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JOHANN EVANGELISTA PURKYNĚ'S CONTRIBUTION TO THE ADVANCE OF THE NATURAL SCIENCE AND MEDICINE

Johann Evangelista Purkyně's (1787–1869) [1] painstaking work on the dislosing of regularities in nature coincides in time with the period of the declining dispute that had been going on in the philosophy of nature between the mechanicists, i. e. those advocating a material interpretation of the life of the organism confined to physical and chemical phenomena, and the vitalists, who adhered to idealistic explanations of the processes of life. The beginnings of that dispute must be sought for as early as in the 16th century—in the vitalistic elements in the teaching of Theophrastus Paracelsus [2] and of his followers, and in the 17th century—in the views of the iatrochemists or chemiatrists supported by Descartes' mechanistic materialism. Later they were aided by the discoveries of Kepler, and especially of Newton. In the 18th century, the dispute grew in intensity but with a slight shift in its emphases. The main opponents in it became then the French materialists, such as La Mettrie, Voltaire and the encyclopaedists on the one hand, and the representatives of the new vitalistic school at Montpellier (Bordeu Barthez), who under the impact of Newton's achievements as well as of Condillac's sensualism already referred to scientific argumentation. The dispute was attenuating towards the end of the French Revolution, at the dawn of positivism that was the product of a new type of naturalists, namely those who fully realized that the life of an organism consists not only in the mere physical and chemical processes, even with the addition of a vague vitalistic factor, but a total of the specific processes pertaining to the "living matter". In order to disclose them,

[1] M. Matoušek, *Život Jana Evangelisty Purkyně,* Státni Zdravotnické Nakladatelstvi, Praha, 1962.

[2] W. Pagel, *Paracelsus. An Introduction to Philosophical Medicine in the Era of the Renaissance,* Basel-New York, 1958, pp. 277ff; L. Zembrzuski, *Dzieje kierunków, teoryj i doktryn filozoficzno-lekarskich* (The story of philosophical-medical trends, theories and doctrines), Kraków, 1935, p. 117.

the common methods applied previously had to be abandoned. The new naturalist methodology was expected to yield a new science of life. At first, the image of such a science was rather vague, but some attempts to render it more specific were made. One such attempt was the excellent book of Jędrzej Śniadecki entitled *Teoria jestestw organicznych* (A theory of organic beings). [3] The book furnished a picture of a new general biology on the foundation of the facts known then and of some deduction; it was only in later years that the latter found their confirmation in scientific experiments. Śniadecki's work failed to achieve a popularity commensurate to its importance among the French scientists, although it had been translated into that language. But in won great recognition in Germany, especially from the eminent naturalist Johann Müller. [4] The new approach towards the problem of life, which was then in its first phase of development, demanded not only an erudite knowledge but, above all, a high ingeniousness in experimenting that could produce new sensational discoveries. One example of this is Claude Bernard (1813–1878), [5] recognized as the founder of several branches of physiology, who applied vivisections.

The same path was taken by Purkyně. The underlying intention of his efforts was not merely to disclose the secrets of nature responsible for the processes of life but moreover to repeat them in laboratory conditions both as evidence of the truth and for his teaching needs. The naturalist trend employing this approach become known as organicism; [6] it led eventually to the foundations of modern biology. Its practitioners had to have a good knowledge of anatomy, physics, chemistry, botany, zoology, ichthiology *etc.* and moreover to be able to make efficient use of the microscope, as the latter became the richest source of new discoveries. The new trend in naturalist studies refuted the erroneous theories of the past, such as preformism or animalculism, under the impact of new experimental results which partially referred to those obtained by William Harvey as early as in the 17th century and by A. Haller or Xavier Bichat in the 18th century. [7]

A contemporary of Purkyně was Karl Ernest Baer (1792–1876), [8]

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[3] L. Świeżawski, *Jędrzej Śniadecki,* Petersburg, 1900; J. Nusbaum Hilarowicz, *Szlakami nauki ojczystej* (On the trace of national science), Warszawa, 1916, pp. 1–34; *J. Śniadeckiego Teoria jestestw organicznych,* jubilee edition by A. Wrzosek, Poznań, 1905; B. Skarżyński, *O Jędrzeju Śniadeckim,* Warszawa, 1955.

[4] W. Szumowski, *Historia medycyny* (A history of medicine), Warszawa, 1961, p. 324.

[5] J. Schiller, *Claude Bernard et les problèmes scientifiques de son temps,* Ed. du Cèdre, Paris, 1967.

[6] Cf. M. Uklejska, *Zarys rozwoju nauki i jej organizacji* (An outline of the development of science and its organization), part II, Warszawa, 1963, p. 320.

[7] Cf. T. Bilikiewicz, *Die Embryologie im Zeitalter des Barock und des Rokoko,* Leipzig, 1932, pp. 54ff.

[8] Entry „E. Baër" in: *Histoire de la science des origines au XXe siècle,* ed. by Maurice Daumas, Encyclopédie de la Pléïade, 1963, pp. 1210, 1214, 1373.

who joined in the dispute that had been continuing from the 17th century between the "preformists" (those maintaining that the parts and organs of the body are fully developed though in miniature already in the embryo) and the "epigenesists" (who thought that the body differentiated together with the growth of the embryo) and took the side of the latter theory, which afterwards proved to be the only correct one. In the course of his work he added more and more concrete observations, which began to transform the theory of epigenesis into a new science—embryology. Specifically, he discovered the egg cell in mammals, he proved that organisms develop from several germ layers which gradually grow into definite groups of organs. He also demonstrated that the initially monotype parts of the embryo, such as the ectoderm, or the mesoderm, become in the course of development heterotypic, for in this differentiation the structure of the organism becomes more and more complex but at same time its functions acquire an increasing degree of perfection. Purkyně found himself in full agreement with Baer, and contributed to the developing embryology. Scrupulous historical researches have shown that Purkyně had described the embro-vesicle still before Baer.[9] It was this discovery that inspired Baer to further embryological investigations.

The existence of the cell, this fundamental element in biological sciences, was known already in the middle of the 17th century when Leeuvenhoek made some of the first microscopic discoveries. Of course Leeuvenhoek did not use the concept of "cell". This term was coined in its present meaning by Robert Hooke (1635–1703). The discovery of the cell was followed by cellular theory, which had its most significant proponents in the German zoologist Caspar Friedrich Wolff (1753–1794) and the English botanist Robert Brown (1773–1838), besides some other scientists. Brown has been acknowledged the discovery of the cellular nucleus but could not elucidate its role. This was done by Matthäus Schleiden (1804–1881) and Theodor Schwann (1810–1882). Schleiden went one step further in that he suggested that the whole plant is composed of cells constituting a biological unity. Schwann developed the view of the cellular structure of the organisms of plants. Again, historical researches have shown that the same view had been uttered by Purkynje several years earlier,[10] but his well-deserved priority has been overlooked in the literature, including some Polish publications.[11]

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[9] Cf. M. Matoušek, *op. cit.*, pp. 76f.

[10] In the published report from the session of the Warsaw Medical Society (1866) J. F. Nowakowski argued that Purkyně had discovered cells before Schwann and that he had been the first to hold that animal epithelium and epidermis are composed of "grains" containing a nucleus. I. Raschkow repeated this opinion in *Pamiętnik Warszawskiego Towarzystwa Lekarskiego*, vol. 55, 1866, pp. 420–422.

[11] Cf. B. Seyda, *Dzieje medycyny w zarysie* (An outline of the history of medicine), part II, Warszawa, 1965, p. 42.

The cellular theory attenuated the previously rigid distinction between plant and animal organisms to the effect that from that time onwards many phenomena could be treated parallelly. Johann Müller (1801–1858) was one of the first to study, for instance, sensory illusions, and his investigations of the sensory organs and their functioning led to him to postulating a specific sensory energy, which it appeard impossible to explain by the previous procedures of the mechanicists or the vitalists. The new theory simply did not fit into the scope of the obsolete views. This circumstance can be regarded as a new "paradigm" in the development of naturalism in this respect. Purkyně devoted much of his work to sensory impressions, especially to the sense of sight.[12]

Herrmann Ludwig Helmholtz (1821–1884) studied the time of response to impulses; he built an ophthalmoscope that later proved highly very useful in opthalmologic diagnostics, whereas his work on auditory impressions comprised a broad range of problems from acoustics through physiology of hearing to psychology, aesthetics and theory of music. Purkyně also experimented using an opthalmoscope of his own construction, which will be mentioned again below.

His life coincides with the work of a great many ingenious naturalists, such as Magendi (1783–1855) who was his rival in competing for the scientific prize of France, or the afore-mentioned Claude Bernard and others. Purkyně's achievements can be placed within the context of their activities. This seems to be a fruitful field of possibilities for future studies. It may be generally said that in conditions of the hard competition from the new type of experimenters, or, as I would call them, "organicists", Purkyně won an excellent place, and his achievements became not only an expression of progress in the historical perspective but have managed to persist in science as still valid.

This could be achieved by his steady improvements in the methods of experimenting and the extension of his scientific background.

At first, when he was still at Prague he contented himself with simple sensory observation accessible to all. Frequently he experimented on himself then. From that period (1818–19) survived his works concerning the sense of sight.[13] He resumed his investigations of sight in his later scientific career but with the use of devices of his own construction. He had remarkable achievements in this respect too. He studied the construction of the eye itself, especially the dependence of the size of the picture on the refractional curves of the eye, and determined the illumination of the inside of the eye. With this he preceded

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[12] J. E. Purkyně, *Beiträge zur Kenntniss des Sehens in subiectiver Hinsicht,* Prag, 1819; *Commentatio de examine physiologico organi visus et systematis cutanei,* Vratislaviae, 1823.

[13] *Ibid.*

by 28 years the method of visual examination by the ophthalmoscope, which is associated in the literature with the names of Helmholtz and of Ruet. He described what was called "Puryně's figure", i. e. the shadows of the blood vessels cast at a lateral illumination of the retina. He also observed the persistence of a visual impression for a very short moment after the disappearance of the object perceived from the sight, i. e. the "after-image", and moreover the fusion of a series of pictures projected on the retina into one relatively steady picture. This experiment induced him to build an instrument called forolyte, later the cinesiscope, which became a prototype of the cinematographic camera. [14]

Purkyně made vivisections on laboratory animals and on fish. He was the first to give a description of capillary vessel *in vivo.* Another of his famous discoveries was that of fingerprints, [15] which furnished the foundations of dactyloscopy, a method that rendered invaluable services in criminology.

The giddiness experienced for instance on the merry-go-round [16] inspired Purkyně to search for its causes. The winner of the 1914 Nobel Prize for a study of the vestibulatory organ, R. Barany (1876–1936) expressly indicated Purkyně as the first scientist to have made any discoveries in this respect.

The methods of his investigations were remarkably extended in his study on the bird's egg prior to hatching (*Symbolae ad ovi avium historiam ante incubationem,* Vratislaviae 1825) and in another one on the spores (1830). These embryological and histological studies had to be made on living objects of observation. The results obtained enabled Purkyně to describe the not only the embryo-vesicles but also the protoplasma and the granular structure of animal tissue. The terms introduced by Purkyně, which were popularized by Hugo Mohl (1805–1872), furnished the foundation of the cellular theory, one of the most important achievements of the former half of the 19th century. This theory was developed by Max Schulze (1825–1874). True enough, the cellular theory was emaciated in the second half of the century by Rudolf Virchow, who had propagated the idea of organism as a collective structure and transformed the cellular theory into an idealistic interpretation of biological processes denying the possibility of evolution. His theory was losing in importance together with time and the cellular theory survived in its morphological pattern.

After many exertions Purkyně managed to obtain a Plössel micro-

[14] Purkyně delivered a report on the forolyte on January 27, 1841, at the session of the Schlesische Gesellschaft für vaterländische Cultur. A communication on this report is to be found in *Übersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterländische Cultur für 1841,* Wrocław, 1842, pp. 62-64.

[15] Cf. *Commentatio...,*

[16] Cf. M. Matoušek, *op. cit.,* pp. 37ff.

scope in 1833. This fact opened a new phase in his investigations. He admitted this himself in one of his letters to R. Wagner at Göttingen. At once he took ardently to histological investigations both on plants and animals. Soon he saw that there are innumerable problems to be investigated. His first study with the new microscope dealt with the perspiratory glands. Almost every day brought new discoveries, especially in his collaboration with his disciples, applicants for the doctor's degree. At present 14 dissertations by his disciples are considered to have been due to direct instigation, among them those by M. Fraenkel, *De penitiori dentium humanorum structure observationes* (Vratislaviae 1835); I. Raschkow, *Meletemata circa mammalium dentium evolutionem* (Vratislaviae 1835); F. Raeuschel, *De arteriarum et venarum structura* (Vratislaviae 1836); M. Meckauer, *De pentiori cartilaginum structura symbolae* (Vratislaviae 1836); A. Hanuschke, *De genitalium evolutione in embryone femineo observata* (Vratislaviae 1837); O. Luening, *De velamentis medullae spinalis* (Vratislaviae 1839); J. F. Rosenthal, *De formatione granulosa in nervis aliisque partibus organismi animalis* (Vratislaviae 1839); B. Palicki, *De musculari cordis structura* (Vratislaviae 1839); W. Kasper, *De structura fibrosa uteri non gravidi* (Vratislaviae 1840); D. Rosenthal, *De numero atque mensura microscopica fibrillarum elementarium systematis cerebrospinalis symbolae* (Vratislaviae 1840), and others. These studies laid the foundations for the Wrocław histological school developing in the latter half of the 19th century.

The miscroscope that Purkyně had at his disposal seemed to him inefficient, and therefore he decided to improve it. The new miscroscope became known as the Durst–Purkyně miscroscope. He also improved the technique of obtaining miscroscopic sections by means of a microtome-squeezer of his own construction. The improved techniques of work on the microscope enabled him to discern additional details. One of the most valuable achievements in this respect was the discovery of the peculiar cells in the cerebellum that are still today known by his name. This discovery abolished K. Burdach's (1776–1847) contention that the cerebellum consists of fibres only. Another of his microscopic discoveries was that of the nerve fibres that are responsible for the automatic action of the heart. These fibres bear his name too. Their participation in the action of the heart can be observed most easily on a model of the successive phases of an electrocardiograph. The conductive power fo the Purkyně fibres in the myocardium is responsible for approximately first part of that graph (*Q*, *R*, *S*). Purkyně worked also on the heart ventricles and auricles. He demonstrated the action of these parts by an instrument called cinesiscope. A black disc with slits cut in it was set in motion so as to enable the spectator to observe the action of the valves. This instrument as well as the other ones used by him and specially brought from Prague were included in the 1959 Wrocław exhibition of his life and work. Purkyně had also invented the spirometer long before Hutchinson, whose name it bears today.

In laboratory work Purkyně employed also chemical reactoins, whether in the experiments themselves or in the preparation of the dyes he needed. Also in this field he had his own achievements.

A separate topic of his work was a study in which he compiled the results of the toxic effects of some medicines, such as emetine, camphor, opium, belladonna, terpentine, strammonium and others. This type of studies marked the beginning of pharmacognosy and pharmacodynamics, which however deserves a separate discussion.