جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

كلية العلوم

قسم الادلة الجنائية

المحاضرة الرابعة

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المادة : الخلية The Cell

المرحلة : الأولى

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Cells and Transport processes

Most of the substances that move across membranes are

- **Dissolved gases** (oxygen, carbon dioxide, and nitrogen)
- **Ions** (sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), and hydrogen (H^+) ions
- **Small organic molecules** (solutes), which are *metabolites*—substrates, and products in the various metabolic pathways such as sugars, amino acids, and nucleotides.

To survive and grow, cells must be able to exchange molecules with their environment. They must import nutrients such as sugars and amino acids and eliminate metabolic waste products. They must also regulate the concentrations of a variety of inorganic ions in their cytosol and organelles. A few molecules, such as CO2 and O2, can simply diffuse across the lipid bilayer of the plasma membrane. But the vast majority cannot. Instead, their movement depends on specialized membrane transport proteins that span the lipid bilayer, providing a passageways across the membrane for select substances.

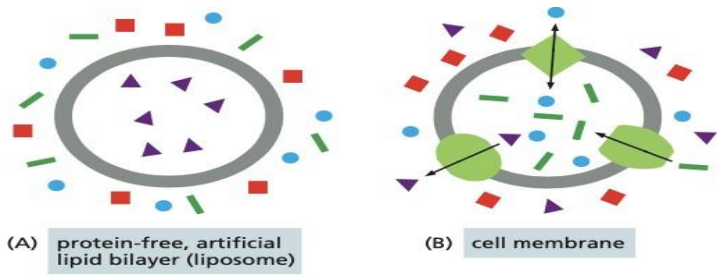

Figure : Cell membranes contain specialized membrane. A) Protein- free, artificial lipid bilayers such as liposomes, (B) Cell membranes, by contrast, contain membrane transport proteins (*light green*), each of which transfers a particular substance across the membrane.

Solutes Cross Membranes by Either Passive or Active Transport

Cells contain two main classes of membrane transport proteins: transporters and channels. These proteins differ in the way they discriminate between solutes, transporting some but not others.

Channels discriminate mainly on the basis of size and electric charge: when the channel is open, only ions of an appropriate size and charge can pass through.

Transporter transfers only those molecules or ions that fit into specific binding sites on the protein, such as binding of enzyme to a substrate.

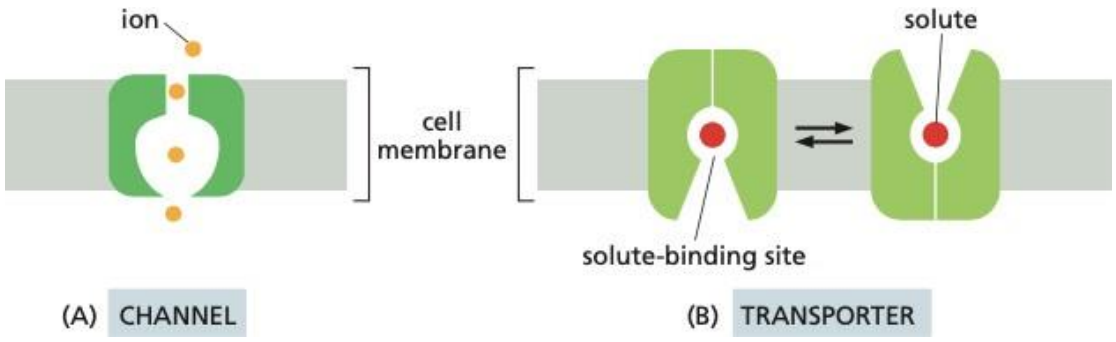

Figure 2: Main classes of membrane transport proteins. A) channel proteins, B) transporter proteins

Transporters and channels allow small, hydrophilic molecules and ions to cross the cell membrane.

The direction of transport depends only on the relative concentrations of the solute on either side of the membrane. Substances will spontaneously flow "down-hill" from a region of high concentration to a region of low concentrations.

Types of passive transport

1. **Simple diffusion:** is a passive process of transport. A single substance tends to move from an area of high concentration to an area of low concentration until the concentration is equal across a space. Example: diffusion of **gases** (O_2 and CO_2) in our lungs and **RBCs**.

Factors That Affect Diffusion

- **Shape, size and mass of the molecules diffusing**: Large and heavier molecules move more slowly, while smaller and lighter molecules move faster.
- **Temperature**: higher temperatures increase the energy and therefore the movement of the molecules, increasing the rate of diffusion. Lower temperatures decrease the energy of the molecules, thus decreasing the rate of diffusion.
- **Solvent density**: As the density of a solvent increases, the rate of diffusion decreases. The molecules slow down because they have a more difficult time getting through the denser medium. If the medium is less dense, rates of diffusion increase.
- **Solubility:** nonpolar or lipid-soluble materials pass through plasma membranes more easily than polar materials, allowing a faster rate of diffusion.
- **Surface area and thickness of the plasma membrane**: Increased surface area increases the rate of diffusion, whereas a thicker membrane reduces it.
- **Extent of the concentration gradient:** the greater concentration, the more rapid diffusion. The closer the distribution of the material to equilibrium, the slower the rate of diffusion becomes.

2. **Facilitated diffusion** : is a type of a passive diffusion, where materials diffuse across the plasma membrane with the help of membrane proteins (**channel proteins or carrier proteins**) embedded in the plasma membrane.

The integral proteins involved in facilitated transport are collectively referred to as **transport proteins**, and they function as either channels for the material or carriers. Different channel proteins have different transport properties. Passage through the channel allows polar compounds to avoid the nonpolar central layer of the plasma membrane that would otherwise slow or prevent their entry into the cell.

Channel proteins are either open at all times or they are “gated.” The latter (gated) controls the opening of the channel. Various mechanisms may be involved in the gating mechanism. For instance, the attachment of a specific ion or small molecule to the channel protein may trigger opening. Changes in local membrane "stress" or changes in voltage across the membrane may also be triggers to open or close a channel.

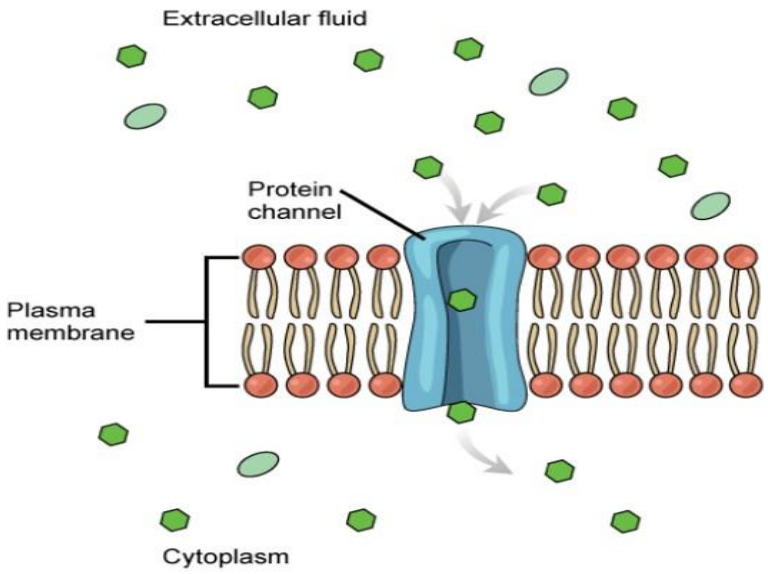

Figure: Facilitated transport moves substances down their concentration gradients. They may cross the plasma membrane with the aid of channel protein

Carrier protein. Carrier proteins are typically specific for a single substance. Carrier proteins play an important role in the function of kidneys. Glucose, water, salts, ions, and amino acids needed by the body are filtered in one part of the kidney. This filtrate, which includes glucose, is then reabsorbed in another part of the kidney with the help of carrier proteins. Because there are only a finite number of carrier proteins for glucose, if more glucose is present in the filtrate than the proteins can handle, the excess is not reabsorbed, and it is excreted from the body in the urine.

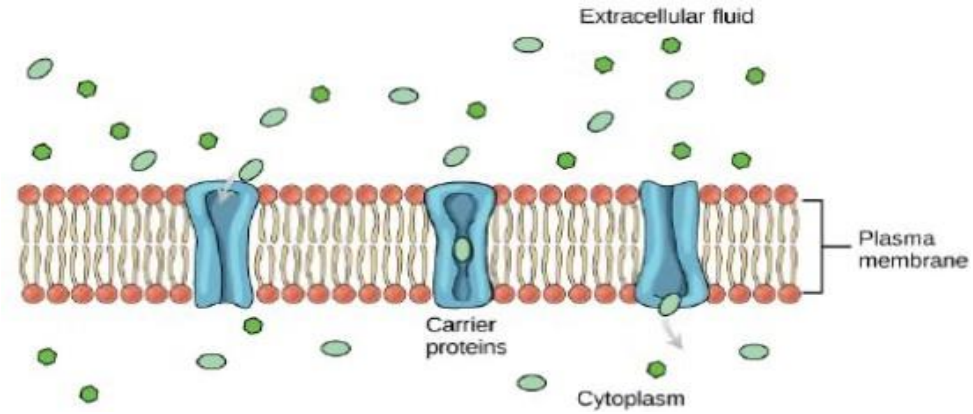

Figure: Some substances are able to move down their concentration gradient across the plasma membrane with the aid of carrier proteins. Carrier proteins change shape as they move molecules across the membrane.

Osmosis the diffusion of water across membrane

Osmosis is the movement of water through a semipermeable membrane according to the concentration gradient of water across the membrane, which is inversely proportional to the concentration of solutes. While diffusion transports material across membranes and within cells, osmosis transports *only water* across a membrane and the membrane limits the diffusion of solutes in the water.

Mechanism

Osmosis is a special case of diffusion. Water, like other substances, moves from an area of high concentration to one of low concentration. An obvious question is what makes water move at all? Imagine a beaker with a semipermeable membrane separating the two sides or halves. On both sides of the membrane the water level is the same, but there are different concentrations of a dissolved substance, or solute, that cannot cross the membrane. If the volume of the solution on both sides of the membrane is the same, but the concentrations of solute are different, then there are different amounts of water, the solvent, on either side of the membrane. So the solute cannot diffuse through the membrane, but the water can. Thus, water will diffuse down its concentration gradient, crossing the membrane to the side where it is less concentrated.

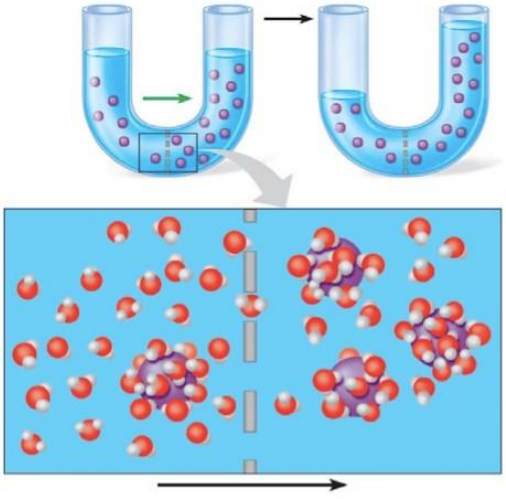

Figure: Osmosis the diffusion of water across membrane

The concentration of all solutes in a solution determines the **osmotic concentration** of the solution.

If two solutions have unequal osmotic concentrations,

The solution with the higher concentration is **hypertonic**,

The solution with the lower concentration is **hypotonic**.

When two solutions have the same osmotic concentration, the solutions are **isotonic.**

Active transport

Active transport: to move a solute against its concentration gradient "uphill" from a region of low concentration to a region of higher concentration. To do so, proteins and a source of energy (ATP) are available to transport molecules and ions across cell membrane against.

Active transport is carried out by special types of transporters called **pumps**, which gain an energy source to power the transport process.

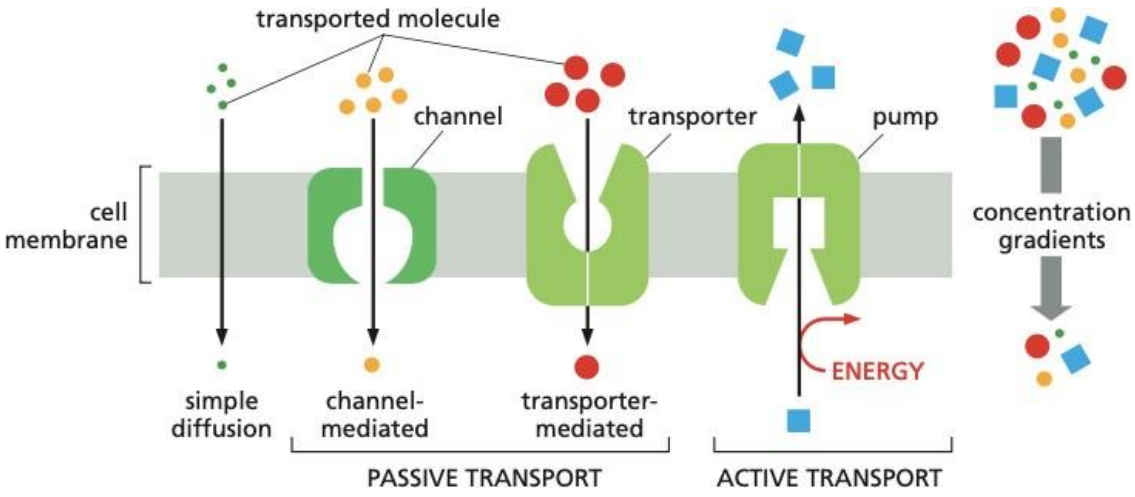

Figure: Solutes cross cell membranes by either passive or active transport.

Two mechanisms are existed for this transport

1. **Primary active transport** moves ions across a membrane and creates a difference in charge across that membrane, which is directly dependent on ATP.

Secondary active transport describes the movement of material that is due to the electrochemical gradient established by primary active transport that does not directly require ATP.

Endocytosis: is uptake process of molecules and transport it across cell membrane into the cell interior 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:

A. Phagocytosis: means "cell eating", occurs when large solid materials taken inside the cell, such as food particles, dead cell, cell debris or another cell such as bacteria. Best example on phagocytic cell is white blood cells (WBC) can engulf bacteria and worn- out red blood cells by phagocytosis. Digestion occurs when the resulting vacuole (phagocytic vacuole) fuses with a lysosome.

B. Pinocytosis: means "cell drinking", occurs when vesicles form around fluid droplets. e.g. cells that line the kidney tubules or intestinal wall use this method of ingesting water substances. Also an inherited form of cardiovascular disease occurs when cells fail to take up a combined lipoprotein and cholesterol molecule from the blood by pinocytosis.

C. Receptor- mediated endocytosis: A special form of endocytosis uses a receptor, a special form of membrane protein, on the surface of the cell to concentrate specific molecules of interest for endocytosis.

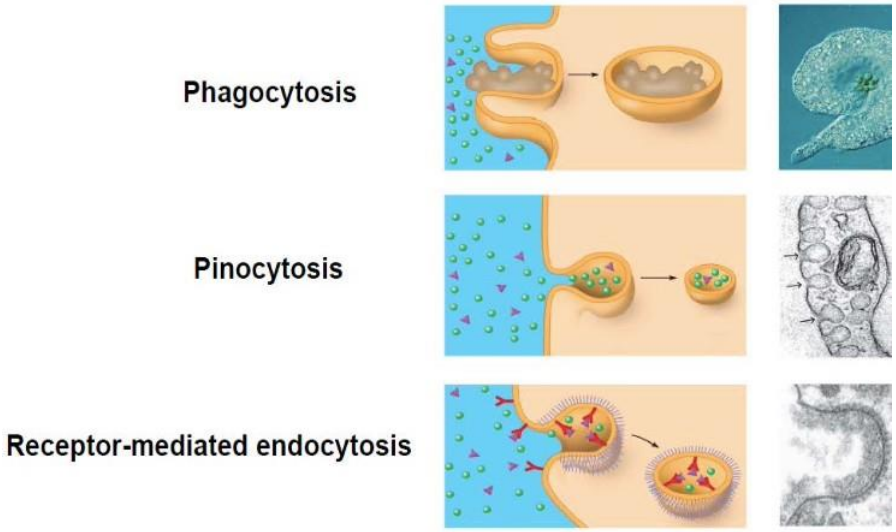

Figure: Methods of endocytosis

Exocytosis: is release process of material from the cell. During exocytosis vesicles often formed by Golgi apparatus and carrying a specific molecule fused with plasma membrane and secretion occurs. e.g. release of insulin molecules from beta cells.

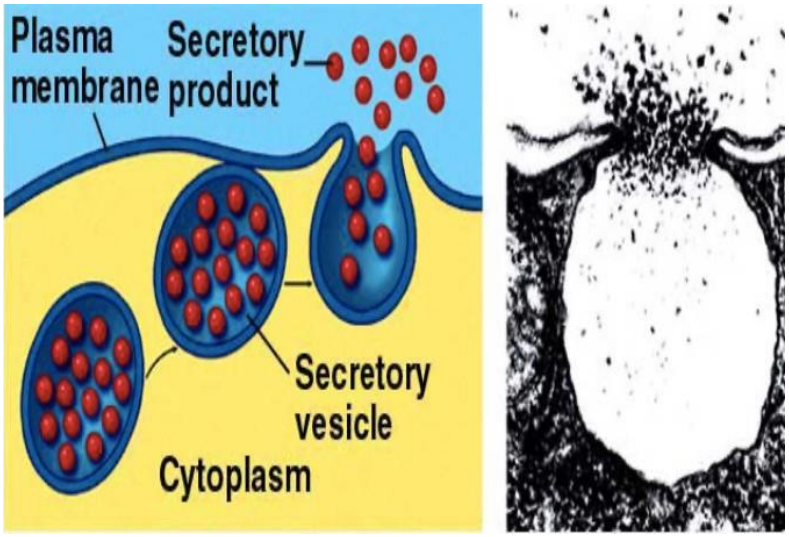

Figure: Method of exocytosis