RUSSIAN CHEMICAL REVIEWS
Uspekhi Khimii

March 1969

U.D.C. 54.001.47

The Development of Russian Chemistry and the Mendeleev Society† (The Centenary of the All-Union D.I.Mendeleev Chemical Society)

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A hundred years ago chemistry in Russia was represented by several score scientists, chiefly teachers, whose research interests were mostly concerned with the analysis of naturally occurring substances and their technological application. Only a few Russian scientists were engaged in theoretical studies on the borderlines between chemistry and physics, and investigations of organic syntheses only began in the middle of the last century.

M. V. Lomonosov's genius introduced fundamental concepts into many aspects of theoretical and practical chemistry, and foresaw the lines of development of chemistry for centuries to come; Lomonosov left a scientific legacy which exercised an immense influence over the subsequent advances of Russian chemistry.

Two scientists are regarded by science historians as the founders of the first large schools of chemistry in Russia: firstly, A. A. Voskresenskii, Professor at the Chief Pedagogical Institute, St. Petersburg, and at the University of St. Petersburg, who trained a number of generations of chemists including D. I. Mendeleev, N. A. Menshutkin, P. A. Il'enkov and others, justifying his reputation as the "grandfather of Russian chemists"; and secondly, N. N. Zinin, Professor at Kazan University and later at the Medical and Surgical Academy at St. Petersburg, whose students included, among others, A. M. Butlerov and A. N. Engelgardt.

Voskresenskii's and Zinin's outstanding activities reached their peak during the Forties and Fifties of the last century.

In 1854–1857, in St. Petersburg, P.A.Il'enkov, N.N.Sokolov, A. N. Engelgardt and several other chemists organised two small groups who used to meet at their houses to exchange the results of their work, help one another and engage in lively discussions of the ways to advance chemical industry and chemical education. Sokolov and Engelgardt equipped a private laboratory at home for the members of their group, offering facilities for those who wanted to experiment or to try out experimental techniques. The laboratory proved to be a great success. However, after only 3 years it had to be abandoned because of a lack of funds, and all the equipment was donated to St. Petersburg University, where Sokolov went in 1860 to deputise for D. I. Mendeleev, who was abroad. At that time, the chemical laboratory for the University students consisted of a single room, and the chemical laboratories of the Academy of Sciences numbered 4 rooms. This brief reference shows that the organisers of the abovementioned groups were active, forward-looking and public spirited men. Their biographical backgrounds are also interesting. Sokolov was a Law graduate of St. Petersburg University, who then joined the Natural Philosophy Faculty, graduating as Candidate of Philosophy. He worked for several years in various chemical and physical laboratories in Germany and France; then he studied the natural deposits of the Urals; eventually he became interested in organic chemistry, obtained his Doctorate, and embarked on courses of lectures in general and organic chemistry, which were brilliantly presented and greatly appreciated by students. Engelgardt graduated from the Artillery Academy, became interested in chemistry, retired, and began teaching chemistry at the Institute of Forestry. He was awarded a doctorate by St. Petersburg University, without defending a thesis, for his work on the

† An augmented paper given on 24th October 1968, at the Palace of Congresses in Moscow, at the plenary meeting to celebrate the Centenary of the All-Union D. I. Mendeleev Chemical Society, by the Society's President, S. I. Vol'fkovich.

Kursk phosphorites and on the development of the methods of alkali treatment of bones, among other topics. In 1870 he was arrested for being a member of the "Land and Liberty" party, and after serving a term of imprisonment at the Petropavlovsk fortress he was exiled from St. Petersburg and deprived of the right to live in University towns. He settled at the Batishchevo estate in the Smolensk region, where he lived for many years, working on agricultural problems, especially experiments on the use of phosphorites and the development of agricultural technology. It was not until 1880 that Engelgardt regained his right to free movement, through the good offices of the Russian Chemical Society. Lenin is known to have read Engelgardt's articles "Letters from the Country" with interest, noting their educational and populist bias.

Mendeleev took an active part in these groups, showing from the very start of his scientific and teaching career great social initiative, putting forward bold and original ideas. He never undertook any work or proposed any hypotheses without public discussion, at the same time taking an interest in the work of others and assessing it critically; also he always maintained close contact with Russian industry and with foreign scientists. Other members of these groups were also socially aware and progressive men.

They soon came to feel the need for attracting wider circles of chemists in order to enhance the scope of the work in various areas of chemistry. A proposal was made to organise an officially functioning Society.

Until 1868 a number of chemists were members of the oldest Russian scientific Society, whose membership was made up of widely varying specialists—the Free Economic Society (founded in 1765) and of the Russian Technical Society (founded in 1866), whose members were mostly connected with industry. Advances in chemistry and increasing specialisation created a need for more profound and many-sided contact between people working in chemistry, at that time still not a very popular science, and largely unfamiliar to many engineers, technologists, biologists, economists and other specialists.

THE FIRST FIFTY YEARS

The Eighteen-Sixties in Russia were a period of important social developments. The abolition of serfdom, the beginnings of capitalism and the first steps towards the exploitation of native natural resources had a great influence on the Russian intelligentsia.

The first congress of Russian natural scientists, called together on the initiative of the Chemical section, took place in St. Petersburg from 28th December 1867 to 4th January 1868 and adopted a resolution stating that it was desirable to organise a Chemical Society which would "have members in all Russian cities" and whose publications would include "the work of all Russian chemists". A special commission worked out the constitution of the Russian Chemical Society, and on 1st October 1868 the first organisational meeting of the Society took place under the chairmanship of G. G. Gustavson, at which Mendeleev reported on the views of the Scientific Committee of the Ministry of Public Education concerning the projected constitution of the Society. The constitution was approved by the Ministry on 6th November. At the first meeting of the Russian Chemical Society, with a membership of 35, on 18th November 1868 N. N. Zinin was elected President and N. A. Menshutkin—Secretary. The latter was Editor of the Society's Journal, which first appeared in 1869, for thirty years.

The Physical Society, which was organised in 1872 at St. Petersburg University, amalgamated with the Chemical Society in 1878 to form the Russian Physico-Chemical Society which soon acquired great authority and international popularity. This was especially due to the fact that the Society's Journal and the Society's members' meetings became a focal point and forum for many outstanding communications, investigations and discoveries.

In 1878 A. M. Butlerov was unanimously elected President of the Society.

It is possible to state, without "jubilee exaggerations", that no serious chemical investigation went without a report to the Society or publication in Zhurnal Russkogo Fiziko-Khimicheskogo Obshchestva, which over a period of 62 years (1869–1931) published about six thousand papers; the Journal was taken by all chemical libraries and laboratories abroad. Mendeleev presented his work to the Society and published 135 of his papers in its Journal, where A. M. Butlerov published 58.

Russian chemists considered it an honour to give a paper at the Society's meetings or have a paper published by the Journal. In fact, the epoch-making report of Mendeleev's discovery of the Periodic Law of the chemical elements was made at the Society's meeting by N. A. Menshutkin, on the author's behalf since Mendeleev himself was ill, on 18th March 1869; the paper was entitled "The Relation of Properties to the Atomic Weight of the Elements".

A. M. Butlerov first presented his theory of the chemical structure of organic compounds to the Society.

The first report on the invention of radio was made by A. S. Popov in 1895 at a meeting of the Russian Physico-Chemical Society. D. N. Chernov, who created the science of metallography, also presented a paper at the Society.

From the first days of its inception the Society was interested in science and industry, and tried to promote the development of productive potential and the creation of a Russian chemical industry.

To encourage original work and to attract younger scientists to research, the Society established a series of commemorative prizes for the best research projects.

Apart from the discoveries by Mendeleev and Butlerov mentioned above, a number of other outstanding investigations were carried out by Russian chemists in the last century.

In 1842 N. N. Zinin discovered the reaction for the preparation of aniline which formed the basis of the aniline dyestuffs industry all over the world. His work on primary aromatic amines initiated the synthesis of a number of intermediate products, pharmaceutical preparations, nitroglycerine, etc. The important dye, fuchsine, was discovered by Ya. Natanson in 1855.

In 1840 Hess discovered one of the basic laws of thermochemistry—the law stating that the sum of the heats is constant‡. His text-book "The Fundamentals of Pure Chemistry" saw seven editions during the author's lifetime.

In 1838–1841 A. A. Voskresenskii obtained a new alkaloid —theobromine, which found extensive application in medicine—and quinone, whose derivatives became intermediates in dyestuffs synthesis.

Professor K. K. Klaus of Kazan University discovered a new element—ruthenium, in 1844 and studied a number of other platinum metals.

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‡ Hess formulated his law 2 years before the appearance of Meyer's publication and 7 years before Helmholtz indicated the general significance of the principle of the conservation of energy.

During the Eighteen-Forties B.S. Yakobi invented galvanoplasty, without applying for a patent so as to make the method available for universal use.

In 1868 A.N. Engelgardt first established the effectiveness of using phosphorites as fertilisers in acid soils; I.A. Il'enkov proposed in 1865 an alkali method for making bone fertilisers.

N.N. Beketov first isolated metals from their solutions by means of hydrogen under pressure (1862–1865) and developed the alumothermal method of obtaining pure metals by reducing their oxides with aluminium.

In September 1883 K.E. Tsiolkovskii sent a number of papers, among them "The Work of Gravity" and "The Mechanics of a Congruently Changing Organism" to the Journal, whose editors, P.I. Borgman and I.M. Sechenov, noted the author's ability. In 1897 Tsiolkovskii asked for his projected experiments on the dirigible to be considered, and, should they be found to be promising, for a grant of 200 roubles to be made from the Society's funds. The Society found the proposed experiments to be most important and much larger scale investigations to be essential. In 1900 on the recommendation of the Society, Tsiolkovskii was given a grant by the Academy of Sciences, for experiments with large models.

A series of original papers on periodic systems, on the "Evolution of the Worlds from a Modern Astrophysical and Geophysical Point of View", and others, was presented to the Society by the former inmate of the Schliesselburg Fortress, the Populist N.A. Morozov. It is remarkable that Morozov, despite 29 years of solitary confinement in Tsarist prisons, must have been the first to postulate a hypothesis of a radioactive origin of the planets and stars.

At the First Mendeleev Congress, D.N. Pryanishnikov reported the results of his investigations of root secretions and his original work on the nitrogen feeding of plants.

In the Seventies and Eighties V.V. Markovnikov studied in depth the composition of Caucasian oil and discovered a new type of hydrocarbon compounds—the polymethylenes.

In our time it is superfluous to talk of the world-wide importance of Mendeleev's Periodic Law, discovered in 1869 and of Butlerov's theory of the chemical structure of organic compounds; these are now familiar not only to chemists but also to all educated people. It is fitting, however, to mention here that Mendeleev and Butlerov made great contributions to other areas of chemical science, industry and agriculture, as well as to public life.

Mendeleev, Butlerov, Zinin, Menshutkin, Beketov and their colleagues can, like their contemporaries in music, be justly called the "mighty bunch" in chemistry. They were indeed giants in chemical science. Engels wrote in his "The Dialectics of Nature": "Mendeleev made an immensely important scientific achievement in unconsciously applying the Hegelian law of the transformation of quantity into quality..."

Several other chemists who carried out outstanding investigations at the end of the last century should be mentioned.

A.P. Borodin, Professor of Organic Chemistry, physician and composer, reported in 1869 to the Society his studies of the products of acetaldehyde condensation and the discovery of a new aldol compound.

I.G. Kucherov discovered and elaborated (1881) a method for preparing acetaldehyde by catalytic hydration of acetylene, which became widely used for the production of acetic acid.

In the Eighties, N.A. Menshutkin became one of the pioneers in the study of the kinetics of a number of important reactions and the relation between the reactivity and the composition and structure of organic compounds.

A.E. Favorskii discovered and studied the interconversions of acetylene hydrocarbons, thus laying the foundations of an extensive range of industrial processes.

In the Eighties and Nineties D.P. Konovalov discovered the laws determining the evaporation and boiling of binary liquid systems.

I.A. Kablukov first discovered in 1889–1891 anomalous electrical conductivity in solutions of electrolytes in non-aqueous organic solvents.

In the Nineties, A.N. Bakh formulated the peroxide theory of slow oxidation, which explained the action of oxidising enzymes, the mechanism of respiration and a number of other fundamental questions.

N.A. Shilov, in 1904, studied the nature of conjugated reactions and developed the methodological basis for anti-gas protection.

In 1905 L.A. Chugaev discovered the rule of cycles in the chemistry of complex compounds, prepared for the first time a series of organic platinum compounds, and pioneered the use of organic reagents in analytical chemistry.

A.E. Arbuzov published in 1905 the first paper in an extensive and important cycle of investigations of the structure, synthesis and properties of organo-phosphorus compounds.

At the beginning of the twentieth century A.V. Kistyakovskii developed a detailed oxide theory of the appearance of reticulate films which passivate metals, this was of practical importance in connection with anti-corrosion measures.

N.S. Kurnakov undertook, in the Nineties, a systematic study in depth of the relationship between the composition and the properties of metal alloys, salts and other systems, developing his studies over half a century and founding a large school of physico-chemical analysis.

V.N. Ipat'ev published in 1901 his catalytic methods of preparation of a series of organic compounds, at high pressures and temperatures (hydrogenation, decomposition and other reactions), which found application in the petroleum industry and the technology of other hydrocarbons.

In 1897 L.V. Pisarzhevskii and P.E. Melikashvili (Malikov) published in the Society's Journal their work on the structure and properties of the peroxide compounds of a number of metals and peracids.

At the beginning of this century M.S. Tsvet created a new adsorption method of analysis—chromatography, which now enjoys the widest application and further development not only in analysis but also in technology, for the separation of complex mixtures of substances.

V.I. Vernadskii deserves special mention for creating the new branches of science which combined chemistry with geology and biology—geochemistry and biogeochemistry—and for laying the foundations of extensive radiochemical investigations and a systematic study of Russia's productive potential.

N.D. Zelinskii is gratefully remembered for developing in 1915 a carbon gas-mask which saved the lives of many thousands of soldiers during the First World War; he also pioneered much work on catalytic transformations of hydrocarbons, petrochemistry, and the chemistry of proteins and other substances.

The list of outstanding research of the last century and the beginning of the present one could, naturally, be very much extended, but even the above selection suffices to illustrate the high level of originality and the fundamental significance of the investigations undertaken in the unfav-

ourable climate of pre-revolutionary Russia. All the research work mentioned above was either reported to the Society or published in its Journal.

In his speech at the annual meeting in 1924 the President of the Chemical Society in England, Wynne, stressed the great importance of the work of Russian chemists and advised young English chemists to study the Russian language in order to be able to read Russian publications in Zhurnal Russkogo Fiziko-Khimicheskogo Obshchestva in the original. Similar views were expressed by scientists in other countries.

It is worth mentioning that strong materialistic, progressive and democratic tendencies were characteristic of the Russian Chemical, and subsequently the Russian Physico-Chemical, Society. Many of its leading members repeatedly attacked the reactionary Tsarist regime and social oppression.

N. N. Zinin, N. N. Sokolov and others often spoke against idealistic philosophy, pointing out that it ignored the achievements of materialistic natural science.

Leading Russian chemists were sharply critical of Wilhelm Ostwald from the time of the appearance of his energetic teachings; in 1895 he read a paper entitled "The Untenable Nature of Scientific Materialism", rejecting atomic and molecular concepts. Mendeleev, Beketov, Vernadskii, Kablukov, Kurnakov, Kurbatov and many others were among the many chemists and physicists who defended materialistic concepts and the atomic-molecular theory. These discussions often appeared in the pages of the Journal. Mendeleev had this to say about Ostwald's views: "There are scientists who deny matter, since, they say, we know only energy .... matter is only energy .... such concepts ... cannot be entertained in any sane mind"[1]. Lenin is known to have considered Ostwald's views critically and in detail in his work "Materialism and Empiric Criticism", in which he called Ostwald "a very great chemist and a very confused philosopher"[2]. As the result of discussions and a series of experimental verifications, Ostwald was forced to admit, in 1908, that he had been mistaken.

In another guise, the pre-eminence of energy, and in particular, of electricity and electrification in relation to chemistry and its application formed the subject of numerous discussions[3-8]. G. M. Krzhizhanovskii wrote: "Chemistry is becoming a section of the general subject of electricity". The resolution of the Plenary Session of the Central Committee of the Communist Party of the Soviet Union dated 13th December 1963 states: "We can now say, with full justification, that Communism is Soviet power plus electrification of the whole country plus the application of chemistry to the national economy".

The Society has often discussed the economic problems of the chemical industry, including metallurgy, the production of building materials, the food, textile and other industries, as well as the production and use of mineral and organic fertilisers.

The Society's members have often expressed anti-Malthusian views. Mendeleev called the "theory" and proposals put forward by Malthus—"ravings", and D. N. Pryanishnikov, who gave a lecture on "Malthus and Russia"[9], said that "... for another 150 years Russia need not worry about the supplies of food, even if it doubled its population every 50 years".

Despite his dualism in some of his social and political views, Mendeleev was a true revolutionary not only in science and technology, but also in many state and public undertakings. He not only urged the industrialisation of the country and help for agriculture by industry, but also actively assisted this by his fundamental economic studies, his frequent visits to mines, industries, factories, agricultural and forestry concerns. He did much to promote higher education for women, encouraged cooperation, and despite the approaches of capitalist oil-producers and others, refused on principle any participation as a member or shareholder of their concerns.

Both Mendeleev himself and his closest friends were both great patriots and convinced internationalists who maintained friendly scientific contacts with chemists abroad.

In 1870, when the German chemists Kolbe and Volhard put forward nationalistic views, chauvinistically designed to debase the importance of French chemical research and elevate German work, Zinin, Butlerov, Mendeleev and Engelgardt published a protest against nationalism and chauvinism in science.

An excerpt from the telegram sent by the Russian Physico-Chemical Society in April 1906 to the French Physical Society on the death of Pierre Curie is interesting for ideological insight. It said: "Curie should be dear to all nationalities. He belonged to that part of the French people who work for the benefit of all humanity and do not serve the base interests of finance or reactionary governments".

Mendeleev was not only a man of the highest principles and progressive concern for social advancement, but also a bold and courageous citizen who never put personal interests before those of the community. One example of this was when he left the University as a protest during student unrest.

He took the refusal to elect him as an active member of the Academy of Sciences as a public affront, since almost all the Universities and learned societies in Russia and a number in other countries had elected him as an honorary member, and expressed their angry indignation at this rebuff.

It is instructive to recall that, despite the deep friendship between Mendeleev and Butlerov, when they were involved in their well-known controversy about the existence of spiritualism Mendeleev spent much effort and time in attempting to refute Butlerov's errors and misconceptions by experimental and strictly scientific means—with objectivity, loyalty to principles and love of truth which never deserted them.

The Society reacted vigorously more than once to the reactionary actions of the Tsarist government. Below is a characteristic excerpt from the minutes of the meeting of the Chemical Section of the Russian Physico-Chemical Society, four days after the infamous mass shooting of the workers in the Palace Square on 9th January 1905. The minutes, signed by N. S. Kurnakov, say: "In view of the terrible events of recent days and the impossibility of finding the peace of mind needed for the discussion of scientific reports, the Chemical Section, on the suggestion of the Council, resolved to close the meeting... The memory of those who fell was honoured by standing". Several subsequent meetings of the Society were also overshadowed by the political events of those times.

On 9th January, Mendeleev, troubled by the atrocities in the streets, went to see S. Yu. Vitte, in an attempt to persuade him to stop the massacre, but returned extremely depressed, since it was all to no avail[10].

The Society not infrequently approached the Tsarist government with requests and proposals concerning improvement of higher chemical education, greater autonomy for the Universities, admission of women to Universities, financial aid for research and other questions, but these were almost always rejected.

During the First World War, when the whole Russian industry, including the chemical, stood revealed in all its enormous backwardness, being unable to meet the needs of

defence and the production of essential medical supplies, the chemical community showed great initiative and persistence, and obtained permission to extend the scope of the most nationally-important scientific investigations.

Russian chemists throughout the last century devoted much time and effort to the popularisation of chemistry. Popular scientific lectures were often given by Hess, Butlerov, Il'enkov, Kittary, Khodnev, Sokolov, Markovnikov, Lesgaft, Shugaev, Shilov and Kablukov; these lectures were a great success. The Society took part in several exhibitions, where new synthetic compounds and apparatus, created with the Society's help, were demonstrated.

The Moscow Polytechnical Museum was founded in 1872, chiefly through the efforts of Professors Bogdanov and Arkhipov of Moscow University, and the Moscow Society of the Friends of Natural Sciences, Anthropology and Ethnography§. A number of exhibits was given to the Museum by members of the Russian Physico-Chemical Society, who gave popular lectures at the Museum.

It is clear from the above that the pre-revolutionary development of the Society was often chequered. It may be interesting to recall that among those professors and lecturers who left Moscow University as a sign of protest against the actions of the Tsarist Minister Kasso were such prominent members of the Chemistry Department as V. I. Vernadskii, N. D. Zelinskii, A. V. Rakovskii, N. A. Shilov, A. E. Chichibabin, S. S. Nametkin, A. K. Reformatskii and many others. The Chemistry Department noted in its records the enormous loss suffered by the University as the result of this action and in appreciating the immense sacrifice made by the people concerned, it expressed to them its deep sympathy and certainty that "in any case their gifts would not be lost to science, which is close to us all". Vengeful Tsarist officials stooped so low as to forbid the Russian Physico-Chemical Society twice to make a collection towards a monument to A. M. Butlerov in Kazan.

Mendeleev and Menshutkin died in January 1907. These grievous losses naturally led to an even stronger wish to consolidate the "chemical fraternity" (Mendeleev's expression), and the special meeting of the Russian Physico-Chemical Society dedicated to Mendeleev's memory and held in March 1907 adopted the resolution to organise periodically Mendeleev Congresses of Pure and Applied Chemistry¶. The First Mendeleev Congress took place in December 1907 in St. Petersburg; it united not only chemists but also physicists, engineers, technologists and a number of biologists. For this reason, the Chairman of the Congress was the eminent chemist N. N. Beketov; the Praesidium of the Congress included, as Vice-Chairman, P. N. Lebedev, the physicist; N. E. Zhukovskii, the mechanical engineer; I. A. Kablukov, S. N. Reformatskii, F. M. Flavitskii and P. I. Valden, the chemists; D. N. Pryanishnikov, the chemist and agricultural chemist; the Swedish chemist Arrhenius, and as Secretaries—L. A. Chugaev and K. P. Kasterin.

The First Mendeleev Congress was very representative and fruitful. Over a thousand delegates from 80 cities took part in it. All the most eminent Russian chemists, physicists, and technologists played an active part in the work of the Congress.

The Second Mendeleev Congress took place in St. Petersburg in December 1911. It was concerned not only with questions of general chemistry and physics, but also with chemico-technological, metallurgical, silicate, pharmaceutical and food problems. N. A. Umov was Chairman of the Congress, N. D. Zelinskii, T. A. Tamman, D. A. Goldgammer and A. G. Gruzintsev were Vice-Chairmen, and L. V. Pisarzhevskii and A. F. Kolli—Secretaries.

Foreign scientists attended the Congresses. During the Second Congress the Mendeleev Museum, situated in part of his University flat, was opened at St. Petersburg University. This is not merely a commemorative institution, but also a scientific one, since it contains Mendeleev's collected manuscripts and published works, which are still being studied and republished†.

The fact that no funds were made available to establish a Chair of Physical Chemistry at St. Petersburg University was lampooned in a specially written satirical play by B. B. Byzov and colleagues "A Tragedy of Physical Chemistry or the Fatal Hole in the University Stocking", which was performed at the Second Congress.

Further Mendeleev Congresses took place after the October Revolution.

THE SECOND FIFTY YEARS

The October Socialist Revolution, which turned the history of mankind in a new enlightened direction, naturally also had a revivifying effect on the chemical community. Scientific life, like the life of any organism which is bound up with its environment—climate, sources of nutrition and other vital conditions—is bound up with the social structure, the ideological interests of the society, its economic possibilities and aims, its cultural level, etc.

Thus the second fifty years of the Society's activities are characterised not only by an approximately 300-fold growth of its membership, but also a sharp change in the content and form of its work. Whereas formerly most of the members were science teachers predominantly from capital and large cities, after the Revolution there has been an ever growing influx into the Society's membership of specialists in chemical and allied industries, as well as industrial innovators and students, working in all the chemical centres of the Soviet Union.

At present the Mendeleev Society consists of 1949 primary organisations, 81 Republican, area and regional associations and a total of 171,000 members. The membership of the Russian Physico-Chemical Society in 1917 totalled 565.

In addition to the many specialised sections, the Society has under its aegis many teams working on special projects, and various commissions, institutes, laboratories, courses, schools, groups—with numerous annual cycles of lectures and practical courses for raising scientific and technical qualifications, excursions to leading industrial concerns and research Institutes both in the Soviet Union and in other countries, predominantly the Socialist ones. Participation of students and pupils from the higher forms of high schools has recently increased considerably—the "Young Chemist" section of the Society, organised 3 years ago, now has a

§ In response to public requests, the Government together with industrialists assigned 500,000 roubles towards the establishment of the Museum. A special building was built for the Museum in 1877; it now belongs to the All-Union Society "Nauka" (Science).

¶ These Congresses are now known as the Mendeleev Congresses of General and Applied Chemistry.

† In connection with the forthcoming centenary (in 1969) of the discovery of the Periodic Law, the Government has decided to place the whole of Mendeleev's flat at the disposal of the Museum and to refurbish it. The Leningrad section of the All-Union Chemical Society organises annual Mendeleev readings, devoted to present day chemical problems.

membership of 75 thousand. The All-Union Chemical Society, together with the "Nauka" Society, organises chemical contests and exhibitions and publishes popular scientific literature. The Mendeleev Society organises hundreds of scientific and technological meetings and conferences in various towns and factories every year.

The Mendeleev Congresses of Pure and Applied Chemistry enjoy great popularity in the Soviet Union and abroad; they are milestones in chemical circles, attracting thousands of active participants in recent years. Each Congress has been carefully prepared and has served not only as a review of achievements, but also as a gateway to new and fruitful lines of research and progress.

The Third Congress, convened in 1922 in Moscow (the first after the October Revolution) paid particular attention to the development of the chemical industry, which at that time was going through a difficult period of recovery.

The Fourth Congress took place in 1925, in Moscow; a number of fundamental theoretical studies in chemistry, physics and biology were reported, as well as communications concerning new chemical technological investigations.

The Fifth Congress took place in 1928, in Kazan—"the Russian chemical Mecca"‡; it was dedicated to the memory of A. M. Butlerov and his scientific legacy. In addition to the theoretical papers, the Congress approved unanimously a note on the application of chemistry to the national economy submitted not long previously to the Government, and adopted a number of resolutions aimed at the construction of chemical plants and the application of chemistry to agriculture on a new scientific and technological basis. This Congress initiated the All-Union Bureau of Higher Chemical Education, the Commission for the Chemical Nomenclature of Inorganic Compounds, and expressed a wish to establish a chemical research Institute in Kazan, which was created under the directorship of A. E. Arbuzov and has been for many years now active in much original work.

The Sixth Mendeleev Congress was held in 1932 in Kharkov, during the final period of the First Five-Year Plan; it was planned to coincide with the fifteenth anniversary of the October Revolution. At this Congress it was possible to summarise the significant achievements of Soviet Chemistry during the early years of the First Five-Year Plan and to outline new perspectives for the Second Five-Year Plan. The Congress looked particularly closely at the problems of further development of the main branches of the chemical industry—the production of sulphuric acid, synthetic ammonia, phosphorus and potassium fertilisers, the development of electrochemical industries, the production of artificial fibres, plastics, and synthetic rubber, as well as the training of chemists and the various aims of applying chemistry to the national economy. This Congress adopted the resolution concerning the need for uniting the chemists working in different areas of science and technology within the single Mendeleev All-Union Chemical Society.

The Seventh Congress took place in 1934 in Leningrad and celebrated the centenary of Mendeleev's birth. Many foreign scientists attended this Congress. The main papers dealt with the modern status of the Periodic Law and Mendeleev's other fundamental work in various spheres of science and technology, and the current problems in these directions.

The Eighth Congress was held in Moscow in 1939 and was the best attended and most representative of all the others. Hundreds of the most diverse papers were given in plenary and specialised sessions, which reflected the considerable achievements in theoretical and industrial research; the main goals of chemistry within the National Seven-Year Economic Plan were also considered. Foreign scientists contributed many papers at this Congress§.

The war which broke out in 1941 delayed the Ninth Congress by many years, in fact until 1965. This Congress, unlike its predecessors, dealt with narrower, more current problems linking chemistry with biology and the corresponding areas of technology: the application of chemistry to agriculture, medicine and the production of food. It took place in Kiev. The Congress discussed fertilisers, animal feedstuffs and sanitary preparations, chemicals for the protection of plants, pharmaceutical preparations, perspectives in synthetic foodstuffs, and many other problems.

The Tenth Mendeleev Congress will take place in the autumn of 1969 in Leningrad, and will celebrate the centenary of the Periodic Law, and deal with its status, applications and perspectives.

The connections between the Society and various Ministries and scientific and economic organisations are growing closer every year.

Many books[12,13] and articles[14-38] dealing with the achievements of Soviet chemistry during the last half-century were published in connection with the Jubilee of the October Revolution in 1967. We shall be dealing later with the Society's work at various periods of Socialist progress. Together with the development of well-established schools, many new schools of chemistry and many new lines of research appeared in the Soviet Union, some of which have gained world recognition, and are developing vigorously not only in the direction of chemical science and industry, but also in close contact with physics, biology, geology and other natural and technological sciences. The new Soviet schools of chemical kinetics and catalysis, photochemistry, electrochemistry, polymer chemistry, fundamental organic synthesis and organo-elemental chemistry, naturally occurring compounds, radiochemistry and isotopes, physicochemical mechanics, and others, are well known.

"Hybrid" sciences have appeared and are rapidly developing: among them chemical physics, biochemistry and agricultural chemistry, bio-organic chemistry, molecular biology, polymer chemistry, radiochemistry, geochemistry and biogeochemistry, photochemistry, chemotherapy, chemical microbiology, astrochemistry and cosmochemistry, chemical materials science, chemical cybernetics.

Schools of chemistry and research have been developing, since the Revolution, in all Soviet Republics and regions, in industry, farming, clinics, expeditions on land, sea and in space.

It is relevant to recall that before the Revolution there were no national organisations coordinating and directing the development of chemistry; there were only small groups of qualified chemists working in the Academy of Sciences, colleges and factories. There was not a single Chemical Research Institute. Therefore the Russian Physico-Chemical Society, whose active members included practically all the leading and most highly qualified chemists in the country, rapidly became the most authoritative scientific association of chemists not only in Russia, but also abroad. Mendeleev, in his remarkable note, only published in 1966, "What kind of Academy is needed in Russia?"[39] stressed the need for the integration of science

‡ A. E. Favorskii's expression.

§ Detailed information about the work of all the Mendeleev Congresses is available in the Transactions; that of the first eight is described in V. V. Kozlov's monumental work[11].

and technology and the importance of the Academy of Sciences as a social factor. He said:

"The monastery, the academy and the university—these are the successive stages of the development of science, characteristic of past centuries... It could be said that the rôle of the monastery in science was first progressive and then conservative. In the most recent times.... science made a further step, directly into life itself. Almost every Ministry needs a scientific committee...where possible mutual contacts have been established, and scientific societies formed....

The history of the development of Russian scientific societies is short, but it is already very instructive.... by summation of resources achieving a more significant resultant... Without taking into account the development of scientific Societies in our country it seems to me impossible to achieve any further understanding of the rôle of the Academy of Sciences. Science is absolutely free. That is how it has come to be in scientific societies... The Academy will have dual responsibilities: firstly, as a central scientific society... secondly as a central scientific council, which should also deal with undertakings of practical national importance.

....Science is pre-eminently not a private and detached concern, but a social and public one....

...The Academy should have the funds not only for its own research programmes but also for helping other societies in this respect..."

Much of what Mendeleev was urging only came to be realised after the Revolution.

The qualitative and quantitative growth of chemical science and technology in the USSR has, undoubtedly, been determined to a great extent by the industrialisation of the country and the genuine cultural revolution which has been, and is being, promulgated by the Communist Party since the first days of the October Revolution. In fifty years Soviet chemistry has grown into a mighty power, which at present produces about fifteen thousand various products in amounts several hundred-fold greater than before the revolution. As early as December 1917 a chemical section was established within the Supreme National Economic Council, in which highly qualified chemists with a social awareness played the most active role, under the direction of L.A.Karpov. Lenin, in his article "Current Aims of the Soviet Government" put the development of the chemical industry among the top-priority aims, and in his "Outline Plan for Scientific and Technical Developments" he said: "The Academy of Sciences, having started a systematic investigation and survey of the productive potential of Russia, should be commissioned forthwith by the Supreme National Economic Council to form a series of specialist commissions to expedite as rapidly as possible a plan for the reorganisation of industry and the economic progress of Russia"[40].

The Russian chemical community, represented by the most outstanding scientists such as L. Ya. Karpov, A. N. Bakh, V. N. Ipat'ev, E. V. Britske, P. M. Luk'yanov, Ya. V. Samoilov, D. N. Pryanishnikov, N. S. Kurnakov, N. D. Zelinskii, N. F. Yushkevich, V. P. Kamzolkin, V. S. Kiselev, M. N. Gurvich, I. A. Tishchenko, B. S. Shvetsov, P. P. Budnikov and others, came out on the side of the Soviet government at once, without vacillation.

The enthusiasm and deep sense of responsibility to their country felt by Soviet chemists is well illustrated by the now historical note, sent by a considerable group of scientists to the Soviet Government in March 1928, offering their services to the development of chemical science and technology, and the use of their achievements in other areas of the national economy and culture. These proposals were discussed with a delegation of scientists¶ and considered by a specially appointed Government Commission, made up by Ya. E. Rudzutak, G. K. Ordzhonikidze, A. I. Mikoyan, G. M. Krzhizhanovskii and N. P. Gorbunov; as the result of this, the Council of the People's Commissars of the USSR issued an edict on 28th April 1928 "Measures for the Application of Chemistry to the National Economy", which was followed by the formation of a very representative Committee of highly qualified specialists and Government officials, and the organisation of a chemical section in the State Planning Organisation of the USSR. The Committee was chaired by Ya. E. Rudzutak, and then by V. V. Kuibyshev.

The remarkable note mentioned above, which even now makes most interesting reading, said:

"..... The profound changes which have recently occurred in the concepts of the elementary nature of matter mark an epoch in the history of science. In the field of chemistry the past decade has seen attempts at penetrating the structure of matter, which open up limitless future possibilities of its technological exploitation (catalysis, radioactivity, intra-atomic energy, etc.). The achievements of theoretical chemists have created such an integrated picture of the interaction of atoms that it has become possible to elaborate systematically and rationally an experimental elucidation of, among others, the chemical processes in the soil and in plants. Chemistry is now at the point of transition to the most extensive and profound development of all its technology.

The new chemistry has created a large number of materials until recently completely unknown, such as synthetic fibres, oil, leather, rubber, plastics, tanning substances, light alloys, etc., and its further development is bound to create a revolution in the industrial economy. Even greater economic achievements are foreshadowed by the use of all wastes, i.e. raw materials present in the wrong place which have so far not found their application.

A general plan of economic development must take into account all the prospective developments of modern science, which clearly show the ever growing influence of chemistry on the replacement of many mechanical processes in industry, agriculture, defence and daily life by chemico-technological ones.

A great advantage for the creation of future new technology in the Soviet Union is likely to be, paradoxically enough, its very poverty at this time, i.e. the absence of large investments in the form of capital and equipment, since experience has shown that the application of advanced scientific ideas is often hampered in capitalist countries by the need to run the equipment down to complete depreciation.

These measures designed to advance chemistry can effect the most radical changes both in the technological aspect and the economic structure of industry, be it metallurgy, mechanical engineering, mining, transport, textiles and other branches of the national economy, considerably lowering the costs of production and raising the efficiency of capital investment.

The solution of the above economic problems is particularly bound up with the development of chemical science in the USSR.

¶ The delegation was led by A. N. Bakh, who later became the first President of the Mendeleev All-Union Chemical Society.

The Soviet Union, as a country which has taken giant steps in the rearrangement of the social and economic conditions must first of all direct the full might of chemical thought towards the fullest development of chemical technology. This will give a firm basis for economic development and at the same time ensure the country's invulnerability and independence in the event of possible hostile actions.

History has shown that the rapid flowering of chemistry in the nineteenth century, which created all the brilliance of chemical science seen now, was initiated and determined by theoretical scientists: Lavoisier, Brane, Dalton, Faraday, Dumas, Le Chatelier, Frankland, Hoffmann, Bayer, Clapeyron, Zinin, Mendeleev, Butlerov, and others. Lavoisier, Faraday, Lomonosov and Mendeleev examplify the fact that the greater the scientist as a theorist, the clearer his view of the requirements conditioned by life and by technology.

In order to utilise rationally the country's immense and varied natural resources it will be inevitably essential to solve a series of new problems on the basis of our own, original, creative and purely scientific work. It is not sufficient to make use of Western discoveries—we must ourselves be at the forefront of chemical research.

It follows from this that our country's urgent aim should be the widest development of scientific research, regardless of cost, and not only in applied but also in theoretical chemistry.

In addition to extensive planned research related to current industrial needs, generous funds should be allocated to theoretical research outside such a plan, which would provide starting points for radical changes in chemical technology.

It is essential to extend and reinforce mutual contact between our scientists and industrial organisations and the leading countries of the world, making these contacts more constantly systematic and easy, by increasing the number of visits to foreign countries, by inviting foreign consultants to the USSR, and by other means.

Scientists should be involved in the development of a general plan for the chemical industry and agriculture, and play a bigger part in the work of factory laboratories and industrial workshops.

Great care must be given to the organisation and equipment of factory laboratories, and to improving the working conditions of factory technical personnel, always providing opportunities for improving their qualifications.

The call to organised work embracing such wide horizons will, naturally, bring to life the potential creative forces and enthusiasm in both the mature and the young chemists, physicists and technologists.

The undersigned appeal to the Government to organise within the Soviet People's Committee a special Commission on the application of chemistry to the national economy, to discover and apply all the measures necessary for achieving this goal"[41].

The Soviet People's Committee defined the main aims of the Commission as follows:

"The Commission must give top priority to a detailed scientific, technological and economic study of the following problems: the rational utilisation and extension of native natural resources; the application of modern chemical developments to individual branches of industry and social needs—building, transport, public health, and others; the production of agricultural fertilisers and insecticides and fungicides; the establishment of a potash industry; the further development of the organic dye-stuffs industry; the radical reconstruction of the coke and petroleum industry; the industrialisation of modern forest chemistry; the investigation and maximal development of the rare elements industry; the basic problems of modern synthetic chemistry (synthetic rubber, petrol and liquid fuels, synthetic esters, etc.); and the increased production of chemically pure reagents and laboratory equipment in the USSR"†.

The penetration of chemistry, its methods and products, into the different areas of the national economy became so important and widespread that a special term "chemisation" was coined for it in the Soviet Union, later used also in other countries; it has come into common usage in much the same way as "mechanisation" and "electrification".

During the First Five-Year Plan vast deposits of Khibinsk apatites, and Solikamsk potassium salts were discovered and developed; the first synthetic ammonia plants were built and a series of other basic mineral and organic chemical concerns established. Large teams began working within a single plan, in a coordinated tackling of research, design, construction, equipment and production. The chemists and engineers showed great creative enthusiasm in those years, helping in a variety of ways to solve the difficult problems of prospecting for and utilising mineral deposits, and to apply scientific discoveries to practical needs.

Members of the Society initiated the establishment of a series of Institutes, both in central and remote regions. They now number over 150.

A group of organic chemists led by I. P. Losev prepared the first comprehensive report on the paths for the development of basic organic chemical industry, which was approved by the planning bodies.

During the Second World War the Society carried out diverse research and production projects for defence. Many leading specialists offered their help to the Government in the very first days of the war; as the result of this, the State Committee for Defence appointed an executive to deal with chemical matters, with a staff of specialists who helped to mobilise those working in colleges, research, and industrial organisations for development work required to meet the needs both of the frontline and the rear. Much was achieved in mobilising natural resources and raw materials, organising the production of sanitary and medicinal preparations, and in matters of chemical defence.

Whereas the role of chemists in the early Five-Year Plans was primarily consultative, on their own initiative, and concerned with individual proposals, after the war the All-Union Chemical Society has been organically and systematically included within the general State economic planning; this has occurred in accordance with Party and Government resolutions. The Society now not only puts forward its proposals and criticisms but also makes practical contributions towards the realisation of plans, the improvement of the quality and tempo of research, of design and construction projects and of building and industrial undertakings. This activity of the Society is continually growing and gaining in variety, especially on sites.

In recent years much work has been done by the Society's sections dealing with higher education, polymers, silicates, and the application of chemistry to agriculture (chiefly in the South-Western regions).

Evaluation commissions, reviewing and recording many hundreds of research and industrial papers, have been

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† Detailed data on this are in the Transactions of the Commission's plenary sessions and also in the Journal published by the Commission "Khimiya isotsialisticheskoe Khozyaistvo" (Chemistry and Socialist Economy) (Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatelstvo).

working hard both at headquarters and in some of the branches. The Society acts as scientific and technical consultants in many industrial concerns. The State Committee of Science and Technology at the Council of Ministers of the USSR, the Academy of Sciences of the USSR, and the Trade Unions maintain regular contact with the Society, to mutual advantage. The Society aims not only at responding creatively to various Party and Government resolutions, but also at initiating and promoting progressive ideas, techniques, and theoretical and practical achievements.

Special mention should be made of the Society's work over many years in organising systematic courses, conferences and reference publications on the chemistry and technology of polymers, which are very popular among chemists for bringing them up to date. Some sections of the Society have done similar work on new analytical techniques and production control. The Society also has considerable consultative functions in connection with the current economic reforms. However, these progressive functions are concerned more with chemico-technological and industrial matters, than with theoretical and scientific ones. Therefore the Society is now assisting with the development of fundamental research both in Institutes and in industrial laboratories.

Among the most active leading members of long standing in the Society during the Soviet era have been: N. S. Kurnakov, N. D. Zelinskii, V. M. Rodionov, V. S. Kiselev, I. P. Losev, P. P. Budnikov, P. M. Luk'yanov, A. I. Lazarev, V. V. Kozlov, Z. A. Rogovin, S. N. Danilov, S. A. Shchukarev, A. I. Brodskii, M. M. Dubinin, A. E. Porai-Koshits, L. K. Lepin, E. A. Shilov, I. I. Chernyaev, S. S. Nametkin, N. M. Zhavoronkov, O. E. Songina, V. M. Kakabadze, O. S. Stepanova, N. M. Karavaev, S. V. Gorbachev, and other chemists.

We shall now mention some achievements in those spheres of modern Soviet chemistry where the main contributions have been made by active members of the Society.

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The variety of chemical elements and natural raw materials used by chemical industries increases annually. Petroleum, industrial and natural gases, coal, wood pulp, sand, limestone, clay, aluminosilicates and many other widely distributed natural raw materials are extensively utilised. The scope of synthetic chemistry has grown tremendously.

The advances of atomic physics and chemistry have made it possible to synthesise and to degrade elements, thus laying the foundation of revolutionary transformations in chemistry and in chemical technology. The remarkable words of A. M. Butlerov, written about ninety years ago, are relevant to the immense and rapidly expanding advances in organic synthesis. He wrote: "... it is certain that every organic substance can be synthetically produced"[42].

These words have become the slogan of modern chemistry, whose aim it is to synthesize the most varied and complex substances with tailor-made properties, utilizing for this purpose common and preferably cheap raw materials. At the same time there has been a great increase in the utilization of mineral raw materials containing rare and transition elements, coloured and noble metals, etc. Chemists are paying more and more attention to complex processing methods and to the elimination of industrial waste.

The problem facing contemporary science is extremely important and difficult: the relationship between the properties of numerous and varied materials and substances and their composition and structure. Many of these substances are novel and important, including semi-conductors, thermostable materials, quantum-generating and biologically active substances.

The deep penetration of organic chemistry into biology has led to the most refined and complicated syntheses of analogues of natural products—e.g. sex hormones, vitamins, enzymes, antibiotics, etc.—and to the discovery of substances carrying genetic information and of mutagens, thus demonstrating the great achievements of science. Similarly, the collaboration of physicists and chemists has resulted in the discovery of twelve elements of the periodic system (eleven transuranium elements) and over 1800 radioactive and stable isotopes. Many of these have proved useful in various spheres of industry, public health and scientific investigations. The achievements of inorganic chemistry have been enormous in the last twenty-five years, especially in radiochemistry, the chemistry of rare and transition elements, extra pure semiconductors, ultra hard and chemically stable substances, etc., as well as in studies in depth of the structure, properties and transformations of inorganic matter. Many of the rare and transition elements have remarkable properties and play an important part in the production of special steels and metal alloys, endowing them with hardness, thermostability, resistance to corrosion and many other valuable properties. Certain rare elements are widely used in electronics, in radio engineering, photographic technology, production of ignition compounds, in medicine and in agriculture. Compounds of some chemical elements are used as microfertilizers and in food supplements in animal husbandry, etc.

As a result of notable achievements in organic syntheses, various classes and groups of organic compounds previosuly regarded as strictly individual have become interconvertible, and some considered inactive ("chemical corpses" in the acute words of M. I. Konovalov) are now easily converted into other compounds. These successes have opened up possibilities of using less valuable, extensively occurring raw materials instead of more valuable and scarce ones. The raw material resources of chemical industry are thus constantly expanding.

On the basis of extensive creative efforts of Soviet chemists the petroleum and gas industries have created numerous new processes which form a solid foundation for basic and heavy industrial organic synthesis.

The production of high molecular weight compounds has developed extensively and fruitfully, particularly since the plenary session of the Central Committee of the Communist Party of the USSR in May, 1958. Soviet industry produces many scores of various types of rubber, plastics, fibres, films, etc. Many synthetic high-molecular weight compounds have remarkable properties superior to those of natural products. The achievements in this area have resulted in a peculiar competition between the synthetic and natural materials.

The notable work of S. V. Lebedev and other chemists has resulted in the Soviet industry's being the first in the world to produce synthetic rubber from alcohol. The method of Lebedev has found wide application in several countries abroad. Synthetic rubber is also made in the USSR from other raw materials, e.g. gases from petroleum processing, acetylene, etc.

Work on the synthesis of organosilicates has acquired great interest and increasing importance since their use in the production of rubber-like plastics results in great sta-

bility to temperature variations, and in electrical insulation, hydrophobic and other properties. They are also used in making special high quality resins, lacquers, etc.

Soviet workers have synthesised and studied in detail a series of new and modified synthetic fibres of high quality, used in many branches of technology.

Considerable advances have also been made in recent years in the production of inorganic polymers of high thermostability, particularly among polyphosphates and polysilicates.

High molecular weight ion exchange resins capable of removing various ions from solutions are widely used in many technological processes which require the isolation of rare, valuable or radioactive elements from very dilute solutions. The resins are also used in the high purification of water, in analysis and in other spheres. Soviet chemists have synthesized scores of divers highly efficient ion exchange agents.

Among the outstanding achievements of Soviet organic chemists over the last 20–30 years the following should be mentioned as having theoretical and practical significance: dehydrocyclization of paraffins to cyclopentane hydrocarbons; the development of the cumene process of phenol synthesis and the synthesis of acetone from isopropylbenzene; the development of the synthesis of benzene homologues; the discovery of the disproportionation reaction of cyclopentane in the presence of vanadium oxide; the discovery of the opening of three-membered rings through the action of mercury acetate; the development of processes for the production of alcohols and fatty acids through the continuous oxidation of paraffins, etc.

Of great future significance are the numerous studies in various spheres of organo-elemental chemistry. Among these especially noteworthy are the development of the diazo methods of synthesis, the investigations of ferrocene, and the study of the reactions of radicals in solution.

A series of new methods of preparation of aromatic compounds has been developed. A method for the production of anthraquinone sulphonic acid has been worked out; interesting studies of the chemistry of heterocyclic compounds have been carried out. A new area of organic chemistry—fluoro-organic compounds—has been developed. V. M. Rodionov has worked out original methods of synthesizing beta-amino acids. V. E. Tishchenko has studied in depth pinene and camphene, whilst A. E. Arbuzov has investigated terpenes.

A. E. Favorskii and his school have produced extensive and very fruitful work in the field of organic syntheses based on acetylene, including the production of synthetic rubbers, glues and other high-polymer materials.

One of the most important problems facing chemical industries is the substitution of synthetic raw materials for edible plant raw materials currently used for technological purposes.

Considerable successes have been achieved in the syntheses of new and of more effective medicinal, disinfectant and analgesic compounds. Soviet medicine is indebted to I. N. Nazarov for the discovery of promedol and of other very effective analgesics. Substances enhancing the maturation of blood corpuscles, organic fluoro-compounds and other polymers are used successfully in surgery in replacements of blood vessels, and of bone and other tissues.

A. E. Chichibabin, V. M. Rodionov, their students and collaborators and other investigators have carried out detailed investigations into drugs and into series of analogues of natural products. Recent years have seen successful collaboration between chemists and biologists and doctors on the synthesis of powerful agents against tuberculosis, pneumonia, encephalitis, dysentery, poliomyelitis, leukemia and various infectious diseases.

Numerous chemicals have been developed which are active against plant pests and diseases and against weeds; defoliating and desiccating agents for the pre-harvest removal of leaves from cotton plants, potatoes and other vegetables; stimulants and regulators of plant growth and many other physiologically active substances. Herbicides and scores of pesticides as well as defoliants (particularly in cotton cultivation) are widely used in agriculture.

A. E. and B. A. Arbuzov, in Kazan', have carried out basic research into the synthesis of organo-phosphorus compounds and of medicinal substances. It is noteworthy that these studies which have great practical importance resulted from purely theoretical investigations by A. E. Arbuzov into the various aspects of a new class of compounds, viz. esters of phosphoric acids. Many agricultural toxic chemicals which have found extensive application were synthesized by workers of the Institutes of the Academy of Sciences, at the Scientific Fertiliser and Insectofungicide Institute (NIUIF), the All-Union Institute for the Chemical Protection of Plants (VNIIKhZR) and others. Institutes in Moscow, Kazan', Kiev and other towns have produced extremely valuable work on the synthesis of organo-phosphorus insecticides and other producs.

Important original work on the synthesis of dye-stuffs, photoreagents for colour cine-film and various fine chemicals has been done by M. A. Il'inskii, A. E. and B. A. Porai-Koshits, N. M. Kizhner, A. I. Kiprianov, N. N. Vorozhtsov and others. The remarkable theoretical work of A. N. Terenin in photochemistry should be mentioned. The study and synthesis of organo-elemental compounds has greatly expanded in the Soviet Union. Among these compounds many are effective agricultural agents, intermediates in the production of polymers, etc. The Institute of Organo-elemental Compounds of the Academy of Sciences of the USSR was established for the extensive development of studies of these compounds because of their theoretical and practical significance.

Considerable achievements in inorganic chemistry have resulted in recent years from the work of I. I. Chernyaev, A. A. Grinberg, A. F. Kapustinskii, S. A. Shchukarev, V. G. Khlopin, E. V. Britske, N. F. Yushkevich, G. G. Urazov, B. A. Nikitin and others.

Outstanding achievements must be noted in inorganic materials science, which have ensured the production of various compounds for atomic, nuclear and electronic technology. These achievements were preceded by an enormous amount of original work on the isolation of rare and radioactive elements and their isotopes. Many of these are isolated in the so-called spectroscopically pure state (this degree of purity allows the presence of one atom of admixture to 10^8–10^{12} atoms of substance).

Numerous new metal alloys, glass, ceramic and other materials have been created, possessing previously unattainable stability, hardness, thermostability and resistance to radiation and various chemical actions (e.g. corrosion). Soviet industry is now producing a whole series of valuable types of glass, glass fibres, thermo- and electro-insulating materials. The development of silicate chemistry owes much to the work of I. V. Grebenshchikov, P. P. Budnikov, I. I. Kitaigorodskii, N. A. Toropov and many workers in the building materials industry.

The achievements of Soviet chemistry have also been great in the theory of complex compounds and in the development of new methods of production and refining of the platinum group of metals, viz. rhodium, iridium, osmium, ruthenium, etc.

The chemistry of rare and radioactive elements has been widely studied, entailing the development of many novel, refined methods of investigation, of isolation, separation and profound purification of substances. Whilst in the years immediately following the October Revolution main efforts were directed to the development of methods of isolation of radium from ores and to the utilization of certain rare metals in metallurgy, in recent years the creation of atomic technology has resulted in extensive original work on the chemistry and technology of uranium, thorium and other transuranium radioactive elements, as well as beryllium, zirconium and others.

The rapid development of the production of semiconductors has led to divers studies and investigations in depth of substances possessing electronic conductivity whose magnitude places them midway between metals and insulators. With this aim in view, various sources of raw materials have been investigated as well as methods for obtaining such elements as germanium, silicon, indium, tellurium and others in a pure state, and for preparing a whole series of their chemical compounds.

Contemporary aircraft equipped with jet engines and other new technological developments require the creation of novel types of metal construction, stable to high temperatures, pressures, corrosion and other influences. Chemists and metallurgists have succeeded in solving numerous difficult problems in utilizing for these purposes metals new to the industry—viz. magnesium, titanium, and various alloys containing rare elements.

Great contributions to radio- and isotope chemistry have been made by V. G. Khlopin, I. D. Bashilov, I. V. Kurchatov, G. N. Flerov, A. P. Vinogradov, I. E. Starik, A. I. Brodskii, V. I. Spitsin and others.

The successes of Soviet chemistry have resulted from profound theoretical studies, based to a considerable degree on the use of refined physical methods of investigation, i.e. spectroscopy, X-ray analysis, radioactive isotopes, mass-spectrometry, chromatography, polarography and many others. Much original theoretical and practical work in analytical chemistry has been done by Soviet chemists.

Thanks to the high precision and rapidity of the new analytical methods automatic control and regulation of continuous industrial processes has become possible. Modern achievements in the production of ultra pure substances, in nuclear and electronic technology, in many areas of biology, medicine and other branches of science and technology would be impossible without the new analytical methods incorporating chemical and physical methods with high standards of instrument technology.

Penetrating and varied studies of divers important chemical reactions have been carried out, as well as of methods of their acceleration by means of catalysts, high temperatures, high pressures and other "levers" influencing the course of reactions. Significant contributions to this sphere have been made by the eminent Soviet scientists N. D. Zelinskii, N. N. Semenov, A. A. Balandin, V. N. Ipat'ev, E. V. Britske, P. P. Fedot'ev and others. Studies on reaction rates have resulted in the intensification of some industrial processes and the development of new technological procedures. N. N. Semenov was awarded the Nobel prize for his outstanding contributions to chemical kinetics and chain reactions (the Nobel prize was simultaneously awarded to the eminent British chemist Cyril Hinshelwood for his studies of chemical reaction mechanisms). This sphere of science originated in the Soviet Union and has developed fruitfully there for over a quarter of a century: the leading centre for these studies is the Chemico-physical Institute of the Academy of Sciences of the USSR. Outstanding theoretical studies on the structure, reactivity and energetics of chemical reactions have been carried out during the period of Soviet rule.

In recent years penetrating and extensive studies have been initiated into the mechanisms of surface phenomena which play a large part in the accomplishment of many technological processes, e.g. gas absorption, flotational enrichment of ores, resistance of metals to corrosion, etc. This sphere has been well served by A. N. Frumkin, V. A. Kistyakovskii, P. A. Rebinder, N. A. Izgaryshev, G. V. Akimov and others.

The most difficult problem of mastering atomic and nuclear processes has been solved in a short period of time by collaborative efforts of physicists, chemists and technologists.

Soviet chemical engineers have achieved considerable successes in utilizing native mineral resources, including many types of raw materials containing coloured metals and rare elements, phosphorus, boron and various other ores (work of geologists and chemists including A. E. Fersman, I. M. Gubkin, Ya. V. Samoilov and others, as well as E. V. Britske, N. F. Yushkevich, I. P. Bardin and others); before the Revolution most of the mineral raw materials were imported into Russian from abroad.

The discovery 40 years ago by the Academy of Sciences expedition and the exploration by NIUIF beyond the Polar circle of the world-scale deposits of Khibin apatite-nephelite ores as well as the discovery before World War II of large deposits of phosphorite in Karatau (Southern Kazakhstan) and of other deposits, have led to the establishment of extensive phosphate fertiliser industries producing at present about 450 times more fertilisers than before the Revolution. Utilization of novel types of raw materials (volcanic apatites, nephelites, etc.) previously not used, demanded much original work by chemists, which has enabled Soviet chemical and metallurgical industries to produce from these materials scores of valuable products—phosphate fertilizers and salts, phosphorus, fluorine salts, aluminium, soda, potash, cement, glass, etc.

The discovery and exploration in 1926 of the largest in the world deposits of potassium salts in northern Urals (in the Solikamsk district), and then of further potassium deposits in various areas of the USSR, laid the foundation for an extensive industry producing potassium fertilizers, magnesium, bromine, rubidium and various salts. It is relevant to mention here the extensive studies of other natural salts, based on their chemico-physical analysis (marine and lake sulphates, soda, borates, etc.), carried out by N. S. Kurnakov, G. G. Urazov, V. P. Il'inskii, E. V. Burkser, N. N. Efremov and many others.

Abundance of food stuffs and of raw materials for light industry is ensured in the USSR by the organisation of extensive, advanced and rapidly growing industry based on fixed nitrogen, together with developments in the production of phosphorus and potassium fertilizers and of chemical agents for the protection of useful plants and animals and of feed-preserving and sanitary substances used in animal husbandry.

The so-called combustible minerals, viz. petroleum, coal, natural gases, turf, etc., as well as wood pulp, are more and more widely used not only as fuel but also as valuable chemical raw materials. Their processing is complex, using energo-chemical methods. Chemico-technological methods of processing underground mineral deposits in situ are being studied, including the possibilities of dissolving, melting or gasifying a series of salts and ores ("geotechnological" processes).

Technologists have worked out complex methods of processing natural raw materials which eliminate enormous losses of valuable components in the solid, liquid and gaseous industrial wastes. In recent years much work has been devoted to the acute and important problem of air and water polution—a growing problem related to the expansion of industry.

Since the Revolution the science and methods of chemical technology, i.e. the mass conversion of raw materials into useful products, have been transformed. The enormous problems of Socialist construction have revivified it. Before the Revolution this science was largely empirical, it developed in a chaotic manner in the rapacious interests of profit-making concerns. In the Soviet Union the development of chemical technology proceeds according to plan and expediently, based on the theory and progress of all branches of physico-chemical and technical sciences, in the interests of maximal satisfaction of the needs of society as a whole.

New sectors of chemical technology are growing rapidly in the USSR, e.g. studies of processes and of apparatus, physico-chemical bases of industrial processes, their optimization and programming, as well as the science of chemical materials and machine construction.

Valuable results have been obtained from theoretical studies of chemico-technological processes by Soviet chemical engineers, especially in the field of contact processes and apparatus, intensification of production and separation and purification of products.

Valuable forward-looking work has been done on the production of oxygen and its application in various areas of chemical and metallurgical industries, resulting in considerable intensification of some important production processes (I. P. Bardin, P. L. Kapitsa et al.).

The growth of research and planning in new chemical industries has been considerably influenced by developments of theories of similarities and by model processes and apparatus, and in recent years by mathematical and physical methods of planning experiments related to the problems of chemical cybernetics. The study of processes and apparatus are much indebted to I. A. Tishchenko, L. F. Fokin, K. F. Pavlov, A. G. Kasatkin and others.

Recent decades have seen a particularly deep penetration of chemical methods not only into physics but into biology including its applied branches, viz. medicine, horticulture, animal husbandry, microbiology both bacterial and viral, and into the food industry. The cross-fertilization of natural and technological sciences has so great an influence on the direction of chemical efforts penetrating all spheres of life, that there is already talk of the coming of the "age of biology" in which the main roles will be played presumably by biochemistry, physiology, bioorganic chemistry, molecular biology, chemical cytology and other hybrid sciences coupled with the widest possible application of the latest physical and mathematical methods of research. After all, the knowledge of life processes, of metabolism, growth, fertility, transmission of heredetary characteristics, the functioning of the nervous system, variation of micro- and macro-organisms, is still modest. Significant results have been obtained in certain intermittently advancing areas of experimental physiology and biochemistry. It is obvious that problems involved in the life sciences require the most sophisticated and complex chemical and physical research methods. Until comparatively recently chemists and biologists collaborated in expeditions, in descriptive, analytical and synthetic methods of investigating natural products (this must have given rise to the conventional and imprecise term "chemistry of natural products"; strictly speaking, mineral substances forming the earth's crust, water and air also form natural products). Chemists and biologists are faced with the need to study in depth the processes occurring in living organisms. Whilst quite recently research was directed towards the composition, structure and properties of protein ("bricks"—amino-acids, hydrocarbons, lipids, terpenes and other components of natural and technical products, in the last decades research has concentrated on vitamins, enzymes, hormones, antibiotics and other physiologically active substances including medicinal and agricultural products as well as other regulators of life processes, possessing genetic, mutagenic and toxicogenic functions. Industrial production of certain vitamins and medicinal substances has been established in the USSR on the basis of experience at home and abroad (including the work of A. E. Chichibabin, V. M. Rodionov, A. E. Arbuzov, M. M. Shemyakin, A. P. Orekhov, Kh. U. Usmanov and others).

In recent years Soviet chemists have achieved successes in the synthesis of a series of important protein-peptide substances, in the studies of muscular contraction mechanisms, of the conditions of enzyme action in amino-acid metabolism, of the basis of the bioactivity of the main types of proteins and peptides. Of great significance are the studies to clarify the mechanisms of the transmission of hereditary characteristics by means of investigating the structure of deoxyribonucleic acids, as well as of one of the most important messenger ribonucleic acids involved in the synthesis of the protein chain from amino-acids. Valuable pioneer work has been carried out in the USSR on the use of numerous chemical compounds selectively altering hereditary characteristics (mutagens). Methods have been worked out for obtaining male and female sex hormones from available raw materials and for the synthesis of other steroid hormones. Significant results have come from investigations by Soviet biochemists into the synthesis of vitamins produced industrially (at the present time vitamins A, B_1, B_2, B_6, C and others are being produced). Developments are taking place in studies of blood, and blood substitutes have been developed. Considerable achievements have been made in the synthesis of physiologically important carbohydrates and lipids. Chemists, biologists and doctors are collaborating in the search for effective preparations against malignant tumours, carcinomata, sarcomata, etc.

Research work is becoming more and more team-work and increasingly complex. The clear demarcation previously existing between inorganic and organic or inorganic and physical chemistry is becoming blurred in many areas. Theoretical, methodological and prospecting investigations are increasingly done by the combined forces of the Academies of Science, graduate schools, professional institutes and plant laboratories according to a common, agreed plan. Much of this work is stimulated by the competitions and discussions initiated by the Mendeleev Society.

PROSPECTS IN CHEMISTRY

Soviet chemists are faced with tremendous and exciting problems. Developments in the study of the theory of structure and of reactivity of chemical compounds, of kinetics and chemical reaction rates, of the course of nuclear processes are opening more and more prospects of directed synthesis and transformation of elements and of their compounds and of enhancing the possibility of regulating life processes of creating new materially valuable products.

In the coming decades energetics will presumably cease to be the limiting factor in the development of electrochemical, electrothermal and other energy requiring industrial processes. This view is based on the long experience of the construction and exploitation of large thermo- and hydroelectric power stations and on the considerable advances in recent years in the building and use of atomic power stations. It is therefore to be expected that the production and use of oxygen, hydrogen, nitrogen, chlorine, caustic alkali, light metals, silicon, phosphorus and other elements and their compounds will expand, making these substances more easily available and cheaper. Because of new resources and of new forms of energy new technological processes will come into being, and many of the existing ones will be radically changed. Processes taking place at high or super-high temperatures will be increasingly important not only in the chemical and metallurgical industries but in many other branches of technology (mining, building construction etc.). Processes at extremely low temperatures will also be developed. The use of medium and of high vacuum will be extended. Electromagnetic and electrostatic action, ionizing radiation, radiolysis, photolysis and other physical "levers" will speed up processes in the desired directions.

These developments will lead to numerous new processes, apparatus, chemical products and construction materials. Even now the world chemical industry produces tens of thousands of compounds, and their number is constantly and rapidly increasing. The number and variety of chemical products is limitless.

Soviet research laboratories produce annually many thousands of new chemical compounds, hundreds of which are then produced industrially. This progress may be likened to an avalanche; it is directed to the satisfaction of requirements in the national economy, public health, defence, culture and everyday life.

Chemical technology has up to the present studied and achieved syntheses, degradations and other transformation on the "molecular level"; in the future these processes will also be developed on the "atomic-nuclear level". Radioactive processes of transforming one element into another, already realizable, will in the future extend the raw material sources of elements deficient in the earth's crust. The chemistry of organo-elemental compounds is expanding rapidly.

Significant progress is to be expected in the biochemical and especially the microbiological industry, solving important problems in the sphere of food production, of medicine, etc.

Thanks to new sources of energy, and to chemical and mechanical advances, it will be possible to investigate and to extract mineral raw materials from great depths of our planet—tens of kilometres, or even deeper, down. These problems are only beginning to be studied (at present the deepest bores are 7–8 kilometres deep, the average diameter of the earth being 6510 kilometres). At the same time the problems of the extraction and processing of mineral raw material underground (by dissolving, melting out, gasification) will be tackled, similarly to the underground extraction of solutions of rock salt which are distributed to soda-producing plants, and to the melting of underground deposits of sulphur by means of steam (a method long used in Louisiana). In the first instance such methods of extraction could apply to water soluble salts, e.g. potassium (as has been done in recent years in Canada), magnesium and others, as well as to low-melting minerals or those decomposable at comparatively low temperatures.

Electrochemical sources of power will introduce radical changes into land, air and cosmic transport. In the USSR as well as in other countries vigorous research is being pursued which should provide in the near future powerful, economic and portable chemical sources of power, replacing in many processes the heavy accumulators and the usual fuels, e.g. kerosene, gasoline, compressed and liquefied gases, etc., and possibly competing in certain applications with atomic power generators.

There is no doubt of the importance of research into the processes of photosynthesis, which play so tremendous a part in life processes on Earth.

The number of chemical elements known at the present time is 104 (element 104 of the periodic system was discovered by I. V. Kurchatov and named "Kurchatovium" in his honour); approximately 1800 radioactive and stable isotopes are also known. The heavy elements series of the periodic system is expected to be considerably extended in the future.

Concurrently with the studies of physical, chemical, biological and technological properties of the elements, their use and novel application are being developed. Obviously the widest and most varied application will be found for those elements which are most abundant in the earth's crust, in water and in air. To this type of raw material belong sand, clay, limestone, gypsum, salts and other common mineral raw materials. Petroleum and natural gas are of especial interest in many parts of the world. The enormous deposits of coal have to be used on the largest possible scale in conjunction with the production of a wide assortment of chemicals, similarly to the petrochemical industry. This also applies to peat deposits. Much more attention should be paid to the chemical technology and diversified use of wood pulp—the most widely available and self-replacing natural raw material.

The chemistry of high-molecular weight compounds will be developed on the widest possible scale.

The threatening shortage of pure fresh water in certain areas will be eliminated by desalination and purification of sea water and of underground water by chemical, mechanical and physico-chemical means, including the utilisation of heat from atomic reactors and of helio-technology.

Industrial waste waters present an acute and complex problem which will require complex methods and means of elimination to be worked out by joint efforts of science and technology (as has been done in recent years in the USSR in connection with some important problems in this sphere).

There are large areas in the USSR where the soil is acid, saline or eroded—and these defects will have to be remedied to ensure effective agricultural development. A solution of these problems is liming of acid soils, and treatment with gypsum of solonetz and solonchak soils. These measures are to be extended. The struggle against wind and water erosion—present on a very large scale in places—will have to involve the collaboration of chemists, physicists and soil scientists. A number of polymers, latex-like substances, silicates, etc. capable of binding and strengthening soil particles has already been investigated. But the economic aspects of this problem are not yet solved: they have attracted insufficient efforts and expenditure so far.

In the coming decades the plant foodstuffs will not be basically replaced, but will be enriched and supplemented by synthetic products (protein concentrates, amino-acids, carbamide, phosphates, microelements, vitamins, etc.).

Some food and feed production problems have, however, already been solved by synthetic chemistry, by-passing

crop raising, and this process will undoubtedly develop further.

The three sources of plant nutrition—nitrogen, phosphorus and potassium—are found in nature in widely differing situations. The supply of nitrogen from the air is limitless, as well as the content of oxygen. Soviet deposits of water-soluble potassium salts are also enormous, ensuring sufficient amounts for agriculture for millenia. The case of phosphorus is different: the deposits of reasonably rich sources of phosphorites and apatites so far explored can ensure large-scale development of the fertilizer industry for several decades only.

The process of binding nitrogen as synthetic ammonia—used in many countries—is complicated and cumbersome. The electric arc process of binding atmospheric nitrogen and oxygen to form nitric acid and its salts, used at the beginning of the twentieth century in some foreign plant proved uneconomical because of the enormous expenditure of energy and of extremely low efficiency. This problem is being tackled from different directions by various research and pilot-plant establishments in the USSR and abroad. Plasmas, radiolysis, new types of furnaces with high efficiency coefficients, have been studied, as well as the mechanism of the biological utilization of atmospheric nitrogen as its oxides and ammonia in the hope of replicating it technologically. It is to be hoped that all these conjoint efforts will succeed in the next few decades in synthesising economically nitrogen compounds from atmospheric nitrogen.

The research, begun before World War II by the All-Union Institute of Halurgy, into the underground extraction and processing of soluble potassium salts should develop further.

Because of the comparatively limited natural deposits in the USSR of phosphates, geological exploration in Siberia, Central Asia and the Caucasus should be developed; at the same time all possible measures should be taken to work out economic methods of enrichment and chemical processing of low-content, contaminated with undesirable admixtures, phosphorites. The rapid and extensive construction of power stations and the consequently cheaper supplies of energy will result in the more economical electrothermal processing of poor phosphate ores into phosphorus and phosphoric acids. It may become possible to obtain phosphorus anhydride directly through thermal dissociation of calcium phosphates, by-passing the reduction of elementary phosphorus and its oxidation. Similar processes may be of interest in the future in the production of other acid anhydrides.

The contention put forward by Soviet scientists over half a century ago regarding the necessity of developing complex (multiple and mixed) fertilizers including liquid ones, has become universally accepted. Up to the present the widespread use of the considerably cheaper liquid fertilizers has been limited by administrative and technical difficulties, viz. the need to mass-produce machines for introducing them into the soil, to build special storage containers and to ensure transport facilities.

Hydroponics will be developed in northern areas, unsuitable for ordinary agriculture, with conditioned and automated supply of liquid complex fertilizers to the plants.

Chemical industry faces the great and acute problem of satisfying, in the shortest possible time, the qualitative and quantitative needs of animal husbandry for feed-stuffs, preservatives and sanitary agents. Chemical industry has entered the sphere of animal husbandry later than that of horticulture. The economic effect of using feed-stuffs is considerably greater than that of using mineral fertilizers. We shall not dwell here on the numerous problems facing the chemical, petrochemical, silicate and other branches of industry covered by the plans for the immediate future, as these are dealt with in other publications[45].

In view of the rapidly expanding use of pesticides there will be considerable expansion of investigations by chemists, biologists, agriculturists, doctors, veterinary surgeons and other experts to ensure the safety of applying these agents; at the same time steps will be taken to enlighten the users of the agricultural agents. In recent times research organisations and ministries have worked out measures to expand biological and agro-technical means of protecting plants, and to integrate their use with that of chemical agents which are the most quick-acting and most widely-available.

Future researches of chemists and biologist will undoubtedly succeed in combatting various human and animal infectious diseases, malignant tumours, sclerosis, mental and other serious illnesses. Collaboration between chemical and medical establishments and between relevant learned societies could prove very effective in these researches.

FUNDAMENTAL PROBLEMS OF THE SOCIETY

The significance of the activities of learned societies is constantly increasing in view of the rapidly growing rôle of science in industrial progress, penetrating as it does all spheres of life, and in view of the collaboration among various specialists. Naturally, under conditions of socialism and at the time of a scientific-industrial revolution when on the one hand there is growing specialization and division of labour and on the other hand cooperation and integration of effort, the content, form and effect of the work of the Chemical Society must be given special attention and must be perfected. The significance of the resolution of the Soviet Peoples' Committee signed in 1921 by Lenin has not decreased but grown, viz. "...the creation of scientific and technical societies is to be encouraged"[43]. In this document it was submitted that "....engineering and technical societies, in the interests of optimal development and elucidation of technical and economic and administrative problems, (are) to be given all facilities for holding meetings and conferences, for publishing their reports and results of work, and for liason with scientific and technical organizations abroad".

Other government and party resolutions have been of great significance in promoting the effectiveness of scientific and technical societies, especially the resolution of the Council of Ministers of the USSR of 17th October, 1962: "On improvements of the utilization in the national economy of the recommendations of scientific and technical societies".

The Chemical Society has gone a long and honourable way in the last hundred years. The number of members has grown in the past ten years over 50-fold; the activities of the Society have become more diversified and concerned closer with problems posed by life; it takes an active and creative part in socialist construction.

It should be remembered that the Mendeleev Society had initiated the publication of several journals: "Khimiya v Shkole" (Chemistry in the School), "Uspekhi Khimii", Referativnyi Khimicheskii Zhurnal (Journal of Chemical Abstracts), of the popular scientific journal "Khimiya i thizn" (Chemistry and Life), the Journal of the All-Union D. I. Mendeleev Chemical Society, every issue of which publishes a diversified account of a given branch of the science and of technology, its state and problems, thus acting as a live, constantly expanding encyclopaedia of chemistry and

its relationship with the disciplines bordering on it. After the October Revolution the Journal of the Russian Physico-chemical Society split into the Journal of General Chemistry (Zhurnal Obshchei Khimii) and the Journal of Applied Chemistry (Zhurnal Prikladnoi Khimii). In 1920, on the initiative of chemists, was created the Chemico-technological publishing house (now the publishers "Khimiya"[44]).

The annual competitions organized by the Society for the best research work in a given subject attract several thousand scientists each year. A great stimulus is also provided by the annual review of the adoption of new techniques in industry and in institutes; this review is undertaken jointly by the Society and by the trade unions of the petroleum processing industry and of chemical industry and by the ministries concerned.

On the initiative of the All-Union Chemical Society the Government inaugurated in 1965 the award of a Mendeleev Gold Medal for outstanding chemical work of significance to the national economy. The award is made jointly by the Praesidium of the All-Union Chemical Society and the Academy of Sciences of the USSR.

Apart from Mendeleev congresses and numerous conferences and symposia, the Society organizes seminars and schools dealing with chemical achievements and experience; conjointly with the society "Knowledge" lectures and publications are used to disseminate chemical information. Consultations and expert advice services are expanding—especially to industry, to novel undertakings, to workers and young people, to inventors and innovators. A great deal of attention is devoted to everyday problems in chemistry and to local industries.

The most important problem facing the Society in the immediate future is the improvement of the quality of its activities: effectiveness, creative initiative, the involvement in scientific and industrial work of all its members. In the course of recent congresses and plenary sessions of the Society its members were exhorted to take all possible measures to develop independent creative work in divers chemical spheres and to strengthen the contacts and expand the cooperation with physicists, biologists, technologists and other specialists. At the present time the Mendeleev Society is endeavouring to enhance the interest in, and the quality of, theoretical and research studies, attracting a wider circle of young scientists and especially of students.

The current economic reforms necessitate further efforts by economists and engineers to perfect the planning and stimulation of industry, the prognosis of the directions in which chemistry will benefit the national economy, the optimal geographical placing of industrial plant, the methodology of technical economic estimates in industry and in science.

It must be noted with great satisfaction that many retired chemists continue with extremely useful activities, viz. as consultants, experts, organizers; giving guidance to young scientists working for higher qualifications and solving scientific and technical problems.

The complexity of many problems to be solved demands increasingly efficient organization, and the selection and education of gifted, erudite, highly educated organizers and leaders with a great deal of initiative; their numbers are still deficient in the USSR.

Problems arising from the progress of science and technology necessitate continuing searches along the limitless routes of chemical synthesis and continuing expansion of the assortment and properties of the countless products; the physico-chemical mechanisms of chemical reactions have to be studied in depth; technological processes have to be intensified and improved; methods and agents for harmless and safe chemical industrial processes have to be developed, and nature and people have to be safeguarded; research has to be speeded up and the tempo of assimilation of novel techniques by industry has to be accelerated.

This acceleration and a decrease in the cost of experimental work is aided by the efforts of members of the Society who are intensifying the study and application of powerful new means, viz. mathematics, computer techniques, automation and cybernetics, of pilot-plant work and of developing optimal conditions for chemical processes.

The Society has to respond to the pulse of life, to recognize as quickly as possible "growing points" and to ensure their development.

Chemical propaganda at the present time is carried on on a higher plane: it reaches deeper and is directed not only to dissemination of basic information to a wide public but aims at the raising of qualifications of chemists who are specialists in borderline topics of chemistry and technology. The spasmodic lectures and discussions, on the most popular level, are increasingly giving way to systematic cycles of lectures, schools, seminars, laboratory sessions and excursions. Because of the wide range and many-sidedness of the Society's activities the Praesidium is entertaining hopes of creating "Houses of Chemistry".

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Modern chemistry in a socialist state is a powerful and noble force, increasing productivity and helping to raise the level of well-being and culture of the people.

In celebrating the centenary of the "chemical troop" we are not only surveying with legitimate pride the Society's record of successes whilst analysing the mistakes and shortcomings, but we also look to the future, and hope to inspire and direct our members to new creative efforts "for the common harvest", to accelerate the achievement of a happy, thriving human society.

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