Chapter 7

Membrane Structure and Function

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PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: Life at the Edge

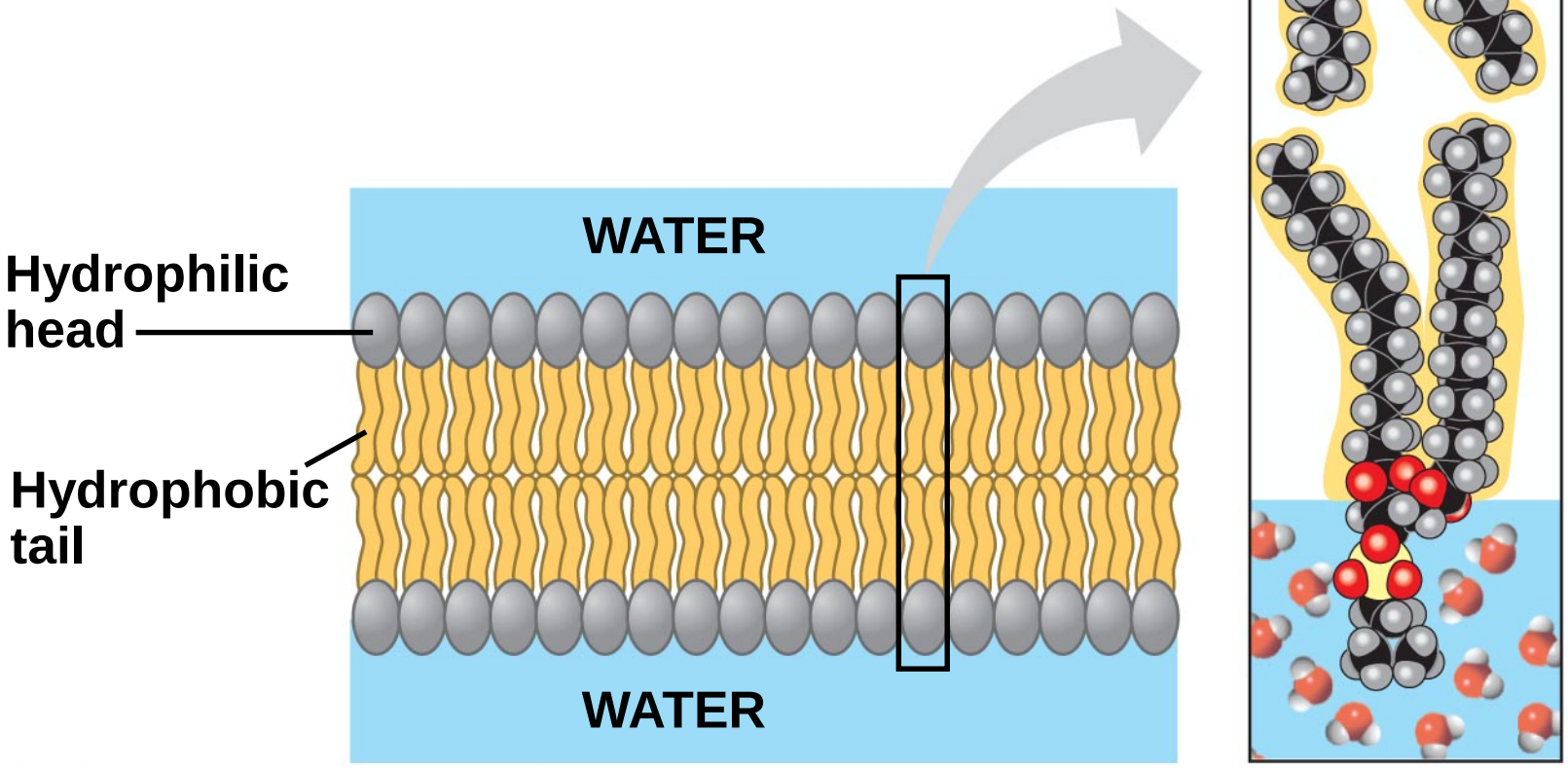
- The plasma membrane is the boundary that separates the living cell from its surroundings
- The plasma membrane exhibits **selective permeability**, allowing some substances to cross it more easily than others

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

Fig. 7-2

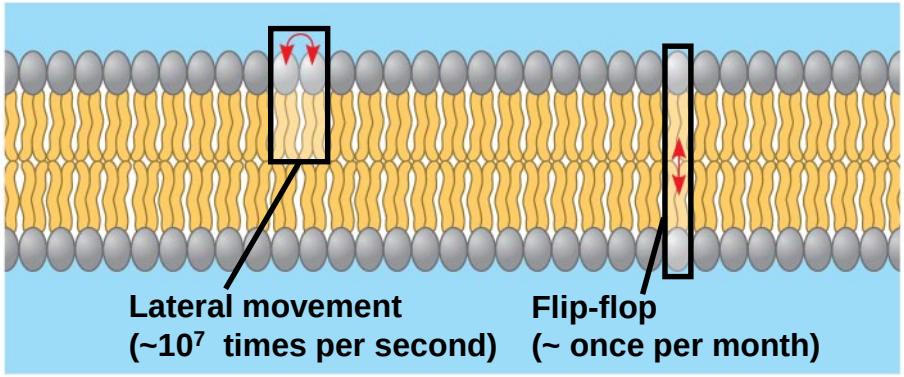
- Membrane composed of proteins and lipids
- Membrane is a phospholipid bilayer



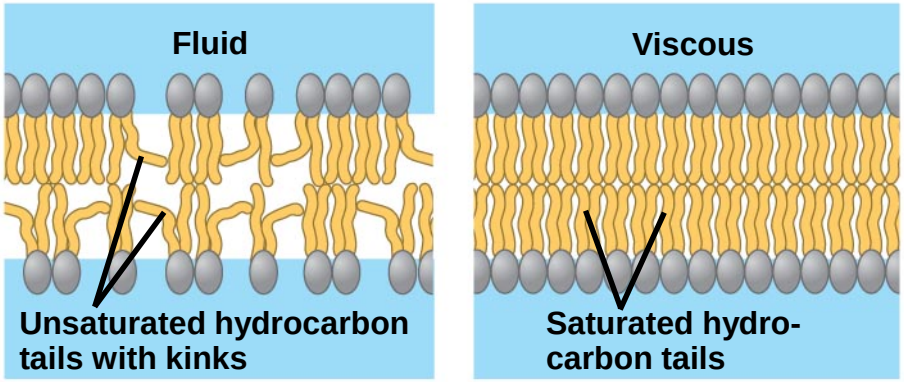
The Fluidity of Membranes

- 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

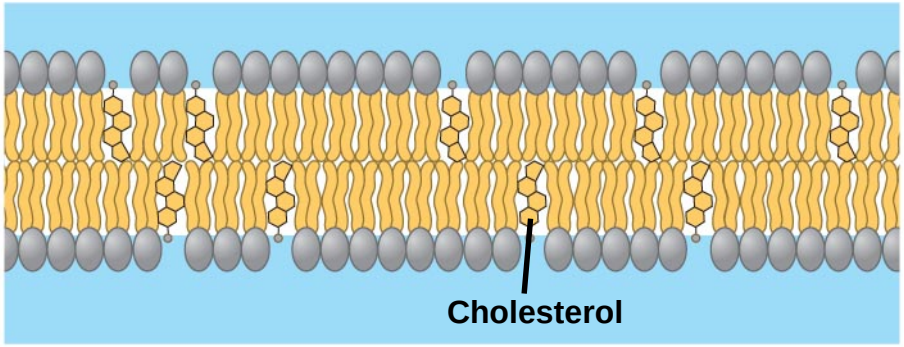
Fig. 7-5



(a) Movement of phospholipids



(b) Membrane fluidity



(c) Cholesterol within the animal cell membrane

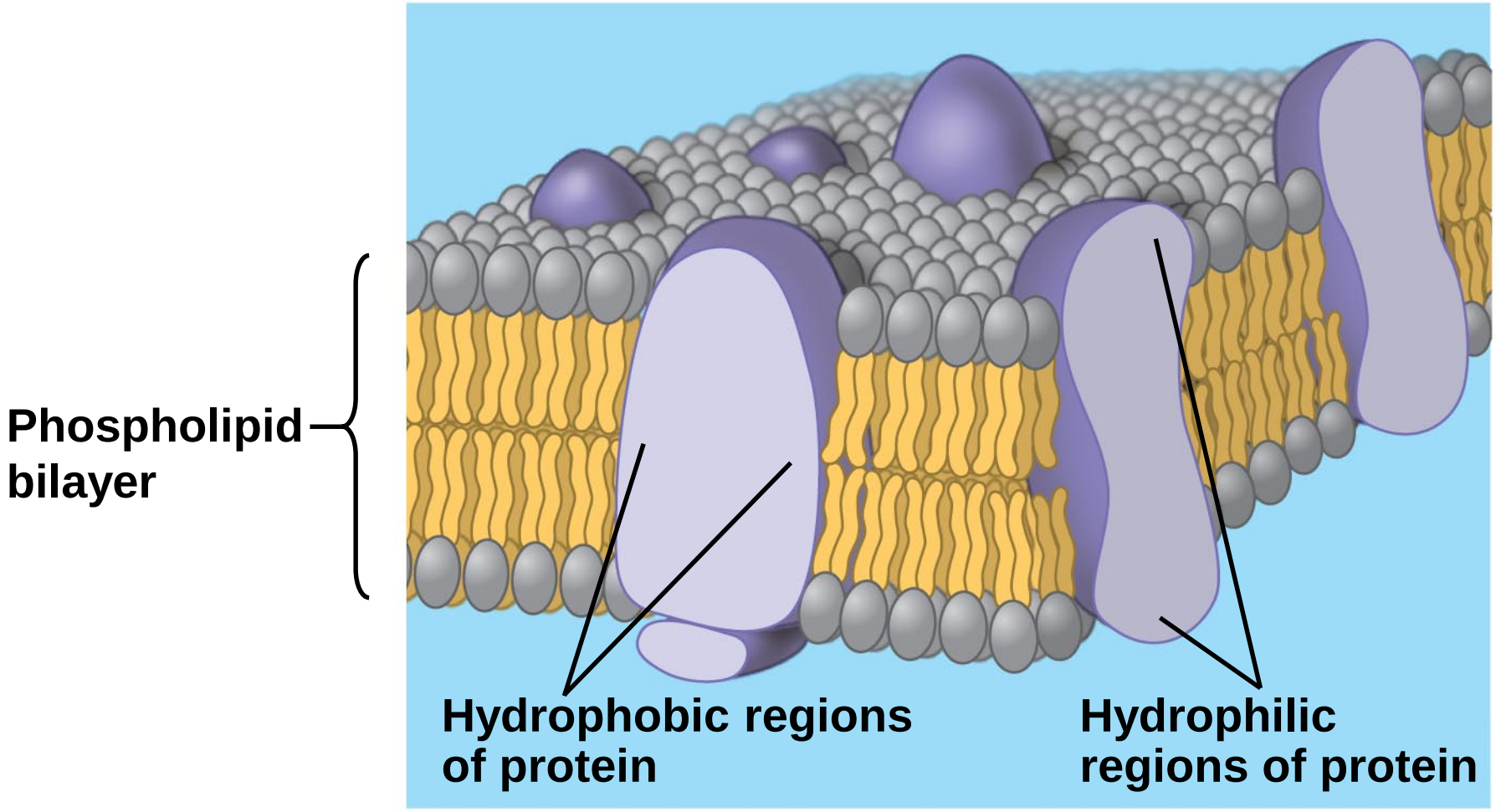
- As temperatures cool, membranes switch from a fluid state to a solid state
- The temperature at which a membrane solidifies depends on the types of lipids
- Membranes rich in unsaturated fatty acids are more fluid that those rich in saturated fatty acids
- Membranes must be fluid to work properly; 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

Membrane Proteins and Their Functions

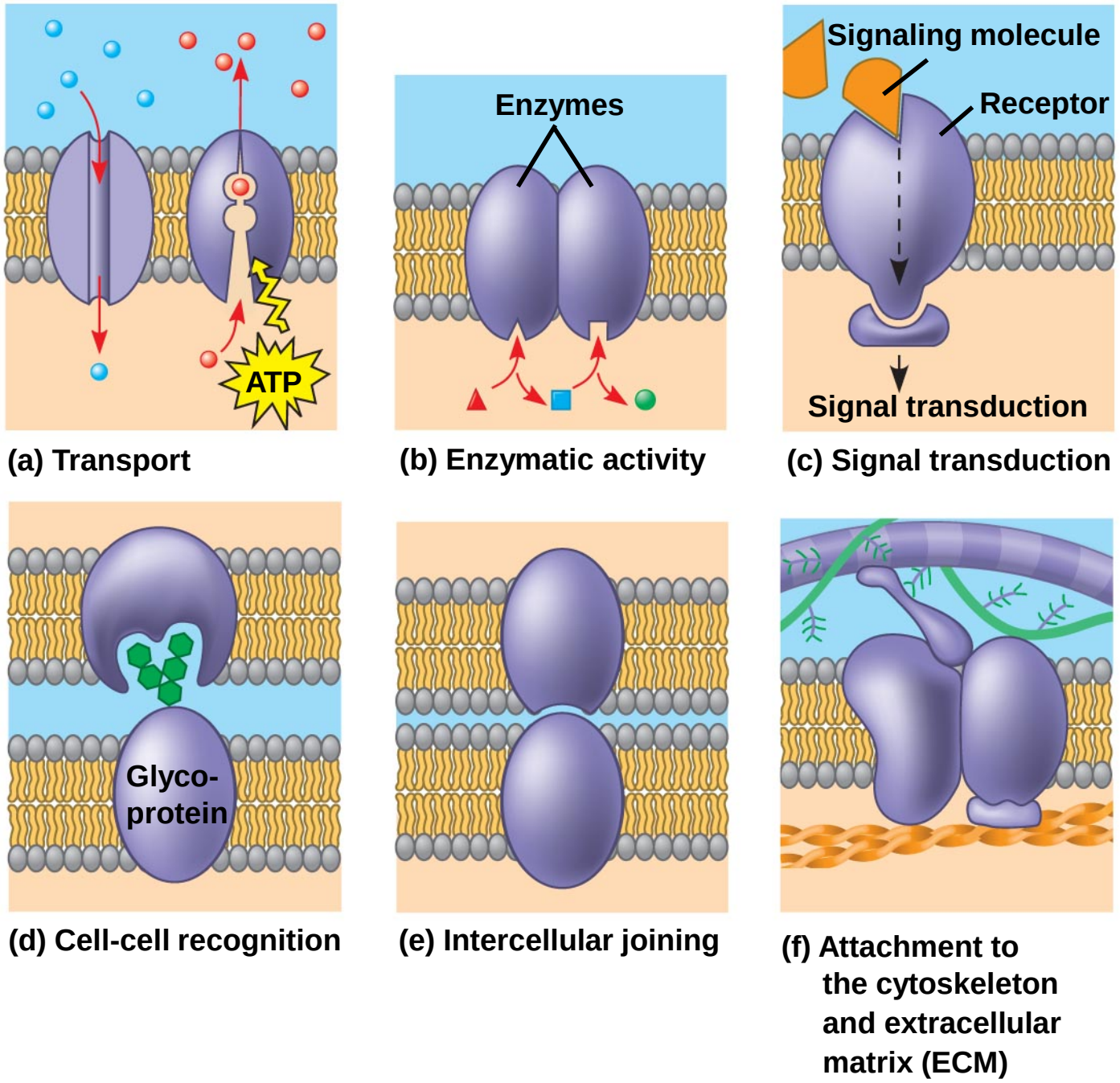
- Proteins determine most of the membrane's specific functions
- **Peripheral proteins** are bound to the surface of the membrane
- **Integral proteins** penetrate the hydrophobic core
- Integral proteins that span the membrane are called transmembrane proteins

Fig. 7-3



- Six major functions of membrane proteins:
  - Transport
  - Enzymatic activity
  - Signal transduction
  - Cell-cell recognition
  - Intercellular joining
  - Attachment to the cytoskeleton and extracellular matrix (ECM)

Fig. 7-9



(a) Transport

(b) Enzymatic activity

(c) Signal transduction

(d) Cell-cell recognition

(e) Intercellular joining

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

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

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

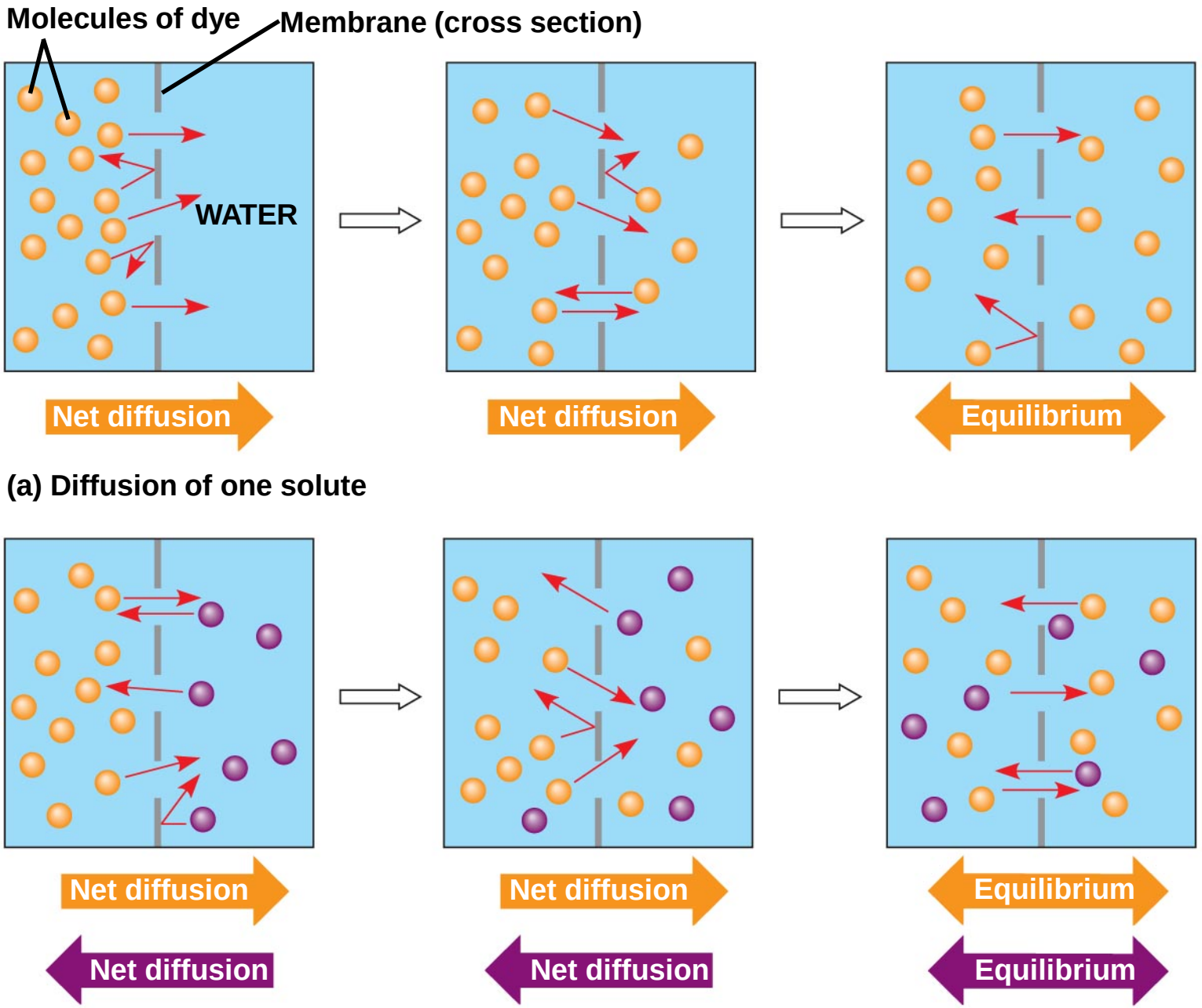
- **Transport proteins** allow passage of hydrophilic substances across the membrane
- Some transport proteins, called channel proteins, have a hydrophilic channel that certain molecules or ions can use as a tunnel
- Channel proteins called **aquaporins** facilitate the passage of water

- 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

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 exhibit a net movement in one direction
- At dynamic equilibrium, as many molecules cross one way as cross in the other direction

Fig. 7-11

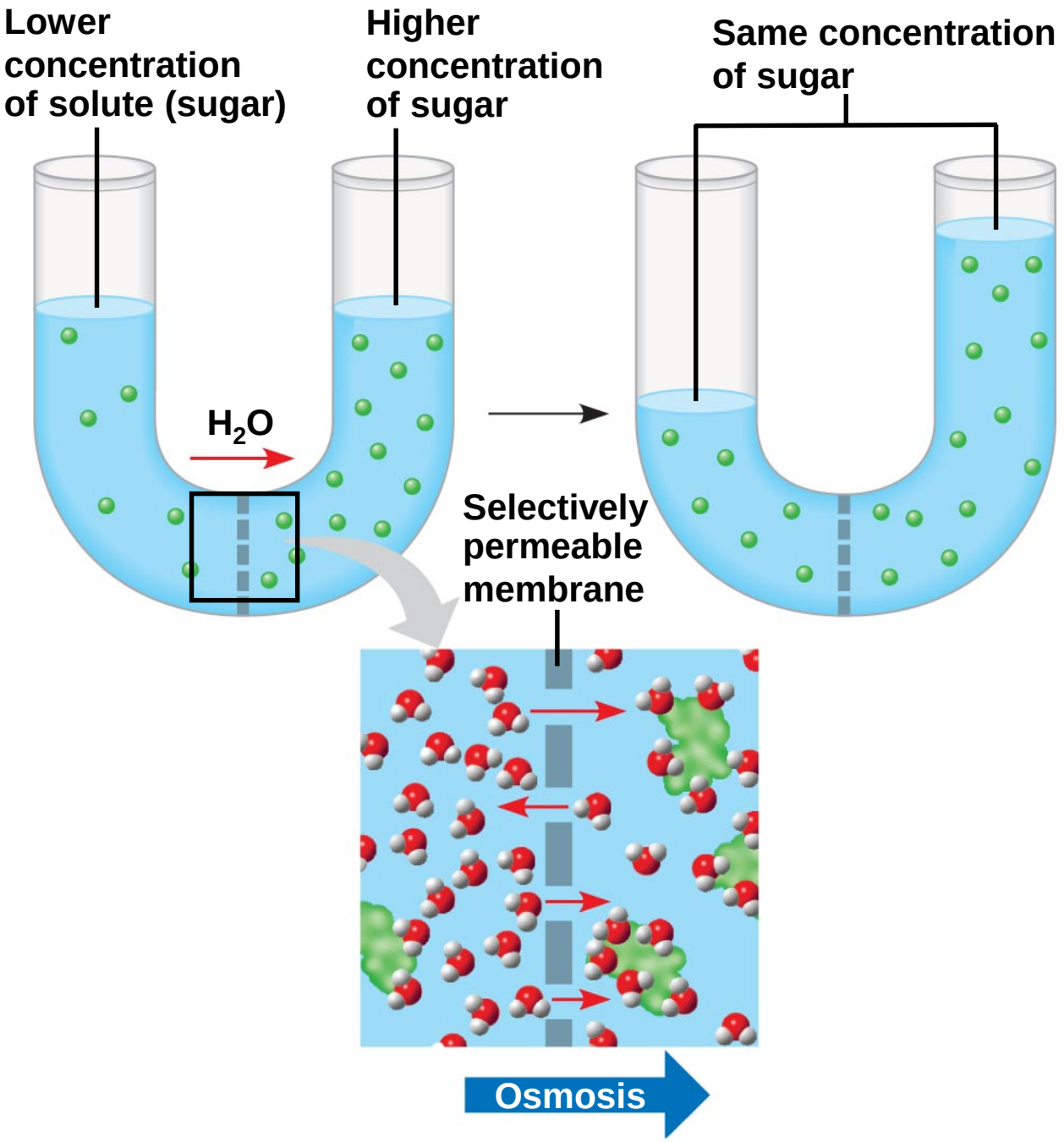


- Substances diffuse down their **concentration gradient**, the difference in concentration of a substance from one area to another
- No work must be done to move substances down the concentration gradient
- The diffusion of a substance across a biological membrane is **passive transport** because it requires no energy from 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

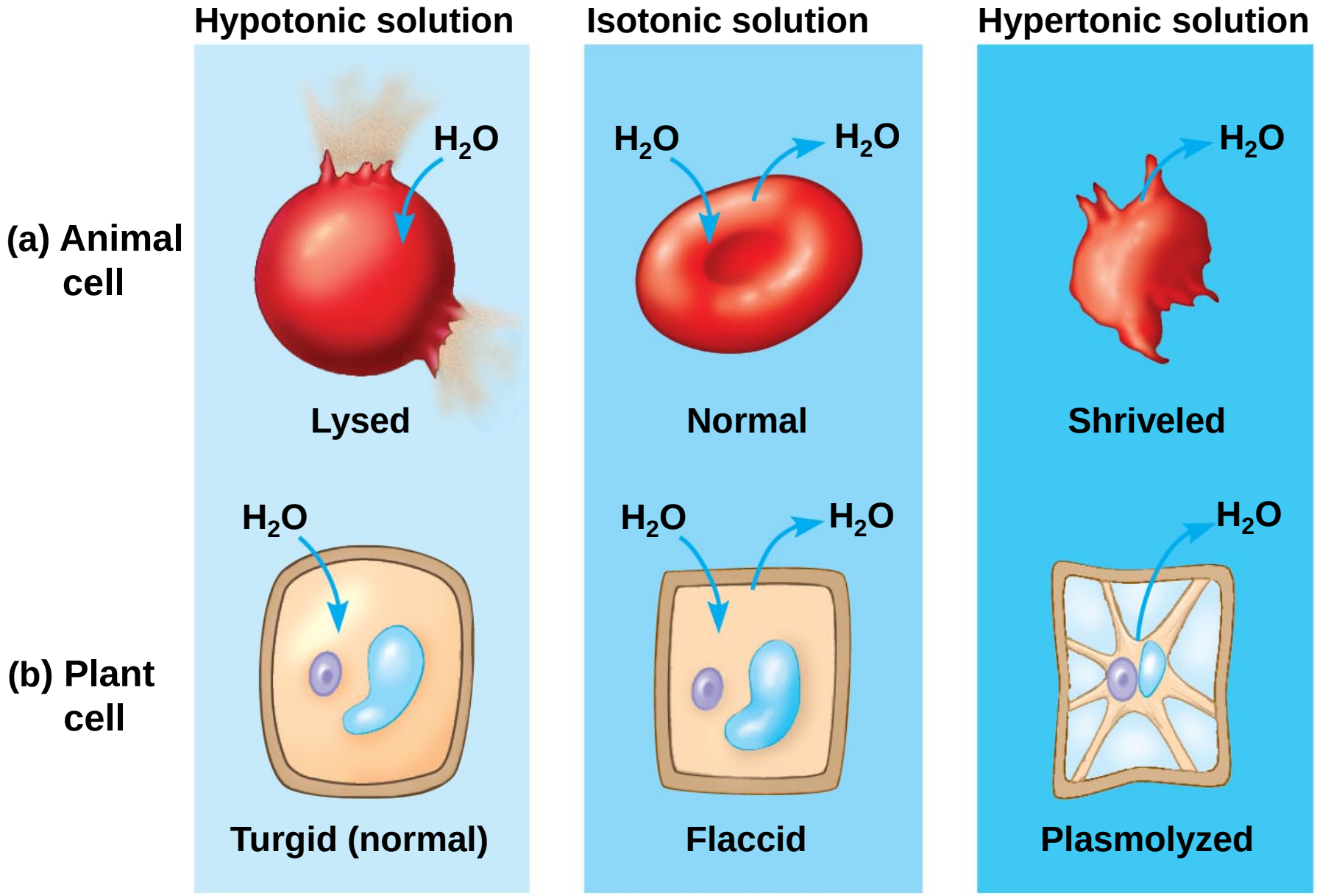
Fig. 7-12



Water Balance of Cells Without Walls

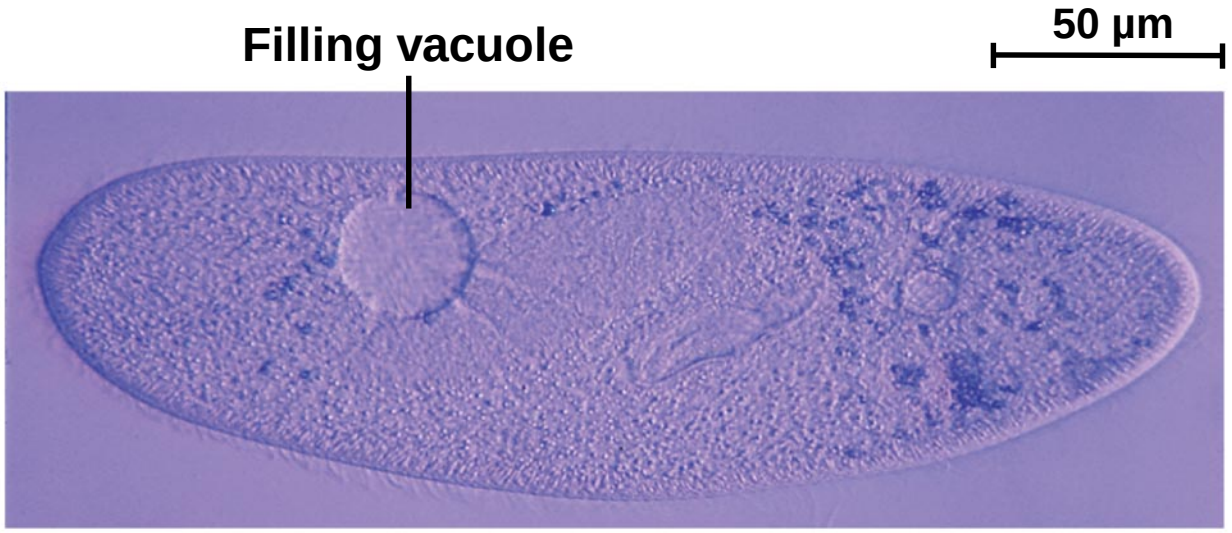
- **Tonicity** is the ability of a solution to cause a cell to gain or lose water
- **Isotonic** solution: Solute concentration is the same as that inside the cell; no net water movement across the plasma membrane
- **Hypertonic** solution: Solute concentration is greater than that inside the cell; cell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

Fig. 7-13

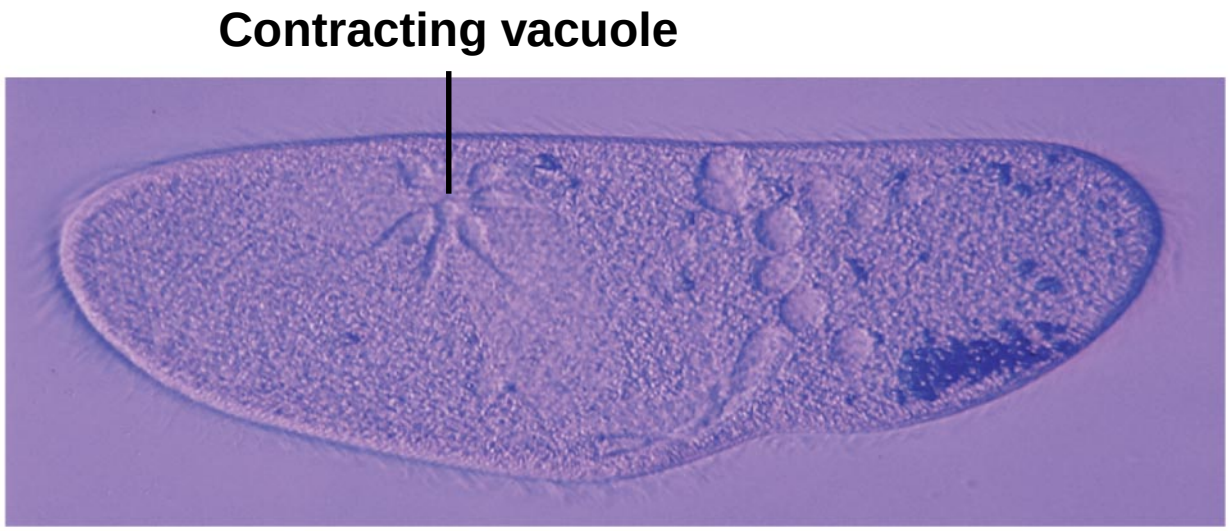


- Hypertonic or hypotonic environments create osmotic problems for organisms
- **Osmoregulation**, the control of water balance, is a necessary adaptation for life in such environments
- The protist *Paramecium,* which is hypertonic to its pond water environment, has a contractile vacuole that acts as a pump
- https://www.youtube.com/watch?v=9Ynm5ZOW59Q

Fig. 7-14



(a) A contractile vacuole fills with fluid that enters from a system of canals radiating throughout the cytoplasm.

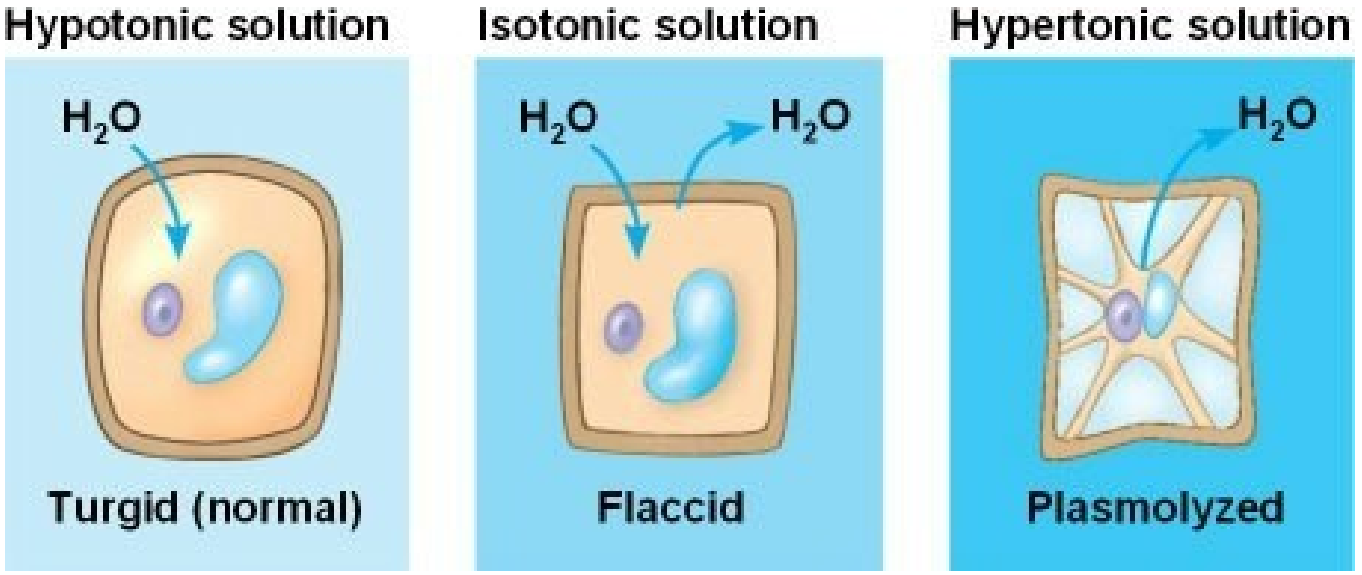


(b) When full, the vacuole and canals contract, expelling fluid from the cell.

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

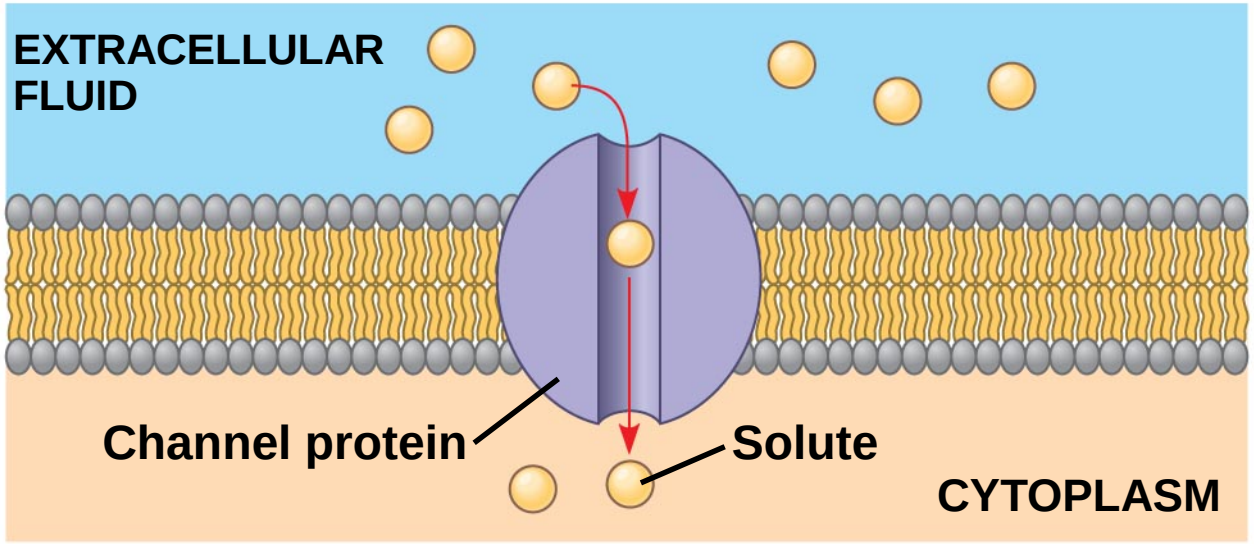
- In a hypertonic environment, plant cells lose water; eventually, the membrane pulls away from the wall, a usually lethal effect called **plasmolysis**



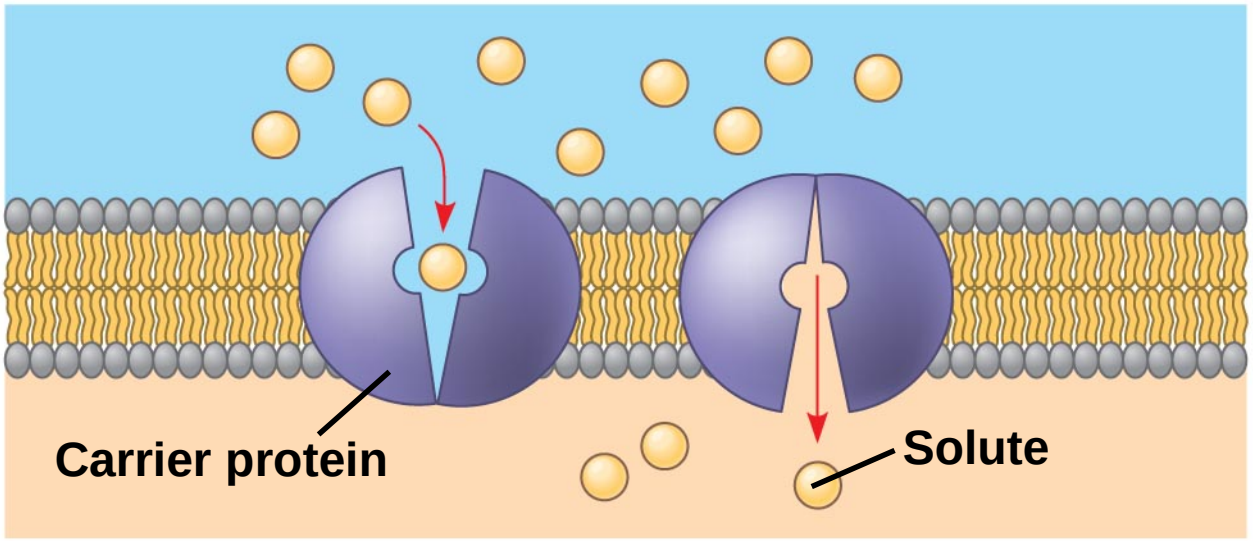
Facilitated Diffusion: Passive Transport Aided by Proteins

- 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

Fig. 7-15



(a) A channel protein



(b) A carrier protein

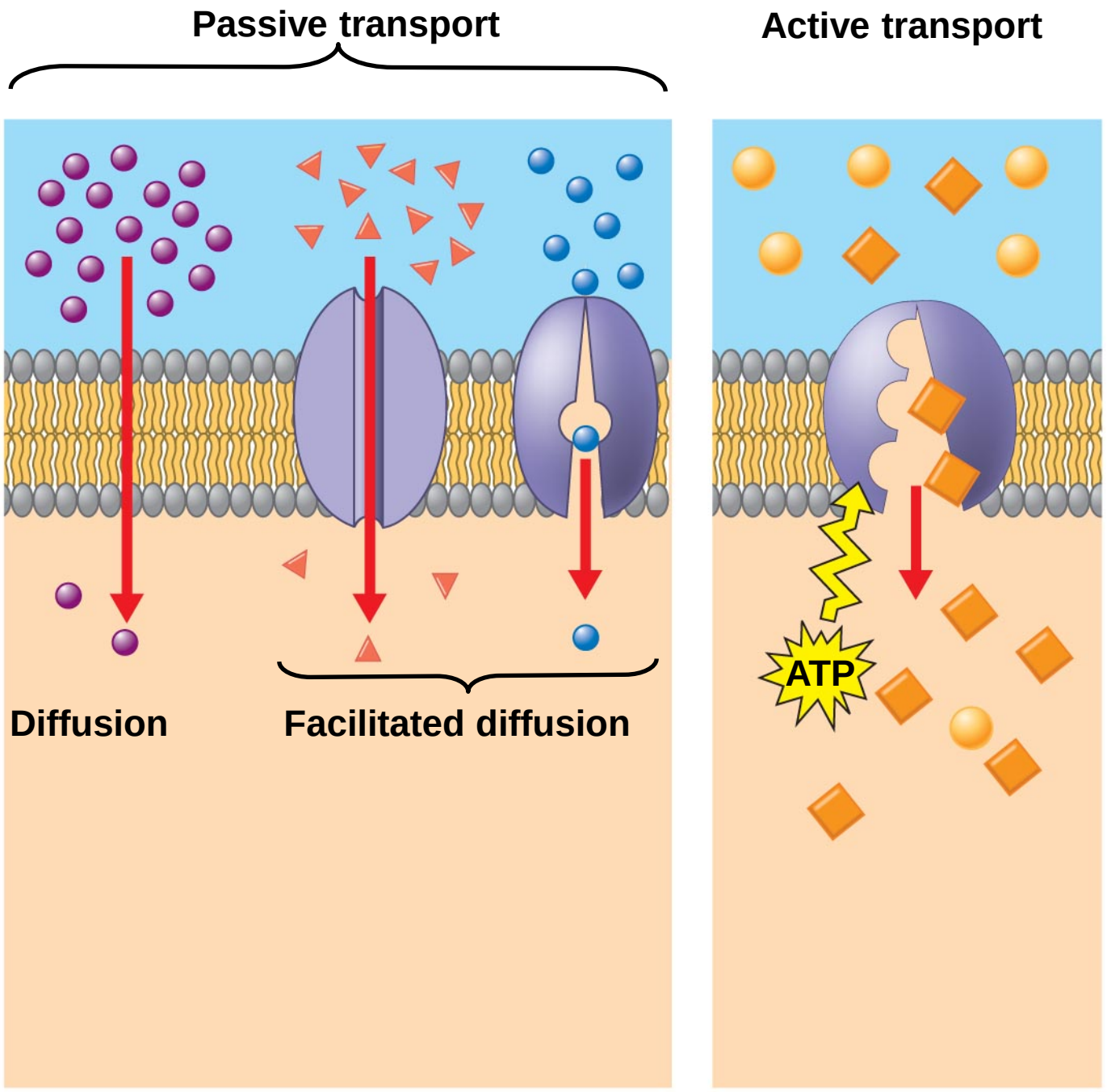
Concept 7.4: Active transport uses energy to move solutes against their gradients

- Facilitated diffusion is still passive because the solute moves down its concentration gradient
- Some transport proteins, however, can move solutes against their concentration gradients

The Need for Energy in Active Transport

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

Fig. 7-17



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 by transport proteins
- Large molecules, such as polysaccharides and proteins, cross the membrane in bulk via vesicles
- Bulk transport requires energy

Exocytosis

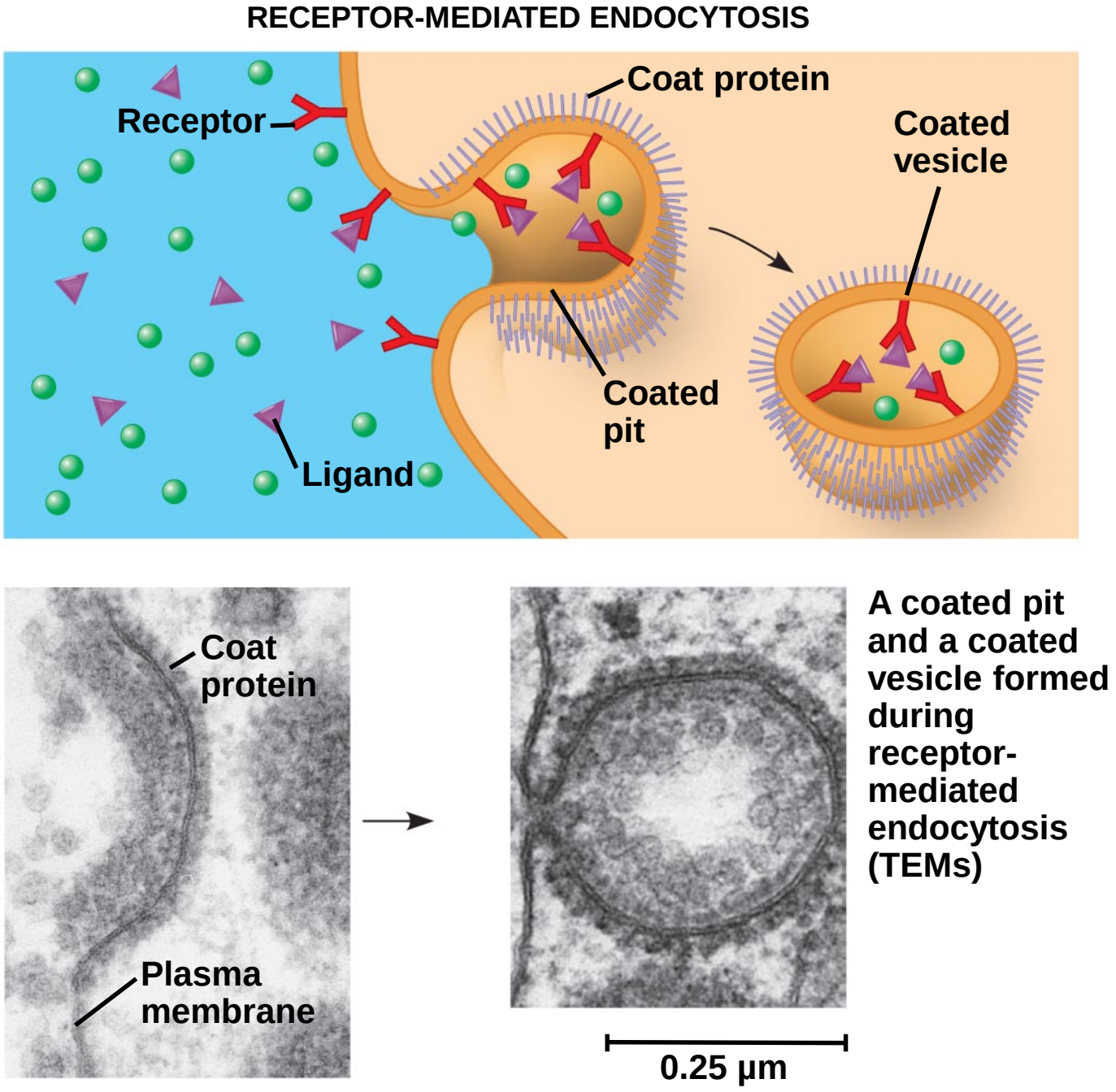
- In **exocytosis**, transport vesicles migrate to the membrane, fuse with it, and release their contents
- Many secretory cells use exocytosis to export their products

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:
  - Phagocytosis (“cellular eating”)
  - Pinocytosis (“cellular drinking”)
  - Receptor-mediated endocytosis

- 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
- Many pathogens - some bacteria and all of the animal viruses infect cells by exploiting these natural cellular processes
- https://vimeo.com/9828553

Fig. 7-20c



A coated pit and a coated vesicle formed during receptor-mediated endocytosis (TEMs)

You should now be able to:

1. Define the following terms: amphipathic molecules, aquaporins, diffusion
2. Explain how membrane fluidity is influenced by temperature and membrane composition
3. Distinguish between the following pairs or sets of terms: peripheral and integral membrane proteins; channel and carrier proteins; osmosis, facilitated diffusion, and active transport; hypertonic, hypotonic, and isotonic solutions

4. Explain how transport proteins facilitate diffusion

5. Explain how an electrogenic pump creates voltage across a membrane, and name two electrogenic pumps

6. Explain how large molecules are transported across a cell membrane