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*Short communication*

# Title: Mechanoreceptor of the hearing organ

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## Abstact

The receptor that receives auditory sensations from the outside world is part of the hearing organ, it is an exteroreceptor. Receiving signals at a distance, it is a telereceptor. It is stimulated by sound wave stimuli, which are mechanical energy - it is a mechanoreceptor. A receptor is a specialized cell of the nervous system that transmits received information through synapses and the auditory nerve to the analytical center in the brain.

## Introduction

The receptor that receives auditory sensations from the outside world is part of the hearing organ, it is an exteroreceptor. Receiving signals at a distance, it is a telereceptor. It is stimulated by sound wave stimuli, which are mechanical energy - it is a mechanoreceptor. A receptor is a specialized cell of the nervous system that transmits received information through synapses and the auditory nerve to the analytical center in the brain. It receives and converts the mechanical energy of the sound wave into the electrical energy of the receptor potential, which leads to depolarization of the hair cell and the formation of an action potential. This is mechanotransduction [1].

It was believed that mechanical energy acting on the cell membrane of the hair cell causes its deformation and a change in the tension of the cell membrane [2], which results in the opening of ion channels in the cell membrane and the inflow of positive ions into the cell, which leads to its depolarization. The only truth is that the hair cell depolarizes. This simple method of transporting sound wave information to the receptor does not ensure full transmission of the information encoded in the sound wave. There is no transmission of harmonic components, phase shifts, or quantity. Without this information, speech cannot be understood and music cannot be heard.

The mechanism of converting the mechanical energy of a sound wave transmitting the encoded wave energy into the electrical energy of the receptor and then into the energy of chemical bonds transmitting intracellular information takes place at the submolecular and electronic level [3]. Frequency and intensity transmission is not a problem. However, it is difficult to understand how harmonic tones, phase shifts, quantity and accent are transmitted. The path of the auditory signal described by the traveling wave theory, through the cochlear fluids and basement membrane, is not able to transmit information at the level of nanostructures and nanoprocesses.

Perhaps the situation is similar to the organ of vision, where a mixture of electro- magnetic wave frequencies received directly by the receptor creates a multicolored image in the brain.

The adequate stimulus for the hearing organ is the energy of the sound wave; in the case of speech, the sound wave, specifically formed in the larynx and resonators of the upper respiratory tract, is transferred by vibrating particles of the sound wave to the receptor. All molecules as well as all atoms in the sound wave molecule conducted through the environment and the molecules and atoms that make up the hearing receptor are in constant motion. It is a progressive movement - oscillatory and rotational, or a mixture of these movements. Motion is associated with the kinetic energy of molecules. In addition to kinetic energy, the molecule has potential energy, which consists of chemical bonds and the forces of electrostatic attraction and electromagnetic interactions. The sum of these energies creates the internal energy of the molecule's body. The internal energy also depends on the temperature and the mass of the molecule. Providing external energy - in the case of the hearing receptor - a sound wave - to the acceptor molecule (hearing receptor) increases the internal energy of the molecule receiving the signal.

The particles vibrating in a sound wave have a positive, negative or neutral charge. Neutral particles transfer potential energy depending on the vibration speed and frequency, as well as electronic energy through the contact of the electron clouds of the molecules. Every atom has electrons that form an electron cloud around the nucleus of the atom. The size of this cloud depends on the number of orbits in which electrons are distributed. Electrons in the outer orbit - the valence orbit - easily enter into compounds with other atoms, forming atomic and covalent bonds. There is an incomplete number of electrons in the valence orbital, these electrons are easily given up to form atomic bonds, or electrons are accepted to complete the orbit. The closer to the nucleus, the more energy the electron has. For the hydrogen atom - which very often takes part in reactions - the energy of the electron located in the first orbit is minus 13.6 eV. The subsequent electron shells 1,2,3,4, etc. are quantum main numbers. The electron can change its orbit, but to move to an orbit closer to the nucleus, it must receive additional energy. Changing 1 orbit from 2 to 1 requires 3.4 eV. Such transitions are quantized, which means that there is or is not a jump - there is no middle ground. If an atom in the acceptor molecule receives a quantum of energy from another atom or molecule (sound wave), the acceptor electron jumps to an orbit closer to the nucleus - its internal energy increases - in a quantized step. The so-called the excited state of an atom, which, unlike the ground state, is unstable. This state is unstable and immediately tries to return to the ground state by emitting 1 photon of energy - when the problem concerns the transition of 1 atom by 1 orbit. If in the combination of receptor molecule + sound wave energy there are countless such transitions, or transitions of 2 orbits or more, there are $10^{20}$ possibilities of transmitting different types of quantized energy. This gives an endless amount and variety of information transmitted. This energy transfer reaches molecules inside the potassium ion channel, which is responsible for regulating the openness of the ion channel. These molecules form activation gates of the potassium channel. The channel activation gate together with the inactivation gate determine the channel capacity depending on the energy of the sound wave [4].

There are indications that the wave energy acts on molecules that gate the ion channel, called sound-sensitive molecules. There are changes in atomic rotation, bond angles, and oscillations, which leads to conformational changes in the molecules, and the resulting conformers perform the work of closing and opening the ion channel. This activity is very precisely regulated by the encoded information in the sound wave.

The operation of the ion channel selectivity filter is very important, as it is responsible for the passage of one type of ions that have been dehydrated in the central part of the channel. The sound wave regulates the flow of K+ ions. When fully open, 6 million ions flow per

second. The entrance to the potassium channel is 1 nm in diameter, while the part narrowed to 0.3 nm determines the specificity of the passing ions.
The influx of positively charged K+ ions into the cell begins its depolarization. If this change in membrane potential exceeds - approximately 10 mV, the potential-dependent Ca++ ion channels are activated. The hydrated calcium ion has a diameter of 150 pm. Local depolarization increases, further Ca++ channels open, dependent on greater depolarization, and Na+ channels on the lateral surface of hair cells. The inside of the cell has a negative potential of -90 mV, thanks to the large amount of negatively charged proteins and the constant operation of sodium-potassium pumps throwing 3 sodium ions out of the cell in exchange for 2 potassium ions transferred into the cell. This creates a loss of positive ions in the cell. Outside the cell there are high levels of Na+, Ca++ and Cl-, which together with the high electrical potential create a high electrochemical potential for sodium and calcium ions. A wave of Ca++ ions flows into the cell, causing the cell to release calcium ions from the mitochondria, endoplasmic reticulum and cell nucleus. The calcium level outside the cell is 10,000 times higher than the basal calcium level inside the cell. The electrochemical potential directs calcium ions into the cell through the open ion channels of the cell side wall. Calcium levels in the cell can increase up to 100 times.

After stimulation, the membrane potential changes into the receptor potential. In the cell, calcium combines with calcium-dependent proteins, changing their properties. The most important of them is calmodulin, which has very different actions [5].
Information is divided into constitutive activities related to the normal functioning of the cell and regulated activities related to the production, transport and secretion of the transmitter to the synapse. After increasing the calcium level and transmitting the information, the calcium level in the hair cell decreases rapidly. Calcium pumps and ion exchangers work, throwing calcium ions out of the cell, and some of the calcium moves back to the mitochondria, endoplasmic reticulum and nucleus. The lower the level of calcium in the cell, the more sensitive the cell is to receiving a new signal. This is a background law. Intracellular transmitters (messengers), variable calcium levels and the actions of intracellular proteins are responsible for intracellular amplification.

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