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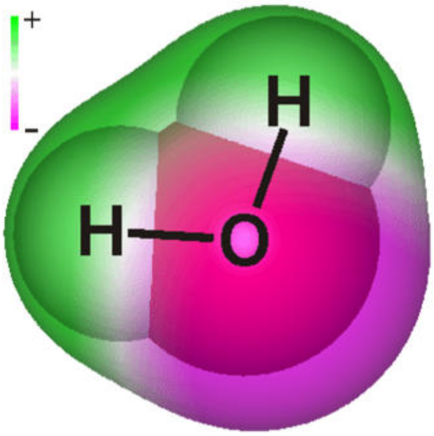
Water

- **Water structure, Introduction**

Water is a tiny bent molecule with the molecular formula H_2O, consisting of two light hydrogen atoms attached to each 16-fold heavier oxygen atom. Each molecule is electrically neutral but polar, with the center of positive and negative charges located in different places. Each hydrogen atom has a nucleus consisting of a single positively-charged proton surrounded by a 'cloud' of a single negatively-charged electron and the oxygen atom has a nucleus consisting of a eight positively-charged protons and eight uncharged neutrons surrounded by a 'cloud' of a eight negatively-charged electrons. On forming the molecule, the ten electrons pair up into five 'orbitals', one pair closely associated with the oxygen atom, two pairs associated with the oxygen atom as 'outer' electrons and two pairs forming each of the two identical O-H covalent bonds.



The Importance of Water in Plants and in Crop Agriculture: A Climatic Factor

The importance of water relates to its essential functions in perpetuating both plant and animal life. It is an absolute requirement for all living organisms. Anaerobic organisms can live without oxygen, but they cannot without water.

In crop agriculture, water is an important climatic factor. It affects or determines plant growth and development. Its availability, or scarcity, can mean a successful harvest, or diminution in yield, or total failure. According to FAO (2011), irrigation typically doubles farm yields and the number of crops grown in one year is increased from 1 to 2.

But plant responses differ and the importance of water likewise differ depending on plant species. Most plants are mesophytes, that is, they are adapted to conditions with moderate supply of water. But some, called hydrophytes, require watery or water-logged habitats while others, called xerophytes, are more tolerant to dry conditions. The resurrection plants are in fact capable of surviving near complete dessication. They are capable of losing 90% or more of cellular water in their vegetative tissues and still remain alive. They can remain dried and appear somewhat dead for several years but, when rehydrated, suddenly spring back to life (Le and McQueen-Mason 2006).

Diffusion :

Diffusion is the net movement of molecules or atoms from a region of high concentration (or high chemical potential) to a region of low concentration (or low chemical potential). This is also referred to as the movement of a substance down a concentration gradient.

A gradient is the change in the value of a quantity (e.g., concentration, pressure, temperature) with the change in another variable (usually distance). For example, a change in concentration over a distance is called a concentration gradient, a change in pressure over a distance is called a pressure gradient, and a change in temperature over a distance is a called a temperature gradient.

The word **diffusion** derives from the Latin word, *diffundere*, which means "to spread out" (a substance that “spreads out” is moving from an area of high concentration to an area of low concentration).

A distinguishing feature of diffusion is that it is dependent on particle random walk and results in mixing or mass transport, without requiring directed bulk motion. Bulk motion (bulk flow) is the characteristic of advection.[1] The term convection is used to describe the combination of both transport phenomena.

Factor Affect on Rate of Diffusion

Four Things That Affect Rate of Diffusion

1. TEMPERATURE

Of all the factors that influence diffusion rate, temperature is the most important. Temperature has the greatest effect on diffusion rates and is the easiest of the factors to change. Increasing the temperature increases the diffusion rate by adding energy to each particle. This is because particles with more energy bounce against each other more frequently and spread evenly throughout the material volume. Similarly, lowering the temperature will lower .the diffusion rate by lowering the energy of each particle

2. CONCENTRATION DIFFERENCE

The rate of diffusion depends on the difference between concentrations across the host material, with higher concentration differences resulting in higher diffusion rates. For example, diffusion through a thin wall or membrane will occur quickly if there is a high concentration of the gas on one side and none of the gas on the other side of the wall. If there is already an almost equal .amount of gas on both sides, diffusion will be much slower

3. DIFFUSION DISTANCE

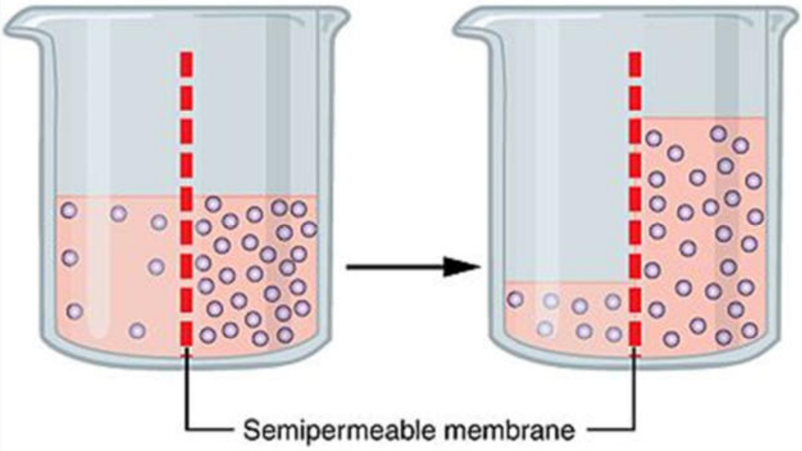
The rate of diffusion is inversely related to the distance through which the material is diffusing. That is, smaller distances result in faster diffusion rates and larger distances result in slower diffusion rates. This makes sense, since a gas diffuses through a thin wall .much faster than it would diffuse through a thick wall

4. DIFFUSING AND HOST MATERIALS

Diffusion rate also depends on both the material that is diffusing and the material it is diffusing through. At a certain temperature, all particles have the same average energy. This means that lighter atoms, such as hydrogen, carbon, oxygen and nitrogen travel faster and are more mobile than larger atoms such as copper or iron. Materials made of these lighter atoms diffuse faster than heavier materials.

osmosis

For other uses, see Osmosis (disambiguation).



The process of osmosis over a semi-permeable membrane, the blue dots represent particles driving the osmotic gradient

Osmosis is the spontaneous net movement of solvent molecules through a semi-permeable membrane into a region of higher solute concentration, in the direction that tends to equalize the solute concentrations on the two sides.[1][2][3] It may also be used to describe a physical process in which any solvent moves across a semipermeable membrane (permeable to the solvent, but not the solute) separating two solutions of different concentrations.[4][5] Osmosis can be made to do work.[6]

Osmotic pressure is defined as the external pressure required to be applied so that there

is no net movement of solvent across the membrane. Osmotic pressure is a colligative property, meaning that the osmotic pressure depends on the molar concentration of the solute but not on its identity.

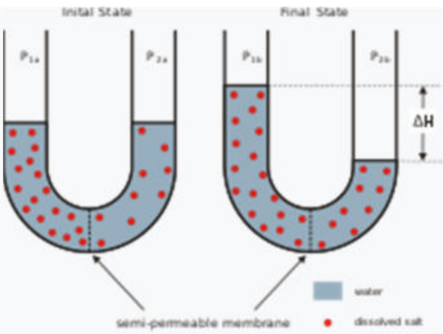
Osmosis is a vital process in biological systems, as biological membranes are semipermeable. In general, these membranes are impermeable to large and polar molecules, such as ions, proteins, and polysaccharides, while being permeable to non-polar and/or hydrophobic molecules like lipids as well as to small molecules like oxygen, carbon dioxide, nitrogen, and nitric oxide. Permeability depends on solubility, charge, or chemistry, as well as solute size. Water molecules travel through the plasma membrane, tonoplast membrane (vacuole) or protoplast by diffusing across the phospholipid bilayer via aquaporins (small transmembrane proteins similar to those responsible for facilitated diffusion and ion channels). Osmosis provides the primary means by which water is transported into and out of cells. The turgor pressure of a cell is largely maintained by osmosis across the cell membrane between the cell interior and its relatively hypotonic environment.

Jean-Antoine Nollet first documented observation of osmosis in 1748.[7] The word "osmosis" descends from the words "endosmose" and "exosmose", which were coined by French physician René Joachim Henri Dutrochet (1776–1847) from the Greek words ἔνδον (*éndon* “within”), ἔξω (*éxō* “outer, external”), and ὠσμός (*ōsmós* "push, impulsion").[8]

Mechanism

Osmosis is the movement of a solvent across a semipermeable membrane toward a higher concentration of solute. In biological systems, the solvent is typically water, but osmosis can occur in other liquids, supercritical liquids, and even gases.[9][10]

When a cell is submerged in water, the water molecules pass through the cell membrane from an area of low solute concentration to high solute concentration. For example, if the cell is submerged in saltwater, water molecules move out of the cell. If a cell is submerged in freshwater, water molecules move into the cell.

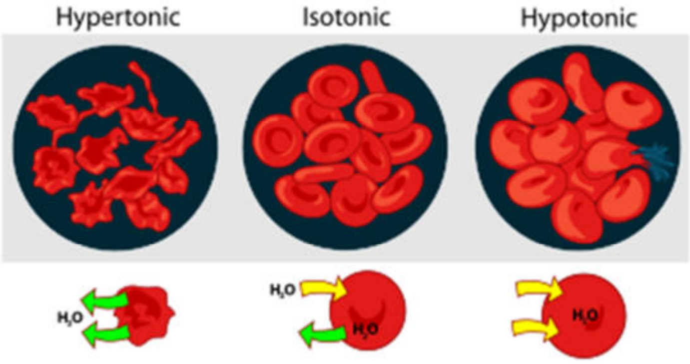


Water passing through a semi-permeable membrane

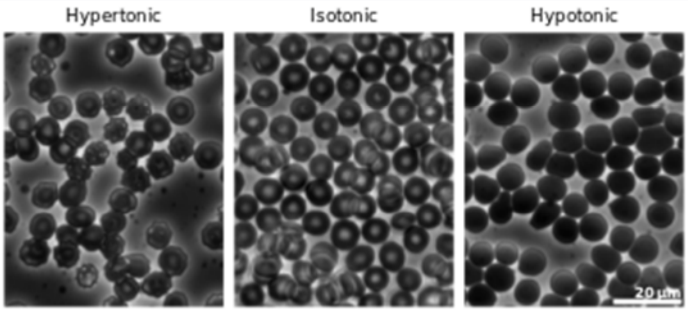
When the membrane has a volume of pure water on both sides, water molecules pass in and out in each direction at exactly the same rate. There is no net flow of water through the membrane.

The mechanism responsible for driving osmosis has commonly been represented in biology and chemistry texts as either the dilution of water by solute (resulting in lower concentration of water on the higher solute concentration side of the membrane and therefore a diffusion of water along a concentration gradient) or by a solute's attraction to water (resulting in less free water on the higher solute concentration side of the membrane and therefore net movement of water toward the solute). Both of these notions have been conclusively refuted.

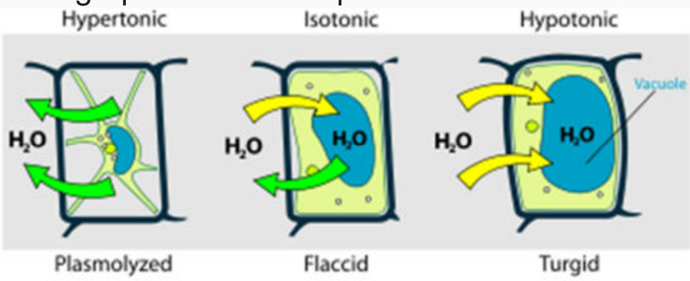
The diffusion model of osmosis is rendered untenable by the fact that osmosis can drive water across a membrane toward a higher concentration of water.[11] The "bound water" model is refuted by the fact that osmosis is independent of the size of the solute molecules—a colligative property[12]—or how hydrophilic they are.



Effect of different solutions on blood cells



Micrographs of osmotic pressure on red blood cells(RBC)



Plant cell under different environments.

It is hard to describe osmosis without a mechanical or thermodynamic explanation, but basically, there is an interaction between the solute and water that counteracts the pressure that otherwise free solute molecules would exert. One fact to take note of is that heat from the surroundings is able to be converted into mechanical energy (water rising).

Many thermodynamic explanations go into the concept of chemical potential and how the function of the water on the solution side differs from that of pure water due to the higher pressure and the presence of the solute counteracting such that the chemical potential remains unchanged. The virial theorem demonstrates that attraction between the molecules (water and solute) reduces the pressure, and thus the pressure exerted by water molecules on each other in solution is less than in pure water, allowing pure water to "force" the solution until the pressure reaches equilibrium.[13]

Osmotic pressure is the main cause of support in many plants. The osmotic entry of water raises the turgor pressure exerted against the cell wall, until it equals the osmotic pressure, creating a steady state.

When a plant cell is placed in a solution that is hypertonic relative to the cytoplasm, water moves out of the cell and the cell shrinks. In doing so, the cell becomes *flaccid*. In extreme cases, the cell becomes plasmolyzed – the cell membranedisen gages with the cell wall due to lack of water pressure on it.

When a plant cell is placed in a solution that is hypotonic relative to the cytoplasm, water moves into the cell and the cell swells to become *turgid*.

Osmosis is responsible for the ability of plant roots to draw water from the soil. Plants concentrate solutes in their root cells by active transport, and water enters the roots by osmosis. Osmosis is also responsible for controlling the movement of guard cells.

Osmosis can be demonstrated when potato slices are added to a high salt solution. The water from inside the potato moves out to the solution, causing the potato to shrink and to lose its 'turgor pressure'. The more concentrated the salt solution, the bigger the difference in size and weight of the potato slice.

In unusual environments, osmosis can be very harmful to organisms. For example, freshwater and saltwater aquarium fish placed in water of a different salinity than that to which they are adapted to will die quickly, and in the case of saltwater fish, dramatically. Another example of a harmful osmotic effect is the use of table salt to kill leeches and slugs.

Suppose an animal or a plant cell is placed in a solution of sugar or salt in water.

1. If the medium is *hypotonic* relative to the cell cytoplasm — the cell will gain water through osmosis.

2. If the medium is *isotonic* — there will be no net movement of water across the cell membrane.
3. If the medium is *hypertonic* relative to the cell cytoplasm — the cell will lose water by osmosis.

Essentially, this means that if a cell is put in a solution which has a solute concentration higher than its own, it will shrivel, and if it is put in a solution with a lower solute concentration than its own, the cell will swell and may even burst.

Chemical gardens demonstrate the effect of osmosis in inorganic chemistry.

Factors

Osmotic pressure

Main article: Osmotic pressure

As mentioned before, osmosis may be opposed by increasing the pressure in the region of high solute concentration with respect to that in the low solute concentration region. The force per unit area, or pressure, required to prevent the passage of water through a selectively permeable membrane and into a solution of greater concentration is equivalent to the osmotic pressure of the solution, or turgor. Osmotic pressure is a colligative property, meaning that the property depends on the concentration of the solute, but not on its identity. It also is involved in facilitated diffusion.

Osmotic gradient

The osmotic gradient is the difference in concentration between two solutions on either side of a semipermeable membrane, and is used to tell the difference in percentages of the concentration of a specific particle dissolved in a solution.

Usually the osmotic gradient is used while comparing solutions that have a semipermeable membrane between them allowing water to diffuse between the two solutions, toward the hypertonic solution (the solution with the higher concentration). Eventually, the force of the column of water on the hypertonic side of the semipermeable membrane will equal the force of diffusion on the hypotonic (the side with a lesser concentration) side, creating equilibrium. When equilibrium is reached, water continues to flow, but it flows both ways in equal amounts as well as force, therefore stabilizing the solution.