Plasma Membrane

- Functions of the plasma membrane
  - Isolates the cell's contents from environment
  - Regulates exchange of essential substances
  - Communicates with other cells
  - Creates attachments within and between other cells
  - Regulates biochemical reactions

Membranes Are "Fluid Mosaics"

- Membranes are dynamic, ever-changing structures
- "Fluid mosaic" model of a membrane proposed in 1972
  - A lumpy, constantly shifting mosaic of "tiles" or proteins
  - Proteins float around in a sea of phospholipids

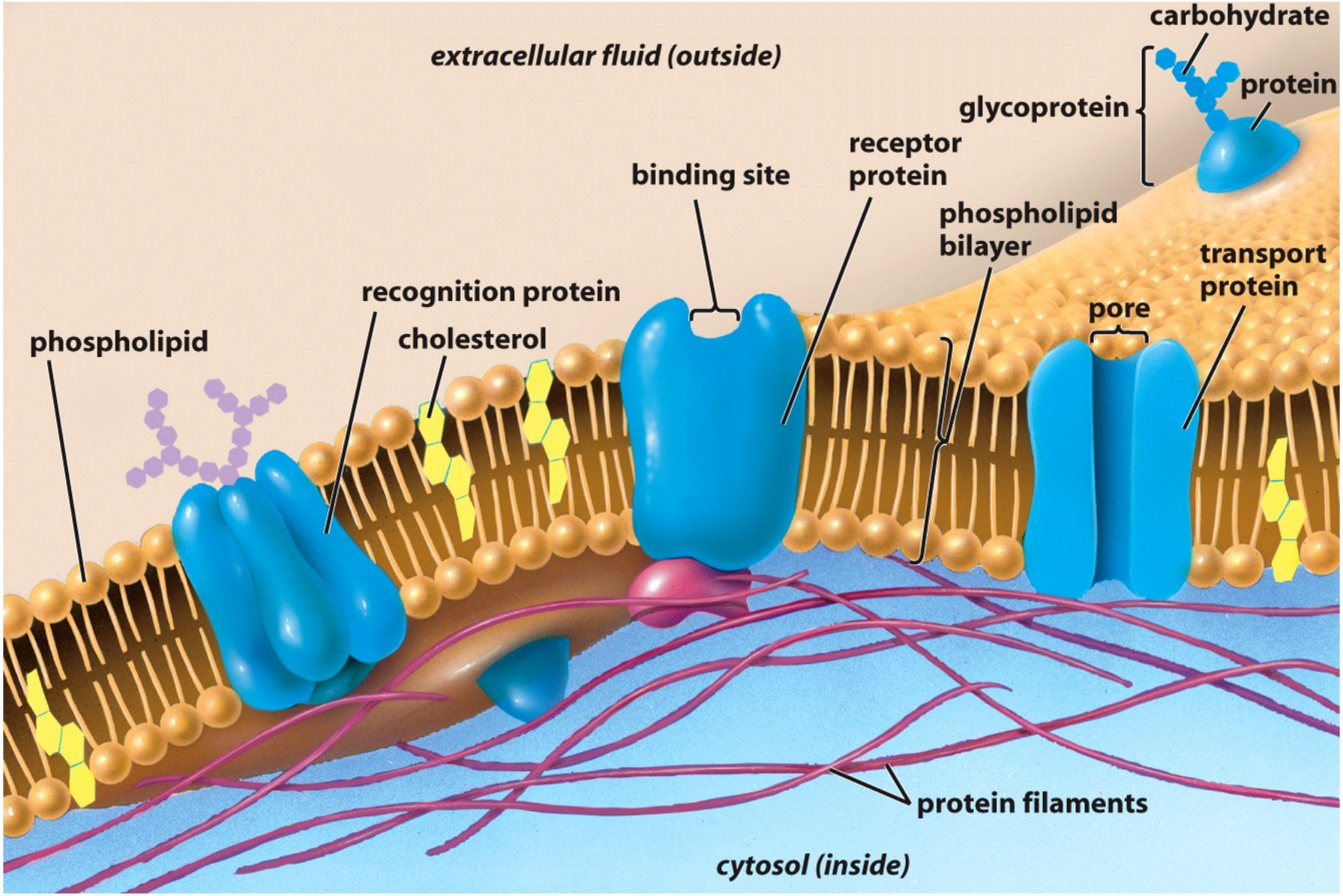


Figure 5-1 Biology: Life on Earth, 8/e

The Phospholipid Bilayer

- Phospholipid bilayer is a flexible, fluid membrane to allow for cellular shape changes
- Individual phospholipid molecules are not bonded to one another
- Some of the phospholipids have unsaturated fatty acids, whose double bonds introduce “kinks” into their “tails”
- The above features make the membrane fluid

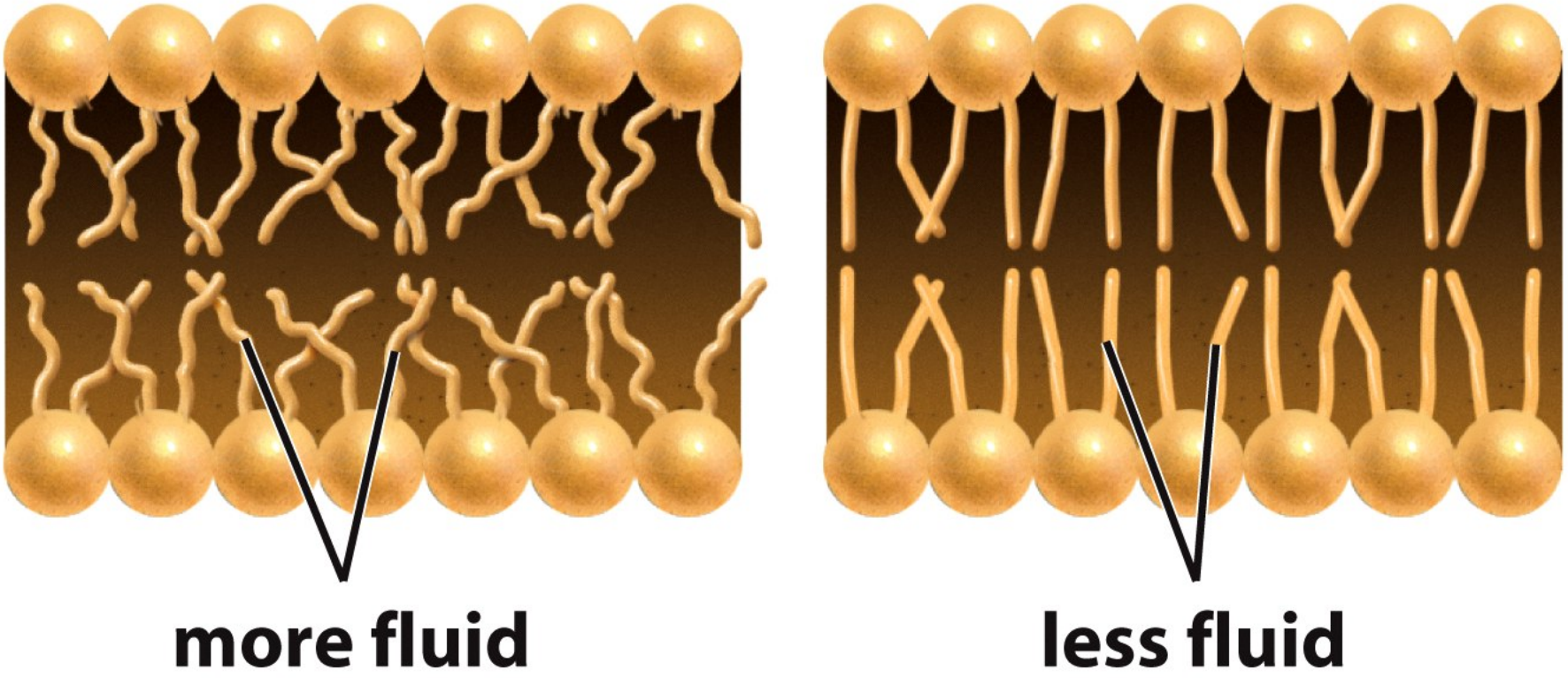


Figure 5-4 Biology: Life on Earth, 8/e

Membrane Proteins Form a Mosaic

- Proteins are embedded in the phospholipid bilayer
  - Some proteins can float and drift
  - Other proteins are anchored by protein filaments in the cytoplasm
  - Many proteins have attached carbohydrates (**glycoproteins**)

Membrane Proteins Form a Mosaic

- Categories of membrane proteins
  - Receptor Proteins
  - Recognition Proteins
  - Enzymatic Proteins
  - Attachment Proteins
  - Transport Proteins

Membrane Proteins Form a Mosaic

- **Receptor Proteins**
  - Trigger cellular responses upon binding specific molecules, e.g. hormones
- **Recognition Proteins**
  - Serve as identification tags on the surface of a cell

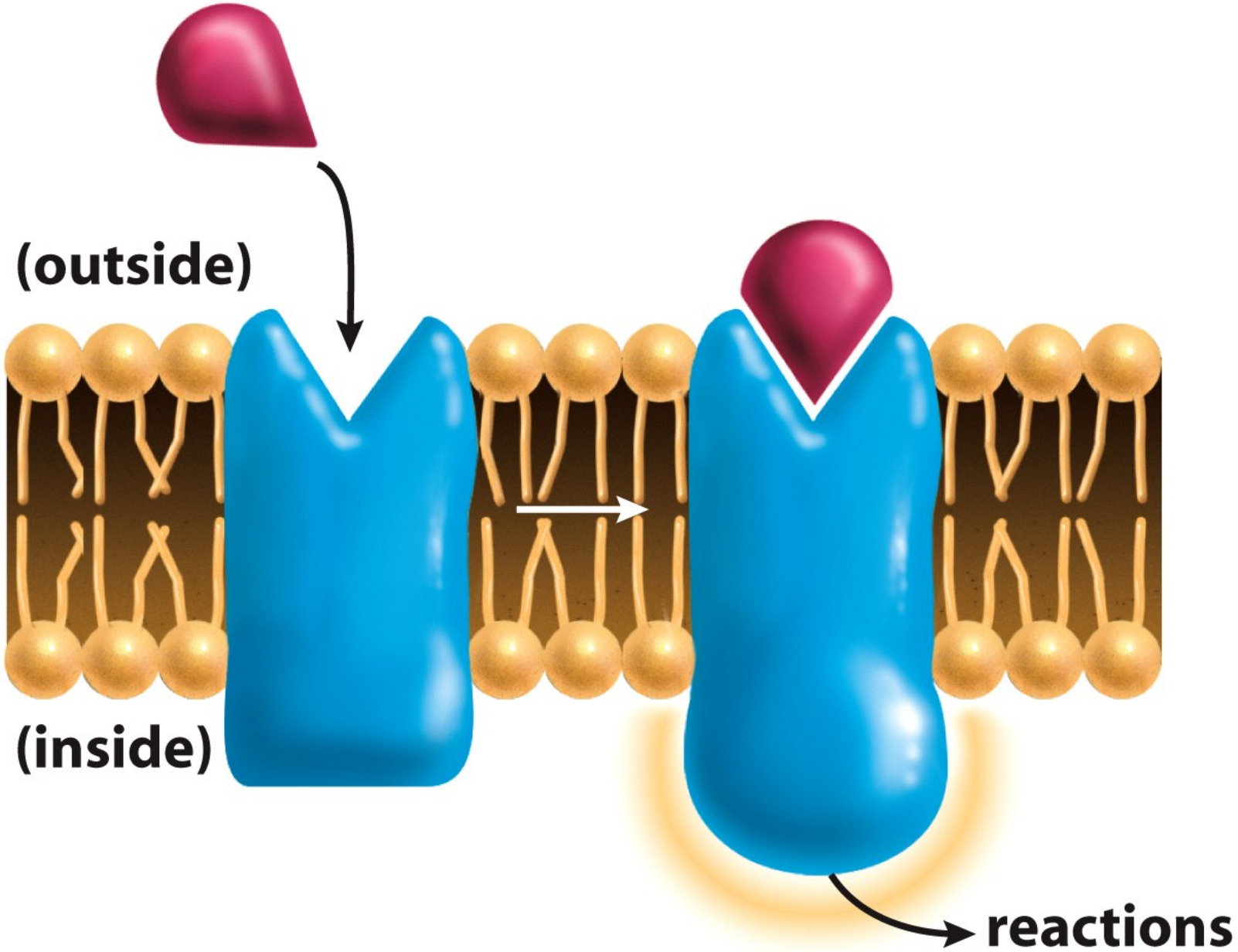


Figure 5-5 Biology: Life on Earth, 8/e

Membrane Proteins Form a Mosaic

- **Enzymes**
  - Promote chemical reactions that synthesize or break apart biological molecules
- **Attachment Proteins**
  - Anchor the cell membrane to inner cytoskeleton, to proteins outside the cell, and to other cells

Membrane Proteins Form a Mosaic

- **Transport Proteins**
  - Include **channel** and **carrier proteins**
  - Regulate import/export of hydrophilic molecules

Movement of Molecules in Fluids

- Definitions relevant to substance movement
  - A **fluid** is a substance that can move or change shape in response to external forces
  - A **solute** is a substance that can be dissolved (dispersed as ions or molecules) in a solvent
  - A **solvent** is a fluid capable of dissolving a solute

Movement of Molecules in Fluids

- Definitions relevant to substance movement (continued)
  - The **concentration** of molecules is the number of them in a given volume unit
  - A **gradient** is a physical difference in temperature, pressure, charge, or concentration in two adjacent regions

Movement of Molecules in Fluids

- Why molecules move from one place to another
  - Substances move in response to a **concentration gradient**
    - Molecules move from high to low concentration (**diffusion**) until **dynamic equilibrium** is reached

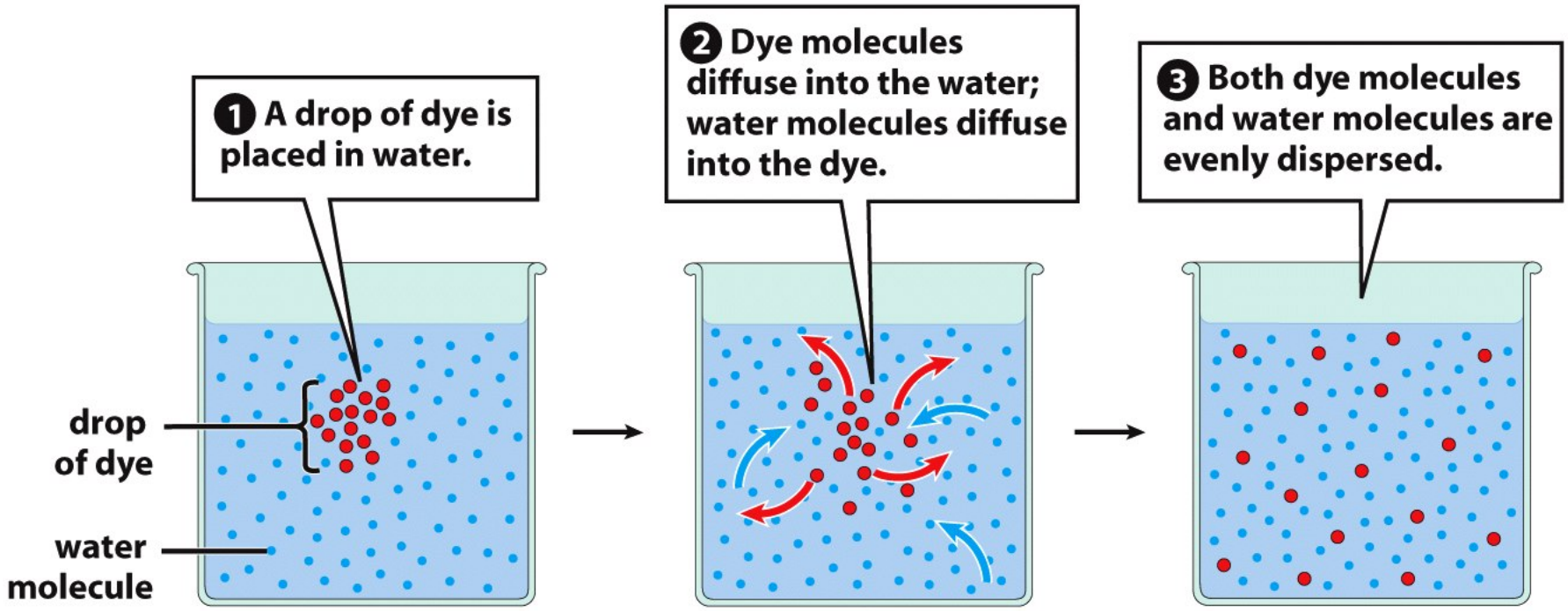


Figure 5-6 Biology: Life on Earth, 8/e

Movement of Molecules in Fluids

- The greater the concentration gradient, the faster the rate of diffusion
- Diffusion cannot move molecules rapidly over long distances

Movement Across Membranes

- Concentration gradients of ions and molecules exist across the plasma membranes of all cells
- There are two types of movement across the plasma membrane
  - **Passive transport (No energy added)**
  - **Active transport (Energy-requiring transport)**

Table 5-1 Transport Across Membranes

Passive transport	
	Diffusion of substances across a membrane down a gradient of concentration, pressure, or electrical charge. Does not require the cell to expend energy.
Simple diffusion	Diffusion of water, dissolved gases, or lipid-soluble molecules through the phospholipid bilayer of a membrane.
Facilitated diffusion	Diffusion of water, ions, or water-soluble molecules through a membrane *via* a channel or carrier protein.
Osmosis	Diffusion of water across a selectively permeable membrane from a region of higher free water concentration to a region of lower free water concentration.
Energy-requiring transport	
	Movement of substances into or out of a cell using cellular energy, usually ATP.
Active transport	Movement of individual small molecules or ions against their concentration gradients through membrane-spanning proteins.
Endocytosis	Movement of large particles, including large molecules or entire microorganisms, into a cell; occurs as the plasma membrane engulfs the particle in a membranous sac that enters the cytosol.
Exocytosis	Movement of materials out of a cell; occurs as the plasma membrane encloses the material in a membranous sac that moves to the cell surface, fuses with the plasma membrane, and opens to the outside, allowing its contents to diffuse out.

Table 5-1 Biology: Life on Earth, 8/e

Movement Across Membranes

- Passive transport
  - Substances move down their concentration gradients across a membrane
  - No energy is expended
  - Membrane proteins and phospholipids may limit which molecules can cross, but not the direction of movement

Movement Across Membranes

- Active or Energy-requiring transport
  - Substances are driven against their concentration gradients
  - Energy is expended

Passive Transport

- Plasma membranes are **selectively permeable**
  - Different molecules move across at different locations and rates
  - A concentration gradient drives all three types of passive transport: simple diffusion, facilitated diffusion, and osmosis

Passive Transport

- **Simple diffusion**
  - Lipid soluble molecules (e.g. vitamins A and E, gases) and very small molecules diffuse directly across the phospsholipid bilayer

Simple diffusion through the phospholipid bilayer

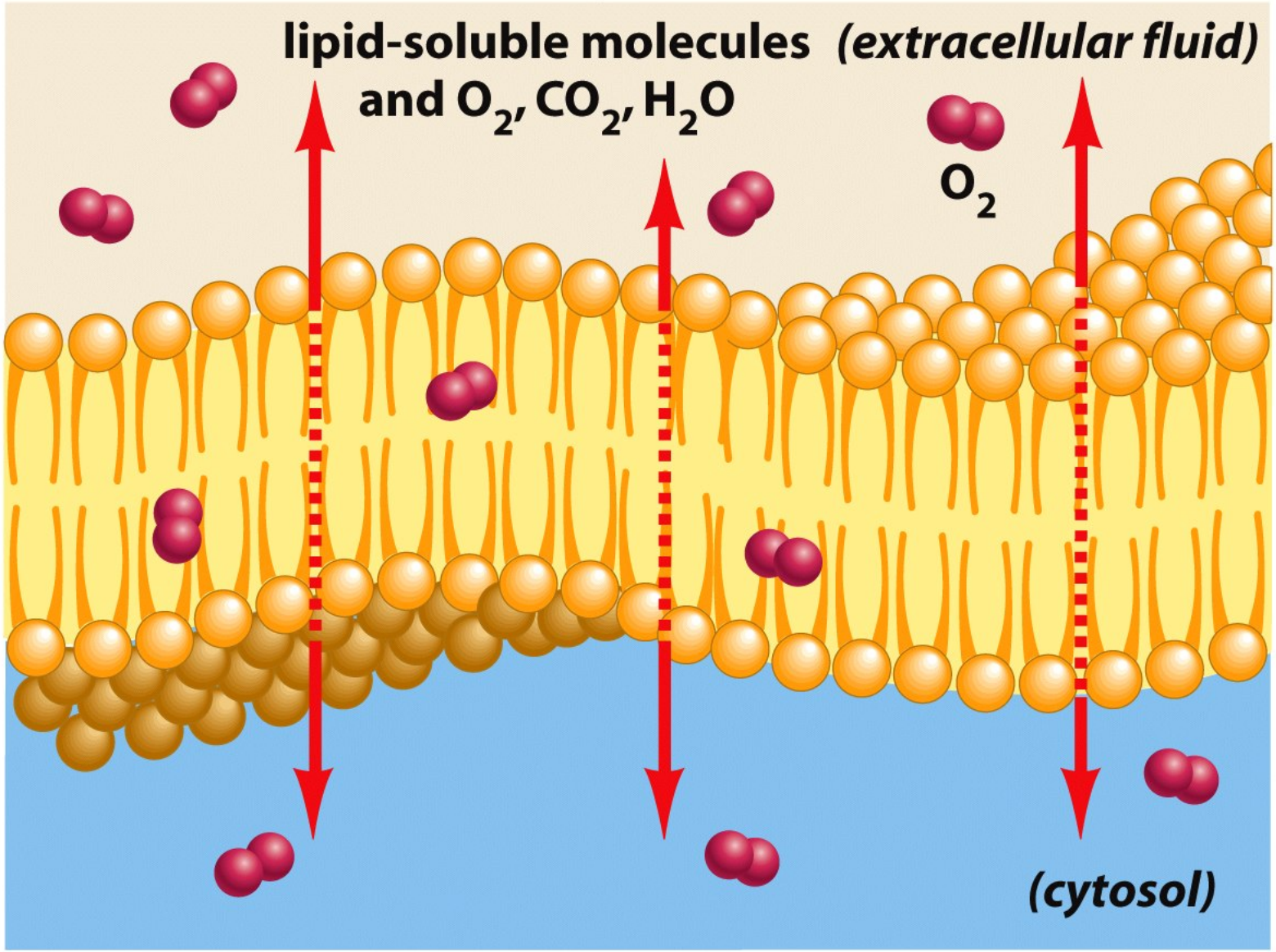


Figure 5-7a Biology: Life on Earth, 8/e

Passive Transport

- **Facilitated diffusion**
  - Water soluble molecules like ions, amino acids, and sugars diffuse with the aid of channel and carrier transport proteins

Facilitated diffusion through a channel protein

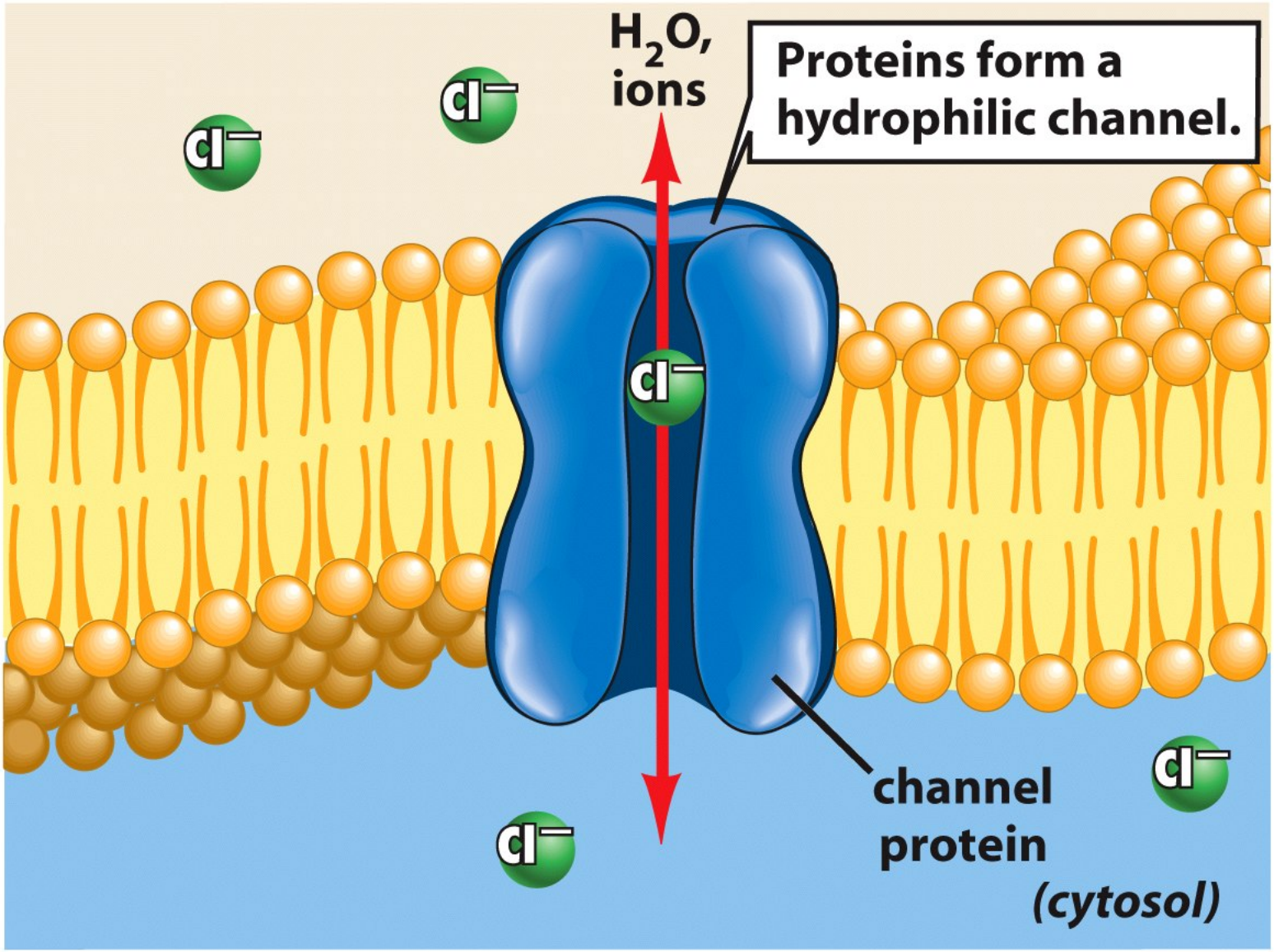


Figure 5-7b part 2 Biology: Life on Earth, 8/e

Facilitated diffusion through a carrier protein

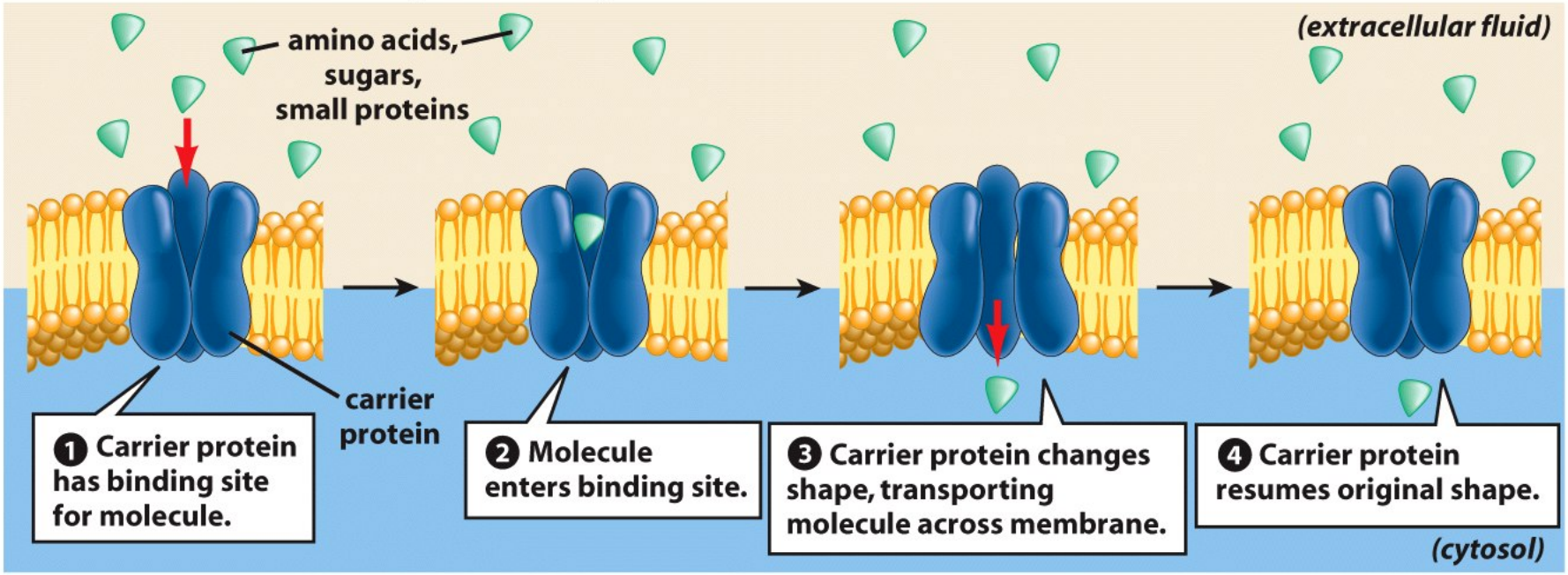


Figure 5-7c part 4 Biology: Life on Earth, 8/e

Passive Transport

- **Osmosis** – the special case of water diffusion
  - Water diffuses from high concentration (high purity) to low concentration (low purity) across a membrane
  - Dissolved substances reduce the concentration of free water molecules (and hence the purity of water) in a solution

isotonic: no net flow of water

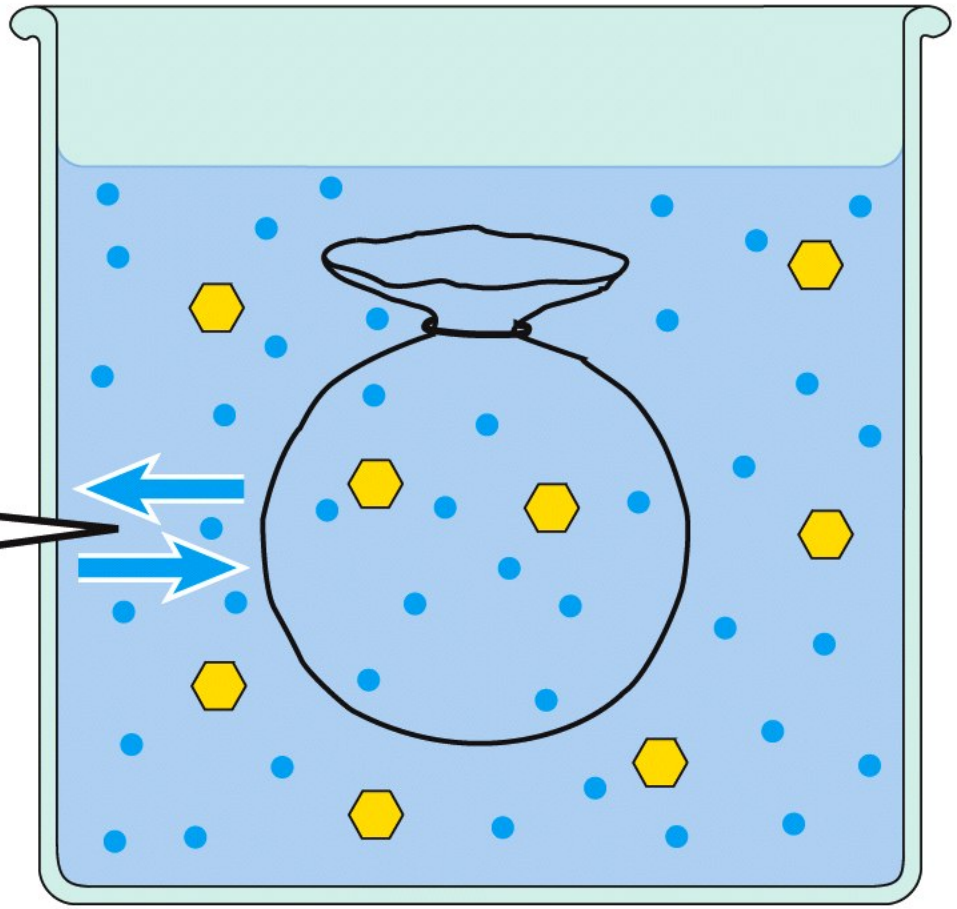


Figure 5-8 Biology: Life on Earth, 8/e

Passive Transport

- **Isotonic** solutions have equal concentrations of water and equal concentrations of dissolved substances
  - No *net* water movement occurs across the membrane

Passive Transport

– A **hypertonic** solution is one with lower water concentration or higher dissolved particle concentration

Passive Transport

– A **hypotonic** solution is one with higher water concentration or lower dissolved particle concentration

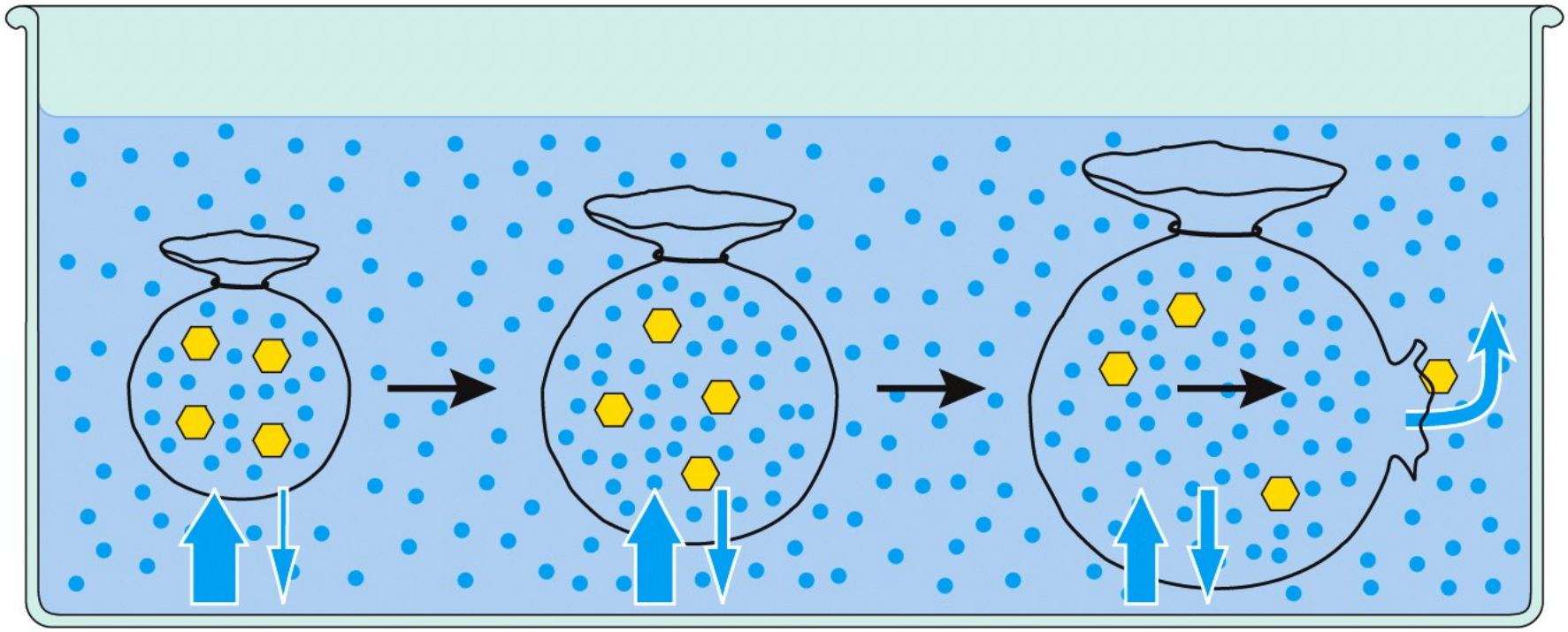
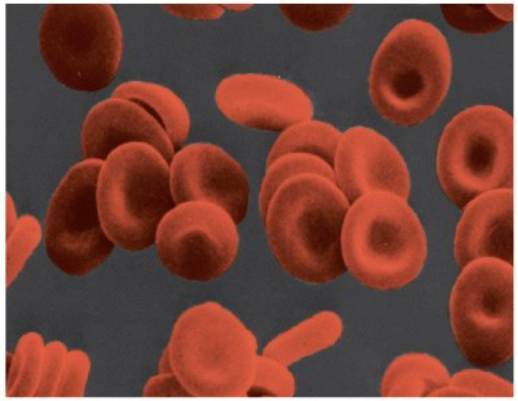


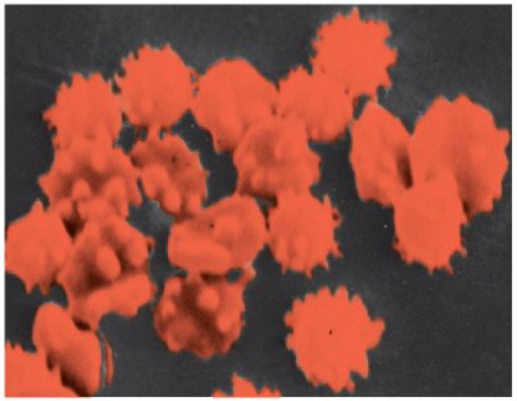
Figure 5-9 Biology: Life on Earth, 8/e

Passive Transport

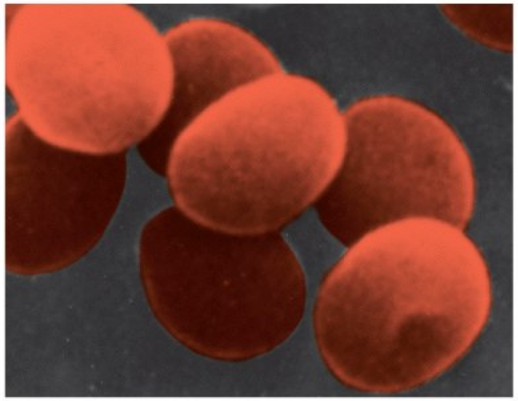
- The effects of osmosis are illustrated when red blood cells are placed in various solutions



(a) Isotonic solution



(b) Hypertonic solution



(c) Hypotonic solution

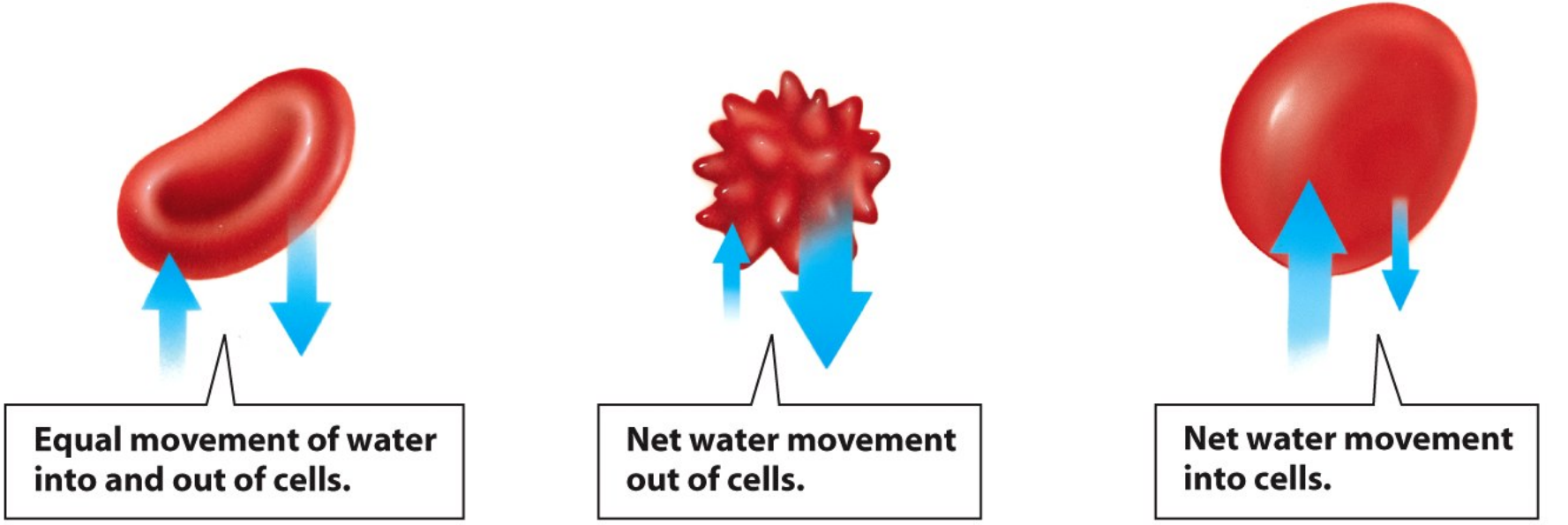
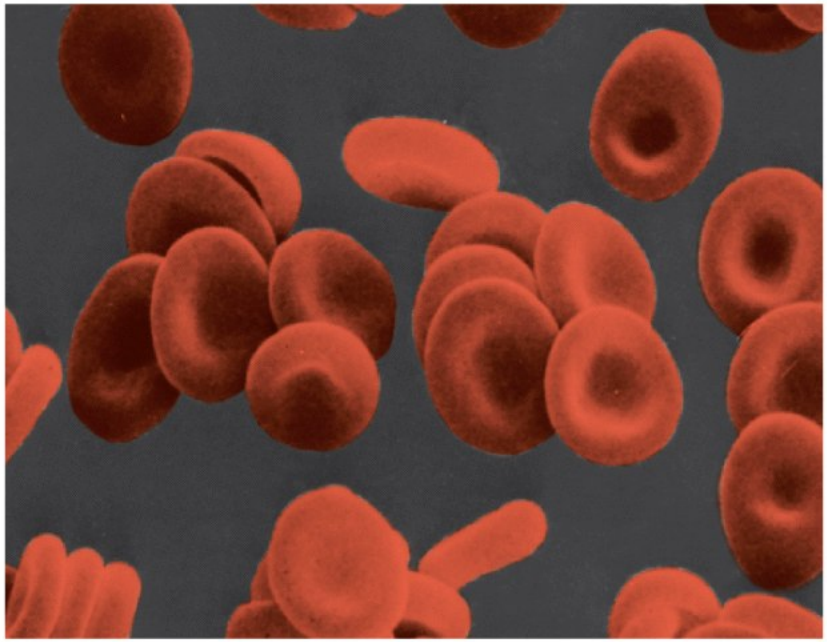


Figure 5-10 Biology: Life on Earth, 8/e



Isotonic solution

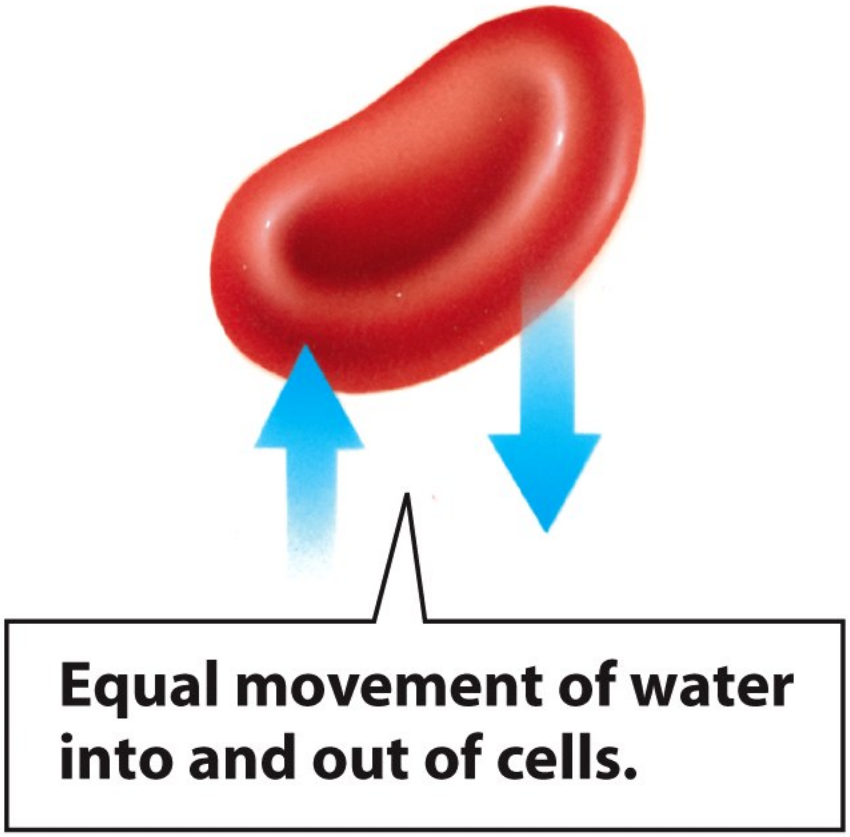
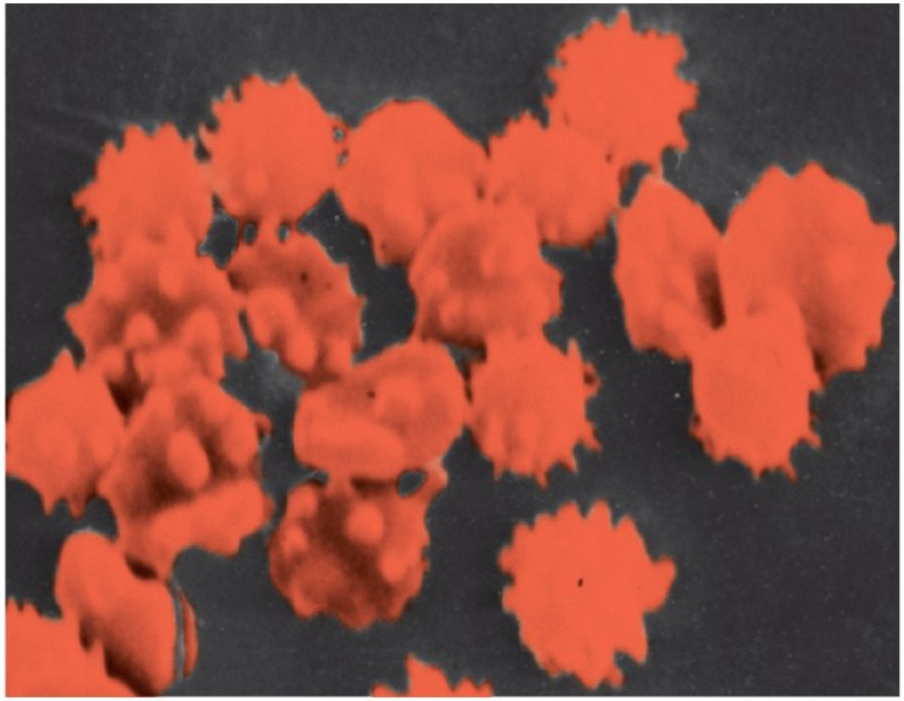
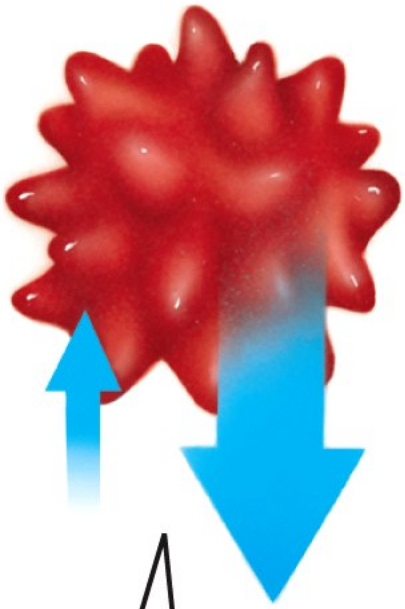


Figure 5-10a Biology: Life on Earth, 8/e

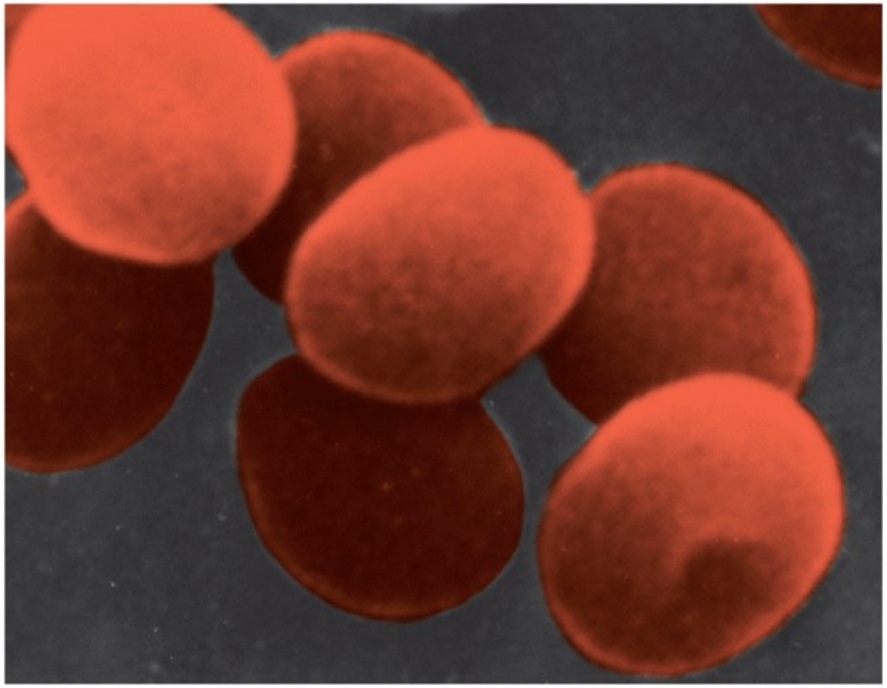


Hypertonic solution



Net water movement out of cells.

Figure 5-10b Biology: Life on Earth, 8/e



Hypotonic solution

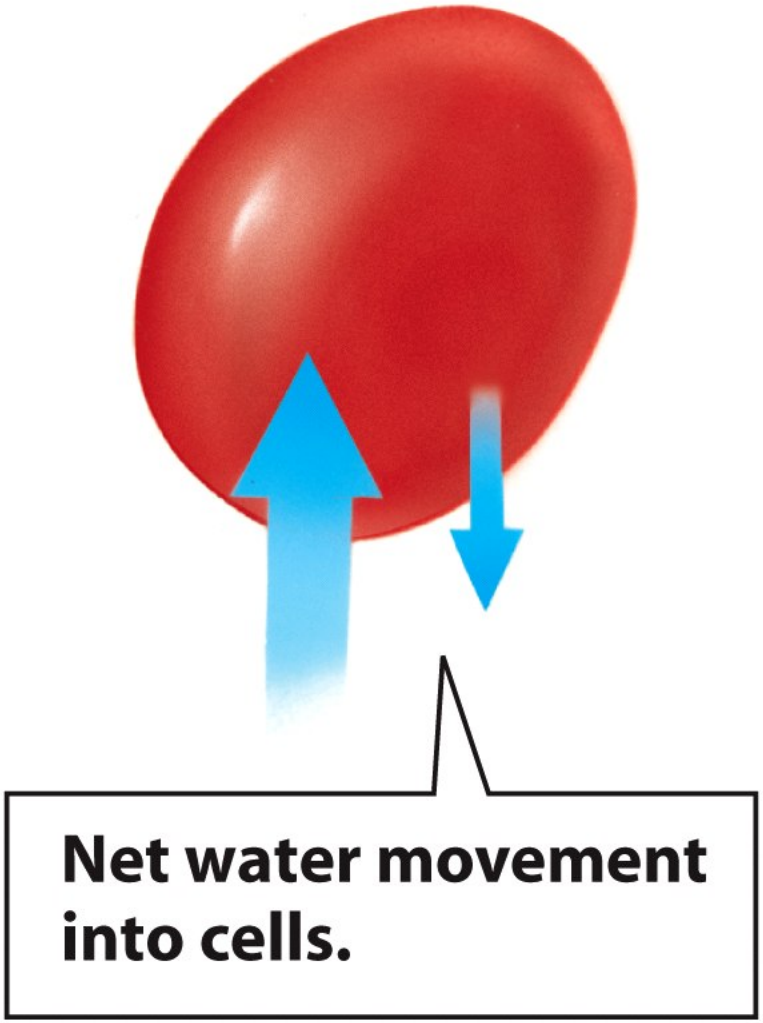


Figure 5-10c Biology: Life on Earth, 8/e

Passive Transport

- Osmosis explains why fresh water protists have contractile vacuoles
- Water leaks in continuously because the cytosol is hypertonic to fresh water
- Salts are pumped into the vacuoles, making them hypertonic to the cytosol
- Water follows by osmosis and is then expelled by contraction

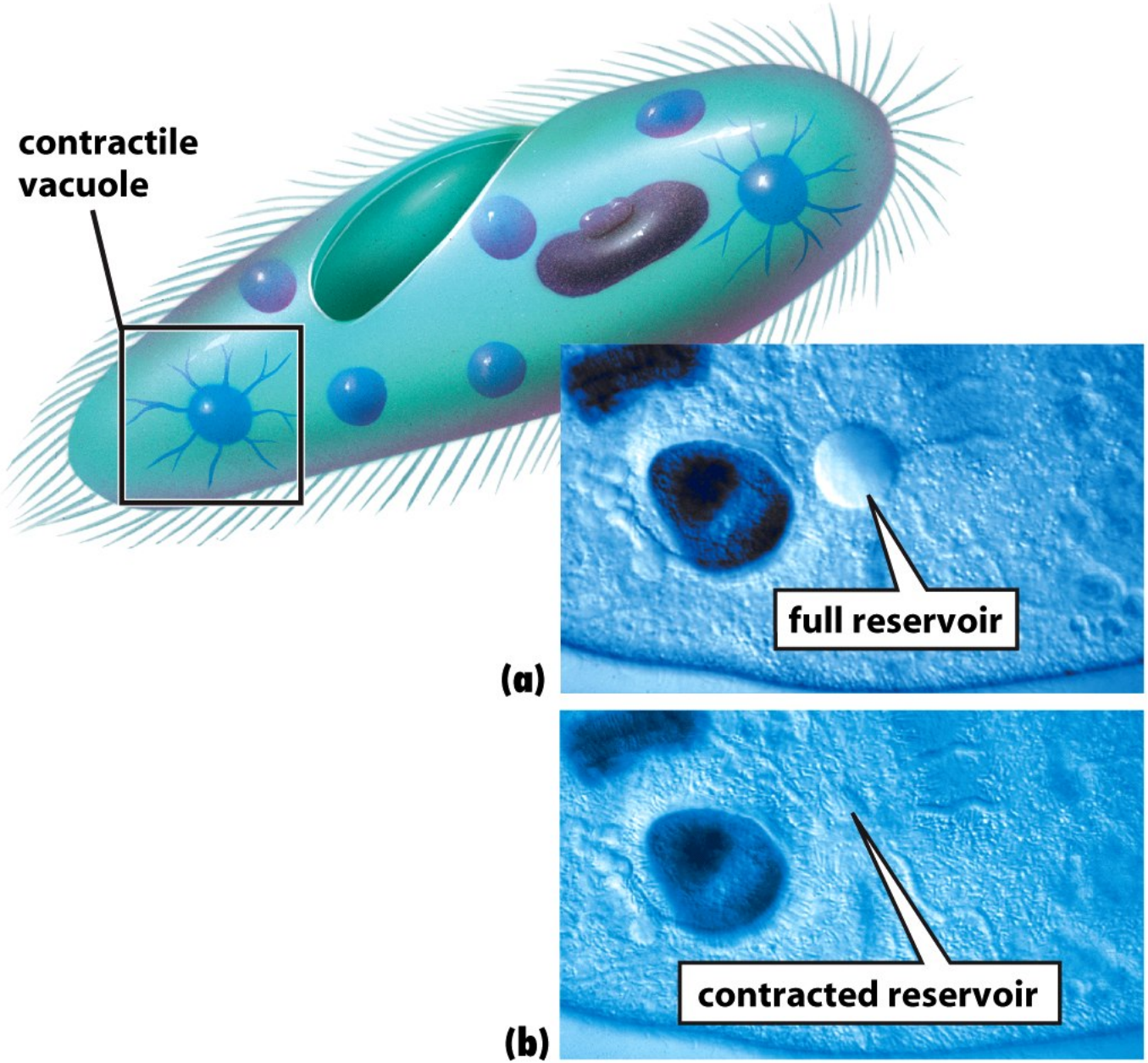


Figure 4-16 part 1 Biology: Life on Earth, 8/e

Active Transport

- Cells need to move some substances against their concentration gradients
- Active-transport membrane proteins move molecules across using ATP
  - Proteins span the entire membrane
  - Often have a molecule binding site and an ATP binding site
  - Often referred to as **pumps**

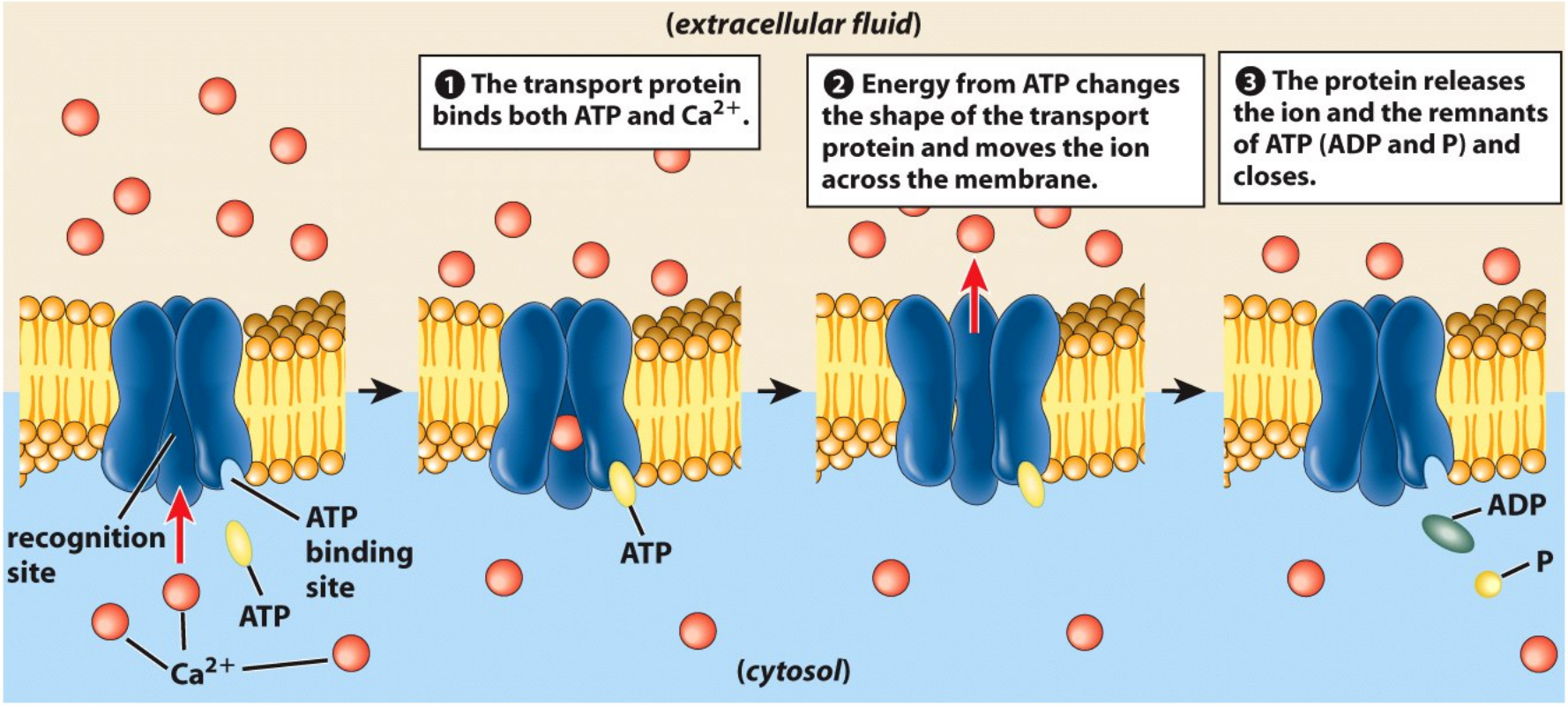


Figure 5-12 Biology: Life on Earth, 8/e

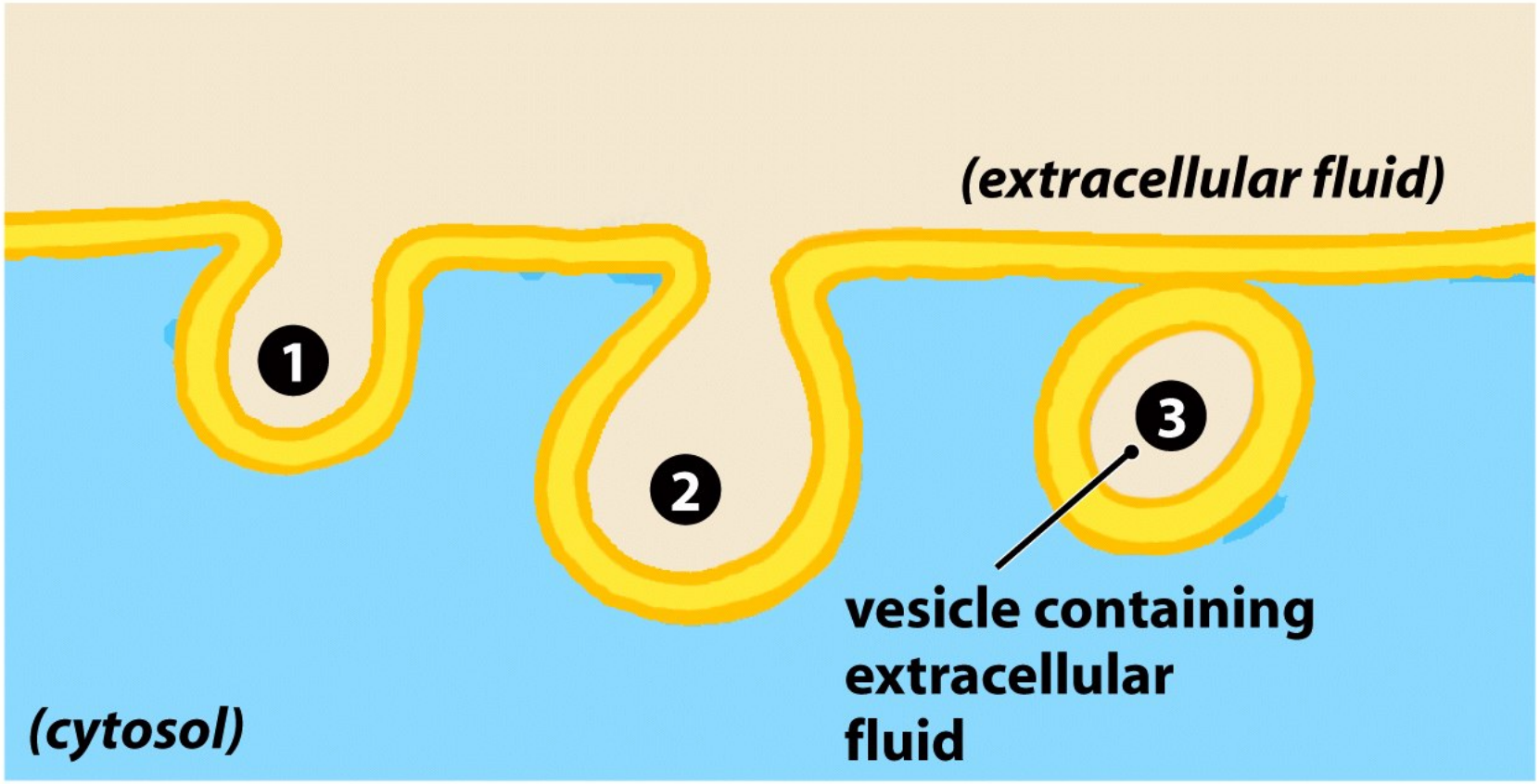
Endocytosis

- Cells import large particles or substances via **endocytosis**
- Plasma membrane pinches off to form a vesicle in endocytosis
  - Types of endocytosis
    - Pinocytosis
    - Receptor-mediated endocytosis
    - Phagocytosis

Endocytosis

- Types of endocytosis
  - **Pinocytosis** (“cell drinking”)

Pinocytosis



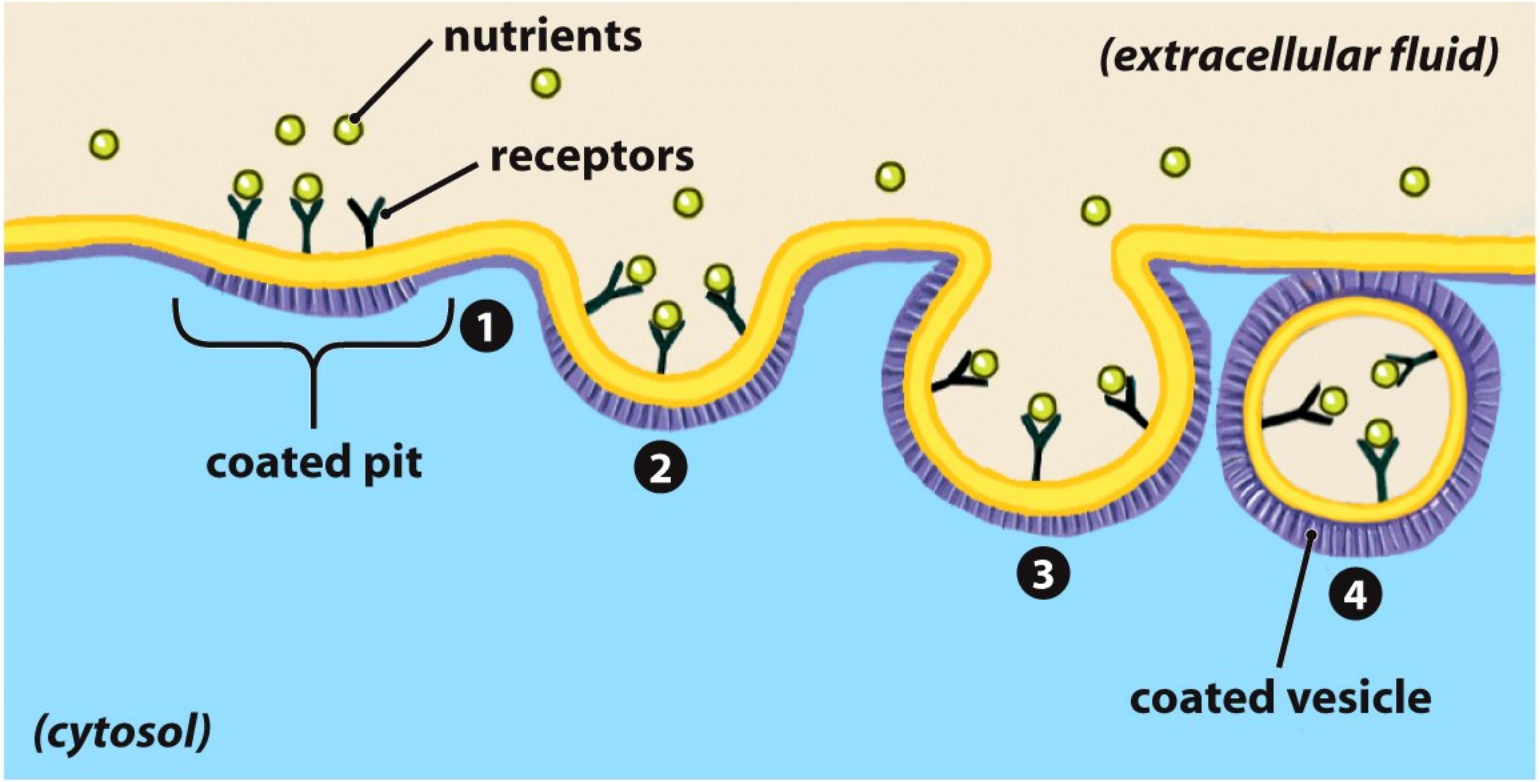
1 A dimple forms in the plasma membrane, which 2 deepens and surrounds the extracellular fluid. 3 The membrane encloses the extracellular fluid, forming a vesicle.

Figure 5-13a Biology: Life on Earth, 8/e

Endocytosis

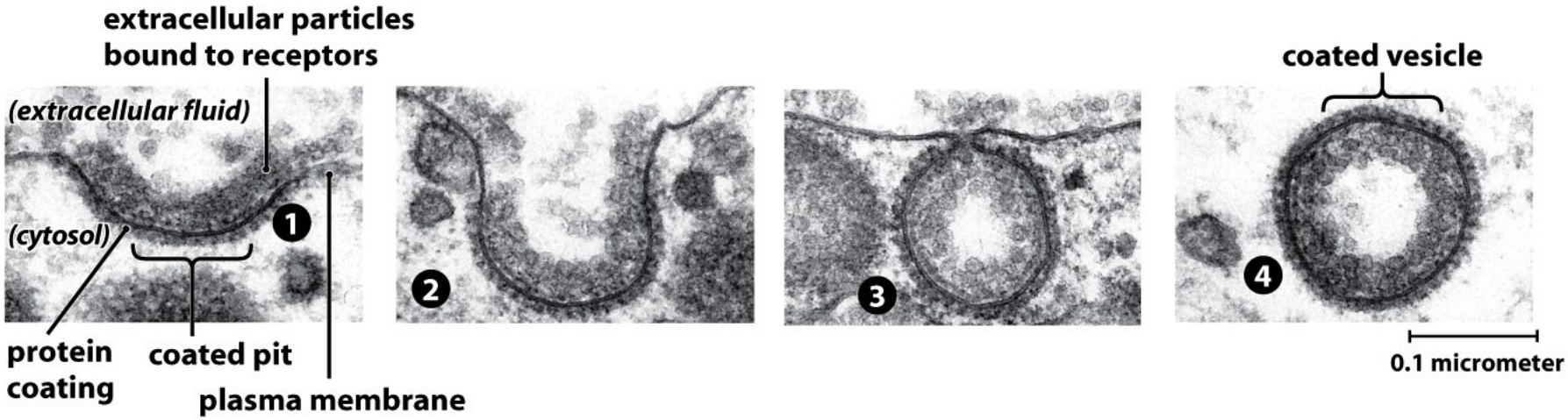
- Types of endocytosis
  - **Receptor-mediated endocytosis** moves specific molecules into the cell

Receptor-mediated endocytosis



1. Receptor proteins for specific molecules or complexes of molecules are localized at coated pit sites.
2. The receptors bind the molecules and the membrane dimples inward.
3. The coated pit region of the membrane encloses the receptor-bound molecules.
4. A vesicle ("coated vesicle") containing the bound molecules is released into the cytosol.

Figure 5-14 part 1 Biology: Life on Earth, 8/e



1 Receptor proteins for specific molecules or complexes of molecules are localized at coated pit sites.

2 The receptors bind the molecules and the membrane dimples inward.

3 The coated pit region of the membrane encloses the receptor-bound molecules.

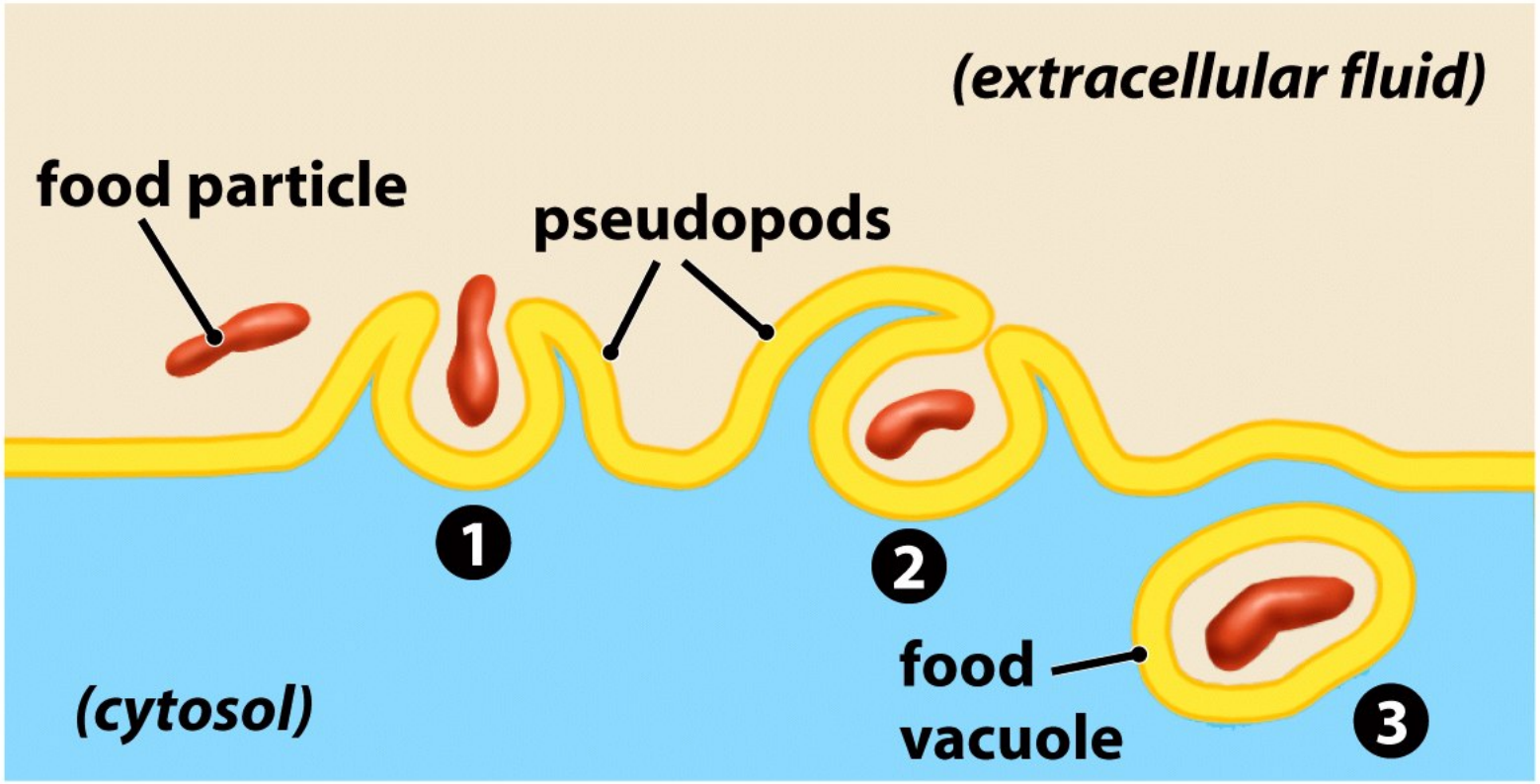
4 A vesicle ("coated vesicle") containing the bound molecules is released into the cytosol.

Figure 5-14 part 2 Biology: Life on Earth, 8/e

Endocytosis

- Types of endocytosis
  - **Phagocytosis** (“cell eating”)

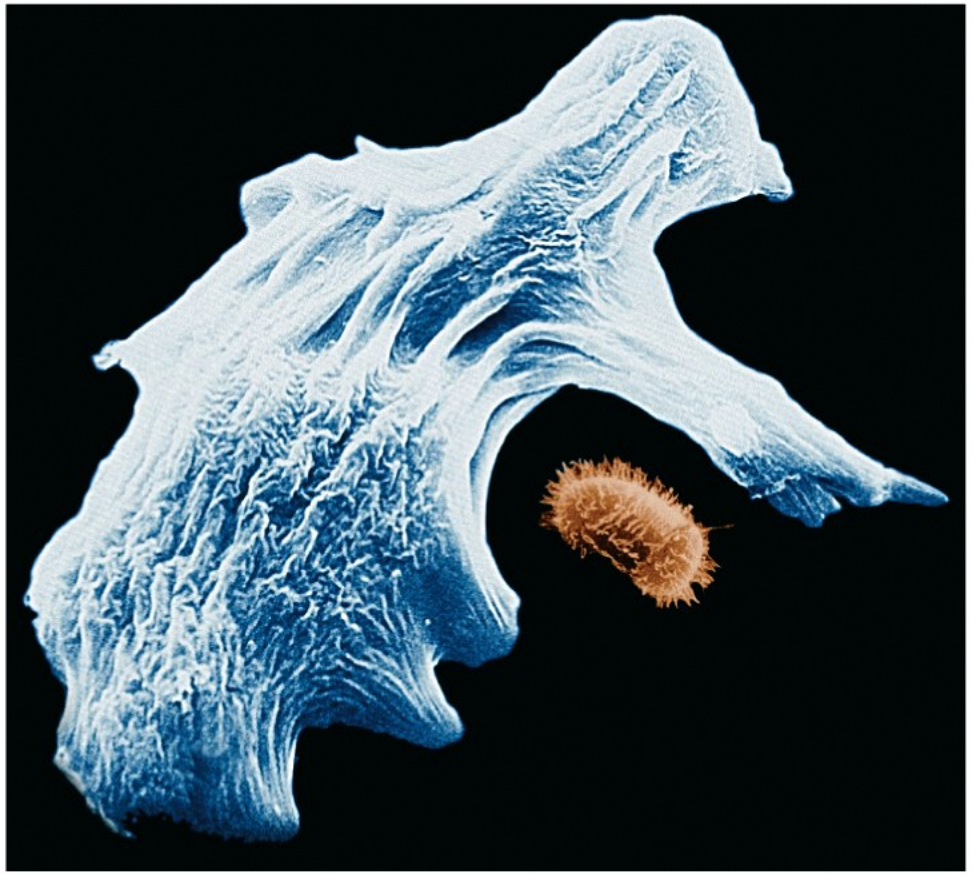
Phagocytosis



1 The plasma membrane extends pseudopods toward an extracellular particle (for example, food). 2 The ends of the pseudopods fuse, encircling the particle. 3 A vesicle called a food vacuole is formed containing the engulfed particle.

Figure 5-15a Biology: Life on Earth, 8/e

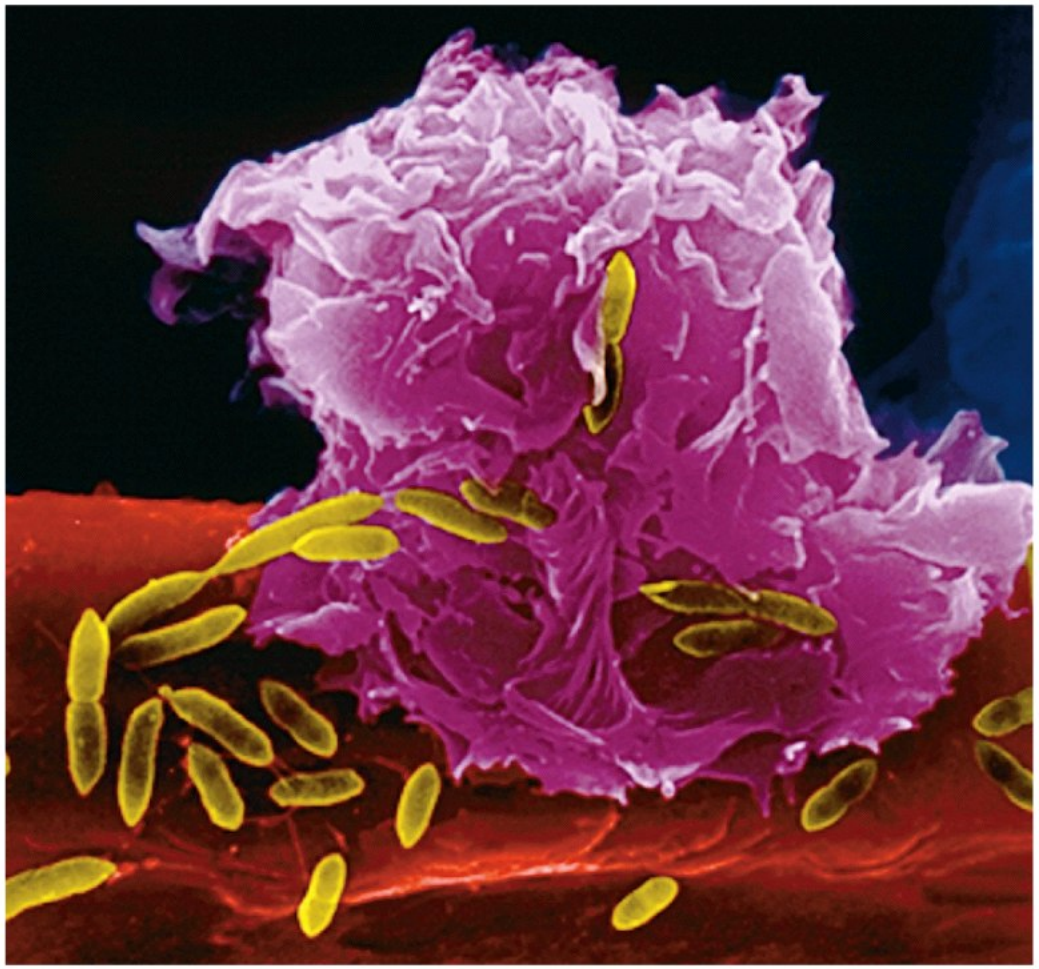
Amoeba



An *Amoeba* (a freshwater protist), engulfs a *Paramecium* using phagocytosis.

Figure 5-15b Biology: Life on Earth, 8/e

White blood cell



A white blood cell ingests bacteria using phagocytosis.

Figure 5-15c Biology: Life on Earth, 8/e

Exocytosis

- Exocytosis
  - Vesicles join the membrane, dumping out contents in exocytosis

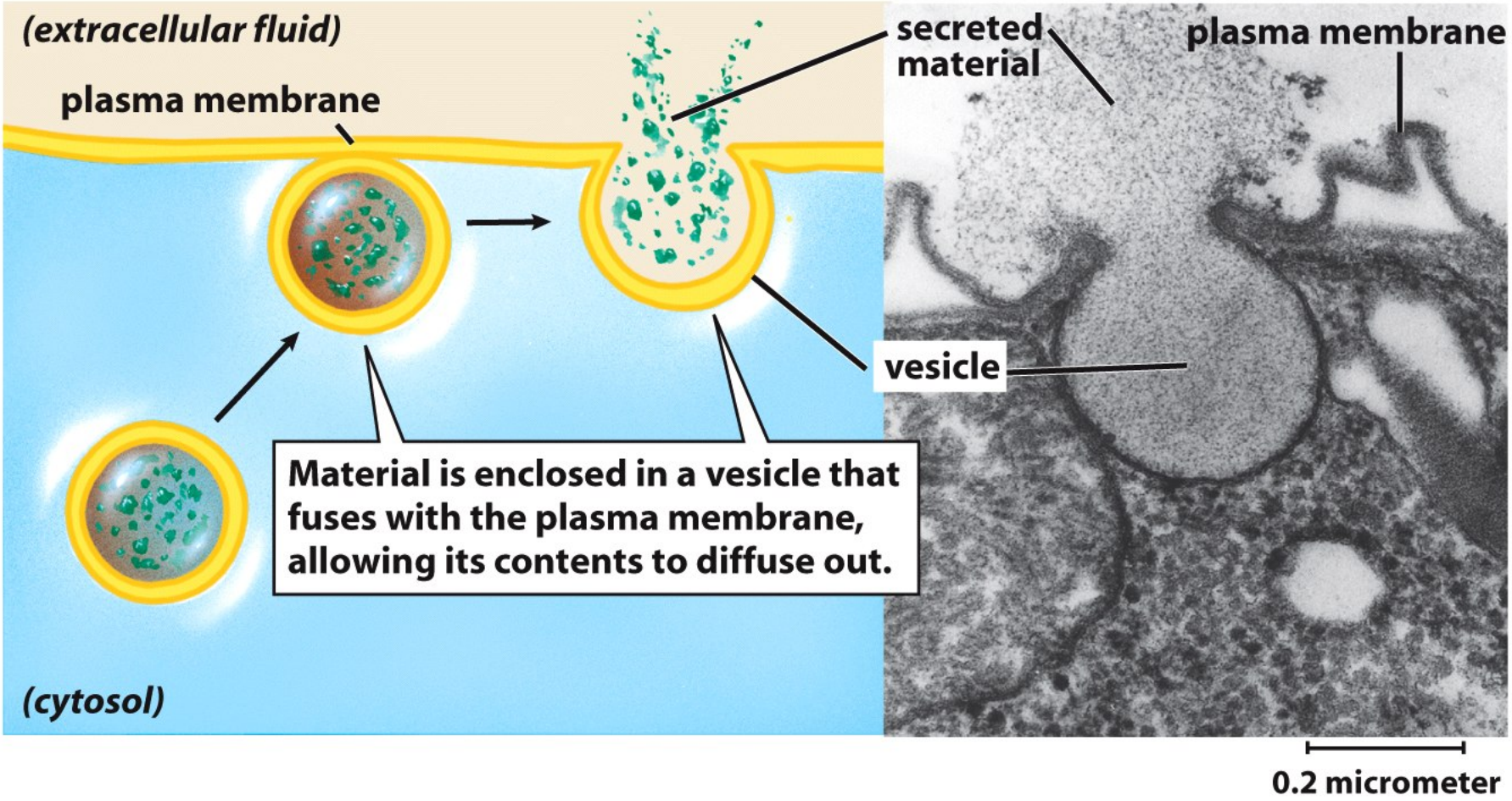
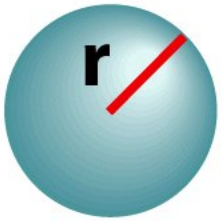
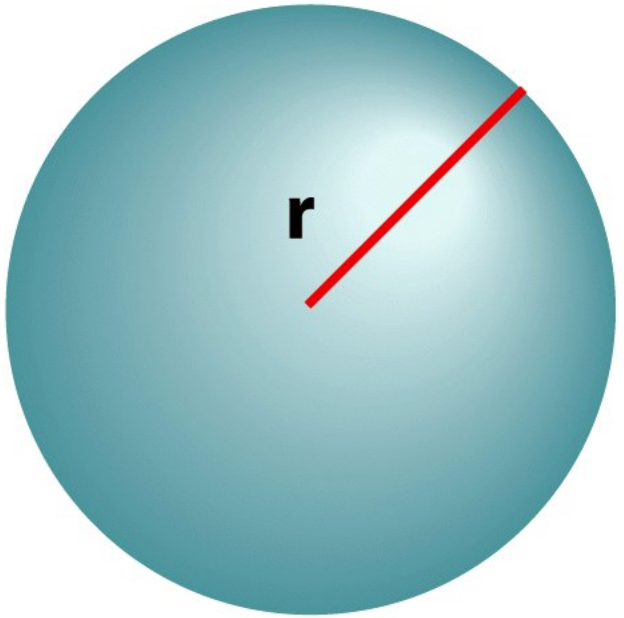


Figure 5-16 Biology: Life on Earth, 8/e

Cell Size and Shape

- Exchange affects cell size and shape
  - As a spherical cell enlarges, its innermost parts get farther away from the plasma membrane
  - Also, its volume increases more rapidly than its surface area
  - A larger cell has a relatively smaller area of membrane for nutrition exchange than a small cell





distance to center (r)	1.0	3.0
surface area ($4\pi r^2$)	12.6	113.1
volume ($4/3\pi r^3$)	4.2	113.1
surface area/volume	3.0	1.0

Figure 5-17 Biology: Life on Earth, 8/e

Desomosomes

- **Desmosomes** attach cells together
  - Found where cells need to adhere tightly together under the stresses of movement (e.g. the skin)

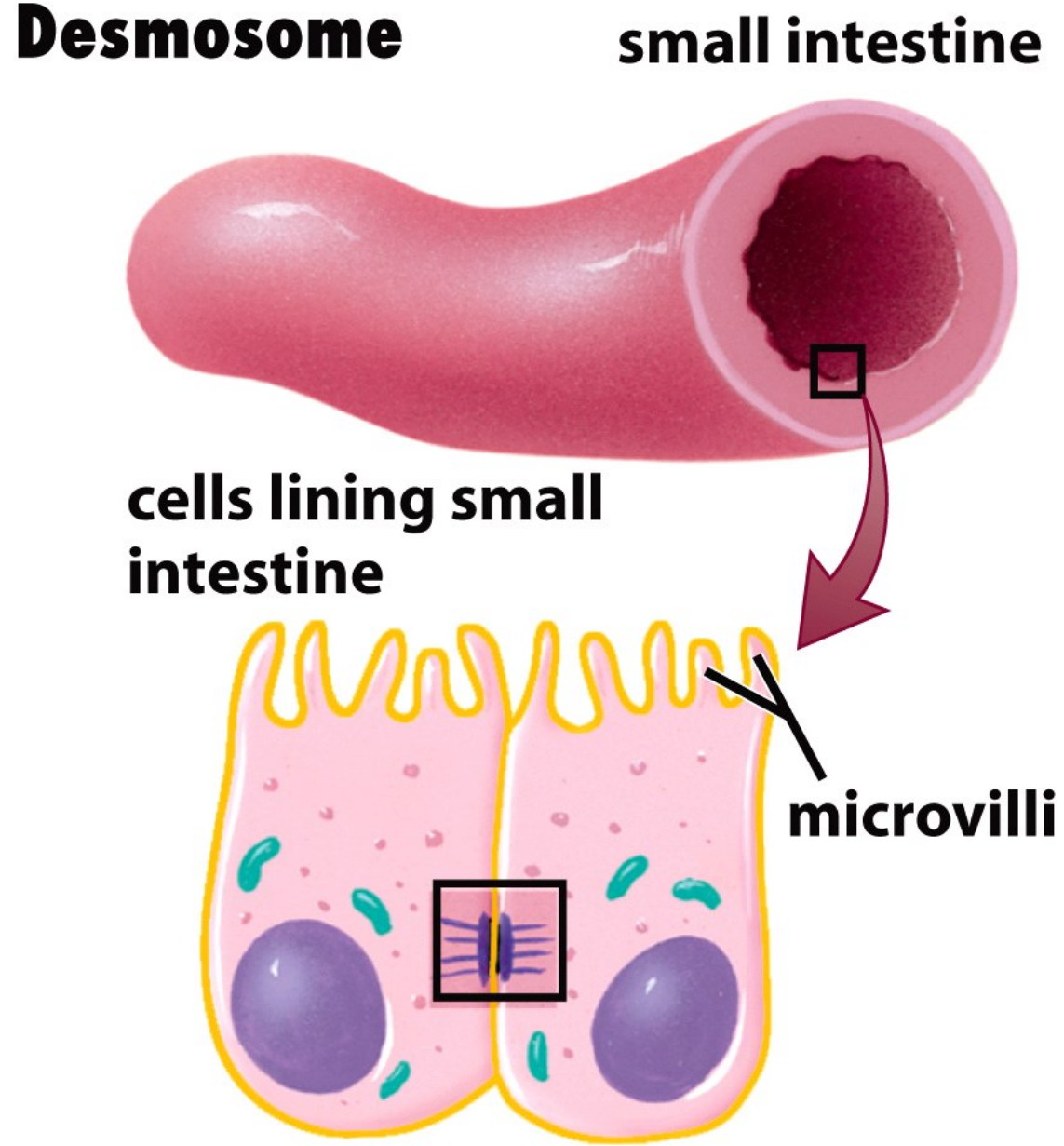


Figure 5-18a part 1 Biology: Life on Earth, 8/e

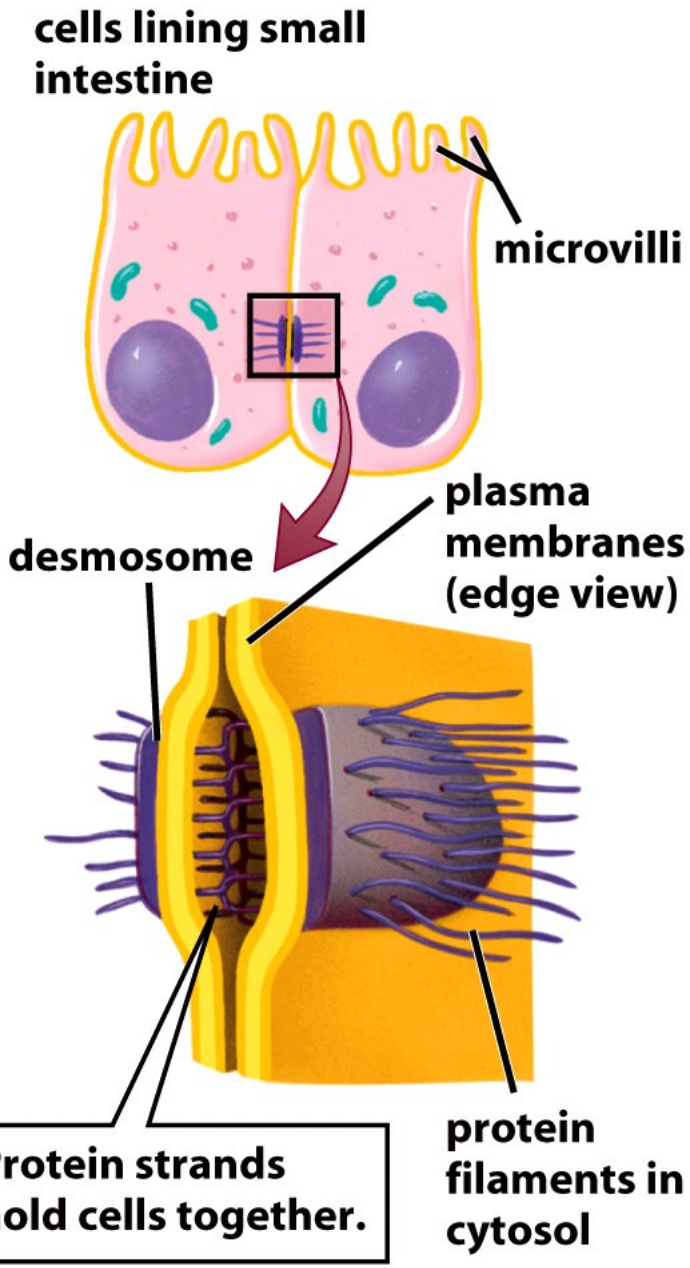


Figure 5-18a part 2 Biology: Life on Earth, 8/e

Tight Junctions

- **Tight junctions** make the cell leakproof
  - Found where tubes and sacs must hold contents without leaking (e.g. the urinary bladder)

Tight junction

urinary bladder

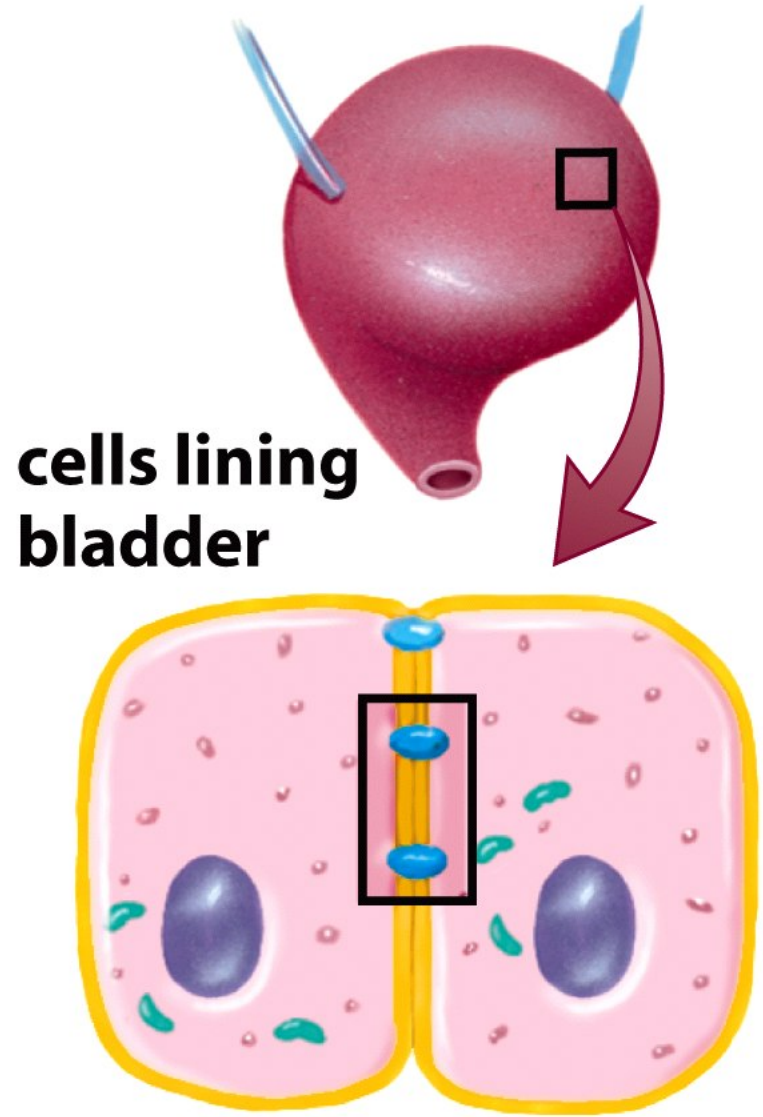


Figure 5-18b part 1 Biology: Life on Earth, 8/e

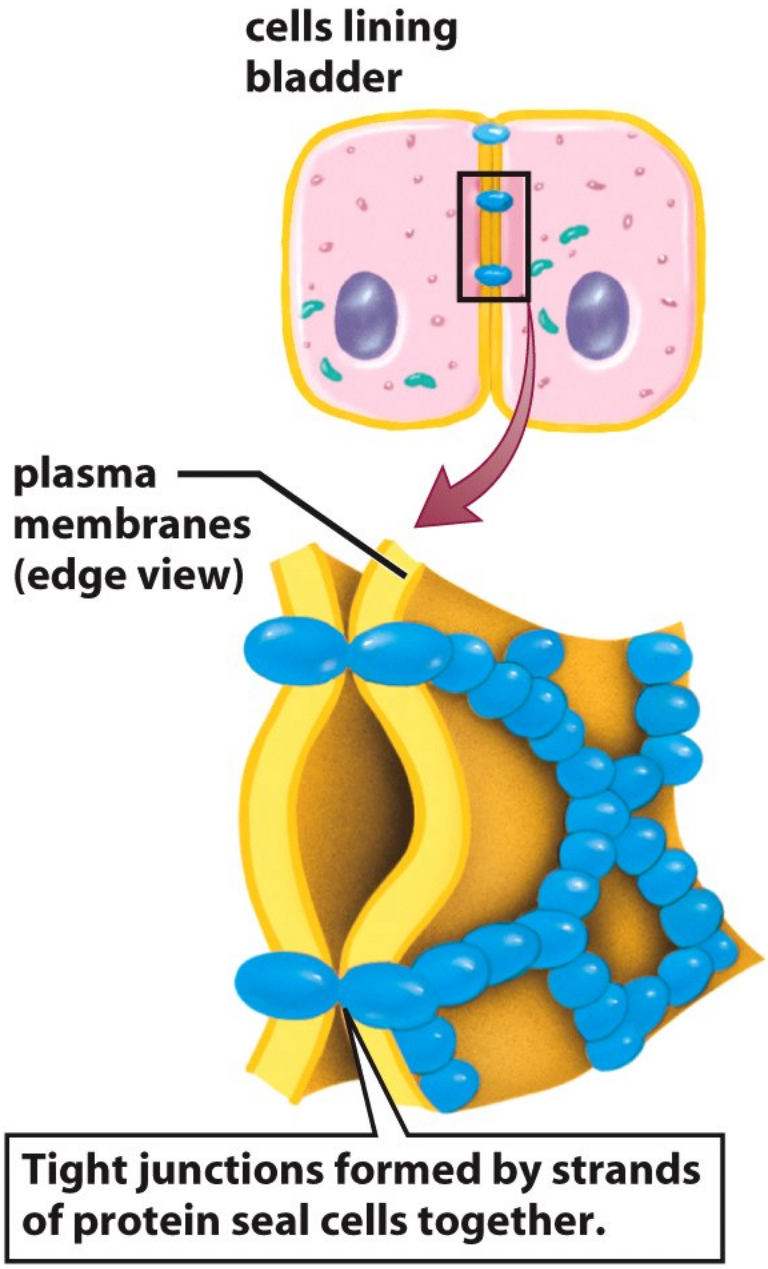


Figure 5-18b part 2 Biology: Life on Earth, 8/e

Gap Junctions and Plasmodesmata

- **Gap junctions** and **plasmodesmata** allow for communication
  - Cell-to-cell channels allowing for passage of hormones, nutrients, and ions in animal cells are gap junctions
  - Plant cells have cytoplasmic connections called plasmodesmata

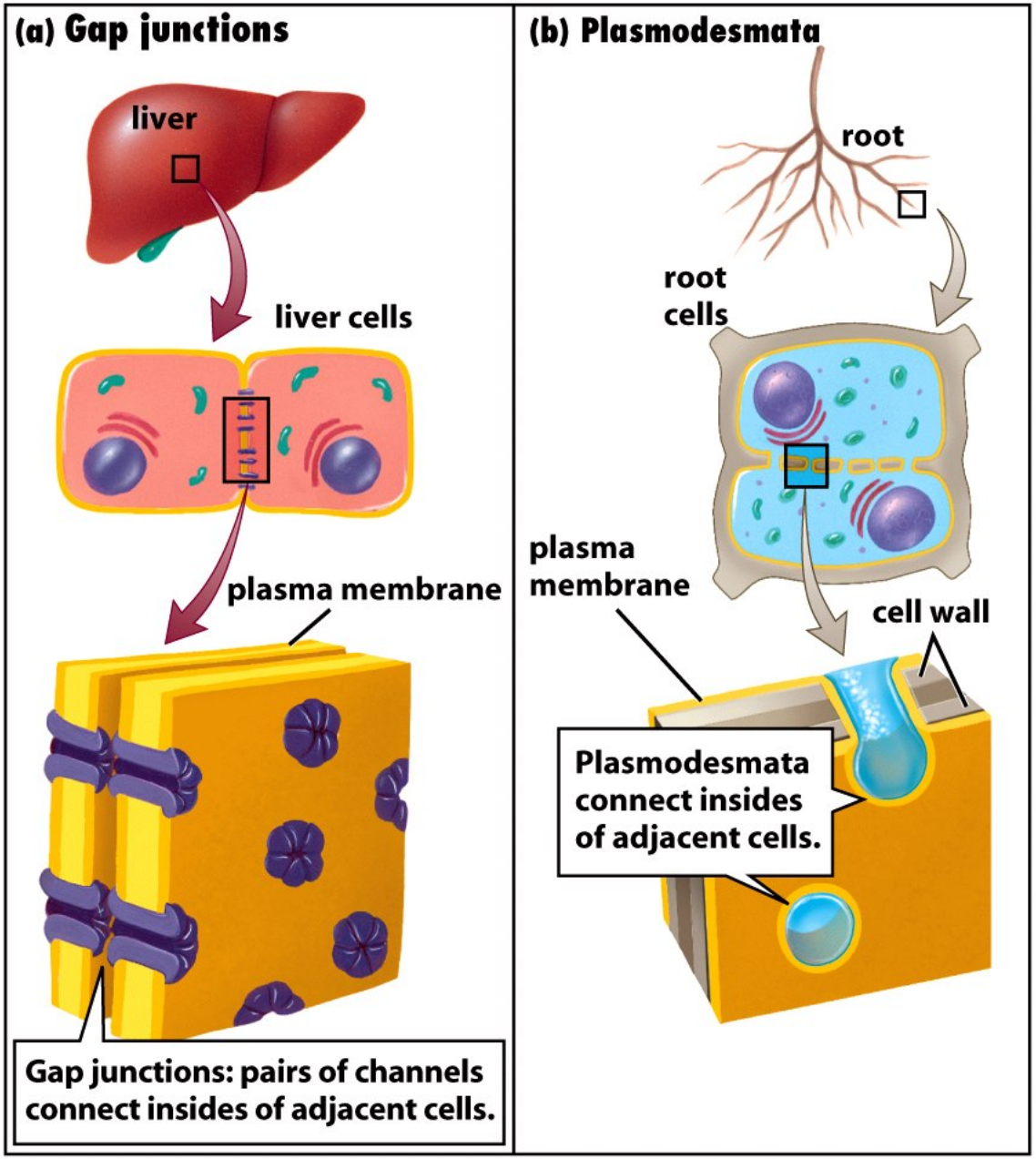


Figure 5-19 Biology: Life on Earth, 8/e

Gap junctions

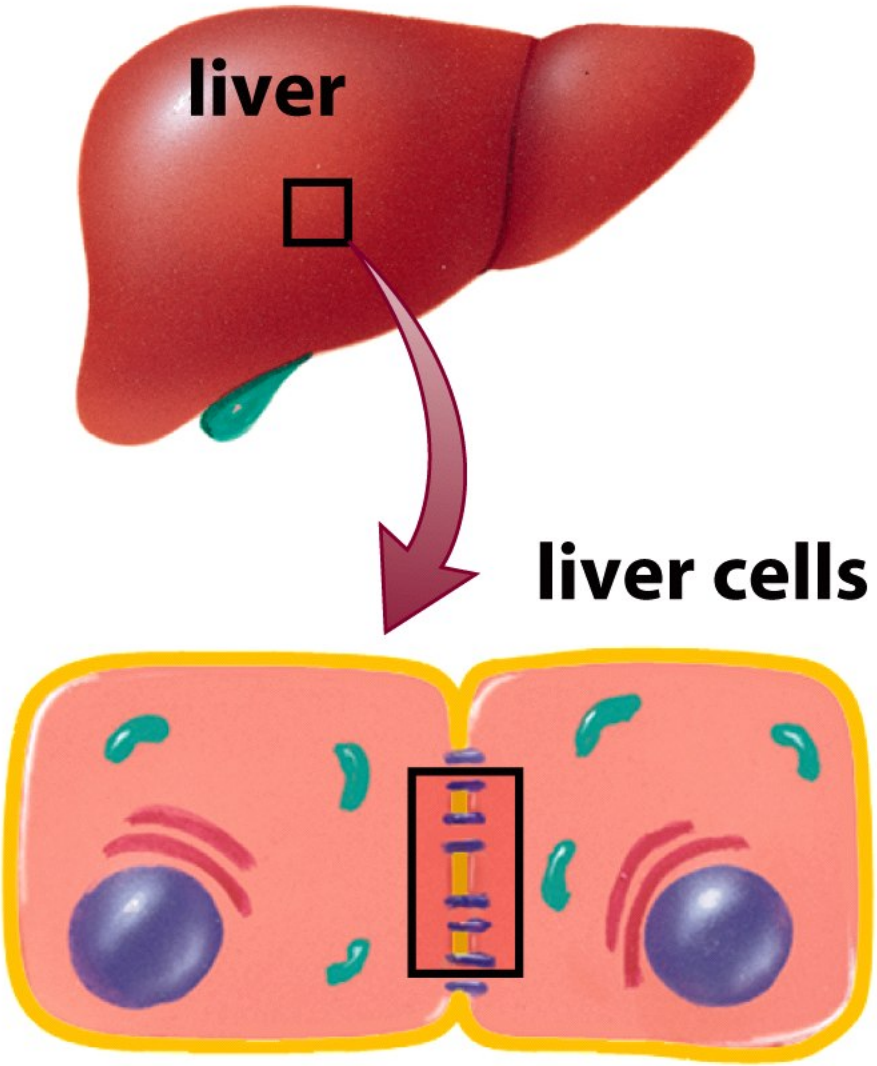


Figure 5-19a part 1 Biology: Life on Earth, 8/e

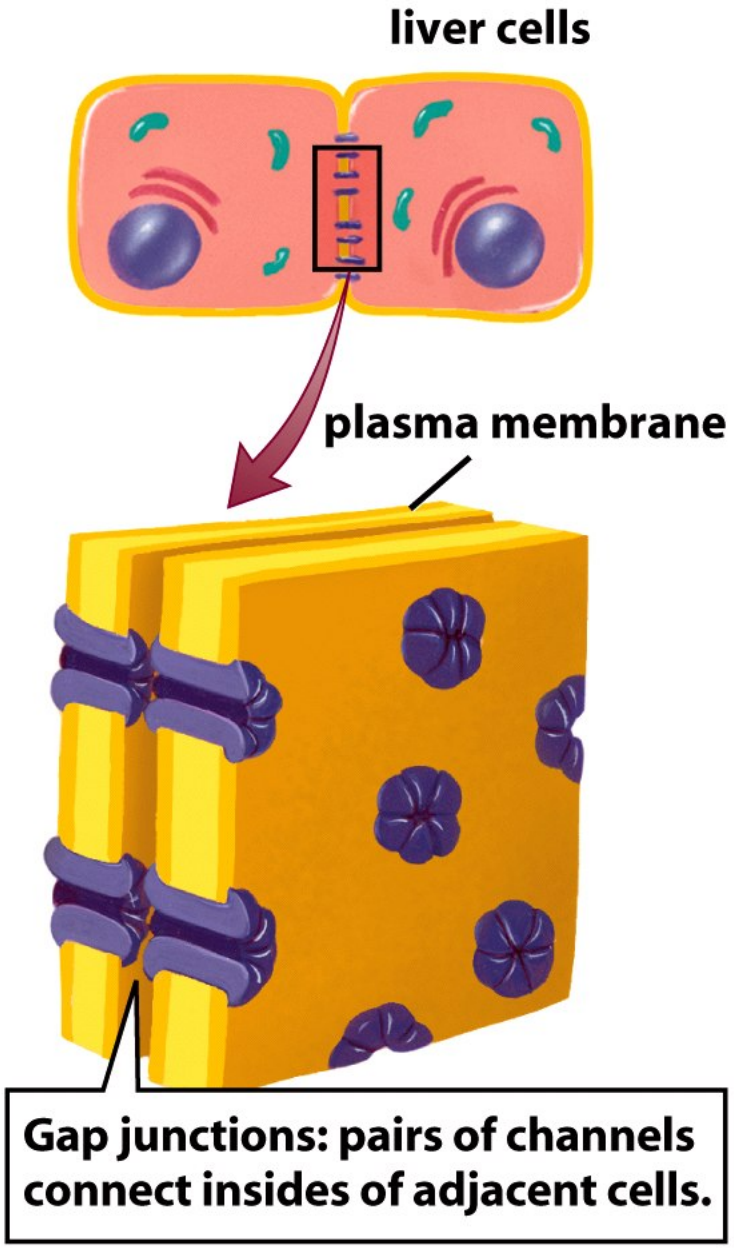


Figure 5-19a part 2 Biology: Life on Earth, 8/e

Plasmodesmata

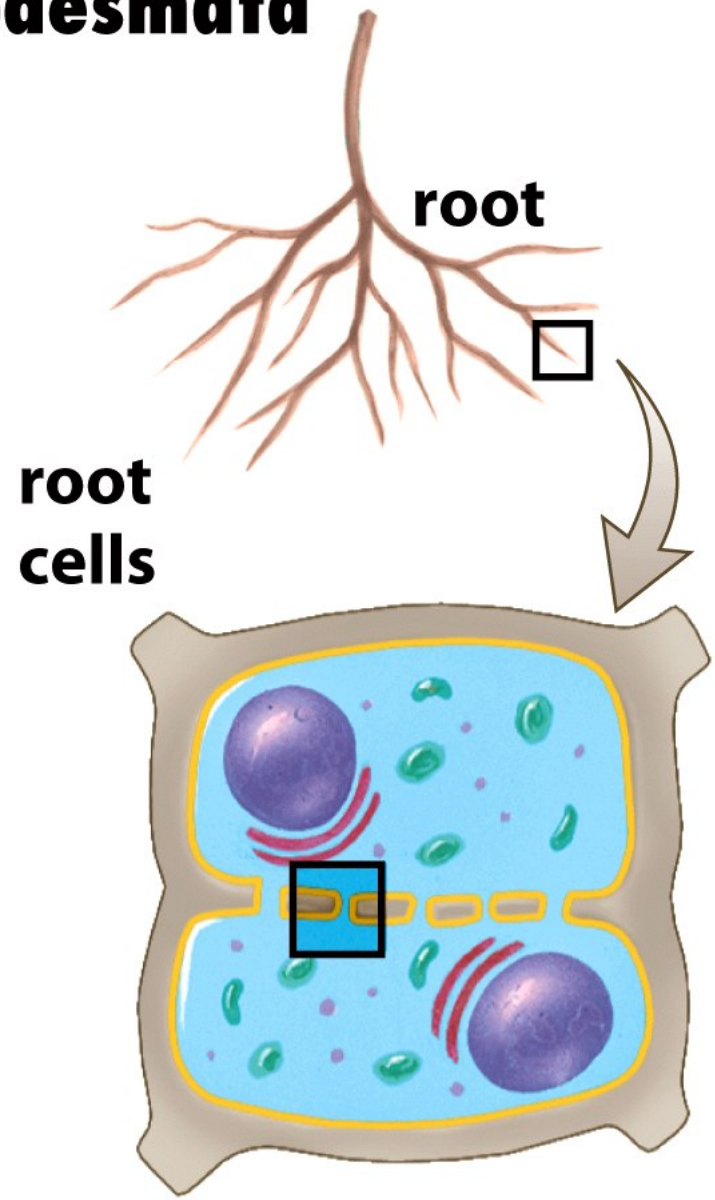


Figure 5-19b part 1 Biology: Life on Earth, 8/e

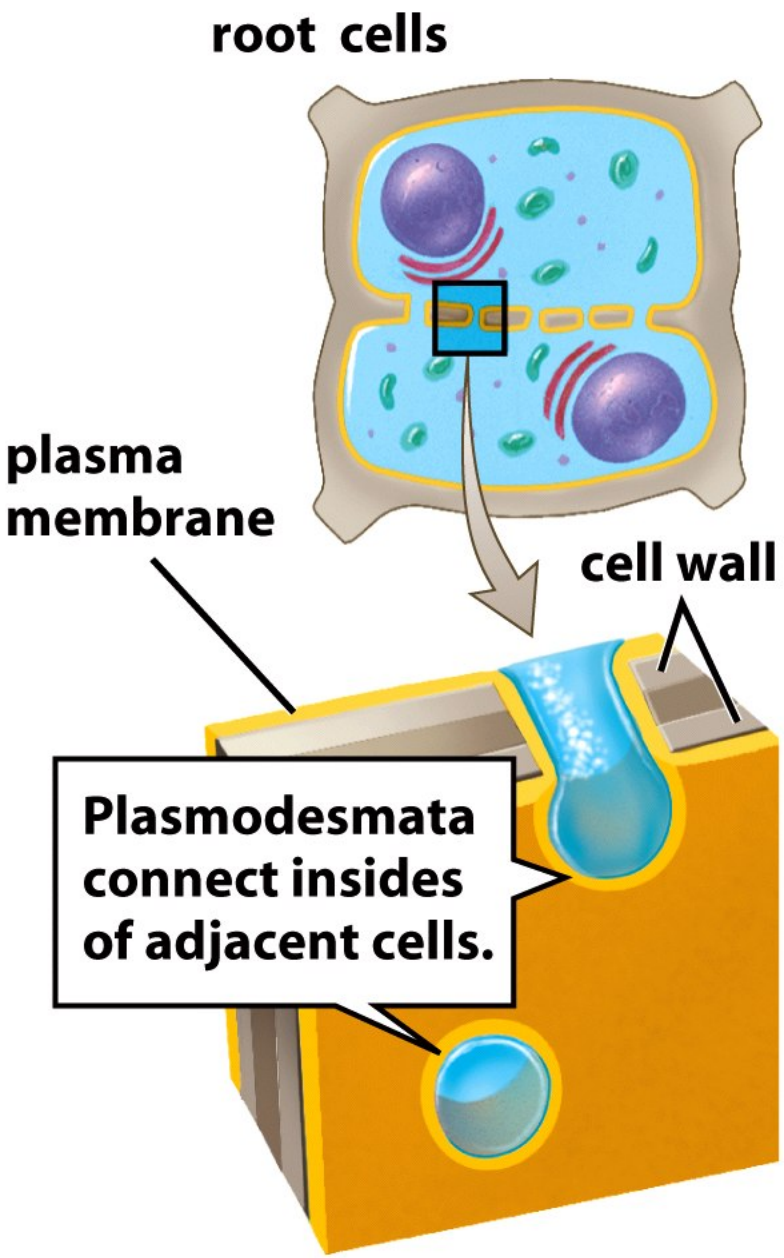


Figure 5-19b part 2 Biology: Life on Earth, 8/e

Caribous Legs and Membranes

- Membrane function varies between organisms
- Plasma membrane phospholipids in caribous legs adapted for cold
  - Cold areas near hooves have more membrane unsaturated fatty acids to keep cell membranes fluid

Figure 5-20 Biology: Life on Earth, 8/e

Viscous Venoms

- Snake and spider venoms contain phospholipases, enzymes that break down phospholipids
- Venoms attack cell membranes, causing cells to rupture and die
- Cell death destroys tissue around bite

Figure 5-21a Biology: Life on Earth, 8/e

Figure 5-21b Biology: Life on Earth, 8/e