

## Lecture Series 4 Cellular Membranes

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### Reading Assignments

- Read Chapter 11  
Membrane Structure
- Review Chapter 21  
pages 709-717 (Animal Cell Adhesion)
- Review Chapter 12  
Membrane Transport
- Review Chapter 15 regarding  
Endocytosis and Exocytosis

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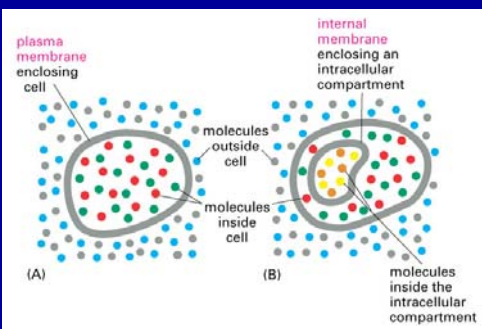
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### Selective and Semi-permeable Barriers



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## A. Membrane Composition and Structure

- Biological membranes consist of lipids, proteins, and carbohydrates. The **fluid mosaic model** describes a phospholipid bilayer in which membrane proteins move laterally within the membrane.
- Phospholipids are the **most abundant** lipid in the plasma membrane and **amphipathic**, containing both hydrophobic and hydrophilic regions.

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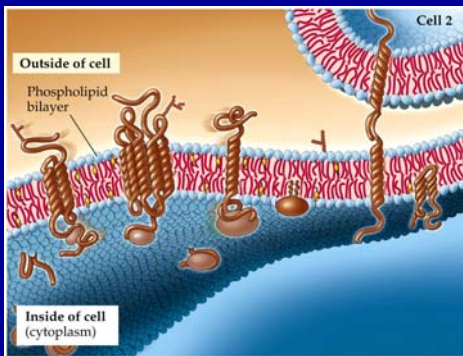
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*The Fluid Mosaic Model*



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## A. Membrane Composition and Structure

- Cell membranes are bilayered, dynamic structures that:
  - ◆ Perform vital physiological roles
  - ◆ Form boundaries between cells and their environments
  - ◆ Regulate movement of molecules into and out of cells
- The plasma membrane exhibits selective permeability.
  - ◆ It allows some substances to cross it more easily than others

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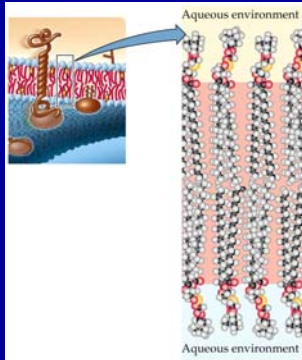
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*A Phospholipid Bilayer Separates Two Aqueous Regions*



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## A. Membrane Composition and Structure

- The lipid portion of a cellular membrane provides a barrier for water-soluble molecules.
- Membrane proteins are embedded in the lipid bilayer.
- Carbohydrates attach to lipid or protein molecules on the membrane, generally on the outer surface, and function as recognition signals between cells.

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## A. Membrane Composition and Structure

- All biological membranes contain proteins.
- The ratio of protein to phospholipid molecules varies depending on membrane function, which can vary greatly.
- Many membrane proteins have hydrophilic and hydrophobic regions and are therefore also amphipathic.

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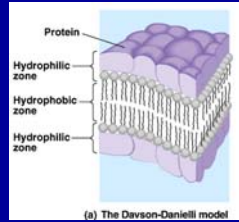
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- Davson-Danielli's Sandwich Model of membrane structure (1935):

- ◆ Stated that the membrane was made up of a phospholipid bilayer sandwiched between two protein layers.
- ◆ Was supported by electron microscope pictures of membranes.




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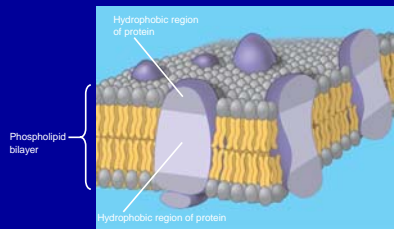
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- Singer and Nicolson's Fluid Mosaic Model (1972):

- ◆ Proposed that membrane proteins are dispersed and individually inserted into the phospholipid bilayer.




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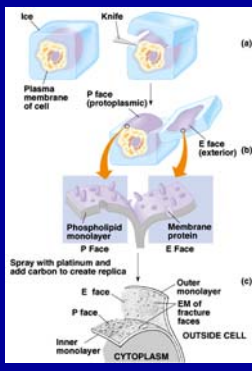
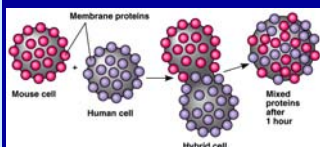
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- Freeze-fracture experimentation provided evidence for the Singer-Nicolson model of membrane structure (embedded proteins than spanned membrane).

- Additional evidence when different cells are fused and the migration of membrane proteins are observed.




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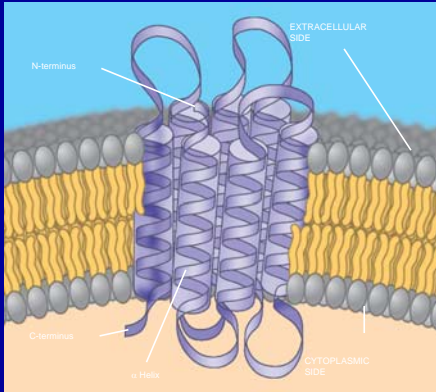
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### Interactions of Integral Membrane Proteins



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## A. Membrane Composition and Structure

- **Integral membrane proteins** have hydrophobic regions of amino acids that penetrate or entirely cross the phospholipid bilayer.
  - ♦ **Transmembrane proteins** have a specific orientation, showing different "faces" on the two sides of the membrane.
- **Peripheral membrane proteins** lack hydrophobic regions and are not embedded in the bilayer.

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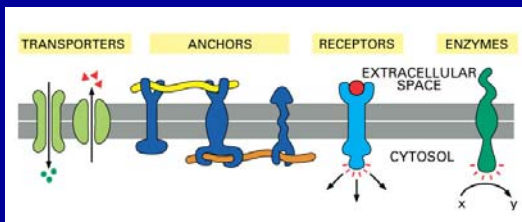
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Integral or transmembrane proteins play several different roles in a cell. Each of these distinctive proteins is encoded by a particular gene and thus has a very specific amino acid sequence.

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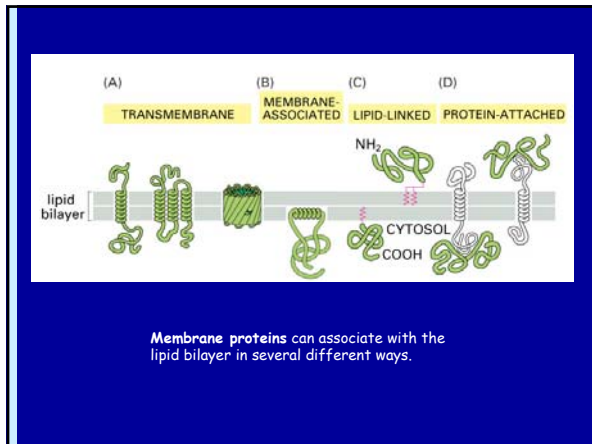
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## B. Animal Cell Adhesion

- **Tight junctions** prevent passage of molecules through space around cells, and define functional regions of the plasma membrane by restricting migration of membrane proteins over the cell surface.
- **Desmosomes** allow cells to adhere strongly to one another.
- **Gap junctions** provide channels for chemical and electrical communication between cells.

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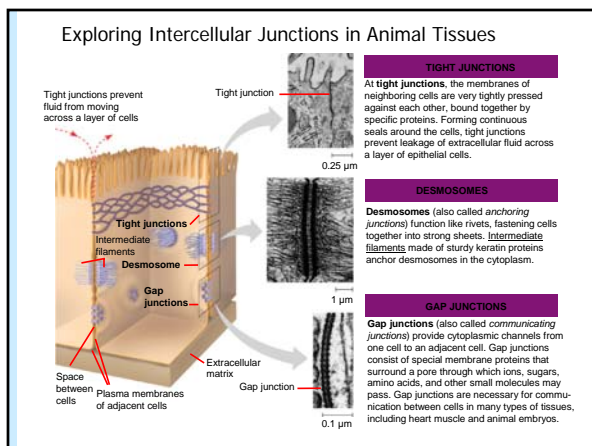
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## C. Passive Processes of Membrane Transport

- Substances can diffuse passively across a membrane by: unaided diffusion through the phospholipid bilayer, facilitated diffusion through protein channels, or by means of a carrier protein.

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### 5.1 Membrane Transport Mechanisms

	SIMPLE DIFFUSION	FACILITATED DIFFUSION	ACTIVE TRANSPORT
Direction	With concentration gradient	With concentration gradient	Against concentration gradient
Energy source	Concentration gradient	Concentration gradient	ATP hydrolysis
Membrane protein required?	No	Yes	Yes
Specificity	Not specific	Specific	Specific

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## C. Passive Processes of Membrane Transport

- Solutes diffuse across a membrane from a region with a greater solute concentration to a region of lesser. Equilibrium is reached when the concentrations are identical on both sides.

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**EXPERIMENT**

**Question:** Does diffusion lead to uniform distribution of solutes?

**Conclusion:** Solutes distribute themselves by diffusion, uniformly and independently of each other.

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### C. Passive Processes of Membrane Transport

- The rate of simple diffusion of a solute across a membrane is directly proportional to the concentration gradient across the membrane. A related important factor is the lipid solubility of the solute.
- In osmosis, water will diffuse from a region of its higher concentration (low concentration of solutes) to a region of its lower concentration (higher concentration of solutes).

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*Osmosis is the movement of water across a semipermeable membrane*

**Selectively permeable membrane**

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## C. Passive Processes of Membrane Transport

- Small molecules can move across the lipid bilayer by simple diffusion.
- The more lipid-soluble the molecule, the more rapidly it diffuses.
- An exception to this is water, which can pass through the lipid bilayer more readily than its lipid solubility would predict.
- Polar and charged molecules such as amino acids, sugars, and ions do not pass readily across the lipid bilayer.

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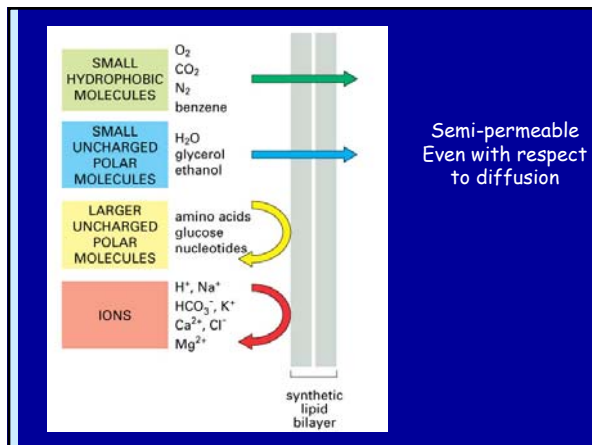
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## C. Passive Processes of Membrane Transport

- In hypotonic solutions, cells tend to take up water while in hypertonic solutions, they tend to lose it. Animal cells must remain isotonic to the environment to prevent destructive loss or gain of water.

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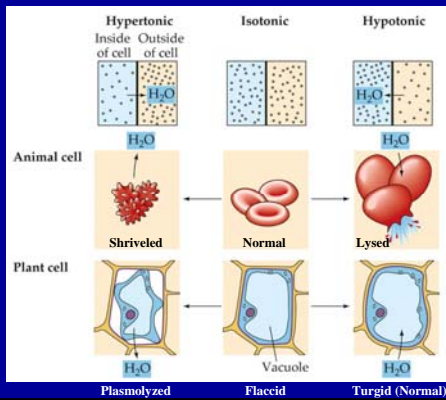
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*Osmosis Modifies the Shapes of Cells*




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**C. Passive Processes of Membrane Transport**

- The cell walls of plants and some other organisms prevent cells from bursting under hypotonic conditions. Turgor pressure develops under these conditions and keeps plants upright and stretches the cell wall during cell growth.

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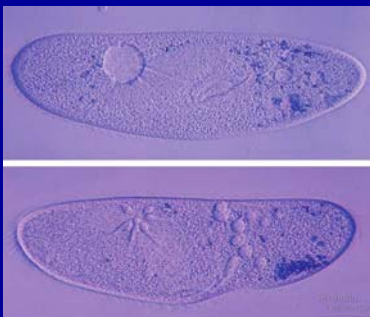
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A *Paramecium* (or any organism living in a hypotonic solution) has a special problem. Water tends to move into the cells and swell and burst them. *Paramecium* has a particular structure, called a contractile vacuole, which constantly pumps water outside of the cell, and thus reduces pressure upon the membrane.

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## C. Passive Processes of Membrane Transport

- Channel proteins and carrier proteins function in facilitated diffusion.
- Rem: Polar and charged molecules such as amino acids, sugars, and ions do not pass readily across the lipid bilayer.

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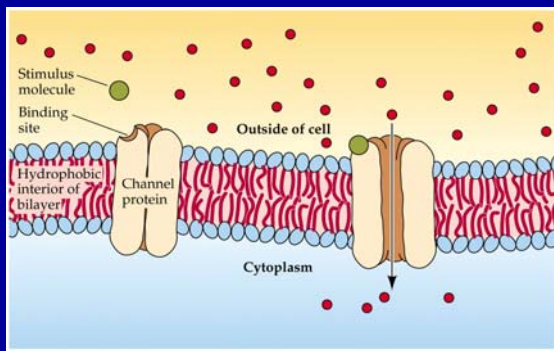
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*A Gate Channel Protein Opens in Response to a Stimulus*



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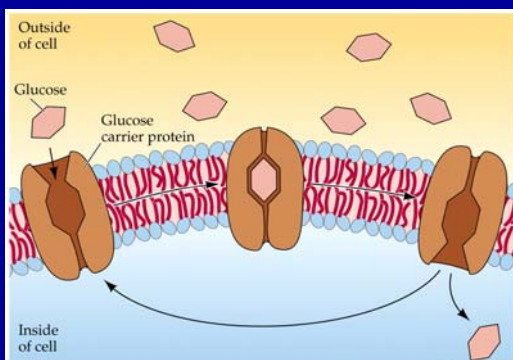
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*A Carrier Protein Facilitates Diffusion*



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## C. Passive Processes of Membrane Transport

- The rate of carrier-mediated facilitated diffusion is at maximum when solute concentration saturates the carrier proteins so that no rate increase is observed with further solute concentration increase.

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## D. Active Transport

- Active transport requires energy to move substances across a membrane AND against a concentration gradient.

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## D. Active Transport

- Three different protein-driven systems are involved in active transport:
  - ◆ **Uniport** transporters move a single type of solute, such as calcium ions, in one direction.
  - ◆ **Symport** transporters move two solutes in the same direction.
  - ◆ **Antiport** transporters move two solutes in opposite directions, one into the cell, and the other out of the cell.

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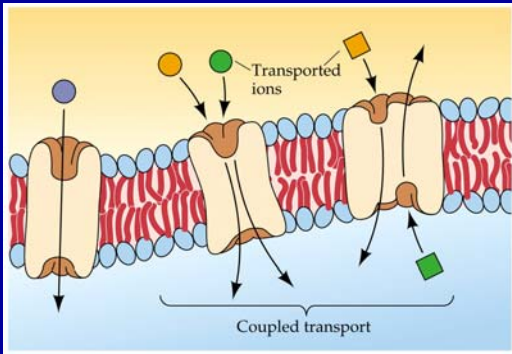
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Three Types of Proteins for Active Transport




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D. Active Transport

- In primary active transport, energy from the hydrolysis of ATP is used to move ions into or out of cells against their concentration gradients.

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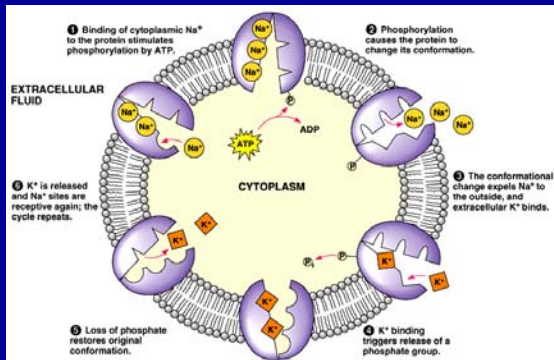
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Primary Active Transport: The Sodium-Potassium Pump




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## D. Active Transport

- Secondary active transport couples the passive movement of one solute with its concentration gradient to the movement of another solute against its concentration gradient. Energy from ATP is used indirectly to establish the concentration gradient resulting in movement of the first solute.

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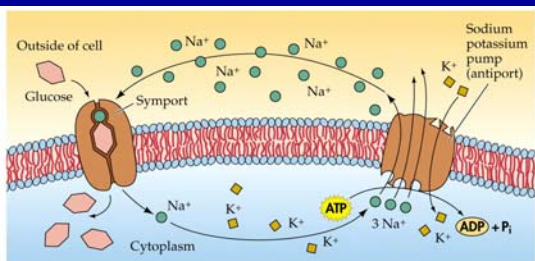
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### Secondary Active Transport



An example is the symport system found in intestinal cells, which moves glucose up its concentration gradient, while moving sodium ions down its ion concentration gradient.

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## E. Endocytosis and Exocytosis

- Endocytosis transports macromolecules, large particles, and small cells into eukaryotic cells by means of engulfment and by vesicle formation from the plasma membrane.
- There are three types of endocytosis: phagocytosis, pinocytosis, and receptor-mediated endocytosis.

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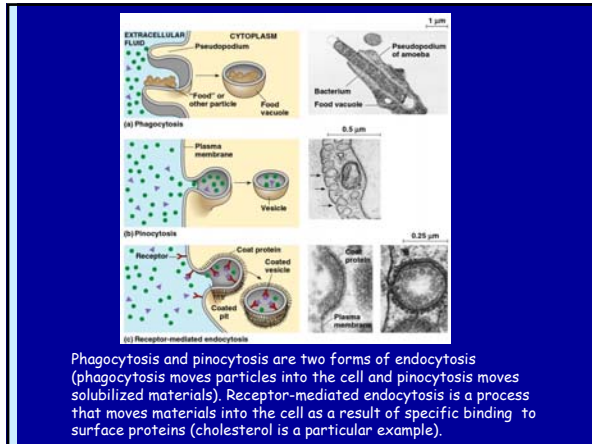
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## E. Endocytosis and Exocytosis

- In receptor-mediated endocytosis, a specific membrane receptor binds to a particular macromolecule.
- Receptor proteins are exposed on the outside of the cell in regions called coated pits.
- Clathrin molecules form the "coat" of the pits.
- Coated vesicles form with the macromolecules trapped inside.

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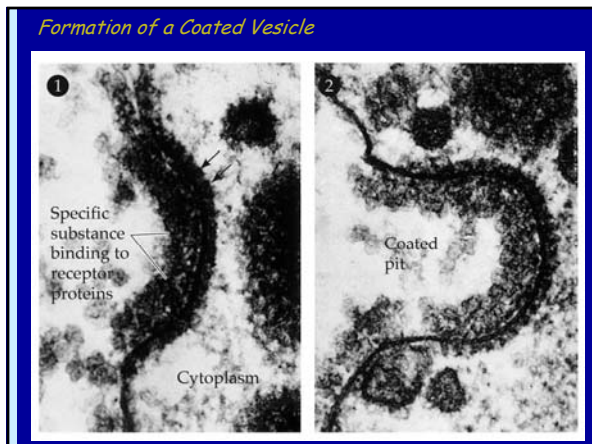
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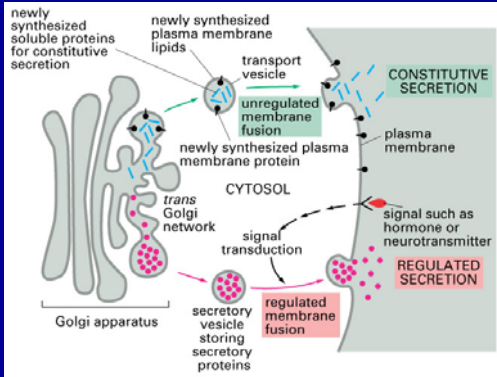
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### Mechanisms for Exocytosis



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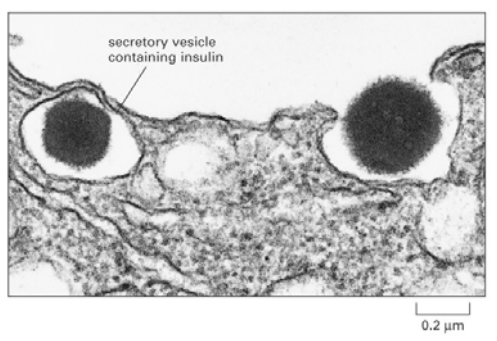
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### Pancreas Secretory Vesicles containing Insulin



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