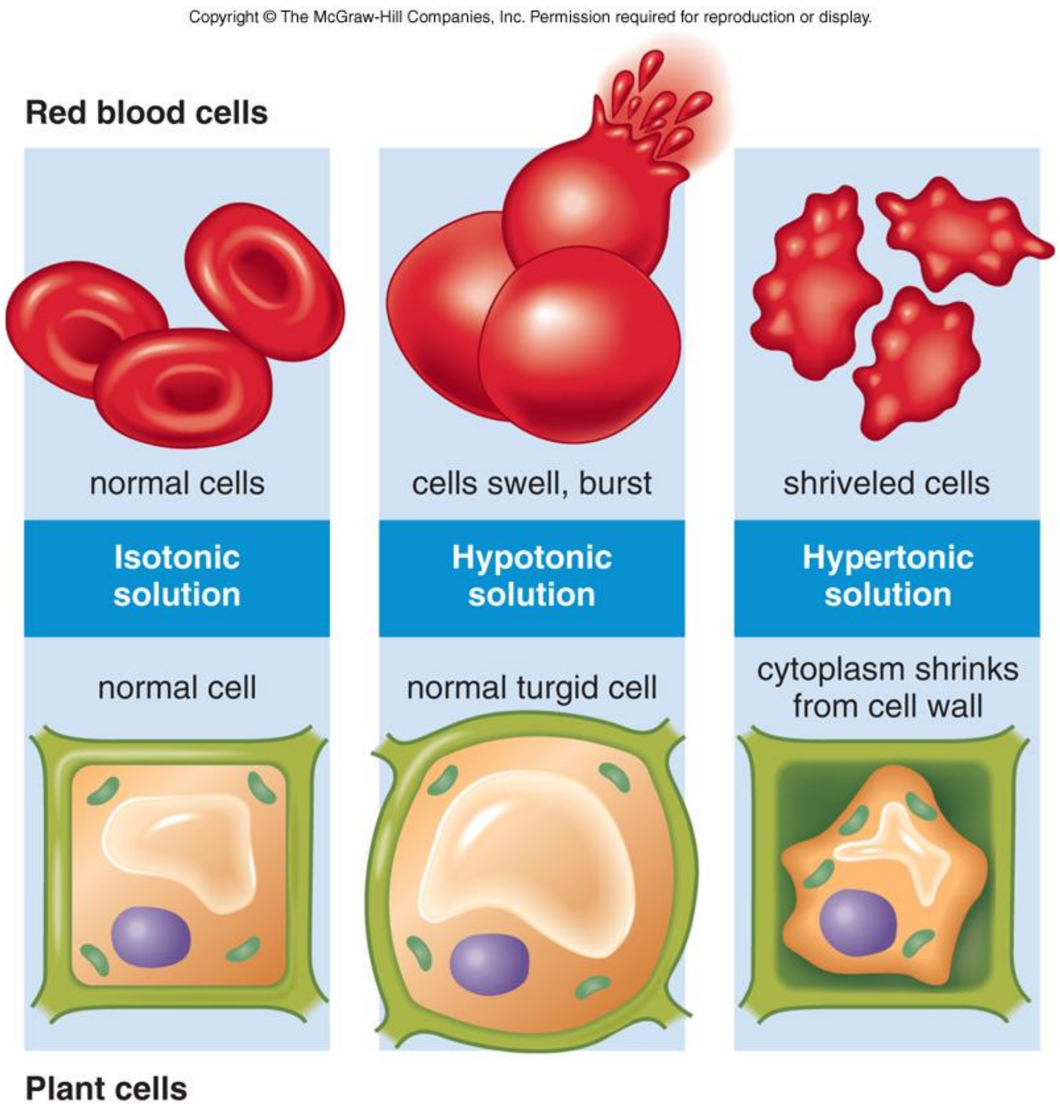
- **Isotonic** solution: Solute concentration is the same as that inside the cell; no *net* water movement across the plasma membrane.
- **Hypertonic** solution: Solute concentration is greater than that inside the cell; cell loses water
- **Hypotonic** solution: Solute concentration is less than that inside the cell; cell gains water

The Effect of Osmosis on Cells

- Cells placed in an isotonic solution do not change because the concentration of water on both sides of the membrane is the same. There is no net gain or loss of water.
- Cells placed in a hypotonic solution gain water because the concentration of water is higher outside the cell and water rushes in. if water keeps going inside the animal cell, it swells and finally burst (lysis). While in plant cells, the large central vacuole gains water, and the plasma membrane pushes towards the cell wall in a pressure called: turgor pressure. The plant cell doesn’t burst because the cell wall is rigid. The plant cell is said to be “turgid”.

- Cells placed in a hypertonic solution lose water because the concentration of water is higher inside the cell and water rushes out. In animal cells, the cell shrinks and becomes shriveled. While in plant cells, the plasma membrane pulls away from the cell wall, and the large central vacuole loses water. The cytoplasm shrinks and the cell undergoes plasmolysis.

The Effect of Osmosis on Cells



Active Transport: Energy Required

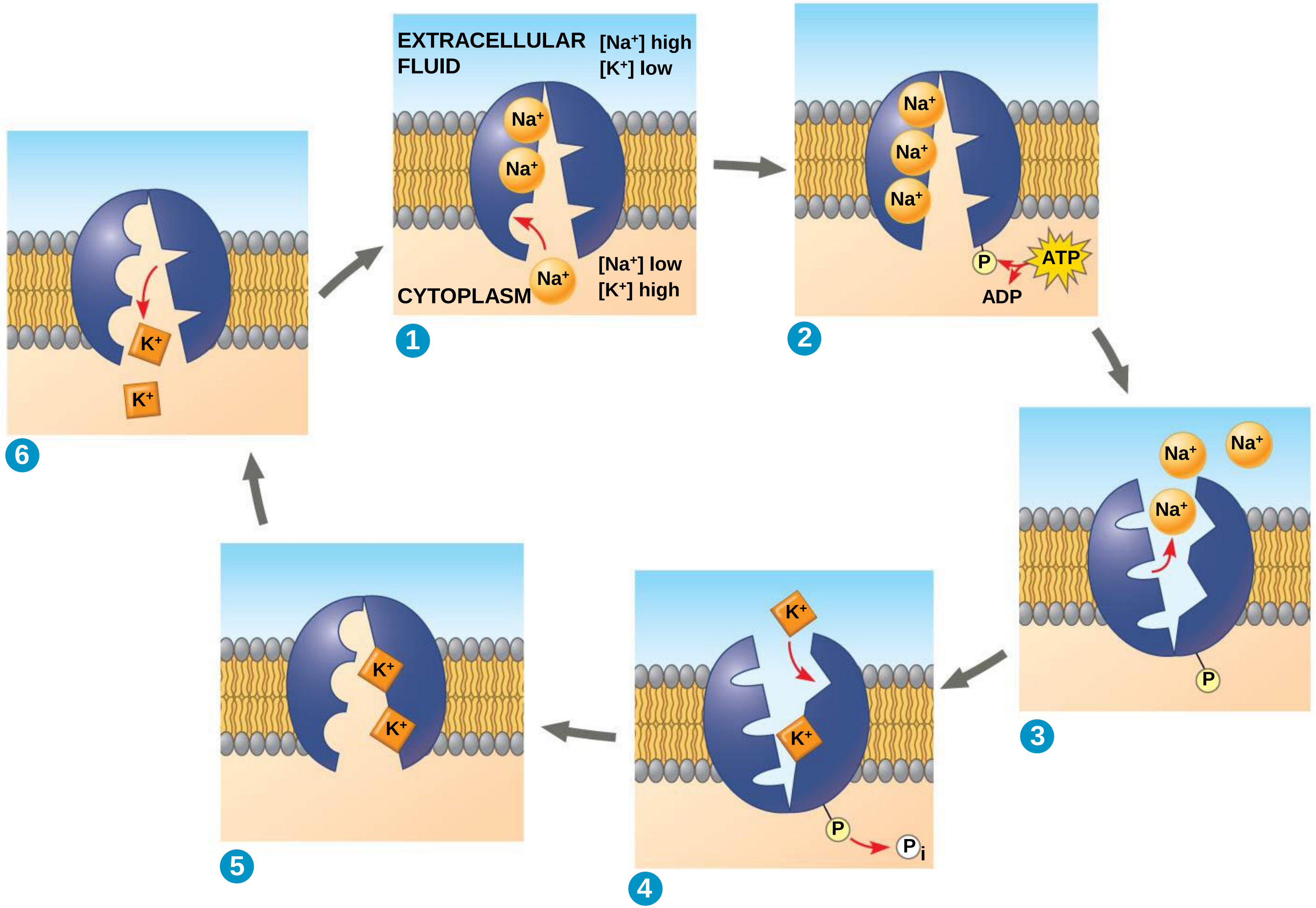
- During active transport, molecules move against their concentration gradient (from low concentration to high concentration).
- Active transport requires a membrane protein (carrier or channel) and energy (ATP) to move the molecule.
- The energy for active transport is generally provided by the mitochondria.

Active Transport: Energy Required (cont.)

- Proteins engaged in active transport are often called pumps.

- The sodium-potassium pump is an example of an active transport process critical to nerve conduction. It moves 3 sodium ions to the outside of the cell, and 2 potassium ions to the inside of the cell.

Figure 7.15


EXTRACELLULAR FLUID
[Na+] high
[K+] low
CYTOPLASM
[Na+] low
[K+] high
Na+
Na+
Na+
1
Na+
Na+
Na+
P
ATP
ADP
2
Na+
Na+
Na+
P
3
K+
K+
P
Pi
4
K+
K+
5
K+
K+
6

Animation: Active Transport

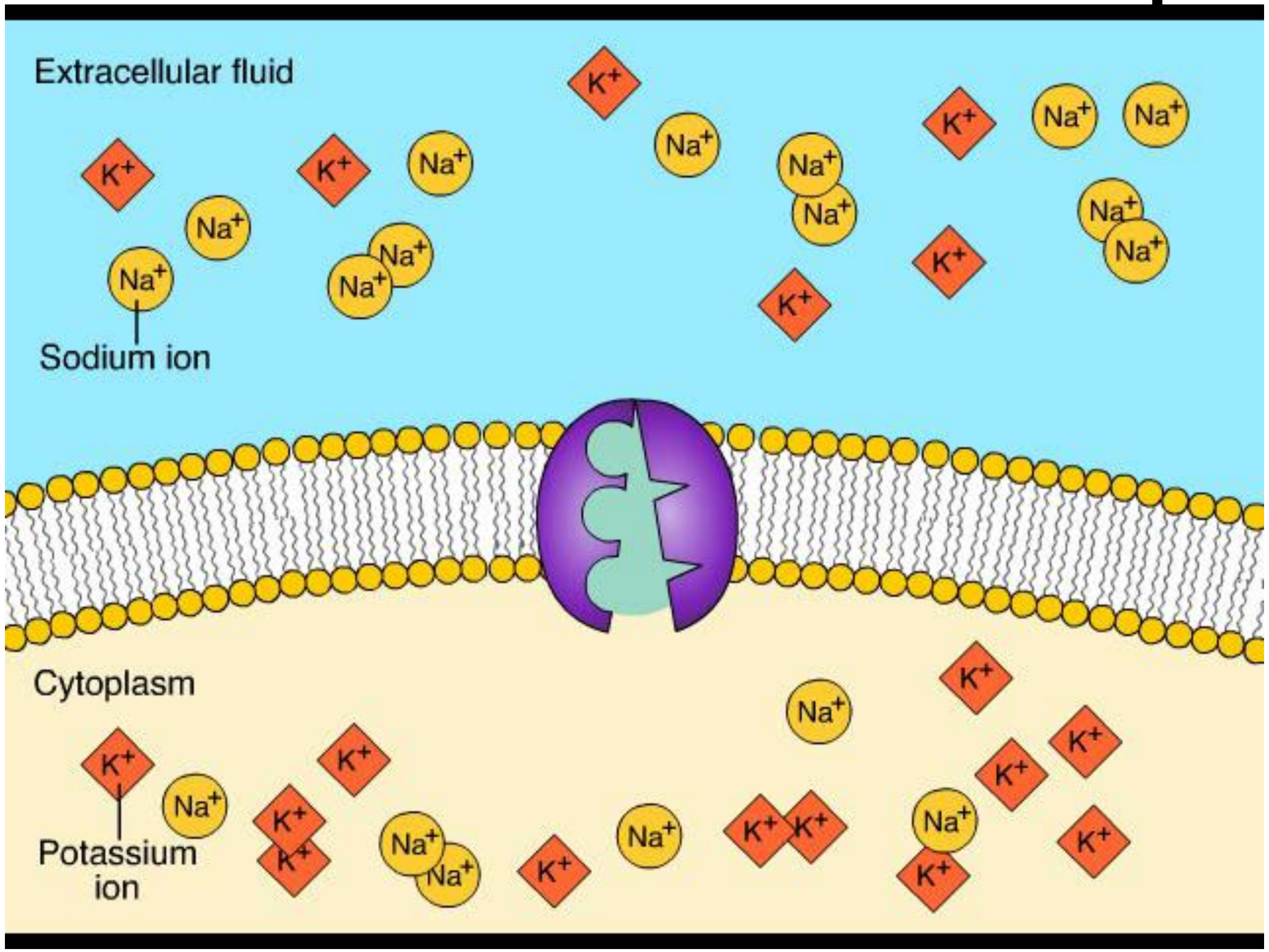
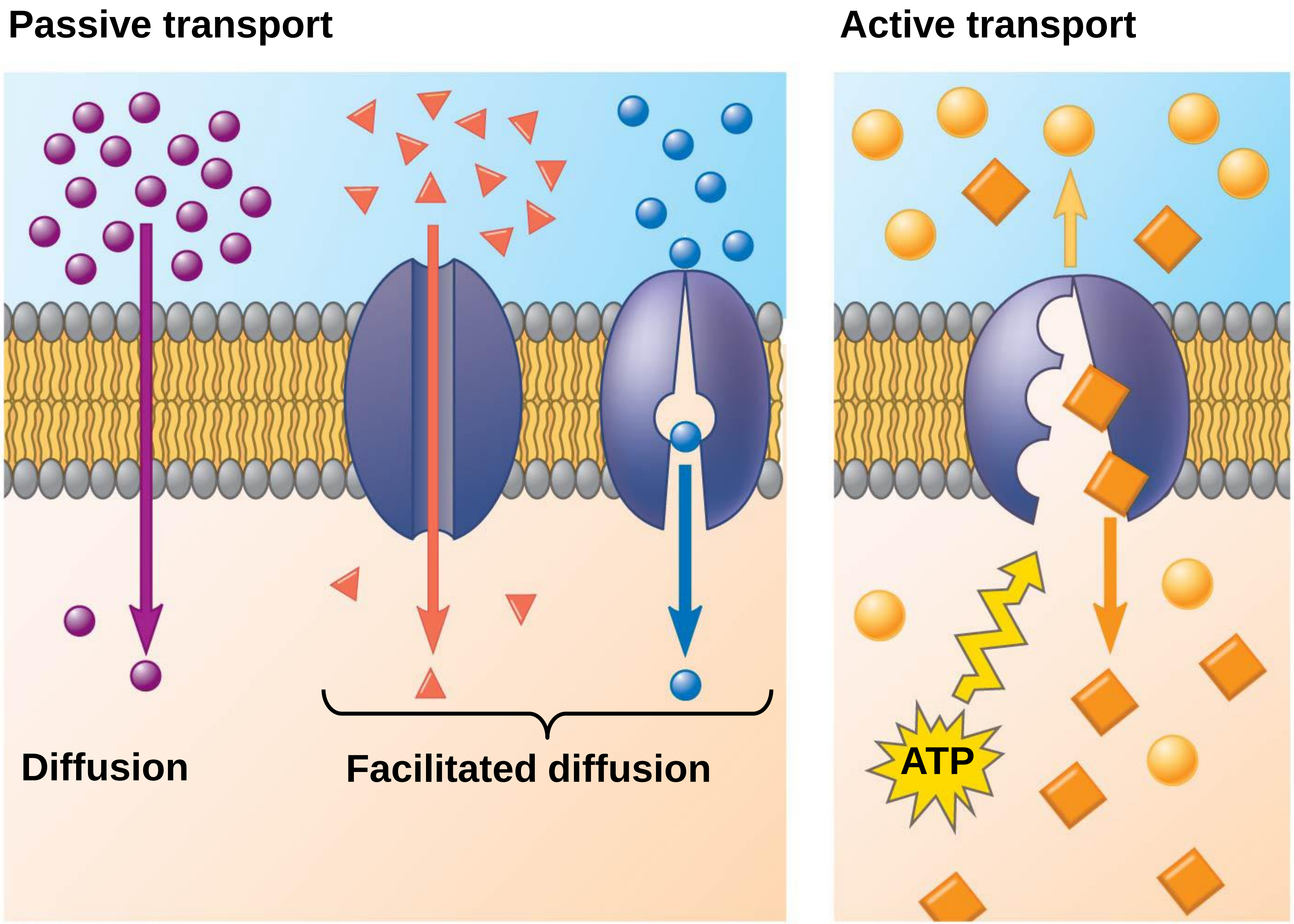


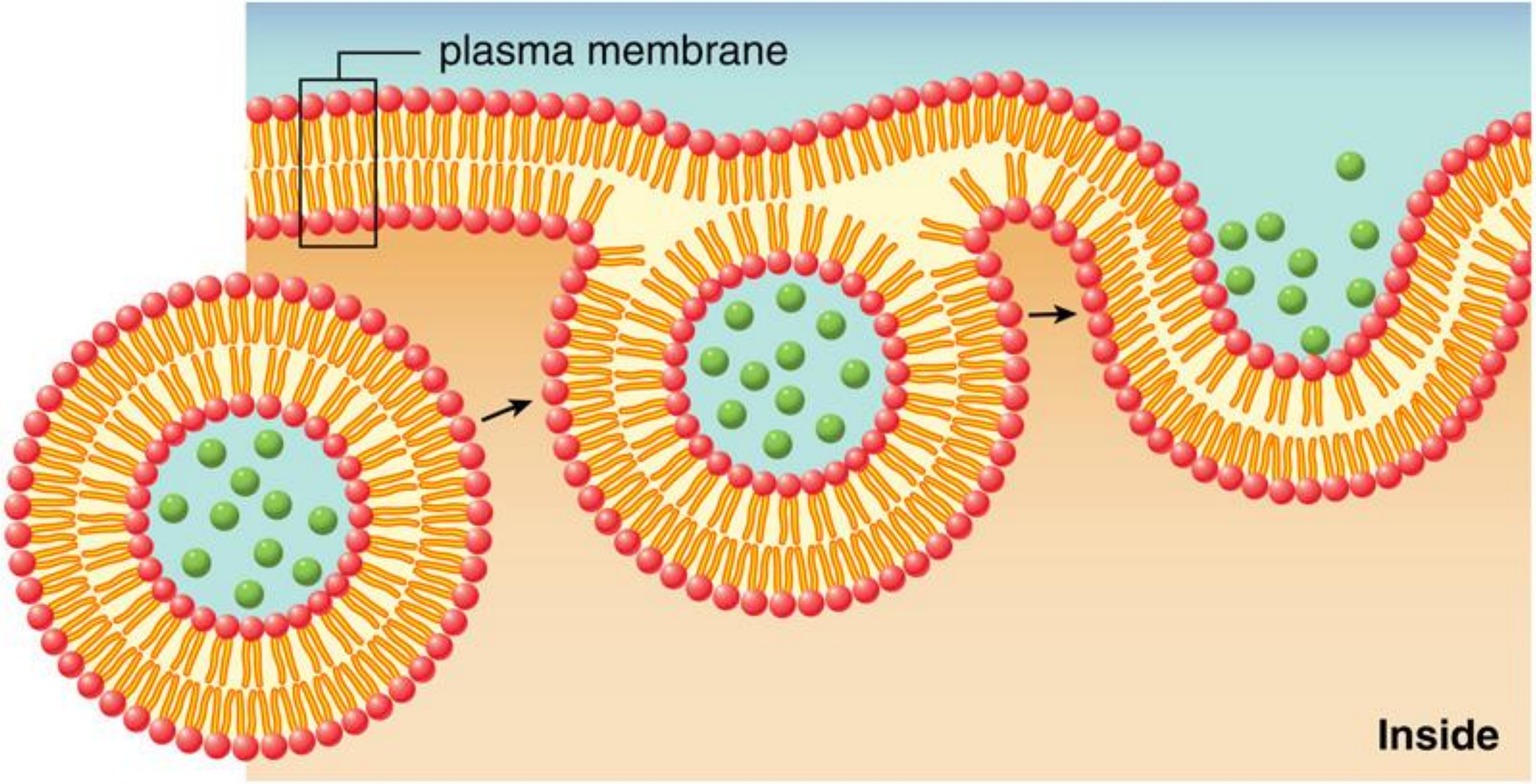
Figure 7.16


Passive transport
Active transport
Diffusion
Facilitated diffusion
ATP

Bulk Transport

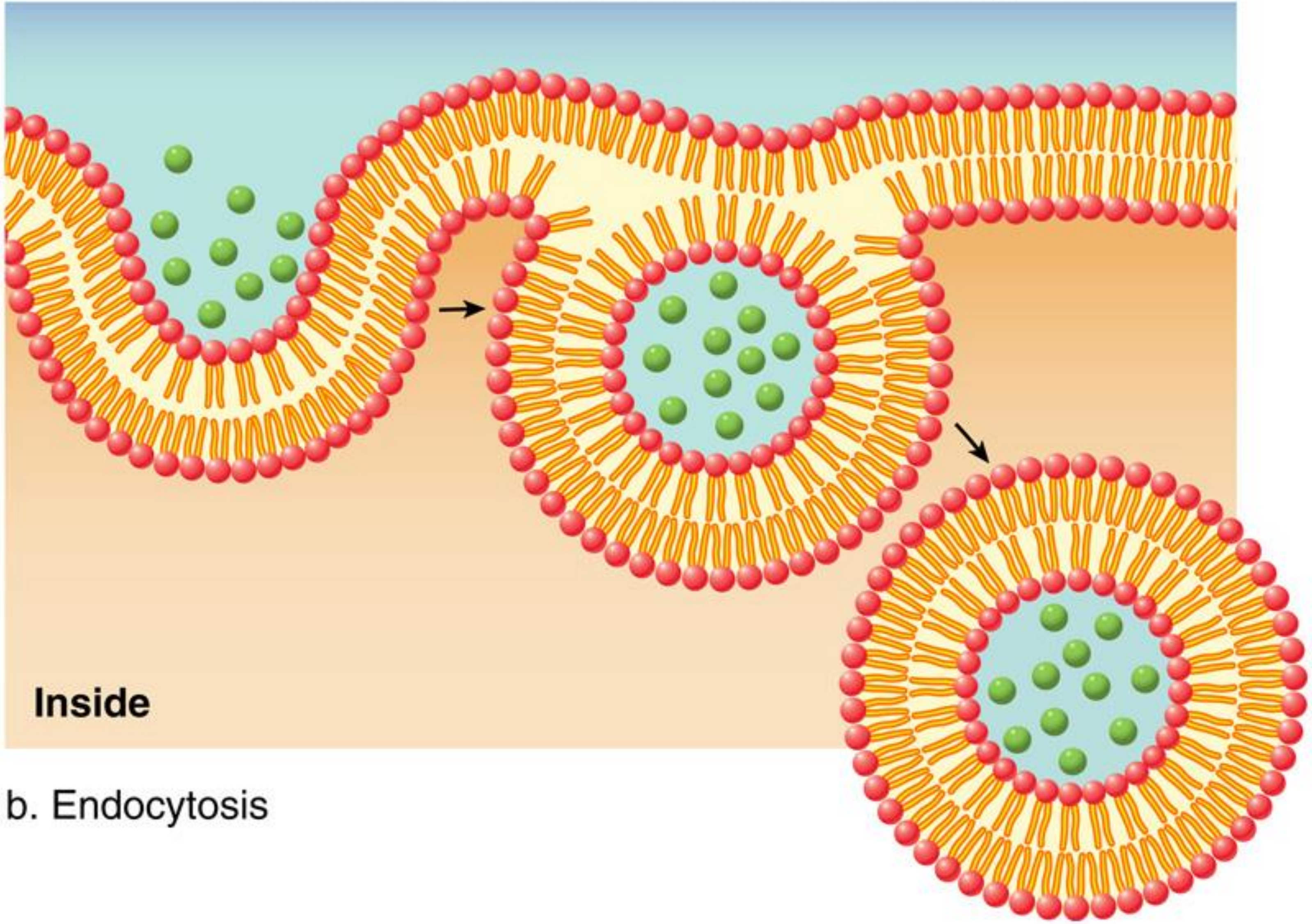
- Macromolecules are too large to move with membrane proteins and must be transported across membranes in vesicles.
- The transport of macromolecules out of a cell in a vesicle is called exocytosis.
- The transport of macromolecules into a cell in a vesicle is called endocytosis.

Bulk Transport (cont.)



a. Exocytosis

Bulk Transport (cont.)



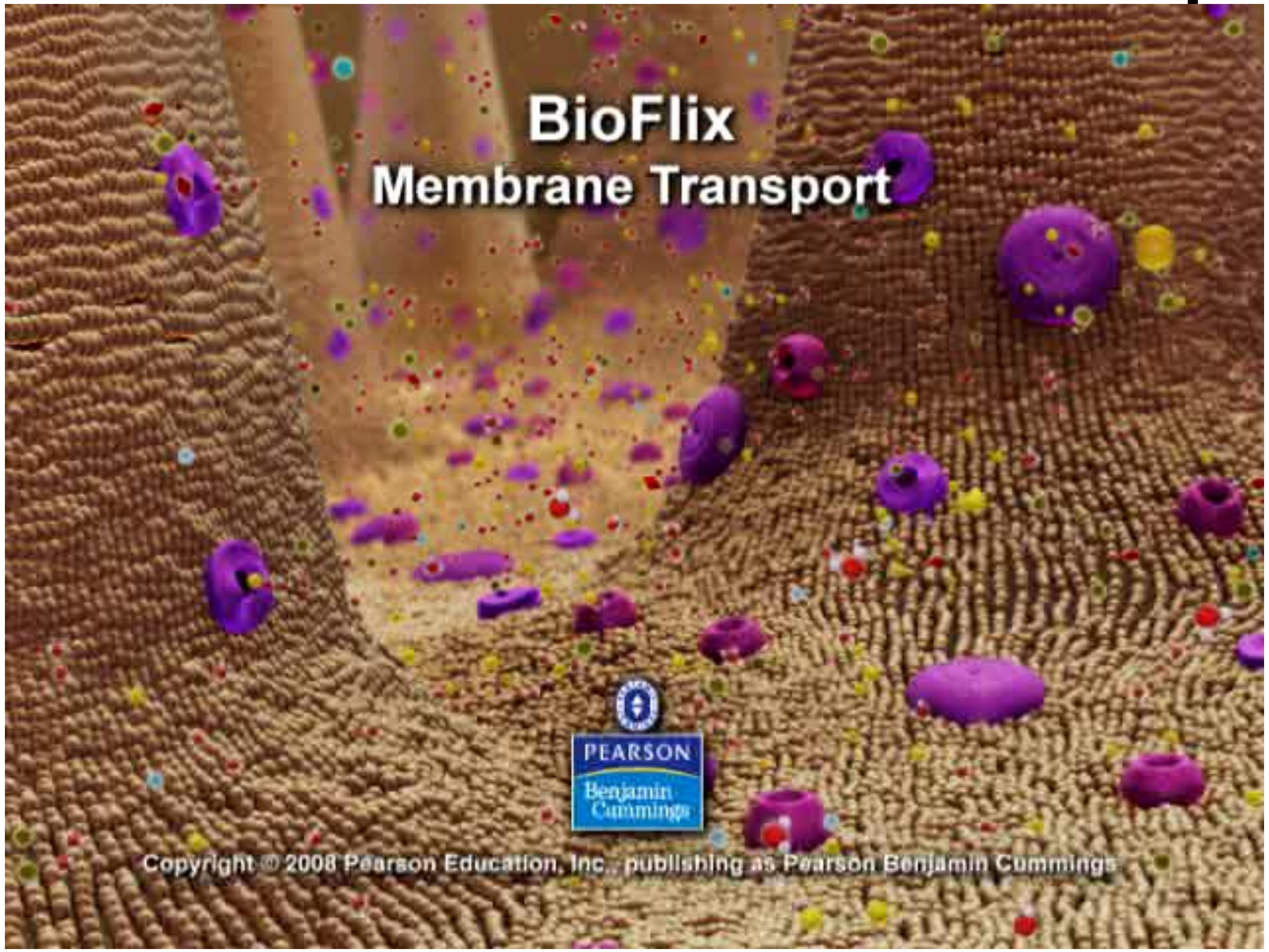
b. Endocytosis

Bulk Transport (cont.)

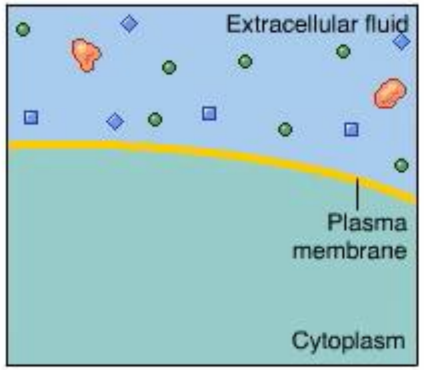
- Three types of endocytosis:

1. If the material taken up by endocytosis is a large particle it is called phagocytosis. This type is important in amoeba and in white blood cells in humans.
2. If the material taken up by endocytosis is a liquid or small particle it is called pinocytosis.
3. Receptor-mediated endocytosis is a selective, highly efficient form of endocytosis, that requires a protein on the plasma membrane.

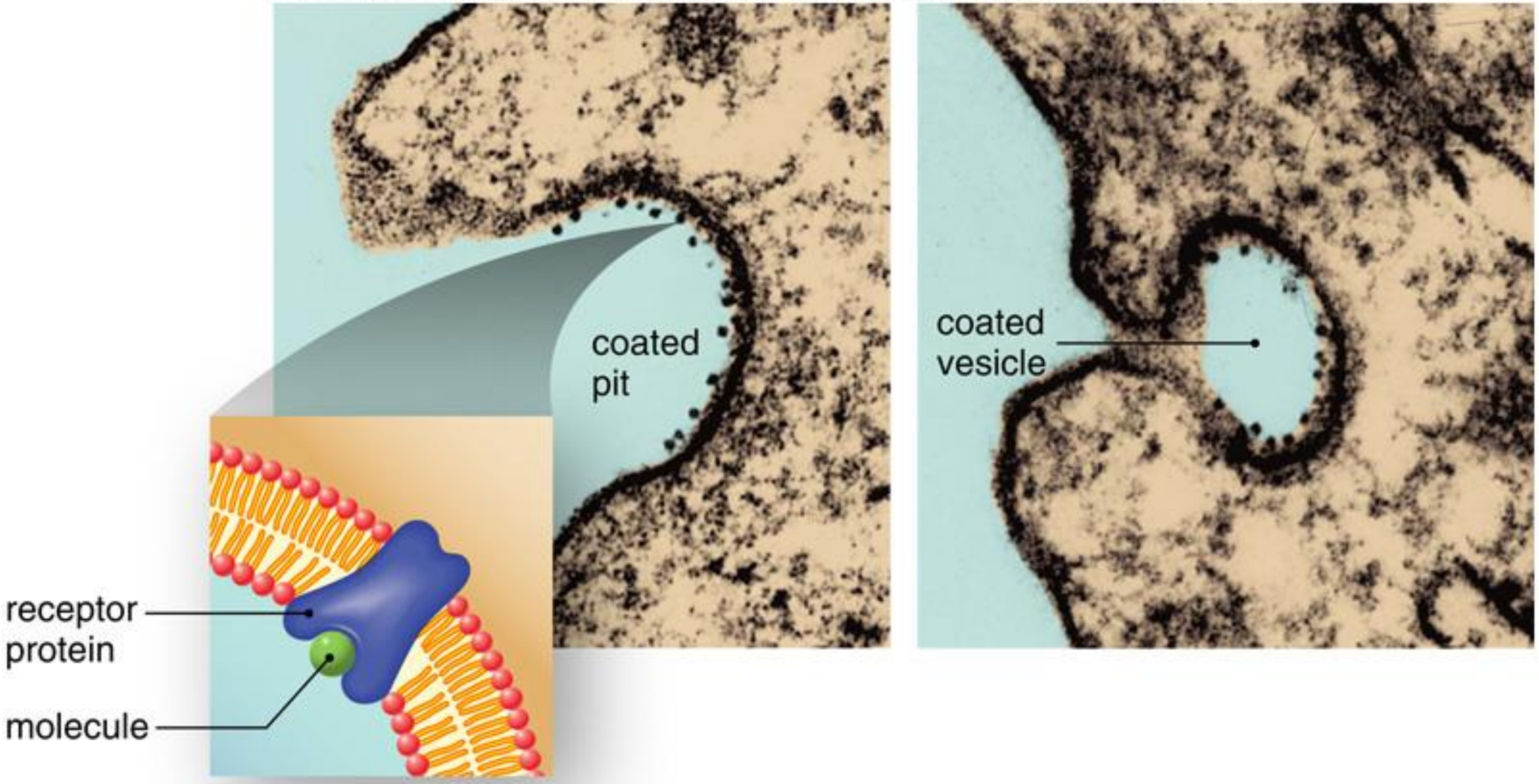
BioFlix: Membrane Transport



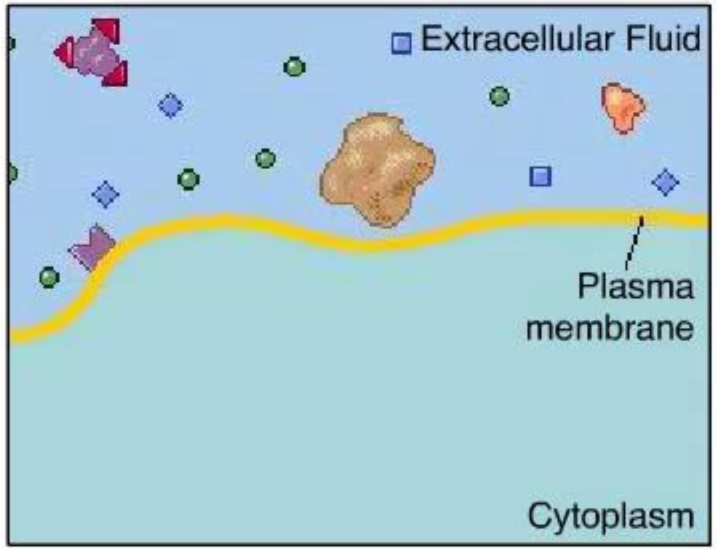
Animation: Exocytosis and Endocytosis Introduction



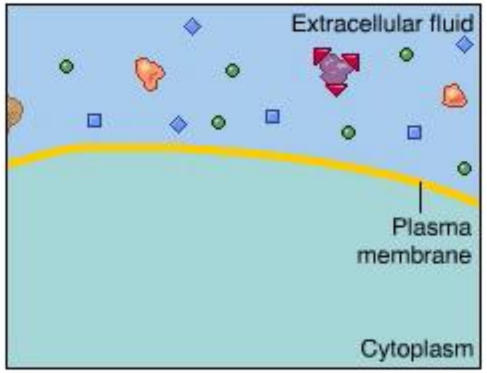
Bulk Transport (cont.)



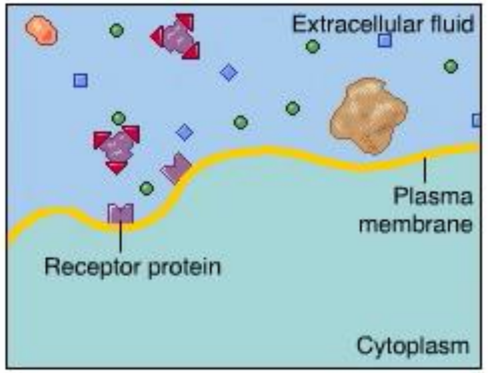
Animation: Phagocytosis



Animation: Pinocytosis



Animation: Receptor-Mediated Endocytosis



5.4 Outside the Eukaryotic Cell

- Most cells have external, or extracellular, structures.
- These structures are formed from materials the cell produces and then transports across the plasma membrane.

Cell Surfaces in Animals

- Animals cells have two primary external features.
  - An extracellular matrix
  - Various junctions between cells.

Extracellular Matrix

- An extracellular matrix is a meshwork of proteins and polysaccharides, embedded in the gelatinous polysaccharide matrix.
- Collagen and elastic fibers are examples of structural proteins in this matrix.

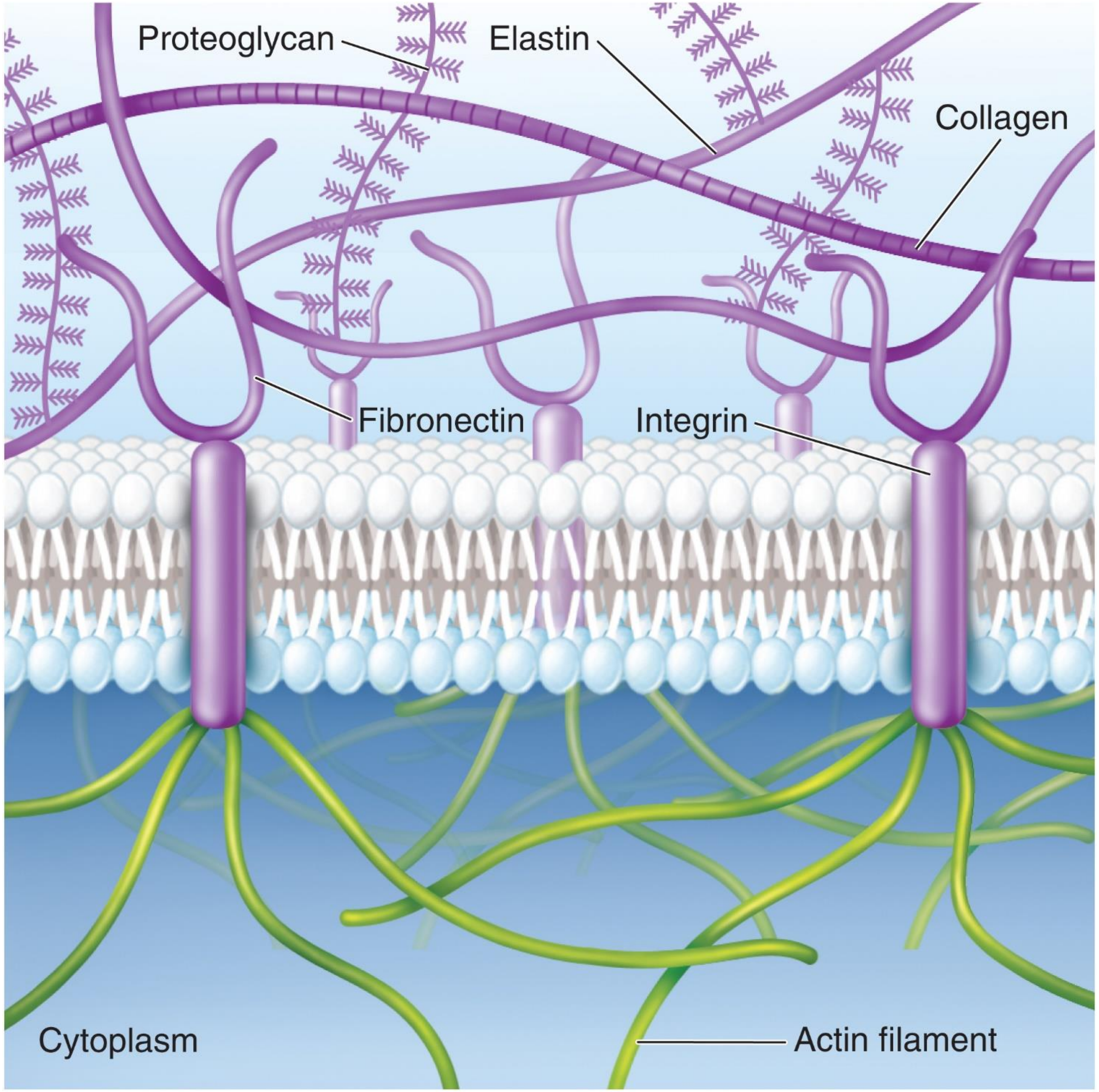
- Collagen resists stretching and elastin gives flexibility.

- Another protein is fibronectin, which binds to protein in plasma membrane called integrin. Integrin also connected to cytoskeleton inside the cell.

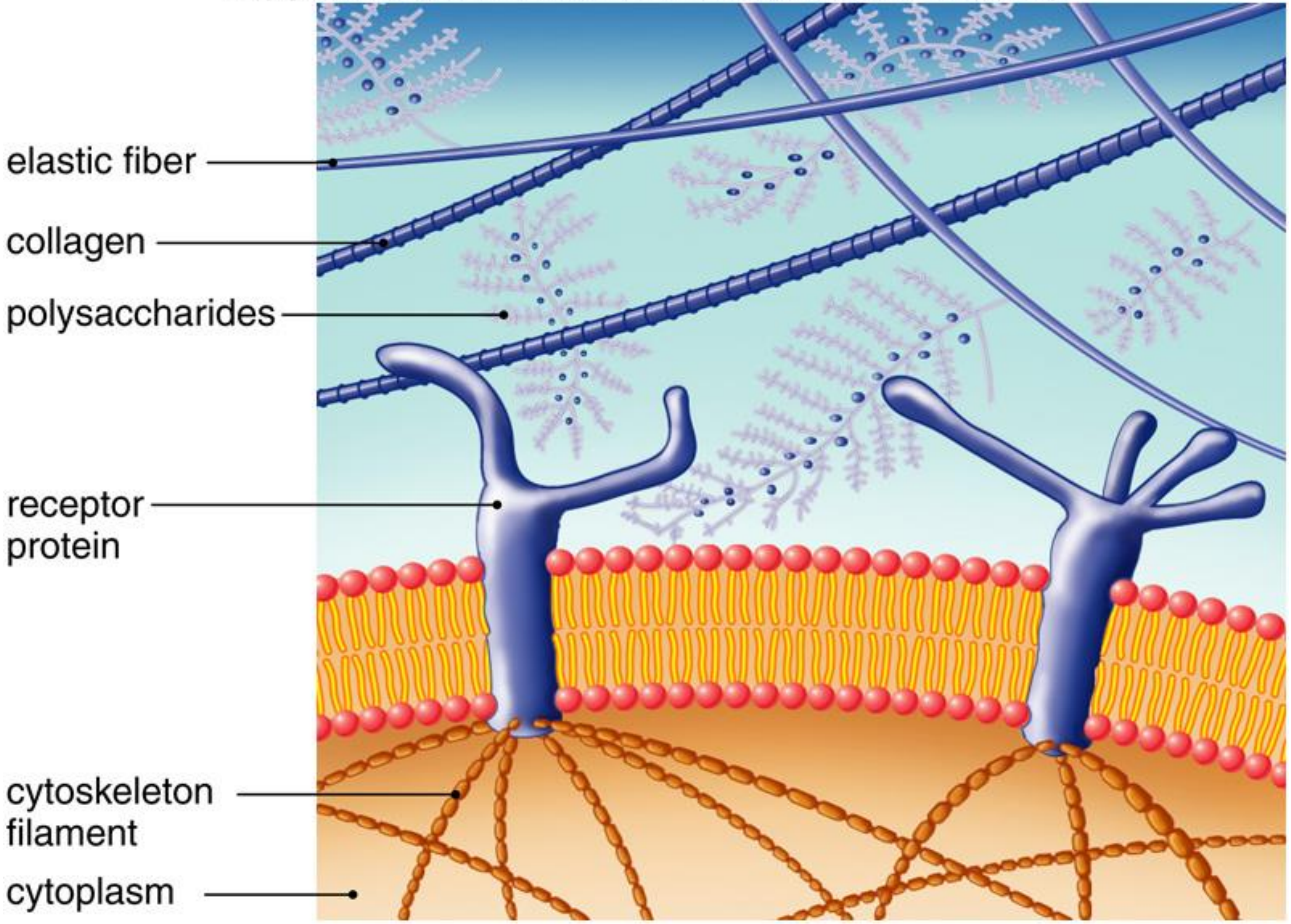
Extracellular Matrix (cont.)

- The strength and flexibility of extracellular matrix varies.
- The extracellular matrix of cartilage can be very flexible.
- The extracellular matrix of bone is hard because mineral salts are deposited outside the cell.

Fig. 4.19


Proteoglycan
Elastin
Collagen
Fibronectin
Integrin
Cytoplasm
Actin filament

Extracellular Matrix (cont.)



Junctions Between Cells

- There are three types of junctions between cells.

- Adhesion junctions form sturdy flexible sheets of cells.
  - The cells are connected by intercellular filaments.

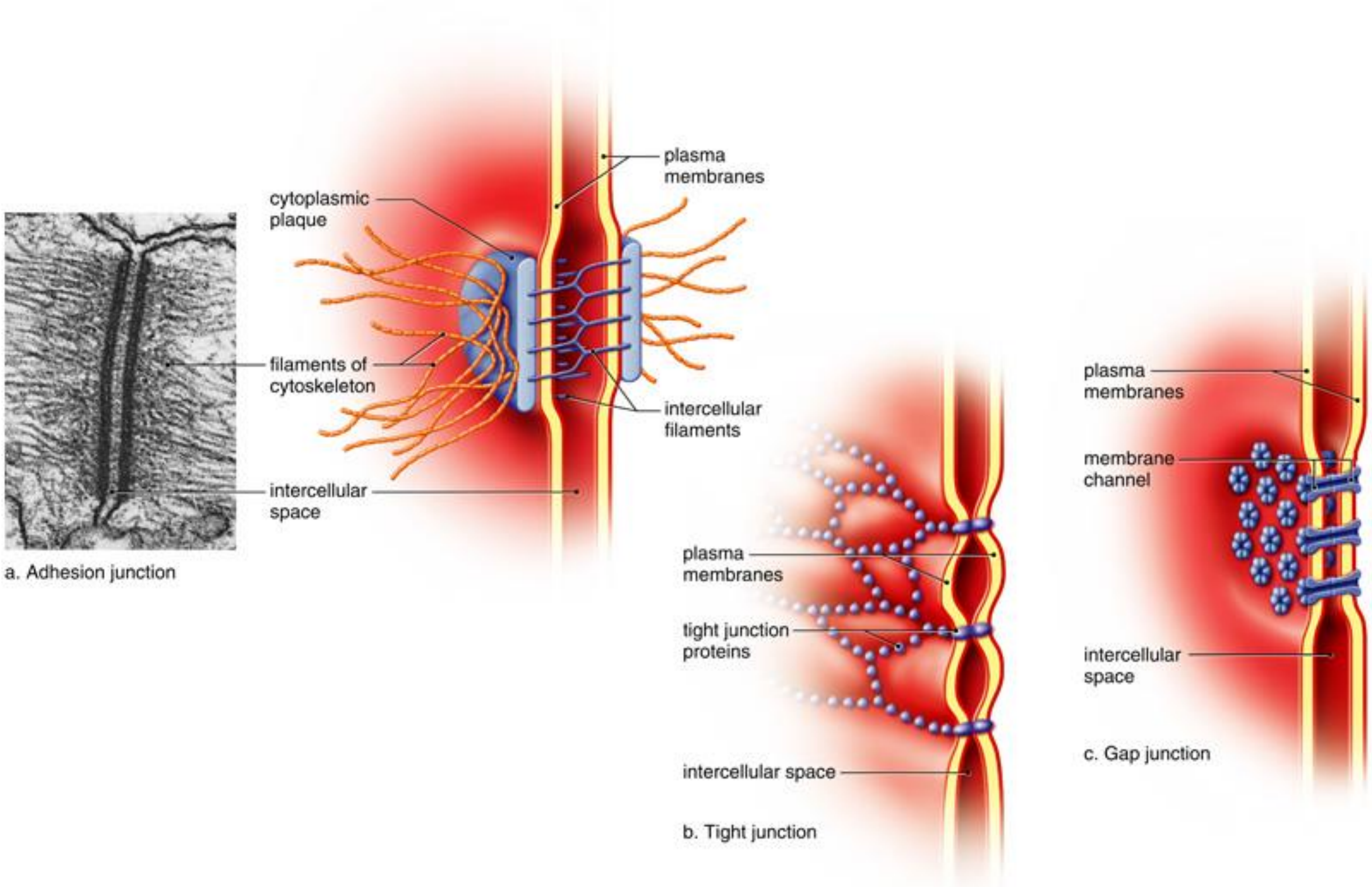
  - Adhesion junctions connect cells in organs such as the heart, stomach, and bladder.

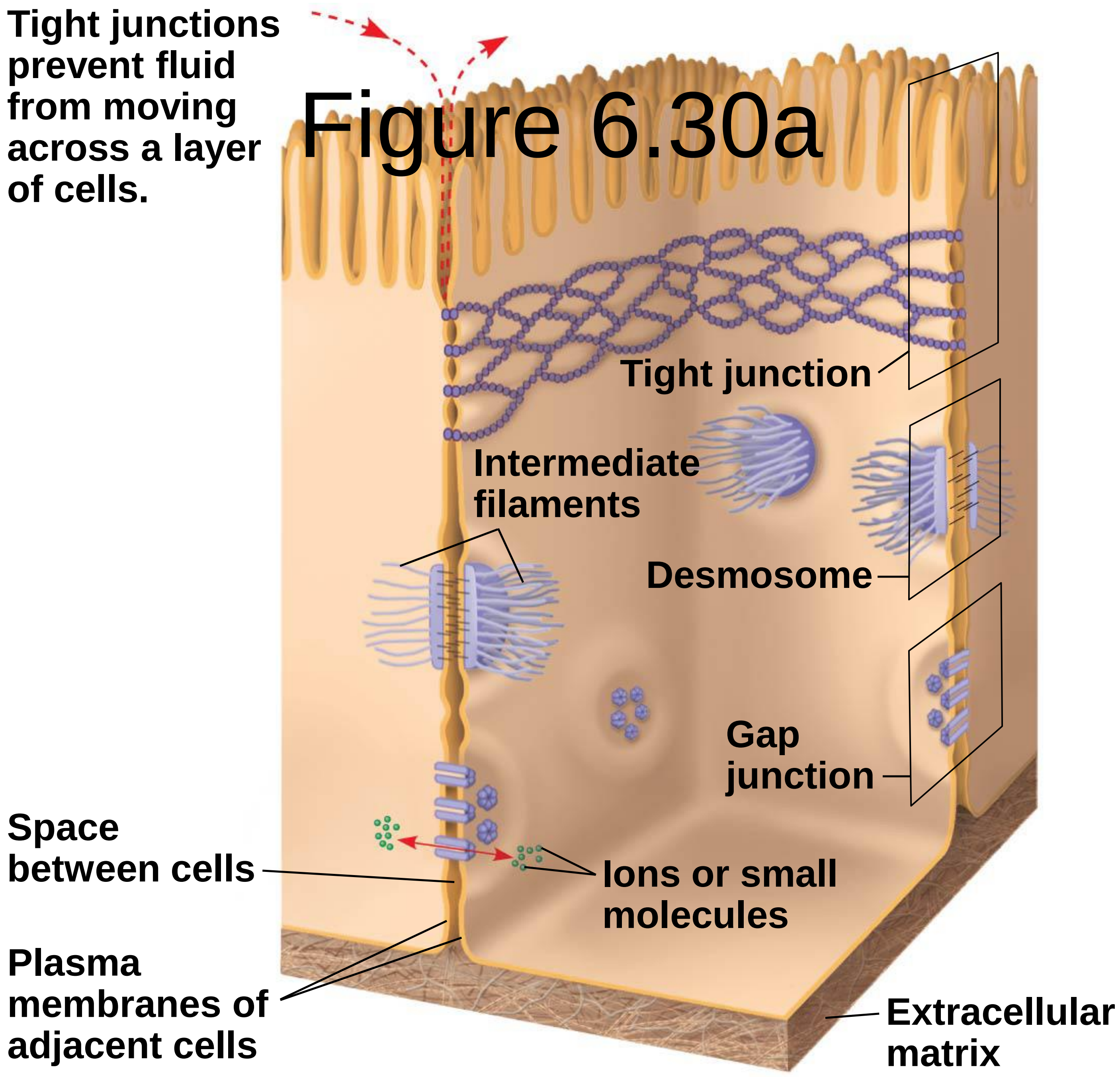
Junctions Between Cells (cont.)

- Membrane proteins of adjoining cells can attach together to form tight junctions.
  - Tight junctions connect cells like zippers.
  - Kidney cells are connected by tight junctions.

- Cells communicate across gap junctions.
  - Gap junctions form when two identical plasma membrane channels join.
  - The cells of the heart and other smooth muscles communicate with each other through gap junctions.

Junctions Between Cells (cont.)



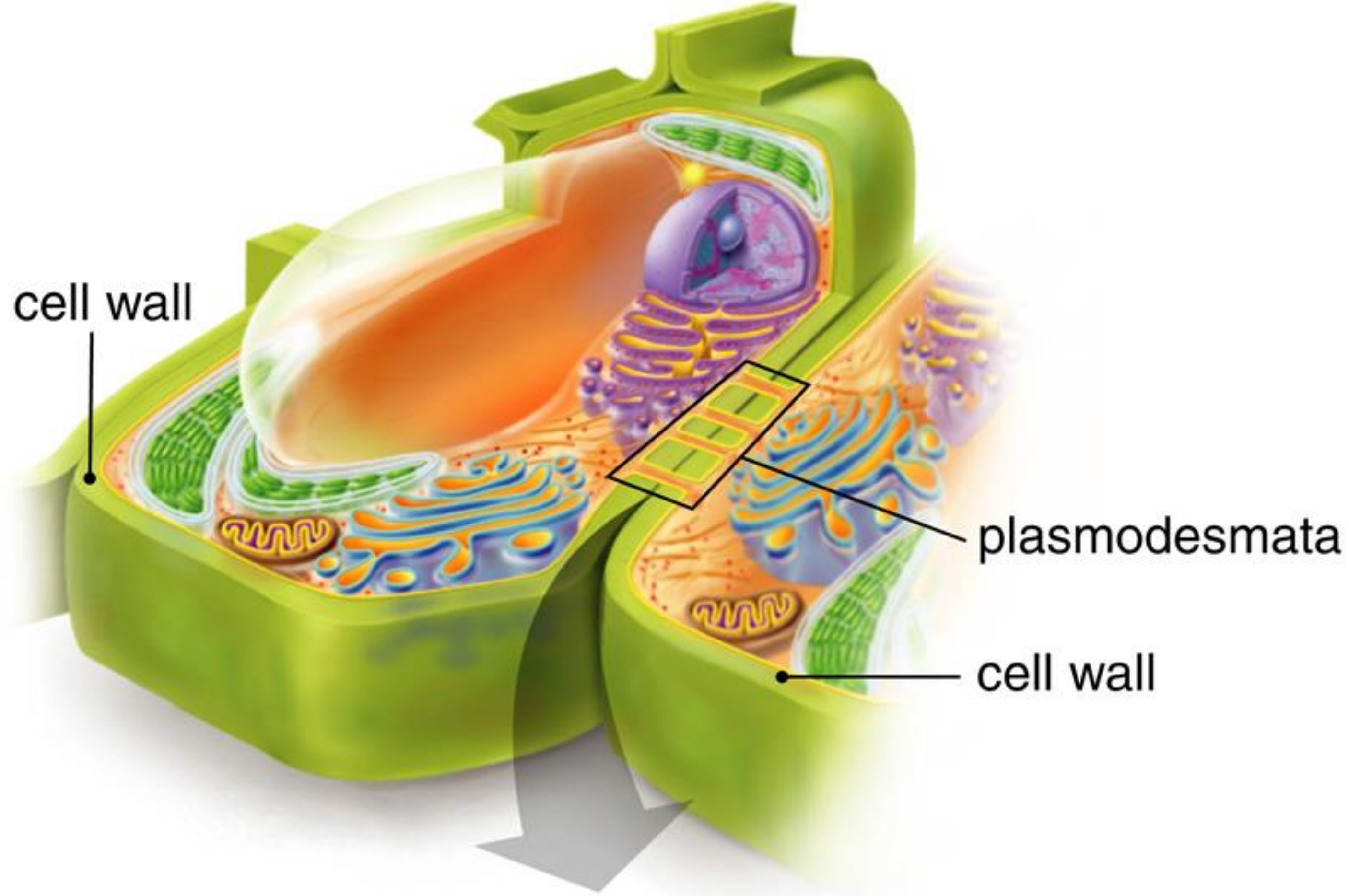

Tight junctions prevent fluid from moving across a layer of cells.
Figure 6.30a
Tight junction
Intermediate filaments
Desmosome
Gap junction
Space between cells
Ions or small molecules
Plasma membranes of adjacent cells
Extracellular matrix

Plant Cell Walls

- All plants have cell walls.
  - The primary cell wall contains cellulose fibrils and non-cellulose substances that allow the cell to stretch when growing.
  - Woody plants have a less flexible secondary cell wall which consists mainly of cellulose microfibrils and lignin.

- The cell wall protects the plant cell, maintains its shape, and prevents excessive uptake of water
- Living cells are connected by narrow, membrane-lined plasmodesmata.

Plant Cell Walls (cont.)



Plant Cell Walls (cont.)