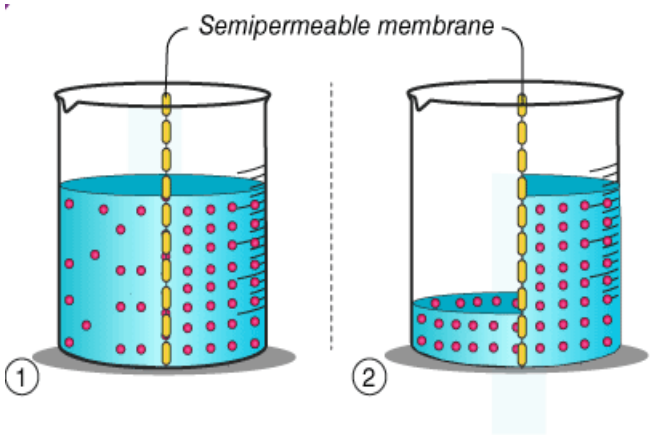
B.Sc. Botany 3rd Year

by Dr. Raman Kumar Ravi

Osmosis

"Osmosis is a process by which the molecules of a solvent pass from a solution of low concentration to a solution of high concentration through a semi-permeable membrane."



Osmosis is a passive process and happens without any expenditure of energy. It involves the movement of molecules from a region of higher concentration to lower concentration until the concentrations become equal on either side of the membrane. Any solvent can undergo the process of osmosis including gases and supercritical liquids.

Osmotic Solutions

There are three different types of solutions:

- Isotonic Solution
- Hypertonic Solution
- Hypotonic Solution

- An **isotonic solution** is one that has the same concentration of solutes both inside and outside the cell.
- A **hypertonic solution** is one that has a higher solute concentration outside the cell than inside.
- A **hypotonic solution** is one that has a higher solute concentration inside the cell than outside.

Types of Osmosis

Osmosis is of two types:

- **Endosmosis**– When a substance is placed in a hypotonic solution, the solvent molecules move inside the cell and the cell becomes turgid or undergoes deplasmolysis. This is known as endosmosis.
- **Exosmosis**– When a substance is placed in a hypertonic solution, the solvent molecules move outside the cell and the cell becomes flaccid or undergoes plasmolysis. This is known as exosmosis.

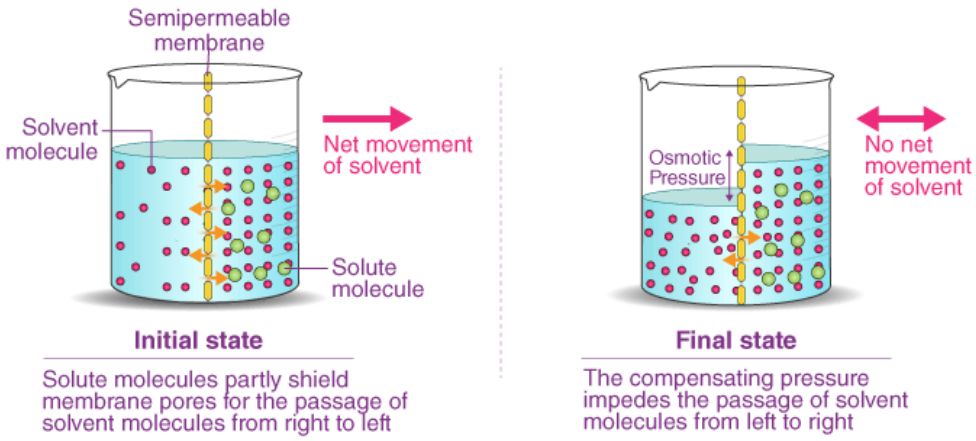
Effect of Osmosis on Cells

Osmosis affects the cells differently. An animal cell will lyse when placed in a hypotonic solution compared to a plant cell. The plant cell has thick walls and requires more water. The cells will not burst when placed in a hypotonic solution. In fact, a hypotonic solution is ideal for a plant cell.

An animal cell survives only in an isotonic solution. In an isotonic solution, the plant cells are no longer turgid and the leaves of the plant droop.

The osmotic flow can be stopped or reversed, also called reverse osmosis, by exerting an external pressure to the sides of the solute. The minimum pressure required to stop the solvent transfer is called the osmotic pressure.

Osmotic Pressure



Osmotic pressure is the pressure required to stop water from diffusing through a membrane by osmosis. It is determined by the concentration of the solute. Water diffuses into the area of

higher concentration from the area of lower concentration. When the concentration of the substances in the two areas in contact is different, the substances will diffuse until the concentration is uniform throughout.

Osmotic pressure can be calculated using the equation:

$\Pi = MRT$

where Π denotes the osmotic pressure,

M is the molar concentration of the solute,

R is the gas constant,

T is the temperature

Significance of Osmosis

- Osmosis influences the transport of nutrients and the release of metabolic waste products.
- It is responsible for the absorption of water from the soil and conducting it to the upper parts of the plant through the xylem.
- It stabilizes the internal environment of a living organism by maintaining the balance between water and intercellular fluid levels.
- It maintains the turgidity of cells.
- It is a process by which plants maintain their water content despite the constant water loss due to transpiration.
- This process controls the cell to cell diffusion of water.
- Osmosis induces cell turgor which regulates the movement of plants and plant parts.
- Osmosis also controls the dehiscence of fruits and sporangia.
- Higher osmotic pressure protects the plants against drought injury.

Examples of Osmosis

Osmosis has a significant role to play in plants, animals and also in humans. In an animal cell, osmosis helps in absorbing water from the intestines to the blood.

Listed below are some examples of Osmosis.

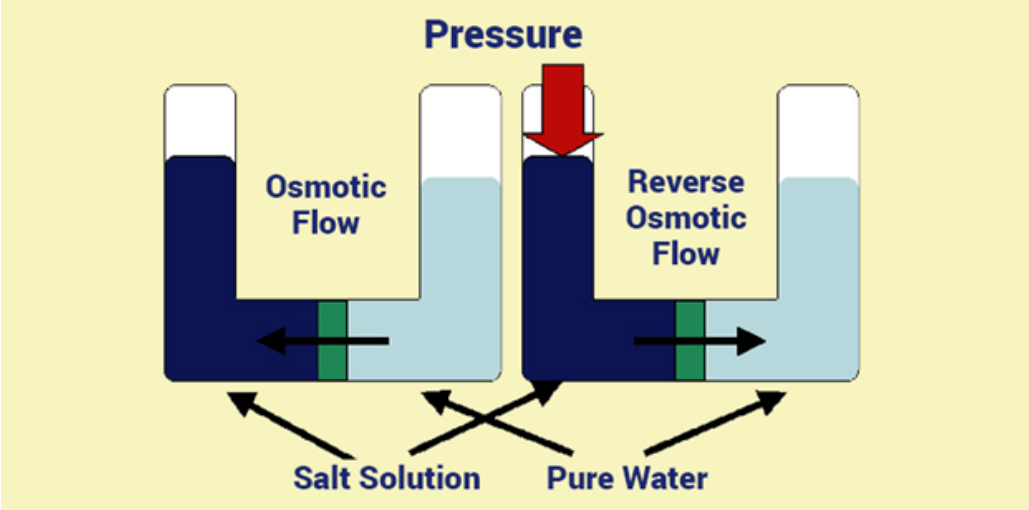
- The absorption of water from the soil is due to osmosis. The plant roots have a higher concentration than the soil. Therefore, the water flows into the roots.
- The guard cells of the plants are also affected by osmosis. When the plant cells are filled with water, the guard cells swell up, and the stomata open.
- If a freshwater or saltwater fish is placed in the water with different salt concentrations, the fish dies due to the entry or exit of water in the cells of the fish.
- Humans suffering from cholera are also affected by osmosis. The bacteria that overpopulate the intestines reverse the flow of absorption and do not allow water to be absorbed by the intestines, which results in dehydration.
- When the fingers are placed in water for a longer period of time, they become pruney due to the flow of water inside the cells.

Reverse Osmosis

> "Reverse osmosis is a special type of filtration that uses a semi-permeable, porous membrane that allows only pure water to pass through it filtering the larger molecules or impurities."

Reverse osmosis is the process in which pressure is applied to overcome colligative property and osmotic pressure that is directed by a thermodynamic parameter and a chemical difference of a solvent.

This application is mainly applied in the production of potable water in water plants and in industries. The end result will be the solute. It happens when the pure solvent is allowed to follow to one end of the membrane thus allowing a solute to retain in a permissible side of a membrane. Reverse osmosis removes suspended and types of dissolved species from water including bacteria.



Reverse Osmosis Principle

Reverse osmosis works by reversing the principle of osmosis. The salt solution is subjected to pressure and pressed against the semi-permeable membrane. Here, the applied pressure is greater than the osmotic pressure. Thus, the molecules move from a highly concentrated solution to a less concentrated solution.

Working of Reverse Osmosis

Diffusion is a process by which the molecules move from the region of higher concentration to lower concentration. There is a net movement meaning more molecules moving in one direction than in the opposite direction.

In osmosis, the water molecules and the concentration gradient occurs over the semipermeable membrane which allows the entry of water and blocks the passage of ions and other larger molecules including sodium, chlorine, bacteria, glucose, etc.

Reverse osmosis is the process or the technology which is used to remove ions, mineral chemicals, and other impurities from drinking water. In this process, greater pressure is applied, forcing the water to travel through the semipermeable membrane in opposite to natural osmosis.

Reverse Osmosis works on the same principle as osmosis, but in the reverse direction. In this process direction of water flow is reversed by applying greater pressure.

For instance, consider a semipermeable membrane placed between the freshwater and concentrated aqueous solution. In natural osmosis, the freshwater will cross the semipermeable membrane and dilutes the concentrated solution. In reverse osmosis, the pressure is applied

towards the concentrated aqueous solution and the water molecules are forced to cross the membrane towards the freshwater.

Contaminants Removed by Reverse Osmosis from Water

Reverse osmosis removes 99% of dissolved salts particles, colloids, bacteria, pyrogens from feed water. The contaminants are separated by the RO membrane on the basis of size and charge. The smaller the charge of the contaminant, the more are the chances for it to pass through the RO membrane. For e.g., sodium and calcium are monovalent and divalent respectively. Due to their smaller charges, they can easily pass through the membrane. Similarly, RO cannot remove gases such as carbon dioxide from the water because they are not highly ionized.

Difference between Osmosis and Reverse Osmosis

Following are the major differences between osmosis and reverse osmosis:

Osmosis	Reverse Osmosis
This is the process by which the molecules of a solvent pass through the semi-permeable membrane from a region of lower concentration to a higher concentration.	This is the process by which the molecules of a solvent pass through the semi-permeable from a region of higher concentration to lower concentration when pressure greater than the osmotic pressure is applied.
It is a natural process.	It is an artificial process.
Occurs along the potential gradient.	Occurs against the potential gradient.
This is observed during the opening of stomata and absorption of water from the soil by the roots.	This is used in water purification systems.