NOTA HISTÓRICA

Jan Evangelista Purkinje, a brilliant, multifaceted Czech biologist: nerve tissue.

Jan Evangelista Purkinje, um brilhante multifacetado biólogo checo: tecido nervoso.

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ABSTRACT

Jan Evangelista Purkinje was a Czech physician with an exceptional capacity for innovative thinking, and he was one of the fathers of experimental physiology, experimental pharmacology, experimental psychology, histology, embryology, and physical anthropology. Several achievements are named after him, from his prodigious productivity. Of special interest of this paper was his pioneering role in the rise of experimental physiology, microscopical anatomy, and histological methods by the 1830´s that allowed him define more accurate data concerning the structure of nerve tissue of animals and humans such as the now known "Purkinje's cells" and others cells of the brain. He investigated the structure of neuronal processes, including the dendrites. Purkinje recognized possible functional differences between a variety of types of neurons and speculated about their interrelations. He was one of the great geniuses of science.

Key words: Jan Evangelista Purkinje, neurohistology, Purkinje cells, dendrite

RESUMO

Jan Evangelista Purkinje foi um médico checo com excepcional capacidade de pensamento inovador e um dos pais da fisiologia experimental, farmacologia experimental, psicologia experimental, histologia, embriologia e antropologia física. Várias conquistas receberam o nome dele, de sua produtividade prodigiosa. De interesse especial deste trabalho enaltece-se o seu papel pioneiro no surgimento da fisiologia experimental, anatomia microscópica e métodos histológicos na década de 1830. Isso permitiu que ele definisse dados mais precisos sobre a estrutura do tecido nervoso de animais e humanos, como as agora conhecidas "células de Purkinje" e outras células do cérebro. Ele investigou a estrutura dos processos neuronais, incluindo os dendritos. Purkinje reconheceu possíveis diferenças funcionais entre uma variedade de tipos de neurônios e especulou sobre suas inter-relações. Ele foi um dos grandes gênios da ciência.

Palavras-chave: Jan Evangelista Purkinje, neuro-histologia, células de Purkinje, dendrito

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INTRODUCTION

Jan Evangelista Purkyně or Johann Evangelista Purkinje (Figure 1), was one of the best-known scientists of his time, pioneer of many research biological areas such as histology, embryology, and pharmacology that encompass the eye and vision, brain and heart function, besides mammalian reproduction, and the composition of cells. In essence, this polymath worked in a large field of natural science, and he was a leading personality of physiology as an autonomous science, and he was also a Czech patriot, poet, translator influenced by the Naturphilosophie[1,3,4,6]. Purkinje reached international recognition, and he became a member of almost all Czech scientific and cultural academies and societies, and also of several scientific, abroad[5]. However, the memory concerning his contributions progressively faded after his death[5].

ted in the theoretical hypotheses on color perception in humans[1,2]. From 1819 to early 1823, Purkinje worked in his Faculty as a prosector for anatomy and physiology. At the time, Purkinje unsuccessfully applied for a professorship at several departments in the Austrian Empire[1,2,4,5]. These rejections occurred in spite of his scientific brightness and interest in teaching methods that led him to establish modem practice in medical education[4].

Later, Goethe's friendship was instrumental for Purkinje obtaining the chair of physiology and pathology (1823–50) at the University of Breslau, Prussia, now Wrocław, Poland (Figure 2). This achievement also influenced Alexander von Humboldt and Karl Asmund Rudolphi, who was an excellent microscopist and histologist, Professor of Anatomy and Physiology of the University of Berlin[4,5]. Consequently, at the age of 35, he was appointed in 1823 professor of physiology and pathology in Breslau,

Purkinje gave proof of struggle against many disappointments and sorrows, obstacles, and prejudices in his personal and academic life. Only through his exceptional achievements, but modesty, besides good character, he began to be valued in his academic world and finally in the society as a whole[4].

He was born to Rosalia Šafráková and Joseph Purkinje who was an estate manager, in Bohemia which was then in the Austro-Hungarian Empire, now it is in the Czech Republic. Purkinje's father's death occurred when he was six years old, and from the age of 10, he had attended a one Piarist monastery school, tuition-free, in exchange for singing in the monastery choir. He later became a Piarist novice[1,3,4,6]. However he left the Piarist order in 1807, and he enrolled as a student at the Philosophical Institute of The Universitas Carolo-Ferdinandea in Prague, where he predominantly attended physics courses[1]. However, due to financial difficulties, he interrupted these studies in 1809. He made his living as a tutor in some aristocratic houses, and he became the private tutor of Baron Hildprandt's son, a position that he kept for 3 yrs[1,45]. In November 1812, he began his medical studies in Prague[1].

In 1827, at the age of 40, Purkinje married Julia Agnes Rudolphi, daughter of his supporter Karl Asmund Rudolphi[6]. The Purkinje couple had two daughters (who died of cholera at an early age) and two sons, and one became a naturalist and a meteorologist, and the younger, well-known portrait painter[1,6]. In 1835, his wife died of typhoid infection, but Purkinje never remarried[1,5,6]. Purkinje died in 1869, in Prague, after a long and painful illness with kidney stones, at the age of 82 years, but he had maintained until the end, his robustness of body and mind[4].

Figure 1- Jan Evangelista Purkinje (Purkyne) or Johannes Evengelista Purkinje (Dec. 17, 1787, Libochovice, Bohemia - July 28, 1869, Prague) (https://upload.wikimedia.org/wikipedia/commons/9/9d/Jan_Vilímek_-_Jan_Evangelista_Purkyne.jpg).

TRANSPOSING FRONTIERS

Purkinje graduated as a physician at the Medical Faculty of the Universitas Carolo-Ferdinandea in Prague, but he followed a researcher career. His MD thesis submitted in 1818, was on the results of his ophthalmologic research, "Beiträge zur Kenntniss des Sehens in subjectiver Hinsicht" ("Contributions to the Knowledge of Vision from the Subjective Point of View")[1]. This work earned him the protection and friendship of the famous German poet Johann Wolfgang von Goethe, who was also interes-

where Purkinje created the Physiological Institute, which was the first such institute in the world (1839)[3,6]. As he had new place, Purkinje "moved his experiments, classes, and animal-breeding efforts from his home to the institute," as quoted by Mazurak & Kusa. Besides, he became the dean of the medical faculty, nominated to this position four times in a row[3]. These 27 years spent in Breslau can be considered as the most fruitful period of Purkyné's life that relied on qualified equipment and novel techniques for the preparation of research material[1,3].

Figure 2-The University of Breslau, 19th century, where from 1823 to 1850 Purkinje has developed his most important works. The previous German University of Breslau. since 1945 became University of Wrocław (https://upload.wikimedia.org/wikipedia/commons/5/5a/Universität_in_Breslau.jpg).

Purkinje is best known for his discovery of the cells nowadays called Purkinje´s cell and Purkinje fibers to be discussed in the next section.

Purkinje carried out researches based on several methods such as self-examination regarding visual sensations, vertigo, and the use of certain drugs, besides experiments in animals[3]. With these approaches, he had several scientific achievements such as accurate descriptions of various visual phenomena; discovery of criteria to classify human fingerprints (1823); experimental effects on humans of camphor, opium, belladonna, and turpentine (1829); visual images produced by the poisoning with digitalis and belladonna. Regarding visual phenomena, it is highlighted the Purkinje effect, Purkinje shift, or Purkinje phenomenon, that is the tendency for the peak luminance sensitivity of the eye to shift toward the blue end of the color spectrum at low illumination levels, as part of the dark adaptation[1,6]. Many others discoveries are also named after him, such as those regarding[1,3]: reflections of objects from the structure of the eye (Purkinje-Sanson images); formulation of the vertigo law - when one stops after rotating around the body axis, the apparent motion of the surroundings changes from horizontal to vertical if the head is inclined toward the feet (Purkinje's law); branched spaces in tooth enamel (Purkinje granular layers); shadows of retinal vessels (Purkinje tree); bone lacunae (Purkinje's corpuscles)[1,5].

He also discovered the sweat glands of the skin (1833) and the birds' eggs germinal follicle, sometimes called the Purkinje vesicle, later identified as egg cell nucleus (1825), and noted the protein-digesting power of pancreatic extracts (1836)[1]. In 1839, Purkinje likewise introduced the scientific terms plasma and protoplasm (protoplasm to describe the living embryonic material of the egg) and most importantly, he noticed that cells are the structural components of animals and plants, in this way, he was the first to establish that the whole body is composed of cells[3,4]. Recap, Purkinje's main interest was the inside of the cell, while Schwann described the cell membrane and was the first to use the word cell[3].

As if it was not enough so many discoveries, and to make them viable, Purkinje created numerous tools that have been broadly used in his scientific work[4].

In the 1820s, achromatic lenses were developed and applied to compound microscopes. Thus Purkinje obtained this new equipment in 1832 and began to examine biological samples. In association, among Purkinje´s achievement, he was the first to use the microtome, potassium bichromate, and Canada balsam in the preparation of histological slides for microscopy[1,5]. With these techniques, he described many histological findings.

In 1850, Purkinje moved to Prague and joined the medical faculty as professor of physiology (1850–69), and in 1851, he was able to open his second institute of physiology, the first of its kind in the Austrian Empire, where he continued his research and teaching practice until his death[2]. At this time, instead of delivering groundbreaking discoveries, Purkinje was very actively integrated into public, cultural, and political life and significantly contributed to the popularization of science [4,5]. Besides, he had aided a return to the use of the Czech language instead of German in the university's communications, and he translated much foreign literature into the Czech language and vice-versa[3,4,5]. In essence, in his later time, he devoted himself to promote and consolidate a patriotic Czech national conscience. This was carried out also as a deputy of the Bohemian Parliament and editor of one of the leading daily newspapers[5].

HIGHLIGHTING THE NERVOUS SYSTEM AND RESEARCH DIRECTED TOWARDS HISTOPHYSIOLOGY

Purkinje studied microscopically various tissues, and he gave the original descriptions of numerous types of cells, but he paid special attention to the structure of the nerve system. This was clearly expressed in his paper presented in Prague, in 1837 under the name "Über Neuesten Untersuchungen aus der Nerven- und Hirn-Anatomie" ("New Investigations on Nerves and Brain"). He was the

first to notice the significance of the grey substance of the brain[3].

In these neurohistological studies, Purkinje accurately described and illustrated different cell nervous types, ganglion bodies, as Purkinje termed them, in the substantia nigra, locus coeruleus, thalamus, corpora geniculata, cornum Ammonis, cerebellar cortex, in the oliva inferior and in the pons Varoli[7]. He also researched the structure of the hippocampus[2]. Purkinje was also the first to describe and illustrate in 1838 the intracytoplasmic pigment neuromelanin in the substantia nigra.

Above all, Purkinje was the first scientist to see and describe the largest nerve cells in the brain, found in the middle layer of the cerebellum, besides he represented and exactly defined the distinct three layers of the cerebellar cortex[4]. These large neurons with many branching dendrites were called by Santiago Ramón y Cajal as Purkinje cells[10]. To publicize these findings, Purkinje hand-illustrated them at his memorable lecture to the professional public in Prague in 1837-published in 1838[8] (Figure 3). This discovery was made possible by examining alcohol-fixed slices of sheep cerebellum[1].

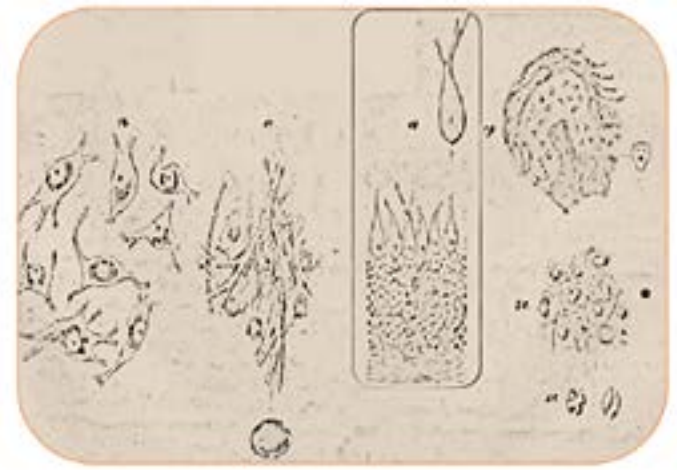

Figure 3. Drawings of the structure of nerve tissue by Purkinje for the Congress of Physicians and Scientists Conference in Prague, in 18378 (1rst part): ganglionic bodies in the brain and in the spinal cord different shapes, among them "Purkinje cells" of the cerebellar cortex with upwards branching processes which Purkinje was able to define and draw in a peculiar way. Highlighted, cerebellar cortex, from top to bottom, the molecular layer, the Purkinje cell layer, the granule cell layer, and the white matter.

Besides, within these ganglion cells, he clearly distinguished the nucleus and the nucleolus[7], and he described these cells, apud John[4], as "central forms which are related to the elementary nerve fibers in the same way as central stations of power generators are to the conducting wires." In this way, Purkinje called the ganglia cells, apud John[4], as "accumulators, manufacturers, and expediters of the nerve power." In this way, in Purkinje´s concept, more specifically, ganglial bodies (somata) play a central role and act as energy generators (Kraftzentra). In this concept, nerve fibers act an energy conductor (Kraftlaitungslinien), with some fibers distributing energy while others serve as energy collectors[7]. In sum, regarding the large numbers of "ganglion bodies" the regular occurrence of defined types in defined parts of the brain, Purkinje considered them as important constituents of the nerve tissue, as some centers in which neural energy is accumulated, generated and distributed. Moreover, a neuronal function is determined by their position within the nervous system hierarchy; like this, Purkinje laid the basis for functional morphology in neurosciences[7]. A climax of Purkinje's investigations in the field of neurosciences was his concept of the function of the nervous system as a whole, which Purkinje formulated in 1847 - heralding neuron theory[7].

Along with describing "Purkinje's cells" and cells of other regions of the brain, Purkinje investigated the structure of neuronal processes, and he can be credited with the first description of dendrites[7]. Besides, Chvátal reported that Purkinje also has a priority in the description of the processes of cells in the brain and spinal cord that were in close relationship with nearby blood vessels, probably the processes of perivascular astrocytes[2].

In the already mentioned famous lecture (1837)[8], he also described neuronal projections (Figure 4). He described that in fresh nerves, placed alongside and squeezed, expelled from their sheaths, there were similar transparent central lines, which he later realized were solid parts and called them to nerve axial cylinders (Nervencylinder, Axiscylinder). As noted by Pokorný[7], neuronal axon was described as Purkinje's axis cylinder (Achsenzylinder) throughout the XIXth century. Besides, Purkinje commented on the content of the nerve fiber, referring to it as a "protein substance." Indeed, Purkinje sought always a correlation between morphology and function, and he continued in an attempt at classifying nerve fibers by their diameter. Fortunately, quantitative measurements were made possible by the then-new and exact ocular micrometer, permitting measurements with an accuracy of up to 1/500 mm. With this new tool, Purkinje, with his co-workers, demonstrated a difference between the thickness of fibers of posterior, sensory roots (smaller diameter), and anterior motor roots (larger diameter), as stated by Pokorný[7].

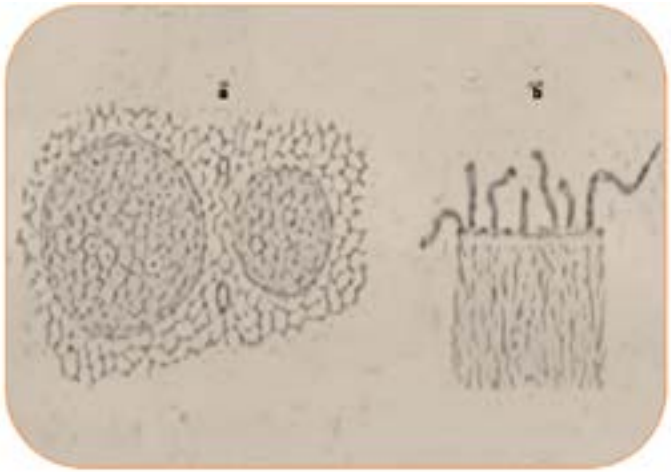

Figure 4. Drawings of the structure of nerve tissue made by Purkinje for the Congress of Physicians and Scientists Conference in Prague, in 18378(2nd part): a: The inner space of the basic nerve fibers in very fine translucent transverse sections; b: Thin longitudinal section of a nerve fiber.

Purkinje's discoveries were often published in the dissertations of his assistants[3]. Indeed, several Purkinje influential disclosures were divulged in monographs of his students[5]. For instance, he supervised the doctorate of David Rosenthal, and they jointly discovered that nerves have fibers inside and analyzed the number of nerve fibers in spinal and cranial nerves[3]. Besides, in 1836, Purkinje´s most eminent ex-student, Gabriel Valentin, described the detailed structure of brain cells (round or elongated bodies with a nucleus, sometimes with a nucleolus). Chvátal[2] considers that these findings were derived from data from the relatively long period of joint work between the student and the master.

Purkinje conducted research on the effects of partial destruction of the animal brain by needles, being one of the earliest researchers to use this method[3]. Besides, he determined the movement of cilia in the genital and respiratory systems, and ultimately, in 1836, he described the results of his study of the ependymal ciliary cells along the brain ventricles and later (1858) he noted, the discovery of ciliary movements in the brain cavities[3,7].

Purkinje is also known for his discovery in 1839 of Purkinje fibers because he revealed a net of gray, flat, gelatinous fibers in the ventricular subendocardium of the sheep heart. Firstly, Purkinje thought that they were cartilaginous fibers; six years later, although, he assumed that they were muscular[9].

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

FUNDING STATEMENT

There is no financial support

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