Osmotic pressure

Osmotic pressure π can be defined as the excess pressure that would have to act on a solution separated from a pure solvent by a semipermeable membrane in order for the levels to equalize.

Osmotic pressure can be calculated from the formula $\pi = i \cdot c \cdot R \cdot T$

- where *c* is the molar concentration
- *R* molar gas constant
- *T* thermodynamic temperature
- *i* expresses the number of osmotically effective particles (for strong electrolytes; for weak electrolytes *i* is equal to 1)

The unit of osmotic pressure is *Pascal*

Osmosis

Osmosis is a process that is characterized by the penetration of a solvent (most often water) through a semipermeable cell membrane, while the extracellular and intracellular environment of the cell is not in equilibrium in terms of the chemical concentration of substances dissolved in the solvent.

Cell membrane

it is semipermeable, ensures the mediation of substances needed for the cell - metabolically / informationally

History

1855 – Nägeli – discovery of the existence of a membrane that protects the cell and description of its semi-permeability

chemical composition described earlier than ultrastructure – by isolating cell membranes by hemolysis of erythrocytes

1925 - Gartner and Grendel - cell membrane formed from a bimolecular layer of lipids with a high content of phospholipids - hydrophilic and hydrophobic parts of phospholipids, protein molecules - binding to the hydrophilic parts of these molecules

1935 – Dawson and Danielli – model of the cell membrane

50's - Robertson - dealt with the ultrastructure of membranes - discovered that individual membranes (cell membrane, biomembranes of organelles, karyolema) differ mainly in thickness

thinner and less compact membranes – formed by phospholipids with unsaturated bonds in the phospholipid molecule the ultrastructure is basically the same in all of them transmission electron microscope – membranes appear triple layered (triple / double contoured), he believed that the dens layers were protein and the middle layer lipid,he called cell membranes - unit membranes - they separate individual compartments

1972 - Singer and Nicholson - new model of the cell membrane fluid mosaic or two-dimensional fluid model components of the membrane coded by the genome → but the resulting form given in a matrix way → multiplication of membranes according to the existing membrane (maternal origin)

The structure of the cell membrane

The basis is a bimolecular layer of phospholipids:

- **outer sheet** – borders the extracellular space

contains molecules of phosphatidylcholine or lecithin and sphingomyelin or sphingolecithin

- **inner sheet** - borders the intracellular space (to the cytoplasm)

contains molecules of phosphatidylethanolamine or kephalin + phosphatidylinositol + phosphatidylserine or serinekephalin

- rotation of phospholipids can occur - within the sheet / flipping of phospholipid from one sheet to another (due to the effect of the scramblase enzyme)

Phospholipid molecules - derived from triacylglycerols, in the cell membrane their long apolar hydrophobic chains are in the center of the cell membrane and their hydrophilic parts form the surfaces

Cholesterol molecules - interspersed between phospholipids, accumulate together with transmembrane sections of protein or glycolipid molecules, thereby limiting their lateral diffusion (i.e. floating through the membrane sheet) forming *lipid rafts* - functional microdomains

Glycolipid molecules – especially in the outer leaf

Proteins - about 50% of the weight of the membrane (representation varies in individual membranes)

→ **Consequence** – asymmetry of the cell membrane

Movement of substances in the body
absorption
distribution
metabolism
exkrece

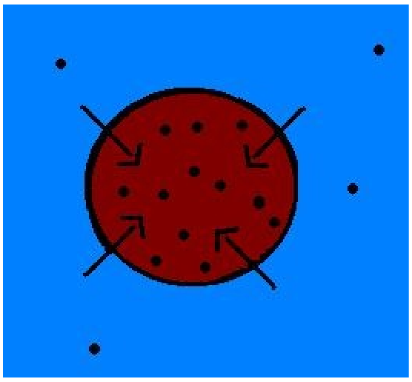
The passage of substances through cell membranes

Active transport	Passive transport
transport using carriers	simple and facilitated diffusion
pinocytóza	permeation through membrane pores
	osmosis
	filtration
	ultrafiltrace

Classification of the osmotic process from the point of view of its functional use in medicine

Hypotonic solution. Hypertonic solution. Isotonic solution.

Total



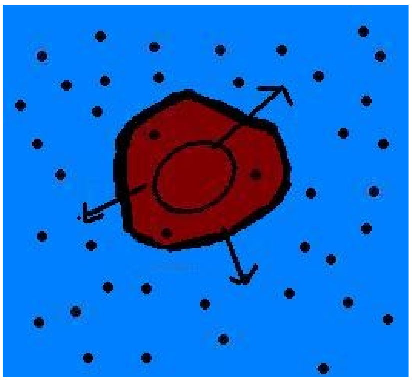
Hypotonic soltuion

1. **Intravascular** - administration of the entire dose of the drug directly into the bloodstream, the fastest effect.

- intravenously - into a vein
- intra-arterial – into the artery
- intracardially - into the heart

1. **Extravascular** - administration of substances into the tissue; substances are absorbed into the bloodstream at the site of application.

- intramuscular - intramuscular
- sublingual - sublingual
- intradermal - into the skin
- subcutaneous - subcutaneous
- oral - oral
- rectal - into the anus
- intraperitoneal - into the abdominal cavity
- inhalation - by inhalation



Hypertonic solution

Local

The substance is administered locally on the surface of the skin, mucous membrane or body cavity, where it is absorbed due to its chemical and physical nature, resulting in a local effect of the substance.

The course of osmosis in terms of environmental variability

Hypotonic environment :

- extracellular environment – lower concentration of solute in the solvent
- intracellular environment – greater concentration of solute in the solvent

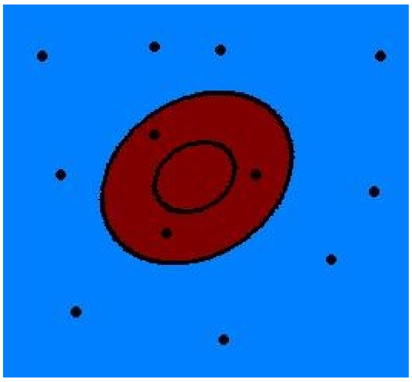
Hypertonic environment :

- extracellular environment – greater concentration of solute in the solvent

- intracellular environment – lower concentration of solute in the solvent

Isotonic environment :

- extracellular / intracellular environment - the same concentration of dissolved substances



Isotonic solution

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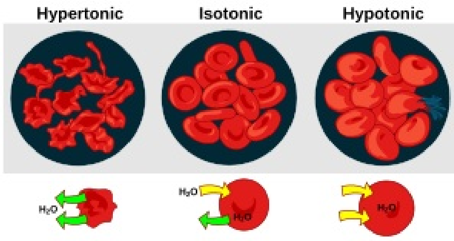
Differential osmotic pressure



Behavior of erythrocytes in hypertonic, isotonic and hypotonic environments.

Behavior of erythrocytes in hypertonic, isotonic and hypotonic environments. The difference in osmotic pressure in the intracellular and extracellular spaces is the trigger for osmosis in living organisms. If the osmotic pressure is higher in the surrounding environment than in the cell, water will begin to pass through the semipermeable plasma membrane out of the cell. We are talking about the so-called *plasmolysis* .

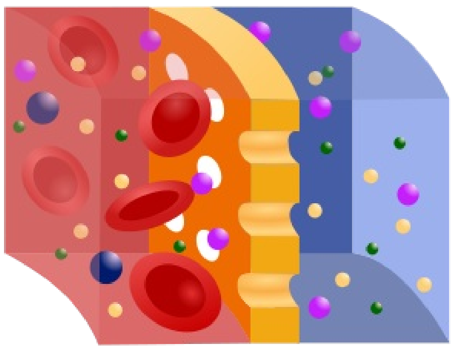
The opposite case is *plasmoptysis* . This occurs when the osmotic pressure in the cell is higher than in its surroundings. Water begins to enter the cell through its cytoplasmic membrane, which can lead to cell rupture. In erythrocytes, this process is called hemolysis and you can see it in the attached image on the far right.

In living organisms, the extracellular and intracellular environment should be isotonic, otherwise cells are damaged by excessive water intake or loss.

Oncotic pressure

Permeation of substances through a semipermeable membrane. Oncotic pressure or *colloid-osmotic pressure* is the osmotic pressure caused by solutions containing particles with a large molecular weight (e.g. proteins)

Osmolarity and osmolality



Permeation of substances through a semipermeable membrane.

To make it easier to compare the concentrations of dissolved particles in practice, we introduce the terms osmolarity and osmolality.

We define osmolarity as the total substance concentration of osmotically active particles in mol/l (referred to the volume of the solution).

Osmolality is then the total substance concentration of osmotically active particles in mol/kg (referred to the weight of the solution). Blood plasma has an osmolality of approximately 300 mmol/kg, and we most often compare the osmolality of other solutions with this value.

Summary and connections between osmosis and osmotic pressure

Osmosis

The solvent tends to penetrate through semi-permeable membranes to places where the concentration of osmotically active substances is higher and dilute them.

- If the solute concentration inside the cell is higher than outside the cell, water will osmotically move in and the cell will swell.

- Ways a cell avoids swelling:

1. the animal cell maintains a low internal solute concentration by actively pumping out ions

2. the plant cell is protected from swelling and bursting by a rigid wall
3. the element periodically ejects the water accumulated in the cell

- If the difference in solute concentration is large enough, the cell will burst.

As a result, the solutions on both sides of the membrane are equally concentrated. Osmotic pressure is one of the fundamental forces that affect living cells because the cytoplasmic membrane is semipermeable.

Osmotic pressure

The flow pressure of a solvent penetrating through a semipermeable (semipermeable) membrane into a solution in which there is a higher concentration of dissolved molecules or ions.

$\pi = i \cdot c \cdot R \cdot T \rightarrow$ depends on the temperature and concentration of the solution

- i is equal to the number of osmotically effective particles, c is the molar concentration, R is the molar gas constant, T is the absolute temperature

Solvent flow through the membrane: $J = k \cdot S \cdot (\pi_1 - \pi_2)$

- π_1 and π_2 are the osmotic pressures of the solutions separated by the membrane, k the permeability coefficient

Links

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