ADOLF BECK, CO-FOUNDER OF THE EEG
AN ESSAY IN HONOUR OF HIS 150TH BIRTHDAY

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On the front cover: Adolf Beck in rectoral robes wearing the ring given in honour of 40 years of his service to the University of Lviv, and holding the textbook written with Napoleon Cybulski (portrait by Stanisław Kaczmór-Batowski from 1935, the painting is now available in the National Museum in Kraków, reprint with the permission of the National Museum in Kraków).

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Adolf Beck, born in Kraków, in 1863, in a poor Jewish family, joined the Department of Physiology of the Jagiellonian University as an assistant in 1880, to work directly under the supervision of its chairman, the eminent professor of physiology – Napoleon Cybulski. Following the suggestion of Cybulski, Beck started experimental studies on the electrical brain activity in various animal species such as rabbits, dogs and monkeys, recorded in response to strong light flashes. Thus, he demonstrated evoked brain potentials, using electrodes applied directly to the visual centres of the brain. His findings concerning the excessive excitation of the visual cortical areas after a flash were published in the German ‘Centralblatt für Physiologie’ in 1890, and initially widely recognized and cited in various scientific magazines. Soon after this success he got a chair at the Department of Physiology of the Jan Kazimierz University of Lviv.

Earlier, in 1875 Richard Caton from the School of Medicine in Liverpool (UK) has already confirmed the existence of the spontaneous waxing and waning of the electrical brain activity, however Beck brought up two new elements. Namely, the localisation of senses with ‘evoked potentials’, and the cessation of electrical brain waves upon sensory stimulation. Thus, as the first one he has described the desynchronisation of the electroencephalogram. In 1929, Hans Berger from Germany has recorded for the first time the electrical activity of the human brain. In this way Berger promoted the non-invasive brain recording technique from animals to humans, and updated this method towards a basic tool for clinical examination of the brain in health and disease.

In considering Beck’s findings, he can, together with Caton and Berger, be considered as a pioneer of encephalography, and a co-founder of this important research methodology. Unfortunately, mainly through the Second World War and the subsequent division of Europe, the Pole Beck is unknown to a large public. He died in a tragic way during the German occupation of Lwów in 1942, when professors of the University were exterminated by the occupant. In this essay, life and work of Adolf Beck, who was born exactly 150 years ago in Kraków, will help to bring him under renewed attention. Moreover, the opening session at the Neuronus IBRO&IRUN Neuroscience Forum in 2013, organised in Kraków, will be entirely dedicated to Beck.
One of the most exciting years in the history of electroencephalography is the year 1890, when a certain dr. A. Beck, affiliated to the Jagiellonian University in Kraków, published a short paper in the leading European physiology magazine ‘Centralblatt für Physiologie’. The paper was entitled ‘Die Bestimmung der Localisation der Gehirn- und Rückenmarksfunctionen vermittelt der elektrischen Erscheinungen’ (see Figure 1). Surprisingly, the paper got an enormous attention. A beginning physiologist, Adolf Beck, an assistant of the famous physiologist Napoleon Cybulski, described the spontaneous and evoked electrical activities in the brain of dogs and rabbits. The young Polish physiologist was able to localise the sensory modalities of the cerebral cortex by electrical and sensory stimulation, investigated with electrical recordings. In this way, he explored parts of the cortex, which reacted with electronegativity upon stimulation. Doing this, Beck found not only the evoked responses, but also the spontaneous fluctuations of the brain potentials. He further showed that these oscillations had to be regarded as genuine electrical brain activities. Moreover, Beck brought up the decrease in the amplitude of these potentials upon sensory stimulation, and a cessation in the fluctuations of the electrical waves as a consequence of the afferent stimulation. Therefore, two essential elements were described: the ‘desynchronisation’ in the electrical waves after stimulation and the ‘evoked potentials’ after sensory stimulation. Consequently, it was evident that the 27-years old Beck claimed to be the discoverer of the electrical brain activity, later indicated as the electroencephalogram.

Figure 1. Adolf Beck as a young man at the period of his doctoral work in Kraków (on the left). The first page of his classic paper in the ‘Centralblatt für Physiologie’ from 1890 (on the right).
Seldom has a publication evoked such a polemic in the world of physiology. A spate of claims followed for priority in finding the electrical brain activity. The first one was from Ernst Fleischl von Marxow (see Figure 2), a famous physiology professor at the University of Vienna (Austria). He wrote that he had already, seven years earlier, deposited a covert letter at the Imperial Academy of Sciences in Vienna, containing claims on the electrical brain activity. Indeed, in that sealed letter indications of electrical brain activity were given, but Fleischl’s observations missed crucial points. Beck responded laconically: ‘Nature held and still holds innumerable riddles under the seal of secrecy. It makes no difference for science whether these riddles are kept under the seal of Nature herself or under that of the Imperial Academy of Sciences in Vienna’. Another remarkable response came from Vasily Y. Danilevsky (Figure 2), a scientist working at the University of Charkov (Ukraine). In his letter to the ‘Centralblatt für Physiologie’, Danilewsky mentioned his doctoral thesis ‘Investigations in the physiology of the brain’, written in the Russian language. In this thesis, he described his research on the electrical activity of a dog’s brain, and gave a description of the fluctuating brain potentials which he had registered. He briefly mentioned the desynchronisation process as well. Unfortunately, Danilevsky published a summary of his thesis in his response-publication to Beck in the ‘Centralblatt für Physiologie’, but not earlier than 1891. The Englishmen Francis Gotch and Victor Horsley also responded. Gotch, the descriptor of the refractory phase after a nerve impulse, performed experiments showing the electrical responses of the spinal cord to cortical stimulation. He did this together with his brother in law, the famous Horsley, the designer of the stereotactic apparatus. Just as Fleischl, however, Gotch and Horsley overlooked essential elements, such as the spontaneous oscillations and the cessation of these fluctuations after stimulation.

Figure 2. Ernst Fleischl von Marxow (1846-1891), a well-known professor in nerve neurophysiology of the University of Vienna. Due to chronic pains, he was treated with cocaine by his friend Sigmund Freud and became addicted (on the left). Vasily Y. Danilevsky (1852-1939) in 1879, shortly after he finished his thesis at the University of Charkov (in the middle). Richard Caton (1842-1926), shown in his thirties when he was working on electrophysiology. Caton was born in Bradford (England), and worked and lived in Liverpool (on the right).
The discussion concerning the claim on the discovery of the electrical brain activity was abruptly ended by a letter of Richard Caton of the School of Medicine in Liverpool. Caton (see Figure 2), a young medical physiologist, referred to a brief abstract of about 10 sentences, published 15 years earlier, in 1875 (see Figure 3). In this abstract published in the British Medical Journal, Caton described the spontaneous waxing and waning of the electrical activity recorded from the brain of rabbits and monkeys. The abstract appeared on the occasion of a meeting of the British Medical Association in February 1875. In a longer paper in the same journal published two years later, Caton more extensively described identical experiments with a larger number of animals, almost with the same results. Caton’s claim was convincing and indisputable. Nowadays, it is generally accepted that Caton’s abstract in 1875 contains the first description of the electroencephalogram. Regrettable for Caton was that his findings ‘produced no single ripple in the pool of physiologists’. Later, Caton resigned from physiology and became Lord Mayor of Liverpool. His family and colleagues were unaware of his discovery, since he took deliberate steps to hide the fact that he had worked on the brain of animals.

Figure 3. The original abstract of Richard Caton with the oldest text referring to the electrical brain waves, published in 1875. At that time Caton’s work was fully ignored.
Beck was, as all physiologists, not aware of Caton’s work, but he explored the electrical brain activity much more extensively than Caton did. Beck delivered important contributions to the nature of electrical brain activity. He accurately described the localization of sensory modalities on the cerebral cortex by electrical and sensory stimulation followed by recording the electrical activities. He did this with clay electrodes and a mirror galvanometer. The abstract he sent to the ‘Centralblatt für Physiologie’ in 1890 was a summary of his extensive thesis which was published one year later in the Polish language (see Figure 4). This thesis was later, in 1973, as the initiative of the expert in the history of neuroscience, Mary Brazier, translated into English. Beck explored, in frogs, as well as in dogs and rabbits, the parts of the cortex which reacted upon stimulation with electronegativity. This was tested for several sensory modalities, and in fact was the first description of ‘evoked potentials’. Doing this, Beck has also found the spontaneous oscillations of brain potentials and showed that these fluctuations were surely not related to the heart and breathing rhythms. Moreover, Beck brought up a new element: the potential decrease upon sensory stimulation. He observed a cessation in the fluctuations of the electrical waves as a consequence of afferent stimulation, either by electrical stimulation of the nervus ischiadicus, or by peripheral stimulation of the eyes with light flashes. Thus, he was the first one who described the desynchronisation in the electroencephalogram following stimulation.

Figure 4. The cover (on the left) and the first page (on the right) of Beck’s dissertation which was published in 1891.
A typical experiment of Beck carried out on an immobilized rabbit, is reported on page 33 in the English edition of his thesis (see Figure 5). In Beck’s own words: ‘Experiment II. Rabbit of medium size. Right hemisphere exposed and both electrodes placed on the occipital region, 3 mm apart, parallel to the sagittal suture (Fig.7aa); deflection was weak, 45 and slowly varying: 45, 40, 35, 40, 35, 31, 30, 27, 25. After exposing the eye to the burning magnesium, there were no changes in oscillations or deflection. I moved the anterior electrode to the parietal region (Fig. 7bb); deflection: 103, 100, 102, 98, 93, 83, 80, 73, 71, 73, 77, 72, 71, 72. After lighting the magnesium before the eye, the deflection increased without oscillations up to 104; after covering the eye it returned to 82 and the oscillation began: 82, 87, 89, 80, 76, 82, 75, 78, 73. After a strong hand clap over the rabbit’s ear, the oscillations ceased, without change in the deflection. Stimulation of the left hind leg had the same effect’.

![Figure 5. Recording places on the occipital and parietal cortex of the rabbit brain. Due to the placement of electrodes, the flash gave an evoked response and the clap only a desynchronisation (on the left). The filtered and plotted reproduction of the experiment described by Beck in his thesis (in the English version, on page 33). The registration shows two essential elements: a visual evoked potential after a flash of the light and the desynchronisation both after the visual stimulus and the hand clap (on the right).](image)

Beck noticed by hand the deflections of the galvanometer, although with an unknown sampling rate. The galvanometer deflections were amplified by a light beam falling on a small mirror fixed on the galvanometer wire, and the reflected beam was directed to a metric scale (see Figure 6). In Figure 5, the original deflections of this experiment, plotted as a DC registration and filtered with a bandwidth between 1 and 30 Hz, are shown. Beck had no problems with explaining the single-trial visual evoked potential. From page 51: ‘It is not difficult to explain this phenomenon. Most probably the stimulation of the eye with light activates the centres of the visual region of the cerebral cortex, and as a result an electronegative potential appears in that region of the cortex’. The evoked potential recorded over the occipital cortex was followed by a desynchronisation. After the hand clap only a
desynchronisation was visible in this visual part of the cortex. Since small amplitude, high frequency waves could not have been registered with Beck's insensitive equipment, a desynchronisation was expressed in a flat line. It was a cessation in the fluctuations of the electrical waves as a consequence of sensory stimulation. The blocking phenomenon, discovered by Beck, was in essence a counter-intuitive finding: the consequence of stimulation was that the electrical activity decreased instead of an expected increase. As it can be supposed, Beck had problems with the interpretation of this phenomenon. To explain this, he formulated the principle of a localized excitation, surrounded by an extended inhibition. In his own words (page 53): ‘An important phenomenon which occurred in nearly all the experiments with stimulation of the cerebral cortex was the arrest of the spontaneous oscillations of the action current. The explanation of this phenomenon is not too easy. I would interpret it as an expression of an arrest of the active state at a certain point and a suppression of the changes which occurred spontaneously in the active state. In a word, one can explain it by inhibition. It is nothing new to us that the excitation of some centres causes inhibition of the active state of others’. Although the principle of excitations surrounded by inhibitions is still a common principle in modern neurophysiology, it may be obvious that more sensitive galvanometers with the use of powerful amplifiers, and even single unit recordings, were necessary to explain the process of desynchronisation in a correct way.

Figure 6. The electrodes used by Beck for recording the electrical brain activity (on the left). These non-polarisable electrodes were made of cotton threads embedded in clay. The clay extended from a glass tube filled with a zinc sulphate solution. Zinc wires entering the solution connected the electrodes to a Wiedemann galvanometer, which was provided with a tiny mirror (on the right). The mirror reflected a light beam on a read-out scale. At that time recording cameras were not available.
It was already forty years later that the German Hans Berger published his first paper about recordings of the electrical activity from the surface of the human brain. Although he had earlier started with dogs in 1902, he switched to human studies in 1924. His children, son Klaus and daughter Ilse, were main, obedient, but often unwilling, subjects. On October 14\textsuperscript{th}, 1927, Berger exclaimed: ‘Eureka! The waves of Klaus are identical to the intracerebral recorded waves. I am able to record the electroencephalogram of an intact skull!’ Berger was the first who recorded the electrical activity of the human brain, and so promoted the technique as a non-invasive registration with clinical perspectives. Moreover, it appeared from his publication in 1929 that Berger was aware of studies published earlier. In the interesting historical introduction of his lengthy paper, he gave full credit to all researchers, even to Caton and Beck. Indeed, already described were the main phenomena, such as the spontaneous fluctuations, the blocking after sensory stimulation, as well as the existence of two pattern rhythms. These rhythms were first distinguished in dogs by Wladimir Práwdicz-Neminski in 1913, and were initially denoted as ‘waves of the first order’ and ‘waves of the second order’. These were later called A-waves and B-waves, and nowadays: alpha- and beta-waves. Práwdicz-Neminski, who worked at the Kiev University of St. Vladimir and later at the Ukrainian Academy of Sciences, was also the researcher who coined the German term ‘Elektrocerebrogramm’ (see Figure 7). For linguistic reasons, Berger changed it to ‘Elektrenkephalogramm’, which in English was translated as ‘electroencephalogram’, abbreviated as ‘EEG’.

\textbf{Figure 7.} The first registration of the electrical brain activity (‘Elektrocerebrogramm’) of dogs made by Władimir Práwdicz-Neminski in 1913. The lower trace is the time in seconds (5 units is 1 sec). The recording has a dominant frequency of 12 to 14 Hz.

Hans Berger (see Figure 8) was a neuropsychiatrist at the hospital in Jena (Germany), and was strongly interested in clinical applications of the electrical brain activity. Berger had a more sensitive galvanometer than his predecessors, while at the same time amplifiers came on the scene. He described the conditions under which alpha- and beta-waves appeared in humans, and these waves placed Berger with an analogous problem as Beck. He noticed that the small beta-waves arose in higher mental activities than the larger alpha waves, appearing under low-active brain states. Berger discussed this only in vague statements, since he was not focused on theory and had a pragmatic
attitude. He described changes in the electrical brain waves during sleep and narcosis, and recorded aberrant activities during epileptic attacks in humans. Berger came to the conclusion that the electroencephalogram was not only a major breakthrough in neurophysiology, but also saw that this technology was of outstanding importance as a diagnostic tool. Also important for Berger was that recognized neurophysiologists of that time, who recorded action potentials from large squid nerves, became less sceptical of his work. Till that time they considered this strange and global brain activity as an artefact. Adrian and Matthews, recognized neurophysiologists at the University of Cambridge (UK), even started to replicate Berger's findings. After their positive replications, his results were seriously considered. Berger slowly convinced scientists of the value of the new method. He strongly promoted the technique for recording the human brain activity as a clinical tool. Since that time, this methodology is indispensable in clinical neurophysiology. For all these reasons, Hans Berger is considered as the grandfather of electroencephalography.

Figure 8. Hans Berger (1873-1941) in 1927, with the ‘Elektrenkephalogramm’ of his daughter Ilse. Upper trace: Ilse in rest (alpha waves), middle trace: Ilse in calculating a sum (beta waves), and lower trace: Ilse in giving the outcome of the sum (mixes waves).

Berger got the honour to be regarded as the grandfather of electroencephalography since he applied the technology, which was developed for animals, to humans. Secondly, and even more importantly, the time was ripe to see the importance of electroencephalography. Caton and Beck were nearly half-a-century ahead of their times in their views about the meaning of this technology for the studies of the brain functions. Nevertheless, in the course of research into the origins of electroencephalography, interest must also be focused on the two earliest discoverers: Richard Caton, whose first announcement of the ‘Electric currents of the brain’ appeared in 1875, and the independent discovery of these currents by Adolf Beck, during his work for the doctoral thesis in 1890. As already
recounted, none of these forerunners of what has become a field of world-wide scientific importance attracted much attention in the Europe or in the USA. In case of Caton, the shortness and inaccessibility of the abstracts played a role, while in case of Beck the barrier of the Polish language undoubtedly contributed to the lack of recognition. While looking back, it seems that the best idea is to attribute the discovery of electroencephalography to the trio of Richard Caton (for his first brief description of brain waves), Adolf Beck (for his extensive brain work in animals), and Hans Berger (for making the recording technique of these waves applicable in humans).
Life and work of Adolf Beck in Kraków

Adolf Abraham Beck (originally Abraham Chaim Beck) was born in the Kazimierz quarter of Kraków on January 1st, 1863 in a Yiddish-speaking sober living family of a Jewish baker. His father was Szaja Dawid Beck, and his mother Gustawa (Bluma Golda) Müller. The ancestors of the Beck family came from a wealthy family of diamond cutters that for centuries had lived in Amsterdam. Kraków was in 1863 a main city in Polish Galicia, the Austrian sector of partitioned Poland. Beck visited the elementary Kraków Jewish School, and since the young Beck displayed a natural talent for studies, he went to the gymnasium (Św. Jacka) in Kraków. This led to his graduation in 1884, and the acceptance as a medical student to the Medical Faculty of the Jagiellonian University, where he studied medicine from 1884 through 1889. His interests were in natural sciences, so he began to work in 1889 as an assistant under the leadership of the well-known physiologist, Napoleon Nikodem Cybulski (1854-1919, see Figure 9). His initial interest was the electrophysiology of the nervous system, and in particular the electrical response of a nerve evoked by sensory stimulation. This was suggested to him by Cybulski, since a hot topic in that time was the excitability of the nerve at all points over its pathway. Based on the fact that the activity is easily travelling over the nerve, the German Eduard Pflüger proposed that the neural excitation gathers strength in its passage down the nerve. This ‘avalanche theory’ states that conduction depends not simply upon an undulatory movement propagating itself, but upon a gradual increment of the potential energy in the nerve over its pathway. Beck began to measure the excitability on two points of the spinal cord in frogs following stimulation of the sciatic nerve. One electrode was placed on a point of the spinal cord and the other over the cerebral hemispheres. It appeared that electronegative variation following stimulation was substantially changing on the cortical level (see Figure 10). This result was explained by the observation that the spontaneous current was already fluctuating, while the evoked activity came on top of these spontaneous oscillations.

These findings led in 1888 to a publication of Beck in the Polish language, translated into English as ‘On the excitability of the various parts of the same nerve’. The oscillations, which Beck and Cybulski saw in the fluctuating baseline, brought them to the idea of the continuous recording of the spontaneous electrical brain activity. In the same year, Beck presented his recordings at his first students’ conference, and gained a prize from the university. After one year, he was appointed to be a demonstrator, and shortly after that – to be an assistant in the Department of Physiology, where he began his extensive research on the electrical processes of the brain. This became the main topic of Beck’s doctorate work, which was finished with cum laude graduation to medical doctor in 1890. The dissertation itself appeared in 1891. In a brief note published in the ‘Centralblatt für Physiologie’ a
year before, Beck described his, polemic evoking, finding of what is now called the electroencephalogram.

Figure 9. Adolf Beck (on the left) and Napoleon Cybulski (on the right) in writing the textbook ‘Fizjologia człowieka’ (‘Human Physiology’), which appeared in 1915. This was a popular must among medical students and doctors. The photo is made in 1911. Napoleon Cybulski was a Polish pioneer in neurophysiology and endocrinology, and was the discoverer of adrenaline in 1895. He also developed a device for measuring blood flow velocity. Cybulski served as the Rector of the Jagiellonian University during the period of 1904-1905.

Figure 10. The response of the cortical surface to electrical stimulation of the sciatic nerve of frogs (Drażnienie n.isch.) is expressed in electronegative deflections. Note the undetailed, poor character of the evoked response which is hardly more than a line, while a time scale is missing. Beck had no camera and made simple hand-drawings of the amplified deflections of the galvanometer.
It is important to mention here that the scientific activity of Beck was not limited to electrophysiology. Beck’s scientific interest was widely ranging, and he extended his research to other fields, such as to general and visceral physiology. Beck had a great talent for innovative research. Together with Cybulski he published papers on diverging topics, such as taste perception, the characteristics of blood circulation, and the properties of urine. In 1894 Beck got his venia legendi (habilitation) in physiology with a thesis titled ‘Changes of blood pressure in vessels’.

Figure 11. The Department of Physiology at Św. Anny street in Kraków, where Beck and Cybulski did most of their electrophysiological work. It is now known as the Collegium Kolłątaja. In 1895 Cybulski’s group moved to the large Collegium Medicum building at Grzegórzecka street, where the Department of Physiology is still located.

Cybulski, initially Beck’s supervisor and professor but later a colleague and friend, soon realised as the head of the department that their electrophysiological work had opened a new field of research. He began to equip his laboratory more effectively for such studies (see Figure 11). Although the university had a limited budget, Cybulski, as a prominent citizen of Kraków, succeeded in this endeavour. Cybulski and Beck were able to pursue their electrophysiological studies and extended the work on brain potentials from rabbits and dogs to monkeys. This formed the subject for a report they made for the Third International Physiological Congress in Berne (Switzerland) in 1895. This was their last joint experimental work, as Beck was offered a professorship at the University of Lemberg (now Lviv, Ukraine). Around that time Beck married Regina Mandelbaum, and they lived together until 1938, when she died. The couple got three children: daughter Zofia who passed away on a relative young age in 1939, son Henryk born in 1896, and the second daughter Jadwiga born in 1901. The last two came to earth in Lemberg.
Life and work of Adolf Beck in Lviv

In May 1895, at the age of 32, Beck accepted the offer to be appointed professor in physiology at the Jan Kazimierz University in Lemberg. He worked there till 1935, and spent the rest of his life in this city. At that time Lemberg was closely connected to Kraków in the region of Galicia, a relatively-independent province of the Austrian-Hungarian Habsburg empire. Lemberg was a multinational city with a mixture of Polish, Ukrainian and German-Austrian inhabitants, as well as with a large population of Jews. After World War I, Lemberg, renamed according to its original Polish name into Lwów, belonged to the independent Polish Republic, but became under Soviet rule in 1939. Presently, Lviv is a city in the west of the Ukraine, since the partition of the Soviet Union in 1991. The University of Lemberg was named the Jan Kazimierz University, and now it is known as the Lviv National Medical University (see Figure 1). Beck started with energy and enthusiasm building up the new Department of Physiology at the Medical Faculty. He organised this department in a similar style as in his Alma Mater, and provided it with modern equipment. He organised an electrophysiological laboratory equipped with the newest galvanometers and registration devices. Beside the main direction of electrophysiology and neuroscience, Beck interests spread also to other aspects of physiology. To create a broad department of physiology, Beck was able to form a staff with expertise in diverging aspects of physiology. In this initial period Beck’s assistants were, among others the physiologist, Dr. Teofil Hołobut, later famous professor in bacteriology, and the medical neurologist Dr. Jakub Rothfeld, later achieving a remarkable position in Polish neurology. In October 1895, Beck gave his inaugural address in Lemberg with a lecture ‘The phenomena of life and the ways of investigating it’ particularly intended to his medical students. The contact with students was important for Beck, and he propagated teaching of physiology by experimental demonstrations. Therefore, he equipped his lecture hall with an expensive multifunctional time projector, ensuring that he could give demonstrations with moving pictures and could have shown the dynamics of physiological processes (see Figure 13). Besides an eminent researcher, Beck was also a gifted teacher and he invested energy in educating young scientists. In his role as teacher and researcher, Beck created the famous School of Physiology at the University of Lemberg, which delivered various prominent physiologists, among them his successors Wiktor Tychowski, head of the Department of Physiology from 1932 until 1937, and Mieczysław Wierzuchowski (head of the department from 1937 until 1943).

In the years following his new appointment, Beck had to give a great part of his time to the organisation and building up his new department, but, despite of this, several of his scientific publications stem from this period. Beck’s research on the electrical potentials of the brain did not cease but was extended, including an attempt to locate the sensation of pain in the brain. He continued research on the nervous system, and he did several investigations to the cerebellum with his proximal...
colleague, Gustav Bikeles (1861-1918). Due to the creative research of Beck and Bikeles, the Department of Physiology got, just as that of Kraków, attention as a centre for expertise in electrophysiology (see Figure 14).

![Figure 12. The main building of the Medical Faculty of the University of Lemberg (now Lviv National Medical University) is shown on this old postcard. The first floor of this building was entirely occupied by the Department of Physiology, headed by Beck.](image)

![Figure 13. The lecture hall of the Department of Physiology where Beck had his lectures and gave his demonstrations is shown on this recent photo. The frescoes on the ceiling are from the time of Beck.](image)
Beck and colleagues performed a diversity of physiological topics, ranging from colour vision to pain sensation. It is obvious that Beck was often involved in common research with his old department in Kraków. In 1896 Beck published together with Cybulski a paper on ‘Further Investigations of the Electrical Processes in the Brain’ (see Figure 15). This work contained four years of cooperative investigations carried out on dogs and monkeys. Besides replication of the previous results of Beck, they obtained some new facts. They showed that with the occurrence of an active state expressed in electronegativity in a cortical area, simultaneously electropositivity in homologue places appeared. Beck and Cybulski specified further on which areas electronegative and electropositive changes were expressed, and were even able to map these areas. With this method, the researchers figured out the existence of cortical localisations, emphasising that specific cortical areas are not clearly demarcated and overlap each other. In this way Beck and Cybulski explored the cortical functional locations, showing that Beck’s methodology was adequate and appropriate to uncover the functional processes of the cerebral cortex. They have also concluded that conscious states are accompanied by physiological changes in the cerebral cortex. In a next work, published in 1906, Beck pointed out that places in the cerebral cortex were evidently associated with pain sensations. Today it is generally accepted that the electrophysiological methodology delivers adequate information on the localization of functions on the cerebral cortex.

Figure 14. Adolf Beck (front row, on the left) and Gustav Bikeles (front row, on the right) photographed during electrophysiological research at the Department of Physiology of the Lemberg Medical Faculty.
In the academic year 1898/1899 Beck went to the Zoological Station in Naples, where he became interested in the electrical phenomena of the retina. These phenomena were already described, but it was unclear which layers in the retina contained the source of the electrical currents. Beck was able to demonstrate that the layer of light-sensitive rods and cones evidently generates electrical phenomena. He proved this by showing the existence of electrical currents in the eye of the cephalopod, *Eledone moschata*, whose retina has only one layer of visual receptors. In 1910, Beck took part in the organisation of the International Congress of Physiology in Vienna, where he closely collaborated with his previous teacher, Napoleon Cybulski. With his old professor and with Kraków colleague, Sabina Jeleńska-Macieszyna, he continued common electrophysiological work. The group was able to publish one of the first photographs of electroencephalographic potentials, and even succeeded to photograph the tracings of a dog showing an epileptic seizure (see Figure 16). Around that time, Beck and Cybulski were writing together the first textbook titled *Fizjologia człowieka* (‘*Human Physiology*’), which was published in 1915. This became the standard and popular teaching text for medical students at Polish universities for a long time.
Beck served the university as a Dean in 1904-1905 and in 1916-1917, and as a Rector in the period of 1912-1913. All activities of Beck were abruptly interrupted in 1914 with the outbreak of the First World War. Lemberg was taken by the Russians in their advance against the Habsburg state. Beck, who was again asked to act as the Rector of the university in 1914-1915, came in an extraordinary situation. Regardless of his prominence as a renowned scientist and rector, he was arrested by the Russian army on June 19th, 1915 (see Figure 17). Together with other Lemberg dignitaries, he was transported to a regional criminal court, and imprisoned in temporary living barracks in Kiev. There Beck survived until he was released by the intervention of the famous Russian scientist and Nobel Prize laureate, Ivan Pavlov (1849-1935), working in St. Petersburg, and a friend of Napoleon Cybulski. Beck was allowed to leave the camp at an exchange of hostages, and travelled to St. Petersburg. After months of wandering through Russia and Sweden, Beck was able to return to Lemberg. Even on Beck’s return in 1916, Lviv was still not a peaceful city. However, even in this time the scientific drive of Beck was expressed by the appearance of a paper on nerve physiology. The data were gathered by his son Henryk, a medical doctor, in the period of his absence. In 1935, shortly after his retirement, Beck published a book containing a detailed story about his time in captivity, and what was happening to the university during his absence.

The year 1919 was a great year in history of Poland, because a free and independent Poland came into being for the first time since 1795 (see Figure 18). In this year Beck lost his friend, Napoleon Cybulski. In a moving eulogy of his old teacher, Beck paid tribute to him as a scientist, a colleague, a friend of the university, and a great human being. At the age of 67, Beck retired. He retired with the title of Professor honoris causa, one of his many distinctions. He was a member of the Academy of Arts and Sciences in Kraków and Vilnius, of the Academy of Medical Science in Warsaw, as well of the Polish Academy of Sciences. As a professor at the Medical Faculty, he produced 180 publications, and he was three times nominated for the Nobel Prize in physiology, once in 1905, then in 1908, and finally in 1911, but he never gained this high honour, which he undoubtedly deserved.
Figure 17. Several of these Lemberg professors were arrested by the Russian army in 1915. Beck is visible in the first row as the 5th person from the right side.

Figure 18. Beck (in the middle of the second row) just after the liberation of Poland in 1918, with a group of Lwów physicians and professors.
During the Second World War, life became even more troubled and dangerous for Beck as in the First World War. The city was occupied by the Nazis, and Beck, who was of a Jewish origin, remained in the town and suffered many indignities and humiliations. When a friend of his son Henryk, Aleksander Zakrzewski (the brother of Jadwiga’s husband, Kazimierz), met him once at Zielona street, Beck was emotional 'Have a look! I have to wear a supposedly disgraced David star on my sleeve!' An old man now, rather to go into hiding, he has chosen to stay in his house at Asnyka street number 4 (now Bohomoltsia street), in the shadow of the university, to which he had given so many years of his life (see Figure 19). But it soon became too dangerous, while many Jews were already murdered in the Janowska and Belzec Concentration Camps. Moreover, several Lviv professors were killed on the Wuleckie Hills near the city. The physiologist and medical doctor, Zdzisław Bieliński, the head of the Department of Physiology, started to take care of his old teacher. Together with Beck’s son Henryk, he found a hiding place for Beck at the ‘Aryan side’. Bieliński recalled this trip: ‘I decided to take him in a cab. I realised that it increased the danger, but there was no other way. Adolf Beck, a man with classical Semitic features and a patriarchal beard is sitting there, next to me. These few kilometers seemed to me the longest and most dangerous in my life. If someone stopped us it would surely mean a torturous death’. Soon thereafter, Beck was betrayed. Just before his 80th birthday, he became unwell, and Henryk and Zdzisław Bieliński brought him to the hospital for an ailment. There, the Nazis were waiting for the almost 80-years-old Beck. At the last moment, Beck’s son, Henryk, could hand his father a capsule with cyanide, giving him the opportunity to commit suicide just before the Nazis could have arrested him and send him to the gas chamber. In the chaos, it is not known which day it was in August 1942. Eye-witnesses Bieliński and Henryk Beck, under great danger, escaped, but both died shortly thereafter. In 1944, Bieliński was killed by unwrapping a package containing a bomb, and Henryk Beck died on a heart failure in 1946 after his life threatening struggle in the Warsaw Uprising. Hence, the exact day of Beck’s death got lost, and it is also not known where he is buried or has a grave.

A remarkable similarity can be seen in the lives of the two main pioneers in electroencephalography: Adolf Beck and Hans Berger. Initially, just as in the case of Beck, the findings of Berger were not taken too seriously by the scientific community. Nevertheless, his international reputation was slowly growing. This brought the modest Berger to the International Congress in Psychology in Paris in 1938, where he was almost recognised as a celebrity. Back in Germany, he found, however, only humiliation by the Nazi regime, who distrusted his work. The Nazis also forced him to give up his Chair at the Psychiatry Clinic in Jena in 1938, and closed down his laboratory. They even did not allow him to receive the Nobel Prize in Stockholm which he was nominated for. Berger fell into a severe and long depression, and on June 1st, 1941 he took his life by hanging. Berger’s wife, Freiin Ursula von Bülow, had a hard time, also since their son Klaus fell on the battlefield in Russia half a year later. Electrophysiology was finished as many fields of research in
Germany, but after the war this type of science was able to climb out of a deep valley. This was mainly due to the work of the famous neurologist-neurophysiologist, professor Richard Jung. He built on the remnants of what was left of the Neurology Department in Freiburg, a clinic with basic research. He did this with an eminent group of researchers. This was in strong contrast with Poland, and in fact with the entire East Europe, since the Soviet regime broke off the main role of electrophysiological researchers. This dogmatic, communistic regime made a choice for the Pavlovian concept, better fitting into its concepts and ideas. This led to an ongoing negation of leading electrophysiologists, and this is mainly responsible for the fact that Beck's value for electrophysiology is currently overlooked and underestimated. This was strengthened by the restricted contacts between East and West researchers, while the inaccessible Polish language was the limit.

![Image of Adolf Beck](image1)

**Figure 19.** The last photograph of Adolf Beck, taken just before the German invasion of Poland.

The death of Beck in this tragic way was the second drama for the Beck family. Shortly before Beck’s death, Kazimierz Zakrzewski, born in Kraków in 1900, the husband of Beck’s daughter Jadwiga, was arrested in Warsaw by the Gestapo at the beginning of 1941 (see Figure 20). Prof. Kazimierz Zakrzewski, a leading Polish specialist in history, was actively involved in the underground movement against the occupying forces. Two months later he was executed by a firing squad in Palmiry. Given the tragedies in the Beck family, it was not surprising that Beck’s son Henryk, born in 1896, a medical doctor specialized in gynaecology and with artistic talents, joined the Warsaw Uprising movement (Figure 20). Henryk with a military background in the Polish army, became one
of the leaders of the Uprising. However, the Uprising did not get support from the Red Army, and after the final capitulation in 1944, he went into hiding in the ruins of Warsaw. Henryk Beck became one of the Robinson Crusoe’s of Warsaw. The life in the cellars, in suffocating air, heat and darkness, while continuous under extreme danger, was a genuine torture. Yet, Henryk Beck provided medical assistance to the wounded, and, moreover, managed to create a huge series of documentary drawings and watercolors. These are now collected in the Central Medical Library in Warsaw, and several are taken up in the book ‘Henryka Becka: Bunkier 1944 roku’, edited by Janina Jaworska. In this book, the heroic life of Henryk Beck is told. Another famous member of the ‘Robinsons’ was the composer Władysław Szpilman, whose story was the subject of the film ‘The Pianist’. Henryk survived the occupation, and in 1945 he got a chair in obstetrics in Wroclaw. Unfortunately, already after several months of promising work, Prof. Beck died of heart failure, undoubtedly following his sufferings of his war-time. Henryk’s wife Jadwiga z Trepków, who had cared him with heart and soul, did not survive the loss of Henryk (see Figure 20). Henryk’s sister, Jadwiga and Aleksander Zakrzewski, the brother of Jadwiga’s husband, put them in Wroclaw to earth in a common grave.

Figure 20. The Beck family. Father Adolf Beck with his oldest daughter Zofia in the Carpathian mountains in 1907 (on the left). Adolf Beck with his son Henryk in his home in Warsaw in 1938 (on the middle left). Adolf Beck with his daughter Jadwiga Beck Zakrzewska at right, and daughter-in-law Jadwiga z Trepków Beckowa, wife of Henryk in the middle, in 1938 (on the middle right). Kazimierz Zakrzewski, the husband of Jadwiga Beck Zakrzewska, who was executed in 1941 (on the right).

In Supplement 3 of the Acta Neurobiologiae Experimantalis from 1973, in which the translation of Beck’s dissertation has also appeared, Beck’s daughter Jadwiga Beck Zakrzewska described in ‘A daughter’s memories of Adolf Beck’ father’s death as following: ‘His death was painfully tragic; in 1942 in Lwów, when this magnificent, strong man had reached the age of 80, after a beautiful and dedicated life, he took poison at the moment when the Germans came for him’. Jadwiga moved to Warsaw, together with her young son Boguslaw, Beck’s grandson, who later became a known economist and lawyer in Kraków. After the war, Jadwiga found in the remains of her burned house in ruined Warsaw Beck’s ring, which was presented to him to regard his exceptional
service to the Medical Faculty of the University of Lemberg. The inscription ‘Bene merenti facultas medica’ on the ring remembering Beck’s great merits, was still readable. The bust of Beck, however, got lost in the ruins (see Figure 21). On the invitation of professor Jerzy Konorski and professor Bogusław Żernicki, Jadwiga was present at a meeting of the Polish Physiological Society at the Nencki Institute of Experimental Biology in Warsaw in 1957, where Beck was posthumously honoured.

Figure 21. The bust of Adolf Beck sculpted by Alfons Karny in 1937, got lost in the burning of Warsaw where daughter Jadwiga’s home was completely ruined.

This year, 2013, marks the 150th birthday of the great scientist and man: Adolf Beck. He will be memorized in a scientific event on May 9 at the Jagiellonian University, where he performed his pioneering studies in his birthplace Kraków.
Epilogue

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The most turbulent period of Polish Galicia, with its two main cities, Kraków and Lviv, is expressed in the life of Adolf Beck. Galicia formed a ping-pong ball between Austria, Prussia and Russia. Beck began his work on the electrical brain activity of animals when Kraków, then still under Austrian rule, was relatively quiet. The thesis of Beck of 1891, together with the pre-publication in 1890, were important contributions to the development of electrophysiology and neuroscience. The investigations of Beck caused various priority claims for the description of sensory evoked potentials and the phenomenon of desynchronisation of the electroencephalogram. At that time, electrophysiology and electroencephalography were blossoming, not only in Poland, with Beck and Cybulski, but also in the Ukraine, with Danilevsky, as well as in Russia, with Práwdicz-Neminski.

On a relative young age, Beck moved to Lemberg/Lviv, founding there a new Department of Physiology at the University of Lemberg. In 1914, the First World War began, and Beck, serving then the University as the Rector, was imprisoned by the Russians. After the war, Beck continued to serve the University of Lviv in an independent Poland. He saw already with increasing disgust that the new regime in Russia got no priority to electrophysiology as a science, although Berger in Germany was continuing and extending his work. The Second World War changed everything. Poland was destroyed and ruined, while Jews, including Beck, became victims of the Nazi’s. The Soviet Union annexed large parts of Poland including Lviv. Europe was split up into the East part, ruled by the communistic regime in Russia, and a free West part, with almost no contacts between the two regions.

Though Beck’s work had a major impact, his name disappeared slowly. In 1973, an attempt was undertaken to bring Beck back into the attention of contemporary researchers by Mary Brazier. She published an English edition of Beck’s Polish thesis in the Acta Neurobiologiae Experimentalis, but the result was not too impressive. Beck, co-founder of electroencephalography, became merely a footnote in the history of electroencephalography. It is great that at the NEURONUS IBRO&IRUN Neuroscience Forum, that will take place in Kraków, in the year 2013, 150 years after Adolf Beck was born in this city, a commemorating session will be dedicated to this famous alumnus of the Jagiellonian University, and great pioneer in electroencephalography.
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