How Nerve Cells Work

1. Ions, Water and Membranes

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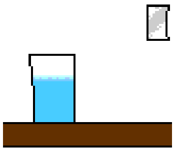
Our body is made mostly of water (around 60% of an adult's weight). Most of the solid substances are dissolved into this water and biochemical reactions can take place only in solution. All cells look like small closed bags of solution, with a wall made of a semi-permeable membrane. Inside the cell we have a complex chemical environment called the intracellular space. The internal structures of a neuron (called organelles) are embedded internally in a cytoplasm that is made up mostly of water, proteins and inorganic salts.

Cells are immersed into another big solution, which is called the extracellular space. The solutions inside and outside the cell have different compositions, and this fact is exceedingly important to cell function, as we will see, particularly excitable cells (cells, such as the neuron and the muscle cells, which can react to stimuli coming from the external environment).

In order to understand how nerve cells can be excited and transmit this excitation to other parts of the nervous system, muscles and glands, first we must understand the role of ions and water, because they are very important for so-called membrane processes, that is, functions which take place across the cell membrane.

When a substance like common salt, or NaCl (made of equal parts of elements sodium (Na) and chlorine (Cl), dissolve in water, the molecule ceases to exist as a solid crystal and becomes a set of particles called ions. Salt is soluble in water because the charged portions of water molecules have a stronger attraction to the salt atoms than to each other.

Ions are formed when sodium and chloride atoms lose or gain electrons in contact with water, thus becoming electrically polarized. In the case of common salt, sodium loses an electron and becomes positively charged (we denote this as Na+), while chloride gains an electron and becomes negatively charged (we denote this as Cl-).



Putting salt into water

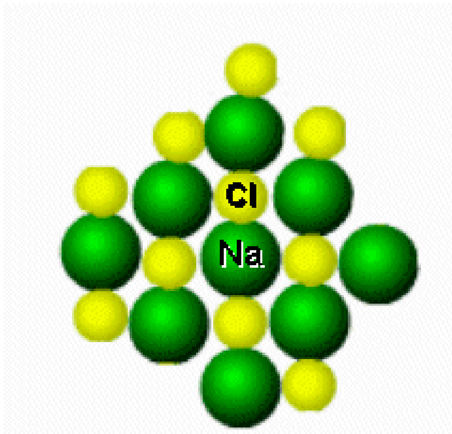
H2O

+

The two hydrogen atoms and the oxigen atom which make a water molecule (H_2O) are bounded together by covalent forces, sharing electrons betwen them.

H= Hydrogen
O= Oxigen

NaCl

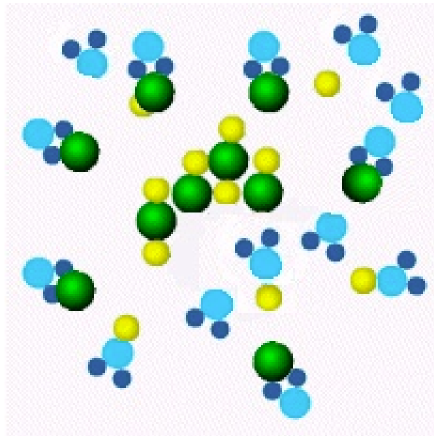


In crystals of common salt (NaCl), the sodium and chlorine atoms are covalently bonded by sharing one electron.

Na= Sodium
Cl= Chlorine

=

Na+ Cl-



In solution, crystals of salt separate and no longer exists as the usual atoms. Salt dissolves in water because the charged portions of the water molecule have stronger attraction for the ions than they have for each other. Sodium loses the electron to form positive ion, Na+; chlorine gains one to make a negative ion, Cl-.

The mean electrical charge of a salt solution is zero, because there is one Na+ ion for every Cl- ion. Thus, they balance each other out.

However, in living cells, an unequal distribution of ions of different charges is achieved. In this manner, the environment around the cell looses its electrical equilibrium and becomes electrically polarized around the membrane. This is the cause of bioelectricity, or the generation of electricity by cells, as we will see in the next section.

Therefore, the ability of nerve cells to process electrical information depends on the special properties of the cell membrane, which controls the flux of nutritive substances and ions from the internal to the external side of the cell and vice-versa. Special molecular channels, called pores, which are open in the membrane allows that a substance or ion traverses it in a given direction.

Ionic movements through channels are influenced by two processes:

- **Passive transportation:** **ions move about following the laws of molecular diffusion, difference of concentration or chemical gradient and difference of electrical charge or electrical gradient. The cell membrane allows certain molecules to pass more easily than others, due to the size of channels and chemical conformation of molecules. Therefore, passive transport takes place across a semipermeable**

membrane.

- **Active transportation: some ions and membranes can be transported actively across the cell membrane. This is done by small molecular "engines" called ionic pumps. The most important membrane pump for excitable cells is the Na+/K+ pump. For each sodium ion it transports across the membrane, it transports a potassium ion in the opposite direction.**

Passive transport is important. However, unequal distribution of substances in the extracellular and intracellular spaces is maintained by the active pumps. Dead cells lose this capability, because active pumps require metabolic energy to work. This energy is extracted from foodstuffs by living cells, by means of complex chain reactions.

Glossary:

ions- particles charged of electricity,
anions - atoms which gain electrons
cations - atoms which lose electrons.

Next: Diffusion and osmosis

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URL: http://www.epub.org.br/cm/n09/fundamentos/transmissao/salt_i.htm