The Nobel Prize in Physiology or Medicine 1961

Presentation Speech

Presentation Speech by Professor C.G. Bernhard, member of the Staff of Professors of the Royal Caroline Institute

Your Majesties, Your Royal Highnesses, Ladies and Gentlemen.

In one of his scientific papers von Békésy describes that on board a ship he became interested in how the fog horn was made, since he had been struck by the fact that the fog signal which was heard for many miles at sea, was practically inaudible in the cabin of the ship. This episode serves as an introduction to a paper analysing those properties of the ear the functions of which are to give - together with a high sensitivity to sounds coming from outside - a remarkably low sensitivity to one's own voice, even though this sound is produced from a nearby source within the body. This quality of the auditory organ is indeed of essential importance both for the speaker and the listener - not least in a big auditorium. The quality mentioned is, however, only one of the many abilities of this highly specialized sense organ whose mechanisms have been the subject of von Békésy's brilliant analysis.

According to the saga, Heimdal was able to hear the grass grow. Our hearing ability is perhaps not of that kind, but our ear is anyhow almost sensitive enough to record the bounce of an air molecule against the eardrum, while, on the other hand, it can withstand the pounding of sound waves strong enough to set the body vibrating. Moreover, the ear is capable of a selectivity which permits a close analysis of sounds the various qualities of which determine the characteristics of the spoken word and of instrumental and vocal expressions in the universe of music.

A sound which hits the ear makes the eardrum vibrate. Within the airfilled middle ear the vibrations are transmitted via a subtle system of levers, the ossicle chain, to the fluid of the inner ear, the cochlea. The footplate of the stirrup which serves as the innermost link of the ossicle chain is movably mounted in the opening of the oval window of the inner ear which faces the middle ear. The vibrations of the fluid engage in their turn the so-called basilar membrane, an oblong partition which divides the spiral-shaped cavity of the cochlea in its longitudinal direction. Along its entire length the membrane carries sense cells, receptors, like fine tapering columns with hairy points reaching up to a covering membrane. The receptor cells, or hair cells, transform the mechanical energy, represented by the vibrations of the basilar membrane, into the specific form of energy which triggers the nerve impulses. The frequency of these impulses serves as the code to the information carried on to the higher nerve centers.

Von Békésy has provided us with the knowledge of the physical events at all strategically important points in the transmission system of the ear. This does not mean that the properties of the oscillating systems of the ear have not been an object of study and theoretical considerations by scientists before von Békésy. The field of physiological acoustics has a noble ancestry, in which the theories of von Helmholtz hold an authoritative position.

Von Békésy's distinction is, however, to have recorded the events in this fragile biological miniature system. Authorities in this field evaluate the elaborate technique which he developed for this purpose as being worthy of a genius. By microdissection he reaches anatomical structures difficult of access, uses advanced teletechnique for stimulation and recording, and employs high magnification stroboscopic microscopy for making apparent complex membrane movements, the amplitudes of which are measured in thousandths of the millimeter.

Among von Békésy's important contributions to our knowledge of sound transmission in the middle ear should be mentioned the elucidation of the vibration patterns of the eardrum and of the interplay of the ossicle movements. His technical and theoretical mastery has reached its peak in those investigations which led to the fundamental discoveries concerning the dynamics of the inner ear. Experimental and clinical data had confirmed von Helmholtz's assumption that the frequency of the sound waves determines the location along the basilar membrane at which stimulation occurs. The physical characteristics of the pattern of the membrane vibrations and the conditions for its appearance had, however, previously only been the object of theoretical considerations. Von Békésy succeeded in unveiling the features of the vibration pattern. He found that movements of the stirrup footplate evoke a wave complex in the basilar membrane, which travels from the stiffer basal part to the more flexible part in the apex of the cochlea. The crest of the largest wave first increases, thereafter quickly decreases. The position of the maximal amplitude was found to be dependent on the frequency of the stimulating sound waves in such a way that the highest crest of the travelling wave appears near the apex of the cochlea at low-frequency tones and near its base at high frequencies. The conditions for the appearance of these specific vibration patterns were determined in model experiments.

Von Békésy then turned to the question of how the hair cells are stimulated. With a thin needle, the point of which touched the basilar membrane, different parts of the membrane could be set in vibrations in various directions. The point of the needle simultaneously served as an electrode for recording the electrical potentials from the receptor cells. It was found that a local pressure on the basilar membrane is transformed into strong shearing forces which act on the hair cells in various degrees.

Thus, von Békésy has given us a clear picture of how the cochlea functions mechanically and his discoveries serve as a basis for our conception of the cochlea as a frequency analyzer.

We have now reached the last strategic point of the system, that is to say the point at which the mechanical energy is transformed into the physicochemical processes which result in nerve impulses. As in the case of other sense organs, the knowledge about the electrical processes in the inner ear constitutes the foundation for further research. Von Békésy has discovered, on the one hand, the so-called endocochlear potential indicating the existence of a large potential difference over the receptor membrane at rest and, on the other hand, slow potential shifts taking place upon stimulation of the hair cells. These discoveries contribute most significantly to the analysis of the relation between the mechanical and the electrical phenomena in the receptors which are involved in the transformation of sound into nerve impulses.

The work of von Békésy has greatly influenced the development of audiology and its clinical application. Thus, the development of refined diagnostic methods has made possible great advances in the treatment of diseases of the ear.

Professor von Békésy. Your outstanding research work has given us an intimate knowledge of the elementary hearing processes. As a whole this is a unique contribution. The main reasons for the award are however your fundamental discoveries concerning the dynamics of the inner ear. With reference to Nobel's intentions it is also a great satisfaction to be able to award the prize for outstanding discoveries which are entirely the result of one single scientist's work. On behalf of the Caroline Institute I extend to you our warm congratulations, and ask you to receive this year's Nobel Prize for Physiology or Medicine from the hands of his Majesty the King.

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