How Nerve Cells Work

3. Movement of Ions: Electrical Charge

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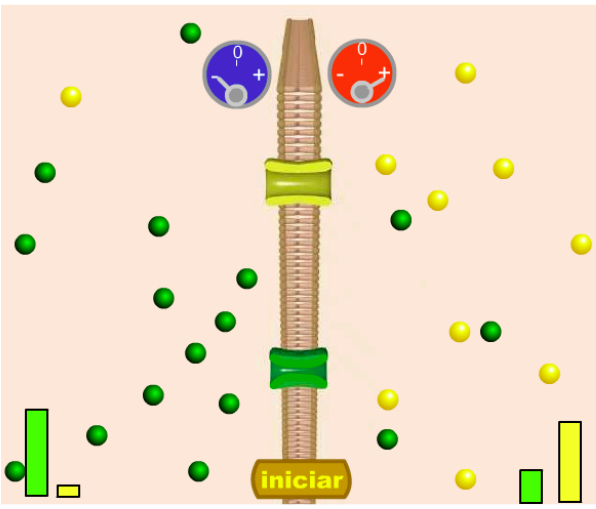
All cells in the human body are characterized by having a net electrical charge across its membranes. We call this "membrane electrical polarization". There is a negative difference between the extracellular and the intracellular compartments, i.e., the exterior of the membrane is electrically negative in relation to the interior. This value is called the "resting membrane potential".

How this potential appears?

Let's repeat the experiment we saw in the previous section: a beaker divided into two by a biological membrane, and salt solutions on both compartments.

Now, instead of putting an impermeable membrane, where only osmosis can occur, or a permeable membrane, where eventually all ions will have the same concentration of both sides (diffusion), we put a selectively permeable membrane. In other words, this membrane will have a higher permeability to one type of ion than to another.



When this happens, the ion (let's suppose, potassium or K+) with a higher permeability will flow more rapidly to the other side, following its chemical gradient. The other ion (let's

suppose, chloride or Cl-) will do the same, but it will flow slowlier. In this manner, after some time, there will be a higher concentration of K+ than Cl- in the right side of membrane, and a higher concentration of Cl- than of K+ in the left side.

Because of this, an electrical charge appears across the membrane. Since there are more K+ inside than outside and more Cl- ions outside than inside, there will appear a negative potential outside in relation to inside. This is essentially how the resting potential is generated.

Now, since there is a polarized charge of one side of the membrane in relation to the other side, ions tend to obey also their electrical gradient. Since K+ is a positive ion and is repelled by positive charges, it eventually will stop following its chemical gradient because the positive charge it is contributing too in the interior, will impede it due to electrical repulsion. The same happens with the negative ion, Cl-

Thus there will be an equilibrium between electrical and chemical forces driving the movements of K+ and Cl- ions across the selectively permeable membrane and the concentrations become stable. As a result, the polarization also stops to change and becomes steady.

A German scientist named Nernst expressed this phenomenon as a law which was named in his honour. It states in mathematical terms that the chemical concentrations of ions and electrical charges are in equilibrium for any given ion, and that the steady potential is proportional to the logarithm of the ratio of concentrations on each side of the membrane.

There will be a Nernst potential for each ion. The resting potential of the membrane is a composite (a sum) of all the Nernst potentials of all ions which are important.

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An initiative: Center for Biomedical Informatics
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