A THESIS ON THE COMPARATIVE NEUROANATOMY OF FISH BY A SCIENTIST FROM THE BALKANS, APOSTOLE ARSAKY, 1813

O TEZĂ DESPRE NEUROANATOMIA COMPARATĂ A PEŞTILOR A UNUI SAVANT DIN BALCANI, APOSTOL ARSAKI, 1813

O. BUDA[1)]

ABSTRACT | REZUMAT

In 1813, during the reign of Napoleon I, Apostole Arsaky (1784-1874), a scholar of Aromanian origin published at Halle, in Germany, entitled ***De Piscium cerebro et medulla spinali***.

This work has become one of the most cited papers in the specialized European field, substantially helping to understand the functional neural structures in different species of fish. Arsaki used early evolutionary models in explaining their morphology.

Arsaki was later involved in the political life of modern Romania, becoming interim Prime Minister and Foreign Minister in 1862. He was a philanthropist and supported Romanian and Greek emancipation from the Ottoman Empire, and founded the Arsakion Institute of Athens.

Keywords: History of Comparative Neuroanatomy, Ichtyology, Evolutionism, Phylogenesis and Ontogenesis

În 1813, în timpurile lui Napoleon I și Ion Vodă Caragea, Apostol Arsaki (1784-1874), un savant de origine aromână a publicat la Halle, în Germania, o teză despre neuroanatomia comparată a peștilor, ***De piscium cerebro et medulla spinali***.

Lucrarea a devenit una din cele mai citate lucrări de specialitate pe plan european, contribuind în mod esențial la înțelegerea funcțională a structurilor neurale la diferitele specii de pești. Folosind teze apropiate evoluționismului incipient (J.B. Lamarck, G.L. Buffon, G. Saint-Hilaire, J.F. Meckel), Arsaki a oferit explicații în parte valabile asupra modelării în timp a morfologiei acestora. El a fost convins că organismele vertebratelor sunt construite pe baza unui tipar universal în contextul cărora se realizează diferitele trăsături caracteristice speciilor și variantelor acestora. Arsaki face astfel parte dintr-o elită a anatomiștilor, medicilor și biologilor care au contribuit la dezvoltarea conceptelor evoluționiste, care se vor impune în a doua jumătate a secolului 19.

Arsaki se va implica ulterior în viața politică a României moderne, ajungând prim-ministru interimar și ministru de externe în 1862. A fost un mare filantrop, a sprijinit reforma culturală din România și Grecia, și a fondat Institutul Arsakion, la Atena.

Cuvinte cheie: Istorie, Neuroanatomie comparată, Ihtiologie, Evoluționism, Filogeneză și Ontogeneză

In 1813, when Napoleon Bonaparte, after a calamitous campaign in Russia, was preparing to patch up a new Grande Armée,an Aromanian [1] scholar earned his doctor of medicine degree in Halle, Germany, guided by the well-known anatomist Johann Friedrich Meckel the Younger (Fig. 1).

The scholar's name was Apostol Arsaki - westernized as Apostole Arsaky (1784-1874) and the thesis he submitted to the jury was entitled *De piscicum cerebro et medulla spinali* (On Fish Brain and Spinal Cord).

Meckel the Younger (1781-1832) was a professor of comparative and pathological anatomy and anthropology at the Martin Luther University in Halle. He is regarded as one of the founders of teratology who focused on the study of birth malformations, until then explained by religious or mystical theories. Meckel was both a student and an admirer of Cuvier (1769-1832) (Fig. 2), an outstanding biologist, one of the fathers of paleontology and of compared anatomy. In 1809 Meckel translated Cuvier's "Leçons d'anatomie comparée", published in five volumes between 1800 and 1805. His evolutionist theory was set forth in his work

1) "Carol Davila" University of Medicine and Pharmacy, History of Medicine Chair, Bucharest, Romania
e-mail: octbuda@gmail.com

entitled *"System der vergleichenden Anatomie" (The System of Compared Anatomy).* Published between 1808 and 1821 in several volumes, the study dwells on the mechanisms underlying the origins and evolution of various new species [24].

Though a fervent disciple of Cuvier, Meckel the Younger stopped short of embracing his master's fixist theory which echoed the immobilism of Carl von Linné (1707-1778). The Swedish physician and zoologist made a creed out of his slogan *"Species tot sunt diversae, quot diversas formas ab initio creavit Infinitum Ens"* (There are as many species as the Infinite Being produced diverse forms in the beginning).

Fig. 1. Johann Friederich Meckel the Younger (1781-1832)

Fig. 2. Georges Cuvier (1769-1832)

Meckel the Younger therefore backed Lamarck's ethological theory according to which evolutionary changes are a reaction to the environment [21, 22]. Moreover, Meckel was also a recapitulationist, paving the way for Haeckel's thesis "ontogeny repeats phylogeny", which draws a parallel between embryonic development and the growing complexity of animal organisms in the phylogenetic tree. It was only natural for Meckel the Younger to sway Arsaki not only to study the comparative anatomy of the nervous system of fishes, but also to highlight features which could have put transformist-evolutionist theory ahead of fixism.

Fig. 3. Apostole Arsaky (1784-1874)

Arsaki (Fig. 3) was born in the village of Hotahova, near Permet, in today's northern Albania, on January 6, 1784. The settlement, same as the entire area of former Epirus, was inhabited by an ethnic community of Romanians (Aromanians) who struggled under the growing pressure from Turks and Albanian Muslims. So, soon after his birth, Apostol's family led by his father Chiriac and his uncle Gheorghe moved to Bucharest, where they made a fortune from merchandising.

By 1804, 20-year-old Arsaki was studying philosophy in Vienna. Six years later he took up medicine in Halle. On March 11, 1812 he earned his doctor of medicine and surgery degree [2] with professor Meckel the Younger [11, 23]. Had he continued as a researcher, he would have made himself a name in European human and animal neurobiology. Unfortunately, following his resounding thesis which came to be cited and widely commented upon by 19th century biologists,

Arsaki chose to become a general practitioner before turning to politics. As a doctor, boasting a long list of patients, he came to be appointed manager of the Coltea Hospital in Bucharest and later chief medical officer (arhiya-tros) of the Romanian capital city [4, 26, 30]. A very active right-wing conservative politician, Arsaki strenuously fought down Marxist concepts like proletarian or surplus value [11]. He made a significant contribution to the union of the Romanian Principalities and to the making of modern Romania.

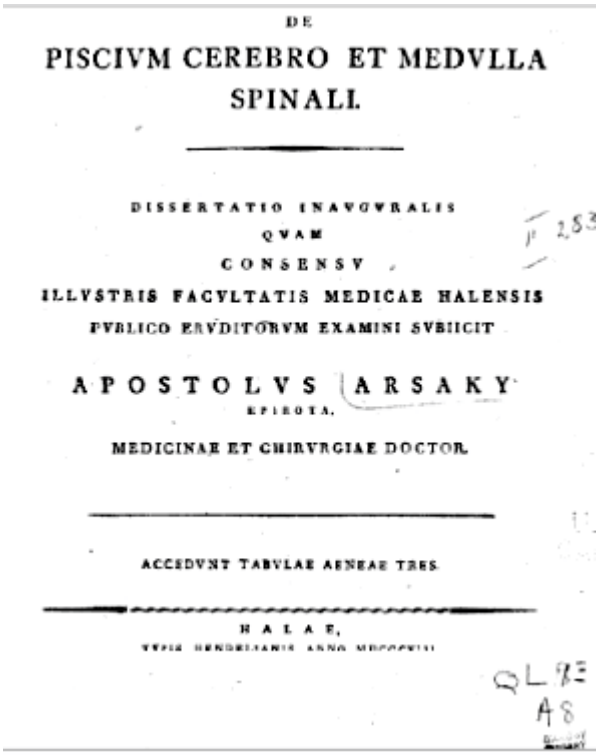
He was appointed interim Prime Minister after Barbu Catargiu was assassinated in June 1862 [5] and became the first foreign minister of modern Romania in that same year. As a philanthropist, Arkasi created the Arsakion foundation to secure young girls' right to education in Athens, a move which won him Greece's acclaim and respect.

De piscium cerebro et medulla spinali

De piscium cerebro et medulla spinali: dissertation inauguralis quam consensus illustris facultatis medicae Halensis (On the brain and spinal cord of fish) is the full name of doctoral thesis that Arsaki presented in 1813 (Fig. 4, 5).

In preparing the paper, he spent several months in Naples, where he managed to fix more than 50 species of Mediterranean fish in bottles of alcohol before examining their brains and spinal cords. Technically speaking, the thesis was a macroscopic description of the brain and spinal cord of fish. The paper lacked microscopic analyses because early 19th century researchers had no idea about how to prepare and particularly how to color histological sections. The first part of the doctoral thesis made a minute description of the spinal cord's exterior and interior in more than fifty species of fish. Arsaki listed the common traits of all vertebrates – fish, batrachians, reptiles, birds, mammals and humans – and minutely described the comparative differences between various species of fish (Fig. 6).

He stressed there was no intumescence in the spinal cord of fish, which he explained, accurately, by the fact that fish do not have limbs. Then he approached the vertebral channel, comparing the length of the spinal cord to that of rachis and to the size of the encephalon. Arsaki insisted on the ependyma, located in the central canal of the spinal cord, which opens into the fourth ventricle, and the presence of the cerebrospinal fluid. For centuries, scientists had been erroneously attaching excessive importance to intra neuraxial cavities. Arsaki cited Morgagni and Santorini in support of the ependymal canal.


DE
PISCIVM CEREBRO ET MEDVLLA SPINALI.

DISSERTATIO INAVGVRALIS
QVAM
CONSENSV
ILLVSTRIS FACVLTATIS MEDICAE HALENSIS
PVBLICO ERVDITORVM EXAMINI SVBIICIT

APOSTOLVS ARSAKY
EPIROTA,
MEDICINAE ET CHIRVRGIAE DOCTOR.

ACCEDVNT TABVLAE AENEAE TRES.

HALAE,

Fig. 4. Arsaky' Thesis, 1813

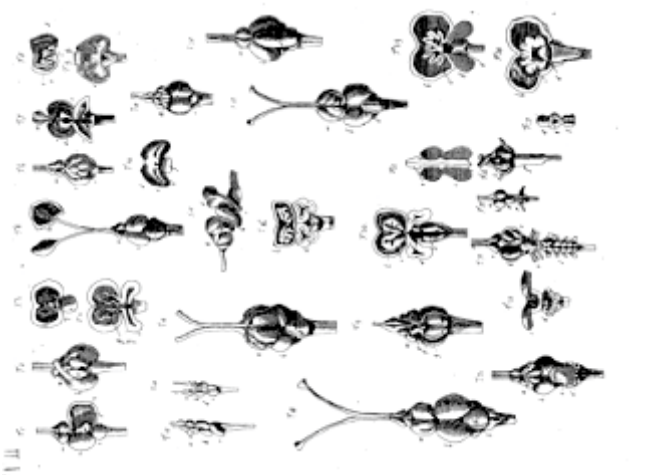


Fig. 5. Plates from Arsaky' Thesis, 1813

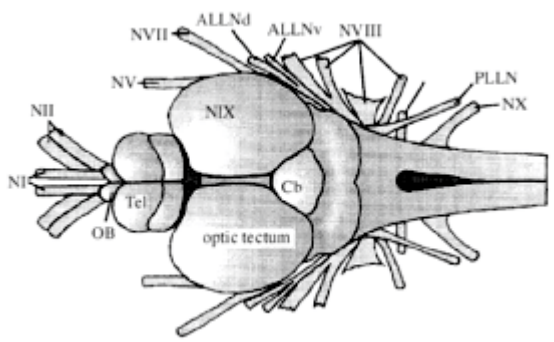


Fig. 6. The typical brain of marine fish.
Tel: Telencephalon; Cb: Cerebellum;
OB: Olfactory Bulbus. The rest are nerves

Arsaki's description of the grey substance encircling the ependymal canal as well as the white substance surrounding the grey one was considered a major contribution to unveiling the nervous system of fish.

The second part of the thesis dwelling on the fish encephalon was also deemed as an extremely important scientific achievement.

He started by stating that the brain of fish is the smallest and simplest among all vertebrates. However, he noted that many of its components grow and develop in bigger and more complex animals (*altioribus animalibus*), reaching their highest level in humans (*summam magnitudinem*). This is a clear example of an evolutionary thinking.

The first item he described was the bulb with two lateral ganglionic eminences, to which he failed to ascribe any function. Scientists are still puzzled over the enigmatic olivary structures (*posteriore ganglio-rum encephalum* or *tubercula medullae oblongata*) which are part of highly complex neural system.

The second item analysed by Arsaki was the cerebellum or the little brain. This time the young researcher dismissed Cuvier's description of the cerebellum as a ganglionic mass located in the median line. Relying on his dissections, Arsaki stated that the cerebellum is made up of a median part (*media impair* or *vermisul*) and two lateral parts (*lateralibus paribus componi* or cerebellar hemispheres), which reach the pons forming the floor of the fourth ventricle.

Arsaki made an essential contribution to biology by stating that the shape of the cerebellum as a "universal" pattern in all vertebrates, explaining that the differences occurring in various species were due to evolution: *ratione evolution cerebeli modo*.

On the third item - the optical tubercles - his exceptional study probably stands out as his most significant contribution to science. Whoever looks at the brain of a fish (or that of batrachian or a reptile) will notice the existence of two large ovoid formations lying on each side of the median line. Relying on shape analogies, anatomists led by Cuvier were convinced that these formations were the same as the cerebral hemispheres of birds and mammals.

Arsaki's totally novel interpretation was that *the optical tubercles of fish were actually the equivalent of the birds' two optical tubercles and of the mammals' four quadrigeminal tubercles (tectum opticum)*. His interpretation has endured to date. Later on, great biologists Cuvier and Owen would themselves aknowledge Arsaki's discovery.

As part of the anterior segment of the brain, Arsaki provided quite a few morphological details about two eminences which he called olfactory tubercles. They did not seem to have cavities but varied in size and shape from one species to another. However, they send nerve fibers to many other areas. Arsaki agreed with previous scientists that these tubercles play a certain role in the olfactory senses of fish.

Arsaki's statement that these tubercles would evolve into the cerebral hemispheres of birds and mammals received Cuvier's full praises. It still holds true today.

International Commendation

As a token of recognition, a second edition of Arsaki's thesis was published in Leipzig in 1836, nearly 25 years after it fist came out and four years after Meckel's death. The new edition was published by Gustav Wilhelm Münter (Latinized as Minter), who also wrote a substantial introductory study [3] (Fig. 7).

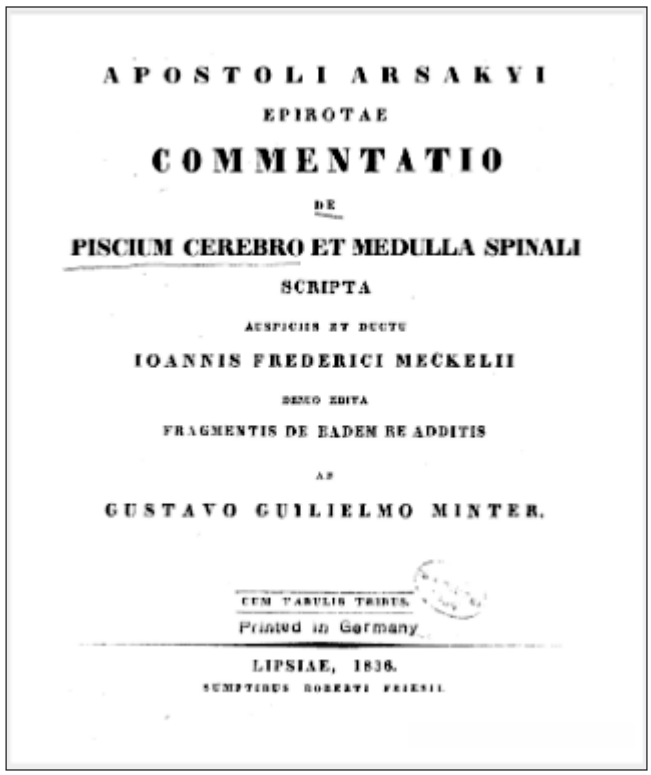

APOSTOLI ARSAKYI
EPIROTAE
COMMENTATIO
DE
PISCIUM CEREBRO ET MEDULLA SPINALI
SCRIPTA
AUSPICIIS ET DUCTU
IOANNIS FREDERICI MECKELII
DENO EDITA
FRAGMENTIS DE EADEM RE ADDITIS
AB
GUSTAVO GUILIELMO MINTER.
CUM TABULIS TRIBUS.
Printed in Germany
LIPSIAE, 1836.
SUMPTIBUS ROBERTI FRIESII

Fig. 7. Reissue from 1836

Münter (1804-1870), too, had studied medicine at Halle,under the guidance of tireless Meckel the Younger. He was an exceptional anatomist and he took his MD in 1836 with the thesis *"Disertatio inauguralis phisiologia prodomum systens zoologiae generalis"*. He succeeded Meckel at the universities of Halle and Jena [20].

However, the highest praise ever received by the Aromanian scientist came from Cuvier's monumental work *"Histoire naturelle des poissons"* written jointly with Achille Valenciennes (1794-1865) in 22 volumes, between 1828 and 1849. Quite uncustomarily, the two authors underscored the importance of Arsaki's research and conclusions which, as already mentioned, were quite opposed to Cuvier's own ideas.

Arsaki came to be cited even by Sigmund Freud [12,13], the father of psychoanalysis, in a 1877 study on the origins of posterior roots of spinal nerves in the lamprey (Petromyzon Planeri), an ancestral fish with a tubular shape, much like the eel. Arsaki's work was also cited by great scientists such as Friedrich Burdach (1776-1847), Carl Gustav Carus (1789-1869), Jean Cruveilhier (1791-1874), Franz Josef Gall (1758-1828), Karl Gegenbaur (1826-1903), François Magendie (1783-1855), Richard Owen (1804-1892), Johann Gaspar Spurzheim (1776-1832), Giuseppe Sterzi (1876-1919) , Friedrich Tiedemann (1781-1861) and many others [6, 7, 8, 14, 15, 10, 25, 27, 28, 29].

REFERENCES

1. *Ariens Kappers C.U.* (1906) The structure of the teleostean and Selachian brain, The Journal of Comparative Neurology and Psychology, Volume XVI, January, nr. 1, 2.
2. *Arsaki A.* (1813) De piscium cerebro et medulla spinali - Theses Medicae quas consensu ordinis medici in regia Fredericiana Halensi praeside Ioann Frider. Meckel… pro gradu doctoris summisque in Medicina et Chirurgia honoribus legitime consequendis d. XI. Mart. MDCCCXII publice defendet [sic] Apostolus Arsaki, Epirota, Halle: Hendel, Arhivele Universității Martin Luther (Halle).
3. *Arsakyi A., Minter G.G.* (1836) Apostoli Arsakyi epirotae commentatio, De piscium cerebro et medulla spinali scripta auspiciis et ductu Ioannis Frederici Meckelii denuo edita fragmentis de eadem re additis, Sumptibus Roberti Friesii, Lipsiae.
4. *Bălăceanu-Stolnici C.* (2002) Saga Bălăcenilor. Șapte secole de istorie, Ed. Vitruviu, București, 267-268.
5. *Bălăceanu-Stolnici C., Buda O.* (2012) Autopsia unui asasinat politic: Barbu Catargiu, Istorie și Civilizație, an IV, nr. 30, martie, București, 5-11.
6. *Burdach C.F.* (1819) Vom Baue und Leben des Gehirns, Vol. 1, Dyk'schen Buchhandlung, Leipzig, 248.
7. *Carus C.G.* (1827) An introduction to the comparative anatomy of animals, comp. with constant reference to physiology, and elucidated by twenty copperplates, transl. Gore R.T., Vol. 1, Longman, Rees, Orme, Brown and Green, London, 233.
8. *Cruveilhier J.* (1837) Anatomie descriptive, Tome second, Meline, Cans et Compagne, Bruxelles, 266, Tome quatrième, Labé Editeur, Librairie de la Faculté de médecine, Paris, 424.
9. *Cuvier G.* (1828): Histoire naturelle des poissons, avec M. Valenciennes, Tome 1, Chez F.G. Levrault, Paris, 1828, 417-418.
10. *Desmoulins A., Magendie F.* (1825) Anatomie des systèmes nerveux des animaux à vertèbres: appliquée à la physiologie et à la zoologie, Méquignon-Marvis, Paris, 142, 145, 150-152, 159-162, 171, 180, 287.
11. *Filitti-Penelea G.* (1996) Apostol Arsaki, un personaj istoric uitat (Le docteur Apostol Arsaki), Magazin Istoric, 30, nr. 1, 20-22.
12. *Freud S.* (1877) Über der Ursprung der hinteren Nervenwurzeln im Rückenmark von Ammocoetes (Petromyzon Planeri), in: Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, LXXV, vol. III.
13. *Sulloway F.J.* (1979) Freud, Biologist of the Mind: Beyond the Psychoanalytic Legend, Basic Books, New York, 160, 267-269.
14. *Gall F.J.* (1835) On the Functions of the Brain and of Each of Its Parts: Critical review of some anatomico-physiological works; with an explanation of a new philosophy of the moral qualities and intellectual faculties, Marsh, Capen & Lyon, Boston, transl. Lewis W., vol. VI, 1835, 217.
15. *Gegenbaur C.* (1874) Manuel d'anatomie comparée, traduit sous la direction de Carl Vogt, C. Reinwald, Paris, 695.
16. *Gottsche C.M.* (1835) Vergleichende Anatomie des Gehirns der Grätenfische, in: Archiv für Anatomie, Physiologie und wissenschaftliche Medicin, Hrsg. Müller J., Im Verlag von G. Eichler, Berlin, 444, 447-448, 450, 462-463, 479.
17. *Haeckel E.* (1866) Generelle Morphologie der Organismen. I: Allgemeine Anatomie der Organismen. II: Allgemeine Entwickelungsgeschichte der Organismen, Verlag von Georg Reimer, Berlin.
18. *Ionescu M.* (1985) Publicațiile anatomice românești din secolul al XIX-lea, în: Brătescu G. (sub red.): Retrospective medicale, Editura Medicală, București, 297-302.

19. *Jouber J.* (1757) Dictionnaire français et latin tiré des meilleurs auteurs..., André Perisse, Lyon.
20. *Kapitza Babette* (2004) Dr. Gustav Wilhelm Münter (1804-1870) und die Meckelschen Sammlungen. Dissertation zur Erlangung des akademischen Grades Doktor der Zahnmedizin (Dr. med. dent.) vorgelegt an der Medizinischen Fakultät der Martin-Luther-Universität Halle-Wittenberg.
21. *Lamarck J.B.* (1802) Recherches sur l'organisation des corps vivans..., Maillard, Paris; (1809) Philosophie zoologique, ou Exposition des considérations relatives à l'histoire naturelle des animaux..., Dentu, Paris.
22. *Mayr E.* (1984) Die Entwicklung der biologischen Gedankenwelt. Springer Verlag, Berlin.
23. *Michalopoulos D.* (2008) Arsaki. La vie d'un homme d'Etat, Ed. Academiei Române, București.
24. *Meckel J.F.* (1806) Abhandlungen aus der menschlichen und vergleichenden Anatomie und Physiologie, bey Hemmerde und Schwetschke, Halle; (1808) Beyträge zur vergleichenden Anatomie, vol.1, erstes Heft, Carl Heinrich Reclam, Leipzig.
25. *Owen R.* (1866) On the Anatomy of Vertebrates, vol. 1, Longmans, Green and co., London, 272.
26. *Petresco G.Z.* (1940) Le premier oculiste titré en Valachie, Bulletin de L'Académie de Médecine de Roumanie, extrait, V-ème Anée, Tome X, nr. 4.
27. *Spurzheim J.G.* (1826) The Anatomy of the Brain with a general view of the Nervous System, transl. by R. Willis, S. Highley, London, 144.
28. *Sterzi G.* (1912) Il sistema nervoso centrale dei vertebrati: ricerche anatomiche ed embriologiche del dote, Vol. 2, Part 2, A. Draghi, 1912, 1304.
29. *Tiedemann F.* (1826) The anatomy of the foetal brain, with a comparative exposition of its structure in animals, transl. by Jourdan A.J.L. and Bennett W., John Carfrae & Son, Edinburgh, 266.
30. *Vătămanu N.* (1969) Doctorul Apostol Arsache (1789-1874), în: Studia et Acta Musea Nicolae Bălcescu, 365-376.