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CONTRIBUTION OF SCIENTISTS OF SAINT VOLODYMYR UNIVERSITY IN THE DEVELOPMENT OF PHYSIOLOGICAL SCIENCE IN THE SECOND HALF OF THE 19th – THE BEGINNING OF THE 20th CENTURY

Abstract. The purpose of the research *is to elucidate the main directions of development of physiology as a science and academic discipline, to summarize the priority achievements of prominent scientists-physiologists of St. Volodymyr University in the context of world physiological science development in the second half of the 19th – the beginning of the 20th century.* ***The research methodology*** *is based on the integrated use of the principles of historicism, science character and*

objectivity, as well as general scientific, interdisciplinary and special historical methods. ***The scientific novelty*** *is that for the first time on the basis of previously unknown archival documents, important facts on the biography and scientific activities of domestic physiologists of St. Volodymyr University have been analyzed. It has been proved that one of the important factors in the development of physiological science was its international nature, which contributed to the expansion of the interaction of domestic and foreign scientific experience on the performance of sectoral research work.* ***The Conclusion.*** *Successful cooperation of scientists of the Russian Empire with the English, the Holland, the Italian, the German, the Hungarian, the Franch and the Czech researchers ensured the implementation of research based on the systematic exchange of information about physiological processes in plants, animals and a human body that accelerated the receipt and increased effectiveness of the research results introduction in practice. Accumulated experience in research and training systems at St. Volodymyr University were important not only for the development of domestic and world achievements in physiology, but also in biochemistry, ecology, embryology, entomology, cell engineering and the others. This accumulated experience contributed to the efficiency growth of the domestic scientific research, which was not inferior to foreign study in its achievements. Owing to significant achievements, domestic scientists-physiologists increased their international prestige and confirmed that domestic physiological science took an honorable place abroad.*

Key words: *development, human physiology, plant and animal physiology, Cathedra of Physiology, Cathedra of Anatomy, scientific school, St. Volodymyr University.*

ВНЕСОК УЧЕНИХ УНІВЕРСИТЕТУ СВЯТОГО ВОЛОДИМИРА У РОЗВИТОК ФІЗІОЛОГІЧНОЇ НАУКИ У ДРУГІЙ ПОЛОВИНІ XIX – НА ПОЧАТКУ XX ст.

Анотація. Мета статті *– розкрити основні напрями розвитку фізіології як науки та навчальної дисципліни, узагальнити пріоритетні здобутки видатних учених-фізіологів Університету Святого Володимира у контексті розвитку світової фізіологічної науки у другій половині XIX – на початку XX ст.* ***Методологія дослідження*** *ґрунтується на комплексному використанні принципів історизму, науковості і об'єктивності, а також загальнонаукових, міждисциплінарних та спеціальних історичних методів.* ***Наукова новизна*** *полягає у тому, що вперше на основі невідомих раніше архівних документів, відображено важливі факти з біографії та наукової діяльності вітчизняних учених-фізіологів Університету Святого Володимира. Доведено, що одним із вагомих чинників розвитку фізіологічної науки став її інтернаціональний характер, що сприяв розширенню взаємодії вітчизняного і зарубіжного наукового досвіду щодо виконання галузевої науково-дослідницької роботи.* ***Висновки.*** *Плідне співробітництво вчених Російської імперії з англійськими, голландськими, італійськими, німецькими, угорськими, французькими, чеськими науковцями забезпечило виконання досліджень на основі систематичного обміну інформацією про фізіологічні процеси у рослинах, тваринах та організмі людини, що прискорювало надходження і підвищувало ефективність впровадження результатів наукових досліджень у практику. Нагромаджений досвід виконання наукових досліджень та системи підготовки фахівців в Університеті Святого Володимира, мали значення не тільки для розвитку вітчизняних і світових здобутків у фізіології, а й у біохімії, екології, ембріології, ентомології, клітинній інженерії та ін. Це сприяло зростанню ефективності виконання вітчизняних наукових досліджень, які за своїми досягненнями не поступалися зарубіжним. Завдяки вагомим здобуткам вітчизняні вчені-фізіологи підвищили свій міжнародний авторитет та підтвердили, що вітчизняна фізіологічна наука займала почесне місце за кордоном.*

Ключові слова: *розвиток, фізіологія людини, фізіологія рослин і тварин, кафедра фізіології, кафедра анатомії, наукова школа, Університет Святого Володимира.*

The Problem Statement. Under the conditions of new civilizational challenges, the level of a human being health determines the future development, the capacity of spiritual and cultural growth of the nation. Undoubtedly, human health is also a determining factor in the economic development of the country, the growth of the well-being and standard of living of

its citizens, social and economic security, culture and prosperity. Under the conditions of a prolonged economic and energy crisis in Ukraine, reduction of raw resources, socio-political complications, global climate changes, man-made disasters, solving the problem of harmony of physiological laws of a human life as the basis of health protection is gaining more and more topicality. World practice proves that targeted influence on physiological processes occurring in a human body, ensures the growth of his or her health and longevity, as well as vitality and labour productivity. In addition, optimization of physiology of plants and animals requires significant attention, since a rational combination of plant and animal industries is the basis for a sustainable agricultural production, which is necessarily related to food security of the country and growth of its competitiveness under the conditions of the world market. Taking into account the scale of research, in the context of European integration, the direction of covering the history of development of physiology is updated, as a science and educational discipline, in the Ukrainian lands in the second half of the 19th – at the beginning of the 20th century. Discoveries and achievements in this important field are one of the main factors in the further development of regional aspects of the history of science and technology in Ukraine, establishment of specialized research and educational institutions, scientific potential formation of the nation.

The Analysis of Sources and Recent Research. Modern researchers of the history of science elucidated the main tendencies in the development of physiology in the Russian Empire, to which the Ukrainian lands belonged, in the second half of the 19th and at the beginning of the 20th centuries (Demkovych & Shevchuk, 2020; Samoilov, 2005; Shulha, 2020; Sorokina, 2012). The scholars highlighted the main milestones of establishment of anatomy and physiology departments at the University of St. Volodymyr, on the basis of which physiological science was started (Musijenko, Ostapchenko, Taran, & Bacmanova, 2020; Suhanov, 1884; Vladimirskii-Budanov, 1884; Zhmudskyi, 1959). The scholars analyzed certain aspects of development of plants and animals physiology on the territory of Ukraine (Borodai, 2012; Kovalenko, 2014; Kovalenko & Hloba, 2021; Morhun, 2001a, 2001b). A number of scientific works are dedicated to well-known scientific schools and individual physiologists who expanded pedagogical and scientific activities at St. Volodymyr University (Babskyi, 1956; Spivko, 1955; Voroncov, 1947). However, until now there has not been presented a comprehensive scientific and historical analysis of the development of physiology as a science and educational discipline at the University of St. Volodymyr, the significance of cooperation achievements of domestic and foreign physiologists to the development of research practice at branch departments has not been elucidated, taking into account a personal contribution to the development of main theoretical and methodological provisions, elaboration of educational and methodological manuals and textbooks, etc.

The purpose of the research is to elucidate the main directions of development of physiology as a science and academic discipline, to summarize the priority achievements of prominent scientists-physiologists of St. Volodymyr University in the context of world physiological science development in the second half of the 19th – the beginning of the 20th centuries.

The Results of the Research. Let us consider the history of physiology emergence as a science and educational discipline in the global dimension. Back in 1542, this term, as a process of functioning of human organs, was first used by the French doctor J. Fernel in the publication "De Naturali Parte Medicinae" (Lemoine & Pradeu, 2018, p. 236). Physiological and embryological science was initiated by the English anatomist and naturalist V. Harvey, who formalized the statement about the large and small circles of blood circulation in a

human body in 1628. In the middle of the 17th century the English philosopher F. Bacon for the first time theoretically substantiated the experimental method of physiological research of plants, and the Dutch naturalist Jan Baptista van Helmont did experimental research and discovered the water theory of plant nutrition. At the end of the 17th century the Italian physiologist, Professor of the University of Pisa, G. Borelli, applied the laws of mechanics to do research on the mechanism of respiratory movements in animals. At the beginning of the 18th century the scientific achievements of the English physiologist and chemist, a member of the London Royal Society and the Paris Academy of Sciences S. Gales, were of great importance, who is considered the founder of plant physiology. While studying the process of transpiration, he found out the rate of water evaporation in plants, measured the growth of their shoots and leaves, and determined the pressure of plant sap. When studying respiration of plants, he found that they absorb carbon dioxide from the air. In 1718, he found out the effect of solar heat on the rise of plant sap in plants, determined the norms of blood pressure in animals. He summarized the results of many years of research on plant physiology in the book "Vegetable Statics" in 1727, on animal physiology – in the book "Haemastaticks" in 1733 (Kogan, 2004, p. 46).

In the middle of the 18th century physiological research expanded owing to the development of Chemistry, Physics, and Mathematics. The French entomologist and naturalist, a member of the Paris Academy of Sciences R. Réaumur and Italian zoologist and entomologist, a member of the London Royal Society and the Italian Academy of Sciences L. Spallanzani discovered the chemical mechanism of digestion. etching. The French chemist, a member of the London Royal Society, French and Italian Academies of Sciences A. Lavoisier recreated the patterns of breathing and oxidation processes. L. Galvani, Italian physician and physicist, Professor at the University of Bologna, for the first time described a bioelectric phenomenon in a human body. Discovery of the French physiologist and mathematician, a member of the French Academy of Sciences R. Descartes was improved by the Czech anatomist and physiologist, Professor of the University of Vienna J. Prohaska. They used the reflex principle to explain activity of a body as a result of persistent external stimuli occurring through the central nervous system (Kogan, 2004, p. 47).

The study of physiological processes that took place in neuromuscular tissues was of significant importance to the formation of physiology as a science. For this purpose, the German physiologists – E. du Bois-Reymond, Professor of Friedrich Wilhelm University and K. Ludwig, a founder of Leipzig Physiological Institute, Professor of Zurich, Marburg and Vienna Universities, invented the induction apparatus, the kymograph and the float manometer for measuring blood pressure, as well as the blood clock for calculating the rate of blood circulation, etc. The French physiologist, president of the French Academy of Medicine and the French Academy of Sciences E. Marais designed a special device for recording the movement of chest. The Italian physiologist, Professor of the University of Turin A. Mosso developed equipment for the study of blood supply to organs and fatigue, weighing table to find out the redistribution of blood, developed a method of neuroimaging for monitoring the functional state of a person. The study of electrical phenomena in a human body, which was started by the Italian physiologist, a member of the Royal Society of London A. Volto and a medical physicist, Professor of the University of Bologna L. Galvani, was actively continued by E. du Bois-Reymond and L. Herman (Samoilov, 2005, pp. 25–26).

Thus, the development of plant, animal and human physiology took place in separate directions. Instead, at the end of the 18th century it was established that plants and animals have common

features, in particular, embryogenesis and osmotic phenomena. In 1820, the French botanist and physiologist R. Dutrochet emphasized the integrity of physiology, which dealt with doing research on functioning of the entire living world. In 1830, the German physiologist, Professor of Louvain and Liège Universities, a member of the Paris Academy of Sciences T. Schwann developed cellular physiology. In 1839, in the book "Mikroskopische Untersuchungen über die Übereinstimmung in der Struktur und dem Wachstum der Tiere und Pflanzen" T. Schwann summarized his research on the functioning of plant and animal cells. In the second half of the 19th century a significant contribution to the formation of modern physiological science was made by a German botanist and biologist, Professor of the University of Prague J. von Sachs, who specialized in the study of seed plants physiology (Lemoine & Pradeu, 2018, p. 237).

It should be noted that foreign scientists used radioactive radiation in physiological science. In particular, the French physicists A. Becquerel, Pierre and Marie Curie, who for the discovery of radioactivity became the first laureates of the Nobel Prize in Physics in 1903. Experimentally the scientists proved that radioactive radiation was of great physiological and biochemical activity. For example, it destroyed body tissues, killed bacteria, cured diseases, and in small doses – activated physiological processes in plants. In 1913, the Hungarian chemist D. Heveshi was the first one who suggested using the method of labelled atoms in biology and medicine, and became a laureate of the Nobel Prize in Chemistry in 1943. His discovery consisted in the use of isotopes as radioactive indicators, to determine physiological and biochemical processes in plants, animals and a human body. For example, to determine the paths of radioactive phosphorus and permeability of erythrocyte membrane (Kovalenko, Borodai & Shchebetiuk, 2021, p. 300). Owing to these discoveries, there was a deeper and more detailed study of the processes of entry and distribution of nutrients in plants and animals, their assimilation during metabolism in a human body. Opportunities were created to elucidate new ways of improving physiological and biochemical processes in plants and animals in order to increase their productivity and obtain quality food products.

In the Russian Empire, the formation of physiological science took place in the first half of the 18th century due to establishing of specialized faculties and departments in higher education institutions. In particular, the Department of Anatomy and Physiology was established at St. Petersburg Academy of Sciences, headed by the Swiss physiologist, academician of St. Petersburg Academy of Sciences, a member of Bologna, Berlin, and Paris Academies of Sciences D. Bernoulli. A medical faculty was established at Moscow University, at which Professor S. G. Zabelin conducted lectures on Physiology. As early as in 1776, a separate department of physiology operated at the medical faculty, which was headed by Professor M. I. Skiadan. It should be noted that the publication of branch manuals and the defense of theses were of great importance to the development of plant, animal and human physiology. In particular, in 1783, the Ukrainian botanist and phytotherapist, Doctor of the University of Strasbourg N. Maksymovych-Ambodyk compiled the first anatomical and physiological dictionary and studied the metabolism of plants. In 1794, the extraordinary Professor of physiology and dietetics of Moscow University F. I. Barsuk-Moiseev, who graduated from the Kyiv-Mohyla Academy, was the first one who defended the thesis on respiratory processes in animals. In 1836, a scientist-physiologist, Professor of Moscow University, a founder of experimental medicine A. M. Filomafitsky published the first manual on human physiology (Shulha, 2020, pp. 37–38).

Discoveries in organic chemistry, namely the law of conservation and transformation of energy, the cellular structure of the body, the theory of evolutionary development of the

organic world, etc., were of significant importance in the formation of domestic physiology. A special role belongs to the studies of the Russian scientist-naturalist, a member of the Swedish Royal Academy of Sciences, Russian and St. Petersburg Academies of Sciences M. V. Lomonosov, who studied at the Kyiv-Mohyla Academy. He focused on the importance to the study the regularities of chemistry in revealing the physiological processes of both plants and human beings (Kovalenko, 2014, p. 69). In 1862, I. M. Sechenov, a member of the St. Petersburg and Russian Academies of Sciences, the founder of the physiological science school, was the first one who recorded electrical phenomena in a human central nervous system, thoroughly did research on the process of its inhibition. His student, later Academician of the Academy of Sciences of the USSR O. O. Ukhtomsky, laid a solid foundation for the doctrine of the dominant, as the principle of activity of nerve centers. S. P. Botkin, a founder of scientific medicine, Professor of the St. Petersburg Medical and Surgical Academy, a member of the Belgian Royal Academy of Medicine, as well as the founder of science about higher nervous activity and digestive processes, a member of the US National Academy of Sciences, Russian, St. Petersburg and French Academies I. P. Pavlov formalized the concept of nervousness. They convincingly proved the importance of a nervous system in the regulation of physiological processes that constantly occur in a body of human beings and animals. Their studies of a nervous system influence on a vital activity of an organism initiated a traditional direction of the Soviet physiology (Sorokina, 2012, p. 53).

A significant contribution belongs to Professor I. P. Pavlov, who determined the regularities of digestive glands activity, mechanisms of their nervous regulation, the formation and action mechanisms of digestive juices. The scientist discovered the formation and inhibition basics of conditioned reflexes, established the world-renowned scientific school, whose representatives developed the main areas of human and animal physiology. In particular, one of the founders of evolutionary physiology, Professor of the Military Medical Academy, later academician of the Academy of Sciences of the USSR L. O. Orbely developed the adaptation-trophic theory of sympathetic innervation, proved the trophic influence of the nervous system, laid the foundation of evolutionary physiology. One of the most talented students of I. P. Pavlov – a physiologist, academician of the Academy of Sciences of the USSR K. M. Bykov discovered the influence of the large hemispheres of brain on functionality of organs, the formation of conditioned reflexes from interoceptors. The author of classic studies of reflex regulation of pulmonary blood circulation, the founder of one of the mechanisms that regulate blood flow to the heart, V. V. Parin initiated the use of methods of mathematics, cybernetics, radio electronics in physiological practice (Samoilov, 2005, pp. 25–26).

In the second half of the 19th – at the beginning of the 20th century, on the Ukrainian lands, the discoveries gained significant importance and world recognition, when physiological science was formed as an educational discipline at the first specialized departments at the natural and medical faculties of the leading universities of Lviv, Kyiv, Odesa, Kharkiv. These studies were very successful because they were conducted under the guidance of experienced scientists, who completed foreign internships in the world-renowned physiological laboratories and had recognized international experience in their implementation. In Kyiv region, the development of physiology began in 1840 owing to the establishment of the Faculty of Medicine at the University of St. Volodymyr (USV) on the basis of Vilnius Medical and Surgical Academy which belonged to the university. The Department of Human Physiology of the USV was headed by a graduate of Vilnius Medical and Surgical Academy, an experienced doctor of medicine E. E. Miram, who defended his doctoral dissertation on the topic "On Nasal Bones"

in 1842. He gained tremendous global experience in Germany, France and England, visiting the authoritative physiological laboratories of J. Müller in Berlin, K. Bernard in Paris and M. Foster in England (Voroncov, Nikitin & Sierkov, 1959, pp. 98–99).

In 1841, at the Department of Anatomy of the USV, field research was carried out under the leadership of a graduate of the University of Derpt, Professor of anatomy O. P. Walter, who had completed an internship being on a foreign assignment in Germany. In particular, he gained extensive international experience while working in the physiological laboratory of the famous German physiologist, a member of the Swedish and Danish Royal Academies of Sciences, as well as the Russian and Prussian Academies of Sciences J. Müller in Berlin. His branch discoveries consist in establishing the reaction of vasoconstrictor nerves and determining their sympathetic signs in animals, which he carried out much earlier than the French physiologist K. Bernard. In 1862 – 1867, working at the Department of Anatomy of the USV, O. P. Walter systematically did research on the role of animal warmth and published a significant number of scientific works in this direction, both in Kyiv publications and abroad. Among them, the book "Thermophy-siologische Untersuchungen" published in German, in Berlin, in 1865. Lectures on the role of animal warmth in physiology, prepared and published by him in 1866 – 1867, were also of great importance to the students of the University of Warsaw. It should be noted that in order to elucidate this topic, the scientist combined various researches. In particular, he studied the warmth of various animals, both warm-blooded and cold-blooded. In addition, he determined the effect of temperature on the activity of heart, blood pressure, neuromuscular system, sense perception organs and central nervous system (Zhmudskyi, 1959, pp. 424–426).

A student of O. P. Walter – V. O. Betz worked at the Anatomy Department, who became interested in working in the anatomical theater while being a student. In 1860, V. O. Betz was sent on a foreign mission to Vienna, where he conducted research in the laboratories of famous Austrian physiologists, based on the results of which he published fundamental scientific works in 1862. In particular, V. O. Betz did the research paper "On Sugar Test in Urine by the Brücke Method" under supervision of Professor of anatomy, a member of the Russian, Prussian and Hungarian Academies of Sciences J. Hirtl and a member of the Swedish Royal Academy of Sciences, Prussian, Bavarian and Turin Academies of Sciences E. Brücke. Under supervision of K. Ludwig, Professor of medicine of Leipzig, Zurich, Marburg and Vienna Universities, V. O. Betz did the research on the mechanism of blood circulation in liver, which was published in German. At the USV, the research paper was submitted to the Medical Faculty as a doctoral dissertation on the topic "On the Mechanism of Blood Circulation in Liver", for which he was awarded the scientific degree of Doctor of Sciences. Of paramout importance were his studies of the structure of brain and spinal cord, the development of method for making thin, total, consecutive and serial sections of brain and spinal cord, and especially cortex of large hemispheres. His discovery of pyramidal cells in cortex of large hemispheres was named in his honour as "Betz cells". He was the first one who introduced the term "brain architectonics" and substantiated the idea that pyramidal cells are motor cells of cerebral cortex (Suhanov, 1884, pp. 205–206).

In 1865, V. B. Tomsy headed the Department of Human Physiology at the USV. After graduating from the University of Prague, he worked as a medical examiner and assistant in pathological anatomy. In 1859, he was an assistant to K. Ludwig at the Vienna Military Medical Academy. One of the greatest achievements of V. B. Tomsy is the establishment of a physiological laboratory at the USV. In fact, he was the first scientist who started developing

experimental physiology in Kyiv. In 1883, he was elected Professor of physiology at the Medical Faculty of the Czech University in Prague. Among his scientific publications, it is necessary to singe out the works on physiology of lymphatic vessels, on lymph formation, on anatomy of beginning of lymphatic vessels and lymphatic pathways of spleen, on innervation of blood capillaries, on physiology of the core of sympathetic nervous system, on the problems of blood circulation in skin, on physiology of brain legs, on anatomy and physiology of skin. Based on the results of the above-mentioned studies, in 1883, V. B. Tomsy published the textbook on physiology for students of the USV (Spivko, 1955, p. 137).

One of V. B. Tomsy's talented students was O. L. Rava, who graduated from the medical faculty of the USV in 1876. Already in 1883, he defended his doctoral thesis on the topic "On Innervation of Blood Circulation in Lungs", in 1885 he worked as a private associate Professor at the Department of Human Physiology at the USV. Back in 1879, O. L. Rava wrote the first scientific work "Cranium Sutures" together with V. O. Betz. In 1884, O. L. Rava continued his research on the splicing of nerves for different purposes and with different functions, the results of which he published in the book "On Innervation of Blood Circulation in Lungs". His discovery about the possibility of central nervous apparatuses and peripheral organs that do not belong to them to be innervated by their artificial connection with nerve conductors. Conversely, the ability of peripheral organs to receive impulses from nerve centers, which they are not subject to innervation, received a worldwide recognition. It is necessary to emphasize the importance of these publications for the development of human physiology, because in modern publications, in particular in the scientific works of V. O. Samoilov, T. S. Sorokina, these studies are not given due attention (Samoilov, 2005; Corokina, 2012).

M. O. Rohovych was another talented student of V. B. Tomsy, who in 1879 graduated from the Medical Faculty at the USV and was a Doctor at the Faculty's surgical clinic for a year. As early as in 1884, he was a candidate for a scholarship to the University council to obtain the title of Professor. In addition, his scientific work "On the Consequences of Removing Thyroid Gland of Animals" was published in "The University Bulletin". M. O. Rohovych carried out the experimental part of his doctoral dissertation on the topic "Theory of Pseudomotor Action of Vasodilator Nerves" in the laboratory of R. Heidenhain, a German physiologist, a member of the German Academy of Naturalists "Leopoldin", a foreign member of the Royal London Society. The results of doctoral dissertation are known among wide circles of physiologists and received world recognition, and the phenomenon he studied was named in his honour as "Rohovych's contracture" (Voroncov, Nikitin & Sierkov, 1959, p. 107).

The contribution of a talented scientist-physiologist S. I. Chiriev should be singled out. Although he called himself a student of E. du Bois-Reymond, the influence of I. M. Sechenov's ideas can be traced in all his research activities. Firstly, while studying at the St. Petersburg Medical and Surgical Academy, he studied Physiology Course conducted by I. M. Sechenov. Secondly, his work as a private associate Professor at the Department of Physiology of St. Petersburg University took place under the leadership of I. M. Sechenov. In particular, S. I. Chiriev's activities focused on the study of electrical phenomena in nerve and muscle tissues, histology and physiology of sense perception organs, in particular eye-sight, and physiology of blood circulation. Since the scientist was a clinical Professor at Kyiv Military Hospital, he published many works on clinical medicine. While working at the Medical Faculty of the USV, he expanded its physiological laboratory significantly by using equipment for electrophysiological research. In 1908, according to the design of H. Lipman, the French physicist, a winner of the Nobel Prize in Physics, he developed

laboratory equipment – capillary electrometer for physiological studies with photographic registration of electrometer readings. With its use, he studied electromotive characteristics of brain, skeletal muscles, and heart (Voroncov, Nikitin & Sierkov, 1959, p. 109). The scientific works of S. I. Chiriev were published in "Izvestia of Academy of Sciences", "The University Bulletins" mostly, as well as abroad, in particular in France. The scientist developed the molecular theory of bioelectric potentials, which was formulated by E. du Bois-Reymond, but he did not recognize nerves and muscles impulses (electric signals). In his doctoral dissertation on the topic "Dependence of Heart Rate on Intravascular Pressure Fluctuations" he made a world discovery and described the sensitivity of nerve endings for the first time (Chiriev, 1876, pp. 32–34).

While working at the Medical Faculty of the USV, S. I. Chiriev developed research on electrophysiology, in particular, determined electromotor properties of nerves and muscles. He published a number of works on the anatomical substrate of higher mental processes. His idea that various external influences on human and animal sense perception organs stimulate certain centers of cerebral cortex, but remain subconscious until they enter into a physiological connection with centers of consciousness, received world recognition. In 1899, he published the original textbook "Human Physiology" on the basis of lecture notes for students of the USV, the first part of which included a short course in Physics, and the second – in Physiology (Chiriev, 1888). In addition, S. I. Chiriev conducted lectures at Kyiv Society of Naturalists and Doctors. Thus, the scientist made a significant contribution to the development of physiological science not only at the USV, but he was also a significant figure in the history of domestic physiology.

Significant contribution of a talented physiologist V. M. Velyky should be noted, who graduated from the Natural Science Department of Physics and Mathematics Faculty of St. Petersburg University and worked as a private Associate Professor at the Department of Physiology under the leadership of I. M. Sechenov. Together with I. P. Pavlov, he determined the significance of the reflex effect on blood circulation, and proved the effect of excitatory and depressor nerves on lymph circulation. V. M. Velyky became famous owing to the research on lymphatic hearts and their innervation, in particular innervation of salivary glands, excitability of the spinal cord, histology of nervous tissue in general and, in particular a spinal cord of lower vertebrates. As a private Associate Professor, he conducted lectures at the Department of Physiology of Natural Sciences Department of Physics and Mathematics Faculty at the USV and at Kyiv Women's Medical Institute (Voroncov, Nikitin, & Sierkov, 1959, p. 111).

In 1910, on the recommendation of S. I. Chiriev, the Council of the Ukrainian Academy of Sciences elected the talented scientist V. Yu. Chagovets to the position of the Head of Physiology Department. As early as in 1873, he entered the Military Medical Academy in St. Petersburg, at which Physiology Course was conducted by Professor I. R. Tarkhanov. During this period, he began the first experimental studies, in particular determined the change in electrical potentials of muscles under the influence of various medicinal substances, determined the formation mechanism of electrical potentials in living tissues. His research focused on the theory of electrolytic dissociation by the Swedish physicist and chemist S. Arrhenius, a laureate of the Nobel Prize in Chemistry, the results of which confirmed the possibility of significant potentials arising during diffusion of electrolytes. The significance of scientific activity of V. Yu. Chagovets consisted in the fact that he calculated the magnitudes of potentials, under the condition of creation in a muscle or nerve due to excitation, an

increased concentration of carbonic acid and other products of enhanced metabolism. Based on these studies, he formulated the diffusion theory of bioelectric potentials and the theory of electrical stimulation of living tissues (Voroncov, Nikitin & Sierkov, 1959, p. 113). In 1896, V. Yu. Chagovets developed the basic principles of the theory of biopotentials and electrical stimulation and published them in "The Journal of the Russian Physical and Chemical Society". A year later, the German physicist and chemist, a winner of the Nobel Prize in Chemistry V. Nernst formulated a somewhat similar theory of irritation, which was fundamentally different from V. Yu. Chagovets's theory. In particular, V. Nernst believed that the irritating factor is not the electric charge of membrane, but concentration near membrane of those chemical substances that are moved by electric signals. On the other hand, V. Yu. Chagovets gave paramount importance to membrane potential in the irritating effect of electric signals (Voroncov, Nikitin & Sierkov, 1959, p. 115). Nowadays, his point of view regarding the mechanism of electrical irritation is generally accepted in physiological science.

In 1903, V. Yu. Chagovets defended his doctoral thesis on electrical phenomena in living tissues. In 1900–1906, he published two parts of the book on this topic. The first of them focused on the creation mechanism of bioelectric potentials, the second one – on the effect of electric signals on irritation of nerves and muscles. The scientist presented the creation of electrical potentials in living tissues as the result of metabolic products diffusion such as carbonic acid (Chagovets, 1903). It should be noted that in physiology it was the first attempt to give a physico-chemical explanation of biological potentials, at the same time a physico-chemical basics of modern electrophysiology was created. In the second part of the book, he discussed the mechanism of electrical stimulation of living cells in detail. Having analyzed the contemporary data on nerve irritation by capacitor discharges, short impulses of a direct signal and signals of various durations, he claimed that all the regularities that had been empirically established by the Dutch physicist L. Hoorweg (1892) and the French physiologist J. Weiss (1901) were just another formulation of the condenser law (Chagovets, 1906).

According to a personal file of V. Yu. Chagovets, it can be stated that in 1909 he submitted applications for participation in contest for vacant Professor positions at Tomsk and Kharkiv Universities and won in both attempts. Preferring his native land, the scientist began scientific activity at Kharkiv University as Professor of the Department of Pharmacology (State Archives of Kiev – SAK, f. 18, d. 2, c. 275, pp. 9–10). In 1910, he continued working at the Medical Faculty of the USV as the Head of the Department of Physiology. It should be noted that these data were not mentioned in the previous publications of researchers of the history of science, instead, the data play an important role in forming a holistic view of the scientist's personality, his patriotic views.

At the time when V. Yu. Chagovets competed for the post of the Head of the Department of Physiology of the USV, he had already received world recognition in electrophysiology as the "Russian Helmholtz". Therefore, having acquired the status of the Head, he tried to use his knowledge as effectively as possible to expand practical research on the basis of the physiological laboratory reconstruction at the USV. For example, he made efforts to obtain a significant sum of money at that time – about 20 thousand krb. for the purchase of the latest equipment abroad: string galvanometers, kymographs, electrical measuring devices, optical devices, etc. He expanded the physiological laboratory significantly: he organized a vivarium, built an operating theatre and clinics for experimental animals based on the model of Pavlov's laboratories. Owing to his efforts, the physiological laboratory at the USV became one of the best in the Russian Empire (Voroncov, Nikitin & Sierkov, 1959, p. 112).

By involving students and employees of the Medical Faculty at USV, V. Yu. Chagovets expanded electrophysiological research significantly. In addition, he was interested in solving the problem of blood circulation, physiology of digestion. The physiological laboratory carried out original research in these directions, the results of which were published in scientific publications. It should be noted that the main interests of the scientist were focused on the development of electrophysiology. In particular, in addition to the study of electrical stimulation of living animals, he found out the effect of electrical phenomena in stomach tissue. Based on the results of these studies, he recommended using an electrogastrogram as a method of studying a secretory activity of stomach. In addition to working at the USV, V. Yu. Chagovets worked in other educational institutions in Kyiv. In particular, he conducted lectures on human and animal physiology at the Women's Medical Institute and at the Agronomic Department of Kyiv Polytechnic Institute (SAK, f. 18, d. 2, c. 275, pp. 10–11). The fact should be emphasized that the scientist made a significant contribution to the development of physiological science of farm animals, which contributed to acceleration of the first special textbook preparation and organization of the first Specialized Department at Kyiv Veterinary and Zootechnical Institute.

A talented scientist – I. V. Belgovskyi, who expanded his professional activity at the USV, contributed to the development of physiological science of farm animals. Back in 1897, he graduated from Kharkiv Veterinary Institute, in 1901 – Novo-Olexandria Institute of Agriculture and Forestry. Since 1902, he worked as a veterinary teacher at Kyiv Polytechnic Institute. It is important that in 1907 he defended his Master's Degree thesis in agronomy at the Natural Science Department of the Faculty of Physics and Mathematics at the USV. In 1908 he was elected a private associate Professor at the Department of Agronomy. In 1913 he was awarded the scientific degree of Doctor of agronomy (SAK, f. 18, d. 2, c. 17, pp. 12–14). In 1903 and 1909, the scientist improved his profession skills owing to a scientific mission abroad (Central State Archives of the Higher Authorities and Administration of Ukraine – CSAHAAU, f. 166, d. 12, c. 439, pp. 4–5). In 1912, I. V. Belgovskyi began doing the research on local sheep breeding in the Caucasus, based on the results of which he published the book "Materials to the Study of Rennet Digestion in Ruminants". In addition, he performed important operations on the formation of a small ventricle from rennet (Belgovskyi, 1912). The technique he developed for an exceptionally complex operation of ruminants received great scientific interest. In addition, the scientist determined the continuity of rennet secretion in ruminants and its specific reaction to some feeds, clarified the problems of feeding farm animals. In 1915, based on the results of his research, I. V. Belgovskyi published the book "On the Question of the Role of Organic Acids in the Process of Peptic Digestion".

It is necessary to note a high level of conducting lectures on branch disciplines at the Science Department of Physics and Mathematics Faculty at the USV. In particular, a wide range of interests of Professor S. M. Khodetskyi included the study of plants for ecologically balanced agricultural production (Kovalenko, 2014, p. 63). Professor K. A. Purievych determined the efficiency of conversion of organic acids in plants and the coefficients of solar energy utilization in the process of photosynthesis. This contributed to the fact that many of Physics and Mathematics Faculty graduates became well-known specialists later. Among them are a botanist, plant physiologist M. H. Kholodny, an agrochemist and plant physiologist E. V. Bobko.

A significant contribution to the development of physiology was made by V. K. Zaleskyi, a student of V. I. Palladin, Professor at Kharkiv University, the Head of the Department

of Plant Physiology at Novo-Olexandria Institute of Agriculture and Forestry, a plant physiologist and biochemist. His main research was devoted to the synthesis of protein substances, determining the role of phosphorus and iron in plant metabolism. The scientist proved the possibility of the formation of protein substances by plants from nitrates and carbohydrates without solar energy. The activity of a botanist, plant physiologist E. P. Votchal is of great importance, who in 1898 founded and headed the Department of Botany and Plant Physiology of Kyiv Polytechnic Institute (Kovalenko, 2014, p. 109). His main scientific works contain the results of research on the electrophysiology of plants. He is one of the founders of agricultural plants physiology, in particular, he developed the basics of field physiology. He established a scientific school of the Ukrainian botanists-physiologists, among whom are the scientists of the Natural Science Department of Physics and Mathematics Faculty at the USV. Among them is V. V. Kolkunov, the founder of ecological physiology of plants, since 1910 – Professor of the Department of Agronomy. He was one of the first to determine the anatomical and physiological patterns of agricultural plants resistance to drought and developed the anatomical and morphological theory of their drought resistance, which was based on the study of their anatomical adaptations to stressful weather conditions. He found out a number of regularities in the structure and properties of plants according to anatomical parameters: the diameter of epidermal cells and the length of stomata (Boiko, 2011, p. 2).

O. V. Baranetskyi, Doctor of Botany, a corresponding member of St. Petersburg Academy of Sciences played a major role in the development of physiological science. In 1866, he graduated from the Natural Science Department of St. Petersburg University. From 1873 he worked as an extraordinary Professor, from 1877 – as a full Professor at the Department of Botany, from 1898 – as a lecturer at the Faculty of Medicine, from 1903 – as a dean of the Faculty of Physics and Mathematics at the USV. His main research is devoted to osmotic phenomena and guttation of plant cells, photosynthesis processes in plants. The scientist established a laboratory of physiology and anatomy of plants at the USV, in which he did research on thickening of parenchyma walls and the structure of wood cells under the influence of mechanical deformations. In addition, he invented and improved physiological devices – osmometer, auxanometer, etc. In 1897, together with the Russian Doctor of botany A. S. Famintsyn, he proved the symbiotic nature of plants (Brayon, 2003). Attention is drawn to the activities of a scientist-botanist and plant physiologist S. M. Bogdanov, who became a well-known specialist not only in the Russian Empire, but also abroad. As early as in 1878, he studied at the Natural Science Department of the Faculty of Physics and Mathematics at the USV. In 1880, for writing a scientific paper on Chemistry on the topic "Chemical Study of Blue and Variegated Clays Found in Kyiv Outcrops" he was awarded a gold medal. He also received the Candidate's Degree of the Faculty of Physics and Mathematics in the field of natural sciences without submitting a thesis. In 1885, he worked as a private associate Professor, in 1891 – as a full Professor and Head of the Department of Agronomy at the USV. As early as in 1889, he organized an agronomic laboratory at the department, where he carried out chemical, physical and physiological research (Kovalenko, 2014, p. 93). The scientist was the first one to connect his theoretical research in the field of botany and plant physiology with practical use in agriculture. In particular, the theoretical conclusions he made about water regime of plants were of exceptional importance to the development of world physiological science (Demidenko, Boiko, Tsimbal & Kovalenko, 2020, p. 734).

The microbiological studies of A. V. Krainsky were important for the development of plant physiology, who in 1903 graduated from the Natural Science Department of the Faculty

of Physics and Mathematics at the USV. In 1909, as a private Associate Professor at the Department of Agronomy, he researched physiology of nitrogen-fixing microorganisms extensively. In 1912, the scientist received a scientific mission to Holland, where he worked in the laboratory of an outstanding Dutch microbiologist M. Bayerink. Already in 1914 in the scientific work "Die Actinomyceten u ihre Bedeutung in der Natur", which was published in German in "Centrallblat f. Bakteriologie", he highlighted the results of microbiological research. In particular, he provided detailed information about morphology, physiology, systematics and ecology of actinomycetes, supplementing this information with numerous data from his own observations (Kostenko & Siropol, 2019, pp. 150–151).

Thus, in the development of physiological science at the University of St. Volodymyr in the second half of the 19th – at the beginning of the 20th century we will highlight several scientific and organizational stages. Their substantiation is based on the analysis of the directions of physiological research, the interrelationship of achievements owing to the cooperation of domestic and foreign physiologists, and the availability of a material and technical base for physiological practice. In particular, in 1840 – 1864, specialized departments were established and Physiology was established as an educational discipline under the influence of the authoritative European laboratories of M. Bayerink in Holland, K. Bernard in France, J. Müller in Germany, M. Foster in England, and the others. Preference is given to the study of animal warmth, the effect of temperature on heart activity, blood pressure, neuromuscular system, sense perception organs and a central nervous system. The study of blood circulation mechanism in the body started. Chief focus was on the study of photosynthesis process in plants. In 1865 – 1883, physiological laboratories were established, experimental direction in physiological science was facilitated. Priority research was carried out on physiology of lymphatic vessels, lymph formation, anatomy of the beginning of lymphatic vessels and lymphatic channels of spleen, innervation of blood capillaries, physiology of the nucleus of sympathetic nervous system, physiology of brain, anatomy and physiology of skin. Osmotic phenomena in plant cells were analyzed. The first branch textbooks and study guides were written for the USV students. In 1884 – 1917, the formation of electrophysiology took place, in particular the study of electrical phenomena in plants and nervous and muscle tissues of animals. Chief focus was on histology and physiology of sense perception organs, physiology of blood circulation and digestion. Environmental physiology of plants, physiology of nitrogen-fixing microorganisms, the basics of field physiology, anatomical and physiological regularities of plant resistance to drought were developed. There was significant influence of the Russian scientific schools of I. P. Pavlov, V. I. Palladin, I. M. Sechenov and the others on the expansion of physiological research in the Ukrainian lands.

The Conclusion. One of the important factors in the development of physiological science at St. Volodymyr University in the second half of the 19th and early 20th centuries was its international nature, which contributed to the expansion of domestic and foreign scientific experience interaction in doing research. Successful cooperation of scientists of the Russian Empire with scientists of England, Holland, Italy, Germany, Hungary, France, and the Czech Republic ensured implementation of research based on systematic exchange of information about physiological processes in plants, animals and a human body, which accelerated income and increased the effectiveness of the results implementation of scientific research into practice. In particular, domestic physiologists used textbooks and manuals written by foreign scientists, and underwent foreign internships in world-renowned European physiological laboratories. Discoveries in Physics, Chemistry, Mathematics, Mechanics,

Microbiology, Radiology, etc., played a significant role in the formation and development of domestic physiology. In particular, in organic Chemistry, namely the discovery of the law of conservation and transformation of energy, the cellular structure of organism, the theory of evolutionary development of the organic world, etc. Certain regularities determined by domestic researchers contributed to the development of world physiology as a science and educational discipline, the positioning of their achievements and immediate international recognition. Accumulated experience of conducting scientific research and the system of training specialists at St. Volodymyr University were important not only for the development of domestic achievements in physiology, but also in biochemistry, ecology, embryology, entomology, cellular engineering, etc. This accumulated experience contributed to the increase in the efficiency of domestic scientific research, which was not inferior to foreign ones in terms of its achievements. Owing to significant achievements, domestic physiologists increased their international authority and confirmed that domestic physiological science occupied an honourable place abroad.

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