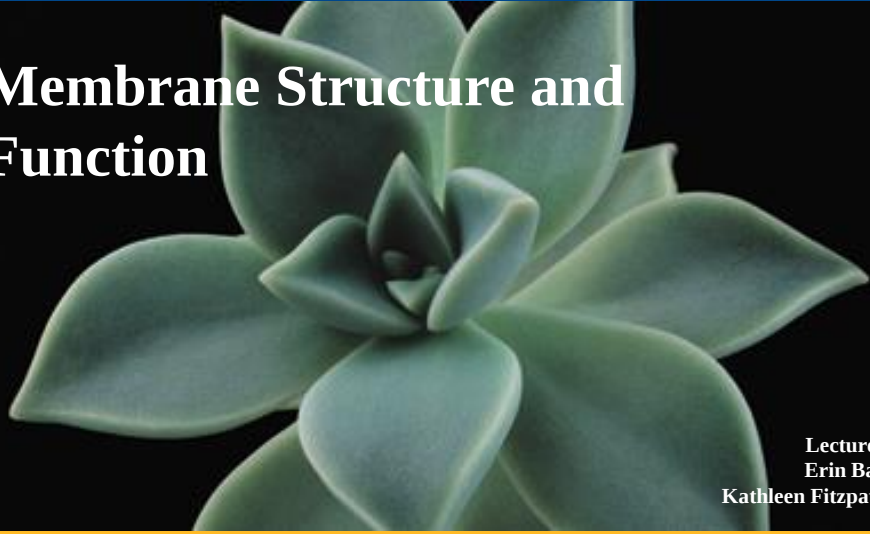


LECTURE PRESENTATIONS
For CAMPBELL BIOLOGY, NINTH EDITION
Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson

Chapter 7

Membrane Structure and Function



Lectures by
Erin Barley
Kathleen Fitzpatrick

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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

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Fig. 6-8

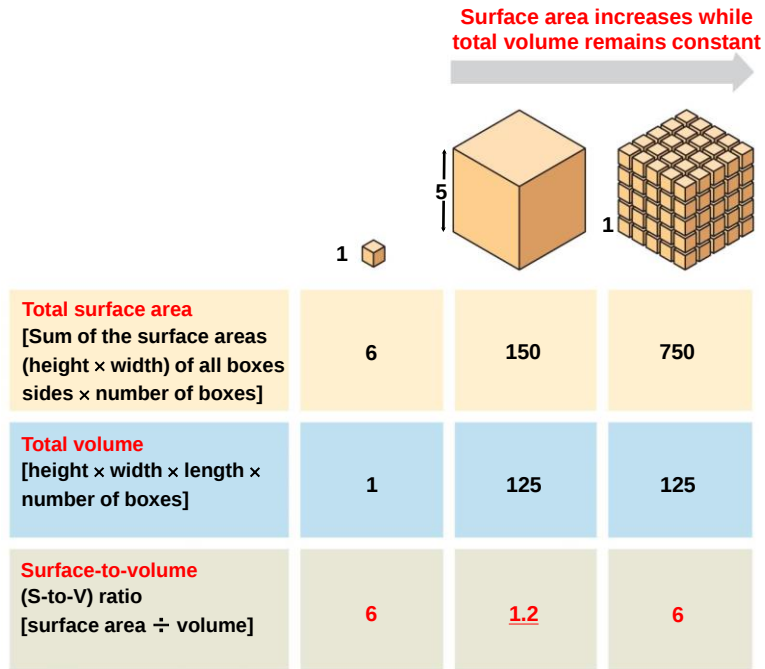
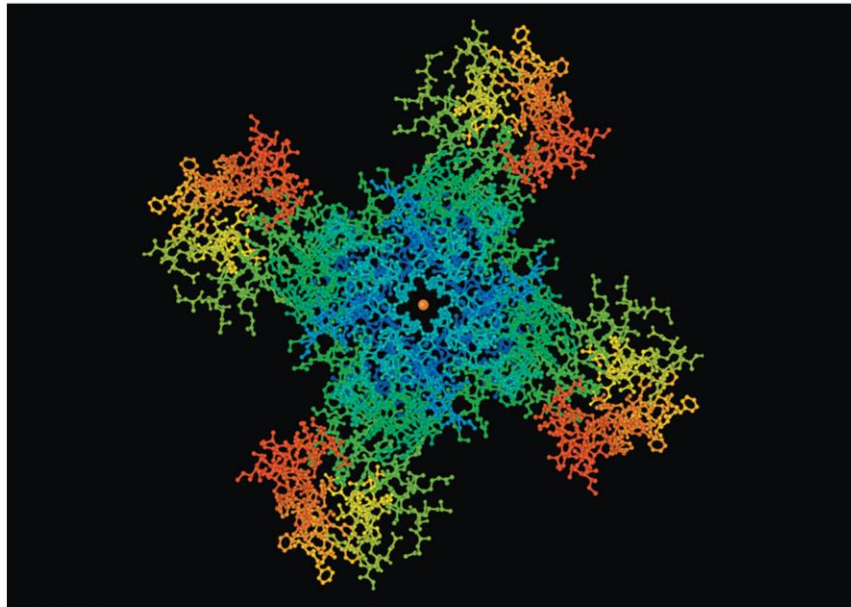


Figure 7.1



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*

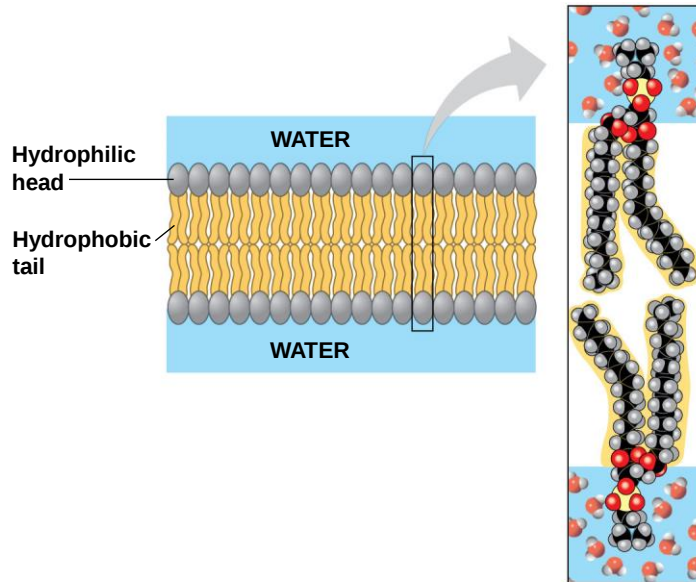
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Membrane Models: *Scientific Inquiry*

- 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**

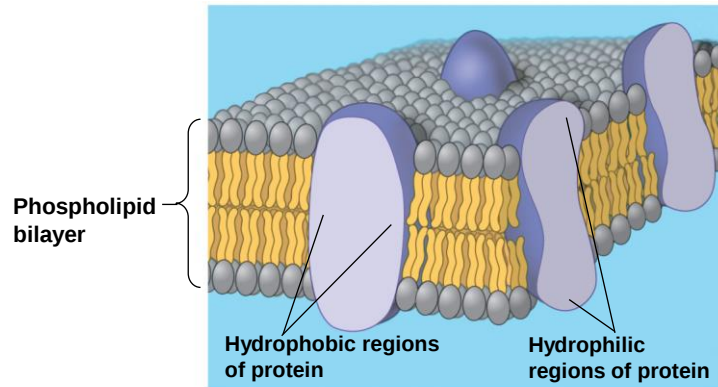
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Figure 7.2



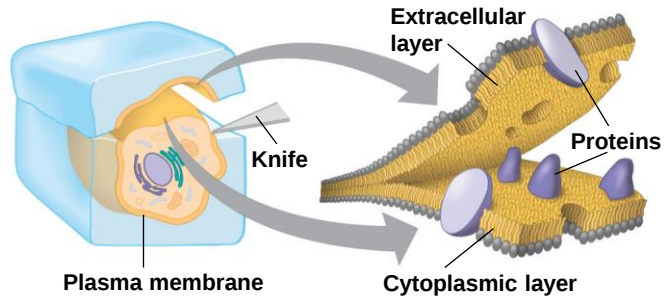
- In 1935, Hugh **Davson** and James **Danielli** proposed a **sandwich model** in which the phospholipid bilayer lies between two layers of globular proteins
- Later studies found problems with this model, particularly the placement of membrane proteins, which have hydrophilic and hydrophobic regions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

Figure 7.3



-
- 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**

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Figure 7.4a

**Inside of extracellular layer**

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Figure 7.4b

**Inside of cytoplasmic layer**

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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

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Figure 7.5

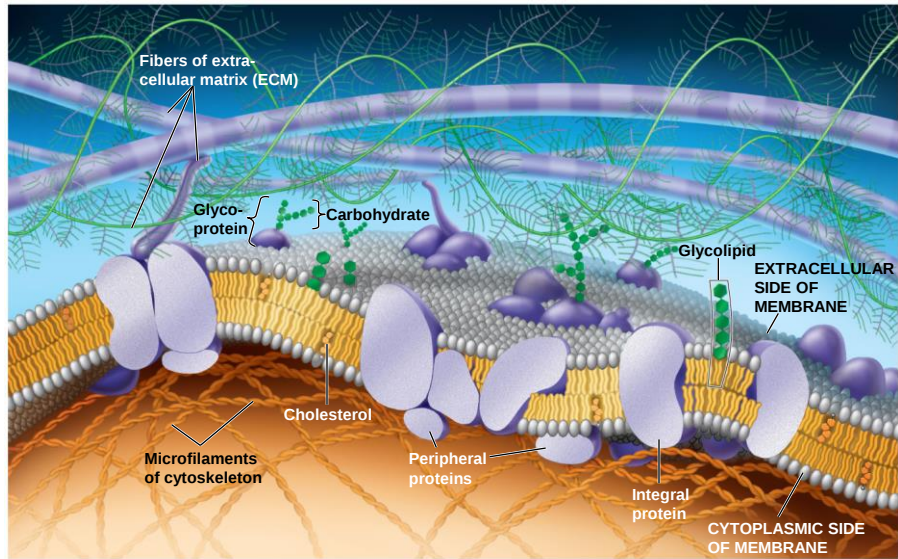


Figure 7.6

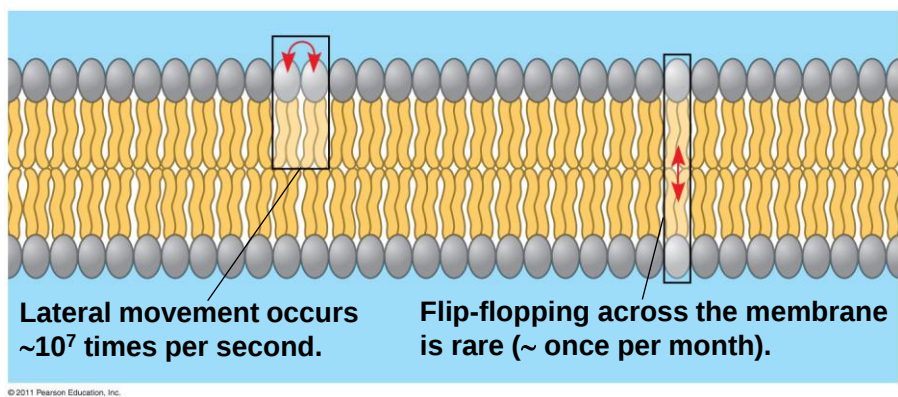
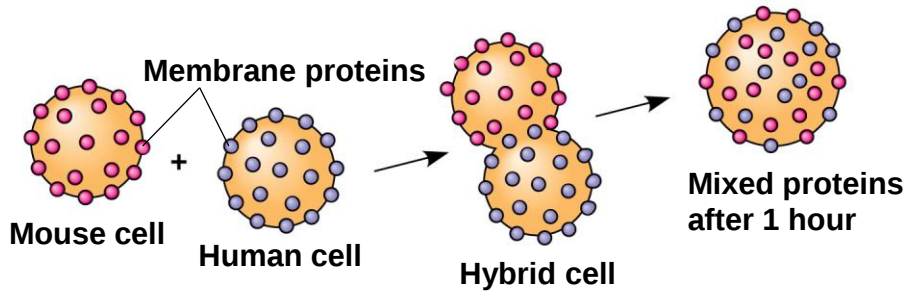


Figure 7.7

RESULTS



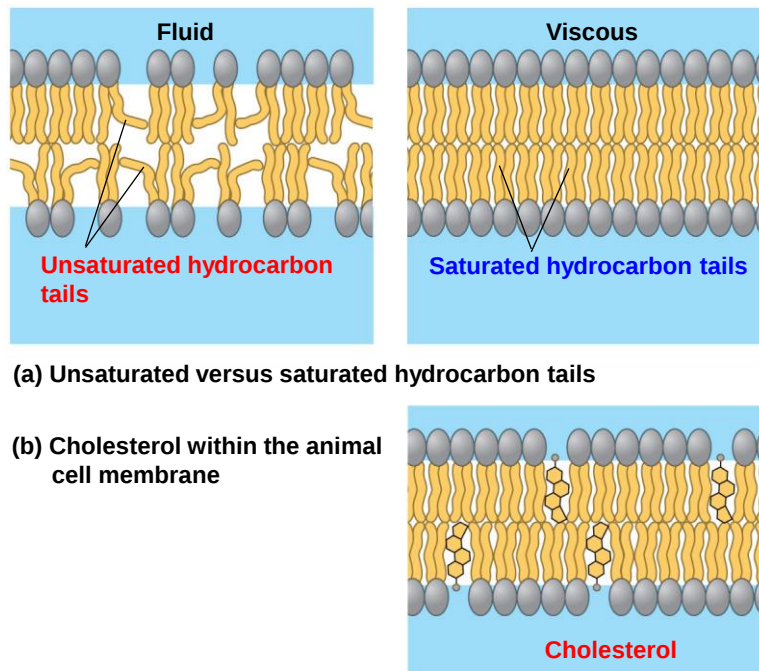
- As **temperatures cool**, *membranes switch from a fluid state to a solid state*
- The temperature at which a membrane solidifies depends on the types of lipids
- Membranes rich in **unsaturated fatty acids** are **more fluid** than those rich in **saturated fatty acids**
- Membranes **must be fluid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

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- 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**

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Figure 7.8



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Membrane Proteins and Their Functions

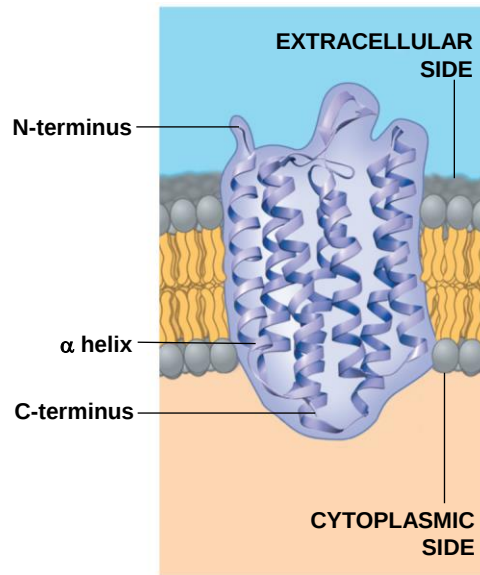
- A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer
- Proteins **determine most of the membrane's specific functions**

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-
- **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***

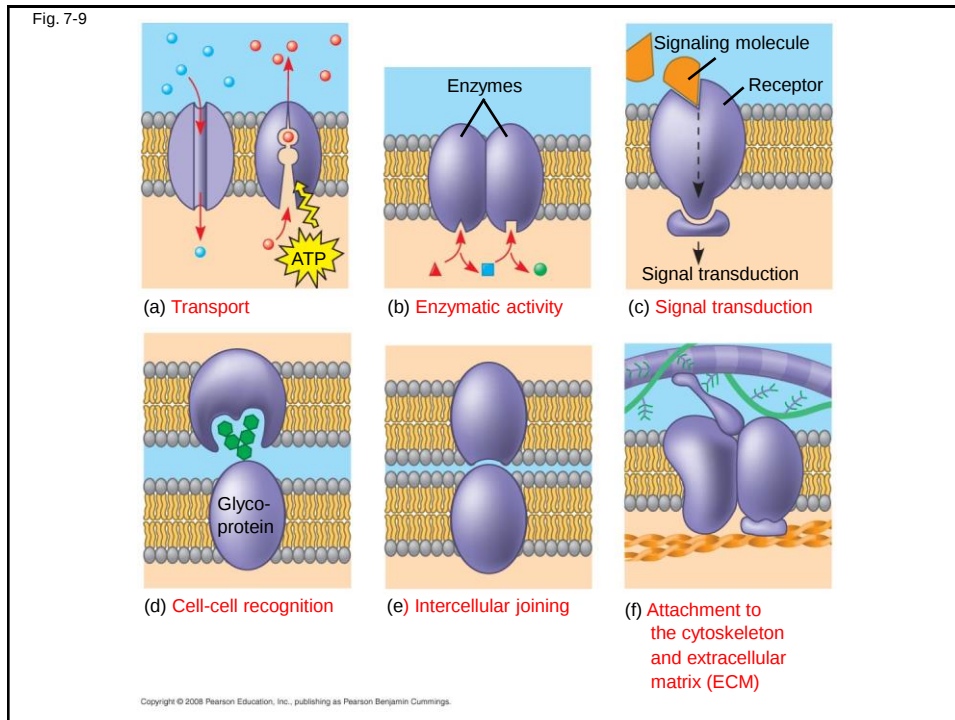
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Figure 7.9



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

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The Role of Membrane Carbohydrates in Cell-Cell Recognition

- Cells recognize each other by binding to **surface molecules**, often carbohydrates, on the plasma membrane
- Membrane carbohydrates may be **covalently bonded to lipids** (forming **glycolipids**) or more commonly to **proteins** (forming **glycoproteins**)

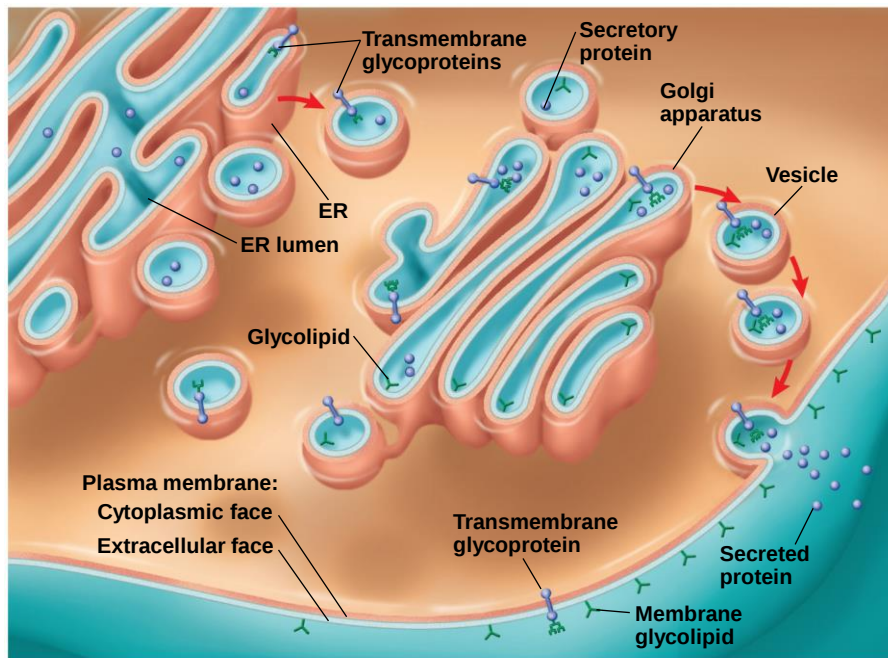
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Synthesis and Sidedness of Membranes

- 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

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Figure 7.12



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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

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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**

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Transport Proteins

- **Transport proteins** allow passage of hydrophilic substances across the membrane
- Some transport proteins, called 1) **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

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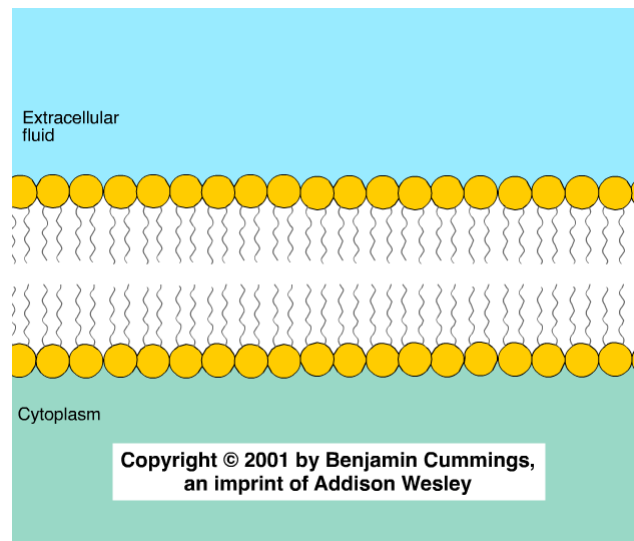
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- Other transport proteins, called 2) **carrier proteins**, *bind to molecules and change shape to shuttle them across the membrane*
 - A transport protein is **specific** for the substance it moves

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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

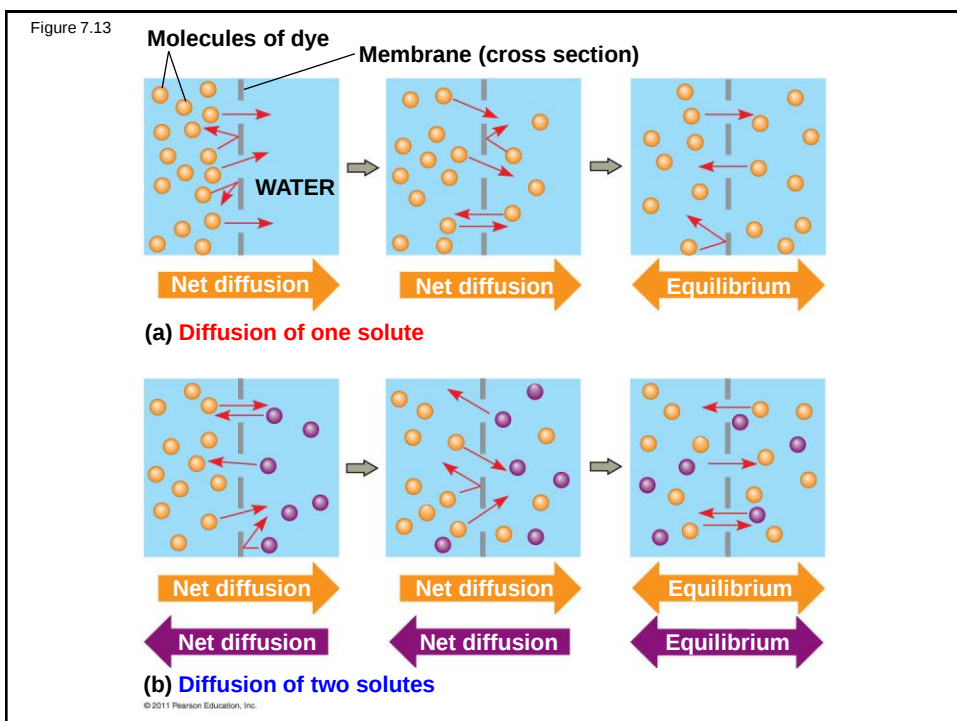
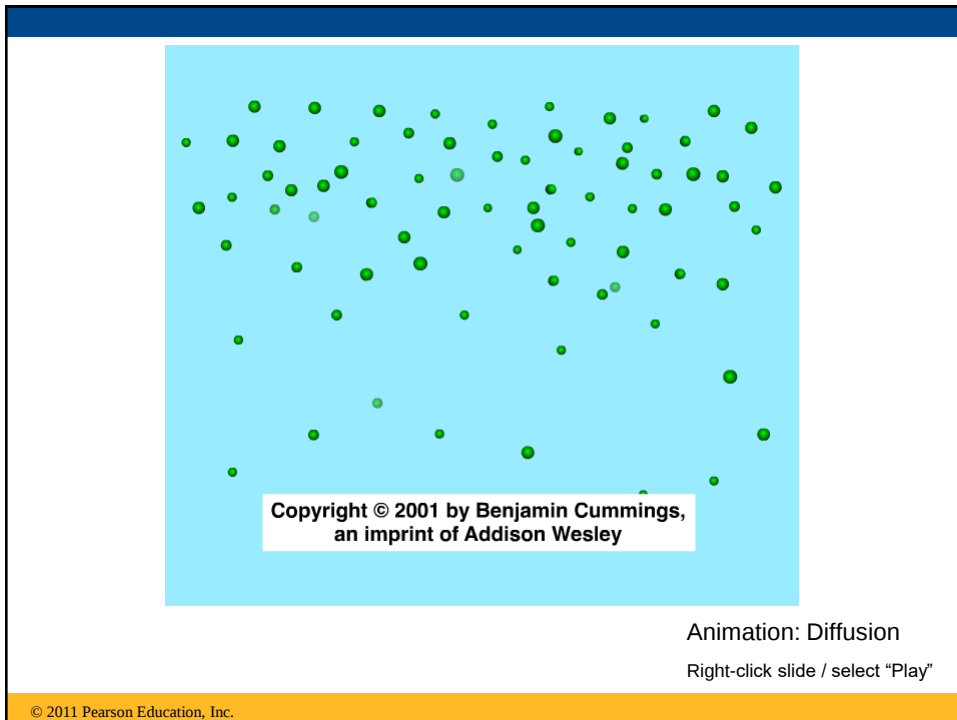
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Animation: Membrane Selectivity

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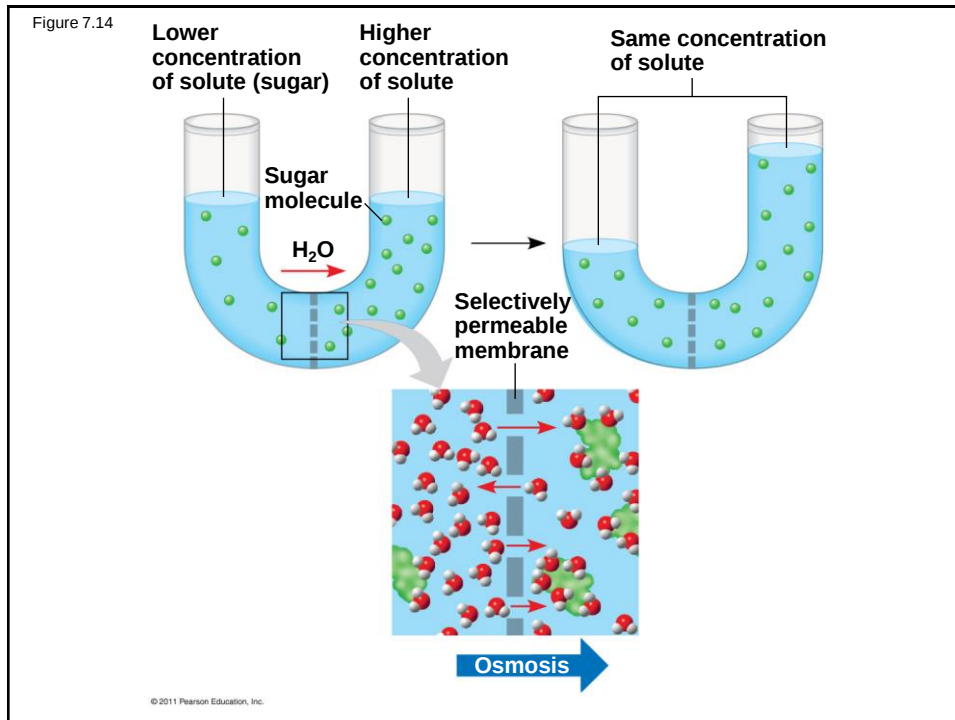
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- Substances diffuse **down their concentration gradient**, the difference in concentration of a substance from one area to another
 - No work must be done to move substances down the concentration gradient
 - The diffusion of a substance across a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

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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

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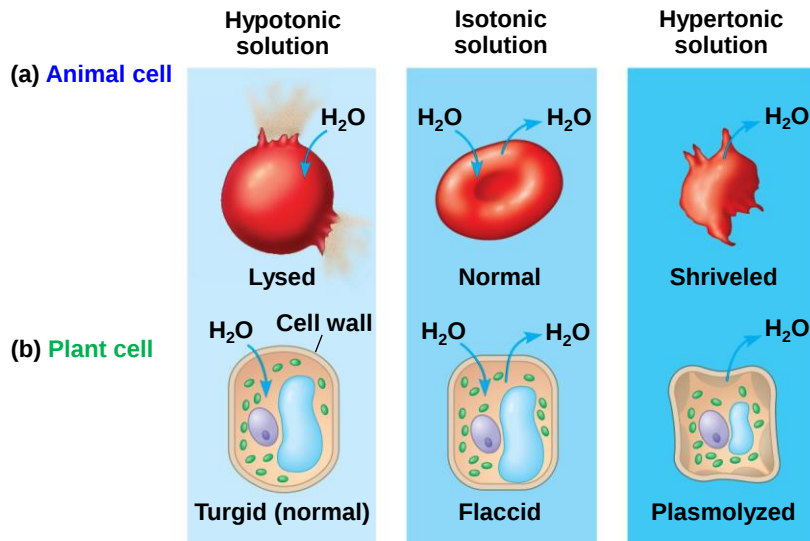


Water Balance of *Cells Without Walls*

- **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

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Figure 7.15



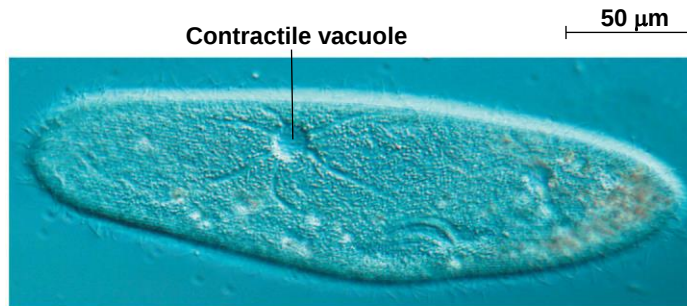
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- **Hypertonic** or **hypotonic** environments create osmotic problems for organisms
- **Osmoregulation**, the control of water balance, is a necessary adaptation for life in such environments
- The protist *Paramecium*, which is hypertonic to its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

PLAYVideo: *Chlamydomonas***PLAY**Video: *Paramecium* Vacuole

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Figure 7.16



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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**

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

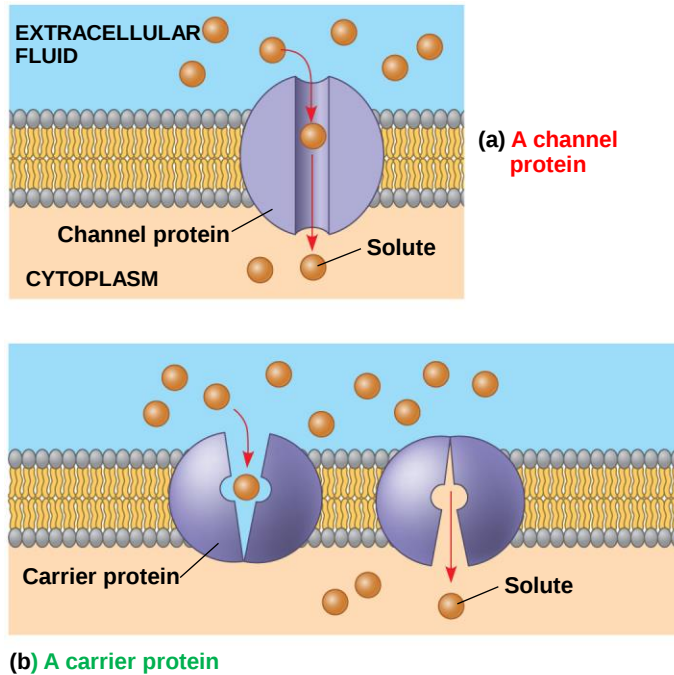
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Facilitated Diffusion: Passive Transport Aided by Proteins

- 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**)

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Figure 7.17

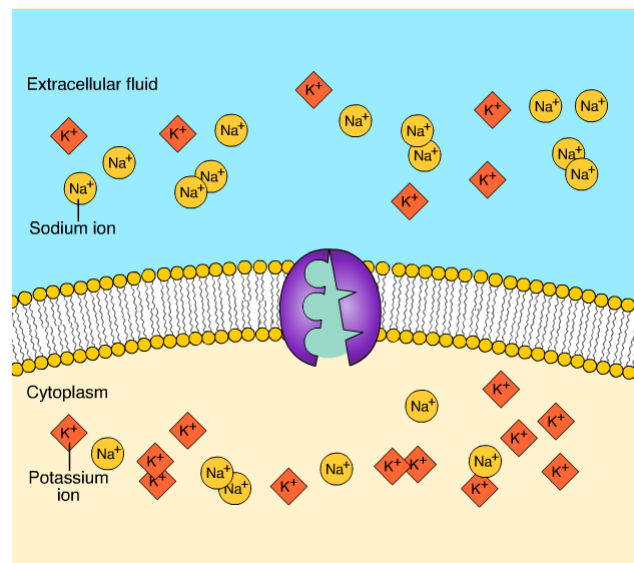


- **Carrier proteins** undergo a subtle change in shape that translocates the solute-binding site across the membrane

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
- Active transport requires energy, usually in the form of ATP
- Active transport is performed by **specific proteins** embedded in the membranes

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Animation: Active Transport

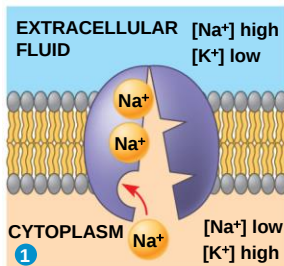
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- **Active transport** allows cells to maintain concentration gradients that differ from their surroundings
- The **sodium-potassium pump** is one type of active transport system

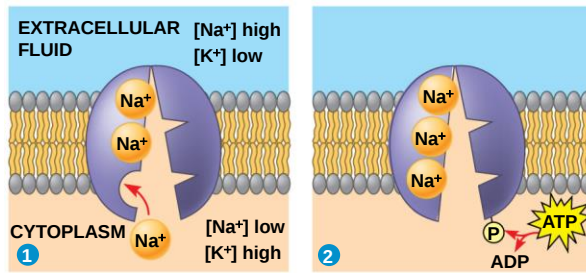
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Figure 7.18-1



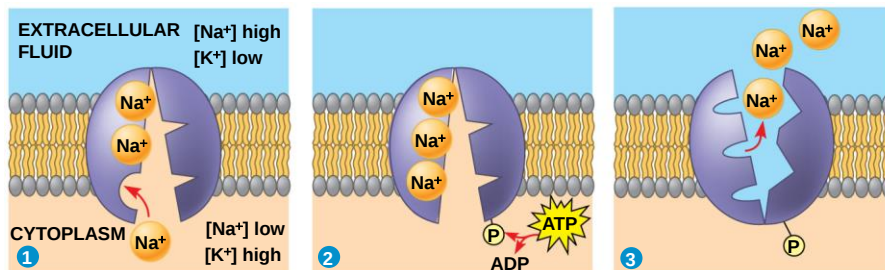
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Figure 7.18-2



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Figure 7.18-3



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Figure 7.18-4

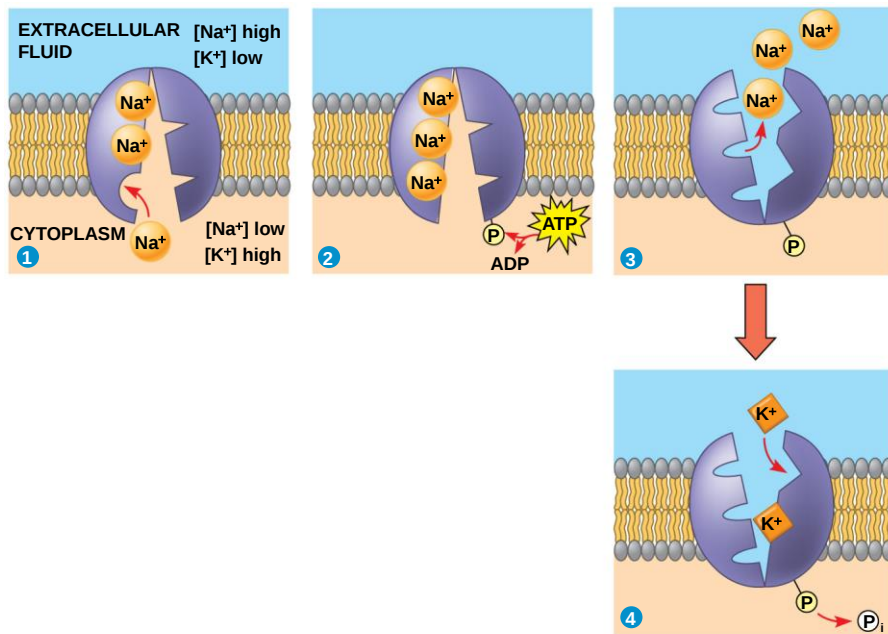


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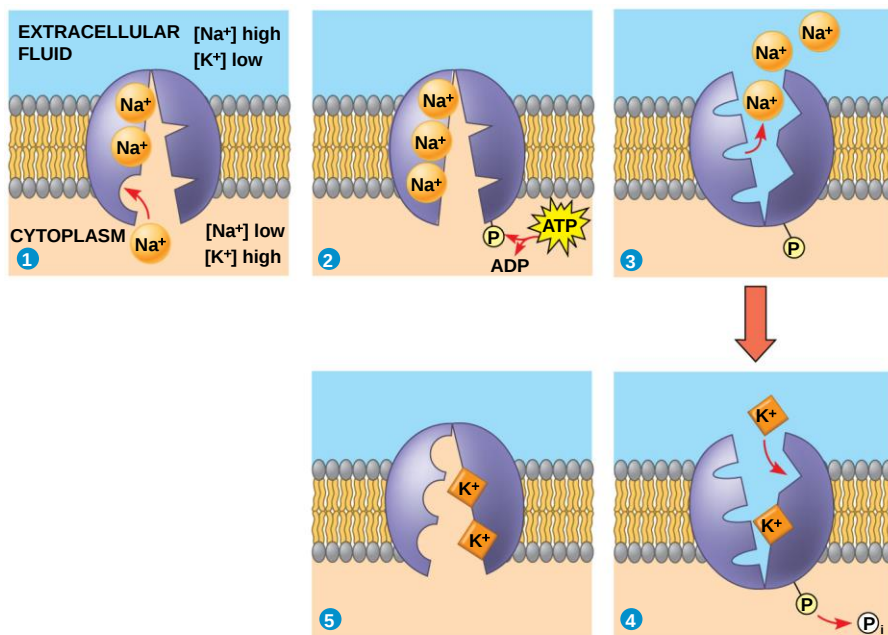


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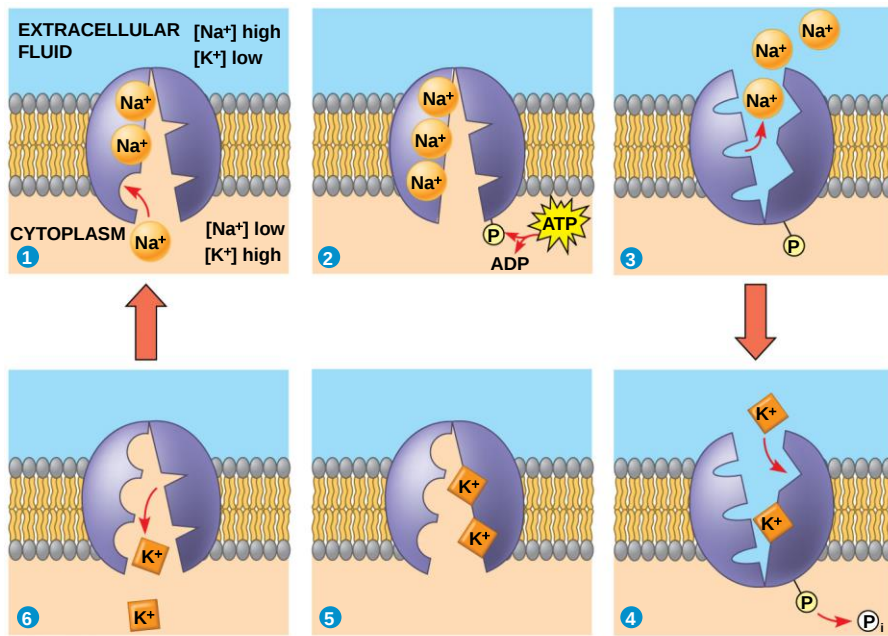
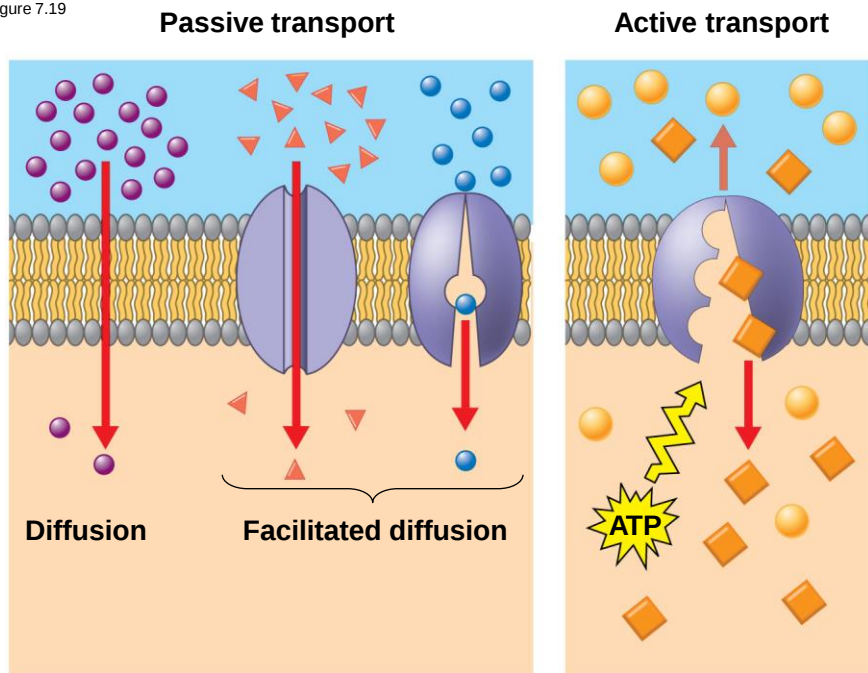


Figure 7.19



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.

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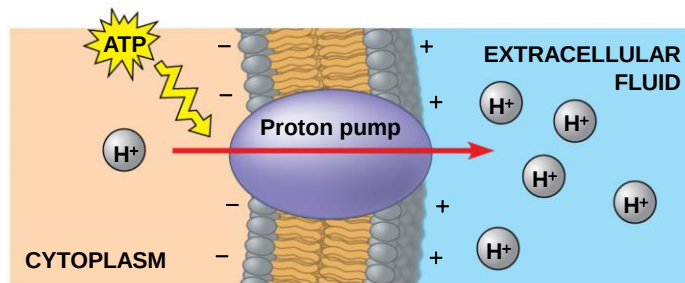
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- Two combined forces, collectively called the **electrochemical gradient**, drive the diffusion of ions across a membrane:
 - A chemical force (the ion's concentration gradient)
 - An electrical force (the effect of the membrane potential on the ion's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

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- 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**

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Figure 7.20



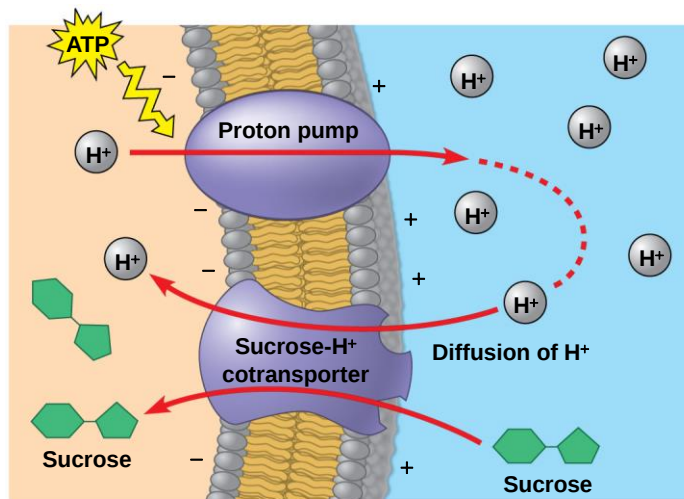
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Cotransport: Coupled Transport by a Membrane Protein

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

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Figure 7.21



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

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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

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Endocytosis

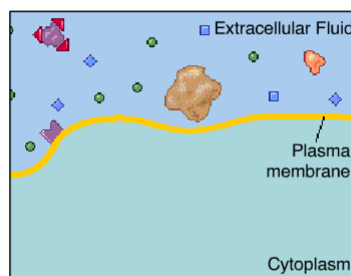
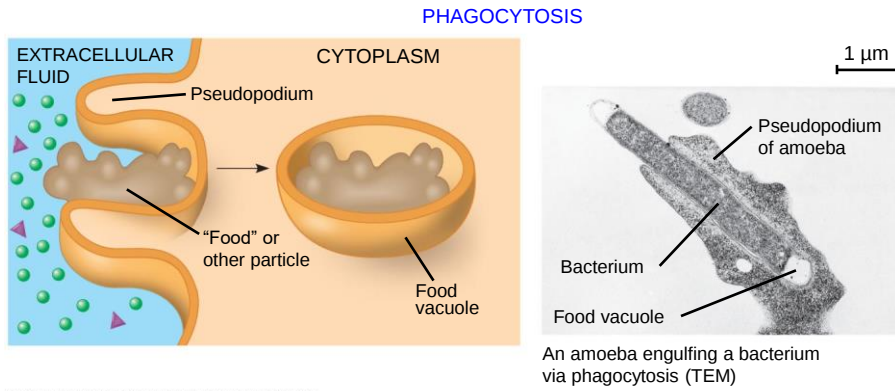
- In **endocytosis**, the cell takes in macromolecules by forming vesicles from the plasma membrane
- Endocytosis is a reversal of exocytosis, involving different proteins
- There are **three types of endocytosis**:
 - **Phagocytosis** (“cellular eating”)
 - **Pinocytosis** (“cellular drinking”)
 - **Receptor-mediated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

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

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Fig. 7-20a



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Animation: Phagocytosis

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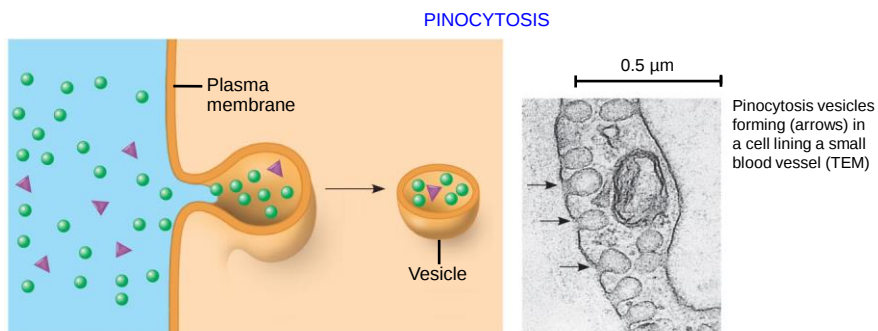
- In **pinocytosis**, molecules are taken up when extracellular fluid is “gulped” into tiny vesicles

PLAY

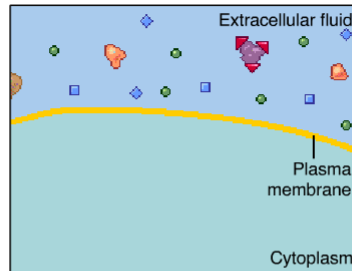
Animation: Pinocytosis

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Fig. 7-20b



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Animation: Pinocytosis

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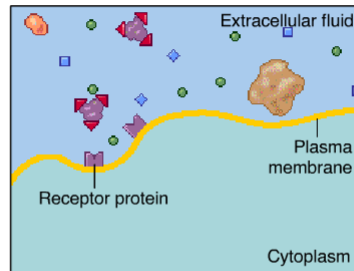
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- In **receptor-mediated endocytosis**, **binding of ligands to receptors** triggers vesicle formation
- A **ligand** is any molecule that **binds specifically** to a **receptor site** of another molecule

PLAY

Animation: Receptor-Mediated Endocytosis

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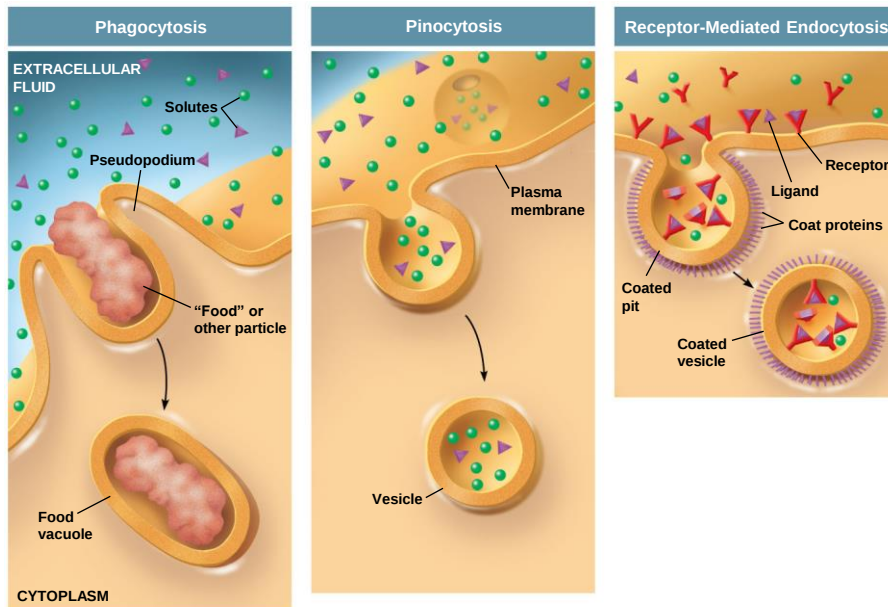
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Animation: Receptor-Mediated Endocytosis

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Figure 7.22



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Familial hypercholesterolemia (FH)

- Cholesterol is transported in blood in particles called LDL
- LDL binds to receptors on plasma membranes & enter cells by receptor-mediated endocytosis
- In FH, LDL receptors are defective or missing >> cholesterol accumulates in blood vessels and lead to atherosclerosis