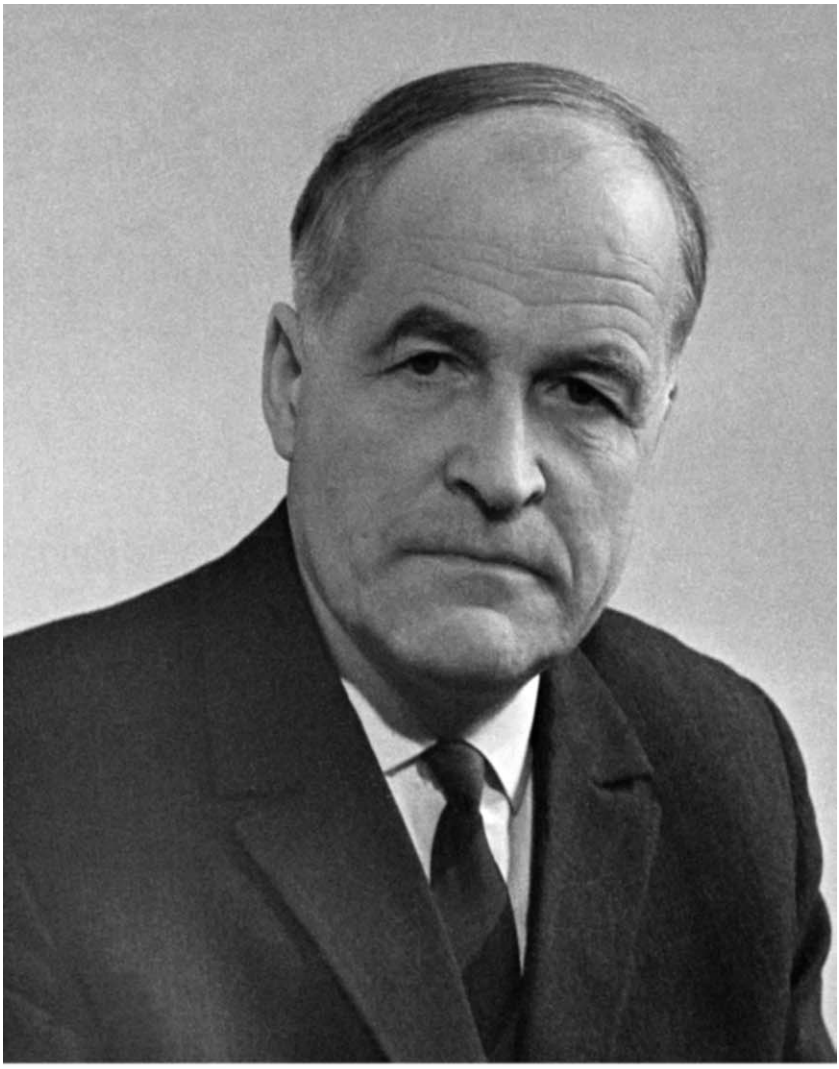

ADVANCES IN CARBOHYDRATE CHEMISTRY AND BIOCHEMISTRY, VOL. 61

NIKOLAY KONSTANTINOVICH KOCHETKOV

1915–2005

Professor Nikolay Konstantinovich Kochetkov was a distinguished Russian scientist of the second half of the twentieth century. He is well known for his outstanding contributions to organic and bioorganic chemistry, especially to carbohydrate research.

He was born in Moscow on May 18, 1915 at the time of World War I. Russia was still a monarchy, ruled by Emperor Nicholas II. Nikolay lived through two revolutions, Democratic and Bolshevik, the Civil War, establishment of the USSR, Stalin's dictatorship, and World War II, during which time he spent six years in the army and at the front. He then relaunched his scientific career from level zero, worked through the period of 'developed socialism', Gorbachev's perestroika, the collapse of the Soviet Union and the establishment of a new Russia. His was quite a long and eventful life …

The family to which Nikolay was born had a small textile business not far from Moscow. His father Konstantin was educated in Russia and Germany as a chemical engineer, and was expected to develop the family business. This did not happen, because all property was confiscated after the Bolshevik revolution. The only thing that his parents could do for Nikolay and his younger brother Alexander (Shura) was to help them to receive the best possible education.

Nikolay finished primary school in 1929. He said his choice for the future was made early, and this was chemistry. However, he had a long and difficult way to go to realize his wish to become a scientist. His middle-class origin was an obstacle for his education, as Soviet authorities gave priority to teaching the children of workers and peasants. A secondary school with a specialized class in chemistry, where Nikolay was accepted after some struggle, was suddenly re-organized and transformed into a technical school preparing technicians for brick factories. Consequently, Nikolay's first job was leading a team of girls at a

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brick factory. From there he moved to the control laboratory at a chemical plant in Moscow where his father worked as an engineer.

When the time came for higher education, Nikolay's first choice was the chemical faculty of the Moscow State University. Again his 'unacceptable' social origin played its part and he did not get a place; so he joined the Moscow Institute of Fine Chemical Technology (MITKhT). He always had good memories of his student years, despite the fact that they coincided with a difficult time for the country and its people. All his life he remembered his teachers, who were educated before the revolution and who were all prominent scientists of their time. He also had a very high opinion of their lecturing skills. Their names—Professors Alexander Reformatskii (inorganic chemistry), Sergei Nametkin, Abram Berkengeim (both organic chemistry), and Academician Yakov Syrkin (physical chemistry) among others—may not perhaps ring many bells in the West today.

Students spent summer holidays traveling around the country, and the Caucasus, with its highest mountain Elbrus being among their favorite regions. They had no money and very little equipment for mountaineering, and used costumes sewn by their mothers from old clothes. Vera Volodina, Nikolay's fellow student and future wife, recalls other events, such as a trip to Leningrad (now St. Petersburg) and nearby palaces once belonging to the Russian royal family, and a Pushkin ball masquerade in 1937 devoted to the 100th anniversary of the poet's death. Nikolay was dressed as a Hussar, and it was then that Vera lost her heart to him for the next seventy years. But they also saw their fellow students disappearing, with Nikolay's closest friend being one of them. Nikolay's father had a special prison bag ready at home, as every night he feared arrest. That shortened his life, and he died in his early fifties.

The end of Nikolay's student years in 1939 was dramatic for all Europe and for him personally. He was a bright student and wanted to specialize in organic chemistry. By the time of his graduation, he was offered two postgraduate positions. The first was from Professor Alexander Orekhov, a specialist in alkaloid chemistry and then head of the Pharmaceutical Institute in Moscow, and the other from Professor (later Academician) Alexander Nesmeyanov, who chaired the department of organic chemistry in the MITKhT since 1938. Nikolay happily chose the latter and passed his examinations. A topic for his research was selected and a place in the laboratory allocated. But he was a postgraduate for only two weeks, after which, in his own words, the government made the choice for him and conscripted him to the army.

His first posting was a place 5,000 kilometers east of Moscow, not far from Lake Baikal. To the end of his life Nikolay could not forget the dreadful living

conditions there. With the winter temperature falling down to -50°C, two to three hundred recruits lived in a huge dugout with a small stove. Add to this lack of warm clothes and boots, and it becomes clear why Nikolay used to say that if he was to choose between freezing and hunger (these two words in Russian, *holod* and *golod*, differ by only one letter), he would choose the latter.

However, Nikolay lived through this nightmare. His chemical education helped and he managed to get a job as a technician in the regiment's pharmacy, which made his life a little easier. As his two-year service was coming to an end he was going to go home, but with the German invasion of the USSR in 1941 the war began and he had to stay in the army for another four years, two of them being at the front. During the war he continued using his chemical expertise, and his rank by the end of the war was head of the regiment's chemical reconnaissance.

With his regiment, Nikolay advanced through Latvia, Poland, Silesia, and Bohemia, and he was awarded the medal *Za Otvagu* (*For Bravery*), which forever remained his most favorite award. He came back in 1945 from Prague, at the same time as Shura, his younger brother. They returned too late to see their father, who had died in 1943; their mother was very ill and died shortly afterwards. In 1946 Nikolay married Vera, who was waiting for him, and he began to restore his career in science after six years in the army—from October 21, 1939 to October 20, 1945.

Science and his work were the two most important things for Nikolay, and it was fortunate that Academician Nesmeyanov, then the head of the organic chemistry department at Moscow State University, offered him a position of lecture assistant. His job was to conduct experiments illustrating the topics of lectures in organic chemistry, which Nesmeyanov gave to about 250 students twice a week. Nikolay struggled to bring back his knowledge of organic chemistry, which he had lost while in the army. Demonstrating experiments to students, together with Nesmeyanov's excellent lectures, helped him to restore his chemical competence.

Kochetkov continued as lecture assistant until 1951, combining this work with research on metalloorganic chemistry in Nesmeyanov's laboratory. He studied organo-mercury compounds, in particular their synthesis by the addition of mercuric chloride to acetylenes. In 1948 Nikolay wrote a thesis and received the Ph.D. degree in chemistry.

Even so his life remained difficult, with little money and severe shortages of food and the necessary things for his family, now including a baby girl Maria born in 1947. Vera accepted once and for all that Nikolay's work was the main

thing for him, and she was always very understanding and supportive. She took on all responsibilities for running the home, and created a comfortable environment for his work. She also managed to take a postgraduate course in inorganic chemistry, write a thesis, and receive the Ph.D. degree in the late 1940s. In 1952, they had a son, Sergey.

Nesmeyanov became rector of Moscow State University while its new building was being constructed in the Sparrow (then Lenin) Hills, and Nikolay watched him dealing with all kinds of emerging problems. He loved Nesmeyanov's style of communicating, which was direct and informal, with occasional jokes, and he later compared that with the style he saw in Cambridge. Nikolay considered Nesmeyanov his teacher who contributed, perhaps more than anyone else, to his becoming a scientist; and he was always grateful to him for that. Nesmeyanov also helped Nikolay out on many occasions in his later life.

Meanwhile, Nikolay had started his new research on the preparation, reactions, and synthetic applications of β-chlorovinyl ketones and related compounds (β-aminovinyl ketones, β-ketoacetals). Efficient synthetic methods were developed and improved, including C-ketovinylation (introduction of the RCOCH=CH group), and a number of useful heterocyclic compounds (pyrazoles, triazoles, pyridines, and so on) were synthesized. The discovery of enamine–imine tautomerism in β-aminovinyl ketones was another remarkable achievement by Nikolay at that time. For these studies he received in 1953 the degree of Doctor of Science in chemistry. He continued as a lecturer and supervisor of postgraduates at the University, becoming docent (associate professor) in 1951 and full professor in 1955.

Nikolay's scientific interests now moved to compounds with potential physiological activities. Still keeping a position at Moscow University, he accepted an offer to head the chemical department at the Institute of Pharmacology and Chemotherapy of the Academy of Medical Sciences of the USSR. There his research focused on the search for and synthesis of physiologically active compounds—potential drugs. Some of them, such as diazoline, chloracon, and thiamine, were launched and used for many years as antihistamine, anticonvulsant, and antituberculosis medicines. Together with his new coworkers Marat Karpeisky and Radii Khomutov, he developed an industrial-scale technology for synthesis of cycloserine and its analogues. Nikolay's achievements in this field were recognized, and in 1957 he was elected Correspondent Member of the Academy of Medical Sciences. He retained contacts with the Institute when he moved later on to new research areas, and in the 1960s in collaboration with Arkadii Likhosherstov, Viktor Kulakov, and Alexander Vasil'ev he contributed significantly to the

synthetic chemistry of pyrrolizidine alkaloids and necinic acids of high biological activity.

After Stalin's death in 1953, contacts between the Soviet Union and the West began developing, and more government officials traveled to Europe. One of these visits had an important implication for Nikolay's future career. The head of the department of organic chemistry at Cambridge University, Professor (later Lord) Alexander Todd, met a Soviet government delegation led by Alexey Kosygin, then the vice chairman of the USSR Council of Ministers. Todd said he could accept two chemists from the Soviet Union to work in his laboratory for six months. However, he put forward three conditions: they had to be good chemists (he said he would send them back if they were not); they would leave politics alone; and the USSR Embassy in London would not supervise them.

On the return of the delegation to Moscow, Todd's proposal was passed to the president of the Academy of Sciences, Academician Nesmeyanov. He suggested that Nikolay should go to England, to which Nikolay agreed, though with some hesitation. At that time traveling to England was like going to the Moon—nobody could be sure that they would return home safely. Many people traveling abroad or communicating with foreigners had been arrested during Stalin's time, which had ended only three years previously. The second candidate appeared to be a brave recent graduate from the chemical faculty at Moscow University, Electron Mistryukov. Seeing Nikolay off to Cambridge, Nesmeyanov said that he would work in a great laboratory and asked him to learn why 'they' (namely in the West) worked so efficiently.

Nikolay wrote later that Professor Todd was very supportive and encouraging, and told him not to worry about anything. He interviewed Nikolay on his arrival about his area of research and sent him to the library to get acquainted with the latest achievements in nucleoside and nucleotide chemistry. Within a week he allocated Nikolay, to his delight, a place in the laboratory and offered a topic involving synthesis of nucleoside glucuronic acid diphosphate. Nikolay worked hard and regretted that he could not finish the work by the end of his term. He said that he met technicians during later trips to Cambridge, and they remembered him as a crazy Russian who worked in the laboratory at weekends.

After years of the Soviet people's isolation from the West, Nikolay suddenly found himself in a leading global scientific center, which many prominent scientists were visiting. He met Sir Robert Robinson, Sir Ian Heilbron, and Professor Christopher Longuet-Higgins among others at meetings and colloquia, where the most complicated scientific problems were discussed in a

casual and merry manner. Nikolay learned a lot from these meetings; he came to love their style and adopted it for himself.

He appreciated Professor Todd's guidance not only in research, but also in his new life in the West, which was completely different from his previous experience. For instance, Professor Todd told Nikolay that he had ordered that no journalists should approach Nikolay and he advised him not to speak to any of them either. This proved to be a good idea, as Nikolay's stay in Cambridge coincided with the Suez crisis and the uprising against the Soviet Union in Hungary, both of which events could make journalists very curious about comments of a Russian.

Six months passed, and Nikolay returned to Moscow. His visit paved the way for other Soviet researchers to come to the UK, and afterwards many of them worked in Cambridge and other places. Communications between Nikolay and Lord Todd continued into the late 1980s. They met at international conferences and every time when they traveled to each others' countries.

The work in England boosted Nikolay's career at home. His return to Moscow from Cambridge came at the start of a boom in biochemistry and molecular biology in the Soviet Union, which followed great discoveries made in the West, including the Watson–Crick double helix. To boost research in the life sciences, the USSR Academy of Sciences asked the government to establish two new institutes. A positive decision did not come easily. First the importance of developing of a new 'exotic' scientific field had to be proved and reasons why it would be expensive explained. Two prominent scientists, Academicians Vladimir Engelhardt and Ivan Nazarov, were among those who pursued the process. Finally in 1958, a decree was issued authorizing the organization of the Institute for Chemistry of Natural Products (IKhPS; now M. M. Shemyakin-Yu. A. Ovchinnikov Institute of Bioorganic Chemistry) and the Institute of Radiological and Physico-Chemical Biology (now V. A. Enghelhardt Institute of Molecular Biology).

Academician Nazarov was nominated as director-to-be of the IKhPS, but he died, and Academician Mikhail Shemyakin, a specialist in the chemistry of antibiotics and vitamins, was appointed instead. Nikolay became his deputy and the head of the laboratory of chemistry of carbohydrates and nucleotides. He was an appropriate candidate; he had experience in the chemistry of monosaccharides and nucleosides, which he received in Cambridge and which was rare in the Soviet Union. At that time there was no nucleic acid chemistry going on in the country, and carbohydrate research was limited to industry-oriented technologies for processing cellulose and a few other polysaccharides.

Nikolay was involved in solving problems emerging during the organization of the IKhPS, and was to be one of the major contributors to the project. The first task was to define directions of research and the organizational structure that should be followed in staff recruitment, a difficult process because of the lack of people appropriately educated and qualified for the new research. Slowly, heads of laboratories and team leaders were found, and some of them brought their teams with them. Nikolay invited Varvara Derevitskaya, a specialist in cellulose chemistry, to be head of the glycoproteins group and his deputy in the laboratory. Eduard Budovsky led the nucleic acids group, and Anatolii Khorlin and Izida Zhukova the groups of structures of plant glycosides and glycolipids, respectively. Lev Kudryashov was appointed head of the monosaccharide synthesis group and later the carbohydrate radiochemistry group.

Attention was then transferred to undergraduates and postgraduates of Moscow University and other institutions of higher education. In 1958, Academician Nesmeyanov formed a special group from graduates of the chemical faculty at Moscow University under Nikolay's supervision. The senior staff of the IKhPS, including Nikolay himself, taught this group the chemistry of proteins, nucleotides and nucleic acids, carbohydrates, and steroids; and then many students were given jobs in the IKhPS. Among young people who joined Nikolay's new laboratory were 'Nesmeyanov's recruits' Oleg Chizhov, Viktor Vas'kovsky, and Boris Dmitriev, who were followed by Vladimir Shibaev, Anatolii Usov, Leonid Likhosherstov, Alexei Bochkov, Yury Ovodov, Mikhail Grachev, Sergei Kara-Murza, Leon Backinowsky, Galina Smirnova, and Evgeny Sverdlov. Later, some of them led research groups in the laboratory, and others became heads of their own laboratories or even directors of institutes and members of the Academy of Sciences.

The challenge that Nikolay and his new collaborators faced was even stronger than in some other laboratories, because none of them had a solid background in carbohydrate and nucleotide chemistry. They had to educate themselves, understand the contemporary level of research in these fields, learn the methodology, find their own niche, and only then move forward. All of the staff was enthusiastic and ready to do everything that was needed. Nikolay launched 'anti-illiteracy' seminars in his laboratory where scientific news would be informally discussed once or twice a week, and that proved successful within the year. A professional team, 'the Kochetkov school', was born.

Apart from scientific challenges, Nikolay had many other problems on his plate. The building that was chosen to accommodate the two institutes was unsuitable for either of them and had to be significantly reconstructed. A

separate problem was to find equipment, such as chromatographs and spectrometers, and to teach people how to use them; there were not many people available who could do that. Nevertheless, with a help of friends from other institutes, these difficulties were overcome and the IKhPS started working.

Soon, it began developing contacts with foreign academic institutions, and the first of them was the Institute of Organic and Bioorganic Chemistry in Prague, in what was then Czechoslovakia. Nikolay recalled that its director, Professor František Šorm, who was also the president of the National Academy of Sciences, helped the IKhPS a great deal. Later contacts deepened, and it became possible to send researchers for training in leading laboratories in Western Europe and the USA.

The first scientific articles from the IKhPS were submitted for publication in the early 1960s, among them being Nikolay's reports on his work in the new field. His major project in nucleotide chemistry was specific chemical modifications of heterocyclic bases. Reactions of hydroxylamine with cytidine and uridine were studied in detail and a new reagent, *O*-methylhydroxylamine, was proposed for modification of cytidine. These investigations aimed at the development of efficient methods for sequencing and analysis of the secondary structure of polynucleotides. Later, a reaction of chloroacetaldehyde with adenosine and cytidine was discovered and used for preparation of fluorescent polynucleotide derivatives.

Kochetkov's involvement in carbohydrate chemistry began with the development of new methods for synthesis of unusual monosaccharides, including deoxy, amino, thio sugars, and higher monosaccharides. Sugar derivatives of α-amino acids and hydroxy amino acids were prepared as model compounds in degradative studies of glycoprotein structure. Natural nucleoside sugar diphosphates and their analogues were synthesized and assayed in enzymatic reactions to reveal their structure–function relationships. A new method of glycosylation, the orthoster method, was elaborated and it gained general recognition, being applied to the synthesis of a number of natural glycosides and oligosaccharides.

Simultaneously, Kochetkov paid attention to the structural elucidation of natural carbohydrates. Analysis of saponins from Far-Eastern plants of the Araliaceae family, including ginseng, revealed that many of them were glycosides of a new type, having polycyclic triterpene aglycones and long (up to 10 monosaccharide residues) oligosaccharide chains. Nikolay was one of the first to realize the high potential of mass spectrometry in carbohydrate chemistry. His pioneering works with Oleg Chizhov revealed the major electron-impact fragmentation pathways of various monosaccharide and oligosaccharide derivatives,

and opened the way to the essential simplification of structural analysis of carbohydrates. This enabled Kochetkov and co-workers to begin studies of more complex carbohydrate-containing products, including animal sphingoglycolipids and mucin-type glycoproteins.

The progress in studies of natural products in the USSR led to the establishment in 1964 of the Institute of Biologically Active Substances (now the Pacific Institute of Bioorganic Chemistry) of the Far-East Branch of the Academy of Sciences in Vladivostok. Its first director and co-founder was Professor (later Academician) Georgy Elyakov, one of Kochetkov's collaborators. Several Ph.D.s from Nikolay's laboratory, including Yury Ovodov and Viktor Vas'kovsky, went to work there, still counting themselves as members of Kochetkov's school.

In 1960 Kochetkov was elected Correspondent Member of the Academy of Sciences. In 1965 he became the coordinator of an international program on the development of carbohydrate chemistry in countries of Eastern Europe, which continued for the next twenty two years. While in the IKhPS, he became a member of the editorial boards of *Carbohydrate Research*, *Advances in Heterocyclic Chemistry,* and a number of national journals. In 1961, in collaboration with Professors Igor' Torgov and Maria Botvinik, specialists in steroid and protein chemistry, Kochetkov wrote *Chemistry of Natural Compounds*, one of the first textbooks in this field in the country.

However, by the mid-1960s, the relationship between Academician Shemyakin and Kochetkov became difficult. Nikolay was dismissed from the post of deputy director and encountered serious problems in his work. Once again, Academician Nesmeyanov helped him. With the support of the then vice president of the Academy of Sciences, Academician Nikolay Semenov, he proposed Kochetkov as a candidate for the directorship of the N. D. Zelinsky Institute of Organic Chemistry (IOKh). The Presidium of the Academy of Sciences ultimately approved him to the post.

Nikolay was more than happy with the appointment, but wanted to take his laboratory with him. After long negotiations the laboratory was split up, with the majority of its carbohydrate unit moving to the IOKh and the nucleotide unit staying in the IKhPS. This was in the snowy winter, and veterans recalled how they used children's sleds as vehicles for transporting the laboratory equipment between the two Institutes, which were about 10 minutes walk apart from each other. During the move some crazy researchers could not interrupt chromatographic separations, and loaded sleds with columns, asking colleagues to pull them and running behind with bottles of solvents!

Nikolay recalled his first day at the IOKh, and how he was in front of the director's office, which he was to occupy for twenty two years. He would often say that he fell in love with the Institute from the first sight. Most of all he loved the people who, as he would note, were intelligent and top specialists in their fields. The directorship in the IOKh became the happiest and most creative period of his life.

Kochetkov's duties included the administration and scientific supervision of the Institute. In line with the Academy of Sciences' practice for directors, he chaired the IOKh's Scientific Council. In one of his last interviews, Nikolay said he thought it would be tragedy for a scientist to become just the manager of an enterprise, and he was able to avoid that. He remained a devoted scientist, while becoming an excellent manager and administrator. He maintained traditions that had developed since the Institute was founded in 1934.

Nikolay was successful in maintaining and extending those fields of organic chemistry in which the IOKh held strong positions. The fundamental research led to results that could be used by various industries. Among them, there were small molecules with potential as human and veterinary pharmaceuticals, insecticides and other plant protectors, and products for the food industry and agriculture. Kochetkov was a pure academic scientist, but he always took pride when he could contribute to the Institute's being able to solve applied problems, posed by the state.

As an enterprise, the IOKh was quite large and employed around 1,200 people—researchers and technicians, engineers of various specialities, pilot production workers, patent experts, librarians, and others. Apart from the academic research facilities, the Institute had a variety of analytical laboratories and services, as well as units for design and construction of new laboratory equipment.

In 1969, Nikolay established a patent department for assessing the value of discoveries and their potential for patenting and licensing. In 1978, the construction of a new laboratory building with modern equipment was completed, almost doubling the Institute's floor space. Nikolay viewed this project as one of the most challenging during the time of his directorship.

Another area of his work at the IOKh was education and publishing. Every year the Institute received a number of postgraduates and graduates, along with trainees from other parts of the Soviet Union and abroad, who had to be taught. There was also a program for the promotion of scientific achievements to the population through special lectures given by scientists and exhibitions. Numerous books, handbooks, monographs, textbooks, and guidelines for applied science institutions and industry were also published.

In 1980, the IOKh won the award of the Academy of Sciences for good work organization and high scientific achievements. In 1981 and 1982 it received similar awards from the Moscow municipal authorities, and in 1984 the Order of the Red Banner of Labour from the Soviet government.

The IOKh's life-science division was developing the chemistry of steroids, terpenoids, proteins, and carbohydrates. Flourishing in the Institute, the Kochetkov's laboratory contributed significantly to the chemistry and biochemistry of carbohydrates and became one of the leading laboratories in this field in the world.

Kochetkov's co-workers who came with him to the IOKh from the IKhPS, along with new people, Tat'yana Druzhinina, Alexander Sviridov, Nargiz Bairamova, Evgenii Klimov, Anatolii Chernyak, Nikolay Arbatskii, Nelly Malysheva, Vitalii Betaneli, Yuriy Knirel, Vladimir Torgov, Leonid Danilov, Andrei Nikolaev, Grigorii Lipkind and others, formed a new team. Alexander Shashkov was invited to develop NMR spectroscopy of carbohydrates. Oleg Chizhov and Anatolii Usov were appointed heads of the IOKh's laboratories of physico-chemical methods of analysis and plant polysaccharides, respectively, and they worked in close cooperation with the Kochetkov's laboratory.

New research projects were launched, and the synthesis of regular homo- and hetero-polysaccharides, including bacterial antigens, was the most challenging. In connection with this task, a number of complex oligosaccharides were synthesized, corresponding to the repeating units of specific polysaccharides of pathogenic bacteria (*Shigella flexneri*, *Salmonella enterica*, *Pseudomonas aeruginosa*, *Streptococcus pneumoniae*). In the course of this work the arsenal of methods for carbohydrate synthesis was developed and improved; however, the synthesis of regular polysaccharides was hampered by the lack of effective stereospecific glycosylation procedures. To solve this problem Kochetkov undertook a systematic study of the glycosylation process, resulting in the development of new, highly stereospecific methods for building 1,2-*trans*- and 1,2-*cis*-glycosidic linkages. Among these, the most useful was found to be the condensation of 1,2-*O*-(1-cyano)ethylidene derivatives with trityl ethers of mono- and oligosaccharides. When both functions occurred in the same molecule, polycondensation took place. Using this approach, a number of linear and branched polysaccharides—structural counterparts of bacterial antigens—were synthesized for the first time.

The trityl-cyanoethylidene polycondensation also permitted the synthesis of polysaccharides having functionalized aglycones for the production of neoglycoconjugates. An alternative approach for preparation of neoglycoconjugates, which could be used for serodiagnosis of infectious diseases (such as

salmonellosis), was developed based on copolymerization of allyl or acryloylaminoalkyl glycosides of synthetic oligosaccharides with acrylamide. Yet another significant achievement in the area of neoglycoconjugate synthesis was the elaboration of a useful procedure for preparation of glycosylamines, known worldwide as the Kochetkov method.

Nikolay's team continued structural studies of glycolipids and glycoproteins and began the analysis of bacterial and algal polysaccharides. The structures of the oligosaccharide chains of gangliosides of starfish and sea urchins, blood-group substances, influenza virus hemagglutinin, and riboflavin-binding glycoprotein of egg white, gel-forming polysaccharides of red seaweeds and antigenic polysaccharides of various bacteria, including acute pathogens, were established. The data obtained were important for taxonomy and classification of the organisms and the development of new synthetic and semi-synthetic diagnostic agents and vaccines. In bacterial polymers, a number of unusual monosaccharides were discovered and identified, including new sugar ethers with lactic acid and two novel classes of acidic amino sugars: 2,3-diamino-2,3-dideoxyhexuronic and 5,7-diamino-3,5,7,9-tetradeoxynon-2-ulosonic acids; their structures were confirmed by chemical syntheses.

Kochetkov made major contributions to the methodology for the structure elucidation of complex carbohydrates. With his co-workers he elaborated new methods for chemical fragmentations and modifications of glycopolymers, including specific or selective cleavages of glycuronans and hexosaminoglycans, solvolytic depolymerization of heteropolysaccharides with hydrogen fluoride or trifluoromethanesulfonic acid, mild solvolytic desulfation of sulfated polysaccharides, and selective splitting of amide bonds and *O*-glycosidic linkages for isolation of glycopeptides and oligosaccharides from glycoproteins. An efficient ^{13}C NMR-based computer-assisted approach was devised for structural analysis of regular polysaccharides, including the determination of absolute configurations of constituent monosaccharides.

Nikolay was also interested in other fields of carbohydrate chemistry and biochemistry, such as conformations of oligo- and polysaccharides, synthesis of highly branched manno-oligosaccharides, radiolysis of carbohydrates, chemoenzymatic synthesis of complex polysaccharides, and studies of enzymes and lipids that participate in their biosynthesis. A joint project with Viktor Zhulin, the head of one of IOKh's laboratories, revealed that high pressure could significantly improve the stereospecificity of glycosylation. Kochetkov initiated research into the synthesis of sugar phosphites (with Eduard Nifant'ev of the Moscow State Pedagogical Institute) and phosphates; a so-called glycosyl-*H*-phosphonate

method was specially designed for synthesis of oligosaccharides with phosphodiester linkages between subunits. His exploration of monosaccharides as chiral precursors of aglycones of macrolide antibiotics with multiple (up to 10) chiral centers culminated in the synthesis of erythronolides A and B and oleandonolide.

Soon after joining the IOKh, Nikolay published two new books, *Chemistry of Carbohydrates* (1967; with Alexey Bochkov, Boris Dmitriev, Anatolii Usov, Oleg Chizhov, and Vladimir Shibaev) and *Organic Chemistry of Nucleic Acids* (1970; with Eduard Budovskii, Evgeny Sverdlov, Natal'ya Simukova, Mikhail Turchinskii, and Vladimir Shibaev); the latter was then translated into English and Japanese. Another of his books, *Radiation Chemistry of Carbohydrates* (1978; with Lev Kudryashov and Mikhail Chlenov), was also translated into English. Later Kochetkov wrote three more books and a number of comprehensive reviews; his publication list exceeded 1200 scientific articles. He became an editor of the journals *Organic Mass Spectrometry*, *Tetrahedron*, and *Tetrahedron Letters*.

In 1979 Kochetkov was elected full member (Academician) of the Academy of Sciences of the USSR. The Soviet government recognized Nikolay as the Hero of Socialist Labour and awarded him with the Golden Star Order, which was then the highest civil state award. He also received a number of other Soviet Union orders and the highest national scientific awards—the Lenin prize for achievements in synthesis and structural analysis of carbohydrates (1988) and the Demidov prize for outstanding achievements in chemistry and biology (1993). In 1995 he received the Academy of Sciences' highest award for scientific achievements—the Lomonosov Great Gold Medal.

Kochetkov was awarded the Gold Medal of the Slovak Academy of Sciences in 1986 and the Haworth Memorial Medal of the UK Royal Society of Chemistry for achievements in carbohydrate chemistry in 1989. He was a member of the Chemical Society of France (since 1973) and a full member of the Polish Academy of Sciences (1988).

In 1988, the heyday of Gorbachev's perestroika, Nikolay was 73. The government had introduced an age limit for administrators at 70, and Academician Vladimir Tartakovskii was elected as new director of the IOKh. Nikolay continued as director emeritus and also remained the scientific chief of the laboratory.

The collapse of the Soviet Union and the ensuing political events hit science badly, with funding dropping and people leaving to work elsewhere. The situation in the IOKh was no different: scientists, having no particular experience in raising funds for research and commercialization of their scientific achievements, suddenly had to learn 'on the run', struggling also to keep their research going. Although Nikolay had never been a Communist Party member, he could not

come to terms with the changes, and they made him upset and angry. He believed that the state's attitude toward science was awful and could destroy it, and that a great country like Russia could not exist without well-developed science.

However, he still remained involved with his laboratory, which was headed by Vladimir Shibaev during 1989–2004, and then by Yuriy Knirel. Nikolay did his best to help the laboratory, to which he had devoted most of his life, to survive, and it has overcome all the challenges during the most difficult years and continues to function. Since 2006, the laboratory has been called the N. K. Kochetkov Laboratory of Carbohydrate Chemistry.

Academician Nikolay Kochetkov died on December 21, 2005 at the age of ninety. He will be remembered not only as a great scientist but also as a tall, handsome, and witty man with charm and a colorful personality, who had a great influence on those who met him.

YURIY KNIREL
MARIA KOCHETKOVA

LIST OF SELECTED PUBLICATIONS BY N. K. KOCHETKOV

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