Diffusion

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Diffusion is a spontaneous process of penetration of particles of one substance into another with an effort to **uniform penetration** into the entire volume.

It can be defined as the movement of particles from a region of high concentration to a region of low concentration across a concentration gradient. So therefore diffusion is the process in which a gas or a substance that is in a liquid expands to fill all the volume equally.

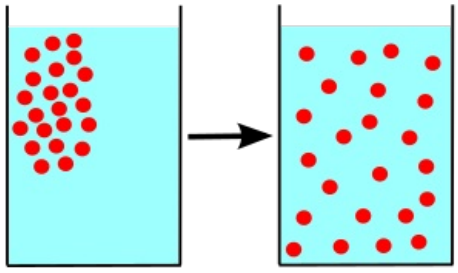
Basic description

Diffusion occurs because of the *disordered thermal movement of particles*. The movement of particles is essentially random, but substances tend to move **from an environment of higher concentration to an environment of lower concentration*. A natural property of substances is that if their particles can move, they disperse throughout the space and gradually equalize the concentration in all its parts. We say that substances diffuse. During diffusion,*** *no energy* is consumed.

The speed of particle propagation is influenced by particle size, temperature and environmental properties. Mathematically, they describe diffusion Fick's Laws.

Diffusion is a spontaneous*, irreversible and thermally activated* process. This fact is clarified by the Einstein-Stokes equation, which describes the dependence of the diffusion coefficient on the temperature T, the dynamic viscosity of the liquid η and the size of the diffusing particles R.

Diffusion enables the movement of substances inside cells and thereby metabolism*. In living organisms, other factors play an important role, for example, **the electric charge* **of particles** or **the** Biological membrane and transport of substances through biological membrane.



Diffusion

Cause of movement

The reason by which the expansion of the gas or the substance in the liquid is due to the motion of its particles. The particles of a substance dissolved in a solvent whether they are molecules or even just an atom are in a continuous random movement. A given particle in the dissolved substance is equally likely to move out of the area or also into the area in which there is a high concentration of the particle present. Due to the higher number of particles in the area of the high concentration, the total number of particles moving towards the lower concentration is greater than the total number of particles moving towards the area with the higher concentration. This is called a 'net flux' of solute particles from areas of high to areas of low concentration.

Diffusion in Physics

Ficks Law in physics is used in physics to describe diffusion and is used to find the diffusion coefficient. Fick’s First Law helps to show the amount of flux that is present under steady states. It describes the laws which describe diffusion in which particles which he refers to as Flux goes from regions of high concentration to regions of low concentration across a concentration gradient.

He was able to find this law by measuring the number of Particle in a substance (X),that crosses an area per second and using this knowledge he was able to find the equation: (Number of X particles)/(Area × Per Second). The resulting figure can be called the flux that is present in a system of diffusion.

Types of Diffusion

1. Simple Diffusion
2. Facilitated Diffusion
3. Diffusion through ion channels
    - Aquaporins

A specific case of diffusion is osmosis.

There are two types of diffusion that occurs in a human body. Both of these are passive process so no energy is required for them.

Simple diffusion can be described as the unassisted net movement of small, non polar substances down their concentration across a selectively permeable membrane. An example of this in the human body would be the exchange of oxygen and carbon dioxide between blood and body tissues.

Facilitated diffusion is the movement of ions and small, polar molecules down their concentration gradient assisted across a selectively permeable membrane by a transport protein.

Facilitated diffusion can then be again divided into two parts: Channel-mediated and Carrier-mediated.

Channel-mediated diffusion is the movement of ion down its concentrationgradienj through a protein channel. examples of this in the human body would be when Na ions move through Na ion channel into cell.

Carrier-mediated is the movement of small, polar molecules down its concentration gradient by a carrier protein. An example in cells is the transport of glucose into cells by glucose repairs.

Diffusion in different states

Gas environment

In a gaseous environment there is a much faster diffusion than in any other environment. Gas particles have the **highest kinetic energy'**. An example of this process is the very rapid spread of the scent throughout the room.

Liquid environment

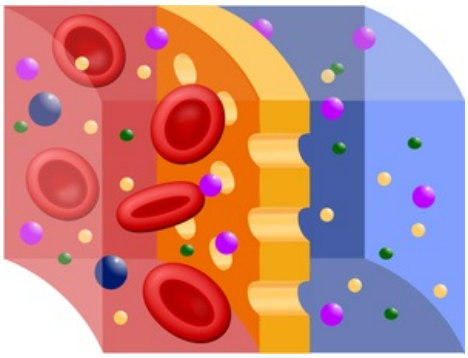
Particles of a liquid substance have **lower kinetic energy'** than particles of a gas. For that reason, slower diffusion occurs in it than in gas. An example is the release of substances from a tea bag after it is poured with hot water.

Solid

Diffusion in the solid state is more difficult, time-consuming, and is the only possible method of substance transfer. However, it also depends on the type of material. An example is the connection of two copper wires with tin.

Diffusion in biological systems

Diffusion is one of the most fundamental phenomena occurring in living organisms. For the transport of substances through the cell membrane, gaseous and liquid diffusion can be used in the human body.



Transmission of substances through a semipermeable membrane

A **constant composition of body fluids** is absolutely necessary for organisms. One of the most important factors for maintaining homeostasis is **transport across the membrane'**. The cell membrane is a selectively permeable (semipermeable) barrier. Its task is to maintain the osmotic and ionic balance between the intracellular and extracellular environments. The cell membrane functions as a barrier that **regulates the passage of particles** between the intra- and extracellular environment. The easiest to penetrate the membrane are *small non-polar molecules* such as oxygen and carbon dioxide, which dissolve very well and therefore diffuse very quickly. This rapid diffusion is important for gas exchange in alveoli and tissues. Lipophilic substances penetrate directly through the phospholipid bilayer of the membrane. The rate of diffusion is directly proportional to their fat solubility. [1]

Electroneutral polar molecules, if they are **small enough** ***(eg water) diffuse relatively easily (not always by the process of simple diffusion). Hydrophilic substances (eg water and ions) are*** *insoluble* ***in the lipid environment of the biological membrane, so they can only diffuse through transmembrane transporters built into the membrane. This is of course important in the*** *possibility of regulation* of the entry of these substances. [1]

Examples of diffusion in an organism

Diffusion is one of the most important physical events that enable the movement of substances inside the organism.

One of the very important events is the creation of **action potential**. This is caused by the transfer of ions across the cell membrane.

🔎 *For more information see Resting Membrane Potential.*
🔎 *For more information see Action Potential (Physiology).*

Another example is the need to give the patient an isotonic solution (a solution with the same concentration as blood plasma). In the case of administration of pure water, the water would diffuse into human cells, which would increase in size and could '*burst* by prolonging the exposure too much. On the contrary, when a too concentrated solution is delivered to the patient, water would be sucked out of the cells - this would lead to the cells shrinking. If the exposure time were long, the cells would be so concentrated that cell death would also occur.

🔎 *For more information see Osmosis.*

Diffusion in Medicine

Diffusion MRI is a magnetic resonance imaging (MRI) method which was first used in the mid-1980s. It allows us to find the diffusion process of molecules, mainly water, in biological tissues in the human body, in the living body and non-invasively. Molecular diffusion in tissues is not free, but reflects interactions with many obstacles, such as macromolecules, fibers, membranes, etc. Water molecule diffusion patterns can therefore reveal microscopic details about tissue architecture, either normal or in a diseased state.

Links

Related Articles

- Transmembrane transport
- Ion Channels
- Active transport
  - Symport
  - Antiport
- Passive transport
  - Diffusion
    - Simple Diffusion
    - Facilitated Diffusion
  - Filtering
  - Osmosis
  - Drug penetration through membranes

Reference

- ŠVÍGLEROVÁ, Jitka. *Difúze* [online]. [cit. 2022-12-25]. <https://web.archive.org/web/20160306065550/http://wiki.lfp-studium.cz/index.php/Difúze>.

Source

- LEOŠ, NAVRÁTIL – ROSINA, JOZEF – AND COLLECTIVE,. *Medical biophysics* [online]. [cit. 2014-16-11]. <https://www.grada.cz/medicinska-biofyzyzika-3633/> (https://www.grada.cz/medicinska-biofyzyzika-3633/)>.

1. ŠVÍGLEROVÁ, Jitka. *Diffusion* [online]. [cit. 2010-11-13]. <https://web.archive.org/web/20160306065550/http://wiki.lfp-studium.cz/index.php/Difúze>.