MEMBRANE TRANSPORT

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MEMBRANE TRANSPORT

Movement of materials across a membrane will depend on both the size and solubility of the material. **Large** and **charged** molecules **cannot** freely cross the plasma membrane without additional assistance.

- Small, lipophilic molecules can freely pass across the bilayer (e.g. O_2 , CO_2 , water, steroids)
- Larger molecules or polar / charged molecules require membrane proteins to cross (e.g. glucose, ions)

TYPES OF TRANSPORT

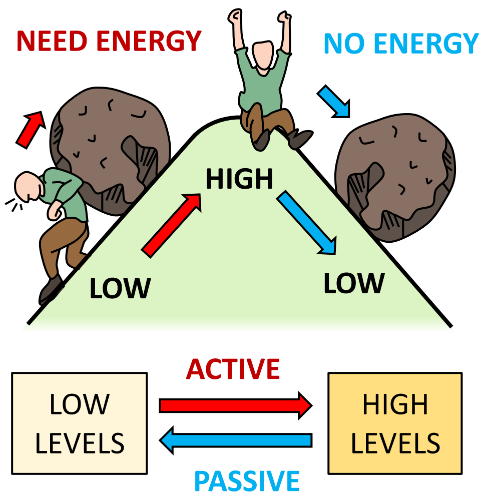
Movement of materials across a membrane may occur via:

Passive Transport:

- Movement from high concentration to low concentration (i.e. movement is **along** or **down** a concentration gradient)
- Does **not** involve the expenditure of energy (no ATP used)

Active Transport:

- Movement from low concentration to high concentration (i.e. movement occurs **against** a concentration gradient)
- **Does** involve the expenditure of energy (ATP is hydrolysed)

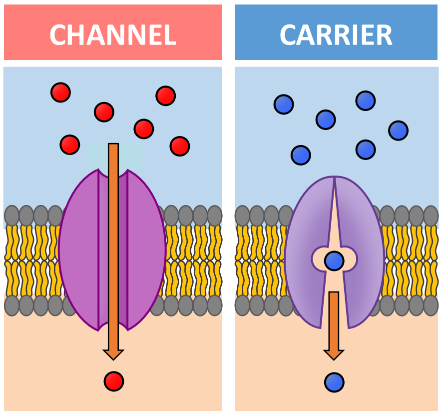


Passive transport mechanisms include either simple diffusion, facilitated diffusion or osmosis. The type of passive transport is determined by the **permeability** of the molecule involved. Active transport always involves *impermeable* molecules moving against a gradient (otherwise, they would simply move back passively along the gradient). Additionally, molecules may enter or exit the cell without crossing the membrane via cytosis. The membrane physically breaks and reforms around the material to facilitate its passage – this is an energy-dependent process and requires the use of ATP (but it is **not** active transport).

SIMPLE DIFFUSION

Diffusion is the net movement of molecules from a region of higher concentration to lower concentration. This movement along the gradient will continue until the molecules are evenly dispersed (i.e. equilibrium). Simple diffusion occurs when **small** or **non-polar molecules** can freely cross the plasma membrane without impediment (e.g. O_2, CO_2, ethanol, glycerol, fatty acids). The rate of diffusion will be influenced by the size of the gradient and the kinetic energy of the particles.

FACILITATED DIFFUSION



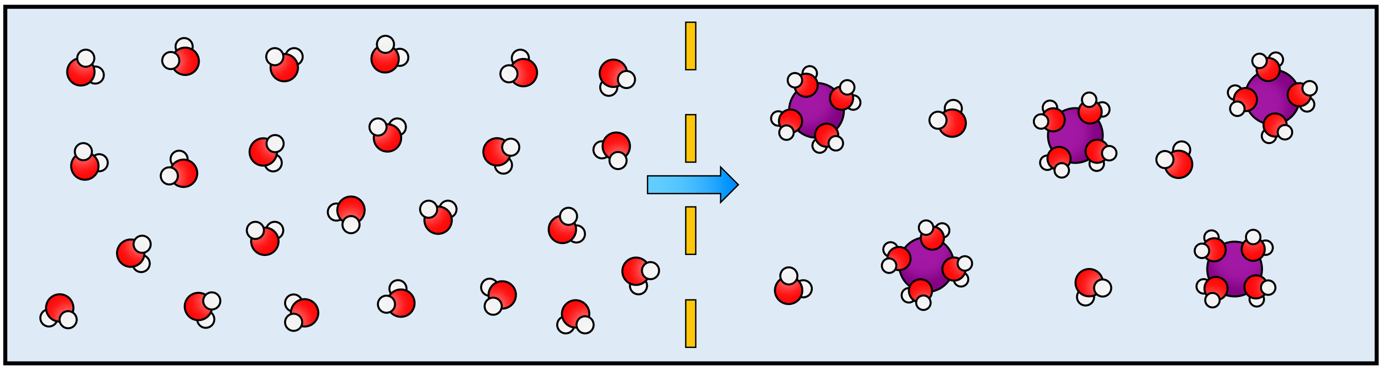
Facilitated diffusion is the passive movement of molecules across the cell membrane via the aid of a **membrane protein**. It is utilised by molecules that cannot cross a phospholipid bilayer unassisted (i.e. **large, polar molecules** or **ions**). The movement is facilitated by transport proteins (either carrier proteins or channel proteins).

- **Channel proteins** contain a hydrophilic pore to enable passage
- **Carrier proteins** undergo a conformational change in order to translocate molecules across a bilayer (slower than channels)

Channel proteins will typically contain a **selectivity filter** that enables the protein to adopt an 'open' or a 'closed' conformation – this allows the protein to regulate the timing and quantity of material being moved.

OSMOSIS

Osmosis is the diffusion of **free water** molecules. While water is a polar molecule, it is still small enough to move across the phospholipid bilayer without assistance. The polarity of water will cause it to move towards charged or polar solutes that cannot freely cross the membrane (water is the **universal solvent**). Hence, osmosis involves the net movement of water molecules across a semipermeable membrane from a region of low solute concentration to a region of higher solute concentration (until equilibrium is reached). A high solute solution will draw water and is called **hypertonic**, while a low solute solution will lose water and is called **hypotonic** (if two solutions have equal solute concentrations, they are described as **isotonic**).



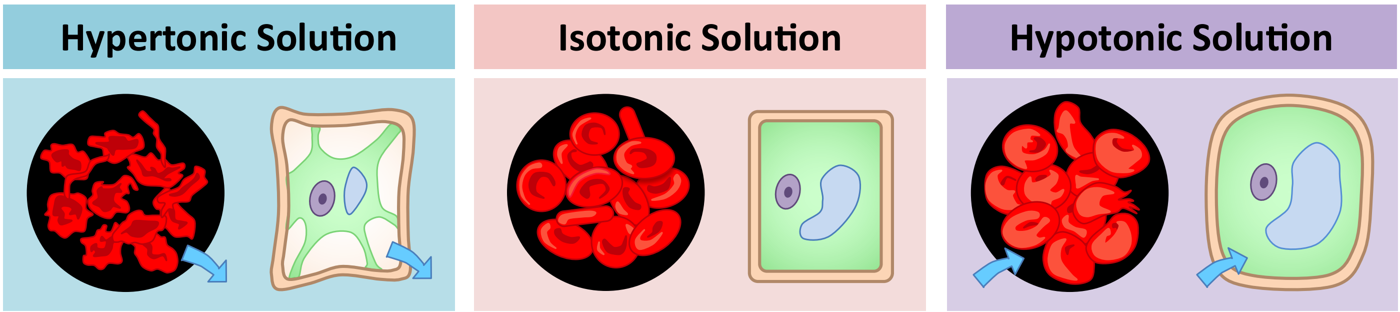
Hypotonic: *low solute levels = high free water* ➡ **Hypertonic:** *high solute level = low free water*

AQUAPORINS

While water is small enough to pass freely across the phospholipid bilayer, certain cell membranes may also include integral proteins called **aquaporins** that function as selective water channels. Aquaporins facilitate a much faster rate of water transport in response to solute concentrations and their levels can be regulated to help control osmotic conditions in cells. Aquaporins are often found in kidney cells (for osmoregulation).

OSMOTIC EFFECTS

An influx of water into a cell (due to an increase in solute concentration) will increase the osmotic pressure within a cell and cause it to swell. If the cell lacks a rigid cell wall, it will eventually burst (**lysis**) – otherwise the membrane will press up against the cell wall, making the cell **turgid**. An efflux of water out of the cell (due to decrease in solute concentration inside the cell) will lower the osmotic pressure within the cell and cause it to shrivel (**crenation**). If the cell has a rigid cell wall, the membrane will move away from this outer boundary and create a region of empty space (**plasmolysis**) – this is why plants will *wilt* in dry conditions.



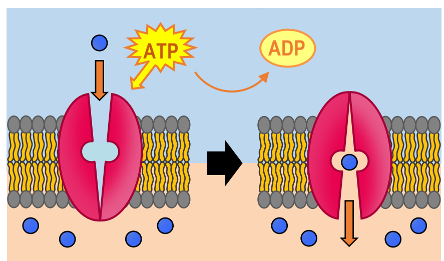
Due to the effects of osmosis on cell morphology, it is important that cells lacking a cell wall are generally maintained in isotonic conditions. This is why organs for transplant must be bathed in isotonic solutions prior to surgery, and also why any intravenous fluids administered as part of **medical treatments** (such as dehydration or excessive blood loss) must be relatively isotonic. Any prolonged exposure to hypertonic or hypotonic solutions would eventually lead to tissue damage and threaten the survival of the individual.

CONTRACTILE VACUOLES

Unicellular organisms (such as protists) are especially susceptible to changes in solute concentration, as the single cell must carry out all the functions of life. These cells will often possess **contractile vacuoles** to help regulate water levels. Radiating canals draw water into contractile vacuoles, causing it to swell (diastole). The vacuole then fuses with the plasma membrane and the excess water is expelled (systole). The amount of water expelled and the frequency of contractions will be determined by external solute concentrations.

ACTIVE TRANSPORT

Active transport uses **energy** to move molecules against a gradient. This involves the use of protein pumps, which use **ATP hydrolysis** to trigger a conformational change that translocates molecules to the regions of higher concentration. Only molecules that cannot freely cross the membrane can be actively transported **against a gradient**.



BULK TRANSPORT (CYTOSIS)

The fluidity of membranes allows materials to be taken in or released by cells **without crossing the bilayer**. The membrane is principally held together by weak hydrophobic associations between the fatty acid tails of the phospholipids. These weak interactions can be spontaneously broken and reformed in a process that is energy dependent and requires ATP hydrolysis. Sections of a membrane can be excised to form internal **vesicles**, while membrane segments can be added as a result of fusion between the membrane and vesicle.

- Exocytosis is the process by which intracellular materials **exit a cell** without crossing the membrane – the materials to be exported must first be packaged into a membranous vesicle by the Golgi apparatus.
- Endocytosis is the process by which extracellular materials **enter a cell** without crossing the membrane.