Medical Biology

Lec 2
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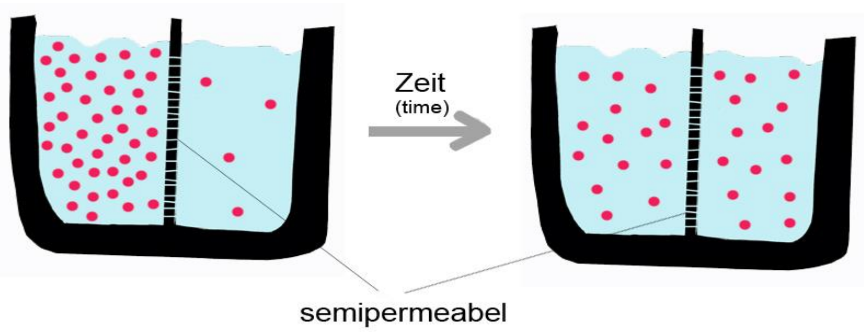
How molecules cross the plasma membrane?

- The plasma membrane is semi permeable, allowing some molecules to pass through (e.g., small, non charged, lipid- soluble molecules).
- Plasma membrane also is often regarded as differentially permeable (or selectively permeable), because not all small molecules can freely pass through it.
- Molecules cross the plasma membrane in **2** ways:
    1. **passive ways**: which do not use energy. Involve: simple diffusion and facilitated diffusion.
    2. **active ways**: use energy. Involve: active transport, endocytosis & exocytosis.

Passive ways

1. **Simple diffusion**: occurs when molecules move from higher to lower concentration, that is, down their concentration gradient, until they are distributed equally. Gases can diffuse through the lipid bilayer; this is the mechanism by which oxygen enters cells and carbon dioxide exits cells.



Osmosis:

The diffusion of water across a differentially permeable membrane has been given a special name, it is called **osmosis**. Osmotic pressure develops on the side of the membrane that has the higher solute concentration.

To demonstrate osmosis, we have the following experiment:
A thistle tube, covered at the broad end by a differentially permeable membrane, contains a 10% sugar solution were put in a beaker contains a 5% sugar solution. The solute is unable to pass through the membrane, but the water passes freely through in both directions. A net movement of water toward the inside of the thistle tube occurs because the thistle tube has a higher percentage of solute. In the end, the net result is that the level of the solution rises in the thistle tube until hydrostatic pressure increases to the level of osmotic pressure.

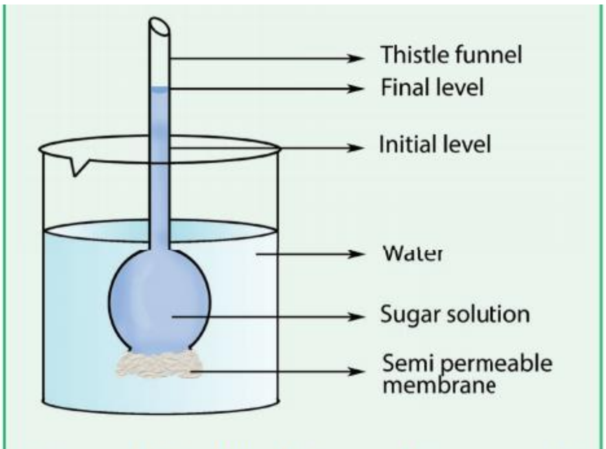


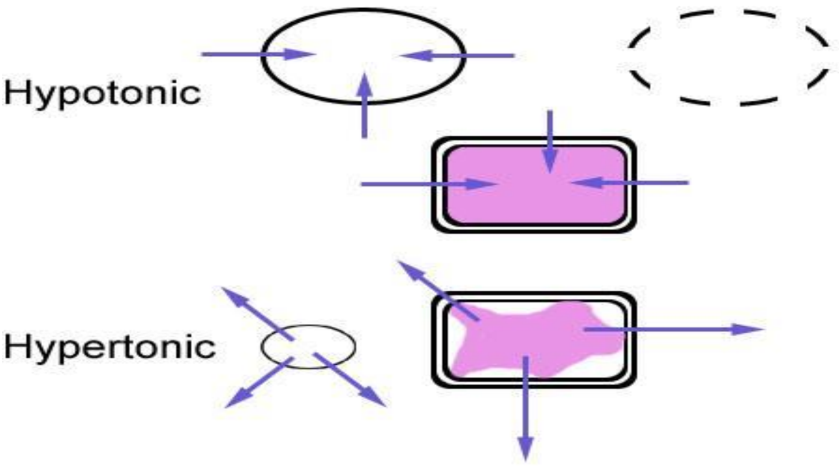
Figure 11.6: Thistle Funnel Experiment

Tonicity:
Tonicity refers to the strength of a solution in relationship to osmosis. Cells can be placed in solutions that have the same percentage of solute (isotonic solution), a higher percentage of solute (hypertonic solution), or a lower percentage of solute (hypotonic solution) than the cell.

Isotonic solution:
- solution that causes cells neither to gain nor to lose water, that is the solute concentration is the same on both sides of the membrane.
- A 0.9% solution of the salt sodium chloride (NaCl) is known to be isotonic to red blood cells because the cells neither swell nor shrink when placed in this solution.
- Therefore, physicians must put this point in his mind when giving blood or fluid to the patients.

Hypertonic solution:
- Solutions that cause cells to shrink due to loss of water.
- Any fluid with a concentration higher than 0.9% sodium chloride is hypertonic to red blood cells.

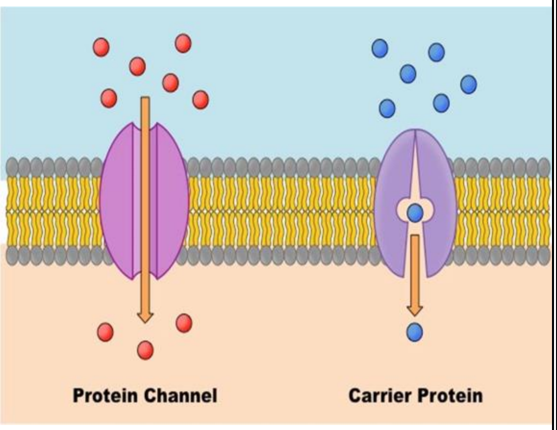
Hypotonic solution:
- Solutions that cause cells to swell or even to burst, due to an intake of water.
- Any concentration of salt solution lower than 0.9% is hypotonic to red blood cell.



2. Facilitated diffusion: includes

1. Channel protein diffusion: this type of passive transport system also doesn't use energy, used for movement of Ions (H- or Cl-) required only channel protein.

2. Carrier protein diffusion: is another type of passive transport system that doesn't use energy but requires a carrier protein assist the movement of glucose or amino acids. Each protein carrier, sometimes called a ***transporter***, binds only to a particular molecule, such as glucose.



Clinical notes:
Type 2 diabetes mellitus results when cells lack a sufficient number of glucose transporters.

Active ways

1. **active transport**:
   - some molecules and ions can be transported across cell membrane against their concentration gradient if the appropriate transport enzymes and a source of energy are available.

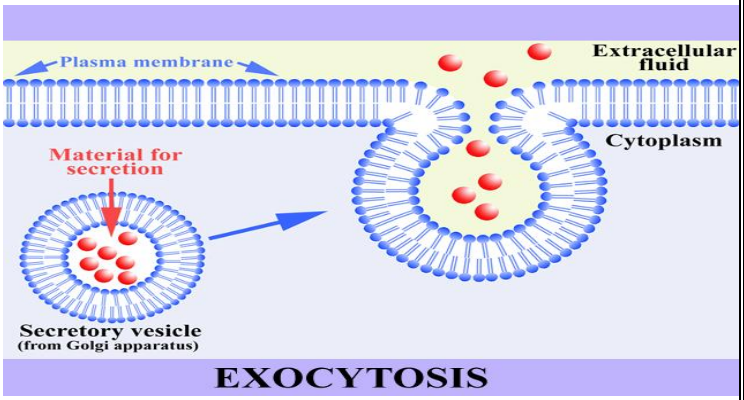
- Proteins involved in active transport often are called **pumps**, e.g., the sodium- potassium pump carries (Na^+) to the outside of the cell and (K^+) to the inside of the cell.

Clinical notes:

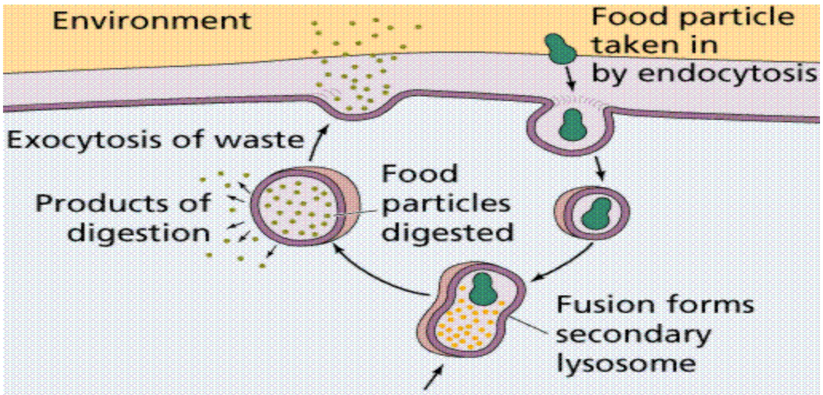
One important clinical application on active transport is **Cystic Fibrosis**.

Cystic fibrosis is a genetic disorder that occurs when there is a defect in a gene on chromosome 7. This gene, called CFTR (cystic fibrosis Transmembrane conductance regulator), codes for the CFTR protein, is a channel protein that controls the flow of H2O and Cl- ions in and out of cells inside the lungs. When the CFTR protein is working correctly, ions freely flow in and out of the cells. However, when the CFTR protein is malfunctioning, these ions cannot flow out of the cell due to a blocked channel. This causes cystic fibrosis, characterized by the buildup of thick mucus in the lungs.

2. **exocytosis**:
   - During exocytosis, vesicles often formed by the Golgi apparatus and carry specific molecules fuse with the plasma membrane and secretion occurs.
   - This is the way that insulin leaves insulin- secreting cells.

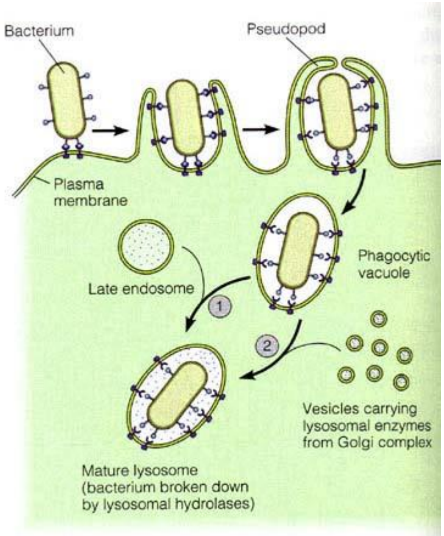


3. **endocytosis**:
   - During endocytosis, cells take in substances by vesicle formation.
   - A portion of the plasma membrane invaginates to envelop the substance, and then the membrane pinches off to form an intracellular vesicle.



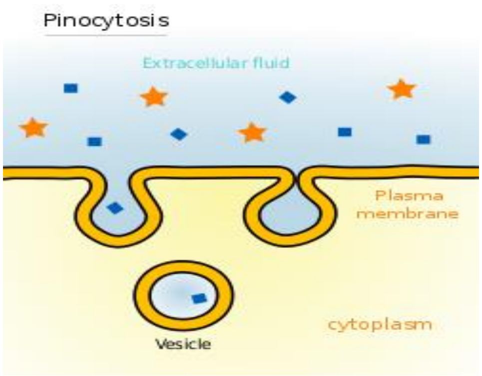
There are *three* methods of endocytosis:

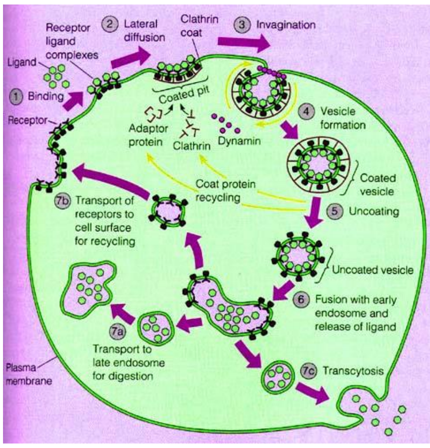
1. **phagocytosis**: means "**cell eating**", occurs when large materials are taken inside the cell, such as food particles or another cell. e.g., white blood cells can engulf bacteria and worn- out red blood cells by **phagocytosis.** Digestion occurs when the resulting vacuole fuses with a lysosome.



2. **pinocytosis**: means "**cell drinking**", occurs when vesicles form around a liquid or very small particles. e.g., cells that line the kidney tubules or intestinal wall use this method of ingesting substances.

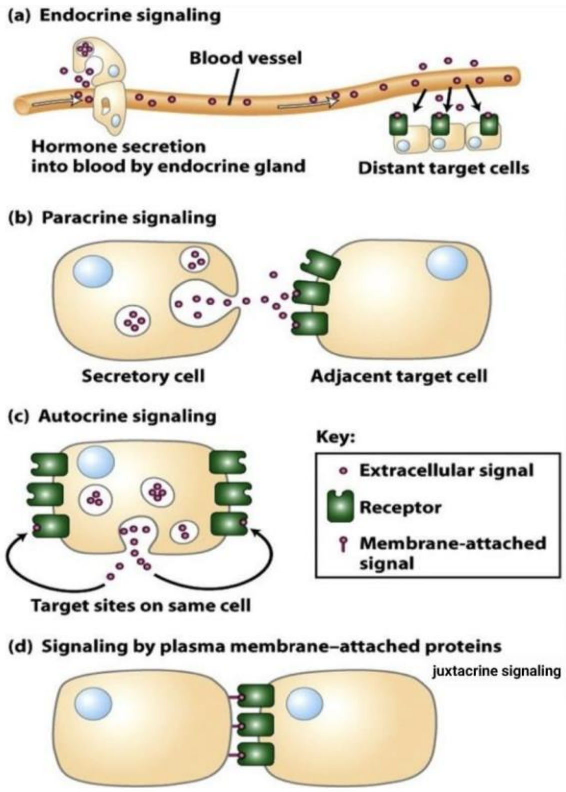
3. **receptor- mediated endocytosis** is a form of pinocytosis that is quite specific because it involves the use of a receptor protein shaped in such a way that a specific molecule can bind to it.





Clinical notes:
An inherited form of cardiovascular disease occurs when cells fail to take up a combined lipoprotein and cholesterol molecule from the blood by receptor mediated endocytosis.

Signal Reception and Transduction



Cells in a multicellular organism need to communicate with one another to regulate their development into tissues, to control their growth and division, and to coordinate their functions. Many cells form communicating junctions that couple adjacent cells and allow the exchange of ions and small molecules.
Through these channels, also called gap junctions, signals may pass directly from cell to cell without reaching the extracellular fluid.
Soluble extracellular signaling molecules bind receptor proteins only found on their **target cells**. Each cell type in the body contains a distinctive set of receptor proteins that enable it to respond to a complementary set of signaling molecules in a specific, programmed way. Such signaling can take different routes:
In **endocrine signaling,** the signal molecules (called hormones) are carried in the blood to target cells throughout the body.
In **paracrine signaling,** the chemical mediators are rapidly metabolized so that they act only on local cells very close to the source.
In **synaptic signaling,** a special kind of paracrine interaction, neurotransmitters act only on adjacent cells through special contact areas called **synapses.**
In **autocrine signaling**, signals bind receptors on the same cell type that produced the messenger molecule.
In **juxtacrine signaling**, important in early embryonic tissue interactions, signaling molecules remain part of a cell's surface and bind surface receptors of the target cell when the two cells make direct physical contact.

Clinical notes:

Several diseases have been shown to be caused by defective receptors. For example, pseudohypoparathyroidism and a type of dwarfism are caused by nonfunctioning parathyroid and growth hormone receptors. In these two conditions the glands produce the respective hormones, but the target cells do not respond because they lack normal receptors.