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Transport Across Cell Membranes

The lipid bilayer is only permeable to small and nonpolar substances.

- Oxygen and carbon dioxide are nonpolar gases that freely diffuse from their areas of higher concentration to areas of lower concentration.
- Steroid hormones have a cholesterol-based structure and are able to pass through cell membranes, although more recent discoveries have demonstrated that even steroid hormones often make use of a variety of protein channels and transporters.
- Ethanol alcohol has a slow and limited ability to cross cell membranes, but it does help to explain some of its toxic effects.
- Even water, although small, is too polar to easily diffuse across the cell membrane.

Passive transport is movement down a concentration gradient.

- Simple diffusion is when the substance can pass through the lipid bilayer.
    - Gas exchange of oxygen and carbon dioxide is the best example for healthcare students of substances that don't need a transport channel.

Facilitated diffusion is passive transport that uses a channel.

- Aquaporins are extremely complex channels, formed from the coordinated interaction of 6 different proteins
    - They are inserted into the membrane under the influence of vasopressin - it allows the body to retain more water in the body and this raises blood pressure.
        - This hormone is also known as antidiuretic hormone (ADH, made in the pituitary gland) to emphasize that by retaining water, we make less urine.
        - Aquaporins facilitate **osmosis**, the diffusion of water. The channels allow water to move either direction. Sometimes water leaves cells, and sometimes it enters cells, always following the rules of diffusion. Understanding the movement of water under different medical circumstances will help you learn about fluid shifts such as what occurs in pulmonary edema or circulatory shock.
- Glucose channels. There are many different types of glucose channels, but almost all of them are passive transporters that merely allow glucose to flow down its concentration gradient.
    - Most relevant for healthcare students are the glucose channels that are inserted into the membrane under the influence of the hormone insulin. Glucose can then move down its concentration gradient from the bloodstream into the cell. This is how insulin lowers blood sugar.
- Voltage-gated sodium channel is an example of an ion channel in cell membranes.
    - Serum sodium is the concentration of sodium in the blood
    - maintained at 135 - 145 mEq/L at all times.
        - If it varies too much from this, patients can die because this exact concentration is essential for life - from brain activity to heart beating and contraction of respiratory muscles.
    - This channel opens its gate when the inside of the cell membrane becomes less negatively charged.

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    - Na+ enters because it is always more concentrated outside of the cell. It diffuses down its concentration gradient to enter the cell.
    - Na+ entry causes depolarization of a cell, and that causes the heart to beat, the respiratory muscles to work, and brain neurons to fire.
- Voltage-gated Potassium channels select only for potassium ions.
    - Serum K+ is very very low
    - only 3.5 - 5.1 mEq/L. This very low level is also essential for these life functions of breathing, heart contraction, and brain activity.
        - Notice the very high concentration of K+ ions that is maintained **inside** of the cell.
    - Opens its gate when the inside of the cell is positive or depolarized.
    - Since potassium is highly concentrated on the inside of the cell, it diffuses OUT of the cell to go down its concentration gradient.
    - K+ exit causes repolarization of a cell to make the inner membrane negative again.

Active Transport PUMPS substances against the concentration gradient and requires ATP.

- Na+/K+ ATPase pump.
    - This channel binds 3 Na+ ions, and forces them OUT of the cell by using the energy from hydrolysis of ATP to ADP. This burst of energy flips the pump outward, and it releases the Na+ ions into the extracellular fluid.
    - While it's flipped like this, it binds 2 K+ and brings them into the cell when it flips back to its original shape.
    - Uses ATP to PUMP UP the concentration gradients of Na+ and K+. Therefore, we call this The Na+/K+ ATPase pump keeps the serum Na+ and serum K+ concentrations steady so that life can continue!
    - This pump is the reason that sodium is always more concentrated outside of cells and potassium is always more concentrated inside of cells.
- Endocytosis, in which ATP energy is used to literally wrap the cell membrane around a substance it wants to bring inside.
    - White blood cells are particularly well-known for this sort of process, which in them we call phagocytosis.

In summary, biological membranes strictly regulate passage of all substances, and without such complex and coordinated regulation life could not exist.