Petr Petrovich Lazarev (on the one-hundredth anniversary of his birth)

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Peter Petrovich Lazarev was born on April 14, 1878 in Moscow into the family of a land surveyor.

After graduating from the 4-th Moscow Gymnasium, Lazarev entered the Moscow University Faculty of Medicine in 1896. Although he had shown great interest in physics, chemistry, and mathematics and was less interested in practical medicine, this step was prompted by the fact that graduation from the Physico-mathematical Faculty offered no clear prospects for later scientific study. On graduating (with distinction) from the Faculty of Medicine, Lazarev nevertheless went to work in the Division of Mathematical Sciences of the Moscow University Physico-mathematical Faculty in the fall of 1902. He passed all the state examinations as an extern in 1903. In the same year, having passed his doctoral examinations in medicine, Lazarev was appointed an assistant at the Clinic for Ear, Nose, and Throat diseases at Moscow University, where he carried out his first investigations, which were concerned with physiological acoustics. However, his acquaintance with P. N. Lebedev and his participation in the colloquia conducted by the latter moved Lazarev to transfer his studies to Lebedev's physics laboratory at the University, to which he transferred in 1907 as a privatdozent. Here he wrote his Master's thesis "On the Temperature Discontinuity in Heat Conduction at a Solid-Gas Interface," defending it in 1911. This was the first experimental study of the effect, which had been discussed by Smolukhovskiĭ on the basis of the kinetic theory of gases.

At the University of Warsaw in 1912, Lazarev defended his Doctorate thesis on the subject "The Fading of Pigments in the Visible Sepctrum: An Experiment in Study of the Basic Laws of the Chemical Action of Light." One of the principal results of this dissertation was its proof of the proportionality between the chemical effect and the amount of energy absorbed by a gas.

Earlier, with a large group of progressive scientists and teachers, which included Lebedev, Lazarev left Moscow University in protest against the reactionary policy of the Minister of Education Kasso, specifically against his sending police to the University (1911).

Lazarev, Lebedev, and their students transferred their activities to the basement of a house in Mertvyĭ Alley (now Ostrovskiĭ Alley), and, soon after Lebedev's death, to the physics laboratory of the Moscow Higher Technical College, where Lazarev was made a professor and where he continued his work on the kinetics of photochemical processes. Due to Lebedev's illness, Lazarev began from 1911 to substitute for him in directing the laboratory and the students, and soon thereafter he acquired his own students—B. V. Il'in, V. V. Srebnitskiĭ, T. K. Molodyĭ, and others. It was at this time that Lazarev suggested to Vavilov the subject of the latter's first scientific study, which was devoted to the kinetics of thermal fading of dyes and its comparison with the kinetics of fading due to exposure to light. Later, Lazarev's insight enabled him to foresee the important results that would be obtained by Vavilov and V. L. Levshin in their studies of luminescence.

A major event was the founding of a number of research institutes by the Moscow Scientific Institute Society, including, in 1917, the first physical research institute in Russia, whose building (Artichect A. N. Sokolov) and been erected on Miusskaya Square with private contributions at the end of 1916. Lazarev was named director of the institute. His research and that of his students and colleagues expanded in this Institute, in which S. I. Vavilov, G. A. Gamburtsev, M. A. Leontovich, P. A. Rebinder, V. V. Shuleĭkin (later Academicians), B. V. Deryagin, A S Predvoditelev, N. K. Shchodro (later Corresponding Members of the Academy of Sciences), M. P. Volarovich, B. V. Il'in, V. S. Titov, D. M. Tolstoĭ, and É. V. Shpol'skiĭ (later professors and doctors) all worked. After the October Revolution, Lazarev, with his characteristic ebullient energy, organized a broad front of fundamental and applied studies with the Institute as a base. A laboratory was set up to aid the Red Army in developing camouflaging and decamouflaging techniques. The Institute of Biological Physics of the People's Commissariat of Public Health was organized in 1920 (it was later reorganized as the Institute of Physics and Biophysics), and participants in its work included N. T. and V. I. Fedorov, P. N. Belikov, M. I. Polikarpov, A. S. Akhmatov, P. P. Pavlov, P. O. Makarov, V. V. Efimov, I. L. Kan, and S. V. Kravkov (later a Corresponding Member of the Academy of Sciences of the USSR). Research on x-rays

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(A. K. Trapeznikov) and their application in medicine was organized, and an X-Ray Electromedical and Photobiological Section was created. Later, the People's Commissariat of Public Health created the Roentgen Institute at Solyanka, and Lazarev was designated its first Director. An x-ray photograph of Lenin's ribcage was made in the x-ray room at the Institute of Biological Physics in 1922 after he had been treacherously wounded.[2)]

In 1917, Lazarev was elected a full Member of the Academy of Sciences. He had been nominated for the Academy by the country's most prominent scientists—the physiologist I. P. Pavlov, the mathematician V. A. Steklov, the specialist in mechanics A. N. Krylov, the geochemist V. I. Vernadskiĭ, and the chemist N. S. Kurnakov.

The year 1918 was memorable for the beginning of extensive research on the Kursk magnetic anomaly. As we know, a detailed chart of this anomaly had been prepared previously by the professor of meteorology É. E. Leĭst. Having departed for medical treatment in Germay, É. E. Leĭst died in 1917, and the charts that he had taken with him fell into the hands of the adventurer Stein, who offered them to the Soviet Government for 5 million rubles in gold. Unfortunately, there were people in our country who were willing to support this proposal. Accordingly, L. B. Krasin, People's Commissar of Foreign Trade, consulted with Lazarev. The latter vigorously opposed the proposals of the fainthearted who regarded our science and engineering as incapable of making practical use of the resources in the region of the Kursk magnetic anomaly. He reported to Krasin and G. M. Krzhizhanovskiĭ that Leĭst's voluminous materials were totally unfit for practical use: Although he had made careful measurements of geomagnetic field elements at numerous points in the area of Russia that he investigated, Leĭst charted these points on the basis of crude estimates of the geographic coordinates and verbal statements of local residents as to the distances of the points from various villages, settlements, and towns. Instead of spending gold reserves to buy Leĭst's questionable charts, Lazarev proposed that a magnetic survey be conducted in the same regions with the up-to-date operational methods used by the fleet, with simultaneous determination of accurate point coordinates by equally operational methods, also borrowed from marine practice. An exhaustive instruction manual on these methods was submitted by Academician A. N. Krylov. Lazarev's proposal was submitted to Lenin, and the Commission to Study the Kursk Magnetic Anomaly was created in the Academy of Sciences of the USSR in 1919 by Lenin's order. Lazarev was elected chairman of this academic commission. He organized a laboratory at the Institute of Physics and Biophysics, in which the magnetic properties of rock specimens sent in from the field were investigated under the direction of N. K. Shchodro. The Special Commission on the Kursk Magnetic Anomaly (OKKMA) was organized in 1921 by Decree of the RSFSR Council of People's Commissars in recognition of the broad scope of the research project. Professor (later Academician) I. M. Gubkin, a geologist, was named its chairman, and Lazarev was designated deputy chairman in charge of the geophysical section.

In 1923, drilling yielded specimens containing iron ore. The mineral wealth that was discovered as a result requires no description today. Our country proved to be the richest in the world in iron reserves, which were, moreover, situated very conveniently from the standpoint of proximity to the country's industrial centers. However, there were also opponents of exploration of the Kursk anomaly, and not only before the iron-ore specimens turned up—there were at that time many who refused to believe that the anomaly could be explained so simply—but even afterward; they maintained that mining of the iron ore would not be economically feasible. There is no question that success in opening up the colossal reserves of iron ore (including high-grade local deposits) was due in part not only to Lazarev's scientific insight and boldness, but also to his courage in dispute with the opponents and enemies of this initiative.

Lazarev combined supervision of the geophysical part of the work on the Kursk magnetic anomaly with the elaboration of the theory of the geophysical survey, including the seismic theory. After being used successfully on the Kursk Anomaly, the latter was subsequently broadly developed under the supervision of G. A. Gamburtsev. One of its variations—the seismoelectric method, which was based on discovery of the piezoelectric properties of various rocks, was augmented and put to practical use by M. P. Volarovich, a student of Lazarev and Shchodro. The great importance of geophysical methods in prospecting is now a familiar fact. Here again, Lazarev's appreciation for what is new and his far-sightedness were fully in evidence. They were also displayed in his organization of the State Geophysical Institute (now the Institute of Theoretical Geophysics of the Academy of Sciences of the USSR), of which he was the first Director.

In speaking of Lazarev's geophysical work, we must not overlook his original studies of the role of the trade winds in the origin of ocean currents, in which he used model experiments. The idea behind these model experiments was also used later by other scientists, primarily V. V. Shuleĭkin. Responding quickly to the initiative of Institute workers and other scientists, Lazarev did all that he could to support Shuleĭkin's work in marine physics, assisting the latter in the building of the Black Sea Hydrophysical Station at Katsiveli (in the Crimea) in 1929. Vigorous support from Lazarev made possible rapid expansion of this tiny station (which eventually grew into the Marine Hydrophysical Institute of the Academy of Sciences of the USSR, now under the Ukranian Academy of Sciences).

After organization of the Institute of Biological Physics, Lazarev concentrated his attention on further development of biophysics, and primarily the biophysical trend that he had originated in the monograph "The Ionic

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[2)] A memorial plaque on the second floor commemorates this event.

Theory of Excitation" (1916), which was later translated into French (1918) and German (1923) and republished in expanded form in 1927. Studies of changes in the sensitivity of brain centers and sense organs (peripheral and central vision, hearing, etc.) under the influence of stimulants, time, the state of the organism, and age were given priority treatment. These studies were reported in the monograph "A Study of Adaptation" (which was published posthumuously in 1947).

Briefly stated, the basic results of these studies reduce to the following. As we know, W. Nernst, and also the Russian physiologist V. I. Chagovets, had advanced the hypothesis that nerve endings or muscles are stimulated by changes in the concentrations of ions that occur at semipermeable membranes under the action of an electric current. Lazarev developed a quantitative theory of this effect, using the laws of diffusion and transport of ions in an electric field and the electrical laws of stimulation that had been discovered by Loeb. The theory was supported by experiments conducted by S. N. Rzhevkin at the Institute of Physics and Biophysics and the Roentgen Institute; the frequency of the stimulating current was brought up to $3 \cdot 10^5$ Hz in these experiments. G. R. Yaure's experiments on the transition from nonperiodic to periodic muscle contractions at a certain composition of the ionic medium provided further confirmation for the theory.

Lazarev later applied the laws of the stimulating action of ions to vision and hearing. In the case of vision, the agents that stimulate the nerve endings are products of the photochemical decay of light-sensitive pigments in the rods (for peripheral vision) and cones (in central vision). This makes understandable the close link between these studies of Lazarev and his photochemical investigations. Recognizing that these studies in photochemical kinetics were themselves pioneering, one cannot help but be impressed by Lazarev's high creative potential and latitude of approach.

These fundamental studies marked the beginning of an enormous literature on the photochemical kinetics of vision. The flood has not subsided yet. We take particular note of the fact that extension of the theory to color vision explains why this theory is often and with good reason referred to as the Young-Helmholtz-Lazarev theory in the literature.

Before Lazarev, the sensitivity of the eye to brightness changes was treated on the basis of the purely empirical psychophysiological Weber-Fechner law. Lazarev took a bold step, supporting it with the premises of a photochemical theory of vision. Later, this law was derived as it applies to all sensations from very general conceptions as to the relation of the differential threshold of sensation to the increase in the number of stimulated nerve fibers. This gives concrete form to a basis for materialistic understanding of sensations.

Later Lazarev was to expand significantly the theory of differential visual sensations. He showed that the very possibility of perceiving gradations of light can be fully understood only when both the discreteness of the sensitive elements of the retina and the discreteness of the luminous flux—its quantum nature—are taken into account. Another major contribution to the quantum theory of vision was made by the remarkable studies of Vavilov and his co-workers (E. M. Brumberg *et al.*) of the quantum nature of the fluctuations in the visual perception threshold. One result of these experiments was the conclusion that the borderline stimulus of a well-adapted eye corresponds not to one, but to several (about five) photons. In accordance with Lazarev's treatment, this implies that stimuli to several sensitive fibers must be summed for perception of a flash of light—a summation that may occur in the visual center of the brain. We note that the dependence of the borderline number of quanta on the duration of the flash and the "illuminated" area must be linked to this summation law. These studies of the summation of impressions are still awaiting development, but how far-reaching were the consequences of Lazarev's physiochemical theory of vision is already clear.

Proceeding systematically, Lazarev himself treated the sensitivity of the eye as a function of the state of the periphery (the extent of decomposition of the light-sensitive pigments) and of the visual centers. In a major series of studies, this enabled him to apply measurements of the eye's sensitivity to study of the sensitivities of centers in the brain. The effects of a wide variety of factors, from drugs to establishment of a periodic dependence of this sensitivity on the time of day, were studies on a broad front. One of the most interesting results was the discovery of a general dependence of visual-center sensitivity on age. This curve was obtained naturally from observations made on various test subjects. Nevertheless, the point scatter did not obscure the general pattern; an increase in sensitivity to age 20–25, followed by a slow decrease in a kind of reflection of the life cycle.

All these things are only examples and landmarks in the development of the research in biophysics of sense organs at the hands of Lazarev and his colleagues and students. This area has now been broadly developed. Throughout his life, and especially in his later years, Lazarev also gave a great deal of attention to the general problems of biophysics. His monograph "Contemporary Problems of Biophysics" (published posthumously in 1945) is of tremendous interest, as are his earlier monographic sketches—"Contemporary Problems of Biological Physics and Their Practical Importance" (1933) and "Biophysics in Russia and in the USSR" (1940) in the book "Biophysics: Selected Papers on the History of Biophysics in the USSR" by Lazarev and P. P. Pavlov.

As in the other fields in which he did creative work, Lazarev always related fundamental research to its practical applications very closely and directly. He carried out numerous and varied studies of the use of adaptation for diagnostic purposes in various diseases, as well as for analysis of various physiological states and the effects of drugs. His range of interests included problems in the dynamics of biological populations, the growth of normal formations and tumors, the effects of closing of an external magnetic field on the bloodvessels of the frog, conditioned reflexes and the mechanism of higher nervous activity, the causes of epilepsy, and many others. In all these areas he drew original conclusions and produced new data.

Not all of his published papers were equally significant (but is it ever otherwise?), but the trail that he left was broad and indelible. Lazarev is rightly considered one of the founders of biophysics as a science and the father of Soviet biophysics. This role of his was determined by his brilliant and original talent, his ability to connect what would appear to be widely separated phenomena and relationships, the ability to see through the particular to the general, which is inherent to physical thought, his enormous and wide-ranging erudition, his skill in evaluating the promise both of particular studies and of whole sciences and fields of knowledge. These last qualities of Lazarev were undoubtedly closely related to his love of the history of science and his knowledge of it. In connection with the Academy of Sciences Anniversary he wrote a brilliant historical outline of the development of the exact sciences in Russia over 200 years, a brief history of Russian physics, and other historical reviews. He was also the author of brilliant and captivating biographies of Russian physicists—P. N. Lebedev, A. G. Stoletov, B. B. Golitsyn, and N. A. Umov—as well as profiles of Rutherford and Newton.

Concurrently with his development of biophysical research, studies in physics and physical chemistry were also being promoted vigorously at the People's Commissariat of Public Health Institute of Physics and Biophysics. Here, during the 1920's, S. I. Vavilov, V. L. Levshin, and L. A. Tummerman were investigating luminescence, N. K. Shchodro was studying the dielectric properties of liquids, G. S. Landsberg was working in optics, V. V. Shuleǐkin in marine physics and A. A. Predvoditelev and B. V. Il'in in molecular physics; P. A. Rebinder discovered the adsorption lowering of hardness and the present author the shear elasticity of thin films of water; Lazarev was guiding research on the photochemical processes that are important in industrial production of sulphuric acid and for clarifying the mechanism by which carbon dioxide is assimilated. Thus, the Institute was the scientific center of Moscow for physics.

Lazarev not only knew how to find practical applications for scientific results obtained, but also responded quickly to various practical demands, combining purely theoretical research with solution of practical problems.

Apart from the research generated by the riddle of the Kursk magnetic anomaly, his studies of the vitreous state, which were important for development of the glass industry, serve as another striking illustration. At his initiative, the first measurements (1928) of the viscosities of molten glasses were made at the Institute of Physics and Biophysics by M. P. Volarovich and D. M. Tolstoǐ on the one hand and by B. V. Deryagin and Ya. S. Khananov on the other; their results agreed in spite of the two different methods used. Experimental studies guided by Lazarev with simultaneous participation of Silicate Institute staff members (A. P. Zak, Yu. P. Simakov, S. I. Ioffe, and others) fully clarified the question as to the nature of tempered glass. Since clay mixes are important in the silicate industry, Lazarev took an interest in the nature of the plasticity of clays. Having analyzed the problem, he introduced the idea that extremely thin water interlayers and their anisotropic structure are of basic importance in this property of dispersed systems. Here again his intuition asserted itself. Subsequent work by this author and his colleagues and by other scientists here and abroad on the singular properties of thin liquid interlayers revealed a whole universe of phenomena that can be used for quantitative explanation of the basic properties of dispersed systems with liquid dispersing agents and has changed the countenance of colloid science. Also of great import was Lazarev's Master's thesis on an experimental study of the temperature distribution in a rarefied gas between differently heated plates. This study, which was carried out on a high experimental level, served as one basis for calculation of the motion of aerosol particles both under the influence of a temperature gradient (thermophoresis), as shown by Yu. I. Yalamov, S. P. Bakanov, and the author, and under the influence of light (photophoresis, the radiometric effect). By virtue of the similarity principle, the temperature discontinuity and the attendant gaskinetic phenomena are also important in calculating the motion of large objects in the stratosphere.

Lazarev's influence on the development of Soviet biophysics, geophysics, molecular physics, and photochemistry was enormously enhanced by his productive organizational and social activity. He organized a number of scientific institutes. Later, the Institute of Physics and Biophysics on Miusskaya Street was reorganized as the P. N. Lebedev Physics Institute of the Academy of Sciences of the USSR (FIAN) and modernized. The Institute's library and Lebedev's reliquary—his instruments for determination of light pressure, his deathmask, his notebooks—were also transferred to the FIAN. When the All-Union Institute of Experimental Medicine was organized, Lazarev headed the Department of Sensory-Organ Biophysics; in 1937 it was transferred (as a biophysics laboratory) to the Academy of Sciences of the USSR. After his death, this laboratory grew into the Institute of Biophysics of the Academy of Sciences of the USSR. He founded the journal "Uspekhi Fizicheskikh Nauk," which he later edited jointly with É. V. Shpol'skiǐ. He also organized and edited the journal "Archive of the Physical Sciences," the "Journal of Applied Physics," the "Journal of Geophysics," and the "Bulletin of the Institute of Biological Physics," and was co-editor of many serial publications ("Contemporary Problems of Natural Science," "Classics of Natural Science," and others).

At the same time, Lazarev had no equal in arousing enthusiasm in readers of his popular sketches and listeners of his popular, instructional, and scientific presentations. Although his speech was not distinguished by smoothness or the use of oratorical devices, he made up for this by showing clearly the importance of his subject and avoiding nonessential details and long-windedness. Most attractive to everyone who met him were his unbounded devotion to science, his exceptional scientific temperament, and the directness with which he stated his views. Without these qualities and his personal charm, it would have been impossible for him to maintain his hectic level of activity and to cultivate a scientific school that included several outstanding scientists who would distinguish themselves in a wide range of fields.

Alas! This frankness and directness sometimes led to misunderstandings, but they occurred only with people who were unable to appreciate these qualities. Lazarev's life—and he could not have conceived of life without science—had its thorny passages, and recognition often came late. But time is the strictest and most righteous judge, and now, 36 years after Lazarev's death, it has become even clearer how significant his work was, not only in historical perspective, but also in the light of the development of his ideas at present and in the light of today's problems.

Lazarev's monuments are the development of the physical and the physicochemical approaches to biological problems, the emergence of applied geophysics, which in its very beginnings gave our country the magnificent reserves of iron that are now being intensively worked, the fundamentals of photochemical kinetics, and new divisions of molecular physics.

Those who knew Lazarev and worked with him will forever cherish his memory as that of a man who always by his deeds showed deep devotion to science and patriotism and was always ready to aid anyone who needed his help with scientific or personal problems.

Translated by R. W. Bowers