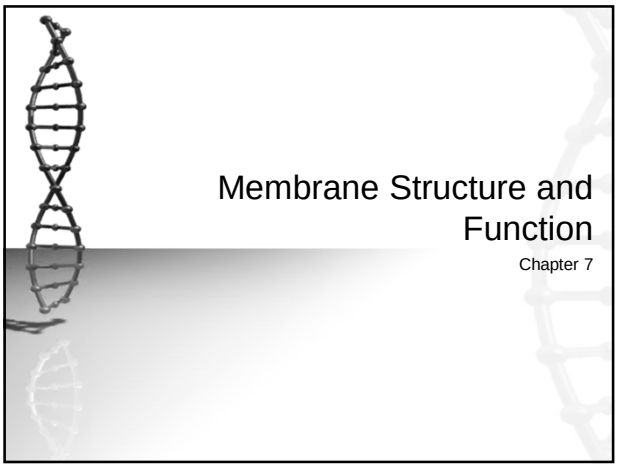

Membrane Structure and Function

Chapter 7

- Objectives
  - Define the following terms: amphipathic molecules, aquaporins, diffusion
  - 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
  - Explain how transport proteins facilitate diffusion
  - Explain how an electrogenic pump creates voltage across a membrane, and name two electrogenic pumps
  - Explain how large molecules are transported across a cell membrane

2

Introduction

- The plasma membrane
  - is the boundary that separates the living cell from its nonliving surroundings
  - exhibits selective permeability
    - it allows some substances to cross it more easily than others
  - partitions organelle function in eukaryotes
  - provides reaction surfaces and organizes enzymes and their substrates

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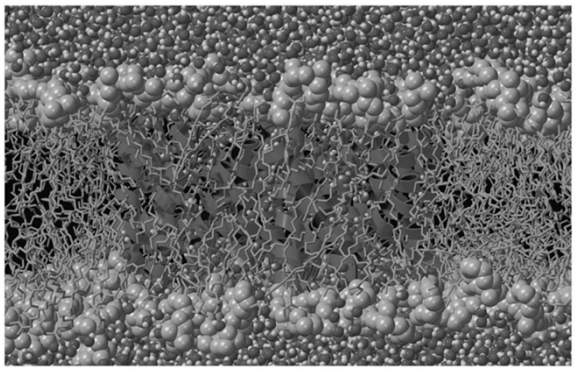

Membrane Structure

- Phospholipids of membranes form bilayers
  - phospholipids have polar “head” and nonpolar “tail”
    - amphipathic
  - form stable bilayer in water with heads out and tails in
  - hydrophobic interior forms a barrier to hydrophilic molecules

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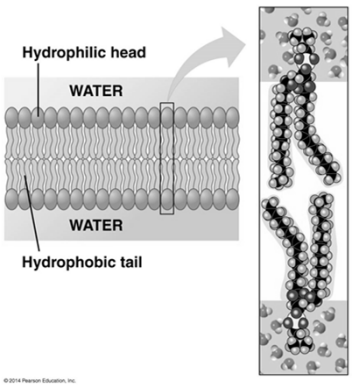

Membrane Models

- Membranes have been chemically analyzed and found to be composed of proteins and lipids
  - scientists studying the plasma membrane reasoned that it must be a phospholipid bilayer

7

- The Davson-Danielli sandwich model of membrane structure pictured the membrane as a phospholipid bilayer sandwiched between two protein layers
  - supported by electron microscope pictures of membranes

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- In 1972, Singer and Nicolson proposed that membrane proteins are dispersed and individually inserted into the phospholipid bilayer

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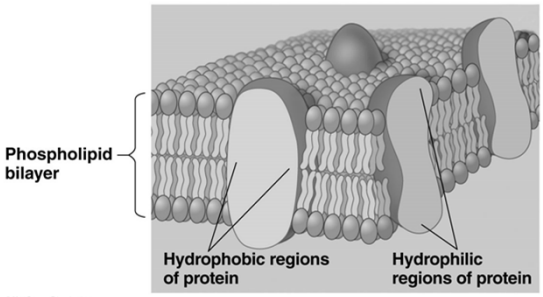

- Freeze-fracture studies of the plasma membrane supported the fluid mosaic model of membrane structure

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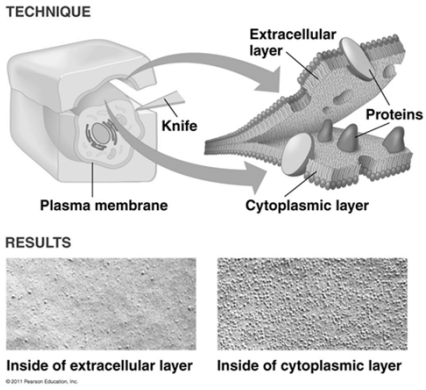

The Fluidity of Membranes

- Lipids in membrane are not fixed
  - lipids can move in membrane - semi-fluid nature of membrane
- Cholesterol helps stabilize animal cell membranes at different temperatures
  - maintains fluidity of membrane at low temperatures

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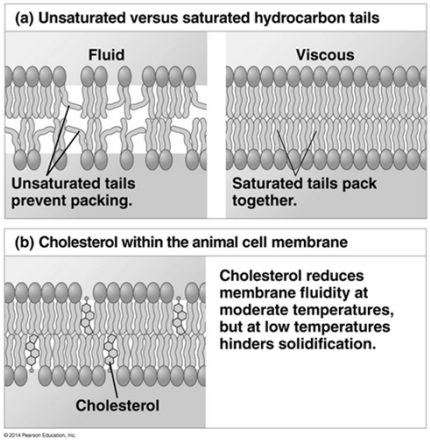

- Proteins are embedded in the phospholipid bilayer
  - individual molecules free to move laterally
    - can drift within the bilayer

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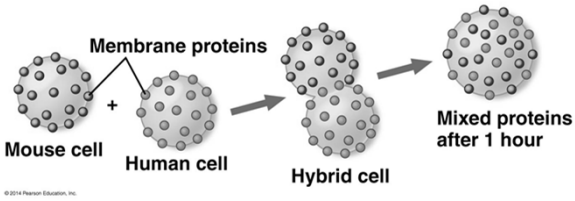
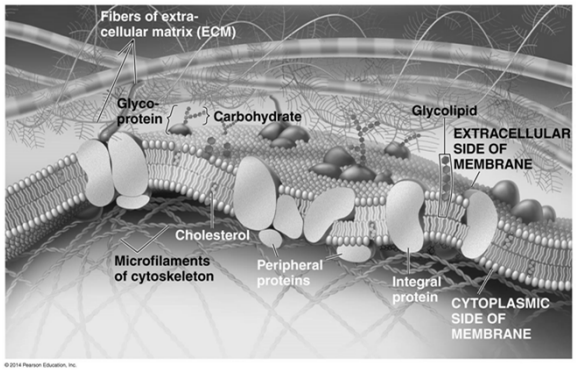


Membrane Proteins and Their Functions

- A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer
- Two major classes of proteins in membrane
  - integral – transmembrane
    - penetrate the hydrophobic core of the lipid bilayer
  - peripheral - loosely associated with membrane surface

17



Membrane Function

- Proteins make membrane a mosaic of function
  - identification tags-glycoproteins
  - enzymes
  - receptors-trigger cell activity when molecular messenger binds
  - cell junctions
  - transporters

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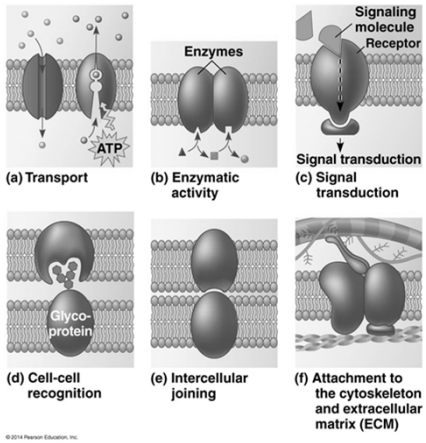

The Role of Membranes in Cell-Cell Recognition

- Cells recognize each other by binding to surface molecules, often containing carbohydrates, on the extracellular surface of the plasma membrane
  - Membrane carbohydrates may be covalently bonded to lipids (forming **glycolipids**) or more commonly to proteins (forming **glycoproteins**)
  - Carbohydrates on the external side of the plasma membrane vary among species, individuals, and even cell types in an individual

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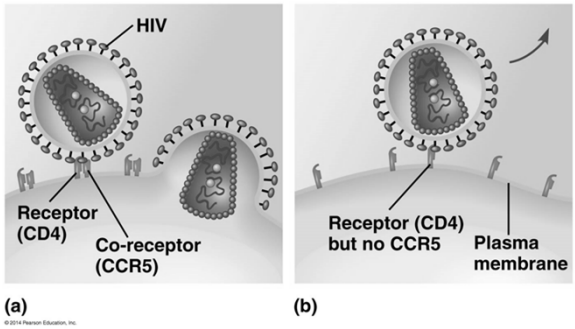

Synthesis and Sidedness of Membranes

- Membranes have distinct inside and outside faces
- This affects the movement of proteins synthesized in the endomembrane system

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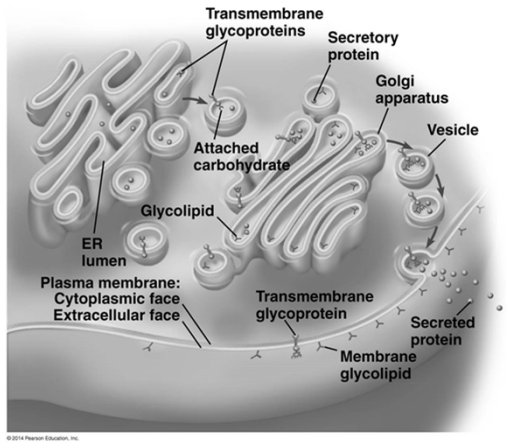


The Permeability of the Lipid Bilayer

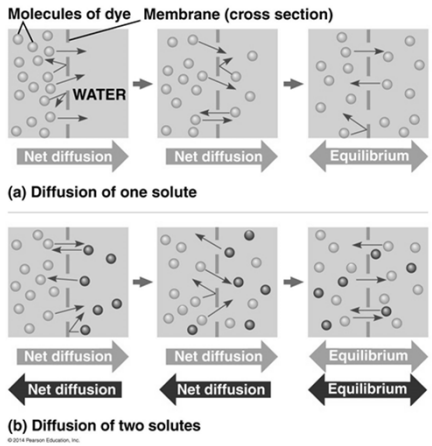
- A cell must exchange materials with its surroundings, a process controlled by the plasma membrane
  - hydrophobic molecules are lipid soluble and can pass through the membrane rapidly
  - polar molecules do not cross the membrane rapidly
- Transport proteins allow passage of hydrophilic substances across the membrane

25

Passive Diffusion

- Passive transport is diffusion across membrane
  - diffusion is the tendency of molecules to spread out spontaneously from areas of high concentration to areas of low concentration
  - passive diffusion across membrane occurs when molecule diffuses down concentration gradient
    - at equilibrium molecules diffuse back and forth-no net gain or loss
  - different molecules diffuse independently of each other

26



Effects of Osmosis on Water Balance

- Osmosis is passive diffusion of water
  - selectively permeable membranes are permeable to water but not all solutes
  - direction of osmosis is determined by differences in total solute concentrations

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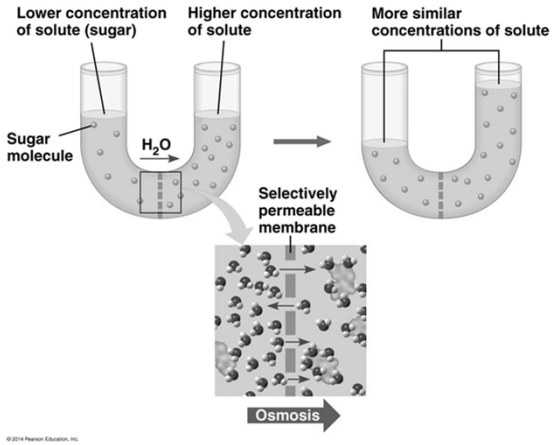


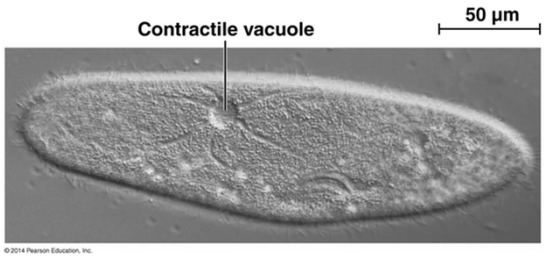
Water Balance of Cells Without Walls

- Tonicity is the ability of a solution to cause a cell to gain or lose water
  - has a great impact on cells without walls
- If a solution is isotonic the concentration of solutes is the same as it is inside the cell
  - there will be no net movement of water
- If a solution is hypertonic the concentration of solutes is greater than it is inside the cell
  - the cell will lose water

30

- If a solution is hypotonic the concentration of solutes is less than it is inside the cell
  - the cell will gain water
- Animals and other organisms without rigid cell walls living in hypertonic or hypotonic environments must have special adaptations for osmoregulation

31



Water Balance of Cells with Walls

- Cell walls help maintain water balance
  - If a plant cell is turgid it is in a hypotonic environment
    - it is very firm, a healthy state in most plants
  - If a plant cell is flaccid it is in an isotonic or hypertonic environment

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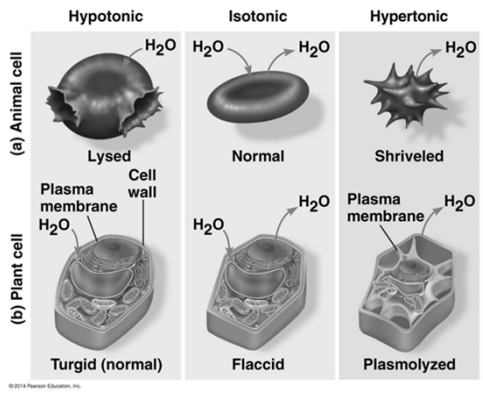

Facilitated Diffusion: Passive Transport Aided by Proteins

- Specific proteins facilitate diffusion across membranes
  - facilitated diffusion occurs when protein pore in membrane allows solute to diffuse down concentration gradient
  - no energy required
  - rate depends on number of transport proteins and strength of gradient

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- Channel proteins provide corridors that allow a specific molecule or ion to cross the membrane
- Carrier proteins undergo a subtle change in shape that translocates the solute-binding site across the membrane

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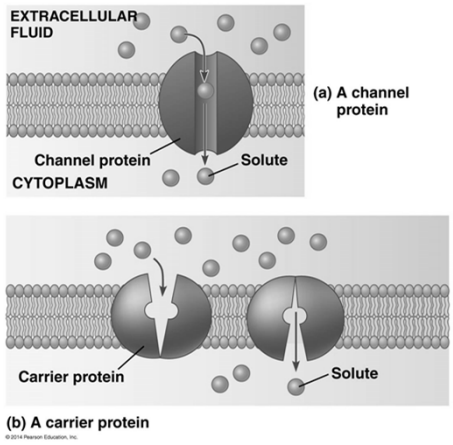


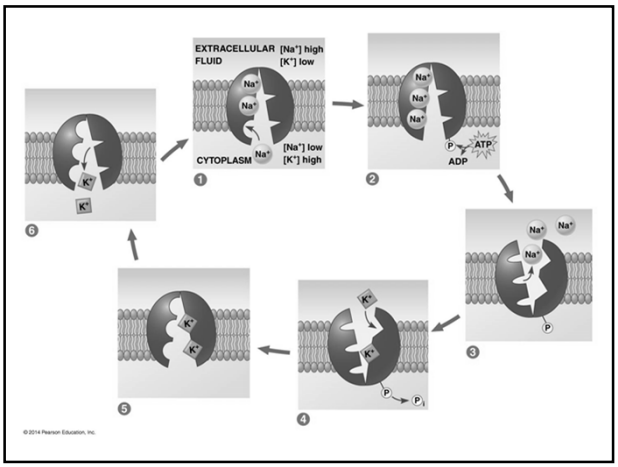
Active Transport

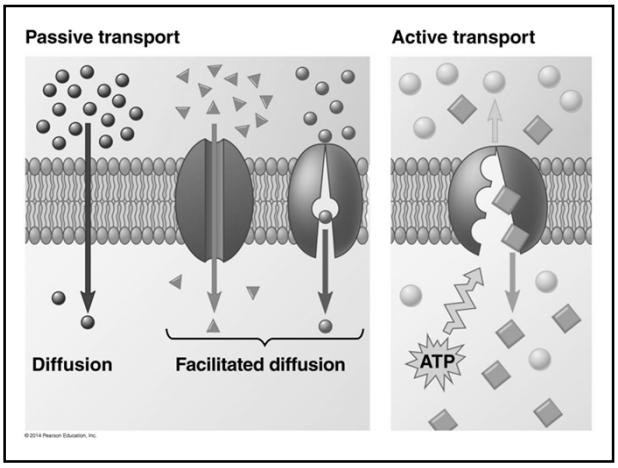
- Cells expend energy for active transport
  - transport protein involved in moving solute against concentration gradient
  - energy from ATP-mediated phosphorylation changes protein shape and moves solute molecule across membrane
  - active transport of two solutes in opposite directions often coupled

38

- The sodium-potassium pump is one type of active transport system

39





Maintenance of Membrane Potential

- Membrane potential is the voltage difference across a membrane
- An electrochemical gradient is caused by the concentration and electrical gradients of ions across a membrane

42

- Electrogenic pumps, like the Na^+-K^+ pump and the H^+ pump, generate voltage (charge separation) across membranes.
  - The resulting voltage, or membrane potential, can be used to drive the transport of ions against a chemical gradient

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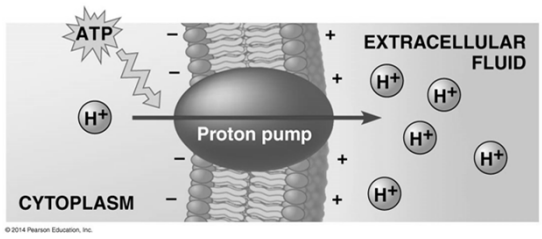

Cotransport: Coupled Transport by a Membrane Protein

- Cotransport occurs when active transport of a specific solute indirectly drives the active transport of another solute

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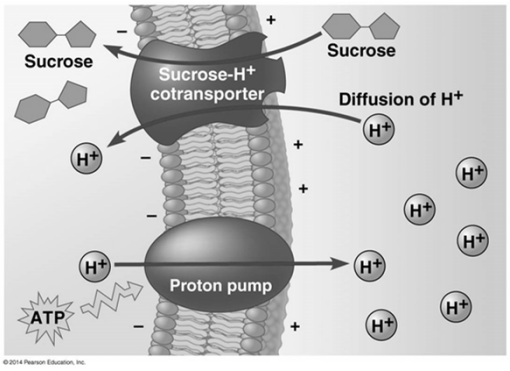

Mass Transport

- Exocytosis and endocytosis transport large molecules
  - exocytosis: membrane-bound vesicles containing large molecules fuse with plasma membrane and release contents outside cell
  - endocytosis: plasma membrane surrounds materials outside cell, closes around materials, and forms membrane-bound vesicles

47

Exocytosis

- In exocytosis transport vesicles migrate to the plasma membrane, fuse with it, and release their contents

48

Endocytosis

- In endocytosis the cell takes in macromolecules by forming new vesicles from the plasma membrane
  - three important types of endocytosis are:
    - phagocytosis
    - pinocytosis
    - receptor-mediated endocytosis

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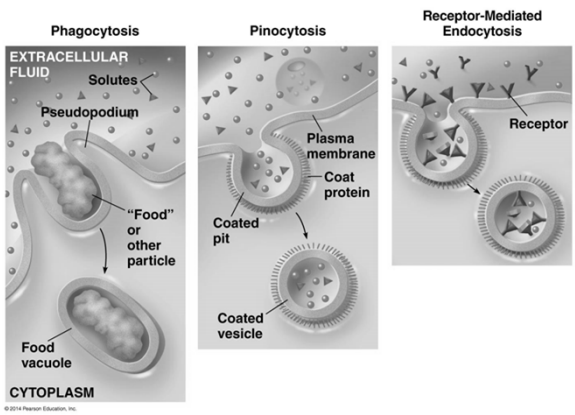

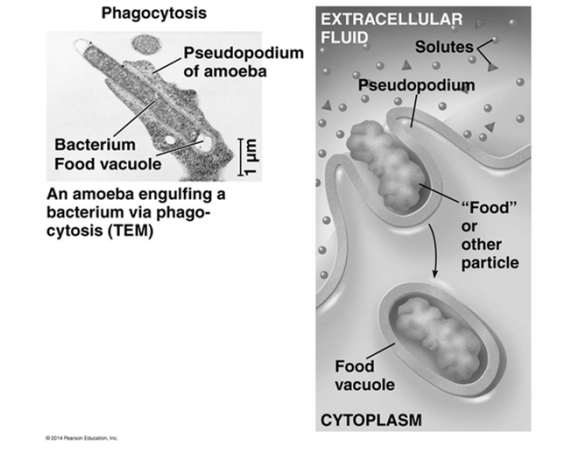

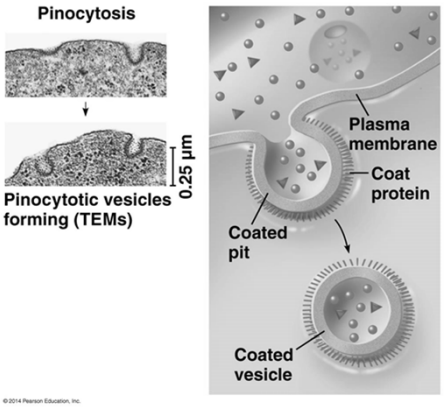

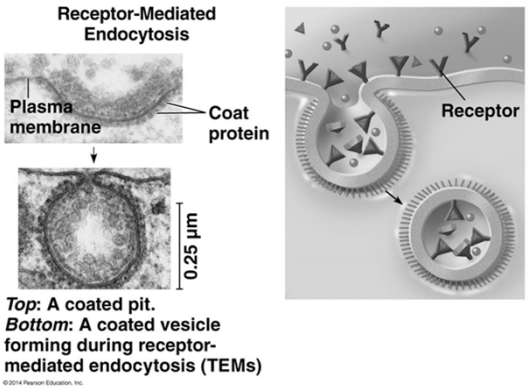

- Receptor-mediated endocytosis plays an important role in removing cholesterol from the bloodstream
  - individuals with genetic predisposition to high cholesterol levels (hypercholesterolemia) have genetically determined low levels of cholesterol receptors on cell surfaces
    - cholesterol poorly bound and removed from bloodstream

54

Figure 5.20 A cell using receptor-mediated endocytosis