

Prof. dr. nob. Georg von Békésy, Nobel Laureate

Janos Vincze, Gabriella Vincze-Tiszay

Health Human International Environment Foundation, Budapest, Hungary

Email address:

ndp@t-online.hu (J. Vincze)

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Abstract: Békésy organized his experiments with great care, and often sought the opinion of those around him. This points to a very important personality trait: I think he was fully aware of the limitations of his knowledge and was trying to expand them through discussions with others. Like Hungarian personalities who went abroad in general, he changed his first name to Georg (instead of György); he used the noble forename von characteristic for English, and this is how he appears in his dissertations. He used his surname in its Hungarian form, having accents on the letters é. In 1961, nobleman Georg von Békésy received the Nobel Prize in Medicine: “for his discoveries of the physical mechanisms of stimulation within the cochlea”. To be sure, Georg von Békésy is the only Nobel Laureate scientist in the entire history of the Nobel Prizes who bequeathed his collection of precious art objects and all the rest of his properties to the Nobel Foundation that he made his exclusive successor. For Békésy the Nobel Prize and the Nobel Foundation created by Alfred Nobel, were innovative products similar to Swedish steel. The *essence of Békésy's* discovery is the clarification of the energy conversion *process in the cochlea*. He succeeded in designing measuring devices with which he could measure all the mechanical functions of the hearing organ, and express it with numerical data. At the end of the article we write the genealogy of Georg von Békésy.

Keywords: Georg von Békésy, Nobel Prize, Genealogy, Audiology

1. Introduction

In 1961, nobleman Georg von Békésy received the Nobel Prize in Medicine: “for his discoveries of the physical mechanisms of stimulation within the cochlea”.

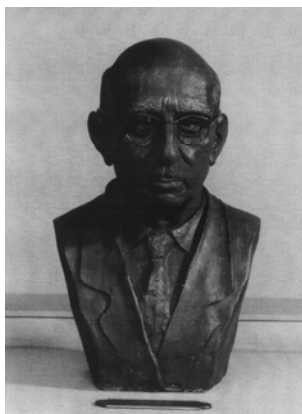


Figure 1. The bust of Georg von Békésy, created by JózsefKampf, exhibited at the King Sigismund University (Budapest, District III) together with the busts of the other Nobel laureates of Hungarian descent.

Békésy was a true and committed researcher throughout his life, who spent a lot of time in his laboratory. In my opinion [1], the following characterized his personality: A real researcher thinks a lot more about the experiment than answers a very important question than about the amount of time spent with carrying out the experiment. In the experiments designed by him, he always strived to achieve results in the simplest possible way. He organized his experiments with great care, and often sought the opinion of those around him. This points to a very important personality trait: I think he was fully aware of the limitations of his knowledge and was trying to expand them through discussions with others. [2]

2. Nobelman Georg von Békésy

Like Hungarian personalities who went abroad in general, he changed his first name to Georg (instead of György); he used the noble forename “von” characteristic for English, and this is how he appears in his dissertations. He used his surname in its Hungarian form, having accents on the letters “é”. Many times they tried to get him to change his last

name, but he would not consider it. On the diploma received with Nobel Prize diploma his name appears as follows: Georg von Békésy. He kept the “y” at the end of his surname, which many foreigners had to learn to pronounce as “e”. We can also document such use of the surname because his last autobiographical writing was published two years after his death (from the *Annual Review of Physiology*, Volume 36, 1974: *Some Biophysical Experiments from Fifty Years ago*, pages 1–18), from where we copied his signature: [3], Figure 2.

Based on the above analysis, it can be stated that Békésy kept more of his name than Hungarian personalities who spent the second half of their lives abroad. Békésy, when he wrote in Hungarian, used his name as GyörgyBékésy.

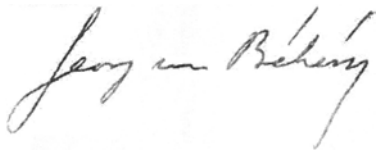


Figure 2. Copy of the original signature of Békésy.

3. Békésy's Experimental Results

Our hearing organ is so sensitive that even the collision of air molecules can be recognized by the eardrum. Further enhancement of this sensitivity would mean that thermal movements could be detected as well. Fortunately, we do not hear these, and many other noises and disturbing sounds are eliminated by the *blocking function* of the ear. For instance, the ear cannot hear the deep sounds of the operations taking place in one's own body, as the ear is *less sensitive to low frequency*. However, the upper limit of perceptible vibration is high.

The *ability of the ear to select* allows it to select the sounds we want to listen to. It can also separately detect the individual sounds of an orchestra.

The *essence of Békésy's discovery* is the clarification of the energy conversion *process in the cochlea*. [4]

It started from the middle ear. Sound waves vibrate the eardrum; the auditory ossicles transfer the vibration to the fluid of the inner ear, which transmits the vibration to the basilar membrane of the cochlea, which ultimately transmits the vibration to the cortex.

At first glance, the transfer mechanism seems to be too complicated. However, this is necessary because the ear has to solve a great mechanical problem. In order to stimulate the ear, it is necessary for the ear to absorb the sound energy. If the sound waves touched only the fluid of the inner ear, the reflection would not leave enough sound to cause a stimulus. Therefore, the middle ear acts as a transformer: it converts low-energy vibrations with high-amplitude into low-amplitude vibrations with higher-energy, and converts the low pressure in the eardrum to a pressure 22 times the original one. [5]

Békésy, to clarify the function of the inner ear, regarding which until then there had only been conjectures, sought to

observe a model similar to the inner ear. He severed a copper frame with a rubber membrane, which replaced the basilar membrane with the organ of Corti. The carbon powder introduced into the fluid of the model made it possible to observe the movement of the fluid. He brought into motion the artificial stapes of the cochlea model electrically with tuning fork vibrations, and noticed a wave running through the liquid and then into the basilar membrane.

However, since the artificial model cannot replace the human ear: Békésy dissected the cochlea under water to prevent the object from cracking or drying out. By sanding the tip of the cochlea, he reached the basilar membrane, which was sprayed with silver powder, and closed the opening at the tip of the cochlea with a glass plate, so he was the first to observe the movements of the cochlea. [6]

Békésy prove that wherever the sound stimulus comes from (through the oval window or by bone conducting), it creates a surface wave from the oval window towards the tip of the cochlea. The propagation speed of the surface wave depends on the increasing width and looseness of the membranabasilaris and, as a result, decreases with distance from the oval window (45 m/s-2 m/s). Surface waves caused by high sounds occur in a narrow, tight area near the windows, while fluctuations caused by deep sounds occur at the far, wider, loose ends. At deep sounds, the fluctuation fills the entire length of the membranabasilaris, while at high sounds it fills only the front. The vibrations of the membranabasilaris bend the hair cells of the organ of Corti affected by the traveling waves, creating an electrical potential difference. The auditory nerve endings associated with stimulated hair cells sum up these potentials, and transmit a series of action potentials to the brain depending on the intensity of the stimulus. In the process of hearing, inner hair cells fulfill the traditional mechanoelectrical transducer function. As a result of sound stimulation, the hair bundles tilt, generating a change in potential in the membranes of the hair cells. In the event of a depolarizing change, an increase in the frequency of the action potential of the nerve cell attached through the synapse occurs, which indicates the state of stimulation.

Based on these observations, he established the modern *theory of wave*, which explains the processes of hearing taking place in the cochlea. He observed the function of the cochlea on animals as well. [7]

During his study of bone conduction, he found that it produces more deep sounds to our ears than the sound waves transmitted by air, and it deepens our own speech or vocal tone. That is why we find our voices when heard on tape recorders to be surprisingly high.

Békésy's room-acoustic experiment is not less interesting. It is well known that the sound reflection and acoustics of different rooms are different. [8] If there is a strong reflection in the room, pianists will reduce the volume of their play. This experiment also proved to be very suitable for ranking artists. Less talented pianists were only able to control this when playing easier piano pieces, they are forced to focus all their attention on the play when interpreting harder pieces,

and have no attention left to reduce the volume of their piano play. He measured the volume of the music with a measuring device, and the ranking based on the data obtained was constant with the opinion of the music experts.

Auditory stimuli in the auditory organ are accompanied by detectable, measurable electrical phenomena. However, Békésy has shown that this is not a simple transformation, as the electrical energy generated in the basilar plate of the cochlea is greater than the mechanical work generated by the sound.

For example, by introducing fine electrodes into the cochlea of a guinea pig snail, he was able to measure the voltage differences even without the sound stimulation. The constant chemical process in the inner ear produces a constant DC voltage. The electrical voltage generated by the sound vibration alters this equilibrium position. Hence, the essence of hearing is not simply that mechanical energy turns into electrical energy. [9]

The physical, mechanical stimulus weakens on the way (friction, reflection), but the sensory cells are likely to undergo enhancement because the stimulus releases energy from the metabolism of the cells.

Békésy succeeded in designing measuring devices with which he could measure all the mechanical functions of the hearing organ, and express it with numerical data.

The Békésy tracking procedure is shown to be a valid and reliable even in recent investigations when modern information, computer and microelectronic technology is available and applied (see e.g. [10-12]). His valuable work is summarized in couple of works in the last decade [13], and the special issue was edited for the honor of 50th anniversary of the award of the Nobel Prize to him [14].

4. In 1961 Békésy Is Awarded the Nobel Prize

Békésy's distinguished attention and original approach to the role and activities of the Nobel Foundation is radiantly described in his speech delivered at the Nobel banquet* (Figure 3).

(<https://www.nobelprize.org/prizes/medicine/1961/bekesy/speech/>):

"Your Majesties, Your Royal Highnesses, Excellencies, Ladies and Gentlemen.

...As you may know, the first recipient of the Nobel prize in Otology, Róbert Bárány, also came from Hungary. I do not think that this is pure accident. Otology in Hungary had very high standards and there was a genuine interest in it. I have always had the impression that there must have been one outstanding man who set the pattern. For a long time I was not able to find his name in any handbooks, but one day I found out about him. His name was Högyes, and a small side street I used to walk on in Budapest was named after him. His work concerned eye movements connected with the vestibular organ, and because he was a proud Hungarian, he published only in the Hungarian language. This is rather hard

to read, though not quite so difficult as Sanscrit. But even so, the scientific atmosphere he left behind him could be felt indirectly.

Your Majesty, I would like to thank you once more for the honor you have bestowed on the field of my scientific interest. This historical continuity, together with the fact that the ear is a point on which many scientific fields converge, gives me hope that whatever contribution I have been able to make will endure."



Figure 3. Békésy at 10 December, 1961 in Stockholm.

5. The Genealogy of Georg von Békésy

Georg Von Békésy was born in June 3, 1899 in Budapest, and he dies on June 13, 1972 in Hawaii. His genealogy is summarized in Figure 4 [15].

His testament written on October 12, 1970, reads as follows: "...

Article fourth: All of the Test, residue and remainder of my estate, real, personal and mixed, wheresoever situated and of whatsoever kind, and any property over which I may possess a power of appointment by will or otherwise, I give, devise and bequeath to THE NOBEL FOUNDATION, Sturegatan 14, Stockholm Sweden, which organization has expressed a willingness to preserve my art object collection intact...." [16].

6. Epilogue

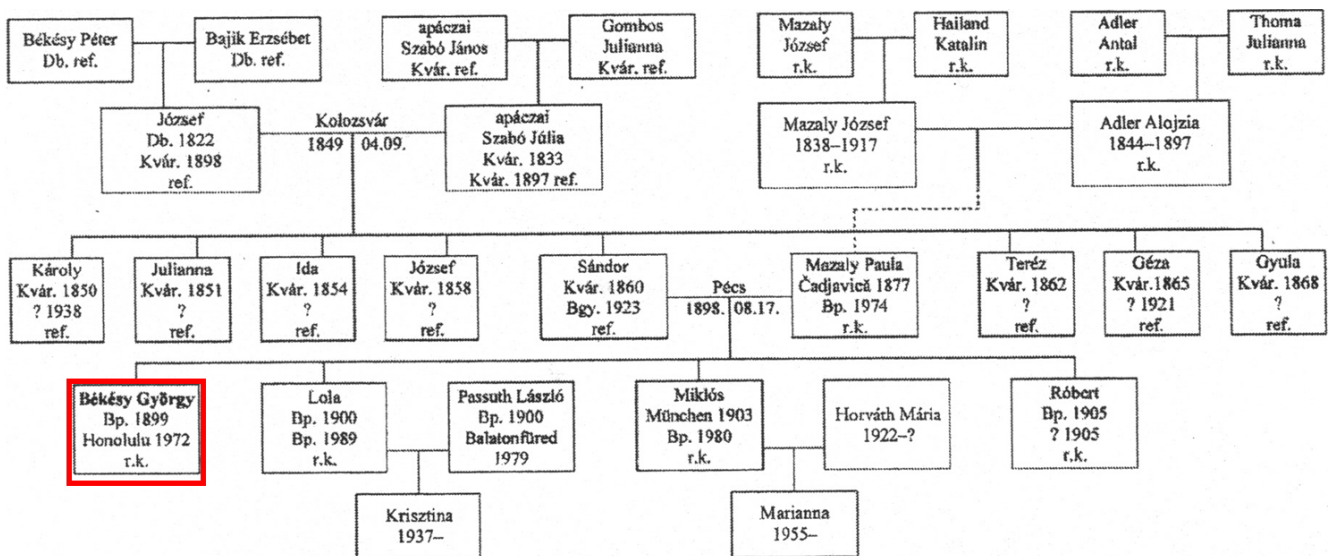
From 1926 to 1946 George von Békésy worked as a postal engineer at the Post Experimental Station. His dedicated laboratory was destroyed by a bomb attack on April 3, 1944.

When the Radio and Television Museum was being constructed the Post Museum (in Diosd, Hungary) contacted the University of Hawaii and requested objects from the Békésy legacy kept there.

News came at the end of April 1995: the complete material of the Békésy Museum would be donated to the Radio and Television Museum managed by the Post and Telecommunications Museum Foundation if the recipient pays the costs of transportation from Honolulu to Budapest.

The Békésy Museum material arrived in 24 crates at the Hungarian Embassy in Washington on June 4, 1995 then continued its journey in the Embassy's container and arrived in Budapest on June 13, 1995.

In this moment two Békésy Commemoration rooms exist at the Post Museum in Diosd.



Abbreviations: Bf. – Balatonfüred, Bp. – Budapest, Bgy. – Balatonyörök, Db. – Debrecen, Kvár. – Kolozsvár, ref. – Calvinist, r.k. – Roman Catholic

Figure 4. The genealogy of Georg von Békésy.

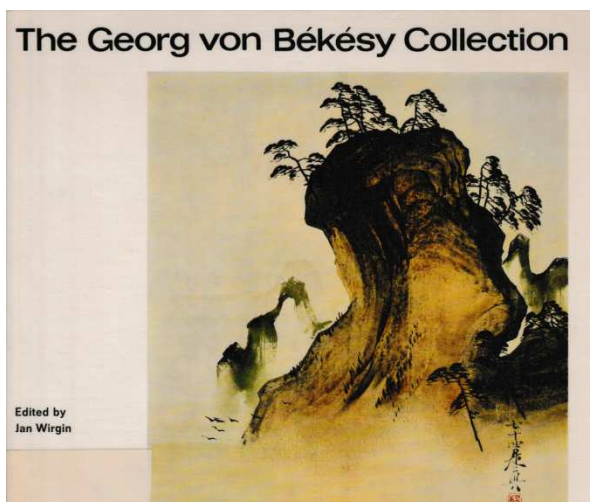


Figure 5. Cover page of Ref. [16].

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