Why do we hear inconsistently with Bekesy's traveling wave theory?

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Introduction:
Auditory information carried by sound waves is received by living beings from 5 Hz (pigeon) to 300 kHz greater wax moth (Galleria mellonella). Some mammals receive sound waves with a frequency of up to 100 kHz, bats up to 200 kHz and humans from 16 Hz to 20 kHz. The sense of hearing in phylogenetic development underwent development on the basis of trial and error. The hearing organ was increasingly complex from simple in moths receiving sound waves up to 300 kHz to the most complex in humans receiving sound waves up to 20 kHz. The structure of the human hearing organ is known, but the mechanisms of receiving, processing and transmitting auditory information are not fully understood and properly described.
For over 2000 years, many theories of hearing have been developed, attempting to explain the secrets of our hearing. None of the previous theories, including the currently prevailing Bekesy traveling wave theory, correctly explain the mechanisms of hearing. This theory, announced in 1928, based on the hydrodynamics of cochlear fluids, the resonance of a longitudinal sound wave with a transverse wave of the basilar membrane, and the mechanical amplification of the sound wave energy, is a distinctly mechanical theory, without due consideration of processes at the molecular and submolecular level.This theory contains elements that are inconsistent with current knowledge and experience. The new vision of hearing, based on analyses and modern research of various scientific centers in the world, encounters resistance from people who believe that Bekesy's theory sufficiently explains all processes related to hearing. The need for a change in understanding our hearing is indicated by many situations contained in the traveling wave theory, which tries to explain the mechanisms of hearing.

Examples.
1. A sound wave falls on the elastic eardrum, which does not reflect 99.9% of the energy, as Bekesy assumed for the calculations, assuming that the wave passing from air to the fluids of the cochlea undergoes such reflection. The eardrum absorbs the energy of the wave and conducts it directly to the ossicles of the middle ear, and part of the wave energy to the temporal bone. In total, about 80% of the energy falling on the eardrum is conducted further [1]. The amplitude of the wave of 90 dB = 500 nm falling on the eardrum decreases to 100 nm in the middle ear = 80 dB
2. The sound wave from the tympanic membrane, ossicles and especially the stirrup plate is conducted to the cochlear housing bone and directly to the receptor.Each point to which a sound wave reaches in the environment becomes the source of a new wave. The vibrations of the tympanic membrane reach the tympanic membrane frame and then to the temporal bone. The sound waves, through the ossicles, which are connected to the wall of the tympanic cavity, and the stirrup plate in the oval window, are conducted to the temporal bone. This is the beginning of a direct signal path to the receptor.
3. The lever mechanism of the malleus body and the articular crus of the incus in a ratio of 1.3:1 reduces the amplitude of the sound wave. The energy of the wave is proportional to the square of the amplitude of the wave. The lever can increase the pressure force, but it reduces the amplitude of the wave and the wave energy transmitted to the inner ear [2,3]. In stapedotomy, the difference between the surface of the tympanic membrane and the surface of the 0.4 mm diameter piston is 100:1. There is no increase in amplitude, there is no amplification of the wave energy. With a 0.6 mm diameter piston, the surface ratio is 50:1. No increase in energy. Why does the ratio of 55 mm2 of the active surface of the tympanic membrane : 3.2 mm2 of the stapes surface increase the acoustic pressure, proportional to the amplitude of the sound wave, by 17 times? Additionally, the funnel-shaped structure of the tympanic membrane is supposed to amplify the acoustic wave twice. In total, the described amplification in the traveling wave theory is 44 times = 33 dB. The question arises: What wave is amplified at this stage by 33 dB?
4. A sound wave of 90 dB – 1000 Hz, acting on the tympanic membrane, has 80 dB = 100 nm on the tympanic cavity side [4,5]. According to the traveling wave theory, the middle ear amplifies the acoustic wave by 33 dB compared to the wave acting on the tympanic membrane. Laser vibrometric studies show a wave amplitude on the stapes plate on the vestibule side of 11.7 nm. A large discrepancy between the traveling wave theory and the studies.
5. Soft sounds according to Bekesy's theory are amplified by 33 dB in the middle ear and 40-50 dB by OHC contractions pulling up the basilar membrane [6]. Despite such amplification, we still hear tones as soft. If there was such amplification of soft sounds, we would not hear such pleasant whispers, rustling leaves.
6. There is no explanation of the mechanism of auditory information transmission by longitudinal wave resonance in cochlear fluids with the transverse wave of the basilar membrane. There is a 900 inconsistency of the plane of excitation of the forcing and forced waves. A very large difference in the wave frequency and the natural frequency of the basilar membrane prevents resonance, especially in animals receiving frequencies up to 200 kHz. The same mechanism operates in mammals as in humans. The damping of basilar membrane vibrations by cochlear fluids prevents the resonance of waves in the area of the auditory threshold. Resonance occurs when the damping is lower than the energy of the forcing wave. Sound waves at the threshold boundary are audible with high damping of the forced wave. We hear thanks to a different signal path to the receptor, bypassing resonance, the basilar membrane and cochlear fluids.

7. Disruption of the signal path to the receptor due to blockage of the basilar membrane during cochlear implant surgery for partial deafness does not affect previous hearing [7]. Electrodes in the tympanic canal block vibrations of the basilar membrane. Immobilization of the basilar membrane does not block hearing. Hearing is still preserved, without changes, to the tones heard before the surgery. This is evidence of the existence of another signal path to the receptor.
8. A 90 dB, 800 Hz sound wave with an amplitude of 500 nm in the external auditory canal, tested vibrometrically on a round window, has an amplitude of 0.5 nm [8,9]. An amplitude of 30 dB at the entrance was tested, and no wave detectable on the round window was found. The question arises: What amplitude can a threshold wave of 8 pm at the entrance have on its way through the basilar membrane and cochlear fluids, decaying on its way. Young people can hear this wave.
Can a wave amplitude many times smaller than the diameter of a hydrogen atom cause a traveling wave on the basilar membrane? Can it generate cochlear fluid flows? Can it bend hairs of hair cells with a diameter larger than a million times the wave amplitude? An 8 pm wave decays on its way through the basilar membrane and cochlear fluids 100-200 times. The diameter of a hair of hair cells is 100 nm. A cosmic size disproportion according to the traveling wave theory! The threshold tone is heard - by a different path.
9. How does a traveling wave in humans with a speed of 2.9 m/s near the top of the cochlea and up to 50 m/s at the base of the cochlea (according to Bekesy) encode information contained in a sound wave in a fluid with a speed of 1450 m/s? Is such a large compression of information transmitted further to the receptor possible? To maintain the transmission of all information, it must be lossless compression. Assuming the speed of the traveling wave near the cap of 10 m/s, the speed of the traveling wave is 145 times smaller! Information recorded on a 145 cm wave is recorded on a 1 cm traveling wave? Is this possible? What does the further transmission of such compressed information to the fluids of the cochlea look like? How is the quantized energy of the wave encoded?
10. How is such dense information encoded not only by the fluids of the cochlea, but also by the hairs of the hair cells, cadherin fibers in the tip-link mechanism? Encoding concerns not only amplitude and frequency, but also harmonic components, phase shifts, accent and time. How does such changed information act on the molecules responsible for gating mechanodependent potassium ion channels?
11. An isolated outer hair cell is stimulated with an electric current to prove that the cell can contract at 50,000/s or more. However, the contractions of the OHC, as a whole cell, depend on the work of voltage-dependent ion channels of the lateral wall of the cell. The activation and inactivation time of the voltage-dependent channel lasts 3-4 ms [10]. The whole hair cell cannot depolarize at 100,000/s at the same time. Without depolarization of the whole cell, there is no hair cell contraction.
12. The signal travel time from the external auditory canal to the test site in ECoG studies is 1.5 ms. Counting the signal travel time to the receptor, according to the traveling wave theory – this time is about 6 ms. The auditory reaction time is one of the most important conditions for the survival of species on Earth. It cannot be 6 ms of the path to the receptor itself. There is still analysis in the center and the centrifugal path.
13. OHC contraction pulls up the basilar membrane, it is supposed to amplify quiet sounds. At 100 dB there is also depolarization and OHC contraction. There is no gain regulation mechanism. The external auditory cell has no connection to the basilar membrane – how does it encode transmitted information? The amplified wave on the basilar membrane amplifies foreign, unknown waves that may not require amplification. The sound wave carries a stream – a sequence of encoded information. This transmitted information is superimposed on an amplified quiet wave, which disrupts the transmitted information. What wave is transmitted to the cochlear fluids after summing these waves? What wave is created and transmitted to the center?
14. In wave motion, vibrating elements that have speed, acceleration, and mass are subject to the law of inertia. There is inertia in the vibrating elements of the middle and inner ear. The theory assumes the flow of fluids in the cochlea-fluids have mass. The described eddies in fluids indicate that these are turbulent flows, which makes information coding even more difficult.
15. At high frequencies, rocking movements of the stapes plate are observed. The movements of the stapes base are not piston-like, they take place in the transverse axis of the plate up to 6000 Hz and in the longitudinal axis of the plate for high tones. When one half of the plate generates a forward movement of the wave or fluid, the other half of the plate simultaneously generates a backward movement of the wave or fluid. The formation of a traveling wave is impossible. Information transfer is impossible. The lack of rocking movements, when only the piston mechanism works in stapedotomy operations, results in the lack of high-frequency transfer. Physiologically, high frequencies are received by the receptor without restrictions. The signal reaches the receptor by a different route [11]
16. The barn owl hears waves of 0.001 nm on entry. In the cochlea, the amplitude of the wave decays several hundred times. A sound wave 100 to 500 times smaller than the diameter of the atoms that make up the basilar membrane will not cause a traveling wave on this membrane. The owl hears perfectly well. It has very good directional hearing. This is further evidence of the existence of another signal path to the receptor.
17. A hummingbird can hear 50 Hz waves of 29 m in the inner ear fluids when the basilar membrane is 1 mm long. Resonance is not possible when one wave period is 29,000 times longer than the basilar membrane. A hummingbird can hear well and recognize frequencies. There is another signal path to the receptor without the basilar membrane and cochlear fluids.
18. Amplification by 40-50 dB by OHC contraction before the signal is received by the receptor is impossible. The received signal does not require amplification at this stage. It is transmitted to the center via afferent innervation. We do not listen to simple harmonic tones, we listen to complex sounds. Every millisecond brings new information. Superimposing amplified waves on current waves is a bad solution. A signal below the hearing threshold cannot be amplified using this method. The received tones, too quiet to reach the center, are amplified in the auditory cell at the molecular and electronic, submolecular, regulated level.
19. Bekesy assumed that the dimensions of the basilar membrane are responsible for frequency and intensity resolution. As the cochlear channels narrow from the base to the top, the dimensions of the cochlear channels decrease threefold. According to the theory, the dimensions of the basilar membrane in this direction increase threefold. The disproportion of the dimensions of the cochlear ducts and the membrane separating them is ninefold. The basilar membrane vibrates. has a 3 cm

long basilar wave - we receive frequencies from 16 Hz to 20 kHz. A young cat has a 1 cm long basilar membrane and receives waves with a frequency of 20 Hz to 100 kHz. As in a cat, the thickness and width of the basilar membrane increase from the base to the top of the cochlea. The dimensions given by Bekesy were adopted, without verification. Cochlear channels with different electrolyte compositions measuring 3-4 mm in height are separated by a 0.2 mm wide basilar membrane. This width of the basilar membrane corresponds to the membrane's own vibrations at this point, according to the theory. Studies of the natural vibrations of human tissues have shown that the vibration values, depending on the type of tissue, range from 5 Hz to 100 Hz. There is a large disproportion between the studies of the natural vibrations of human tissues and the theoretical vibrations of the basilar membrane, studied for an isolated thin layer of tissue, without the load of the organ of Corti and the connective tissue on the lower surface of the basilar membrane. The basilar membrane has no tension regulation, no afferent and efferent innervation. vibrates in the cochlear fluid with high damping properties. In animals hearing up to 100 kHz, in order for the wave in the fluid to resonate with the natural frequencies of the basilar membrane – the natural vibrations of the basilar membranes would have to be between 5 Hz and 100,000 Hz. This is impossible.

20. The amplification of quiet multi-tones causessplitting the signal transmitted to the center. Loud sounds are received and transmitted to the center on an ongoing basis. Quiet sounds are separated, directed to time-consuming amplification, then superimposed on an alien wave and transmitted to the fluids of the cochlea. These two waves simultaneously reach the inner hearing cell. How is information about both sounds transmitted to the center? Separately with a time delay for the amplified tones? Or together with the alien wave? The center does not recognize the frequency. Tonotopy does not work in this case.

Discussion:

A fundamental question arises: Why do we hear despite so many obstacles, so many ambiguities regarding the signal path through the basilar membrane and the fluids of the cochlea? Why would Nature choose such a difficult and time-consuming signal path to the center, when there is a quick and easy way? Billions of beings in the world do not have a basilar membrane or inner ear fluids and hear perfectly well. This is indisputable proof that there is another mechanism of hearing. Such a mechanism in mammals and birds is the signal path from the middle ear directly to the receptor through the bony casing of the cochlea.The sound wave energy is an adequate stimulus for the receptor of the hearing organ.The conversion of the mechanical energy of the sound wave into the energy of sound-sensitive molecules reacting to the energy of the wave takes place at the submolecular, electronic level. The information transmitted is contained in the quantized energy of the sound wave and is then transmitted without changes to the receptor of the hearing cell by generating a receptor potential. The sound wave energy is responsible for gating the mechanodependent potassium ion channels. It causes conformational changes in the molecules it affects [12].The change in conformation occurs in femtoseconds (fs = 10^{-15}s).

The time of excitation of the molecule and relaxation lasts a few femtoseconds, the energy of the molecule returns to the ground state, sending the received energy in the form of energy photons to the environment, to the neighboring molecule, absorbing energy. Such a fast time of excitation and relaxation of molecules allows the transmission of sound wave frequencies up to 300 kHz. This mechanism,this speed of information transfer also applies to intracellular information transfer. Simple reactions take place in 10^{-15} s, while complex reactions take 1000 times longer. This is still 10^{-12} s. The molecule cannot accumulate energy, it quickly returns to its native state, giving energy to another molecule. A given molecule has a genetically determined ability to receive sound wave energy with a strictly limited frequency.This is a similar property to allergies, where the allergen must fit the receptor like a glove fits a hand.

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