SM Otolaryngology ISSN: 2574-2418

Case Report

Analysis of Bekesy's Traveling Wave Theory

Jan Myjkowski*

Retired physician, Specialist in otolaryngology, Poland

Abstract

Hearing is an extremely complex and precise mechanism. It is generally believed that we have already passed the stage of learning all the procedures for receiving, processing and transmitting auditory information. Analyzing the vast knowledge encoded in thousands of works by many specialties, including many Nobel Prize winners, it turned out that already at the initial stage of creating Bekesy's theory, many mistakes were made, which led to the creation of a false image of our hearing. The traveling wave theory was announced in 1928. Processes related to hearing have been attempted to be explained by physics alone. These processes take place at the level of nano structures and nano processes. The most important comments on Bekesy's traveling wave theory are presented in the paper. They result in the need for a new analysis of hearing mechanisms. A new description of hearing was proposed under the name "Submolecular theory of hearing". The change concerns the signal path to the receptor, the reception and processing of information, and the amplification of the signal on

its way to the center.

Keywords: Hearing; Bekesy's theory; Traveling wave theory; Submolecular theory of hearing.

NOTES ON THE THEORY OF HEARING

1. No answer to the question of how we hear the threshold tone of a sound wave with an amplitude of 0.01 nanometers - decaying hundreds of times on the way to the receptor. How does such a small portion of energy reach the receptor through the cochlear fluids and basement membrane? A threshold tone with an amplitude of 0.01 nm decays approximately 100 times on its way through the cochlear fluids, the wave is 0.0001 nm. A hydrogen atom has a diameter of 0.08 nm. Oxygen 0.13 nm. An 800 Hz and 90 dB wave decays 1000 times on its way from the external auditory canal to the round window [1]. The wave disappears most in the section up to the grove. A wave amplitude of 0.01 nm cannot cause a traveling wave on the basement membrane. The receptor receives this signal. What way?

2. If the amplitude of the wave traveling in the cochlear fluid is several hundred times smaller than the diameter of a hydrogen atom, this wave is unable to cause a pressure difference on both sides of the basilar membrane, which is generated by the flow of cochlear fluids, as it bends the hairs of hair cells a million times thicker than the amplitude threshold wave?Is the energy of this evanescent wave capable of causing depolarization of a hair cell? [2].

3. What is the mechanism of gating K+ ion channels in the absence of hair cell movement in the case of cochlear implantation? The basement membrane is immobilized and hearing is preserved. How? [3].

4. How does the contraction of hair cells amplify quiet sounds by 40 dB, regardless of frequency. Mammals can hear up to 100 kHz. Cell contraction depends on OHC depolarization, and depolarization and the full cycle of repolarization and cell excitability last 3-4 ms. If the depolarization and contraction of the cell affects the entire cell at the same time, a problem arises. The maximum contraction frequency of the entire hair cell is then 250/s to 330/s. Why do we hear high frequencies?

5. What is the mechanism for adjusting the gain by 30-40 dB? At 50 dB there is also OHC contraction and no gain. What is the control mechanism? Is there mechanical reinforcement at this stage? The amplification is in the hearing cell. Energy too small to reach the center is increased molecularly. This is an amplification of the energy received by the receptor. Other sense organs use intracellular amplification.

6. How do the basement membrane and fluids conduct multitones when quiet tones require time-consuming amplification? Quiet tones are separated from loud ones and routed to amplification? Loud tones received are sent to the center? Is such information splitting possible? Soft tones amplified as they are transmitted to the center? Along with other waves? The sound wave in the cochlear fluid transmits new information at a speed of 1450 m/s, it does not wait until the quiet tones of the multitone are amplified. Do we hear loud tones and quiet tones of the same polytones at different times?

7. How does tip-links open an ion channel? The tip-links cadherin filament is 15 times thicker (6-8 nm) than the inlet of the potassium ion channel (0.4 nm)? The regulation applies to the interior of the channel with a diameter of 0.3 nm. Opening and closing frequency - in mammals from 5 Hz - 200 kHz. The cadherin thread is also supposed to encode harmonic components and phase shifts. Is energy quantization applicable? How does a single strand of cadherin open and close the circular ion channel inside the protein molecule? The regulation applies to opening and closing speeds up to 200,000/s, and applies to potassium ion throughput from 0 to 6000/ms.

8. As flowers, shrubs and trees hear - they do not have a basement membrane.What is the mechanism for converting sound wave energy into action currents? The mechanism of converting sound wave energy is universal in nature.

9. Explain how insects, butterflies, beetles, tadpoles, fish hear - they do not have a basement membrane. Certain frogs have hearing receptors in their lungs. The 1 cm Seychelles frog hears through its mouth. Other frogs use ultrasound. In the same way, the receptor receives an adequate stimulus - sound waves.

Submitted: 22 August 2024 | **Accepted:** 10 September 2024 | **Published:** 14 September 2024

***Corresponding author:** Jan Myjkowski, Retired physician, Specialist in otolaryngology, Myjkowski Jan, 39-300 Mielec ul. Mala 7, Poland, Tel: 48 782 449 179

Citation: Myjkowski J (2024) Analysis of Bekesy's Traveling Wave Theory. SM Otolaryngol 4: 5.

10. How to arrange frequency amplification zones on the basilar membrane. We distinguish 3000-4000 thresholds and zones - that is, one zone is 1.2 micrometers of our basement membrane. In mammals and birds, when the basement membrane is 1-5 mm long, the vibration sections of the basement membrane are much shorter. Can such a zone vibrate on its own in the case of complex tones in water? Without overtones there is no speech understanding. Can't listen to music.

11. Amplifying multi-tones and complex sounds is a problem. Are harmonic frequencies amplified before the signal is received by the receptor? How does the basement membrane receive, encode, and transmit phase shifts?

12. OHC is 50 micrometers long. It shrinks approximately 4% of its length [4]. If the hairs are embedded in the tectum membrane, they are not pulled out when the cell pulls the basement membrane up during contraction? It shortens by 200 nm. If the hairs are embedded in the covering membrane, can they tilt? Can they only bend? Bending requires more energy. If they are not embedded, they will not change their position during contraction, they will contract without pulling the basement membrane up together with the organ of Corti lying on the basement membrane, because there is no attachment to the upper end of the hair cell. Note the lack of connection between the hair cell and the basement membrane.

    Can the outer hair cells pull up the basilar membrane and the entire organ of Corti up to 200,000/s? Is this possible? Can they encode 100%% accurate energy transfer? Can the basement membrane vibrate on its own, without the entire organ of Corti vibrating - in the cochlear fluid!!? Impossible. The whole mass vibrates. What about the inertia of a mass vibrating in motion and accelerating? It's a law of physics. In the ear does not apply?

13. If the KSZ contracts and pulls up the basement membrane, it disrupts the very delicate synapses of afferent and efferent innervation at the lower pole of the hair cell! These are very delicate and very important in the transmission of information devices with a diameter of 50 nm, filled with liquid into which the transmitter is injected during each depolarization cycle. The distance between the presynaptic and postsynaptic membranes must be constant. The postsynaptic membrane has receptors that receive auditory information. Such jerking during each synaptic contraction destroys the transmission of information.

14. The 40-50 dB gain applies to which wave? before the signal is received by the receptor. The received signal does not require amplification at this stage. What information does the CNS receive? What wave information is encoded? The ones we should hear, the real birdsong? Or those after amplifying by 40 dB. What is the purpose of amplification at this stage, when the signal is received and sent to the center via afferent innervation. A signal below the auditory threshold cannot be amplified using this method. The quiet singing of birds is amplified by 40 dB and we still listen to the quiet singing. It's the same with music. Can't we hear the quiet music? Only amplified by 40 dB?

15. OHCs have afferent innervation and transmit information to the CNS. They do not transmit quiet tones directly to the center, but amplify them and the tones are received by the IHC. This is Bekesy's theory. I would like to point out that it was not Bekesy who invented such reinforcement. This solution was invented and added to the traveling wave theory in the 1980s.

16. The contraction of the KSZ causes a return wave to the middle and outer ear by pulling on the basement membrane in spontaneous otoemission- this is recognized by Kemp's theory [5]. If, during otoemission, the contraction of the OHC causes vibrations of the basilar membrane in the water, which are audible in the external auditory canal, this means that each contraction of the OHC emits sound waves into the external auditory canal. When listening to threshold tones, the backward wave has a greater intensity (20 dB or more?) than the wave heading towards the center? But do we hear threshold tones this way?

17. A sound-sensitive molecule (my invention from 2000) is a molecule sensitive to sound wave energy [6]. Receiving information encoded in a sound wave. The energy of a sound wave causes conformational changes in molecules at the level of bonds, vibrations, oscillations - structure at the nano level? The adequate stimulus for the hearing organ is the energy of the sound wave, not the movements of fluids, the tilting of the hairs of hair cells, or the pulling of cadherin threads for whatever reason. The Nobel Prize on conformational changes and conformers is the explanation.

18. If the movement of fluids tilts the hairs of hair cells due to the flow of fluids, why do we not hear sudden head movements, especially in the horizontal plane? The inertia of the inner ear fluids should provide us with this - just like the receptor of the balance organ works. But we don't hear. The organ of balance works - semicircular canals - Barani's Nobel Prize.

19. In the signal path through the cochlear fluids there are wave reflections, absorption, reflection attenuation, interference attenuation, and dispersion. The difficulty is to explain the resonance of the longitudinal wave in the fluid with the transverse wave of the basement membrane. There is a large disproportion in wave speed, inconsistent direction and, in many cases in mammals and birds, inconsistency between the frequency of the forcing wave and the forced wave. How to explain the increase in energy of a traveling wave on the basilar membrane when there is no wave resonance? The wave speed in snail fluids is 1450m/s. Traveling wave speed 2.9-50 m/s acc. Bekesy's research or calculations. The speed of the wave traveling near the oval window is 50 m/s, on the way to the oval window it decreases to 2.9 m/s. If we assume that at a certain point in the basilar membrane the speed of a traveling wave is 10 m/s, the difference in wave speed is 145 times. A sound wave carries densely packed information in the form of quantized energy. Its speed is constant regardless of the frequency. Only the wavelength changes. With such a difference in speed, how is information recorded on a transverse wave? Does such slowing down of the message and concentration of information interfere with the transmission of information? All information must be transmitted with this compression of sound wave energy. Is it possible?

20. Auditory reaction time - 105 milliseconds in athletes, and the time of all procedures calculated according to macro and micromechanists in accordance with the traveling wave theory is 2-3 times longer. There can be 250-300% discrepancies. The auditory reaction time includes: a) receptor stimulation, b) transmission of excitation to the CNS, c) analysis and formation of the executive signal, d) time of the signal to the muscles, e) muscle stimulation, change in tension and execution of movement. Nerve conduction speed - 60-120 m/sec. After including the synaptic delay, it is 33.9 m/sec. Information processing in the brain takes 60 milliseconds. Studies of mental chronometry are given in publications. For comparison, the visual reaction time of athletes is 140-160 milliseconds.

21. When both windows are blocked - including: in cholesteatoma ear inflammation - we hear through bone conduction [7]. The theory is that the energy of the sound wave in bone conduction is conducted from the bones to the fluids of the cochlea and to the basement membrane. Why?????. Since there is only 2 mm of distance from the bone to the receptor! According to theory, the basement membrane is responsible for frequency resolution. It is logical to transmit the information directly to the receptor. The receptor is responsible for frequency resolution - this takes place at the molecular and electronic level.

22. The contraction of the OHC in spontaneous otoemission pulls the basement membrane, which is immersed in fluid on both sides, causing sound with an intensity of up to 20 dB in the external auditory tract. This means that the sound intensity must be higher in the inner ear. That's what Kemp says - 1978. (not Bekesy) However, a tuning fork excited to vibrate with an intensity of about 40-50 dB and immersed in water immediately becomes silent due to the damping properties of the liquid.

23. Decoding of auditory information and furier analysis takes place in the brain. The theory is that the basement membrane, not the receptor, is responsible for frequency resolution. The basement membrane pulled by OHC contraction is responsible for signal amplification. Mechanical amplification is the amplification of an unknown wave that passes through the cochlear fluid during OHC contraction. The wave in the cochlear fluid resonates with the vibration of the basilar membrane, and the basilar membrane at this time is pulled by the contraction of the OHC, which is said to amplify the signal by 40 dB. One wave energy is superimposed on another wave energy? Who evaluates and decides that unknown waves that are not received by the OHC should be amplified? The received silent signal that is to be amplified is already transmitted to the center by the afferent innervation - it does not require amplification at this stage. If energy is not received, it cannot be amplified. The waves travel 1,450 m/s with a frequency of up to 20,000/s. in humans but in young kittens up to 100,000/s. There is a problem here with OHC contractions being able to occur so frequently. There is incompatibility with the operation of ion channels. There were 2 Nobel Prizes for ion channels.

24. We can hear the sound of 100 Hz well, the wave is 1450 cm long. At what point in the 3.2 cm long basement membrane does resonance occur? How does it work in a bat with a 1 mm long basement membrane - it uses frequencies up to 200 kHz, but the frequency and intensity resolution is similar to ours. Is the basement membrane responsible for procedures? The hummingbird has a 0.5 mm basilar membrane and uses similar frequencies to us. How does it accommodate a sound wave approximately 3,000 times longer on its basement membrane? What natural vibrations does this membrane have? Is resonance possible? The natural vibrations of the basilar membrane must match the frequencies of the sound wave. Otherwise there is no resonance, the direction of action of both waves must be consistent. In addition, the energy of the forcing wave must be greater than the attenuation of the wave forced by the snail fluids. Are these three conditions always met?

25. If the OHC contraction causes fluid movements and the tilting of the IHC hairs, it also causes the OHC hairs to amplify their movements - so it stimulates itself and so on? Who decides that fluid movement - one flow stimulates only OHC and the same fluid flow, but intensified, stimulates only IHC? During time-consuming amplification, new waves in the atrial canal fluid are superimposed on the amplified waves? They work simultaneously.? Who manages the traffic here? Who has priority for fluid flow? Do they operate simultaneously with different intensity, different frequency and different information? Does this not cause confusion in the reception of information?.

26. What does acoustic emission testing on bones look like? It must be stated if it arises as Kemp described it. Bone conducts sound very well, over 3000 m/sec. The loss of wave energy during the transition from water to bone and vice versa is very small. The eardrum is not needed here. Without the eardrum there is no otoacoustic emission - why?

27. During acoustic emission - what is the action potential in the auditory nerve? Why aren't such tests performed? Because they are inconsistent with theory? Maybe the theory needs to be tested. Because you can't Change physiology.

28. What is the duration of the BERA test during spontaneous otoemission? Has anyone researched this? If there is an OHC contraction, a transmitter must be released and a postsynaptic excitatory potential and an action potential must be generated in the auditory nerve.

29. Why is there no otoemission caused by applying a 500 Hz tone to the ear? OHC contractions are here! There is a cause for otoemission - there is no effect.

30. Why doesn't anyone say what the role of Na+ is in depolarization? Everyone writes about K+ and Ca++. These problems do not concern Bekesy. He had no idea how ion channels worked. But a lot has changed and this should be taken into account [8].

31. Is it possible to encode wave energy, frequency, harmonic waves and phase shifts just by the movement of fluids moved by the undulating basement membrane? Fluid flows – is it laminar motion? Is it turbulent, since vortices in the snail fluid are described? Vortices are evidence of fluid turbulence. What does this accurate information transfer look like? Where does the snail fluid flow from? From the oval window to the round window? This is how the snail's window game is described. Is fluid movement in flows continuous? Whether stepwise, graduated, consistent with the quantum theory of energy. This is very important in energy coding.

32. Sound wave energy flows continuously into the ear. Energy cannot disappear, cannot be accumulated, it can only be converted into another form. The traveling wave theory does not explain this.

33. The ear distinguishes not only changes in the intensity of the basic tone, but also recognizes harmonic tones, phase shifts, quantity, accent, encodes them and transmits them for analysis in the CNS. Do the basement membrane and cochlear fluids make this distinction too? What does it look like in the resonance of a longitudinal wave with a transverse wave when there is a conflict of directions? We swing children on a swing. Does pushing the swing from the side at an angle of 900 increase the swing deflection? It rather disturbs the swing of the swing. Do different laws of physics apply in the ear?

34. If there is a gain of 30-40 dB in bone conduction? We should hear this better. Because scientists claim that the sound wave reaches the fluid and the basement membrane instead of the receptor, because it is responsible for frequency resolution. According to this theory, the further path of the signal is the same as in air conduction. That is, the flow of fluid, the tilting of the hair cells of the hair cells and the receptor. Are quiet tones amplified? Aren't these bone waves amplified? No response. Instead of the 2 mm path from the bone to the receptor, the signal travels a long way to cause a traveling wave on the basilar membrane. This is wasted time and wave energy.

35. What is the pressure difference on both sides of the basement

membrane at the amplitude of the sound wave many times smaller than the diameter of the atom? Bekesy tested the 2400 Hz sound, gave a very high intensity (he did not specify what it was) and concluded that a pressure of 30 dB was needed on the inside of the stirrup plate to equalize this pressure with the pressure outside the eardrum. He concluded that the amplification of the middle ear is approximately 30-40 dB. Other authors confirmed this. The question is: Increased pressure compared to what? To what wave? Decibels are a comparative scale, not an absolute value. If the input is 90 dB, is the amplification in the middle ear of this input wave? Is this wave received by the eardrum, where the energy loss is 10-15 dB, maximum 20 dB. There is still a gain of that 70 dB when received- amplified by 40 dB? Impossible. Why? Why 70 dB wave amplification? Up to 110 dB? It was found that the lever mechanism increases the wave energy in a ratio of 1: 1.3, i.e. approximately 3 times. It increases the force but reduces the wave amplitude. The wave energy is proportional to the square of the wave deflection. Additionally, the difference between the surface of the eardrum and the surface of the stapes plate in the ratio of 55:3.2 increases the wave energy 17 times. Moreover, the funnel-shaped eardrum amplifies the wave energy by 2 times. In total, the gain is 44 times. On a logarithmic scale, this gives an increase in sound pressure of 33 dB. According to theory. I still ask: 40 dB amplification of which pressure? The pressure is proportional to the wave amplitude. The energy of a wave is proportional to the square of the wave's amplitude. An increase of 30 dB is an increase of 1000 times. An increase of 40 dB is an increase of 10,000 times. Theoretically, the idea is to compensate for energy losses when the sound wave hits the water directly. Loses 99.9% of energy. Hence the gain calculations. In the ear, the wave does not fall directly on the fluids of the cochlea. Which wave is amplified? Strangely enough, the difference between the surface of the eardrum and the surface of the piston in the stapedotomy is 55:0.5 and there is no signal amplification in the cochlea. According to theory, there should be 100 times amplification. The dice lever reduces the wave amplitude by 3 times and the wave energy is proportional to the square of the wave deflection. So how does the lever amplify the energy of the wave 3 times? If there is an amplification of 40 dB in the middle ear, how can this result be explained? Tests for a wave of 90 dB (500 nm) at the input - laser Doppler vibrometry [9].

Frequency--------plate ------- vestibule. 1000 Hz ---------- 5.09 nm --------0.275 nm 4000 Hz ----------1.37nm---------- 0.00886nm 8000Hz----------0.0905nm-------0.00153nm Theory good, research bad? Or the other way around? Who will decide?

36. A human can distinguish two separate tones in the range of 1000-3000 Hz if they differ in frequency by 0.3%, i.e. e.g. 1000 Hz and 1003 Hz. In this range, 1 Hz would occupy a section of 3 micrometers on the basilar membrane. Can a 9-micrometer-long section of the basement membrane vibrate on its own in fluid, loaded with the organ of Corti? What happens when the basement membrane is 1-5 mm long? How does the basilar membrane recognize differences in the intensity of harmonic polytones? What sections of the fundamental wave vibrate in the fluid?

37. The importance of wave reflection in the cochlea from concave surfaces has not been explained. What is the difference between constructive and destructive interference? Where are reflected sound waves concentrated, what happens to the energy of reflected waves?

38. In an otoemission caused by an 80 microsecond click at a frequency of 4000 Hz, the latency time is 4 milliseconds. With a crackle of 80 microseconds at a frequency of 1000 Hz, the latency time is 10 milliseconds. There is no explanation why this is so.

39. In the remaining sense organs there is a mechanism of intracellular amplification. It also exists in the hearing organ. The theory does not recognize this.

40. Objective BERA test – latency time is 1.5-1.9 ms. The signal runs through the basement membrane with resonance, through the cochlear fluids, is there a depolarization of the entire OHC cell? What about additional time when strengthening? A total of 5-6 ms. What is true? Reproducible research? Is it a theory? Is 3rd true?

41. Straightening the cochlea. Bekesy, in order to facilitate calculations and prove his theses, resorted to a method that was difficult to accept for his convenience. He straightened the spirally twisted wires of the snail into a straight pipe. This has serious consequences in calculations. Sound waves now travel in a straight line. In the cochlea, on their way, they meet the wall of a spiral tube. This wall is soft, uneven, and reflects and absorbs waves. Such reflections are repeated many times. These reflections are from double concave planes (bent pipe), so the reflections are concentrated. The reflected waves fall on the basilar membrane through Reissner's lax membrane and the organ of Corti. The energy of these waves accumulates where it falls - it is partially absorbed. The energy of these reflected waves can influence the formation of a wave on the basilar membrane, which increases with distance from the oval window. Is there an explanation for the increase in wave energy as it moves away from the sound source in the absence of resonance? Beksy did something else very strange: He did not take Reissner's membrane into account in his model and connected the atrial duct with the cochlear duct so that the sound wave could run on both sides of the basilar membrane and cause pressure differences on both sides of the membrane. It is difficult to agree with such a concept. According to Bekesy, the wave travels in parallel, through the vestibular duct and the cochlear duct. First it encounters the tectal membrane, then it passes through the organ of Corti with hair cells and receptors. The sound wave does not transmit information to the receptor here, because its purpose is to create a wave traveling on the basilar membrane, fluid flows that will trigger the tip-links mechanism and depolarization of the OHC, contraction, pulling on the basilar membrane, and amplification. This is a round about way, time- and energy-consuming, and prone to errors. Testing the behavior of a sound wave in a straight pipe - it is exactly like testing the behavior of a car at different speeds instead of on a serpentine road, to make the task easier, the tests should be performer on a straight highway and the results presented as valid. There is evidence - such a study and there are good results to confirm the theory.

42. Bekesy assumed that the dimensions of the basilar membrane are responsible for frequency and intensity resolution. As the cochlear canals become narrower - the width and thickness three times from the base to the top - the basement membrane also increases three times in this direction. So the disproportion is 9. The vibrating basement membrane is 3 cm and we receive frequencies from 16 Hz to 20 kHz. A young cat has a 1 cm long basilar membrane and perceives waves with a frequency of 20 Hz to 100 kHz. I wonder how the thickness and width of the basement membrane increases from the base to the top of the cochlea in a kitten. What do the natural frequencies of the basilar membrane look like in a cat?

43. Nature has made a huge mistake. She ordered the basilar membrane to vibrate, receive and analyze frequencies, and placed such an important organ in water and made it impossible to adjust the tension of the string. All important organs of the body have afferent, efferent and some even autonomic innervation. The basement membrane does not have such innervation, it is an

exception.

44. Nature's second error - the basement membrane comes from the germ layer of connective tissue, unlike the organ of Corti, which comes from nervous tissue. The basement membrane is a fibrous connective tissue that supports a vital organ. There is no connection to the nervous system. It does not transmit information to the center. The tasks of the receptor, i.e. the cells of the organ of Corti, have been wrongly assigned to the basement membrane. The indisputable evidence is hearing, with the elimination of the basilar membrane - immobilizing it effectively does not eliminate hearing. Why is such evidence disregarded? Because faith is stronger than evidence. Hearing works well without the mobility of the basement membrane. The basement membrane, as the name suggests, is the basis for the organ of Corti. Hair cells are arranged in an orderly manner in accordance with the genetic code along the basilar membrane, receiving frequencies from high to low from the base to the top of the cochlea.

45. Tip-links: Followers of Bekechism still believe that the tension of cadherin links is directly responsible for the gating of ion channels. They write that "the overall stiffness of protocadherin 15 includes both enthalpic and entropic components, the contributions of which have been quantified and the entropic capability of cadherin 15 has been demonstrated. Single monomers of PCGH 15 (protocadherin 15) act as an entropic spring that is much softer than itself would suggest." enthalpic stiffness. This means that the protein is a significant part of the gate spring that controls the hair cell's transduction channels. It is difficult to argue with such learned argumentation. But it was reported: Domain folding is responsible for shortening the entire length of PCGH15 [10]. Domain folding time - 155 picoseconds. Relaxation time 160 picoseconds or longer. So the domain contraction cycle is approximately 0.33 msec. At 10,000 Hz, only every 3rd wave will be handled. And there are mammals that can hear up to 100,000 Hz, so only every 30th wave will be handled? Is it possible? The next big doubt: The upper hair is assumed to be displaced by 100 nm - which is impossible at low sound intensity. (assumed - not tested!) The concept of "channel spring" was probably introduced by A. J. Hudspeth. He suggested that myosins are responsible for the process of closing the channels. But myosin molecular motors are too slow for such speeds- high frequencies.

46. In 2000, the sensational discovery of the mechanism of OHC contraction. The protein Prestin was detected in the cell wall [11]. It is illogical that the protein has sensors inside the cell that respond to changes in the level of Cl- or HCO3-. and the Cl- level in the cell is so ow. Cl- level in the cell - about 4 mM (statements vary) Cl- level outside the cell - about 114 mM Cl- level in the endolymph - 130 mM Cl- level in the perilymph - 125 mM The change in the Cl- level depends on the operation of K+ ion channels, Na+ and Ca++ and Cl-. Chlorine ions stabilize the membrane potential, the electrochemical potential. Prestin is part of the structure of the cell membranecell, but it is encoded in the cell nucleus. It is produced in the endoplasmic reticulum. It must be properly folded and transported. What is its lifespan? This protein is globular rather than laminar and does not form filaments. It does not cooperate with myosins, dynein and kinesin - ATP-dependent molecular motors. The conformational change of prestin due to the change in the Cl- level equally reduces the length of the OHC and itsthickness, because prestin wraps around the cylindrical cell - it is in the cell membrane. Compressing a cylindrical cell should lengthen it, not shorten it by pulling on the basement membrane.

47. A sound wave carries densely packed auditory information. This is not a simple harmonic wave that can only be found in the laboratory. This information is quantized energy of various intensity and frequency with harmonic frequencies, phase shifts, quantity and accent. Quantity is responsible for differentiating the duration of syllables or sounds during speech, but it is also important in the transmission of other information. Just as in writing there are spaces between letters, words and sentences, in a sound wave there are spaces between packets of energy quanta responsible for transmitting information. The wave formed in this way travels at a speed of 1450 m/s in the cochlear fluid and, according to the accepted theory, is to transmit complete information to a foreign wave of incompatible frequency traveling in a different plane at a variable speed of 2 - 100 m/s, depending on the place on the basilar membrane (Bekesy reported traveling wave speed 2.9-50 m/s). A sound wave in a fluid has a constant speed and the contents of the wave are repacked into slower waves from 14 times to 725 times. This information compression has consequences regarding the accuracy of the message. This is perfectly accurate and fast information? If a signal lasts a tenth of a millisecond and is received by a receptor, does resonance occur? A wave is created on the basilar membrane? The wave travels through the snail's fluids? Are hair cell hairs tilted? When a signal has only one wave period? The problems and ambiguities of Bekesy's traveling wave theory prompt analysis and presentation of a new vision of hearing called the "Submolecular theory of hearing" There is enough analysis and evidence pointing to a new understanding of the mechanisms of hearing. The dogma of the traveling wave theory is no longer a dogma.

REFERENCES

1. Wysocki J, Kwacz M, Mrówka M, Skarżyński H. Comparison of round window membrane mechanics before and after experimental stapedotomy. The Laryngoscop. 2011; 121; 1958-1964.
2. Kwacz M, Marek P, Borkowski P, Mrówka M. A three-dimensional finite element model of round window vibration membrane before and after stapedotomy surgery. Biomed. Mechanobiol model. 2013; 12: 1243-1261.
3. Koprowski P, Grajkowski W, Kubalski A. Ion channels. Kosmos, Problemy Nauk Biologiczne. 2005: 54: 373-379.
4. Guinan Jr.J, Solt A, Cheatham M. Progress in Cochlear Physiology afte Bekesy: Hear Res. 2012. 293: 12-20.
5. Kemp DT. Stimulated acoustic emission from within the human auditory system. J Acoust Soc Am. 1978; 64: 1386-1391.
6. Piela L. Ideas of quantum chemistry. 2022. PWN Warsaw. 1300.
7. Stieger Ch, Guan X, Farahmand B, Page B, Merchant J, Abur D, et al. Intracochlear Sound Pressura Measurements in Normal Human Temporal Bones During Bone Conduction Stimulation. J Assoc Res Otolaryngol. 2018; 19: 523-539.
8. Myjkowski J. Transforming and transmitting auditory information, Otolaryngologia. 2004; 58: 377-383.
9. Narni Y, Sotomayor M. Tuning Inner-Ear Tip-Link Affinity Trough Alternatively Spliced Variants of Protocadherin-15. Biochemistry. 2018; 57: 1702-1710.
10. He D, Lovan S, Ai Y, Li Y, Baisel K. Prestin ad Year 14: Progress and Prospect. Hear Res.2014; 311: 25-35.
11. Myjkowski J. Submolecular Theory of Hearing. J Otolaryng Head Neck Surg. 2022; 8: 069.