# Life and works of the neuroscientist Oleksandr Chernyakhivsky (1869-1939), the Ukrainian disciple of Cajal

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**ABSTRACT**

The Ukrainian physician Oleksandr Chernyakhivsky (1869-1939) was a highly important figure in his country's science and culture during the turbulent final years of Tsarism, the Russian Revolution, the bloody civil war, and the brief period of Ukrainian independence. Chernyakhivsky led the development of various scientific and higher education institutions in his country, and promoted the use of the Ukrainian language in these environments. When Ukraine joined the USSR, he dedicated his work to Neurohistology, a discipline in which he enjoyed international recognition in the 1920s and 1930s. Chernyakhivsky had close links with the Spanish and German schools of Histology, and particularly with that of Santiago Ramón y Cajal (1852-1934), considered the founder of modern Neuroscience and in whose laboratory Chernyakhivsky worked in 1929. Oleksandr Chernyakhivsky was the first Ukrainian histologist to use silver salt impregnation, and stood out in the study of the nervous system in human embryos. His main discoveries were related to the sympathetic ganglia, the innervation of the heart and the carotid sinus, the inner ear, post–rabies vaccination encephalopathy, the microglia, and the innervation of tumours. He and his family faced reprisals from Stalin for his activities in defence of the Ukrainian nation.

**KEYWORDS**

Neuroscience, histology, embryology, Spanish neurological school, philology, Ukraine, Russia, Pío del Río-Hortega, history of neuroscience

## Introduction

From his brilliant first incursion into the field of neurohistology,[1] Santiago Ramón y Cajal (1852-1934) revolutionised the scientific society of his day, demolishing the prevailing reticular theory of the moment and thereby transforming the brain and central nervous system (CNS) into another territory functioning in accordance with Virchow's cell theory.[2-4] The international recognition of Cajal's findings, thanks to the most influential histologist of the day, August Kölliker, was immediate. Among many other distinctions, he was awarded the first Moscow Prize (in 1900, beating the other candidate, the great Russian physiologist Ivan Pavlov, by a wide margin), the Helmhöltz Medal (1905), and the Nobel Prize in Physiology or Medicine (which he shared with Camillo Golgi in 1906), generating an important movement among Spanish lawmakers that culminated with the triple achievement of the creation of a publicly-funded laboratory for Cajal to continue his research (inaugurated in 1902 as the Laboratorio de Investigaciones Biológicas, now the Instituto Cajal since 1920), the hiring of his first regular collaborators (until

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then, Cajal had worked alone), and the foundation of the Junta para Ampliación de Estudios (Board for Study Extensions; directed by Cajal himself, the institution played a crucial role in the development of Spanish science and society from the time of its foundation in 1907). These constituted the three pillars on which Cajal constructed his own school, known as the Cajal School, the Spanish Neurological School, or (due to its location in the Spanish capital) the Madrid School.[3,5,6] From a very early time, with the arrival of the Belgian Jules Havet and the British-Australian researcher Laura Forster, Cajal's laboratory became an essential destination for training for anybody interested in studying the structure and function of the brain.[2,3,5-7] The majority of foreign researchers who trained directly at Cajal's laboratory and who should be considered members of his school were from European institutions.[3,5,6] Despite the intense relationship between research conducted in Spain and researchers from countries belonging first to the Russian Empire and later to the USSR, such as Aleksandr Dogiel (1852-1922) and Boris Lavrentiev (1892-1944),[3,8,9] the first to train in Madrid was Oleksandr Grigorovich Chernyakhivsky (in Ukrainian, Олександр Григорович Черняхівський; 1869-1939), a Ukrainian physician, philologist, translator, and politician, who played an important role in his country's history (Figure 1A). Already having reached scientific maturity, and having maintained relatively abundant correspondence with Cajal and some of his most prominent disciples, Chernyakhivsky was able to complete a period of advanced training under Cajal in Madrid in 1929.[10,11]

Given the lack of analytical references on the life and noteworthy scientific works of Chernyakhivsky in languages other than Russian and Ukrainian, this study fundamentally aims to analyse original sources in order to offer the international scientific community an analytical study on the scientific production of this multifaceted neuroscientist belonging to the Cajal school (Figure 1B). Chernyakhivsky, together with his wife and daughter, fought for the normalisation of Ukrainian humanistic and scientific culture, which resulted in harsh reprisals from the Soviet government.

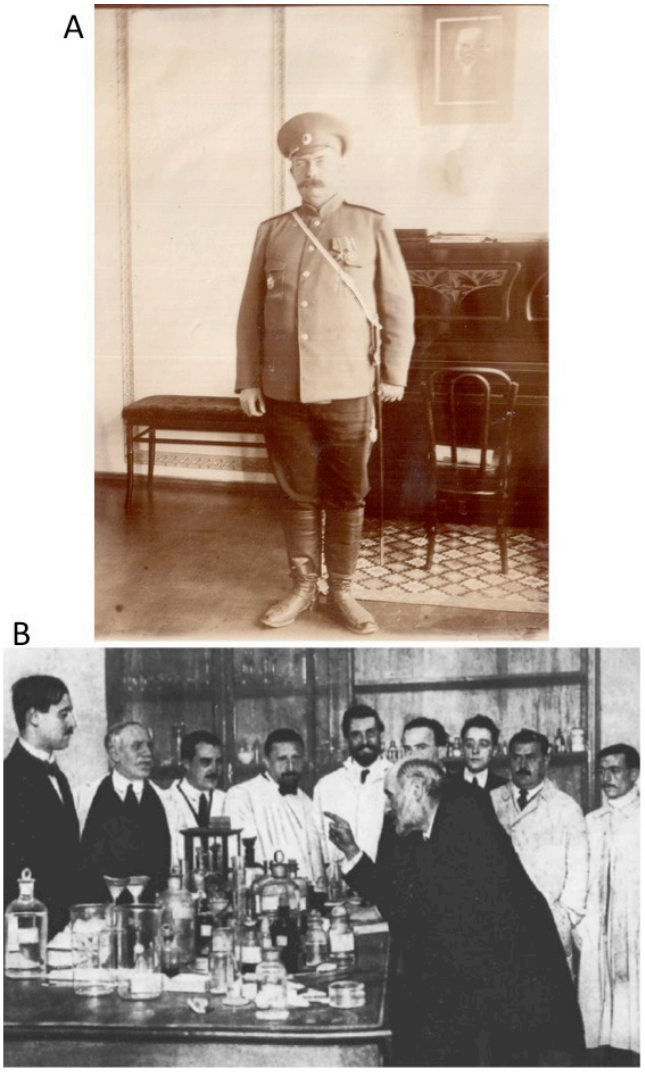


**Figure 1.** Oleksandr Chernyakhivsky before making contact with Cajal. A) Oleksandr Chernyakhivsky shown in uniform, circa 1915.[72] B) A typical image of Cajal and some of his disciples at the Laboratorio de Investigaciones Biológicas, around 1915, originally published in *La Esfera*. Santiago Ramón y Cajal, the teacher, is shown in foreground; in the background, from left to right: Gonzalo Rodríguez Lafora (in profile), Domingo Sánchez, Julián Sanz-Ibáñez, Miguel Gayarre, Nicolás Achúcarro, and auxiliary staff (adapted from de Castro[6]).

## Material and methods

We conducted a systematic review of the figure of Oleksandr Chernyakhivsky, both in his cultural and teaching activities and in the scientific sphere. His name was searched in several languages, mainly Ukrainian (Черняхівський), Russian (Черняхивский), English (Chernyakhivsky), and German (Tschernjachiwsky). In his day, he was known in the international literature by the German spelling of his name. Particular emphasis

was placed on his stay at the Instituto Cajal (Madrid) and his scientific and personal relationships with Cajal himself and with other members of the Spanish neurological school.

We consulted the collections of the Legado Cajal, the Archivo Científico Fernando de Castro, and the Archivo Pío del Río-Hortega, all three of which are jointly listed as world heritage by UNESCO (Memory of the World Register,[12] reference no. 2016-31), and the collection of the Biblioteca Nacional de España.

**Results**

*Chernyakhivsky's life until 1929*

Oleksandr Chernyakhivsky was born on 13 November 1869 in the village of Mazepyntsi (in the Kyiv region, then part of Russia), the son of a parish priest.[13] Two of his siblings, Mykhailo (1859-1922) and Yevhen (1873-1938), were distinguished professors of surgery.[14]

He studied until 1887 at the Third Gymnasium of Kyiv, later enrolling at the Faculty of Medicine of the University of Saint Vladimir, where he graduated in 1893. As a student, he was fascinated by the teachings of the renowned neuroanatomist Vladimir Betz (1834-1894), who discovered the pyramidal neurons of the cerebral cortex that bear his name, and Petro Paremezhko (1833-1893), who described indirect cell division. However, Chernyakhivsky's first work as a scientific researcher was with Fedir Lominsky (1857-1927; Lominsky described how macrophages destroy neurons in pathological conditions), with whom he worked at the University's histological laboratory and at the Kyiv Medical Institute.[15,16]

In 1894, Chernyakhivsky transferred to his university's Laboratory of Physiological Chemistry and, in 1896, became assistant to the prosector at the Department of Histology and Embryology, always at the University of Kyiv, where he was awarded his doctorate in 1900. After a stint working in the Azerbaijani capital Baku, a wealthy oil trading hub on the shores of the Caspian Sea, he returned to Kyiv to work at the Alexander Hospital; in 1906, he was appointed prosector at the Department of Histology and Embryology of the University of Kyiv, becoming a lecturer in 1918.[14,17]

As a youth, Oleksandr Chernyakhivsky also belonged to nationalist groups that opposed the Tsarist government and supported the revival of Ukraine, such as the Brotherhood of Tarasovs, the Old Community of Kyiv, and the Taras Shevchenko Scientific Society of Lviv; as a student of medicine, he joined the Pleiades literary circle, an important Ukrainian cultural hub founded in 1889. It was at Pleiades where he met Lyudmila Starytska (1868-1941), the daughter of Mykhailo Starytsky, founder of Ukrainian theatre, and niece of Mykola Lysenko, a leading figure in Ukrainian classical music. Chernyakhivsky and Starytska married in 1896, which did not prevent Lyudmila Starytska-Chernyakhivska from becoming a distinguished public figure, prose writer, poet, playwright, and translator. They had one daughter, Veronika (1900-1938), who was also a poet and translator (Figure 2A).[18] From the early years of the 20th century, the couple organised gatherings at their home in Kyiv that involved the city's most significant artists, writers, and political figures.[12]

A talented linguist, Chernyakhivsky spoke German, French, and Spanish[17]; this knowledge enabled him to review and to produce Ukrainian translations of numerous works by French, German, English, and Spanish scientists, particularly in the journal *Ukrainian Medical News*.[19] He first read Santiago Ramón y Cajal's magnum opus in French.[20] He also translated the poetry of Goethe, works by Schiller and Heine, and, in 1900, Engels' *Ludwig Feuerbach*, the first book on Marxist theory to be published in Ukrainian.[12,14,15] It should be noted that while he was briefly an active member of the Ukrainian Socialist-Federalist Party, Chernyakhivsky was never a Marxist.

In 1910, Oleksandr Chernyakhivsky was charged with organising the Medicine Section of the Ukrainian Scientific Society of Kyiv, with a view to developing science in the country. From that position, he strove for the introduction of Ukrainian terminology in diverse scientific disciplines, particularly in medicine: he was a co-author of the *Russian-Ukrainian dictionary* (1920) and *Nomina anatomica ukrainica* (the first Latin-Ukrainian anatomical dictionary, published in 1925), and participated in the *Great dictionary of veterinary anatomical terminology*. He was also the sole author of *Material for embryological nomenclature* (the first Ukrainian-language dictionary of embryological nomenclature, published in 1926), compiled a three-volume work on anatomical terminology in dogs (1924-1925), and translated two classical textbooks from German: Oscar Hertwig's *Elements of human embryology* (in 1928) and Philipp Stöhr's *Histology*


**Figure 2.** Oleksandr Chernyakhivsky in 1925. A) The Chernyakhivsky family in Kyiv in 1925 (adapted from de Castro[42]). From left to right: Chernyakhivsky's wife Lyudmila Starytska-Chernyakhivska (an important figure in Ukrainian literature and politics), his daughter Veronika, and Oleksandr Chernyakhivsky. B-C) Front and back of the first known letter between Chernyakhivsky (who signs as "Tchernjachivsky") and the Cajal School, in this case Pío del Río-Hortega, dated 22 February 1925. In the letter, he requests an offprint of the article "Noticia de un nuevo y fácil método para la coloración de la neuroglia y del tejido conjuntivo" (A new and simple method for staining the neuroglia and connective tissue. *Trabajos del Laboratorio de Investigaciones Biológicas*. 1918;15:367-78). The letter is part of the Archivo Pío del Río-Hortega (Censo-Guía de Archivos de España e Iberoamérica, # ES.47186.APR; Valladolid, Spain), which was listed by UNESCO in 2017 in the Memory of the World Register of world heritage as part of the collection "Archives of Santiago Ramón y Cajal and the Spanish Neurohistological School" (Collection ID: 2016-31; https://webarchive.unesco.org/20220331162659/http://www.unesco.org/new/en/communication-and-information/memory-of-the-world/register/full-list-of-registered-heritage/registered-heritage-page-1/archives-of-santiago-ramon-y-cajal-and-the-spanish-neurohistological-school)

(in 1937).[21-24] All this activity led to his selection as chair of the medical section of the Ukrainian Institute for Scientific Language, between 1923 and 1929, and of the Department of Philology and History of the Ukrainian Academy of Sciences.[21] In 1917, Chernyakhivsky was a founding member of the All-Ukrainian Union of Doctors[21]; between 1917 and 1921 he actively participated in the revolution and in the struggle for Ukrainian independence,[12] during which time he held a position in the Ministry of Health. He was evacuated with the Ukrainian government to Kamianets-Podilskyi in February 1918, and did not return to Kyiv until the spring of 1920.[17]

Oleksandr Chernyakhivsky was also one of the creators of the Ukrainian State University in 1918; he was appointed as professor of histology and embryology at the Faculty of Medicine and later at its successor, the Academy of Medicine, which had Russian and Ukrainian sections operating in parallel. In 1921, he

joined the recently created Kyiv Medical Institute; he taught histology and embryology in Ukrainian, there and at the Kyiv Veterinary and Zootechnical Institute, directing the departments at both institutions between 1924 and 1929.[19]

Chernyakhivsky conducted his earliest scientific research as a student, with the publication *An essay on the modern theory of bacteria*.[14] In different Ukrainian publications, he studied amoeboidism[A] in what is today known as neuronal plasticity, the presence of binucleated cells in the CNS, and other neurohistological questions.[14,21,27] In fact, he was the first researcher in Ukraine to use the silver impregnation techniques developed by Cajal and other members of the Spanish Neurological School, especially the method described in 1919 by del Río-Hortega,[28-32] whom Chernyakhivsky is known to have met in 1925 (Figure 2B and C). Furthermore, between 1921 and 1929, his group in Kyiv studied mitochondrial dynamics in regenerative and degenerative processes, the histogenesis of smooth and skeletal muscle, the structure and development of the vitreous humour of the eye, chromosomes, and spermatogenesis. All these lines of research earned Chernyakhivsky a degree of international prestige, and attracted restless youths who trained under him as his disciples; the most distinguished of these were B.I. Deykun (who improved metal impregnation methods and studied the mitochondria of the striated muscle), I. Zavistolevich (who studied the Golgi apparatus and its modifications in mechanically damaged nerve cells), and M. Romashkevich (who dedicated his work to studying the histology of blood vessels).[33-35] Some of his disciples subsequently became the directors of histology departments at the universities of Kyiv, Donetsk, and Dnipro (see below).[17]

*Chernyakhivsky's training in Germany and Spain*

Between October 1926 and March 1927, Chernyakhivsky spent four and a half months at the Neurobiological Institute of the Charité University of Berlin, working at the laboratories of the "localisationists" Oskar and Cécile Vogt (1870-1959 and 1875-1962, respectively) and the neuropathologist Max Bielschowsky (1869-1940). He also worked at the Berlin-Dahlem Institute of Biology, at the department led by Tibor Peterfi (1883-1953), with whom he improved his knowledge of microscopy technology.[19,34] With the Vogts, Chernyakhivsky performed a series of studies on the innervation of the inner ear and such organs as the lungs and stomach; with Bielschowsky, he studied anatomical and pathological changes in brain disease, as well as the effect of insulin on the adrenal gland.[35] Upon his return to Kyiv, he published the article "On a scientific journey through Germany" in *Ukrainian Medical News*.[19] According to some authors, he travelled to Italy after his time in Berlin, although no solid data are available on his activities there.[25,36]

In any case, despite the reminiscence about reticular theory among Bielschowsky's group and at other German laboratories, Chernyakhivsky was always an ardent defender of Cajal's neuron doctrine. During his time in Berlin with the Vogts, Chernyakhivsky also met the youngest of Cajal's direct disciples, Rafael Lorente de Nó (1902-1990), already a true international expert on the structure of and the connections between different elements of the auditory and vestibular systems.[37] It was precisely Lorente de Nó who led Chernyakhivsky to the door of the Instituto Cajal: the Ukrainian neurohistologist worked in Madrid in 1929 (Figure 3A).[19] In one of the letters preserved at the Biblioteca Nacional de España, Chernyakhivsky informs that he will arrive in Madrid on 10 January 1929, and a report from the newspaper *ABC* (21 July 1929) on the new Instituto Cajal specifically mentions Tschernjachiwsky (the German spelling of his name) and includes a photograph of him alongside the Institute's librarian, Enriqueta "Kety" Lewy (Figure 3B).[10] Those months in Madrid represented a great opportunity for Chernyakhivsky: thanks to Cajal and de Castro, he perfected his knowledge of neurohistology, and he also began collaborating with various members of the Spanish Neurological School. As he had done after his stay in Germany, he wrote an article in *Ukrainian Medical News* upon returning to Kyiv, entitled "Impressions of a scientific journey to Spain."[38] Soon after, he began publishing his results obtained in Spain, with articles in *Travaux du Laboratoire de Recherches Biologiques de l'Université de Madrid*, the journal of the Instituto Cajal, in which he published five fundamental studies on the

[A]The term "amoeboidism" was used at the time in reference to neural lineage cells that, during their development, migrated with movements similar to those of amoebae. Today, neuronal and oligodendroglial migration constitute an entire area of study in the development of the CNS (recent reviews of the subject have been published by Lepiemme et al.[25] and de Castro et al.[26]). The concept of "plasticity" in the nervous system was introduced by Cajal around 1895, although, as he did not himself coin the term, he used it little.[5,6]

morphology and histogenesis of the nervous system between 1929 and 1934. The first article addressed a subject previously described by Cajal in 1896, displaced nerve fibres (in French, *égarées*); Chernyakhivsky was the first to describe these in the endolymph of the utricle in three-month human embryos (Figure 4A).[39] The thicker displaced fibres crossed the internal surface of the epithelium and penetrated the endolymphatic space, whereas thinner fibres hit the epithelium but were unable to cross it, curling into loops. These fibres reaching the endolymphatic space must subsequently disappear, as they belong to transient embryonic structures (Figure 4A).[39]

Between 1920 and 1932, Fernando de Castro (1896-1967) and Rafael Lorente de Nó, the youngest (and some of the closest) of Cajal's direct disciples, were responsible for the technical supervision of visiting researchers.[3,5,6] De Castro was Cajal's man in charge of the peripheral nervous system (PNS), and Chernyakhivsky seized the opportunity to study in depth his work and methods. For instance, in another study published in 1929, Chernyakhivsky described the innervation of the heart in human and mouse embryos, including the aortic plexus, depressor nerve, carotid body and carotid sinus, and the presence of displaced nerve fibres in the latter structure (Figure 4B)[40]; this important study confirmed in human embryos various findings previously described by Francisco Tello (1880-1958) and Fernando de Castro in experimental animals.[41-43] This morphological-functional link was not new for the Ukrainian, who had previously performed other studies on the subject.[14] The information presented was extremely timely, appearing at the crucial moment at which, in the light of the aforementioned discoveries of Fernando de Castro,[42,43] Corneille Heymans' (1892-1968) laboratory in Ghent reoriented their research on cardiopulmonary reflexes, shifting their focus from the carotid sinus to the *glomus caroticum* or carotid body, which resulted in Heymans winning the race for the Nobel Prize in Physiology or Medicine , in 1938 (for an in-depth study with important chronological data, see de Castro[44]). In the light of these facts, and given that Heymans first visited the Instituto Cajal in June 1929, after being invited by de Castro, Chernyakhivsky probably would have met the Belgian physiopharmacologist.

At the end of each of these two articles published in 1929 in the journal of the Instituto Cajal, Chernyakhivsky expresses his sincerest gratitude to Fernando de Castro for his inestimable teaching and for his kind assistance in Chernyakhivsky's work at the centre.[39,40] The same year, he published two articles in *Ukrainian Medical News* on the subjects he had written on in the journal of the Instituto Cajal, using the same titles.[19] As we shall see below, Chernyakhivsky's return to the USSR was not without difficulties; thus, the publication of the remaining results of work conducted in Madrid was delayed until 1932.

*Return to Kyiv: the Union for the Liberation of Ukraine and Chernyakhivsky's arrest*

On 22 November 1929, the newspaper *Pravda* reported the discovery of a counter-revolutionary conspiracy by Spilky Vyzvolennya Ukrayiny (SVU, Union for the Liberation of Ukraine).[45] This subversive anti-Soviet organisation did not in fact exist; rather, it was an invention of the Obyedinyonnoye Gosudarstvennoye Politicheskoye Upravlenie (OGPU; State Political Directorate, the political police), which on specific request from Stalin mounted a campaign with charges against 45 of the most prominent representatives of scientific, literary, and social thought in the republic of Ukraine.[15,46] Oleksandr Chernyakhivsky was among the five professors of the Kyiv Medical Institute who were accused of belonging to the SVU; in late December 1929, he was detained together with his wife Lyudmila, and suffered a month of interrogations.[12] A show trial was held in March 1930 at the Kharkiv opera house; it was attended by a large audience and covered by a radio broadcast and press reports. The ruthless judges charged Chernyakhivsky with having associated with dissident émigrés during his trips to Germany and Spain; however, aware of the defendants' international scientific prestige and, fearful of the potential scandal in international public opinion if the news of the trial emerged, they opted to treat Chernyakhivsky and his wife with relative leniency, sentencing them to five years' imprisonment and two years' exile; the sentence was suspended and they were deported to the city of Stalino (today, Donetsk). Chernyakhivsky was the eldest of the five detained physicians, all of whom were widely renowned figures, and his colleagues were less fortunate: they were imprisoned in the dungeons of the Solovetsky islands, and three were executed there by firing squad in 1937.[12,15,46] After the arrest of his brother Oleksandr, the surgeon Yevhen Chernyakhivsky was immediately dismissed from the Kyiv Medical Institute and forbidden


**Figure 3.** Oleksandr Chernyakhivsky in Madrid, 1929. A) A portrait of Chernyakhivsky at the microscope in the facilities of the Instituto Cajal. The original photograph was taken by Fernando de Castro and is part of the Archivo Científico Fernando de Castro (Censo-Guía de Archivos de España e Iberoamérica, # ES.28079.AFC; Madrid, Spain) listed by UNESCO in 2017 in the Memory of the World Register of world heritage as part of the collection "Archives of Santiago Ramón y Cajal and the Spanish Neurohistological School" (Collection ID: 2016-31; https://webarchive.unesco.org/20220331162659/http://www.unesco.org/new/en/communication-and-information/memory-of-the-world/register/full-list-of-registered-heritage/registered-heritage-page-1/archives-of-santiago-ramon-y-cajal-and-the-spanish-neurohistological-school). B) Oleksandr Chernyakhivsky and the Instituto Cajal's librarian, Enriqueta "Kety" Lewy. Photograph published in the newspaper *ABC* in a report on the Instituto Cajal and the construction of the new building at Cerrillo de San Blas.[10]

from practising.[47] Only in 1989 did the Plenary of the Supreme Court of Ukraine overturn the unjust verdict and rehabilitate all those charged in the SVU case.[46]

*Exile in Stalino (1930-1934)*

Banished to Stalino, Oleksandr Chernyakhivsky received the order to join the Department of Histology, Cytology, and Embryology of the new Medical Institute (inaugurated in the autumn of 1930). His assistants there were V.A. Ravvin, O.N. Olekseenko, and M.I. Birkenhof. Vulf Ravvin (1888-1976) had graduated from the University of Lyon (France) and spoke reverently of attending lectures by Cajal during his student years in France. Ravvin was known for his studies into anthracosis of the lungs, and succeeded Chernyakhivsky as director of the department in 1934. Under the direction of Chernyakhivsky, Birkenhof researched the functional significance of the microglia and changes in the CNS during rabies, and Olekseenko (or Alexenko) studied the general laws of the process of differentiation

of muscle tissue, the role of mitochondria and the Golgi apparatus, and the formation of cytoplasmic inclusions.

From Stalino, in 1932, Chernyakhivsky published one of the studies he had started during his time in Madrid with Cajal and de Castro, focusing on the presence of multinucleated sympathetic cells in the human superior cervical ganglion. He hypothesised that these cells were generated through amitotic division: while he observed them in embryos from five months' development and in children aged up to nine years, Chernyakhivsky demonstrated that these multinucleated cells were most frequent between two and four years of age, becoming less frequent with age and practically disappearing in adulthood.[48] This study completed his initial observations published in 1910.[27]

The same year, in an article in *Anatomischer Anzeiger*, Chernyakhivsky confirmed Tello's findings on the innervation of the epithelium forming hair follicles,[49] and published an article in the journal of the Instituto Cajal addressing the differentiation of adrenal medulla cells in monkeys,[50] using samples provided by Oskar and Cécile Vogt at their laboratory in the Neurobiological Institute of Berlin; it is noteworthy that Chernyakhivsky attributes the heterogeneity of cell types to variations in their content of adrenaline, the first hormone to be discovered as such.[51,B]

Shortly before the end of Chernyakhivsky's exile, in 1934, he and Birkenhof published an article in the journal of the Instituto Cajal reporting a fatal case of encephalomyelitis triggered by rabies vaccination in Stalino; the authors provide a detailed description of the clinical symptoms and the anatomo-pathological changes to neurons and glia in the brain (Figure 5).[52] In Stalino, these scientists and professors were able to organise education and research processes within a matter of years, and published in Soviet and European journals.[12,33]

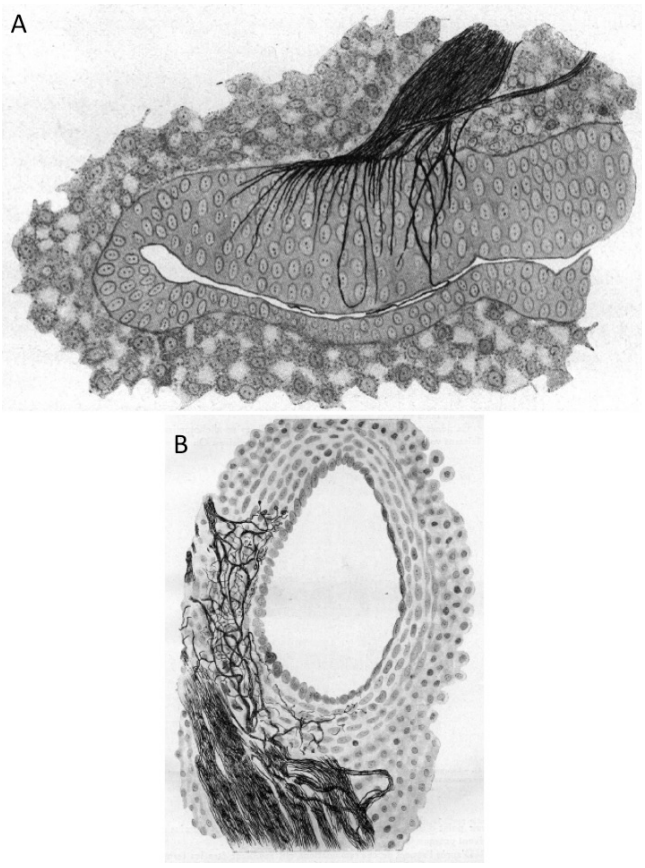


**Figure 4.** Chernyakhivsky's first scientific results in Madrid. A) A drawing originally published as figure A in the article by Tschernjachiwsky,[40] illustrating a section from the utricular macula of a three-month human embryo, stained with the Cajal method (de Castro modification). The displaced fibres ("égarées"), stained black, pass between the epithelial cells, with one crossing the epithelium and entering the endolymphatic space. B) A drawing originally published as figure 10 of the article by Tello[41]; the image shows a white mouse embryo measuring 14 mm, displaying the termination of the depressor nerve in the aortic wall; reduced silver staining (fixed with pyridine).

*Return to Kyiv, 1934-1939*

Chernyakhivsky's parole expired in the autumn of 1934, coinciding with his retirement, and he decided to return to Kyiv. With the help of Oleksandr Bogomolets (1881-1946), president of the Ukrainian Academy of Sciences, he was admitted in October 1934 to the Mechnikov Institute of Biology and Experimental Pathology and in October 1938 to the Clinical Physiology Institute of the Ukrainian Academy of Sciences.[53] Chernyakhivsky was living in an apartment and faced enormous economic difficulties[12]; perhaps precisely because of this, he spent his final years occupied with certain subjects that he

[B]The discovery of adrenaline between 1895 and 1904 is a fascinating story beginning with the Polish physiologists (at the time, Russian subjects) Napoleon Cybulski and Władysław Szymonowicz, with subsequent work by the Japanese chemists Jokichi Takamine and Keizo Uenaka, and culminating with Friedrich Stolz in Frankfurt-am-Main and Henry Drysdale Dakin in Leeds.[51]

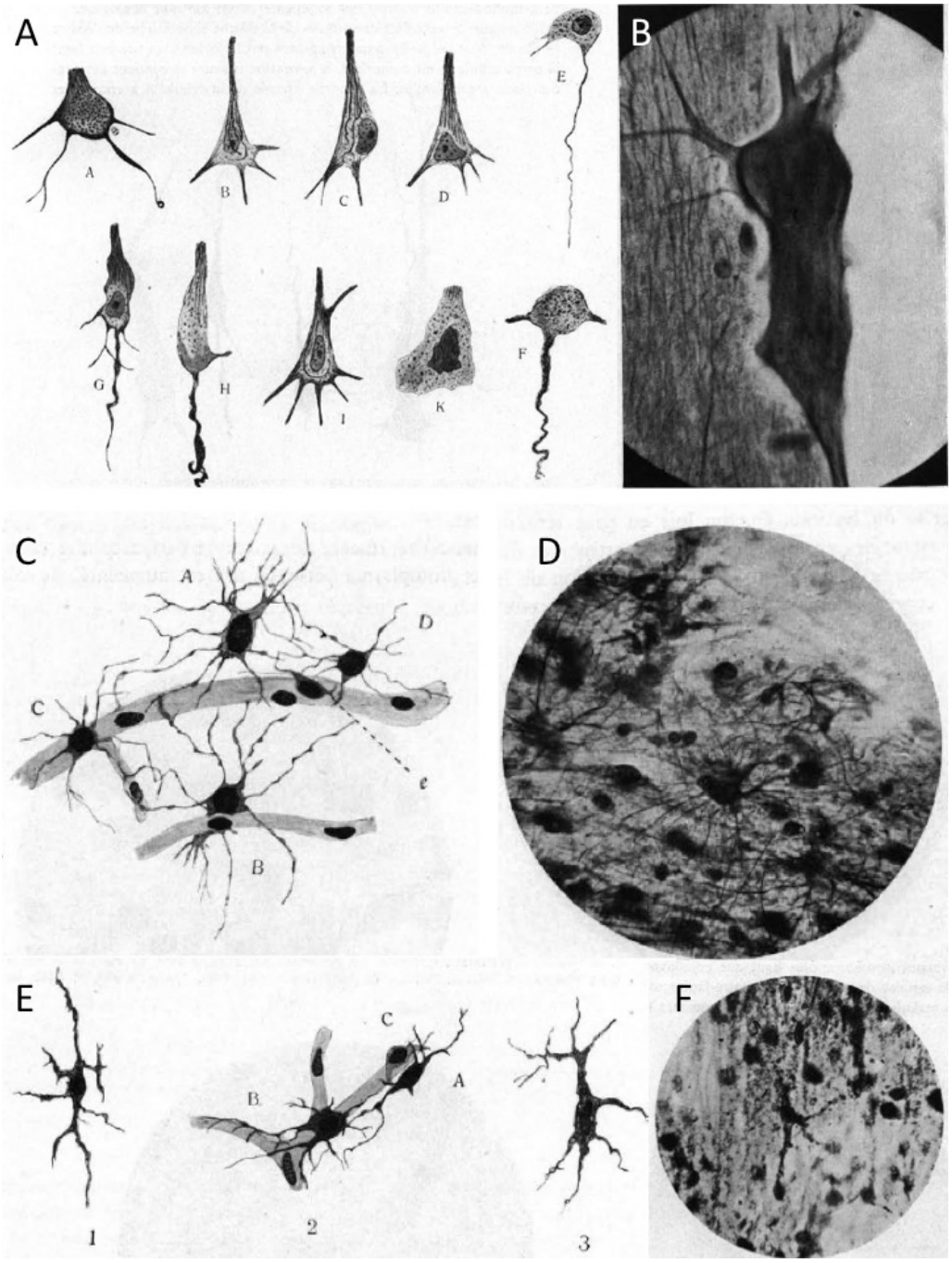


**Figura 5.** A study by Chernyakhivsky of the human brain, applying many neurohistological techniques he learned in Madrid. These results were published in Kyiv in 1934, when he was completing his exile in Stalino with his disciple Birkenhof.[52] The images correspond to figures 7, 11, 21, 14, 26, and 31, respectively, in the original publication. A) An illustration of the different stages of neuronal death in the cerebral cortex; cells are stained with the Cajal method (a, e-g) and the Bielschowsky method (b-d, i, k). B) Photomicrograph of a giant pyramidal cell in which the nucleus is barely visible, although the nucleolus is observed in the medial area. The lower part is almost fully occupied by a vacuole; Bielschowsky staining. C) A group of astrocytes of different levels of degeneration. D) Photomicrograph of a hypertrophic fibrous astrocyte of the white matter. E) Drawings of cells from the perivascular microglia, illustrating different changes in response to pathological damage. F) Photomicrograph of a microglial cell from the cerebellar cortex, displaying clasmatodendrosis (fragmentation of cell processes in a protoplasmic astrocyte). Sections C-F were stained with the silver carbonate method of del Río-Hortega.

had researched in the previous decade. For instance, he demonstrated that in human embryos, the arteries of the third and fourth branchial arch receive specific innervation forming the receptor of the aortic and carotid sinus reflexes; that the ductus arteriosus presents a baroreceptor similar to that of the carotid sinus; and that the aortic bodies are innervated almost exclusively by the nodose ganglion of the vagus nerve,[54,55] as was confirmed soon after by Hollinshead and Boyd.[56,57] Chernyakhivsky presented these findings at a lecture commemorating Cajal[C] at the Institute of Biology and Experimental Pathology in Kyiv (1936); the Ukrainian also dedicated these studies to Cajal.[53-55]

Chernyakhivsky also studied the hypertrophic/hyperplastic effect of antireticular cytotoxic serum (or Bogomolets serum) on the microglia and macrophages, recommending that this serum be used to treat tumour metastases.[12,53,58] In the same issue of the journal, he published another article on the development of the oligodendroglia in 14- to 19-week human embryos, concluding that oligodendrogliosis is initiated long before the end of the fetal phase or early postnatal phase, as had been believed previously.[59] In these articles,[58,59] Chernyakhivsky also took the opportunity to provide a detailed description of the del Río-Hortega staining method,[29-32] which he had learned directly with the Spaniard during his stay in Madrid.[12,53] Always faithful to his interest in histological technique, his later works include the modification of Cajal's double silver impregnation technique, with fixation of the specimens in tungstates, as described by Kerman and Leontovich.[59,60]

Finally, it is worth highlighting that in this final period of his life, Chernyakhivsky performed some interesting studies on the innervation of tumours, which he presented in 1938 at the First Congress of Oncologists of Ukraine, held in Kyiv.[46] These were the last texts published by Chernyakhivsky before his death, and addressed the innervation of Ehrlich experimental carcinomas in mice,[61] and pre-carcinomatous leukoplakia of the lips and cancer of the lip and tongue in humans.[62] In fact, this was the first study to demonstrate this innervation and to describe the nerve terminations on cancerous epithelial cells, which appeared to precede and accompany the appearance of tumours, and also showed processes related to nerve degeneration.[15,53] It should also be noted that at the time of Chernyakhivsky's stay in Madrid, his esteemed Pío del Río-Hortega (1882-1945) was immersed in research to establish a reliable classification of the histogenesis of nerve tumours, a project commissioned by the International Cancer Committee.[5,6,63]

*Chernyakhivsky's correspondence with Cajal and other members of his school*

The Biblioteca Nacional de España holds five letters from Chernyakhivsky to Cajal[64]; in the first, dated 1925, the former requests that offprints be sent to Kyiv; three are dated 1928 (from Kyiv and one from Berlin, organising his visit to Spain); and the last is dated 5 January 1929, sent from Paris, communicating his scheduled arrival in Madrid five days thereafter. The Archivo Pío del Río-Hortega holds letters sent by Chernyakhivsky received from Kyiv on 22 March 1925 (Figure 2B and C) and from Stalino on 26 December 1932.[65] The Legado Cajal preserves a card written in German that Chernyakhivsky sent from Kyiv to Kety Lewy, briefly recounting his move from Stalino and sending his regards "to my colleagues at the Institute."[66] The Ukrainian histologist also had a close relationship with Oskar and Cécile Vogt, Bielschowsky, Peterfi, Tello, de Castro, Lorente de Nó, and others, whose findings he cites or discusses in his research.[35,53] Chernyakhivsky often sent Cajal reprints of his articles; the *Maestro* seems to have viewed them positively: in fact, in *Neuronism or reticularism?*, his last scientific testament to continue his battle in defence of the neuron doctrine from the pugnacious reticularists, Cajal specifically mentions the findings of Chernyakhivsky.[67]

Unfortunately, the correspondence that the Ukrainian histologist received over the years from Cajal and the other Spanish and European scientists discussed, as well as books he owned with personal dedications, were all lost after his personal archive was seized at the time of his arrest in Kyiv in December 1929. Incidentally, the only text that was preserved was an article by Cajal on novelties from his neurohistological research, which Chernyakhivsky translated into Ukrainian.[12,15,17]

*The disappearance of the Chernyakhivsky family*

Oleksandr Chernyakhivsky's misfortunes continued, and in 1938, during the Great Purge, his only daughter, the writer and translator Veronika Chernyakhivska, was arrested: she had been married to a German banker

[C]Santiago Ramón y Cajal died on 17 October 1934.

and was accused of spying for Germany. Her mother, Lyudmila, wrote letters to the Soviet authorities requesting that she be released. She also sent food packages in her daughter's name to the centres holding female political prisoners. The packages sent to Tomsk were not returned, and believing her daughter to be there, she travelled to Siberia to search for her. Oleksandr and Lyudmila Chernyakhivsky would never learn that Veronika was abused and eventually murdered in September 1938 in the dungeons of the Narodny Komissariat Vnutrennij Del (NKVD, People's Commissariat for Internal Affairs) in Kyiv.[18] Veronika had already been held prisoner for several months in Kharkiv during the SVU affair, and was released when her parents were detained (see above).[17]

His daughter's arrest and his concern about her fate had ruined Chernyakhivsky's health, and he died on 21 December 1939 after a severe, protracted illness; he was buried at the Baykovo cemetery in Kyiv.[13,17]

On 20 July 1941, as German troops approached Kyiv, the NKVD arrested key Ukrainian cultural figures. One of these was Lyudmila Starytska-Chernyakhivska, aged 73 at the time, who was accused of having conducted nationalist, anti-Soviet activities over many years. She was sentenced to ten years' imprisonment with no right to appeal. On 14 September, as the Germans approached Kharkiv, she was loaded onto a cattle wagon with other detainees to be transported 2500 km to Akmolinsk, in Kazakhstan. Lyudmila could not bear the harassment, the humiliation, the cold, or the hunger, and died en route. Her body was thrown from the train. After the end of the Second World War, in 1948, members of the political police itself admitted that the Starytska-Chernyakhivska case was no more than yet another cynical invention.[68]

**Discussion and conclusions**

The Ukrainian histologist, instructor, philologist, translator, and politician Oleksandr Chernyakhivsky holds an important position in the history of his country from the late 19th century to his death in 1939. Chernyakhivsky was perhaps the most distinguished Ukrainian histologist, enjoying significant international recognition, and one of the most relevant Russian/Soviet neuroscientists. A key element of his neurohistological work is the use of tissue from human embryos, which enabled him to confirm in humans several relevant findings regarding the heart and carotid sinus, the inner ear, the sympathetic ganglia, multinucleated neurons, the microglia, post–rabies vaccination encephalopathy, and the innervation of tumours. Nearly all of these studies are closely related with the discoveries of key members of the Spanish Neurological School, such as Cajal himself, Pío del Río-Hortega, and Fernando de Castro; in many cases, he published his discoveries in the journal of the Instituto Cajal (for a review of the current relevance of the findings of the Cajal School, see de Castro et al.[69]). An advocate of Cajal's neuron doctrine, Chernyakhivsky was the first Ukrainian to use silver nitrate impregnation techniques; later in his career, he made visits to Berlin and Madrid to perfect his training, which also enabled him to forge close relationships with scientists from the circle of the Vogts (in Berlin), and especially with Santiago Ramón y Cajal, Pío del Río-Hortega, Fernando de Castro, Francisco Tello, and Rafael Lorente de Nó. Among the numerous foreign visiting researchers who sought to study the structure of the nervous system under Cajal and his main disciples, Oleksandr Chernyakhivsky was from farthest east.[3,5,6,63,70] As a curious detail, it is worth mentioning that the first neuroscientist to work with Cajal, the British-Australian Laura E. Forster (1858-1917), died during to a typhus epidemic while she was in Galicia (in today's Ukraine) during the First World War, directing a field hospital of the Imperial Russian Army, under the command of the famous general Aleksei Brusilov.[7]

It is unclear exactly what Chernyakhivsky's Spanish colleagues knew about the difficulties he faced after returning to the USSR in 1929. Postal censorship and the practical absence of any other form of contact prevent us from knowing whether Cajal or del Río-Hortega, for instance, learned of his arrest or political exile. Perhaps if they had known the sectarianism with which the Communist regime had conducted itself with regard to their esteemed Ukrainian colleague, such figures as Pío del Río-Hortega or Fernando de Castro, who were liberals and followers of Lerroux and Azaña, respectively, would not have joined in the foundation of the Association of Friends of the Soviet Union, in Madrid on 11 February 1933.[71] In any case, Cajal was not willing to join in the foundation of the association.

A man of his time who strongly identified with his country's culture, Oleksandr Chernyakhivsky was a prominent translator and normaliser of Ukrainian scientific language. Both he and his wife and daughter suffered terribly under Stalinist repression. Forgotten during the Soviet period, the figures of Chernyakhivsky

and his family have been rescued since the late 1990s, and he is now acknowledged as a part of Ukraine's cultural and scientific heritage. In addition to raising awareness among the international community of this important neuroscientist and his discoveries, which had not previously been recognised beyond the Ukrainian setting, we extend the study of the members and output of the Cajal School to the easternmost point it reached. Ukraine is currently suffering a bloody invasion by Vladimir Putin's Russia.

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**Conflicts of interest**

The authors have no conflicts of interest to declare.

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