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Editorial
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A New Picture of Hearing: A New Theory

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Editorial

After many years of analyses of the latest investigations, there has emerged a new picture of our hearing, essentially departing from the concept presented in the textbooks. A new picture complying with the rules of physics and logic. The theory of hearing, presented by Bekesy in 1928, updated many times, has many weak points, but the thought of making a mistake at the stage of creating the theory of hearing is still unacceptable, nor is there any possibility of other solutions allowed. For tens of years, the circles of professors of laryngology managed to become accustomed to today's theory of hearing, and that is why any attempts at having the theory revised have been efficiently thwarted.

After having analyzed innumerable materials, I personally believe that the truth of the hearing differs from the orthodox theory of Bekesy's travelling wave. As early as on the stage of creating this theory, some serious errors were made. Calculations were performed basing upon a cochlear box model formed into a straight tube. This similarity is like between a motorway and a highland serpentine. In addition, Reissner's membrane was removed from the calculations. It was assumed that the basilemma is able to vibrate freely where it constitutes a part of the massif of the organ of corti; moreover, from the eardrum canal the basilemma is adhered by a layer of connective tissue. The whole is immersed in fluid exhibiting strong attenuation properties.

Basing upon my own analyses and observations I will enumerate in paragraphs some issues which allow having a new look at the sense of hearing. There is a significant difference between the new and today's theory. It is justified to set forth a new theory well substantiated both with research and the Nature's logic.

1. Research has proved a very high loss of energy of the sound wave in the cochlear fluids and in the basilemma as well. From the auditory meatus to the rotund window the amplitude of a1000 Hz and 90 dB wave decreases 800 to 1,000 times. The wave energy is proportional to the square of wave deflection.

2. There is no possibility of hearing the threshold sound if a signal travels to the receptor through the cochlear fluids. The initial amplitude of the threshold wave amounts to 8 to 10 picometers. It is perceived physiologically-it cannot travel through the cochlear fluids.

3. The receptor potential is generated in a time of an order of tenths of a millisecond. A signal traveling through the fluids is unlikely to reach the receptor in such a short time, especially in the case of quiet tones which need amplification.

4. Quiet tones are amplified by 40 dB to 50 dB and are still perceived as quiet?

5. The OHC contractions are responsible for the amplification of quiet tones. The contractions are like in the case of loud tones. They pull at the basilemma and loud tones are not amplified? What is the mechanism of regulation?

6. A short sound, *viz*. under tenths of a millisecond, is perceived and the frequency is recognized. How is a traveling wave generated?

7. Resonance is indispensable for generating a traveling wave and amplification. Is any resonance possible when a signal has only one wave period? The receptor perceives the signal.

8. In what way does the amplitude of the traveling wave increase as it recedes from the source of sound- when there is no resonance? This is in conflict with the laws of physics.

9. How can the traveling wave increase in the initial phase with a difference of the vibration phases of the basilemma and of the reticular membrane?

10. Why is there a 20 μs time difference in the vibration of the reticular membrane and the

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basilemma while they constitute one homogeneous whole? At a phase difference of 180° and at a time difference the traveling wave can neither be amplified nor increased.

11. No explanation of hearing for a cochlear implant surgery in case of partial deafness. The basilemma is immobilized, which does not affect the hearing.

12. Procedure of stapedectomy in case of otosclerosis-no conduction of high frequency sounds. In view of physiology, we can hear up to a level of 20 kHz, whereas some mammals even up to 200 kHz.

13. No analyses related to the inertia of vibrating elements in the middle and the inner ears which have a certain mass.

14. No analyses related to the importance of the swinging movements of the stapes.

15. No analysis of the importance of the soft tissues conduction.

16. No analysis of the working mechanism of the mechanical energy of a sound wave acting upon the receptor's sound sensitive molecules, responsible for generating the motion of the gating mechanism which opens the potassium gating mechanism of mechanosensitive channels upon the hairs of acoustic cells.

17. Tip-links-it is rather unlikely to attribute the role of closing ion channels to myosins the mechanics of myosins is too slow, especially for high frequencies.

18. No description of the mechanism of encoding information through flows of fluids in the subsegmental space through the hairs of acoustic cells, cadherin fibers, pristine and through a slowly traveling wave.

19. Unexplained remains the importance of the difference in the speeds of a sound wave in the cochlear fluids and of a transverse wave traveling upon the basilemma.

20. OHC is merely an amplifier for IHC. But it has afferent innervation. Why should it, if it does not send information to the center?

21. Investigations are carried out for a simple, continuous tone. And what about a traveling wave for multitones, when each tone has several harmonic components?

22. What does the simultaneous reception of loud and quiet sounds look like? The loud ones are perceived and pertinent information is conveyed to the center. The quiet ones are sent for a time-consuming amplification. An amplified sound superimposes on other waves on the basilemma, and in what way can it be selectively amplified? Moreover, the message becomes split. How an amplified sound is conveyed to the center? In a package with other sounds? Neither Hopf bifurcation nor piezoelectricity is helpful here.

23. It has not been elucidated why at 10,000 Hz the biggest deflection of the basilemma occurs per 4 mm of basilemma. No calculations provided.

24. In the textbooks there are some drawings of the frequency resolution, showing there are 16,500 frequencies per 1 cm of basilemma at the cochlear base. Therefore, 0.000606 mm of basilemma falls to 1 frequency.

25. No analysis of the effect of receptor fields of nervous cells of the spiral ganglion upon the frequency and voltage resolution.

26. An analysis of frequency of OHC contractions should take place after prior stimulation with an acoustic, not electrical signal. Important is the action of the ion channels in the side and the inferior area of an acoustic cell. The problems are the times of relative and absolute refractions as well as the time of inactivation of ion channels of Na, K and Cl.

27. No analysis of the operation of the acoustic cell itself, transformations on the molecular level of processing and transfer of auditory information.

28. Disregarded is an intracellular amplification which exists, like in other sensory organs.

29. By means of an OHC contraction it is impossible to perceive and to amplify the subliminal signal with mechanical method. If a signal has been received, an amplification occurs in the acoustic cell. If the signal is too weak to reach the center, it will be amplified in the cell.

30. The fact that not the basilemma is responsible for the frequency resolution is also ignored. Acoustic cells with specific sensitivity to a given frequency of a sound wave are arranged along the basilemma. Tonotopy can guarantee the transmission of information with a frequency of sound signals. There is an amazing similarity to the eye in which rod cells (of retina) and cones exhibit different sensitivities to the length of a light wave. The location of stimulated receptors on the retina constitutes a visual image.

Conclusion

An analysis and description of all issues means a few dozen or so pages of materials.

Basing upon the analyses it may be concluded that apart from the signal pathway through the cochlear fluids and from the basilemma there is another, simple, fast and energy saving signal pathway to the receptor. It runs from the inner ear through the bony housing of the cochlea directly to the receptor. The mechanical energy of a sound wave, encoded in the wave, is perceived by a specific receptor. A sound wave acts upon sound sensitive molecules by influencing vibrations of the respective atoms and molecules, changes in the chemical bonds, angles of bonds, temperature, osmosis, activity of enzymes. And this leads to conformational changes in the protein responsible for gating the potassium mechanosensitive ion channels. All data pertinent to the operation of a potassium channel, opening frequency, duration time and degree of depolarization of an acoustic cell are comprised in the sound wave. In such a way, a sound wave which does not have a mass, is not subject to the inertia law on the entire pathway; the receptor is also free from inertia. This pathway and the perceptive mechanism are of high importance in view of the speed of auditory reactions. To the minimum limited are numerous, superfluous energy transformations and considerably lower is a possibility of errors in the transmission of information.