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Chapter 7

Membrane Structure and Function

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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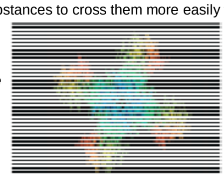
Overview: The Membrane Barrier

- The plasma membrane is the boundary that separates the living cell from its surroundings
- All eukaryotic membranes exhibit **selective permeability**, allowing some substances to cross them more easily than others

Membrane Channel Protein



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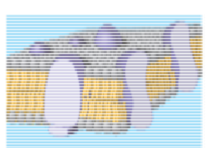
Concept 7.1: Cellular membranes are fluid mosaics of lipids and proteins

- Phospholipids are the most abundant lipid in membranes
- 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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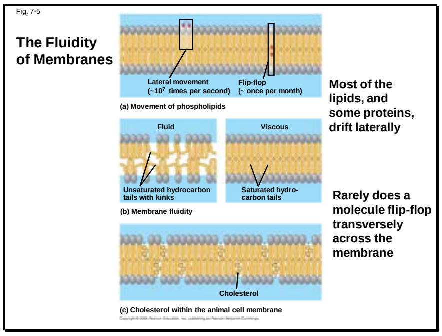

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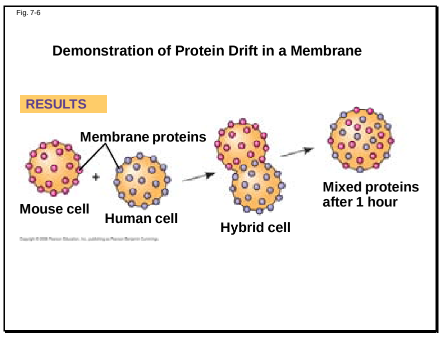

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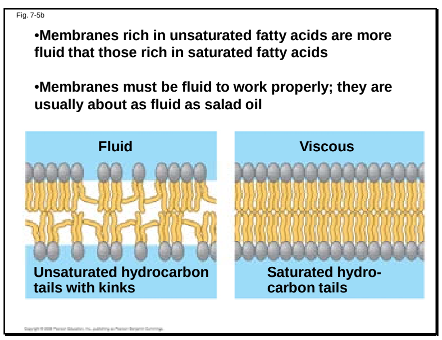

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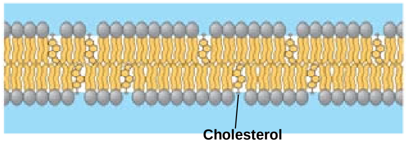
Fig. 7-5c

•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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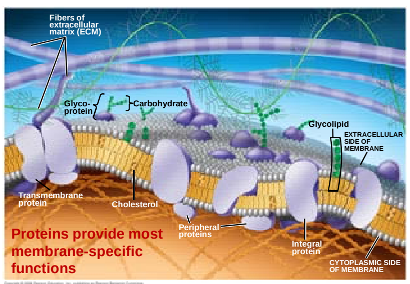

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Fig. 7-8

What types of side chains are on outside of these helices?

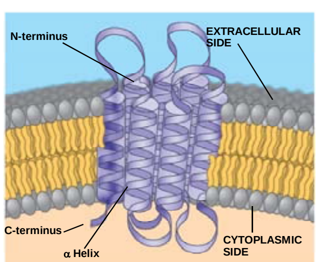

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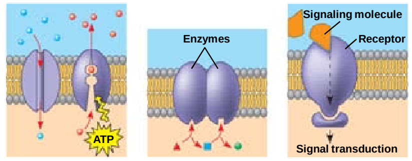
Fig. 7-9ac



(a) Transport (b) Enzymatic activity (c) Signal transduction

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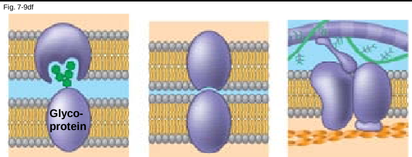
Fig. 7-9df



(d) Cell-cell recognition (e) Intercellular joining (f) Attachment to the cytoskeleton and extracellular matrix (ECM)

Carbohydrates often play important roles on the plasma membrane. Covalently bonded to lipids (forming glycolipids) or more commonly to proteins (forming glycoproteins)

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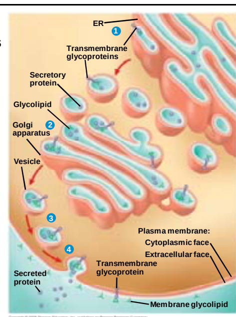
Fig. 7-10

Membranes have distinct inside and outside faces



The asymmetrical distribution of proteins, lipids, and carbohydrates is determined when the membrane is built by the ER and Golgi apparatus

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Selective Permeability

- A cell must exchange materials with its surroundings and compartmentalize its interior.
- This process is controlled by the membranes.
- Membranes are selectively permeable, regulating the cell's molecular traffic
- What does "Selective Permeability" mean?

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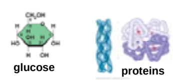
The Permeability of the Lipid Bilayer

Hydrophobic (nonpolar) molecules, such as hydrocarbons, can dissolve in the lipid bilayer and pass through the membrane rapidly

Charged or strongly polar molecules, such as ions, sugars and proteins, do not cross the membrane easily



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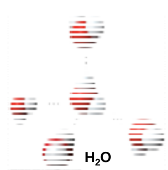
Some small molecules, even if polar, can pass through the lipid bilayer - very slowly......

-oxygen
-carbon dioxide
-urea

-water



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Diffusion: True or False

1. Diffusion requires that the membrane be permeable to the substance that is diffusing
2. Diffusion is spontaneous and passive – requiring no Energy
3. A substance moves against its concentration gradient during diffusion
4. The concentration of one substance can affect the diffusion of another
5. Diffusion occurs because populations of molecules move randomly, but individual molecules can be directional (moving in a particular direction across a membrane)
6. Diffusion results from thermal motion (heat)
7. Osmosis is the diffusion of a solute across a selectively-permeable membrane.
8. At dynamic equilibrium, as many molecules cross in one direction across the membrane as in the other direction

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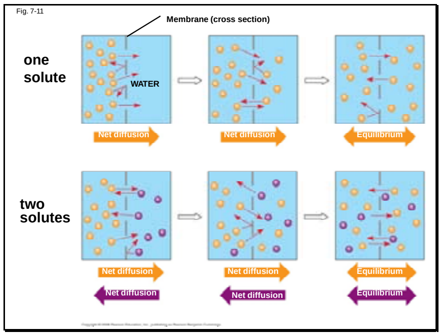

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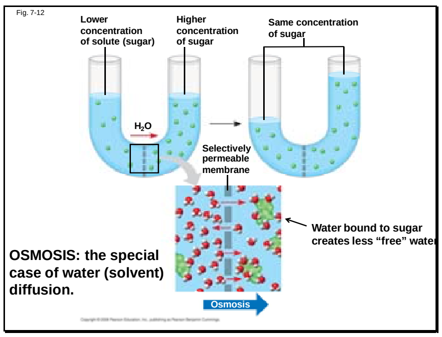

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Water Balance of Cells

- **Tonicity** is the ability of a solution to cause a cell to gain or lose water (e.g., potato in lab)
  - Considers both solute concentration, and
  - Membrane permeability
  - Depends on concentration of non-penetrating solutes
- **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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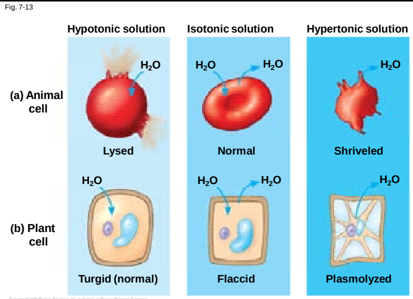
Fig. 7-13



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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
- 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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- Hypertonic or hypotonic environments can create osmotic problems
- **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

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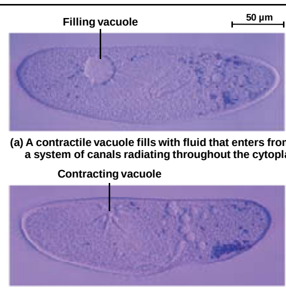
Fig. 7-14



(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.

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Transmembrane 'Transport Proteins' can help hydrophilic substances cross the membrane

1. **Facilitated Diffusion**
   1. Aqueous channels for charged or polar molecules to diffuse through

      \- or -

   2. Passive carrier mechanisms that move molecules from higher to lower concentration – usually in either direction
2. **Active Transport**
   1. ATP-dependent carrier that can move charged or polar molecules against their concentration gradient
3. **All Transport Proteins are very specific for their molecules**

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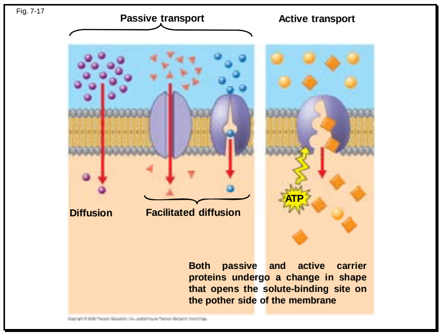

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- Channel proteins include
  - Aquaporins, for facilitated diffusion of water
  - **Ion channels** that open or close in response to a stimulus (**gated channels**)

What kind of "gating" have you heard about?

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- Active transport allows cells to maintain concentrations of things different from what would occur naturally
  - We have **calcium pumps**, **hydrogen ion pumps** and **sodium-potassium pumps,** among others
  - We also have **glucose transporters** and **amino acid transporters** – even large **protein transporters**

Why do you think a cell would want to do that?

ion pumps?____________________________________

transporters?___________________________________

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- What other way have we already learned that big molecules, like proteins, lipids and carbohydrates, can be moved in or out or around within a cell?

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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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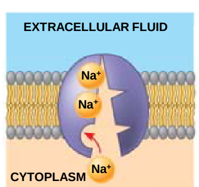
Fig. 7-16-1

Example:
Active Transport



[Na^+] high
[K^+] low

- natural gradients?

[Na^+] low
[K^+] high

1 Cytoplasmic Na^+ binds to the sodium-potassium pump.

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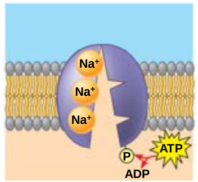
Fig. 7-16-2



2 Na^+ binding stimulates phosphorylation by ATP.

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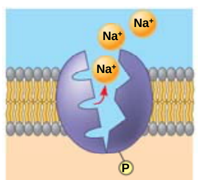
Fig. 7-16-3



3 Phosphorylation causes the protein to change its shape. Na^+ is expelled to the outside.

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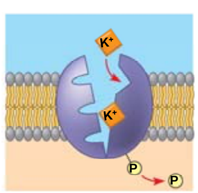
Fig. 7-16-4



4 K^+ binds on the extracellular side and triggers release of the phosphate group.

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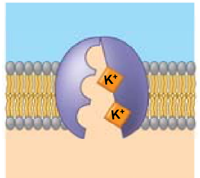
Fig. 7-16-5



5 **Loss of the phosphate restores the protein's original shape.**

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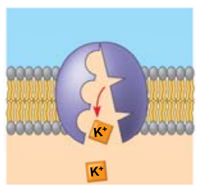
Fig. 7-16-6



6 **K^+ is released, and the cycle repeats.**

Why do we want Na^+ outside of the cell and K^+ inside?

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Neurons and muscle cells in animals and phloem cells in plants rely on electrical signaling.

- **Electricity** is the energy created by the movement of charged particles – it's named for the example of electrons
- When a cell uses electricity it does it by allowing ions that it has concentrated by active transport to rush from one side of the membrane to the other through channel proteins
- The opening and closing of the channels determines when the electrical **current** is flowing
- **Voltage** is a measure of how many ions are on the move
- **Membrane potential** is a measure of how many ions have been actively concentrated across a membrane

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- Concentrated ions diffuse faster than uncharged molecules
- 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**
- Mitochondria and chloroplasts use a proton pump to help make ATP

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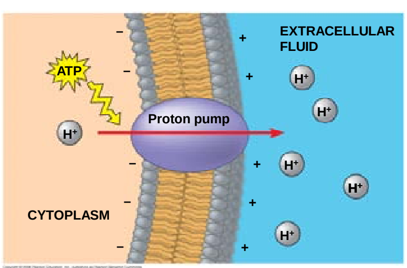
Fig. 7-18



Where else have you heard of a proton pump?

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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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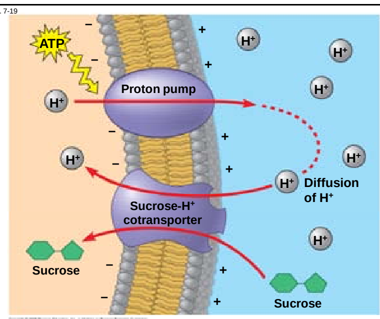
Fig. 7-19



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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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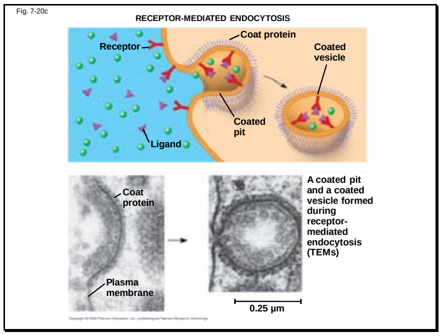

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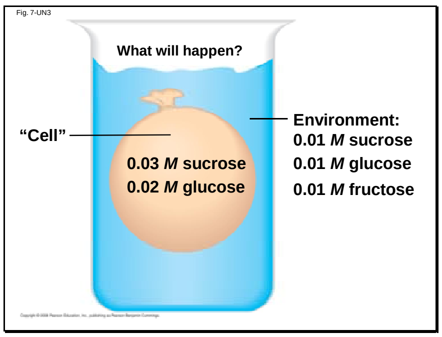

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You should now be able to:

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

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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