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Fifty Years of Soviet Science and Technology

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FIFTY YEARS OF SOVIET SCIENCE AND TECHNOLOGY

The peoples of the multinational Soviet Union celebrated the 50th anniversary of the Great October Socialist Revolution in November 1967. Half a century is not a moment on historical scale. And still, the generation of the present century perceives a radical trasformation of the world. What principal changes have occured in the country which was the first to choose the socialist way of development? Millions of people all over the world want to know the advance of science in a classless society as well as the peculiarities of this advance that constituted the great triumphs of Soviet science.

We do not aim to present an exhaustive list of events comprised by the fifty years of the history of Soviet science; nor do we intend to characterize this science in detail. We set out to outline in brief some principal trends in the advance of Soviet science and technology.

Immediately after the victory of the October revolution the Soviet government undertook resolute measures intended to stipulate a comprehensive development of science and technology. In his concise and concrete "Outline of Scientific and Technological Undertakings", written in April 1918, V. I. Lenin has posed the principal directions of governmental policy in this field.

Early in 1920 Lenin suggested that a draft of the state electrification plan be elaborated. The State commission of the electrification of Russia headed by G. M. Krzhizhanovsky was organized. It managed to enlist the co-operation of the most eminent electricians, technologists, builders, economists, heat engineers *etc.* Thus a detailed plan of reconstruction of the country's industry on the foundations of advanced science and technology was developed.

A very rapid growth in the number of research workers occurred in the twenties and the thirties. Accordingly, the number of scientific problems studied in Russia increased.

Soviet science has always combined its applied tasks with the elaboration of fundamental problems. The Soviet state created possibilities for the growth of large scientific schools handling both practical and quite abstract topics. Although the latter did not promise any immediate practical applications of the results gained by study their future practical effect proved to be immense. This can be shown in regard to mathematics.

In the early twenties a mathematical school created in Moscow on the eve of the revolution and specializing in the theory of functions of real variables made great progress and contributed important discoveries to science. We mean studies on the substantiation of differential and integral calculations. The theory of functions of real variables was thoroughly elaborated in the Soviet Union; these studies make part of the history of world mathematics.

The theory of probabilities was another branch of the application of the theory of function. The axiomatics of the theory of probabilities suggested by A. N. Kolmogorov was universally recognized. Important studies were undertaken on problems of the application of the theory of probabilities in mechanics, physics, technology. Soviet investigators in this field participated in the works on new problems set by cybernetics and the theory of information.

A large new science of most important practical applications, *i.e.* that of the functional analysis, has been growing during the recent decades on the basis of variational calculations, abstract algebra, the theory of functions, multidimensional geometry *etc.*

Let us now consider the subjects which are of primary importance for the new image of the world and are most effective for the reconstruction of industry, transport, communication, the whole mode of life on the grounds of new technology. These subjects secure the progress of all scientific fields, of experimental and theoretical physics. Here Soviet science had made the most amazing advance—from small university laboratories of the pre-Revolutionary Russia to the great modern accelerators and other experimental devices.

The relativist cosmology, *i.e.* the doctrine of the universe based on the theory of relativity, is just making its first steps: however, this enables us to envisage its further progress. This progress not only signifies a new stage of the doctrine of the universe but undoubtedly renders paramount practical results. Suffice it to mention that reactions maintaining the heat of planets are thermonuclear reactions and will be peacefully used for the benefit of industry, culture and science.

Cosmological and cosmogonic concepts proved to be closely connected with notions on the ways of atoms, atomic nuclei and elementary particles.

New methods of observation largely favoured the further advance of

astrophysics. Now it is possible to gain from the Earth information on astrophysical processes not only by means of visible rays, *i.e.* electromagnetic waves in the optical range, but also from radiomodification of celestial bodies and *X*-rays and gamma-rays.

The immense acceleration of scientific progress promises the study and conquest of the outer space by means of space-ships and satellites. The theoretical foundations for the space travels were elaborated by K. E. Tsiolkovsky who formulated the speed of rocket-flight and laid the foundations of rocket-dynamics. Soviet science and technology occupies a number of leading positions in this field; some principally new steps were made in this country (the first satellite and the first man-ship were launched in the Soviet Union; the first man to quit the board of a space ship in flight was a Soviet cosmonaut). This created the possibility to judge of astrophysical processes from *X*-radiation and gamma-radiation, for such radiations with short waves are absorbed by the atmosphere of the Earth. The contribution of Soviet science in this respect is very important. New studies rendered the notions of atmospheric processes more precise and gave practical results employed in weather-forecasting, radio and TV-communication. This, however, is but a small portion of future practical gains coming with the conquest of the outer space.

The study of the micro-world, of the increasingly smaller space and time fields is another capital task faced by science. This task requires the application of very high energies. Particles with high energies are subjected to regularities of the special theory of relativity. This pertains to nuclear processes educing great energy under the uranium division, the division of some other heavy elements and under the influence of the nuclei of the lightest elements placed by Mendeleev at the beginning of his periodical table.

The development of quantum mechanics was an example of international scientific co-operation. Soviet science participated in the creation and generalization of quantum mechanics and in the attempts to elaborate the relativist quantum physics. A number of works resulting in the highly important theoretical generalizations and practical applications were realized in the Soviet Union. Numerous experimental studies making use of the quantum theory enabled Soviet physicists (A. F. Yoffe, Ya. I. Frenkel *et al.*) to elaborate foundations of the modern physics of semiconductors.

Also important were Soviet investigations in low temperatures which led P. L. Kapitsa to the discovery of a pure quantum effect of the superfluidity of helium. Theoretical studies of Soviet physicists form the basis of the use of superconductivity in radio-and electrotechnology.

Discoveries in the field of radioactivity, especially artificial radioactivity, discoveries of new nuclear reactions and new elementary par-

ticles were quite frequent in the thirties. Science has made a significant progress in the doctrine of the atomic nucleus ascertaining its composition. The bombardment of atoms with rapid particles provided abundant information on atoms and nuclei. Cosmic radiation, systematically studied by physicists throughout the world enriched the table of the discovered elementary particles. The study of elementary particles was considerably facilitated by the devices founded on the so-called "Cherenkov's luminiscence", a phenomenon discovered by the Nobel Prize winners I. E. Tamm, I. M. Frank and P. A. Cherenkov and postulated by particles which move in a given medium quicker than light.

A scientific school systematically studying cosmic rays and phenomena which appear during the interaction of cosmic rays with nuclei of atoms was created in the Soviet Union. A great number of new experimental plants, including mountain laboratories, were built for its needs.

During the forties, simultaneously with the American scientist MacMillan V. I. Veksler suggested a new principle of constructing accelerators which furnished possibilities for a limitless enhancement of the energy of particles.

Soviet scientists were active in the exceptionally important series of experiments and generalizations leading to the release and application of nuclear energy. The theory of the heavy nuclei division suggested by Ya. I. Frenkel (simultaneously with the Danish scientist N. Bohr and the American physicist G. Willer) was very important for the study of the atomic nucleus and the use of nuclear energy. Soviet scientists were the first to make in 1940 an important discovery enabling them to realize the process of uranium-division with insignificant dressing of the natural mixture of isotopes. Soviet physicists headed by I. V. Kurchatov solved in brief time the task of creating the atomic and thermonuclear weapons and of the peaceful employment of atomic energy. The series of experimental and theoretical works resulted in the creation of peaceful nuclear energetics; the first large atomic power stations and the atomic ice-breaker "Lenin" were built.

Recently a number of studies in the field of quantum generators and accelerators of radiation (lasers and masers) were undertaken in the Soviet Union. The practically suitable lasers were created in the fifties and the sixties owing largely to the works of Soviet physicists who thus laid foundations of quantum electronics. Soviet physicists N. G. Basov and A. N. Prokhorov (and the American scientist Ch. Towns) were awarded the Nobel Prize for these studies in 1964.

Evidently the best perspectives are to be ascribed to an already developed branch of science studying increasingly higher energies—the physics of high energies. Soviet science has largely contributed to the study of cosmic rays. No less important is its contribution to the accelerators of particles. The greatest accelerator of the world is now being

built in Serpuhov. This accelerator will impart to particles an anergy of 70 billion electron-volts.

Thus, the Soviet Union possesses the most important conditions for the study of high energies. Rocket technique makes possible the study of particles of an energy yet unattainable with accelerators, for instance, particles coming to the Earth from the outer space (we can cite studies by means of heavy "Proton" type satellites investigating cosmic rays). The most powerful accelerators are also available for Soviet scientists.

Attempts to synthesize heavy transuranium elements constitute one of the most significant directions in the physics of the atomic nucleus. Soviet scientists were among the first to discover one of the isotopes of such an element, namely an isotope of the 102nd element. The joint effort of scientists from the Soviet Union and the Socialist countries working in Dubna helped to study the characteristics of four other isotopes of the element. The 104th element of the periodic system was later discovered in the Soviet Union and named "Kurchatovy".

The influence exerted by modern physics upon the scientific, cultural and technological advance is not limited to the physical discoveries exclusively. The influence of physics upon other fields of science is one of the most fruitful tendencies of the present epoch. This might be shown in regard to Soviet chemistry; the related fields and problems are very significant for the successes of the chemical sciences in the Soviet Union. In the field of physical chemistry the use of röntgenoscopy, spectroscopy and other physical methods enabled to define interatomic distances and other values of primary importance for the solution of chemical problems proper. The quantum chemistry emerged.

A school of radiochemistry comprising all the trends in this field developed in the Soviet Union in the twenties. At present radiochemistry, owing to the construction of nuclear reactors and powerful accelerators, possesses some newest fields—the chemistry of nuclear transformations and the chemistry of transuranium elements.

The combination of wide theoretical generalizations and applied results is quite peculiar to the doctrine of the rates of chemical processes. The Soviet scientist, Nobel Prize winner N. N. Semionov, created a theory of chain reactions rendering it one of the fundamental directions in modern science. The theory of chain reactions had led to the investigation of a number of chemical processes employed in industry.

The doctrine of catalysis was also intensively developed in the Soviet Union. The Soviet school of electrochemists carried out numerous studies in the field of theoretical and applied electrochemistry.

Within recent decades a new branch of chemical industry, the chemistry of oil, has grown in the Soviet Union. This industry produces hundreds of valuable items of obviously high technological importance. The rapid progress of the chemistry of oil was secured by the investi-

gations of Russian organic chemists under the guidance of N. D. Zelinsky. Studies in the field of chemistry and physics of the high-molecular compounds were also advanced in the Soviet Union. A number of researches leading to theoretical foundations and immediately contributing to the technological progress were devoted to polymers. Owing to the work of S. V. Lebedev, an intensified industrial production of synthetic rubber was started in the Soviet Union as early as in 1930.

The fundamental advance of Soviet electrochemistry was largely due to the native work leading to the development of some new divisions of theoretical electrochemistry.

The sciences of the Earth are widely developed in the Soviet Union. Here the use of the newest physical and chemical methods of investigation played a great role. Studies by the eminent Soviet scientists V. I. Vernadsky and A. E. Fersman created a new branch of science—geochemistry engaged in the study of the history of chemical elements in the earth-core and of their behaviour under different thermodynamic, physical and chemical conditions existing in nature. Methods of abyssal sounding of the earth were suggested by geophysics; apparatuses for geophysical study of the earth-core, hydrosphere and atmosphere appeared. A network of seismic stations was created. Aided by geophysics and geochemistry Soviet geology secured the solution of some cardinal problems of the earth-core structure and development.

A 15-volume collective work on the *Foundations of Paleontology* issued recently presents a new systematics of the whole stock of fossil organisms; this is a brilliant achievement of Soviet science.

Achievements in the study of geological processes and the structure of the earth-core enabled Soviet scientists to begin in the fifties investigations on the general regularities of the distribution of minerals. Some important discoveries of the last decade (diamonds in Yakutia, large oil and gas deposits in Western Siberia, great gas layers in Milddle Asia *etc.*) are a direct consequence of scientific forecasts made previously when the problem was approached theoretically.

Theoretical work in geology was oriented towards the creation of sufficient basis of mineral resources for Soviet industry. Owing to the wide range of these studies the rapidly developing native industry was always provided with mineral raw materials and no need of import emerged. Soviet stores of many minerals are the largest in the world; this secures the satisfaction of the needs of perspective planning of many industries for decades ahead.

The explorations of Soviet scientists in the Arctic and the Antarctic brought significant achievements. Great submarine ridges and new islands and archipelagos were discovered in the Arctic basin. Some 500 names appeared on the map of the Antarctic since 1955 owing to Soviet studies.

In the field of the doctrine of life Soviet scholars studied the problems of heredity and favoured the advance of molecular biology. They are also active in the field of cosmic biology and in the studies of the influence displayed by radiation upon heredity in radiational genetics.

I. P. Pavlov revealed an objective approach to the knowledge of the regularities of mental activity and, proceeding from here, elaborated a doctrine of higher nervous activity. Aided by modern electrophysiological tenets and certain new principles, his successors penetrated further on into the mechanisms of conditioned reflexes. The new approach has also led to a decisive advance in the knowledge of the brain structures.

Zoologists made a capital job of studying the animal kingdom of the Soviet Union. Animals of economic value were studied most thoroughly. The results of these studies are contained in the numerous monographic editions on the fauna (90 volumes) and determinators for separate systematic groups of animals (93 volumes).

The different branches of parasitology important for the public health and the advance of agricultural productivity were also developed in the Soviet Union. Here we should mention E. N. Pavlovsky's doctrine of natural nidi of transmissive diseases which is recognized throughout the world and widely used by medicine, veterinary science and general biology.

Successes of Soviet helminthology, connected with K. N. Scriabin's doctrine of the devastation of helminths, are universally famous.

The progress of Soviet botanics was intense within the last half-century. A capital 30-volume guide *Flora of the U.S.S.R.* contains characteristics of some 17,000 species of plants.

To sum up our brief account of the advance of Soviet science and technology we must emphasize that the Soviet contribution to the world science and the role of science in the progress of the Soviet Union are immense. Scientific development in the Soviet Union displays great influence on the rise of productivity of the public labour, upon the perfection of the conditions of life. It brings a colossal broadening of the human view of the Universe. The progressive advance of scientific thought in the Soviet Union is connected with the principal traits of Soviet society and with the tasks set by the Soviet people before itself.

The country struggling for peace and liquidation of the threat of a new war was the first country to start the peaceful use of the atomic energy. It was the first country to penetrate into the outer space.

The country where industry and science develop systematically and harmoniously for the benefit of man gives an instance of the most effective practical use of scientific discoveries.

The country where the people is for ever liberated from exploitation and oppression gives rise to thousands of gifted investigators of nature.

The country where science is guided by a strictly scientific outlook is rapidly accumulating data on the material processes underlying the phenomena of nature.

Such is the country where, in V. I. Lenin's words, "all marvels of technology, all achievements of culture" became property of the whole people.

The greater are the people's dreams and intentions, the more important is science to realize them. Therefore in the Soviet Union which solves great economic and cultural tasks, science is an important state domain, an object of care and help from the whole of the people.