

Alexander Samoylov: Founding father of Russian electrophysiology

Alexander Samoylov (Fig. 1) was born on 27 March, 1867, in Odessa. After completing gymnasium school, he began at the Faculty of Physics and Mathematics in Novorossiisk University, but before graduating changed his mind in favor of medicine. He enrolled in the medical faculty at the University of Derpt (now Tartu) and graduated in 1892 as a Doctor of Medicine. In the same year, in St. Petersburg, he presented his thesis “On the Fate of Iron in the Animal Organism” (*Über das Schicksal des Eisens im thierischen Organismus*, Diss., St. Petersburg, 1892), following which he joined the laboratory of the prominent Russian physiologist Ivan Pavlov and became involved in his study of the physiology of digestion. In 1894, he accepted a job offer from another great Russian physiologist, Ivan Sechenov, in Moscow University, and there continued his research. Samoylov’s main academic interest, however, came to focus on the field of electrophysiology. According to his own account, this was inspired by an encounter with the noted Russian physiologist Nikolay Wedensky. In August 1883, the teenaged Samoylov heard a lecture by Wedensky at the Seventh Congress of Russian Natural Scientists and Physicians in Odessa, in which he reported on his studies of the processes of neural and muscular activity in animals using a telephone. That report so impressed the young Samoylov that he decided to devote himself to the study of these processes. However, unlike Wedensky, he chose to examine them by eye rather than by ear. What Wedensky had listened to, Samoylov wanted to see.

At that time, the main research tool used to study electrophysiological processes was the capillary electrometer which Samoylov not only thoroughly explored but also improved in many ways by increasing its mobility, which allowed the curves representing the electrical processes in the heart of a frog to be recorded without lengthy correction and rectification, as had been required previously. He designed a photographic recorder with a fast-moving drum which could be used for reproducing electrical phenomena in the heart muscle on photographic film or paper. His electrograms, together with the atrial and ventricular mechanical curves, displayed all major phases of the cardiac cycle in a frog’s heart: the relationships between electrical and mechanical processes involved in the work of the heart,



Figure 1. Alexander F. Samoylov (1867–1930).

and the sequence of electrical processes in the atria and ventricles (*Archiv f. Physiologie*, 1906, Suppl. Bd.).

In 1904 Samoylov met Willem Einthoven at the International Physiological Congress in Brussels and they soon developed an intense scientific cooperation and close friendship. In 1906, Samoylov started to work with the string galvanometer, a device invented by Einthoven which offered significantly greater capabilities than the capillary electrometer (Fig. 2).

The delicacy and refinement of Samoylov’s technique in the use of the capillary electrometer

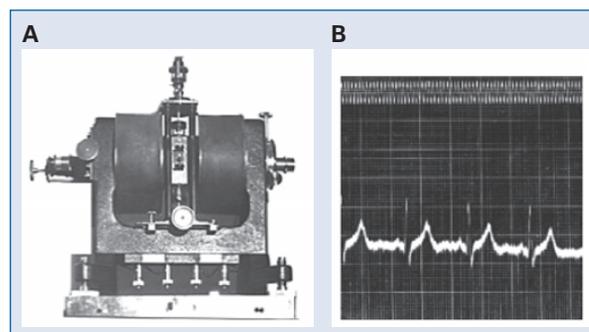


Figure 2. String galvanometer (A) and electrocardiogram recorded by it (B).

were demonstrated in his studies of the currents of muscular activity induced by dual stimulation. This technique, and the combination of the capillary electrometer with the string galvanometer, were discussed in a number of his papers (Le physiologist Russe, 1908, T.V.Archiv f. Physiologie 1908, Suppl., Zentrabalt f. Physiol. Bd. 24, Pflugers Archiv, Bd. 143, 1912), where the multiple photography method used for the first time by Burdon-Sander-son in the 1880s was brought to perfection.

In 1908 Samoylov published a paper titled "Elektro-kardio-grammstudien" (Betrag zur Physiologie und Pathologie), in which he presented examples of electrocardiograms (ECG) with the identification of atrial and ventricular electrical activities, showed the effect of lead electrode positions on the ECG pattern, human respiration phases, and demonstrated a monophasic current curve of ventricular activity and other electrophysiological parameters. Samoylov devoted much time to upgrading the methodology of the string galvanometer, developed techniques for eliminating the tremble of the galvanometer string, rotating images from vertical to horizontal, studying the effects of magnetic fields on the galvanometer string etc. ("Praktische Notizen zur Handhabung des Saitengalvanometers", Archiv f. Physiologie, 1909).

He studied the changes in the ECG of a frog induced by cardio-damaging factors and stimulation of n. vagus (Pflugers Arch. Bd. 135, 1910). The influence of the parasympathetic nervous system on the heart of a frog was discussed in a number of Samoylov's papers in which he demonstrated that the effect of n.vagus stimulation transforms the terminal portion of the T wave on ECG and, at the same time, a shorter period of activation is recorded in the basal ventricular segments. He was the first to study the influences of muscarine and atropine on the heart (Zentralb. F. Physiol. Bd 27, 1913, Pflugers Arch. Bd. 155, 1914). While studying the 'Gaskell phenomenon', which refers to the enhancement of quiescent currents under stimulation of n. vagi, Samoylov noticed that the ventricular quiescent currents are increased by the stimulation of n. vagi which directly results from the influence of the parasympathetic nervous system, rather than as an indirect influence via the lungs as some of his contemporaries believed. This observation had great importance for the development of electrophysiological theory.

The last ten years of Samoylov's life were devoted to the study of the fundamental problems of neuromuscular physiology, electrophysiology and the chemistry of neuromuscular inhibitory transmission (Pflug. Arch. Bd. 208 B, 1925, American J of Physiology vol. XC, # 2, 1929, Pflug. Arch. 225 B., 215, 1930). Examining the length of a single inhibitory impulse after the stimulation of n. vagus, he proved experimentally that, while an inhibitory

impulse exists in the central nervous system, a positive response in the muscle of a cat was either totally absent or severely depressed. It was determined in this study that the inhibition of positive response occurs not only when it is preceded by inhibitory stimulation, but also when it follows the inhibitory stimulation (a positive response in this experiment was obtained by stimulation of m. semi-tendinosus through stimulation of n. peroneus on the same side, and a negative response by stimulation of the opposite n. peroneus).

From this experiment, Samoylov concluded that the path of the inhibitory impulse to the efferent neuron is shorter than the path of the excitatory impulse (Pflug. Arch. Bd. 215, 1927). This study was further developed in his last, posthumous publication devoted to the analysis of a single tetanic contraction, which had been first described by Wedensky. The nature of this phenomenon is that, when a sub-threshold tetanic stimulation inducing no response in a muscle is applied to the nerve, and at the same time a single maximum stimulus is applied higher to the same muscle, the resulting contraction will be tetanic rather than single. However, if the strength of stimulus is increased above a certain limit without any change in frequency, the contraction effect in the muscle will be reduced rather than enhanced. Wedensky had demonstrated that stimulation and inhibition in the organism occur in a parallel manner, and that every co-ordinating movement leads to contraction of some muscles and relaxation of others. This led Wedensky to suggest the principle of reciprocal innervation.

The maximum impulse leaves increased excitability in the neuromuscular apparatus for several seconds, something Wedensky regarded as a function of the nerve. Samoylov saw it as a function of the nerve endings, based on the assumption that the nerve ending exudes an unknown excitatory agent which acts on the muscle as a stimulant transferring neuromuscular excitation from the nerve to the muscle, or from one cell to another. At the same time, the periods of decomposition of the agents inducing excitation and inhibition were different. The agent inducing excitation decomposed in a hundredth of a second, whereas the one inducing inhibition decomposed in a tenth of second. The excitation transfer theory formulated for the first time in this paper was later dubbed the humoral theory and provided a baseline for the mediated transfer theory. The results of research of the chemical nature of the delay were reported in 1926 at the International Physiological Congress in Stockholm. In 1929, Samoylov described having received in 1908 a monophasic curve ECG article which had formed the basis for an explanation of changes of an ECG at a myocardial infarction. In experimenting on the heart of a frog, partially having cut atrio-ventricu-

lar connection, he for the first time described the phenomenon of partial blockade named in a subsequent periodical ‘Samoylov-Venkebach’. In 1930, his article “Ring rhythm of excitation” proved the electrophysiological mechanism of occurrence of atrial flutter. The works of Samoylov were always distinguished by the accuracy, precision and integrity of his experiments.

He used to attach great importance to the quality of obtained ECG and continuously upgraded the equipment used in his studies. Samoylov always sought to steer his scientific accomplishments into practical applications.

On 30 January 1908 he had reported on the prospects and possibilities of ECG in diagnosing heart diseases at the annual meeting of the Moscow Therapeutic Society. Samoylov considered ECG an independent area of clinico-physiological research and specified that its clinical use requires that the doctor’s clinical thinking be based on sound knowledge of the electrophysiology of the heart. For a long time, his laboratory in Kazan was the only centre in Russia training doctors how to conduct an ECG. In the 1920s, he was the first in Russia to set up electrocardiographic rooms for extensive examination of patients, first in Moscow and later in Kazan, where he worked from 1921 until his death in 1930, and where he established one of Europe’s best electrophysiological laboratories. In his clinical practice, Samoylov was a proponent of more extensive application of electrocardiographic possibilities, not only as a diagnostic technique for cardiac arrhythmia, but also as a method of assessing mechanical cardiac performance. He was the first to describe the high P wave in patients with mitral stenosis, having proved the relationship between electrical cardiac effects and heart muscular tension.

Samoylov actively participated in international scientific life, took part in many international conferences, gave lectures in Russia, USA and Europe (including at the invitation of Einthoven in 1922 at Leiden University in Holland where the latter was then working). Samoylov was also on friendly terms and co-operated with the well-known German neurohistologist Otto Fогt, the American physiologists William Cannon and John Fulton, and the great cardiologist Paul White who also was an enthusiast for studying the electrophysiology of the heart. Following his course of lectures on electrocardiography to the physicians at Harvard Medical School, the head of the hospital electrophysiological department, Professor P. Weisse, wrote to the Russian Ministry of Health: “He [Samoylov] is one of the world’s greatest scientists at the present time and we would be happy to see him again with us should such an opportunity arise.” [from the personal archive of Anna Samoylova, A.F. Samoylov’s wife, re-translated from Russian].



Figure 3. Gravestone of Alexander Samoylov in the Vvedensky cemetery in Moscow.

Alexander Samoylov was the author of 115 published papers devoted mainly to physiological problems. His interests however were not limited to physiology alone. He was president of a musical society, wrote several papers and gave lectures to professional musicians on musical theory, acoustic physiology and the history of musical notation, the origin of which he associated with muscular operation. Among his audience and admirers were famous musicians such as Rachmaninoff, Taneev and others. Samoylov died suddenly on 22 July, 1930, aged 63, from a heart attack and was buried in Moscow (Fig. 3).

The life of Alexander Samoylov in all respects reflected his own words as quoted from one of his papers: “Not a single thought is lost in a cultured society. Everyone owns a share in the intellectual legacy and material wealth which will be handed down by us to future generations, and he is happy who has not ruined or wasted those spiritual resources that were measured out for him by nature and which gave him the opportunity to be a part of the totality of joyful life of the present-day and future generations”.

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