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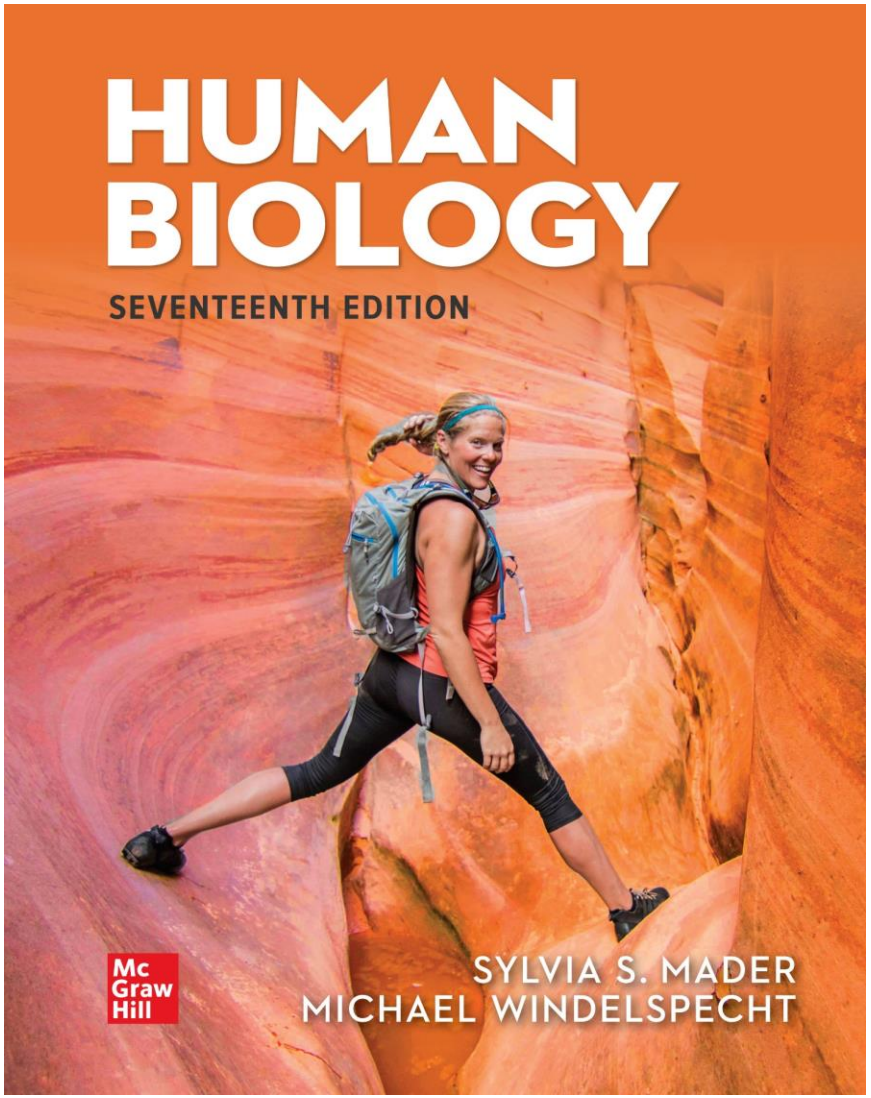

HUMAN BIOLOGY

Seventeenth Edition

Sylvia S. Mader
Michael Windelspecht

Chapter 3
Cell Structure and Function

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3.3 The Plasma Membrane and How Substances Cross It 1

Learning Outcomes:

- Describe the structure of the plasma membrane and list the type of molecules found in the membrane.
- Distinguish between the processes of diffusion, osmosis, and facilitated transport.
- Explain how tonicity relates to the direction of water movement across a membrane.
- Compare passive-transport and active-transport mechanisms.
- Summarize how eukaryotic cells move large molecules across membranes.

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3.3 The Plasma Membrane and How Substances Cross It 2

Plasma membrane.

Phospholipid bilayer with proteins that are attached and embedded.

- When phospholipids are placed in water, they naturally form a spherical bilayer.
- *Hydrophilic* heads face the cytoplasm and extracellular fluid.
- Hydrophobic tails face inward.

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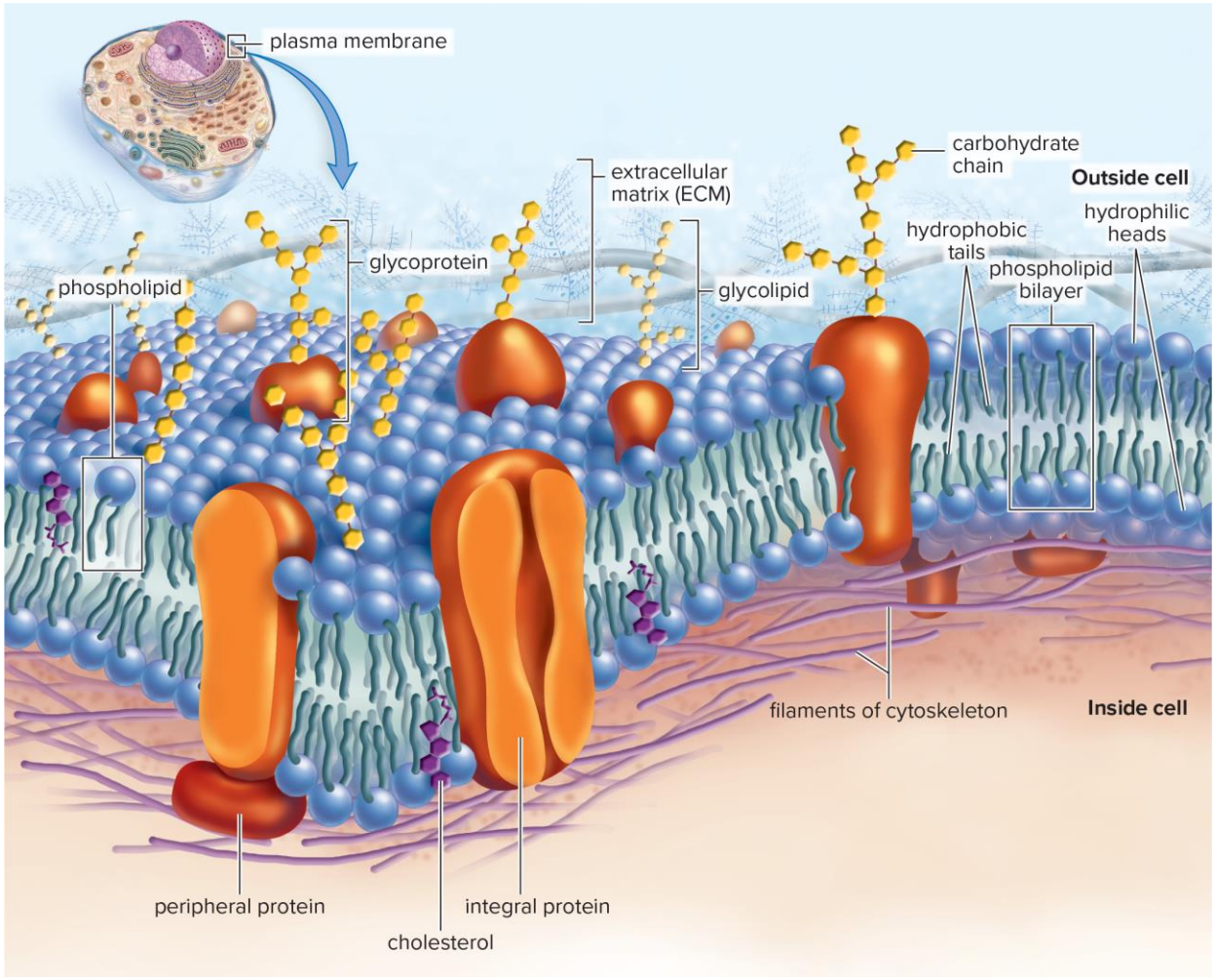
Organization of the Plasma Membrane (Figure 3.6)



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3.3 The Plasma Membrane and How Substances Cross It 3

Plasma membrane, continued.

At body temperature, is the consistency of oil.

Fluid-mosaic model.

- Proteins freely move laterally.

Contains cholesterol for support.

Glycoproteins and **glycolipids**—carbohydrate chains attached to proteins and lipids.

- Identify the cell as “self” or “foreign” and act as receptors.

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Plasma Membrane Structure and Function (3)

Functions of Membrane Proteins

- **Channel Proteins**:
  - Allow passage of molecules through membrane via a channel in the protein
- **Carrier Proteins**:
  - Combine with the substance to be transported
  - Assist passage of molecules through membrane
- **Cell Recognition Proteins**:
  - Glycoproteins
  - Help the body recognize foreign substances

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Plasma Membrane Structure and Function (4)

Functions of Membrane Proteins

- **Receptor Proteins**:
  - Bind with specific molecules
  - Allow a cell to respond to signals from other cells
- **Enzymatic Proteins**:
  - Carry out metabolic reactions directly
- **Junction Proteins**:
  - Attach adjacent cells

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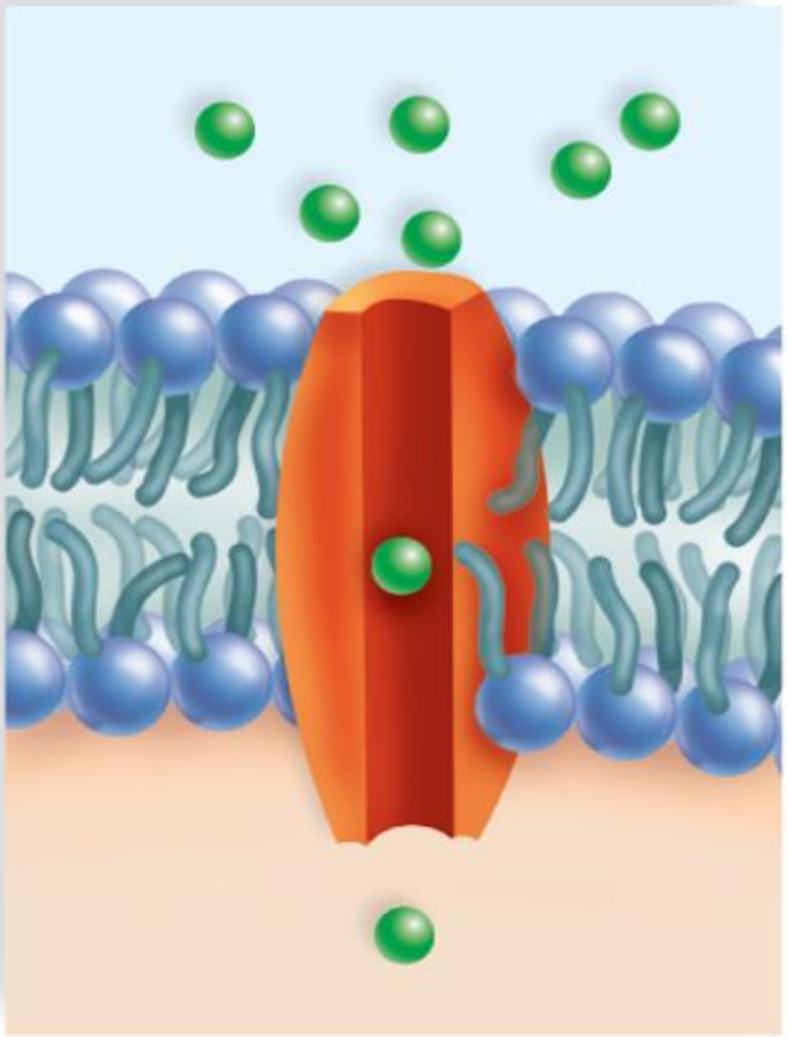
Membrane Protein Diversity (1)



a.

Channel Protein: Allows a particular molecule or ion to cross the plasma membrane freely. Cystic fibrosis, an inherited disorder, is caused by a faulty chloride (Cl^-) channel; a thick mucus collects in airways and in pancreatic and liver ducts.

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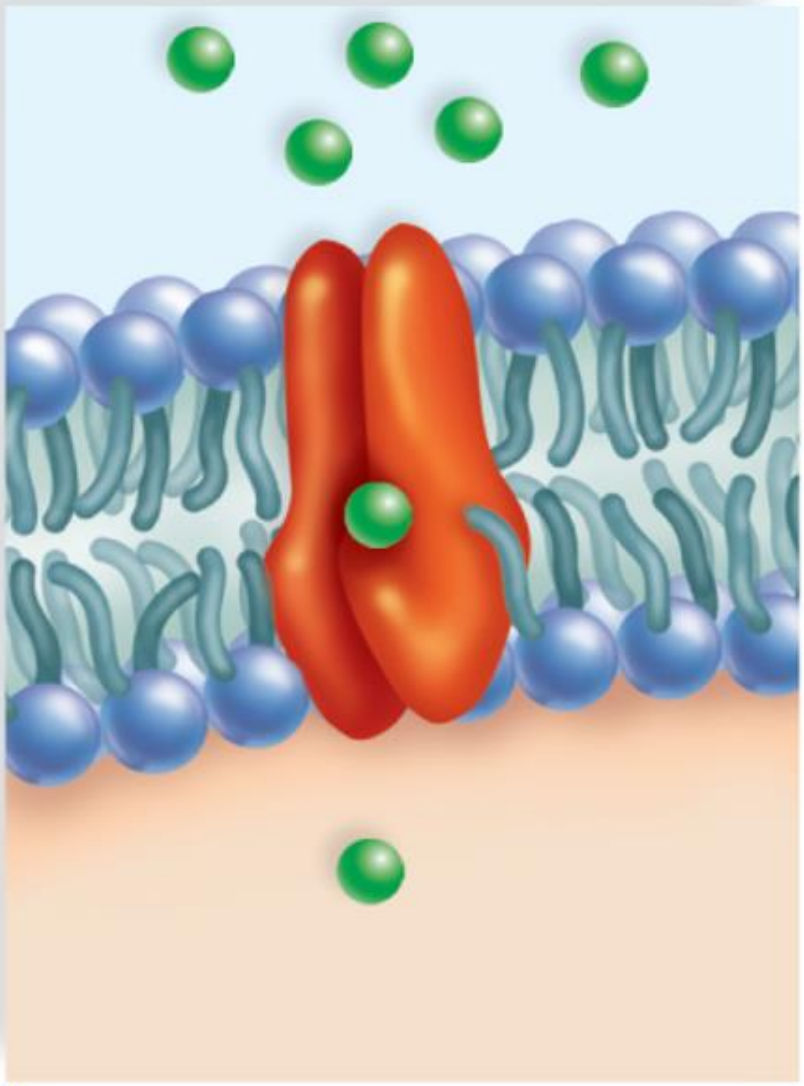
Membrane Protein Diversity (2)



b.

Carrier Protein: Selectively interacts with a specific molecule or ion so that it can cross the plasma membrane. The inability of some persons to use energy for sodium-potassium ($Na^+ - K^+$) transport has been suggested as the cause of their obesity.

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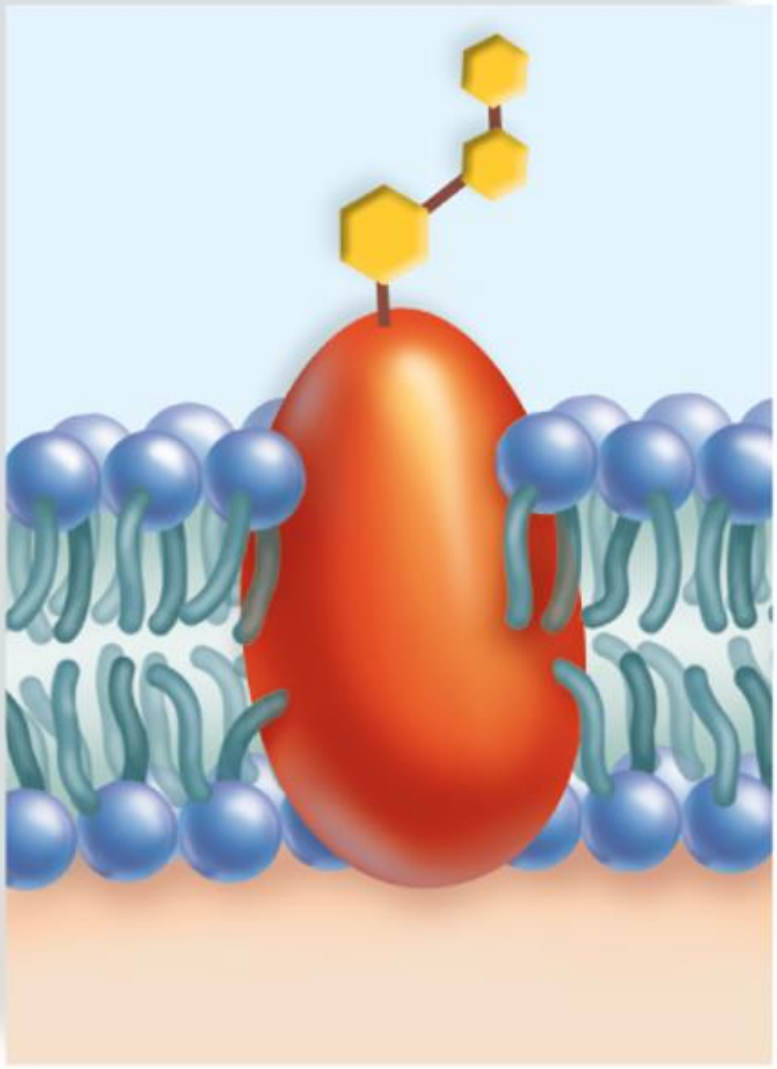
Membrane Protein Diversity (3)



c.

Cell Recognition Protein: The MHC (major histocompatibility complex) glycoproteins are different for each person, so organ transplants are difficult to achieve. Cells with foreign MHC glycoproteins are attacked by white blood cells responsible for immunity.

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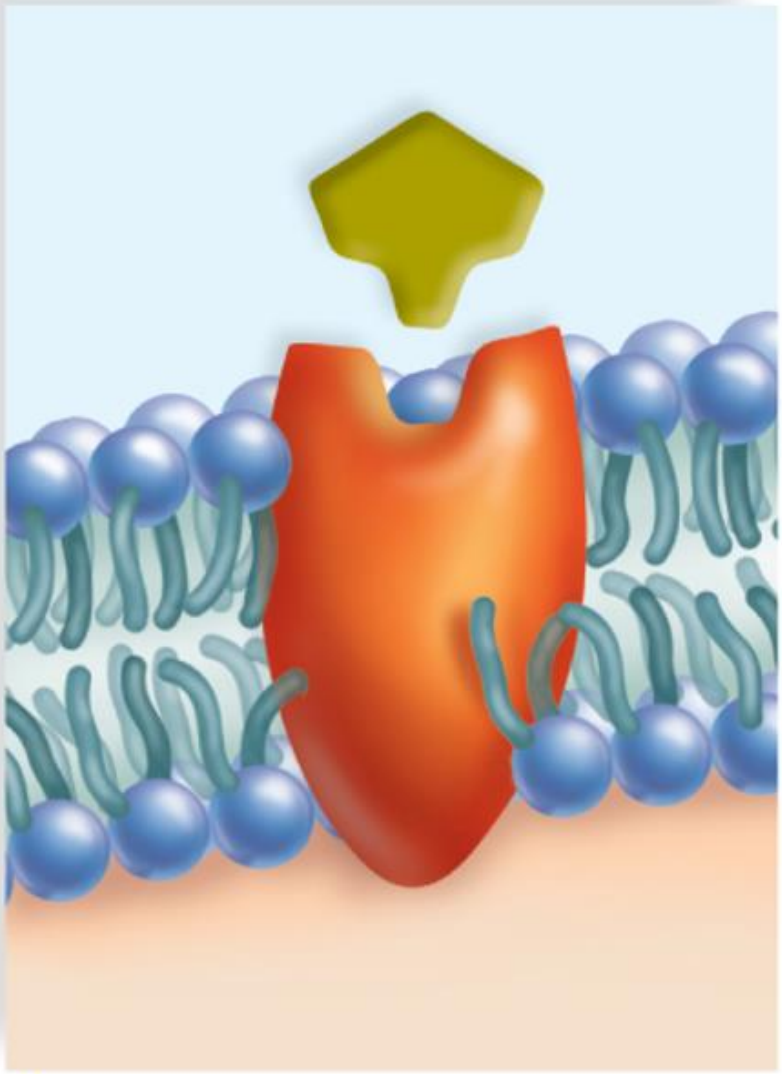
Membrane Protein Diversity (4)



d.

Receptor Protein: Is shaped in such a way that a specific molecule can bind to it. Some forms of dwarfism result not because the body does not produce enough growth hormone, but because their plasma membrane growth hormone receptors are faulty and cannot interact with growth hormone.

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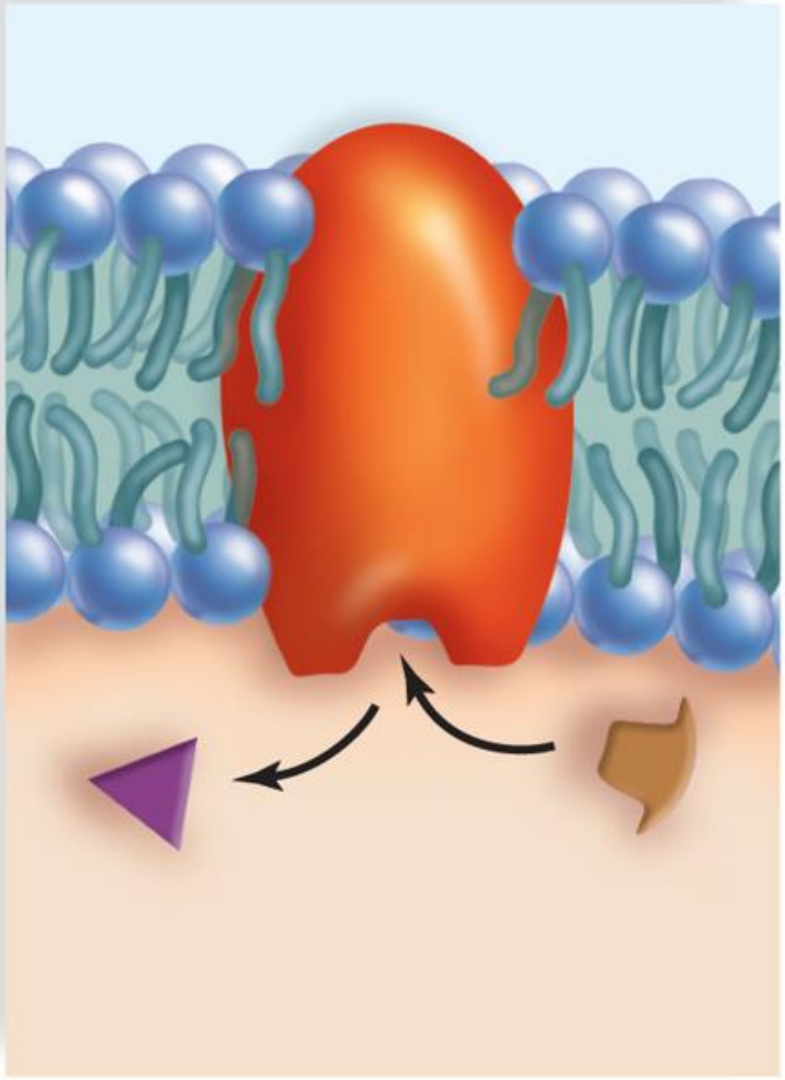
Membrane Protein Diversity (5)



e.

Enzymatic Protein: Catalyzes a specific reaction. The membrane protein, adenylate cyclase, is involved in ATP metabolism. Cholera bacteria release a toxin that interferes with the proper functioning of adenylate cyclase; sodium (Na^+) and water leave intestinal cells, and the individual may die from severe diarrhea.

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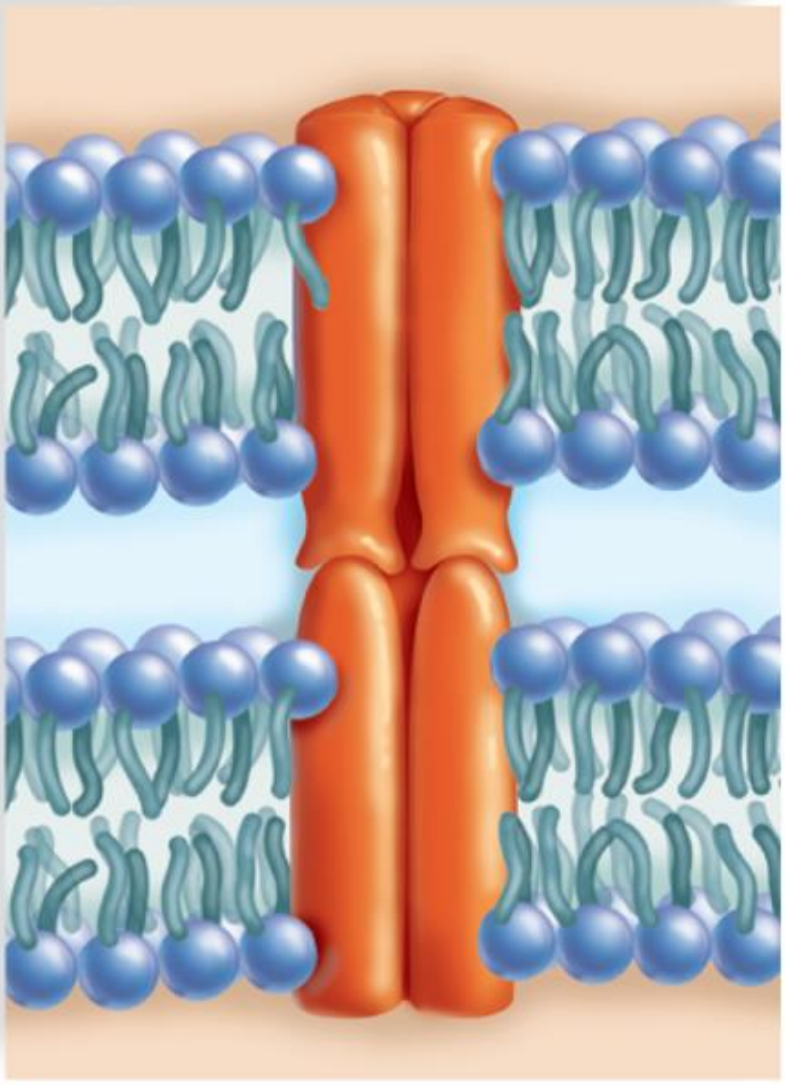
Membrane Protein Diversity (6)



f.

Junction Proteins: Tight junctions join cells so that a tissue can fulfill a function, as when a tissue pinches off the neural tube during development. Without this cooperation between cells, an animal embryo would have no nervous system.

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Plasma Membrane Functions 1

Plasma membrane, concluded.

Some membrane proteins act as channels.

- Allow some things in while keeping other substances out.
- Small, *hydrophobic* substances pass freely through the phospholipid bilayer.
  - That is, gases like oxygen and carbon dioxide.
- Ions and large molecules need help passing through.
  - Water can cross the membrane by passing through channels called **aquaporins.**

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Plasma Membrane Functions 2

Diffusion.

Osmosis.

Facilitated diffusion.

Active transport.

Endocytosis and exocytosis.

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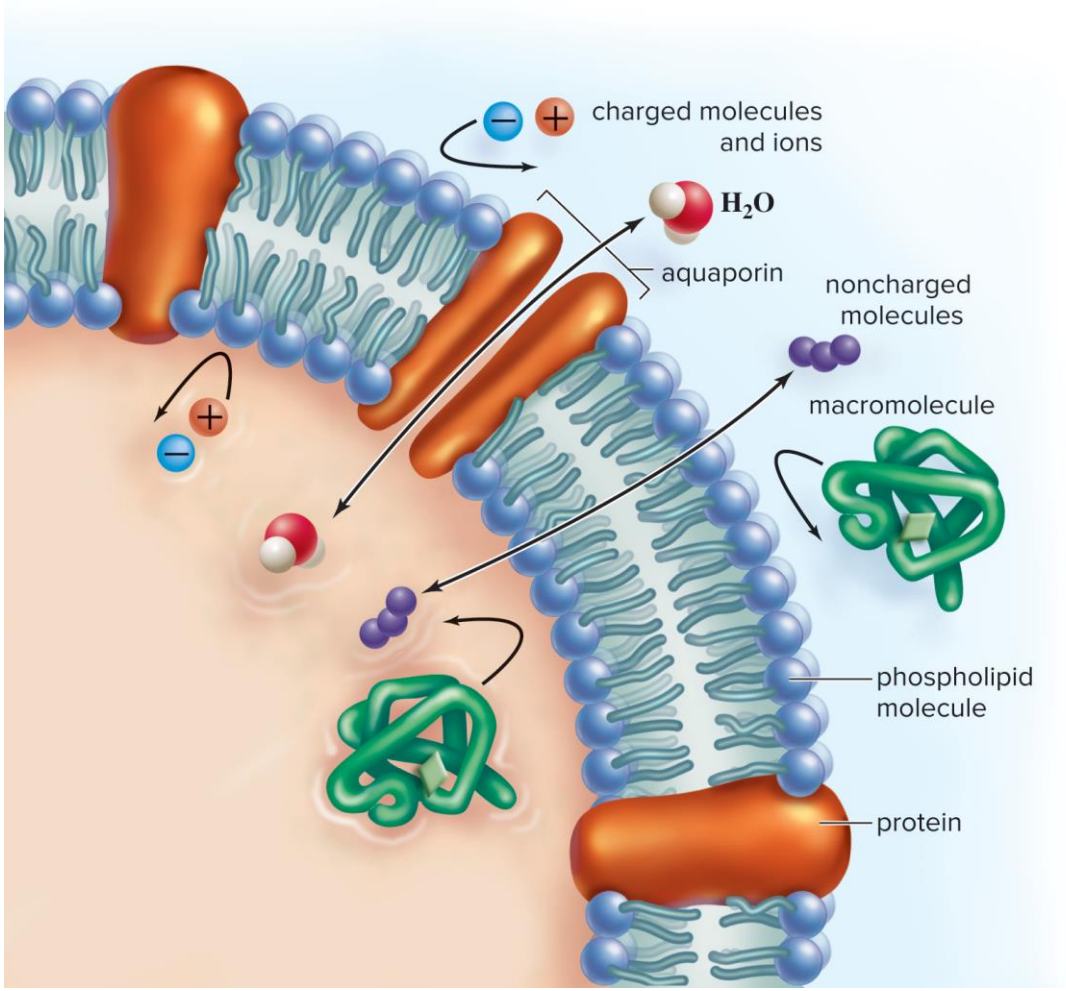
Selective Permeability of the Plasma Membrane (Figure 3.7)



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Passive Transport Across a Membrane

A **solution** consists of:

- A **solvent** (liquid), and
- A **solute** (dissolved solid)

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Diffusion

Diffusion—the random movement of molecules from a higher concentration to a lower concentration.

Until they are equally distributed.

Passive movement; no energy is required.

Molecules move in both directions, but the **net movement** is from high to low concentration.

- At equilibrium, the same number of molecules move in and out of the cell.

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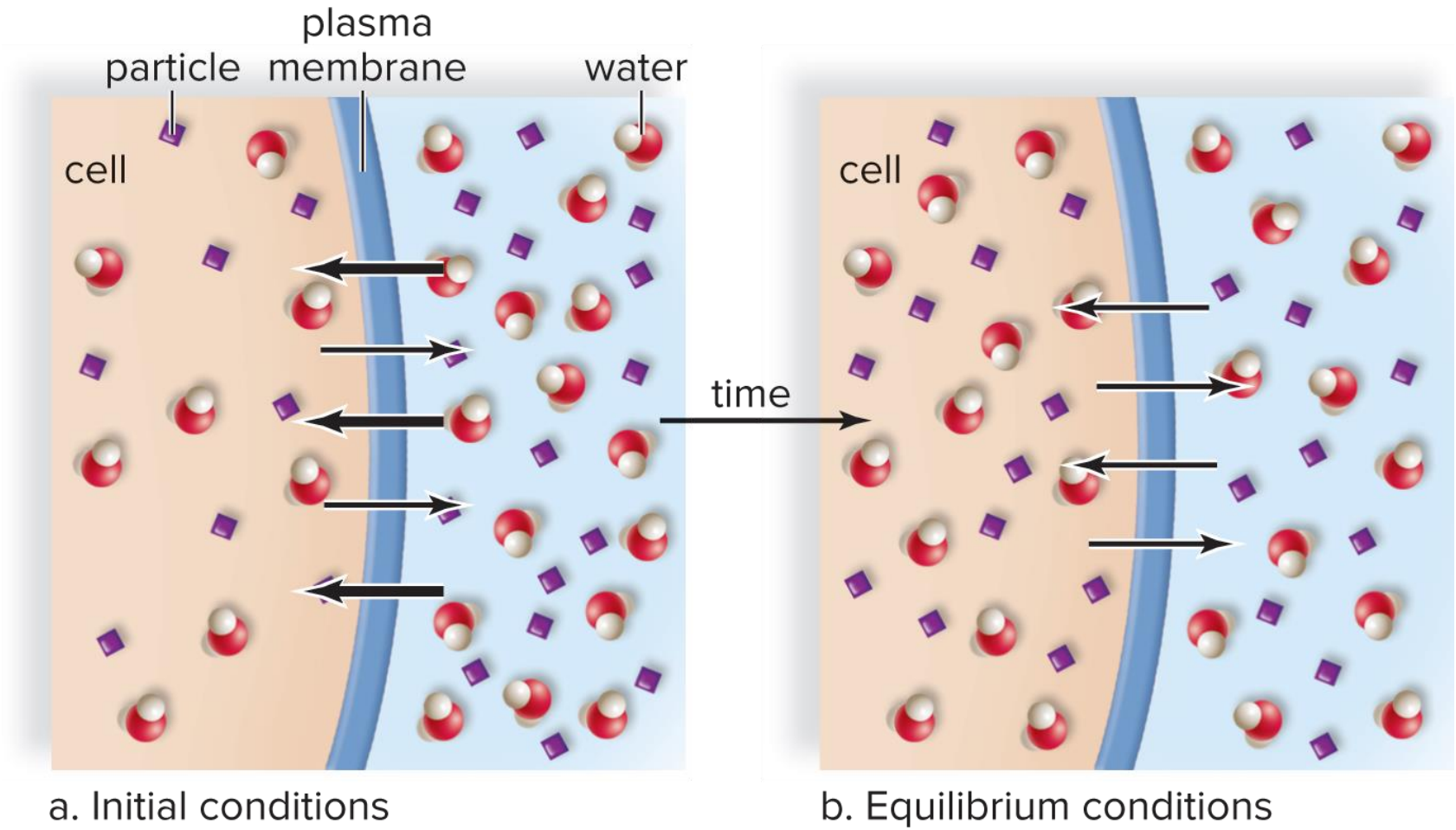
Diffusion Across the Plasma Membrane (Figure 3.8)



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Osmosis

Osmosis—the diffusion of water molecules; from high to low water concentration.

Normally body fluids are **isotonic** to cells.

- The same concentration of impermeable solutes.
- Cells do not change in size.

Hypotonic solutions have fewer solutes.

- Cells swell and can burst (**lysis**).

Hypertonic solutions have more solutes.

- Cells shrink (**crenation**).

Osmotic pressure drives osmosis.

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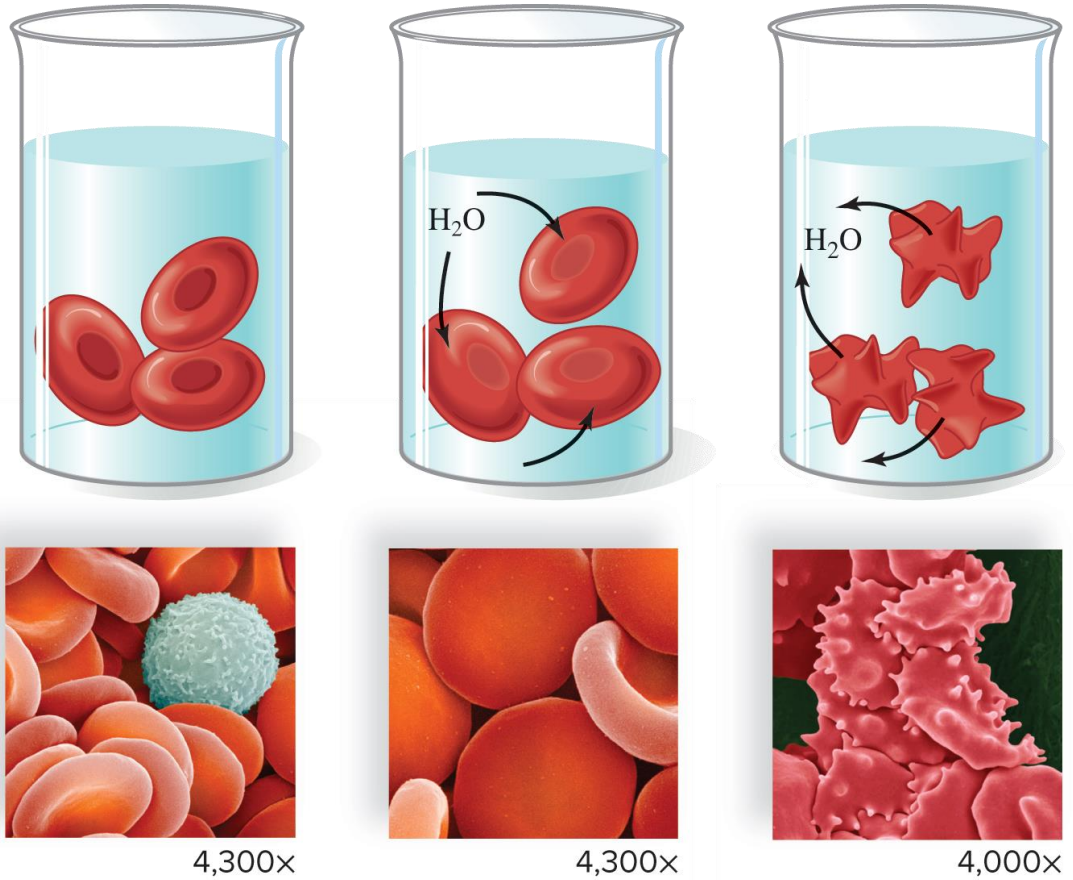
Effects of Changes in Tonicity on Red Blood Cells (Figure 3.9)



a. Isotonic solution (same solute concentration as in cell)

b. Hypotonic solution (lower solute concentration than in cell)

c. Hypertonic solution (higher solute concentration than in cell)

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Facilitated Transport

Facilitated transport.

- The transport of molecules across the plasma membrane from higher concentration to lower concentration via a protein carrier, or *transporter*.
- Passive transport (no energy required).
- Protein transporters are very specific and only move certain molecules.

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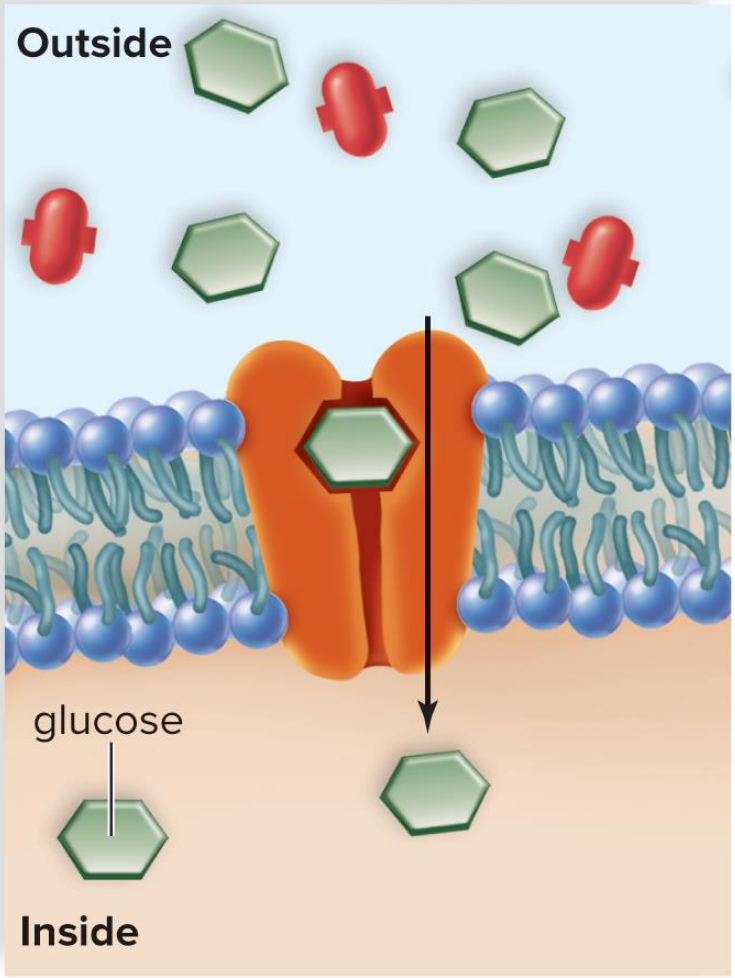
Facilitated Transport Across a Plasma Membrane (Figure 3.10)



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Active Transport

Active transport—the movement of molecules from a *lower* to *higher* concentration.

Uses ATP as energy.

Requires a protein carrier, which is often called a **pump.**

- Example: the **sodium–potassium pump**; active in all the body's cells, moving sodium ions (Na^+) out, and potassium ions (K^+) in.

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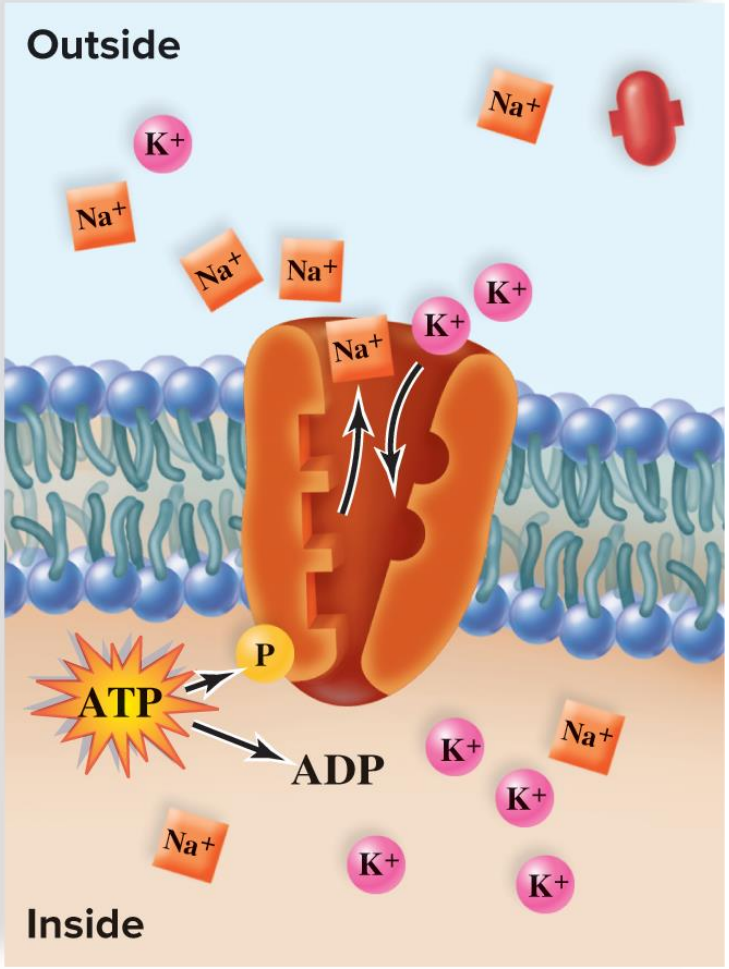
Active Transport and the Sodium-Potassium Pump (Figure 3.11)



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Bulk Transport 1

Cells use bulk transport to move large molecules across the membrane.

Endocytosis transports molecules or cells into the cell via invagination of the plasma membrane to form a vesicle.

- **Phagocytosis**—endocytosis of pathogens (that is, bacteria) by white blood cells.
- **Pinocytosis**—endocytosis of fluid with small particles.
- **Receptor-mediated endocytosis**—particles first bind to receptors in the plasma membrane; this initiates endocytosis.

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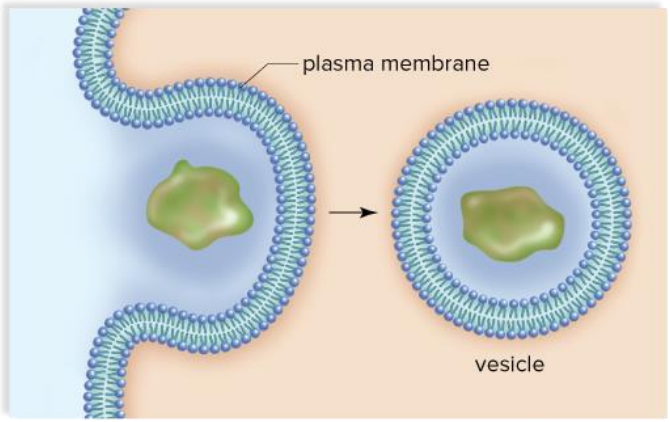
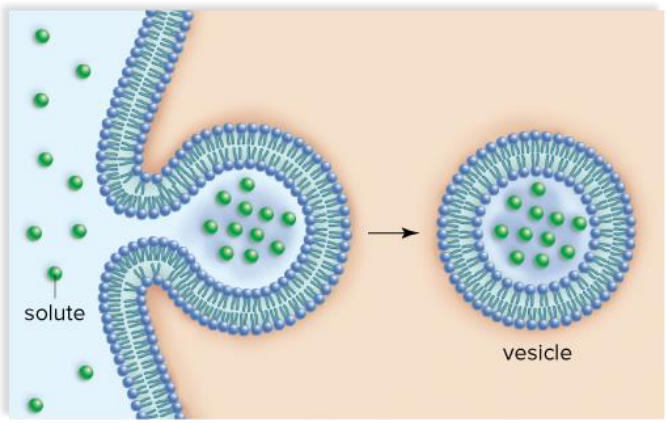
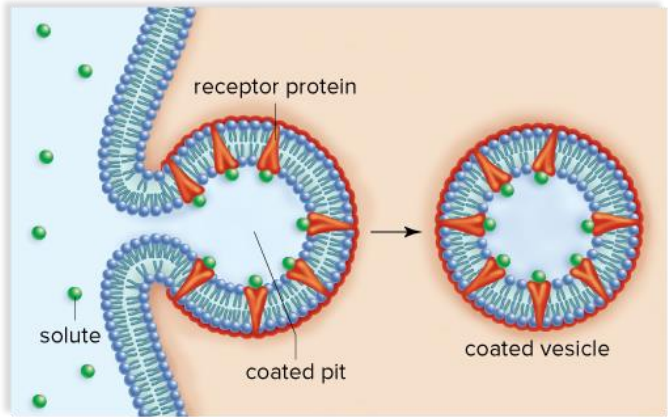
Examples of Endocytosis (Figure 3.12)



a. Phagocytosis



b. Pinocytosis



c. Receptor-mediated endocytosis

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Bulk Transport 2

Bulk transport, continued.

Exocytosis transports molecules outside the cell via the fusion of a vesicle with the plasma membrane.

- Sort of like reverse endocytosis.
- How signaling molecules (*eurotransmitters*) leave one nerve cell to excite the next nerve cell or a muscle cell.

Receptor-mediated endocytosis uses a receptor on the surface of the cell to concentrate specific molecules of interest.

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Extracellular Matrix

Extracellular matrix.

A protective mesh of proteins and polysaccharides.

Surrounds the cell that produces it.

Contains **collagen**, which resists stretching, and **elastin**, which provides resilience.

Fibronectin—an adhesive protein that binds to **integrin**, an integral membrane protein that is connected to the cytoskeleton.

- Plays a role in cell signaling.

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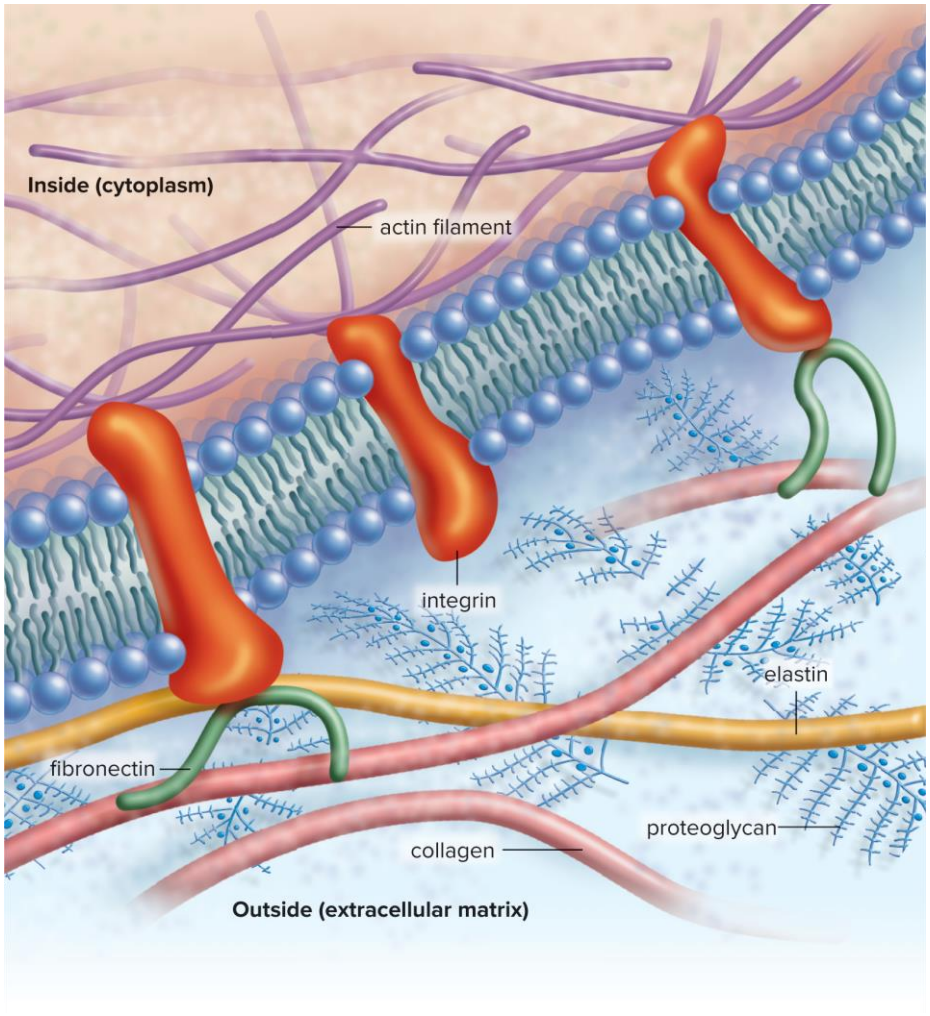
Extracellular Matrix (Figure 3.16)



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Junctions Between Cells

Three main types of junctions between cells:

- **Adhesion junctions**—attach cytoskeletons of adjacent cells.
- **Tight junctions**—produce a barrier.
- **Gap junctions**—two channels fuse, allowing communication between the cells.

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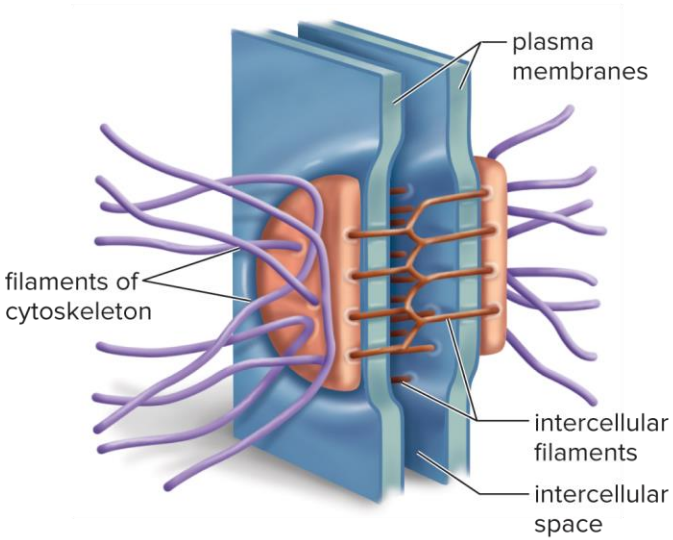
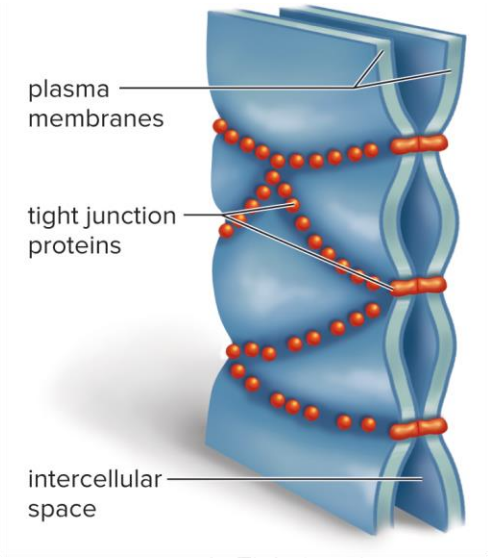
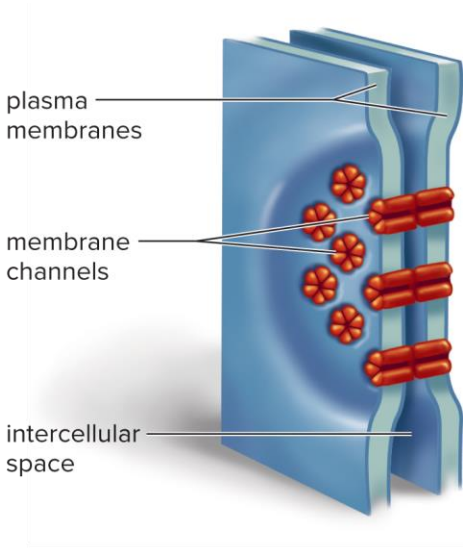
Junctions Between Cells (Figure 3.17)



a. Adhesion junction



b. Tight junction



c. Gap junction

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Check Your Progress 3.5

List the three types of fibers in the cytoskeleton.

Describe the structure of cilia and flagella, and state the function of each.

List the types of junctions found between animal cells, and state a function for each.

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