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PROMINENT UKRAINIAN SCIENTIST VOLODYMYR BETZ AND HIS CONTRIBUTION TO THE DEVELOPMENT OF NEUROANATOMY



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Introduction. The year 2015 marks the 181st anniversary since the birth of Professor Volodymyr Oleksiyovych Betz - an outstanding Ukrainian anatomist, a talented researcher and teacher (Fig. 1).

Betz was a founder of the cerebral cortex cytoarchitecture of humans and animals. In the 70s of the XIX century Betz absolutely reliably showed on a large number of microscopic sections of the brain that the cortex of different lobules is heterogeneous and consists of several types of nerve cells. Even then he found 8 cytoarchitectonic fields with a specific picture of nerve cells and their processes.

There is no anatomy, histology, or neuroscience textbooks in the world which would not mention the fact that in the fifth layer of the human brain cortex the giant pyramidal cells, named "Betz cells" after the great scientist, are located.

Volodymyr Oleksiyovych Betz was born on April 26, 1834 in a small village near a northern Ukrainian town Ostra, which at that time was a part of the Russian Empire.

After school V.O. Betz studied at Nizhyn high school, then - at the 2nd Kiev Gymnasium, from which he graduated in 1853. Later he was a student of Medical Faculty of the St. Volodymyr Imperial University (now – the Department of Human Anatomy at Bogomolets National Medical University). During his studying at the university, V.O. Betz showed his great interest in the study of human anatomy. Being a student, V.O. Betz started working under the direction of prominent scientist and anatomist, the head of the Department of Human Anatomy of the St. Volodymyr Imperial University (1844-1868), professor Oleksandr Petrovych Valter.

After graduation in 1860, with the consent of Professor Valter, V.O. Betz stayed at the Department of Anatomy as

prosector's aide. From May 1861 to September 1862 V.O. Betz was sent (upon the recommendation of O.P. Valter) for a traditional at that time postgraduate training abroad in the leading clinics of Europe [3]. Abroad V.O. Betz began to write his doctoral thesis "On the Mechanism of blood circulation in the liver."

In 1863 he defended his doctoral thesis, in which he described not only static structure of the liver, but also the dynamic physiological processes. As a result, he was elected as prosector of the Department of Human Anatomy of Medical Faculty of St. Volodymyr Imperial University. In 1870 V.O. Betz was confirmed as the professor of the Department of Human Anatomy.

After Valter's death in 1869, V.O. Betz was elected as a head of the Department of Human Anatomy, which he headed till 1890. It was the most productive research period for V.O. Betz, which he devoted to the studying of the anatomy of central nervous system. The desire to study the anatomy of the brain was not accidental.



Fig. 1. Photo of V.O. Betz from "Atlas of the Human Brain", 1879 with his signature. Photo made by J. Lowy, Vienne.

V.O. Betz clearly understood the importance of those achievements, about which he was lucky to learn more while studying abroad, but at the same time he was fully aware of the separation of Western anatomical schools from physiology and histology. On September 22, 1870 during his first introductory lecture Betz said:

“If physiology is not the anatomy-based branch of science, any theory that tries to explain one physiological phenomenon or another will be totally scattered in the face of the first anatomical term.”

In addition, Fritsch's physiological experiments on dogs and Hitzig's on monkeys, based on the classic work of I. Sechenov “Reflexes of the Brain”, proved the existence of “brain centers”. But no one had described their morphological basis before. That was the main field of Betz scientific activity. An important role for the scientist's interest in brain studies was also played by the fact that for many years (from 1871 to 1890) he was a consultant of Cyril Hospital (now Pavlov Kyiv clinical psychoneurological hospital). Therefore, in the first years of his heading the Department of Human Anatomy V.O. Betz understood the importance of clinical focus on neuroanatomy.

The main purpose of histology in the 2nd part of the XIX century was to study the details of the structure of parts of the central nervous system, their connections with each other and with the peripheral nerves. But this could be done only in case of applying the adequate research method that changes nervous structures in the least possible degree.

V.O. Betz said that the best way to study the brain in alcohol was not suitable for painting sections of the brain by carmine, because the preparations absorbed the pigment too much and it was impossible to distinguish gray and white matter of the brain.

The brain fixation using chromic acid was not suitable either due to the formation of thin membrane on the surface of the preparations, which prevented the penetration of chromic acid solution inside the brain. V.O. Betz dipped brain pieces, cut through corpus callosum, into 70% alcohol for two days and stained them with the solution of iodine to light brown color, then relocated them in 96% alcohol with iodine, after that placed in 2 - 4% acidified potassium dichromate to add more firmness; poured into oil and wax for further cutting on microtome, tinted the sections by carmine, lightened them in terebinthine oil and dipped in Dammar varnish [1]. Thus, Betz introduced new techniques in the study of the central nervous system. Hardening the brain with alcohol, iodine solution and in 2 - 4% acidified potassium dichromate, the scientist was able to cut thin sections across the whole hemisphere of the brain; and by painting them by carmine, he discovered cellular elements with their numerous branches. Except this, V.O. Betz had another problem: he needed to cut extremely thin sectors of brain for good visualization under the microscope.

For years he performed thousands of experiments, created special knives and a device for sector thickness regulation, which allowed to get the sections 1/10 - 1/20 mm in thickness (Figure 2). This method was enthusiastically described by the prominent Russian professors N. Yakubovich, F. Ovsyannikov and others.

In 1874 in the “Moscow medical bulletin” journal V.O. Betz published a work “Two centers in the human brain cortex”, in which he presented his research of precentral gyrus and precentral lobes of the human brain cortex, where the giant

pyramidal cells were found. This discovery caused a storm of emotions among the representatives of the scientific world of Russia and the whole of Europe [2].

V.O. Betz not only founded these cells (which were called Betz's cells), but also proved that they were a morphological substrate of motor center which had been earlier described by Fritsch and Hitzig, and regulated the activity of skeletal muscles. Betz has identified the location and boundaries of the motor center of the cerebral cortex in the anterior central gyrus and the second sensitive center, which is located at the posterior central gyrus. So, Betz is a founder of the doctrine of morphological foundations of dynamic localization of functions in the cerebral cortex.

In the article “The details of the human brain cortex structure” (1882) V.O. Betz noted: “... According to my researches, the anterior central gyrus and paracentral lobuli contain the giant cells (giant pyramidal cells) that are localized as nests.”[1].

Betz used Marshy device to prepare histological sections and investigated the vertical connections between neurons of different layers of the cortex, describing them in his article in such a way: “Anterior central gyrus from the upper border of the lower one-third of its length has the following features: firstly, large cells (giant pyramidal cells) appear in this region in the superficial part of layer V; these cells appear as single units or in pairs, and these pairs are localized at considerable distances from each other [9]. Further, these cells are grouped in clusters containing three or four units, and the spacing between these clusters decreases. In more upward parts, these nests are made up of greater number of cells; at least 4, but sometimes 5 or even 7. From the former site, i.e. the superficial part of layer V, these clusters enter layer III and are localized in the latter as an interconnected stratum, and single cells enter layer II and also layer IV and an upper part of layer V. In the paracentral lobule this stratum is again divided into clusters, which occupy different positions”[8].

It should also be emphasized that Volodymyr Betz was the first to describe an important part of the limbic system - the horn of Ammon (hippocampus). Ukrainian morphologists found out that pyramidal cells of Ammon's horn were located opposite one another and looked like a ball, therefore the scientist called



Fig. 2. Some carmine staining histological

them “glomeruli corticales». Modern neurologists highlight that Ammon’s horn is the most epileptogenic part of the whole brain. In addition, the pyramidal neurons of Ammon’s horn play a significant role in memory functions and genesis of mental disorders [7].

V.O. Betz made plaster brain casts (using real brains), then drew on their surface lines that indicated not only the direction of microscopic sections, made by him, but also the boundaries of separate cytoarchitectonic brain regions. During his work Betz created huge collections of anatomical materials of the central nervous system.

The collection of Betz’s specimen consisted of 10 parts. The first three parts contained hardened specimen and plaster casts of the brain. The 4th part demonstrated the schemes of brain gyri distribution, worked out by Gratiolet, Pansha, Bischof and Ecker and produced on painted factory-made plaster matrices, and also a “geometric” Betz’s diagram illustrating a system of gyri of dorsolateral and medial surfaces of the brain [6]. This method demonstrates high achievements of V.O. Betz in the studies of the brain gyri distribution. The exhibits of the 5th part are thin sections, cut through the entire thickness of the human and monkey’s cerebral hemispheres that made it possible to trace the cortex gray matter layers distribution (thalamus, striate body, amygdaloid body, lenticular nucleus, claustrum and their connections with the white matter), which was an urgent task of anatomy, but only partially explored by Vicq d’Azyr, Burdach, Huschke and Reichert. Parts number 6, 7, 8 and 9 of the collection are histological specimens of the medulla oblongata, the pons and of nerve cells of the spinal cord of human and rabbit brains (Section 8). And the last part contains plaster casts of the brain (the matrix) [4]. These anatomical preparations including histological sections were demonstrated at the All-Russian manufacturing exhibition in 1870 in St. Petersburg (at which V.O. Betz was awarded a large silver medal) and at the Vienna World Exhibition of 1873, where he was awarded the “Fortschritts Medaille”. This collection was valued at 7000 Austrian guilders. Being a true patriot of his native country, Volodimir Betz refused the offer of professor V.Benedikt to sell the collection of histological preparations and presented it to the Department of Human Anatomy of Bogomolets National Medical University. And carmine-stained brain sections look vibrant and fresh.

At the Congress of Naturalists and Physicians in Leipzig in 1872 a famous professor K. Ludwig examined the collection of V.O. Betz and offered him to print an atlas of figures of his specimens at the expense of Dresden Academy of Sciences. But Ukrainian scientist rejected this offer, cherishing a hope to print the Atlas in his home country.

The great organizational skills and titanic efforts of V.O. Betz resulted in the publication of the first volume of “Atlas of human brain” (1890) which was a proof and, unfortunately, unique copy and is now kept at the Department of Human Anatomy of Bogomolets National Medical University (Figure 3,4).

At the Fundamental Anatomical Museum of the Department of Human Anatomy of Bogomolets National Medical University the following exhibits are presented:

1. A unique collection of histological sections of different areas of the human brain and spinal cord.
2. A collection of plaster casts of hemispheres of human brain, of the brains of monkeys and other animals.
3. Collection of skulls made by V.O. Betz.
4. Knives, constructed by V.O. Betz for making histological preparations of brain.
5. The Marshy device for holding the brain in the process of cutting and regulating the sections thickness.
6. Bone preparations, made by V.O. Betz.
7. Books, published by V.O. Betz.
8. Betz’s Diploma of medals awarding at the All-Russian manufacturing exhibition and at the Vienna World Exhibition, and a diploma of his election as a corresponding member of the Paris Society of Anthropologists.
9. A single copy of the “Atlas of the Human Brain” published by V.O. Betz at his own expense (1890), which includes figures of macroscopic preparations of the human brain and different animals (Figure 5) [5].

In 1890, a 56-year-old professor V.O. Betz leaves the university after 30 years of scientific and educational activities, but continues his work as consultant of neurology at Kyiv St. Cyril hospital, and then as head physician of South-Western Railway. He remained in this position till the end of his life in 1894. V.O. Betz passed away on October 12, 1894. The tomb of the great scientist is located on the slopes of the Dnieper in the picturesque and secluded corner of Vydybychi Monastery in a few steps from the Church of Archangel Michael - that was the



Fig. 3. Cover page of the “Atlas of Human Brain” published by V.O. Betz in 1890.

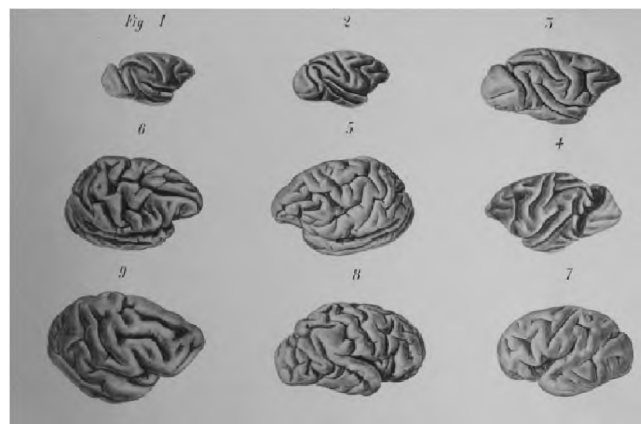


Fig. 4. One page from the “Atlas of Human Brain” published in 1890 by V.O. Betz.



Fig. 5. Collection of Betz's materials keeps at the Department of Human Anatomy of Bogomolets National Medical University.

last will of V.O. Betz. Many generations of Kiev anatomists carefully preserved and now store rich scientific heritage of V.O. Betz. This is not just a memory about a person who worked at the Department; this is a great honor for us to bear a relation to the scientific miracle that changed the world.

Declaration of interest.

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ВИДАТНИЙ УКРАЇНСЬКИЙ ВЧЕНИЙ ВОЛОДИМИР БЕЦ ТА ЙОГО ВНЕСОК У РОЗВИТОК НЕЙРОАНАТОМІЇ

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Резюме: Історія української науки багата на імена людей, що змогли суттєво прискорити її прогрес та сприяти значним досягненням. Одним із таких був Володимир Олексійович Беца – професор, завідувач кафедри анатомії Київського Імператорського Університету Святого Володимира протягом 22 років (1868-1890). За час своєї діяльності в університеті, В.О. Беца написав чимало наукових робіт, проте найбільше його відкриття було пов'язано з вивченням будови центральної нервової системи. Відкриті ним гігантські пірамідні клітини у 5-му шарі кори головного мозку, відомі також як клітини Беца, внесли ясність у анатомію та фізіологію найскладнішої та водночас найцікавішої системи людського організму, а також стали поштовхом для подальшого розвитку світової та сучасної нейроанатомії зокрема. На разі у всьому світі немає жодного підручника з анатомії, гістології, фізіології чи неврології, де б не описувалися ці клітини. За своє відкриття В.О. Беца було відзначено значною кількістю нагород та медалей, він неодноразово отримував пропозиції щодо продажу своєї колекції препаратів, які власноруч виготовив. Проте Володимир Олексійович Беца як відданий патріот своєї країни подарував всі матеріали кафедрі анатомії людини, на якій пропрацював все своє життя. Дана стаття відображає основні періоди життя вченого, а також відкриття ним гігантських пірамідних клітин.

Ключові слова: Беца, нейроанатомія, мозок

REFERENCES

1. Sergiy V. Kushchayev, Vitaliy F. Moskalenko, Philip C. Wiener, Vitaliy I. Tymbaliuk, Victor G. Cherkasov, Irina V. Dzevulska, Oleksander I. Kovalchuk, Volker K.H. Sonntag, Robert F. Spetzler and Mark C. Preul. The discovery of the pyramidal neurons: Vladimir Betz and a new era of neuroscience. *Brain*. – 2012. – №135. – P. 285 – 300.
2. Бобрік І. І. Жизнь и научный подвиг профессора В. А. Беца. – Киев, 1996. – 112 с.
3. Брокгауз и Ефрон. Беца В.А. – В кн.: Энциклопедический словарь. СПб, 1891/ - Т.6. - С. 650-651.
4. Демидюк О.О., Маліков О.В., Дзевульська І.В., Ковальчук О.І. Суспільно-історична унікальність інтелектуальної спадщини професора Володимира Олексійовича Беца. *Український науково-медичний молодіжний журнал*. – 2013. – №2. – С. 77-80.
5. Москаленко В.Ф., Черкасов В.Г. Видатний представник світової наукової та освітянської еліти професор В.О. Беца (до 175-річчя від дня народження). *Внутрішня медицина*. – 2009. – №3. – С.119-124.
6. Москаленко В.Ф., Черкасов В.Г., Д.А. Василенко. Світова слава українського нейроанатома професора Володимира Олексійовича Беца (175 років від дня народження). *Нейрофізіологія/Neurophysiology*. – 2010. – Т.42, №1. – С. 3-9.
7. Спіров М.С. Киевская анатомическая школа и ее роль в развитии отечественной морфологии. – Киев, 1982. – С. 77-79.
8. Спіров М.С. Професор В.О. Беца і його дослідження центральної нервової системи. – В кн.: Спіров М.С. Київська анатомічна школа. Київ, 1965, с.18-38.
9. Цимбалюк В.І. Професор Беца Володимир Олексійович (до 175-річчя від дня народження). *Український нейрохірургічний журнал*. – 2009. – №1. – С.70-71.

ВЫДАЮЩИЙСЯ УКРАИНСКИЙ УЧЕНЫЙ ВЛАДИМИР БЕЦ И ЕГО ВКЛАД В РАЗВИТИЕ НЕЙРОАНАТОМИИ

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Резюме: История украинской науки богата на имена людей, которые смогли существенно ускорить ее прогресс и способствовать значительным достижениям. Одним из таких был Владимир Алексеевич Беца – профессор, заведующий кафедрой анатомии Киевского Императорского Университета Святого Владимира в течение 22 лет (1868-1890). За период своей научной деятельности в университете, В.А. Беца написал немало работ, однако, самое значущее его открытие было связано с изучением строения центральной нервной системы. Открытые им гигантские пирамидные клетки в 5-м слое коры головного мозга, известные также как клетки Беца, внесли ясность в анатомию и физиологию, в сложнейшую, и в то же время интереснейшую систему человеческого организма, а также стали толчком для дальнейшего развития мировой и современной нейроанатомии в частности. На сегодня во всем мире нет учебника по анатомии, гистологии, физиологии или неврологии, в которых бы не описывались эти клетки. За свое открытие В.А. Беца был удостоен множества наград и медалей, получал неоднократные предложения о продаже своей коллекции препаратов, которые он собственноручно изготовил. Однако, Владимир Алексеевич Беца, как преданный патриот своей страны, подарил все материалы кафедре анатомии человека, на которой проработал всю свою жизнь. Данная статья отражает основные вехи жизни ученого, а также открытие гигантских пирамидных клеток.

Ключевые слова: Беца, нейроанатомия, мозг