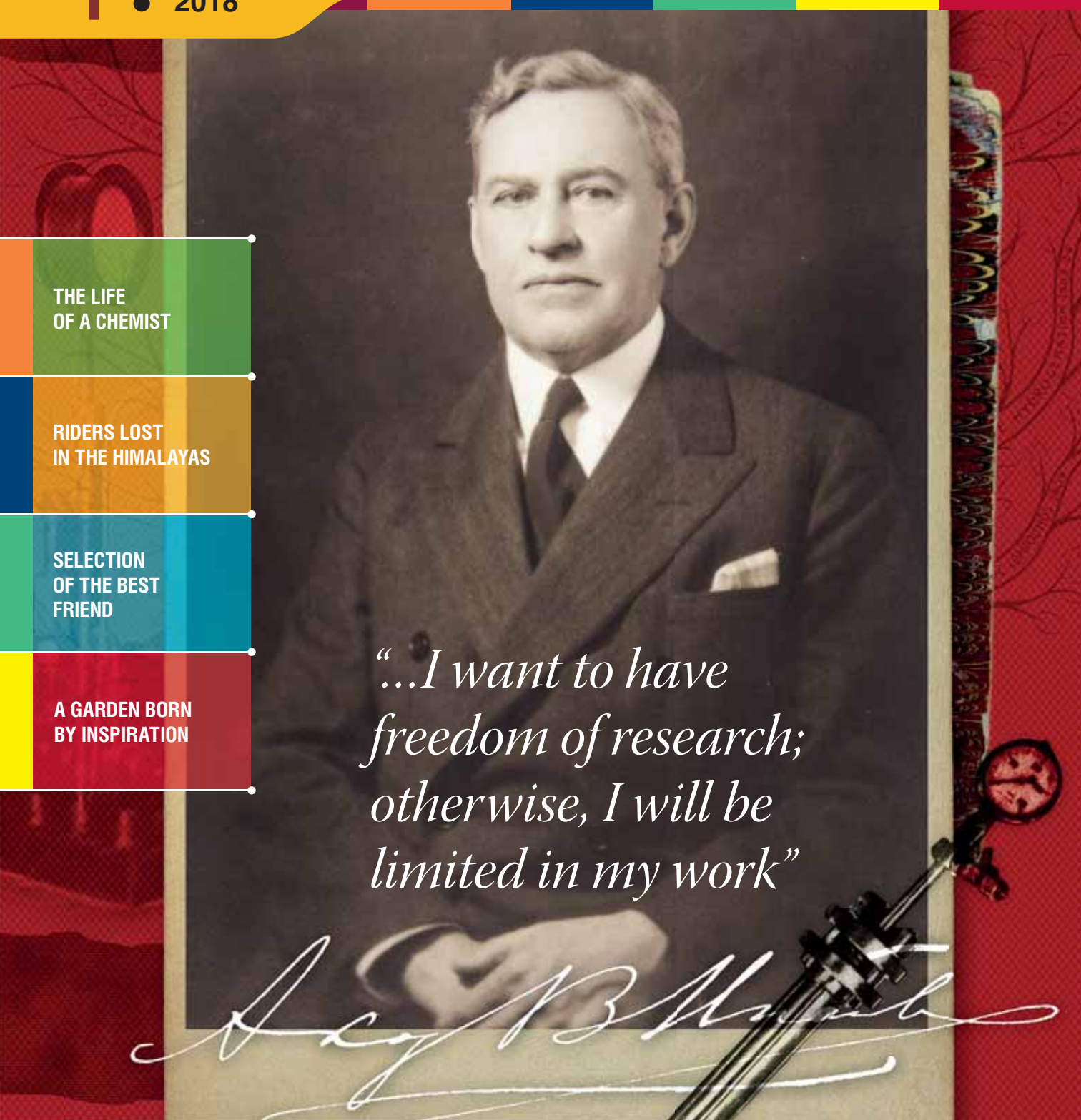
A Good Journal for Inquisitive People

SCIENCE First Hand

1 (48) • 2018

scfh.ru/en/



"...I want to have freedom of research; otherwise, I will be limited in my work"

1. 2018
popular science journal

SCIENCE First Hand

IN THIS ISSUE:

Vladimir Ipatieff, the inventor of technology for the production of polyethylene and high-octane gasoline, was called in 1937 the Man of the Year in the USA and deprived of academic title and citizenship in the USSR

There is no room in ancient history so far for the army of stone horsemen pertified on the slopes of the Pir Panjal mountain range, Himalayas

The publisher of *Science* will donate several thousand copies of the book about the Siberian experiment on fox domestication as a gift to the American schools

Meditation prevents the shortening of the telomeres which protect the chromosomes from damage during cell division

Even a trivial dandelion from the Bonsai Park has an extraordinary story to tell: the creator of this living collection found it at the other end of the world – up in the Andes!

A Journal
for Inquisitive People

"The natural desire
of good men is knowledge"
Leonardo da Vinci

Periodical Popular Science Journal

Published since January 2004

Three issues a year

Founders: Siberian Branch of the Russian Academy of Sciences (SB RAS)

Rzhanov Institute of Semiconductor Physics (SB RAS)

Institute of Archaeology and Ethnography (SB RAS)

Limnological Institute (SB RAS)

Sobolev Institute of Geology and Mineralogy (SB RAS)
Institute of Chemical Biology and Fundamental Medicine (SB RAS)

Trofimuk Institute of Oil and gas Geology and Geophysics (SB RAS)

Limited company INFOLIO

Publisher: Limited company INFOLIO

Address:
11, Zolotodolinskaya Street, Novosibirsk
630090, Russia
Tel. +7 (383) 330 37 33, 330 27 22
Fax: +7 (383) 330 26 67

e-mail: **lidia@infolio-press.ru**

editor@infolio-press.ru

zakaz@infolio-press.ru

The Journal is registered
at the Federal Supervision Agency
for Information Technologies and
Communications

Certificate El No. FS77-37579
of September 25, 2009

ISSN 2310-3000

Date of publication 15 May 2018

Open price

scfh.ru/en/

Dear Friends,

The focus of the new issue is on the fate of two outstanding Russian scientists, one of whom was born together with the Soviet Russia while the other by that time had already achieved worldwide recognition.

November 2017 marked 150 years since the birth of Vladimir N. Ipatieff, the most prominent chemist of the twentieth century, whose name was little known in Russia until recently. He oversaw the development of chemical industry in the last years of the reign of Nicholas II and supervised its restoration after the revolution; he was a member of the Presidium of the Supreme Economic Council and the State Planning Committee of the Soviet Union. However, after the death of Vladimir Lenin, Ipatieff was ousted from all the posts and was awaiting arrest amidst the Stalinist repressions, which had affected many of his colleagues and students. In 1930, he went abroad, together with his wife, to participate in the International Congress and seek treatment, first in Germany, then in the United States, and never came back to his home country.

In the United States, Ipatieff, who was already in his seventies, successfully continued his research, which he began in the Soviet Union. The inventions that made him famous include the catalytic cracking of oil, the production of high-octane gasoline, and the first synthesis of polyethylene. In 1937, the Americans named Ipatieff the Man of the Year – by that time, he had been deprived of both membership in the USSR Academy of Sciences and of Soviet citizenship. For the rest of his life, Ipatieff, who had not won a Nobel Prize only by mistake, lived in a modest hotel, literally out of a suitcase, hoping that someday he would return to his homeland. The fate of this outstanding chemist, which we described in this issue, serves as a vivid example of how a state can irresponsibly, even rascally waste its intellectual wealth.

In 2017, the global community celebrated the 100th birth anniversary of another well-known Russian scientist – Academician Dmitry K. Belyaev. This year, a US publisher released a book How to Tame a Fox (and Build a Dog), *dedicated to his famous evolutionary experiment on the domestication of foxes. Unfortunately, according to Lyudmila N. Trut, one of the authors of the book, a student and follower of Belyaev, whose memoirs became the core of our publication "Selection of the Best Friend," all attempts to publish the book in Russia have failed.*

In 2018, the publisher of the Science magazine – the American Association for the Advancement of Science (AAAS)—announced this work as the best young adult science book of the year. Every year, the AAAS selects winners among popular science books in four categories, and last year, as a result of its partnership with Subaru of America, more than 76 000 winner books were donated to American schools. This year, the AAAS ordered an additional edition of the book that would tell thousands of American students about the unique experiment of the Russian geneticists. Unfortunately, Russian students will have no such opportunity any time soon. However, this event is a good reason to pay heed to the American experience for all those who are concerned about the future of Russian science.

Academician Nikolay L. Dobretsov,
Editor-in-Chief

V.B. FENELONOV

The Life of a Chemist

You, Russians, cannot even comprehend who Vladimir Ipatieff was. Every hour of his life here, in the United States, every step in his research, he dedicated it all to Russia. His limitless love for his motherland, which I have never seen in any of the emigrants, was the soil on which grew the outstanding results of his scientific work...

Herman Pines, chemist; student, friend, and the executor of the will of Vladimir N. Ipatieff, 1967

This article is dedicated to a great Russian scientist, an outstanding chemist Vladimir Nikolaevich Ipatieff, the founder of the science and practice of heterogeneous catalysis at high temperatures and pressures, whose 150th birthday anniversary was celebrated on November 21, 2017. It was about him that Richard Willstätter, winner of the 1915 Nobel Prize in chemistry, said in 1942 that never in the history of chemistry had there been a greater man than Ipatieff. The life path of this great scientist is described both in his own writings and in those by his students and researchers of his creative work. In some countries, for example, in the United States, it is believed that Russia produced three outstanding chemists: Lomonosov, Mendeleev, and Ipatieff. In Russia, however, the name of the latter received the recognition it deserved only in the last decades. In 2011, the Kalvis publishing house printed, in two volumes, the first Russian reedition of Ipatieff's book The Life of a Chemist. Memoirs *(New York, 1945); another autobiographical volume dedicated to his life in the United States in 1930–1941 (Ipatieff, 1959), as well as some other works, will soon be published. Since the milestones of Ipatieff's life path are well detailed in the literature, this article focuses on the creative work of this remarkable scientist, who saw his duty in serving the people rather than those in power*

Vladimir B. FENELONOV, Doctor of Chemistry; Professor, Novosibirsk State University; Professor Emeritus, Boreskov Institute of Catalysis, Siberian Branch, Russian Academy of Sciences (Novosibirsk). Author and coauthor of 260 scientific papers and 15 patents

Portrait photo of Vladimir N. Ipatieff. The exact date when the photographer took this shot is unknown. Judging by the logo on the photo ("Keystone photo agency, N.Y."), it was taken in New York. Ipatieff came to the United States in 1930 at the age of 63. *Photo from the archive of Honeywell UOP (USA)*

My mother's broad-minded influence had ended when I was ten years old when she left for the Crimea for a cure. After that the mistress of the house was our governess, Anna Vasilievna Mazanova (born Bobrova), who was noted for penuriousness, and for whom we had no love or respect, while she in turn had no interest whatsoever in our education and character building. We acquired certain religious prejudices from her which gave us an utterly false understanding of God and His manifestations; and my father, who was a very religious man, supported her beliefs. These unhealthy religious notions very probably affected our mental development. In spite of them I grew up to be religious and have so remained all my life, still glad that the fundamentals of religion were given me during my earliest childhood.

My brother and I took our religion so seriously that, when I was twelve, if we had been too lazy to study our lessons, we often got up early and stopped at church on the way to school in order to pray that the teacher would not call on us. Our mother would have explained how foolish this was, and we might have worked harder thereafter. But without her we had no one with whom to discuss such matters. The teacher of religion, the Reverend Mr. Sakharov, was a man of high religious education but could not gain the respect of the students or hold their interest. His attitude toward his work was purely formal and had no effect on his students' lives.

My mother died of consumption shortly after her return from the Crimea, when I was twelve years old and in the third class at the Gymnasium. Anna Vasilievna Mazanova continued her position as mistress of the house, and ten months later became our stepmother… …My stepmother was the exact opposite of my mother, who was a charming and delightful hostess, with the ability to surround herself with interesting people. During my mother's life, as I was told by my aunt, our house was often visited by educators, doctors, and other members of the intelligentsia.

…At the age of fourteen and a half, still a mediocre student, I was promoted to the sixth class. Soon after this promotion I began to be interested in my work and to study hard. My favorite subject was mathematics, which I studied beyond the class requirements under Uncle Mitia. Thereafter my report card showed a steady improvement, especially in science courses. It was much more difficult to obtain high grades in the Third Cadet Corps than in the other corps, especially those located in provincial cities. Our teacher in mathematics, Professor Protopopov, was very miserly with high grades, and in spite of my perfect answers I never received a grade above ten, which was the highest that he ever gave.

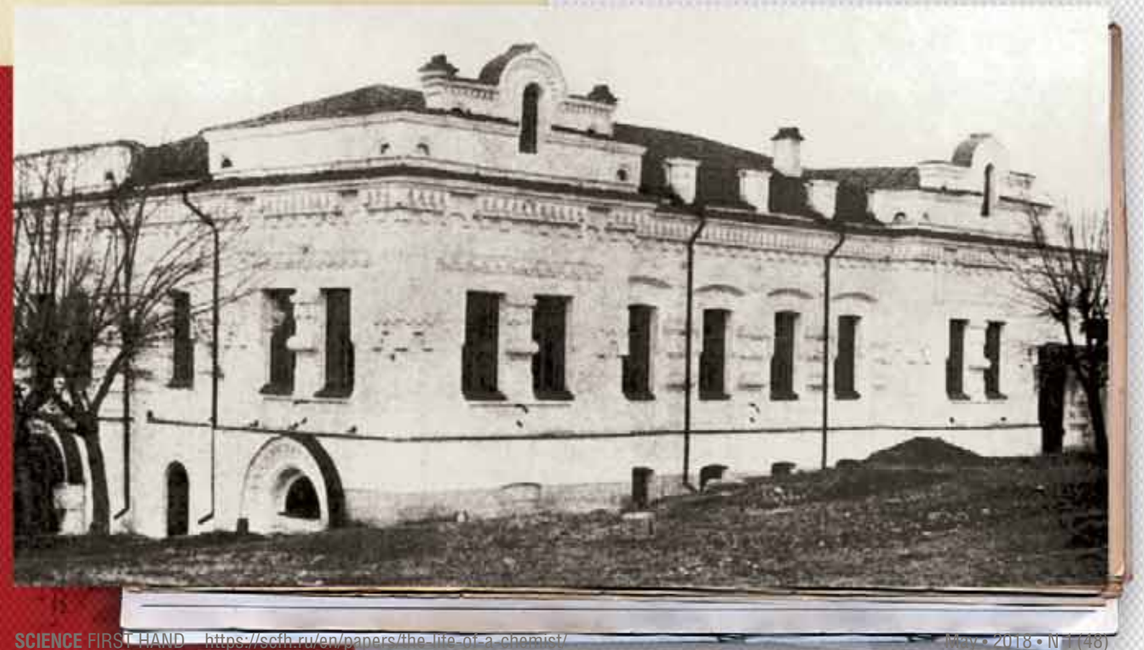
Protopopov, nevertheless, believed that I had sufficient ability to study higher mathematics and that I should be admitted to an artillery or engineering school. Upon graduating from the Corps I applied for admission to the Mikhail Artillery School; but I knew when I did so that my mathematics grades would ruin my chances, since only fifty or sixty boys were admitted from the twenty Cadet Corps. I was rejected and had to enter the Alexander Military School located in Moscow.

On August 31, 1884, in my sixteenth year, I left my father's house forever, thus releasing him from further expense for my education, because the military school supported its cadets on a government grant. My entire education had cost my father almost nothing. During my seven years' schooling in the Gymnasium the cost was no more than 350 rubles, plus clothes and living expenses at home. As I said goodbye to my father he told me that he would give me three rubles a month for gloves and tobacco and added: "In your life be faithful to God, be truthful and honest, and beware of women." I was now independent, except that my freedom was severely limited by the military discipline of the School.

Adapted from: (Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

Anna Ipatieva, born Glinka (1847—1897), mother of Vladimir N. Ipatieff

Ipatiev House, owned by Nikolai N. Ipatiev (Vladimir N. Ipatieff's brother), in Yekaterinburg (Sverdlovsk). It was a corner house situated in the big Voznesenskaya Square; thus, it could easily be isolated from other living quarters. These circumstances determined the choice of Ipatiev House for the residence of the tsar and his entire family and for their murders



Vladimir Ipatieff became fascinated by chemistry as early as in the sixth grade of the gymnasium. A chapter on chemistry he read in a textbook of physics fired his imagination. For the first time, he looked at the world with his eyes open and felt a craving for study in order to understand it better, as he would write later in his memoirs (Ipatieff, 1945). After the gymnasium, he went to military schools, where chemistry was given little attention, but he continued to study it on his own by reading textbooks and doing experiments in a small private laboratory where he reproduced all the problems from the analytical chemistry course by Prof. N. A. Menshutkin (1865—1902). At the Mikhail Artillery Academy, he was fortunate to attend the chemistry course taught by Alexei E. Favorsky (1860—1945), a student of A. M. Butlerov and a future well-known organic chemist and academician (1929). It was Favorsky who consolidated him in his wholehearted love of chemistry (especially organic chemistry) and thereby determined his fate. Upon graduation from the academy, Ipatieff was promoted to captain of artillery and got a position of a chemistry instructor at the academy. In the same year, he married an old friend, Varvara Ermakova. They went together through all the vicissitudes of fate up to the end; she passed away only nine days after her husband.

There is evidence tracing the noble family of Ipatiev back to the times of Ivan the Terrible, or even further. The name of Ipatiev derives from Saint Hypatius ('the highest or the best' in Ancient Greek), the Archpriest of Gangra, who was tortured and murdered by heretics in the year 326 on the territory of modern Turkey. The Ipatiev Monastery (also called Hypatian Monastery) of the Russian city of Kostroma was erected in 1330 in honor of this saint. This monastery played a prominent role in the events of the Time of Troubles. On March 14, 1613, it hosted a solemn ceremony whereby the 16-year-old Mikhail Fedorovich Romanov was announced Russian Tsar, which marked the beginning of the reign of the Romanov dynasty in Russia.

In some inexplicably way, the fate of the Romanovs intertwined closely with that of the Ipatievs. The Ipatiev Monastery became the cradle of the Romanov dynasty; Ipatiev House, which at that time belonged to the engineer Nikolai N. Ipatiev, a younger brother of Vladimir N. Ipatieff, became the last home of the last tsar of the Romanov dynasty, Nicholas II, who was shot there together with his family and heir on the night of July 17, 1918. However, these questions go beyond the scope of this article, which aims to describe Ipatieff's career in science

Key words: V.N. Ipatieff, catalysis, science, fortune, heterogeneous catalysis, chemical industry, cracking, petrochemical synthesis, hydrocarbon dehydrogenation, chemistry

Early years

The second teacher who deeply influenced Ipatieff was the famous Adolf von Baeyer (1835–1917), the future Nobel Prize winner (1905). Ipatieff worked at his laboratory in 1896–1897 at the University of Munich, during his one-and-a-half-year scientific internship, granted to the most promising young instructors of the Mikhail Academy. Baeyer took Ipatieff only at the express request of his old acquaintances from Russia. In Munich, Ipatieff investigated the structure of carone (the bicyclic ketone $C_{10}H_{10}O$) and completed his determination of the structure of isoprene (2-methyl-1,3-butadiene), which he had started in St. Petersburg, and, for the first time, carried out its synthesis (until then, isoprene was obtained only by depolymerization of natural rubber, which consists of its monomeric units). When the work was done, Baeyer suggested that they publish papers under joint authorship, an offer he would seldom make (he usually would not cite a young researcher as a coauthor). The internship at Baeyer's proved extremely useful for Ipatieff because there he mastered the most advanced methodology of chemical experiment and analysis of that time. Ipatieff took a full course of organic chemistry offered by Bayer and several elective courses; he benefited greatly from the almost daily conversations with Baeyer, who made a round of the laboratory at the beginning of each day, discussing results and correcting plans (Ibid.).

Ipatieff presented his dissertation "The Action of Bromine on Tertiary Alcohols and of Hydrogen Bromide upon Acetylene and Allene Hydrocarbons in Acetic Acid Solutions," the topic of which was suggested by Favorsky, at the Mikhail Artillery Academy in 1895. The dissertation was accepted, and he became a lecturer on staff of the academy. The Russian Physicochemical Society (RPCS; it functioned as a department of the Academy of Sciences) awarded Ipatieff for this work with the Small Butlerov Prize. In 1899, he was appointed Professor Extraordinary and in 1902, Professor Ordinary of Chemistry; since 1909, he had been the head of chemical laboratory at the Artillery Academy, teaching courses in theoretical and inorganic chemistry and giving practical classes in analytical chemistry. When preparing for his lectures, he took notes, which he later used to write his first textbook *Inorganic Chemistry*, which was reprinted several times (Ipatieff and Sapozhnikov, 1920).

Ipatieff's bomb

In 1897, Ipatieff became the first to synthesize isoprene from ethanol and thereby laid the groundwork for the synthesis of synthetic rubbers, resins, and gums. In 1900, he began his studies in the field of heterogeneous catalysis. At a RPCS meeting in January 1901, he made a detailed presentation on catalytic decomposition of alcohols. In the same year, Ipatieff's report "On the Double Catalytic Decomposition of Alcohols" became the center of attention at the seminar of the German Chemical Society and at the 10th Congress of Russian Naturalists and Physicians (Ipatieff, 1945). In subsequent years, his research focused on catalysis at high temperatures and pressures in hydrogen medium. In 1904, he invented the famous "Ipatieff's bomb," a failsafe autoclave made of artillery

Barbara D. Ipatieff (born Ermakova). *1882*

Almost every morning he [Baeyer] came to my table and asked about the progress of my work. These daily visits were very instructive and valuable in themselves, for I seldom asked him for advice, since I got most of the information I needed from his assistant. Sometimes, wishing to prove for himself the purity of certain compounds which I had obtained, he would order me to come to his laboratory, where he himself would carry out the reaction in test tubes. He insisted that I always first try a reaction in a test tube before doing it on a large scale. I have always followed his advice and have taught many of my students both in Russia and abroad to do the same.

Adapted from: (Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

Ipatieff before his trip to Munich. *1897*

I was made an officer on the 7th of August, 1887, a day memorable for the solar eclipse when the famous chemist, Mendeleev, made a scientific flight in a balloon.

On becoming an officer each appointee received a sum of money from the government for a saddle and other equipment; but as this would not pay for everything, my father gave me some extra cash for clothing. After making my purchases I found that I still had one hundred rubles left. I could not then decide whether to buy a winter coat or a small chemistry laboratory which I had always wanted. I did not hesitate long, and of course the laboratory was my choice. I rationalized that a regular officer's overcoat was much warmer than the soldier's coat I had been wearing as a cadet, and I never regretted my choice, for with the small laboratory I experimented at my leisure and acquired a fundamental knowledge of inorganic chemistry.

Adapted from: (Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

Prof. Adolf von Baeyer's chemical laboratory. *1896–1897*

steel for studies at pressures of up to 1000 atm. He took the sealing idea from artillery and pioneered the studies of catalytic transformations of organic molecules at high temperatures (up to 700 °C) and pressures (up to 1000 atm). Before Ipatieff, everyone believed that studies at elevated pressures and high temperatures were too complicated and dangerous. Moreover, organic chemists followed the advice of Butlerov, who wrote that the correctness of conclusions about the molecular structure of substances "...should best be evaluated by investigating the ways of their synthetic formation, preferably such syntheses that occur at a slightly elevated temperature and, generally, under conditions where one can track the gradual complication of a chemical particle" (Butlerov, 1953). Therefore, the principle of observing "mild conditions" of chemical reactions lay at the heart of all the experimental works conducted by Butlerov and his school, as well as most representatives of the classical trend in organic chemistry. Ipatieff dared to go against the advice of the great Butlerov and discovered a new continent in the world of molecule transformations in organic chemistry and petrochemistry.

In 1909, Ipatieff showed for the first time the fundamental possibility of obtaining butadiene (divinyl) from ethyl alcohol on an aluminum oxide catalyst, and in 1913, he was the first to synthesize polyethylene. Previously, Butlerov had attempted to carry out the polymerization of ethylene, using H_2SO_4 as catalyst. However, the latter proved ineffective. Ipatieff achieved a success by using $ZnCl_2$ and AlCL as catalysts (Ipatieff, 1945; Butlerov, 1953). In his later works, he used multifunctional catalysts in cracking, reforming, and other cases of oil refining; developed numerous industrially important processes such as the synthesis of polymer benzenes from gaseous olefins (a residue of oil cracking), etc.

In 1908, Ipatieff successfully presented at the University of St. Petersburg his academic dissertation "Catalytic Reactions under High Temperatures and Pressures" and received, upon acceptance, the degree of doctor of chemistry. From 1900 to 1917, he published three monographs, two textbooks, and more than a hundred articles in Russian and foreign journals. Alongside his research work, he continued to teach and work at the Artillery Academy; in 1911, he was promoted to the rank of major general; in 1916, lieutenant general. In 1914, he was elected as a corresponding member of the Academy of Sciences (AS); in 1916, a full member (academician) of the Academy of Sciences (AS).

The works carried out by Ipatieff before 1917 had established the groundwork for thermochemical and thermocatalytic conversion of hydrocarbons as well as petrochemical synthesis in a wide range of temperatures and pressures, leading to the discovery of new research areas in inorganic chemistry. Subsequently, in the United States, he built on and enriched these studies, putting them to practical use by introducing catalytic cracking for the

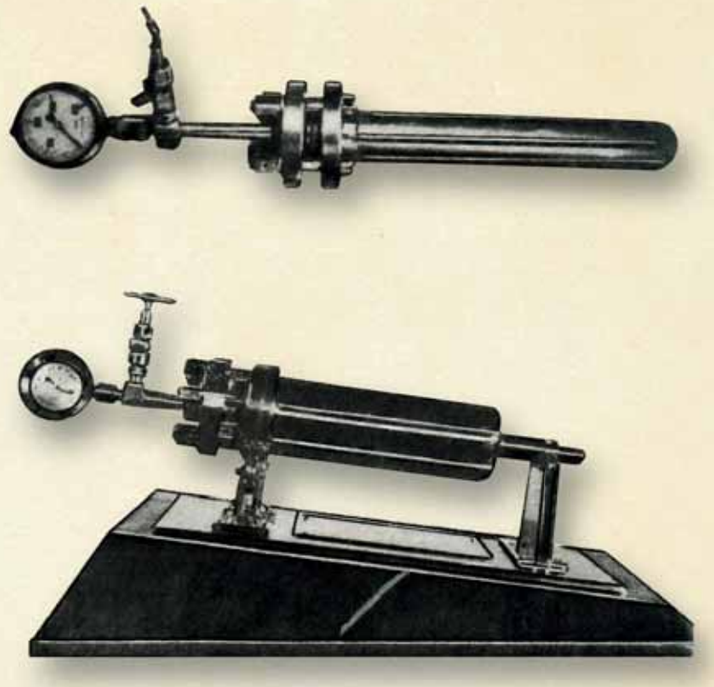
I experimented for a whole year before I constructed an apparatus suitable for high-pressure work. The closure of the bomb or autoclave was achieved by means of a special gasket of heat-treated red copper between two knife edges, one on the top of the bomb and the other on the bottom of the cover. The knife edges cut deep into the soft gasket when the cover was bolted down. Tens of thousands of experiments in Russia and abroad proved that this method of closure was the best for laboratory purposes. It is safe up to 500° C and 450 atmospheres. At lower temperatures, with special steels, this apparatus held a pressure of 1,300 atmospheres, in one case for a whole month. Instead of steels other alloys could be used for the bomb, such as stainless steel, or phosphorous bronze. The gasket can also be made of different metals. When it is necessary to avoid contact of the reactants with the body of the bomb it is possible to use liners of glass, copper, or silver, equipped with capillary tips. For example, I used silver liners and silver gaskets when I studied the pressure oxidation of phosphorus by water to obtain phosphoric acid.
Adapted from: (Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

The investigation which interested me most at the beginning of 1900 was the study of the addition of halogen acids in acetic solution to conjugated diolefins; Professor Thiele had shown that bromine added in a special way to these hydrocarbons. I planned to study the addition of hydrogen bromide to the simplest diene, butadiene; but it turned out that I could not begin this work until the following fall.

When my father-in-law died suddenly in 1896 he had left a very valuable apartment building in the center of Moscow (Brusovsky Lane) and a large piece of land to my wife and her brother, jointly. This was a great surprise to her and to everyone else; for it had always been assumed that her father would leave the bulk of his estate to his son. But her brother never gave the slightest sign that he had been disappointed. He was a kindly man, very fond of our children; and we were on the friendliest terms. Indeed, he may have been glad that I could help him manage the property. His retiring disposition and lack of business ability made it almost impossible for him to do such things, and it is very likely that if he had been the sole owner, he would simply have sold the property at considerable loss.

During this summer vacation he and I began the construction of a four-story apartment house on the vacant land. A property of this sort produced far more income than government bonds, and it would have been unforgivable to have left the land unused. Building some twenty apartments, we spent

Continued on page 16



"Ipatieff's bomb" for studying the process of catalysis at high pressures, a prototype of modern chemical autoclaves and reactors

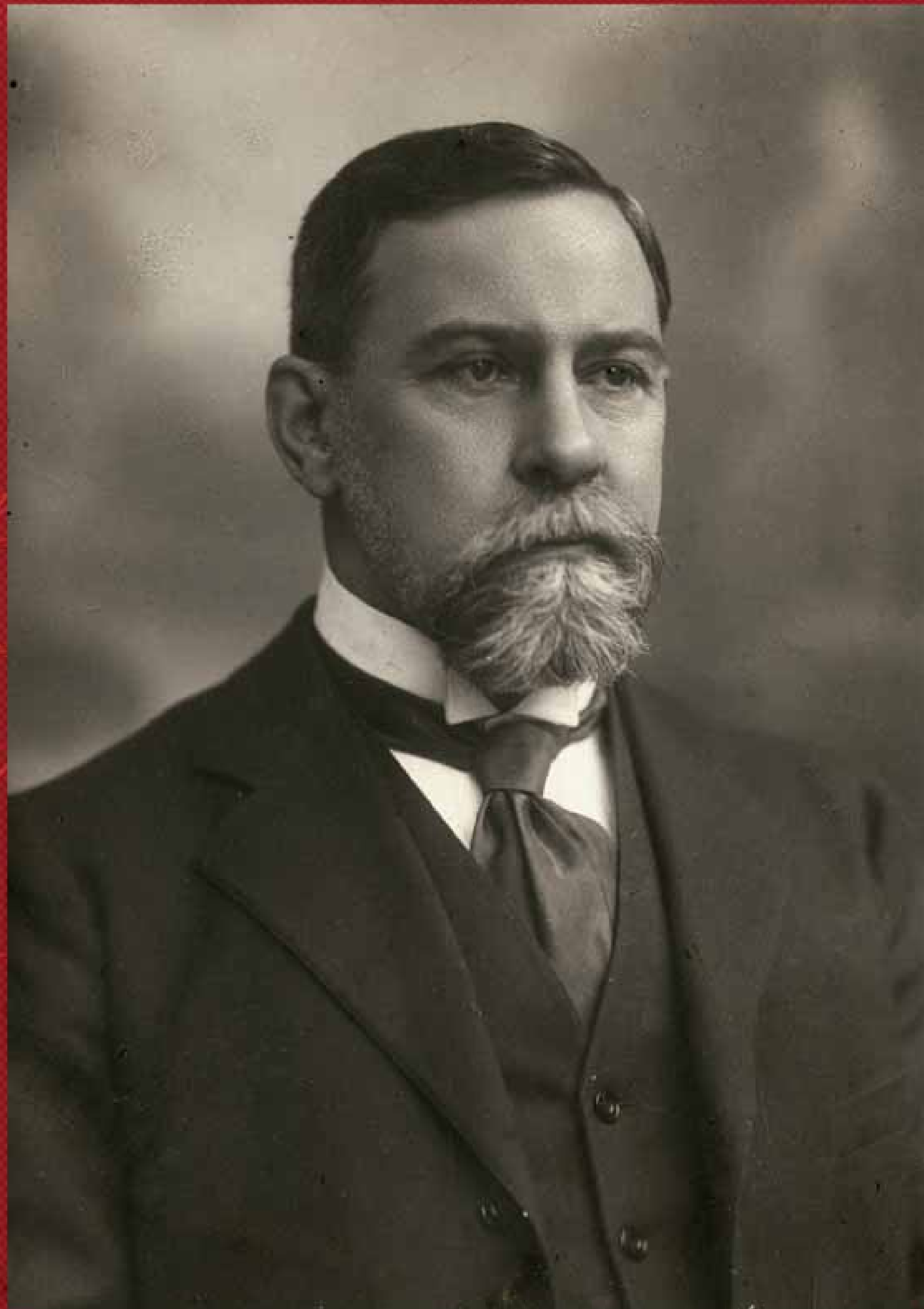
about 300,000 rubles ($150,000). My uncle Gliky, my mother's brother, who lived in Moscow, agreed to manage the building and to supervise most of the construction. In the fall I returned to my investigations and began to prepare butadiene in large quantities. At that time the only method of obtaining it described in the literature consisted in passing the vapors of isoamyl alcohol through a heated tube. The temperature was not specified, but it was apparently around 600 °C. The gases containing a small percentage of butadiene were bubbled through bromine, giving solid butadiene tetrabromide and other bromides. Then the action of zinc and alcohol upon the solid bromide produced gaseous butadiene. Professor Thiele had used this method in preparing butadiene for his experiments on conjugated olefins, employing an iron tube for the pyrolysis instead of a quartz tube, since the former was more suitable for work at a high temperature. I found that in using this method the yield of butadiene was surprisingly small. I tried to discover the reason for this low yield, and I wondered if it might not be because of the polymerization of butadiene under the high temperature used.

Up to this time no attention had been paid to the nature of the liquid products obtained in this reaction; probably most investigators assumed that they were water and undecomposed alcohol. I separated the other liquid products from the water, dried and distilled them, and discovered that the major constituent was isovaleric aldehyde, the remainder consisting of undecomposed isoamyl alcohol. This interesting observation made me surmise that the aldehyde was formed from the alcohol and that the gas should be largely hydrogen. The gas analysis completely substantiated this supposition and I decided to investigate this newly discovered reaction more thoroughly and to determine the conditions under which it took place. First I tested to see if the decomposition took place in glass or quartz tubes, and for the first time I introduced a Le Chatelier pyrometer into the organic combustion furnace. I found that only the iron tubes decomposed alcohol at 500 °C. into aldehyde, and that alcohol passed through glass and quartz tubes unchanged, unless the temperature was raised to more than 700 °C. In glass and quartz tubes, also, the yield of aldehyde was smaller, and the gases contained, besides hydrogen, carbon monoxide, methane, and ethylene.

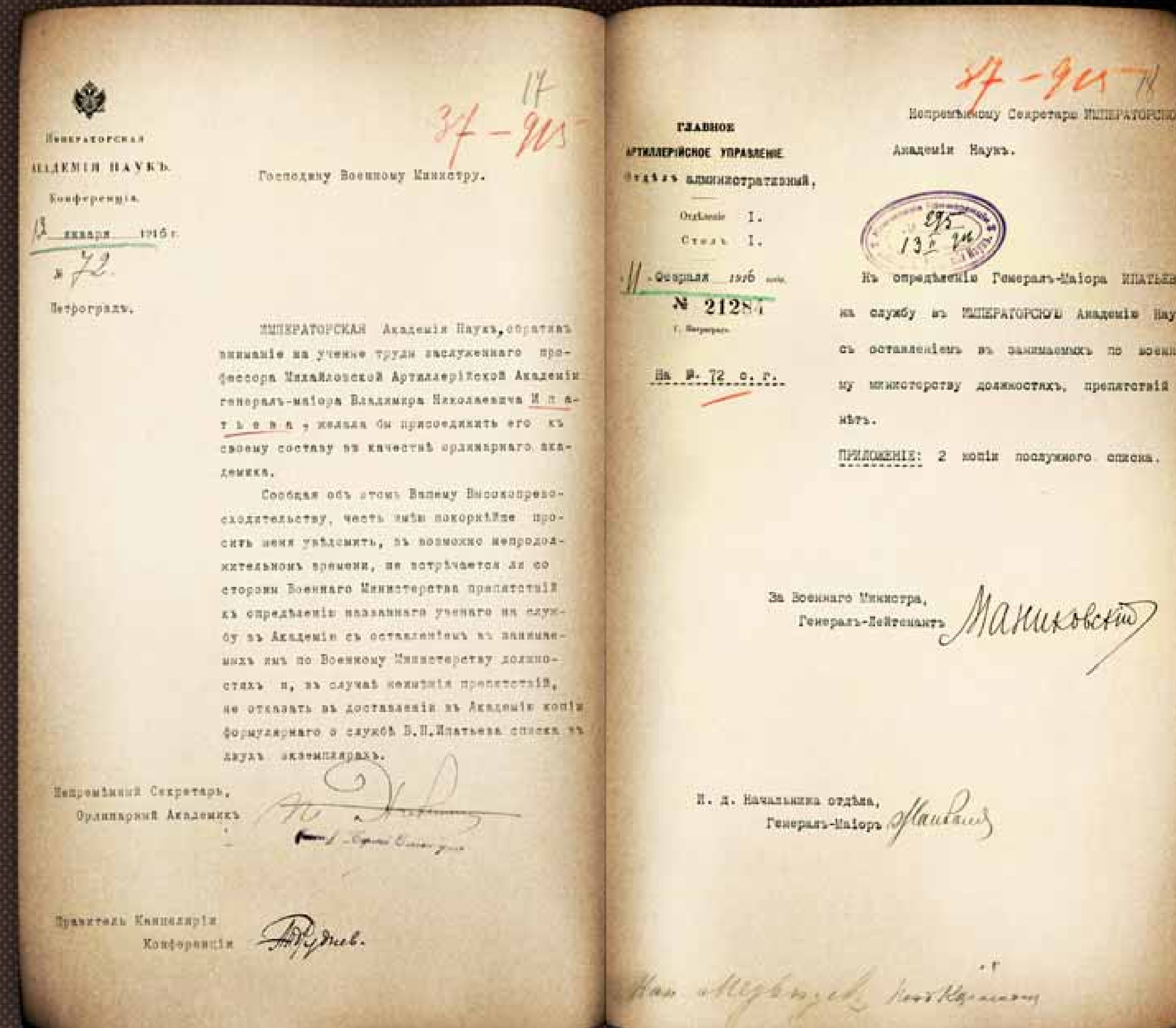
I immediately carried out similar experiments with ethyl alcohol as well as with secondary and tertiary alcohols, and found the following: all primary alcohols give aldehydes and hydrogen upon passage through an iron tube; secondary alcohols decompose into ketones and hydrogen; while tertiary alcohols yield neither aldehyde nor ketone but at higher temperatures decompose into the hydrocarbons and water.

Thus it became apparent that iron was a compound which caused the decomposition of alcohol without undergoing any change itself; in other words, it was a catalyst.

Adapted from: (Ipatieff V. N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)



Portrait photo of Ipatieff before 1917. *SPbB ARAS: Repository 941, List 1, Case 29, Sheet 3. © St. Petersburg Branch, Archive of the Russian Academy of Sciences (SPbB ARAS)*



Императорская
Академія Наукъ.
Конференція.
13 января 1916 г.
№ 72.
Петроградъ.

Господину Военному Министру.

ИМПЕРАТОРСКАЯ Академія Наукъ, обративъ вниманіе на ученые труды заслуженнаго профессора Михайловской Артиллерійской Академіи генералъ-маіора Владимира Николаевича И п а т ь е в а, желала бы присоединить его къ своему составу въ качествѣ ординарнаго академика.

Сообщая объ этомъ Вашему Высокопревосходительству, честь имѣю покорнѣйше просить меня увѣдомить, въ возможно непродолжительномъ времени, не встрѣчается ли со стороны Военнаго Министерства препятствій къ опредѣленію названнаго ученаго на службу въ Академіи съ оставленіемъ въ занимаемыхъ имъ по Военному Министерству должностяхъ и, въ случаѣ неимѣнія препятствій, не отказать въ доставленіи въ Академію копіи формулярнаго о службѣ В.Н.Ипатьева списка въ двухъ экземплярахъ.

Непремѣнный Секретарь,
Ординарный Академикъ

Правитель Канцеляріи
Конференціи

Главное
Артиллерійское Управленіе
Отдѣлъ административный,
Отдѣленіе I.
Столъ I.
11 Февраля 1916 года.
№ 21284
г. Петроградъ.
На № 72 с. г.

Непремѣнному Секретарю ИМПЕРАТОРСКОЙ Академіи Наукъ.

Къ опредѣленію Генералъ-Маіора ИПАТЬЕВА на службу въ ИМПЕРАТОРСКУЮ Академію Наукъ съ оставленіемъ въ занимаемыхъ по военному министерству должностяхъ, препятствій нѣтъ.

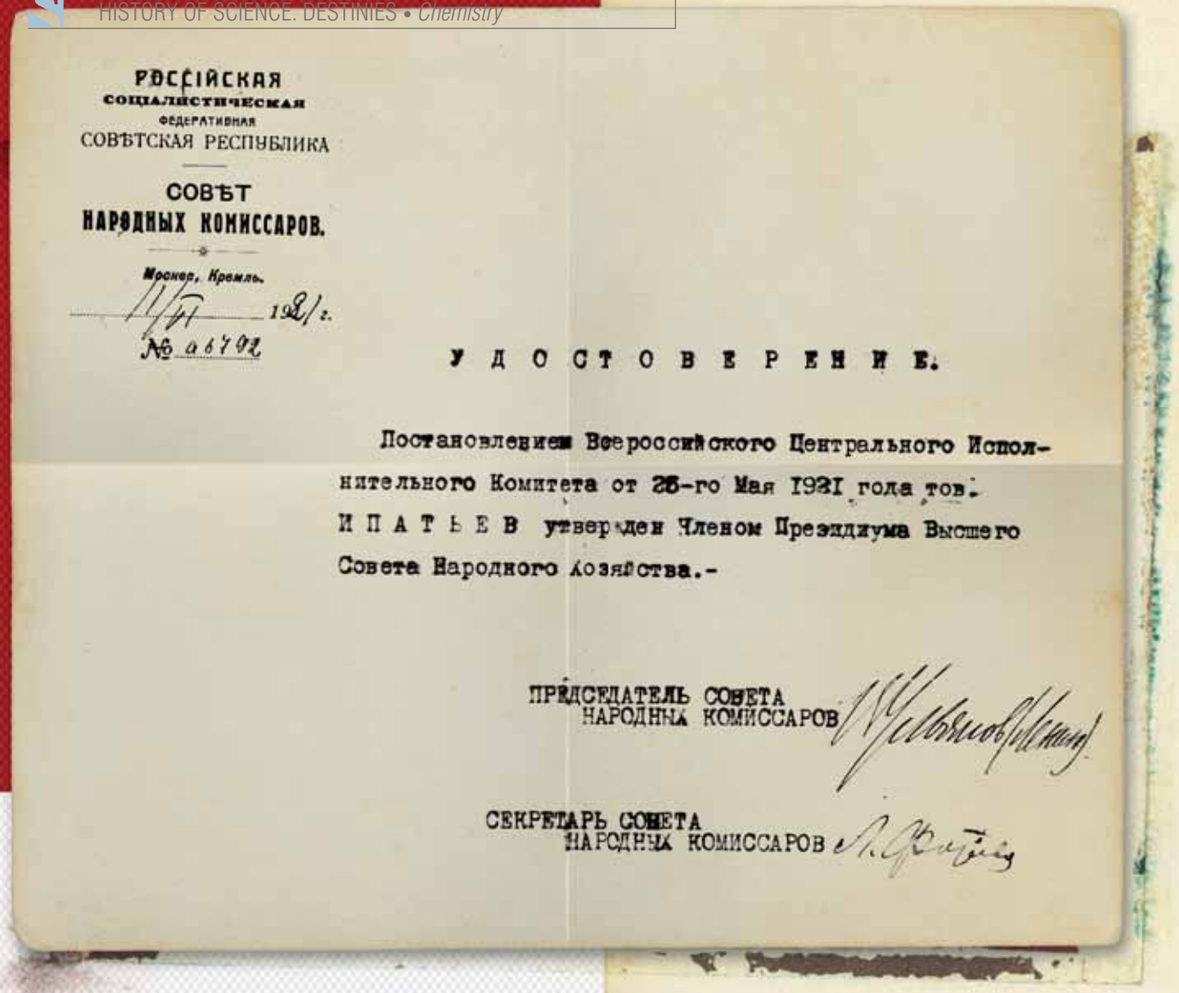
ПРИЛОЖЕНІЕ: 2 копіи послужного списка.

За Военнаго Министра,
Генералъ-Лейтенантъ

И. д. Начальника отдѣла,
Генералъ-Маіоръ

My discovery of the catalytic decomposition of alcohol into aldehyde and hydrogen opened an entirely new field of investigation for me. The reaction was one of catalytic dehydrogenation (the removal of hydrogen), and a detailed study was necessary to elucidate the mechanism and gather sufficient information to predict new catalysts for the reaction. This was so interesting that I put all my time on it, dropping all other investigations.
Adapted from: (Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

Letter from the Permanent Secretary of the Imperial Academy of Sciences to the Minister of War, which states the academy's desire to elect Ipatieff as Ordinary Academician, and the reply from the War Ministry about the absence of obstacles to it. January–February 1916. *SPbB ARAS: Repository 2, List 17, Case 212, Sheets 17, 18. © St. Petersburg Branch, Archive of the Russian Academy of Sciences (SPbB ARAS)*



РОССІЙСКАЯ
СОЦІАЛИСТИЧЕСКАЯ
ФЕДЕРАТИВНАЯ
СОВѢТСКАЯ РЕСПУБЛИКА

СОВѢТ
НАРОДНЫХ КОМИССАРОВ.

Москва, Кремль.

11/VI 1921 г.
№ 06792

У Д О С Т О В Е Р Е Н И Е.

Постановлением Всероссийского Центрального Исполнительного Комитета от 26-го Мая 1921 года тов. И П А Т Ь Е В утвержден Членом Президиума Высшего Совета Народного Хозяйства.-

ПРЕДСЕДАТЕЛЬ СОВЕТА НАРОДНЫХ КОМИССАРОВ

СЕКРЕТАРЬ СОВЕТА НАРОДНЫХ КОМИССАРОВ

Certificate issued by the Council of People's Commissars on the approval of V.N. Ipatieff as member of the Presidium of the Supreme Council of National Economy. *1921. Photocopy. SPbB ARAS: Repository 941, List 1, Case 12, Sheet 3. © St. Petersburg Branch, Archive of the Russian Academy of Sciences (SPbB ARAS)*

industrial production of high-octane motor fuel and other important products, including those used to manufacture most of the modern polymer materials (Ipatieff, 1959; Loktev, 1991).

Ipatieff was the first to use mixed (i.e., promoted) catalysts of one type (e.g., hydrogenating) and of different types (e.g., hydrogenating and dehydrating), which dramatically increased the potential for heterogeneous catalysis and allowed directional changes in the properties of catalysts. Ipatieff's research in organic catalysis revealed so many unknown aspects of catalytic reactions that it necessitated a revision of the existing and the development of new theoretical views on catalysis (Ipatieff, 1936; Boreskov, 1986).

Rivalry between Ipatieff and Sabatier

Independently of Ipatieff, the same problem attracted the attention of the French chemist Paul Sabatier (1854–1941), who had been studying organic catalysis since 1897. He applied a much simpler experimental procedure, i.e., passed vapors of the original organic substance through a tube, heated to 100–200 °C and filled with finely crushed metal catalyst (Sabatier, 1932). He conducted all his experiments at atmospheric pressure and mainly with metallic nickel powder. Unlike Sabatier, Ipatieff introduced into the laboratory and, subsequently,

December 23, 1936 was the opening day of the General Meeting of the USSR Academy of Sciences on the development of chemistry. At the beginning of the meeting, one of the academicians suggested sending their greetings to Comrade Stalin. The text of the greetings was "adopted by acclamation." "Dear and beloved Iosif Vissarionovich," it said, "the Session of the Academy of Sciences on the main problems of chemistry sends you our warmest greetings and expressions of love, devotion and deepest respect. We, Soviet scientists, are happy to work in our free, socialist country, under your wise, ingenious leadership. Long live the great motherland of socialism! Long live the great leader of the peoples, our teacher and friend, our great Stalin!"

Two issues were put on the agenda of the last meeting: (1) the deprivation of A.E. Chichibabin of the title of full member in the USSR Academy of Sciences and (2) the deprivation of V.N. Ipatieff of the same title.

"Academician A.E. Fersman," stated the minutes of the meeting, "presented the correspondence that the Academy had maintained for a long time with Academicians V.N. Ipatieff and A.E. Chichibabin regarding their return to work at the Academy of Sciences. V.N. Ipatieff and A.E. Chichibabin systematically evaded giving a definitive answer on this issue. Only recently, in response to a letter from N.P. Gorbunov, Permanent Secretary of the USSR Academy of Sciences, V.N. Ipatieff and A.E. Chichibabin responded that they did not intend to return to work at the Academy of Sciences. V.N. Ipatieff motivated his refusal by stating that he had signed a contract with a private commercial foreign firm, whose directors categorically object to his trip to the USSR…

"The responses from V.N. Ipatieff and A.E. Chichibabin aroused resentment in many organizations and a huge number of scientific workers. After the announcement of Academician A.E. Fersman, the floor was given to Prof. V.V. Ipatieff, who in his own name and on behalf of his sister expressed outrage at the act of his father, V.N. Ipatieff, and said that he considered the actions of V.N. Ipatieff and A.E. Chichibabin to be completely unworthy of the title of a full member of the USSR Academy of Sciences and irreconcilable with the dignity of the Soviet citizen."

Academician A.E. Fersman announced the draft resolutions on the expulsion of V.N. Ipatiev and A.E. Chichibabin from among the full members of the USSR Academy of Sciences. The President of the USSR Academy of Sciences V.P. Komarov put the drafts to the vote. The following resolution was adopted (for Ipatieff only) by 63 votes in favor, with six abstentions: "Since 1927, the full member of the USSR Academy of Sciences V.N. Ipatieff has stayed abroad. V.N. Ipatieff informed the Presidium of the USSR Academy of Sciences that he considered it impossible at present to return to his homeland and resume work at the USSR Academy of Sciences because he had signed a contract with a foreign commercial firm. By refusing to return to work at the Academy of Sciences and decisively preferring to work for a foreign commercial firm, V.N. Ipatieff flagrantly violates the basic duty of every citizen of the Soviet Union – to work for the good of their homeland.

"Considering V.N. Ipatieff's behavior clearly irreconcilable with the dignity of the Soviet citizen, and even more so with the title of an full member of the USSR Academy of Sciences, the General Meeting of the USSR Academy of Sciences, in accordance with § 24 of the Academy Code, decrees that V.N. Ipatieff shall be deprived of the title of full member of the USSR Academy of Sciences."

тубе. в газ. „Известия" 6/I-37 г.

О лишении гражданства Союза ССР ИПАТЬЕВА В. Н.

Постановление Президиума Центрального Исполнительного Комитета Союза ССР

На основании ст. 17 «Положения о гражданстве Союза ССР» от 22 апреля 1931 года (С. З. Союза ССР 1931 г. № 24, ст. 196) Президиум Центрального Исполнительного Комитета Союза ССР постановляет:

Лишить гражданства Союза С. С. Р. **Ипатьева** Владимира Николаевича, как отказавшегося выполнить свой долг перед родиной, и запретить ему въезд в пределы Союза Советских Социалистических Республик.

Председатель Центрального Исполнительного Комитета Союза ССР
М. КАЛИНИН.

Секретарь Центрального Исполнительного Комитета Союза ССР
И. АКУЛОВ.

Москва, Кремль, 5 января 1937 года.

Clipping from the *Izvestia* newspaper of January 6, 1937 with the publication "On the forfeiture of USSR citizenship of V.N. Ipatieff." *1937. SPbB ARAS: Repository 2, List 17, Case 212, Sheet 167. © St. Petersburg Branch, Archive of the Russian Academy of Sciences (SPbB ARAS)*

From 1913 on I became more and more interested in the actual application of my scientific knowledge to the needs of industry. Unfortunately, the Russian chemical industry was too immature to use the scientific discoveries even then available. I still did not bother to take out patents, and once told one of my friends that I was a scientist and wanted complete freedom in my work, which I would not have if I had to be concerned with patents. Had I been a German chemist I should probably have been infected by the same patent disease as were others.

The German chemical industry made full use of my data at no cost to itself. The first man to utilize my investigations on hydrogenation and destructive hydrogenation under pressure was the German engineer, Bergius, who in 1913 took out the first patents on the conversion of tars and certain types of solid fuel into low-boiling hydrocarbons which could be used as gasoline. His reliance upon my work was obvious; and Kling, the French engineer, correctly pointed out the priority of my work in this field, though Bergius certainly deserves the credit for applying my method in the decomposition of the organic compounds found in tars and coal.

Dr. Willstätter in his review of my book *Catalytic Reactions at High Temperatures and Pressures* (New York, 1936), while speaking of the problem of applying catalysts and pressure in the chemical industry – the synthesis of ammonia by Haber and that of methyl alcohol by Patart and I. G. Farbenindustrie – says: «These new principles were applied very early in Ipatieff's investigations.»

In the summer of 1913 I appreciated the honor of a visit from Dr. Hibbert, an employee of the American Du Pont Chemical Company. He came to St. Petersburg especially to see my laboratory and to talk to me about my high-pressure investigations. We met again in 1928 at The Hague at the convention of the International Bureau of Pure and Applied Chemistry, and I have since seen him often in the United States.

Adapted from: (Ipatieff V. N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

industrial practice a new factor – elevated pressure – as well as numerous previously unused catalysts, e. g., Fe, Al, Zn, Cr, Ni, Th, etc., in the form of metals, oxides, halides, etc. (Ipatieff, 1936). Of utmost importance was the effect of combined action of catalysts (*promotion*), discovered by Ipatieff in 1909. His contemporaries almost immediately recognized the significance of his discovery, as clearly stated, e. g., by Eric K. Rideal and Hugh S. Taylor, founders of the catalytic schools in England and the United States (Rideal and Taylor, 1925).

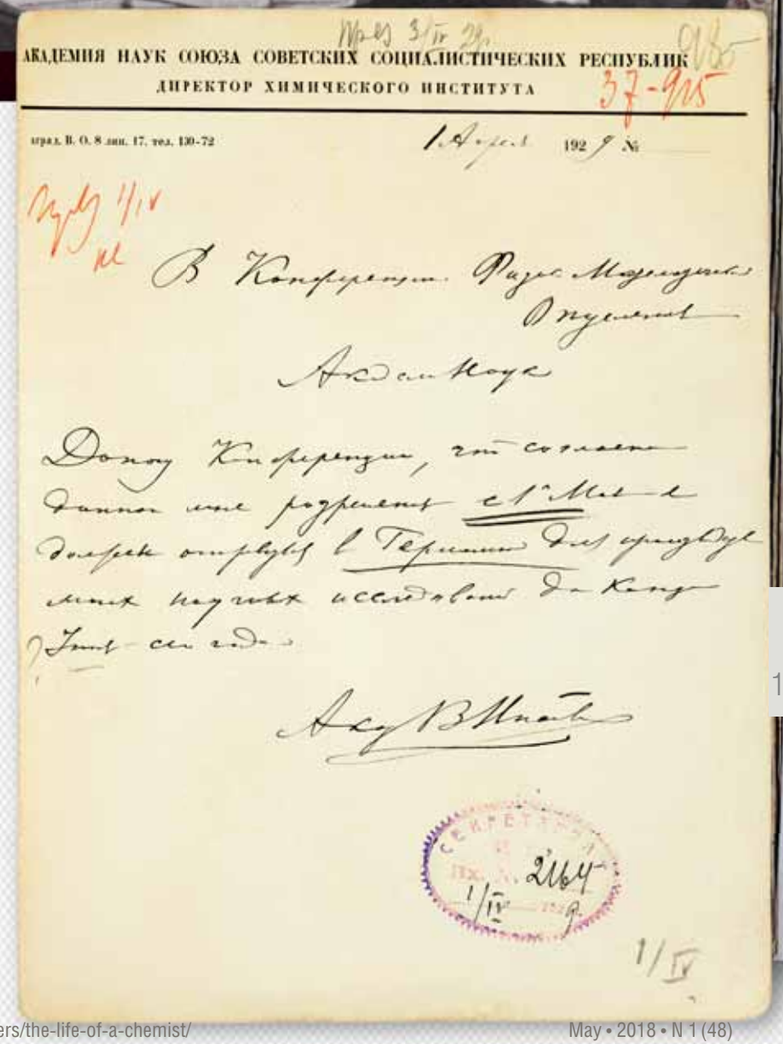
Thus, two chemists who lived at opposite ends of Europe independently developed two chemical theories of catalysis: Sabatier's theory and Ipatieff's theory (Sabatier, 1932; Ipatieff, 1936). According to Sabatier, the mechanism of catalysis consists in the formation and decomposition of unstable intermediate compounds (intermediates) with a catalyst. Accordingly, the catalyst is a substance capable of entering into such a chemical reaction with the reactants. It is here, in this understanding, that one should search for the root cause of catalysis and use it as a framework for selecting catalysts. Ipatieff, who recognized the crucial role of the unstable intermediates, emphasized the chemical nature of catalysis and the more complex physicochemical picture of heterogeneous catalysis. He wrote, "...since the very beginning of my studies of catalytic reactions, since 1901, I tried, contrary to the views of the outstanding physicochemists, to look for chemism in catalytic phenomena and to look for the cause of catalytic reactions in the chemical function of the catalyst... to explain the catalytic properties of a substance through its inherent chemical properties" (Ibid.). In this respect, Ipatieff considered pressure and temperature as strong factors, which can substantially influence the properties and interaction of all the components in a catalytic reaction. A similar view was shared and developed by Academician Georgy K. Boreskov (1986), an "extramural" student of Ipatieff and the author of the following semiphenomenological definition: "Catalysis is an initiation or acceleration of chemical reactions over certain substances (catalysts) which repeatedly enter into an intermediate chemical interaction with reagents and restore their chemical composition after each cycle of this interaction." Without delving into the current state of the theory of catalysis, which has not been finalized yet, I now return to the rivalry between Ipatieff and Sabatier.

In 1912, Sabatier was awarded the Nobel Prize in Chemistry "for his method of hydrogenating organic compounds in the presence of finely disintegrated metals."

After reporting my first work in catalysis at the January meeting of the Russian Physical–Chemical Society, I sent an article to Berlin to be published in the *Berichte of the German Chemical Society*. It was published in March of that year, which meant that my work appeared ahead of the first and famous article by Sabatier and Senderens in the *Comptes rendus* on the hydrogenation of benzene in the presence of reduced nickel.

Adapted from: (Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946)

Ipatieff (*on the very left*) with his students: V. V. Ipatieff, N. A. Orlov, B. N. Dolgov, A. D. Petrov, and V. I. Nikolaev. *Leningrad, 1928*



Ipatieff's letter to the Conference of the Physics and Mathematics Department, USSR Academy of Sciences. *April 1, 1929.*

SPbB ARAS: Repository 2, List 17, Case 212, Sheet 98.
© St. Petersburg Branch, Archive of the Russian Academy of Sciences (SPbB ARAS):

"April 1, 1929.

To the Conference
of the Physics and Mathematics
Department of the Academy
of Sciences

I hereby inform the Conference that, according to the permission given to me, on May 1 I should go to Germany to conduct scientific research until the end of July this year.

Academician V. N. Ipatieff"

His main supporting example was the reduction of ethylene to ethane in the presence of Ag or Ni powders (as catalysts) in H_2 medium at 300 °C and atmospheric pressure. The intermediates were, according to Sabatier, the metal hydrides, which gave their hydrogen to ethylene.

The Nobel Committee and the mistake of Russian inventors

In 1915, Ipatieff was nominated for election as a member of the Imperial Academy. The nominators – Academicians P. I. Valden, B. B. Golitsyn, and N. S. Kurnakov – emphatically compared his accomplishments to those of Sabatier and stated in conclusion that the studies carried out by the Russian scientist were "more diverse than the works of Sabatier, who was awarded the Nobel Prize in 1912" (Ipatieff, 1945). One of the nominators, Prof. Valden (Riga Polytechnic), an eminent expert in solution theory, wrote, "If Sabatier received the Nobel Prize for one catalytic reaction only... then Ipatieff's works undoubtedly deserve the same award because he put catalysts to a much broader use in various reactions... and introduced a completely new high pressure technique, allowing the hydrogenation of substances deemed impossible to work with under Sabatier's method" (Ibid.; Blokh, 2005).

Another chance at the award he deserved arose two decades later, but Ipatieff again missed the opportunity. The 1931 Nobel Prize in Chemistry went to the German scientists Carl Bosch and Friedrich Bergius "in recognition of their contributions to the invention and development of chemical high pressure methods." Bosch had been nominated seven times since 1915; the total number of nominations he received, including by Albert Einstein, reached 20. Bergius was nominated twice, with one nominator per cycle. However, not a single nomination mentioned the actual pioneer from Russia (Blokh, 2005).

In this respect, I cannot but mention an overlook on Ipatieff's own part. In his memoirs, he wrote about the International Congress on Industrial Chemistry, held in Strasbourg in July 1928 (more than three years before the Nobel Prize of Bosch and Bergius). At the congress, he made a presentation, elaborating on his earlier studies on hydrogenation under pressure, and said in conclusion, "Bergius' patents (1911) are entirely based on my works made back in 1903—1904, and my method, which I developed for various organic compounds, was applied in full for hydrogenation of resins and coals" (Ipatieff, 1945; Blokh, 2005). The Society of Chemical Industry, which organized the Congress, duly appreciated Ipatieff's outstanding scientific contribution. In a solemn atmosphere, a representative of the French government, in the rank of minister, presented to the Soviet delegate the society's highest award – the Pierre Berthault Medal.

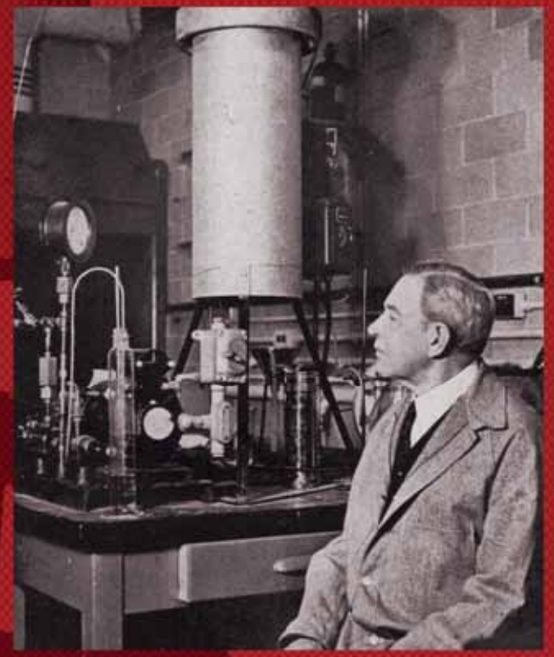
Why did the Royal Academy of Sciences not commemorate the undeniable contribution of Ipatieff? Of course, it might have been due to political preferences, i.e., a disapproval of Ipatieff active political engagement in the first years of Soviet power, when he acted as the leader of chemical science and industry in the young Soviet Republic; when he met personally on numerous occasions with Vladimir Lenin; when he was, in fact, a member of the government, etc. However, the decisive factor appears to have been a pure formality, i.e., the lack of a duly executed patent (Blokh, 2005). Here, the scientist repeated the common mistake of Russian inventors who forgot to timely patent their discoveries. If he had obtained a patent, the Swedish experts would have hardly bypassed him and the members of the Nobel Committee, even in the absence of a nomination, could have used their right to nominate their own candidate on the last day of submission of nominations for the current year. I can only add that the Nobel Prize winner Bergius himself admitted subsequently that his method of destructive hydrogenation of coal to liquid motor fuel was entirely based on Ipatieff's work (Ibid.).

Note that Ipatieff's name appeared again in the Nobel Committee's records in 1949, when he was nominated by Profs. Georges Dupont and Louis Hackspill (Ibid.). But at that time, Ipatieff was way past his prime. He truly could have become the first Russian winner of the Nobel Prize in Chemistry, but he did not, and the primary reason was the astonishing neglect of Russian scientists towards their fellow compatriots.

Life in the USA: Ipatieff's technology at thousands of industrial plants

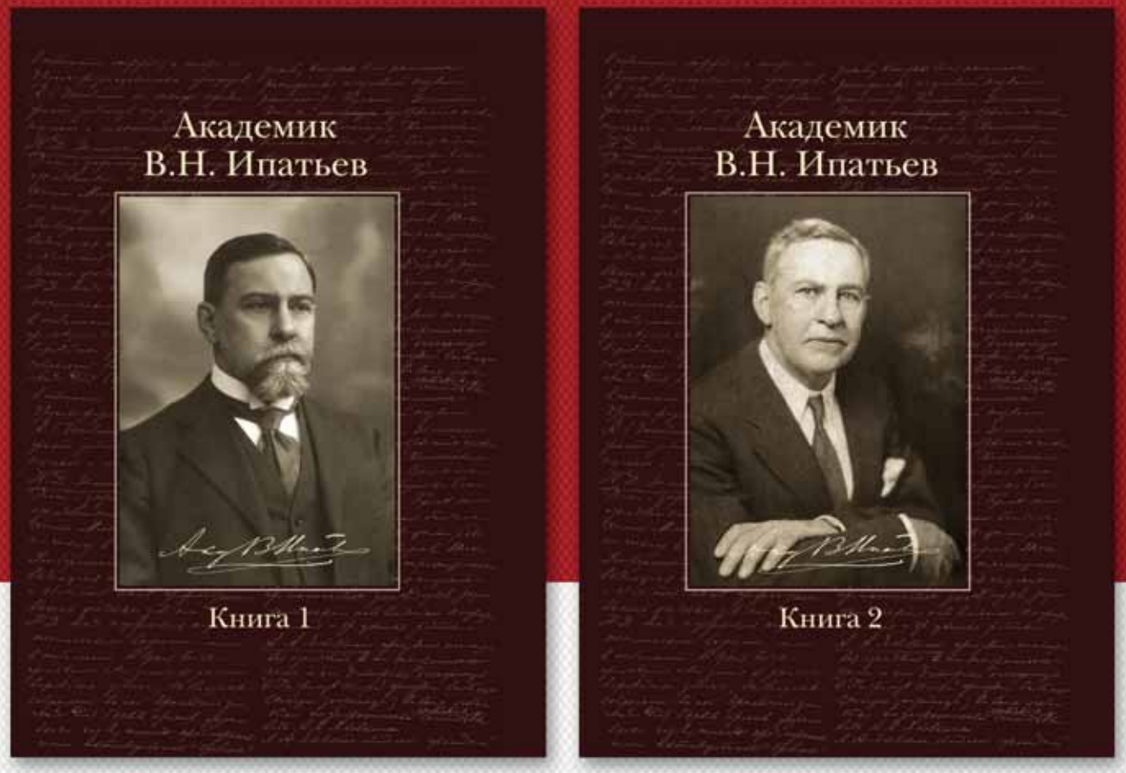
Ipatieff was one of those rare scientists who combine in themselves an excellent theorist with an experimenter or even manager, capable of building tomorrow a plant based on a new technological method that he has just discovered today. His fundamental studies wend hand in hand with their practical application. Thus, in 1913, he supervised the first successful hydrogenation of fats in Russia, performed at the Nevsky Stearin Plant. He advised the firms run by the Nobel brothers (Robert and Ludvig, brothers of Alfred Nobel, who founded the Nobel Foundation), Dupont's firm in the United States, etc. It is this combination of a theorist with a practicing businessman that explains his successful leadership in chemical science and industry during World War One under Nicholas II of Russia and in the first years of Soviet power under Lenin.

I will not dwell on Ipatieff's dramatic biography, which is detailed in his own memoirs (Ipatieff, 1945, 1959) and, even more fully, in the articles published by his students (Orlov, 1927; Haensel, 1940; Pines, 1967, 1981, 1983, 1992;



Ipatieff in the High Pressure Laboratory of Northwestern University. *Evanston, Illinois, United States*

In the photo from left to right: V. N. Ipatieff; R. M. Willstätter, winner of the Nobel Prize in Chemistry; G. Egloff, German organic chemist, director of science at the US oil company Universal Oil Products (UOP); and M. Gomberg, president of the American Chemical Society (1931). It was Gustav Egloff, the famous American chemist nicknamed Gasoline Gus, who offered Ipatieff the post of senior director for research at UOP in Chicago. Today, UOP as a division of Honeywell Corporation is the world's leading supplier and licensor of technologies, catalysts, equipment, and consulting services for the oil refining, petrochemical and gas processing industries. *Chicago, United States, 1933. Photo from the archive of Honeywell UOP (USA)*



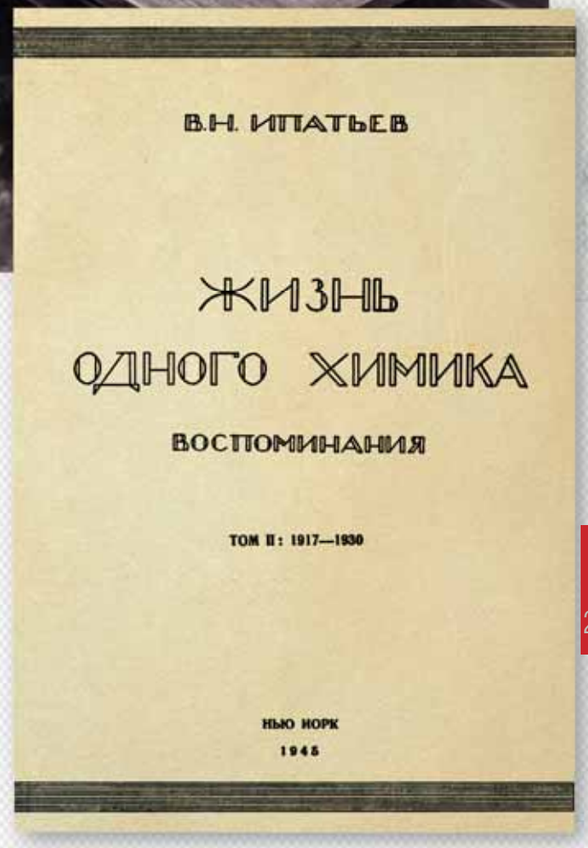
Academician V.N. Ipatieff. Book 1. Moscow: Kalvis, 2011, 444 pp. ISBN 978-5-89530-022-0, 978-5-89530-021-3; Book 2. Moscow: Kalvis, 2011, 496 pp. ISBN 978-5-89530-023-7, 978-5-89530-021-3

In 2011, the Kalvis publishing house printed, in two volumes, the first Russian reedition of Ipatieff's book *The Life of a Chemist*. *Memoirs* (New York, 1945). The core of the collection is the two volumes written by the outstanding chemist of the 20th century Vladimir Nikolaevich Ipatieff, which are complemented by a series of articles by major Russian scientists, revealing the contemporary significance of his works for science in Russia and worldwide.
The collection includes materials from state archives: the Archive of the Russian Academy of Sciences (RAS), the St. Petersburg Branch of the RAS Archive, and the Russian State Archive of Economics, which have been made publicly available for the first time. The collection addresses a broad readership with an interest in the history of Russian and world science

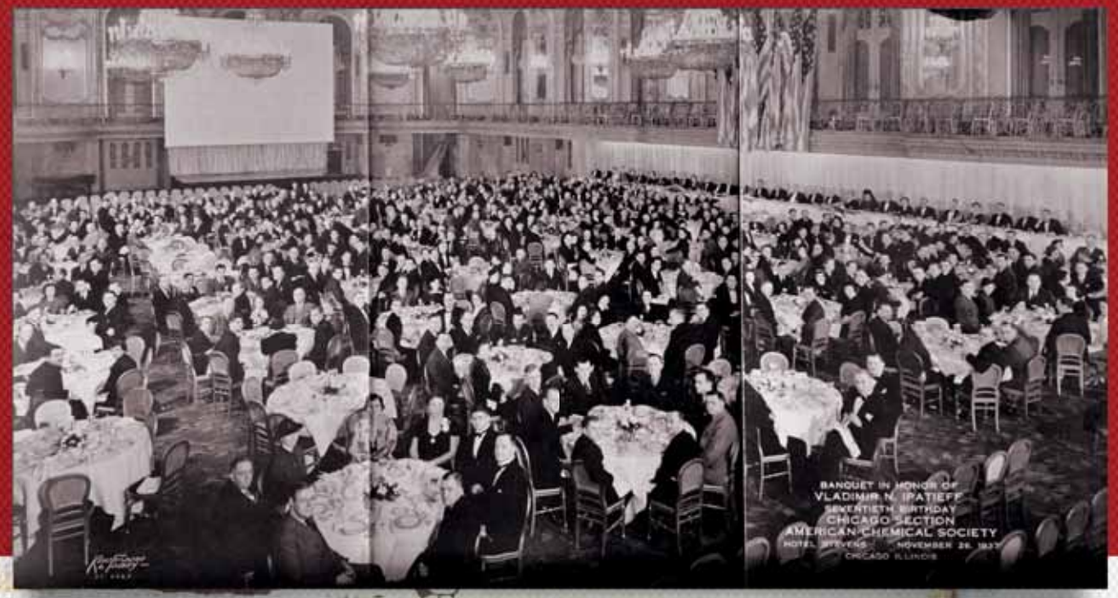
Razuvaev, 1988) and researchers of his work (Loktev, 1991; Kuznetsov, 1991, 1992; Zal'tsberg, 1992; Fenelonov, 2017). You can find this information in the introduction. I will only recall that in the last years of the reign of Emperor Nicholas II, Ipatieff wore the titles of Academician and lieutenant general, and under Lenin, he supervised the reconstruction and development of chemical industry and was a member of the Presidium of the Supreme Council of National Economy (SCNE) and the State Planning Committee, i.e., a member of the government. However, after Lenin's death, he was gradually ousted from his government posts; in 1926, his membership in the SCNE Presidium was revoked without explanation; he was deprived of the right to participate in its meetings even in an advisory capacity and dismissed from the leadership of chemical industry in the line of the Red Army (he learned about that from the newspapers). Ipatieff received increasingly more summons to the OGPU (Joint State Political Directorate) because of denunciations recalling his generalship, his close ties to Nicholas II, his connections with Leonid Trotsky and other saboteurs and "enemies of the people" (Ipatieff, 1945, 1959). He was expecting an inevitable arrest because many of his colleagues, students, and close acquaintances had been arrested (and even shot). In 1930, in view of the circumstances, he was

Ipatieff at a meeting with his colleagues working at Universal Oil Products (UOP), United States. *Photo from the archive of Honeywell UOP (USA)*

allowed to go with his wife to Germany for treatment and participation in an international congress. The trip was initially planned for a year but then was extended for another three years. He sought treatment in Germany, France, and England, but was able to undergo a successful surgery for throat cancer only in the United States, in Chicago. There he settled in a modest hotel, where he spent the rest of his life. In Chicago, Ipatieff began to teach a lecture course on catalysis and, simultaneously, conduct experiments in a laboratory perfectly equipped for him by the Universal Oil Products Company. Until 1937, he regularly sent to the Soviet Union the results of his works performed in the United States; purchased and sent, at his own expense, scientific equipment for the high-pressure laboratory; paid for foreign trips of the researchers. In 1936, however, the USSR government and USSR



Book cover of Ipatieff's memoirs *The Life of a Chemist, Vol. 2, New York, 1945*



Banquet organized by the Chicago Section of the American Chemical Society in honor of Vladimir N. Ipatieff's 70th birthday at the Stevens Hotel (now Chicago Hilton). *Chicago, United States, November 26, 1937. Photos from the archive of the Institute for Sustainability and Energy at Northwestern. Evanston, Illinois, United States*

UOP chemists, future professors Vladimir Haensel and Herman Pines with their teacher Vladimir N. Ipatieff (*at the center*). Ipatieff oversaw the works in the field of platinum catalysts developed by Haensel. These works gave rise, in the middle of the 20th century, to the modern petrochemical industry and the production of plastics. These developments allowed UOP to launch, as early as in 1950, the production of its own proprietary catalysts. *Photo from the archive of Honeywell UOP (USA)*

Academy of Sciences demanded categorically his immediate return. He refused to come back, citing his age and the contracts he had signed; he argued that he had organized the transfer of his scientific results to the Soviet Union, etc. On December 26, 1936, Ipatieff was expelled from the USSR Academy of Sciences, and on January 5, 1937, he was deprived of the USSR citizenship and forbidden from entering the country (Ipatieff, 1959). His contacts with the Leningrad laboratory also ceased. The last work that Ipatieff made for Russia (and the whole world) was his monograph *Catalytic Reactions at High Temperatures and Pressures,* which simultaneously appeared in 1936 in the Soviet Union and United States in Russian and English, respectively (Ipatieff, 1936). This monograph summarized his fundamental scientific results, and it became the reference book for catalytic chemists throughout the world. But in the Soviet Union, it was forbidden to even refer to it.

In the United States, Ipatieff successfully continued the research that he had begun in Russia. In 1936, he was the first chemist to propose catalytic cracking, which allowed a much higher yield of gasoline in the processing of oil or coal (Ipatieff, 1959). The detailed investigation of the alkylation and polymerization reactions during cracking led to his most famous invention – high-octane gasoline and other motor fuels. Ipatieff's detailed studies in the field of polymerization made it possible to control the composition of cracking products, obtain unsaturated hydrocarbons of a given composition, and, as a result, organize the production of a wide range of polymers and plastics, without which modern civilization would be impossible. Ipatieff also proposed to increase the octane number of gasoline from 60–70 to 100 by adding isopropylbenzene (cumene), which forms during the catalytic cracking of certain fractions. Another way is the treatment of cracking products with dry phosphoric acid, a catalyst in the form of H_3PO_4 on an inert carrier. Ipatieff was also one of the first to suggest the currently popular Pt/Al_2O_3 catalysts, whereby highly dispersed platinum is deposited on a carrier of porous alumina. In some cases, the catalytic activity is boosted by preliminary treatment of the carrier with HF vapors (Ipatieff, 1959; Kuznetsov, 1992).

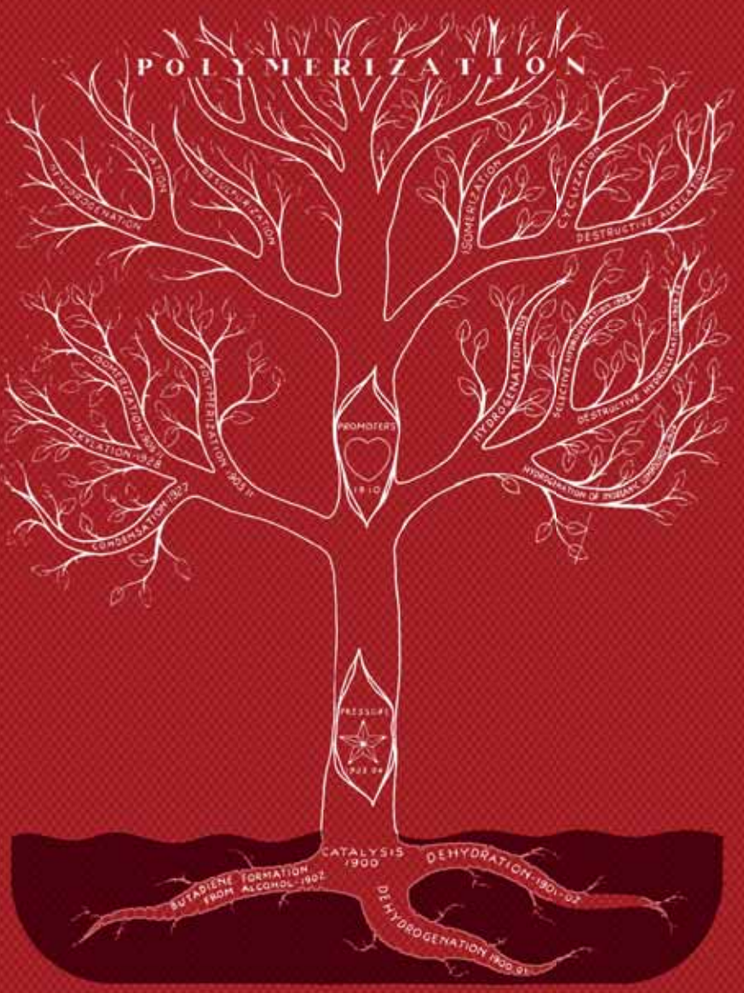
Ipatieff works gave rise to many industrial processes that remain in broad use today. These include the production of motor fuels of various grades, including high-octane gasoline (from oil, coal, etc.); synthetic lubricating oils and additives; solid fats from liquid vegetable oils; hydrogen and synthesis gas from natural gas, etc. This list can be multiplied many times. Today, thousands of oil refineries as well as petrochemical and chemical plants worldwide use in their technology high pressures and the catalysts proposed by Ipatieff.

Since 1947, the American Chemical Society has been awarding the Ipatieff Prize every three years for outstanding experimental work in the field of catalysis and chemistry of processes at high pressures. The Russian Academy of Sciences established a similar award in 1994.

Leading a successful life in the United States, Ipatieff always cherished a devotion to his motherland – Russia – to its culture, language and people. In the United States, he never owned a car or an apartment. He believed that way he would have admitted that he had settled. He thought that he lived and worked there temporarily (for 21 years!) and hoped for a return. During the war, he was touched to the depth of his soul by the victories and defeats of the Red Army and the suffering of the Russian people. Together with Sergei Rachmaninoff and other emigrants, he established a fund to support the Red Army and the people of the Soviet Union. Ipatieff dreamed of rendering his support personally, at least as an experienced military chemist of World War One. During the war, he made three attempts to return to the Soviet Union, wrote applications and tearfully begged Andrei Gromyko, the USSR ambassador in the United States, to help him, but he was turned down all three times (he made his last attempt in 1951, but it was hindered by his illness and death on November 29, 1952).

We would understand many aspects of Ipatieff's complicated biography if we treated his patriotism as civic sense, based on love and devotion to his motherland and his people and on responsibility to the ancestors and descendants, without any special attitude for the existing government and state, which are the basis of state patriotism. State is a more transient notion than those of nation or people. Therefore, Ipatieff remained loyal to the Russian people both when he abandoned his loyalty to Nicholas II and during his emigration to the United States.

Ipatieff's greatest merit is carved in ultimately concise words on his tombstone: "In Memory of Russian Genius Vladimir Nikolaevich Ipatieff. The Inventor of Octane Gasoline."

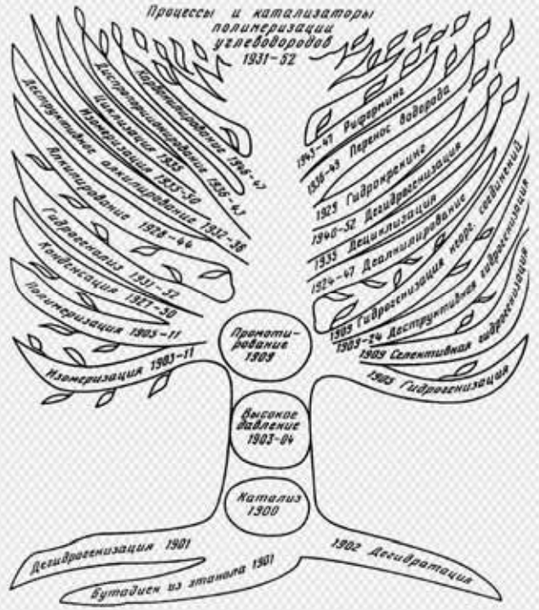


"Ipatieff's Tree," which shows the development of Ipatieff's research in the field of catalytic organic chemistry and petrochemistry; the figures show the dates of the studies. "Ipatieff Tree" covers the whole range of reactions of hydrocarbons in the presence of hydrogen over a wide range of temperatures (up to ~700 °C) and pressures (up to ~1000 atm) and can serve as a basis for studying the conversion of other carbon compounds containing, e.g., S, N, P, and other elements, as well as reactions in other media.

Adapted from: (Ipatieff V.N. The Life of a Chemist. Memoirs. Vols. I–II, New York, 1945)

Ipatieff's best known Russian students areAcademician G.A. Razuvaev, RAS Corresponding Member A. D. Petrov, Profs. B.N. Dolgov, A.V. Frost, V.V. Ipatiev, M.S. Nemtsev, etc. His students abroad are Herman Pines, Robert L. Burwell, and Vladimir Haensel (United States); Jean E. Germain (France), etc. The well-known chemists Aristid von Grosse, Louis S. Kassel, Ralph C. Olberg, Carl B. Linn, as well as many others, also consider themselves as part of Ipatieff's school. Academician Boreskov, founder of the Institute of Catalysis (Novosibirsk) also considered himself his student. And the students of these scientists are, in turn, Ipatieff's scientific grand- and great-grandsons.

By a twist of fate, Russia presented the United States with many great scientists, such as G.A. Gamov (1904—1968), a theoretical physicist, astrophysicist, and popularizer of science, the author of the CMB concept and the idea of the triplet genetic code; V.K. Zvorykin (1889—1982), the inventor of the electron microscope and modern television; I.I. Sikorsky (1889—1972), one of the "founding fathers" of modern aviation, the author of the first four motor planes and helicopters, amphibious aircraft and flying boats. And a rightful place in this Group of the Great belongs to Vladimir Nikolaevich Ipatieff.



Modern version of "Ipatieff's Tree."
Adapted from (Kuznetsov and Maksimenko, 1992)

References

Blokh A.M. Sovetskii Soyuz v inter'ere Nobelevskikh premii (Soviet Union in the Interior of Nobel Prizes), Moscow: Fizmatgiz, 2005 [in Russian].

Boreskov G.K. Geterogennyi kataliz (Heterogeneous Catalysis), Moscow: Nauka, 1986 [in Russian].

Butlerov A.M. Sochineniya v 3-kh tomakh (Writings in Three Volumes), Moscow: AN SSSR, 1953, V. 1, P. 71 [in Russian].

Fenelonov V.B. Ipatieff, an outstanding scientist of the 20th century, one of the founders of heterogeneous catalysis // Kataliticheskii Byulleten'. 2017. V. 84. N 4. P. 4—19 [in Russian].

Fenelonov V.B., Mel'gunov M.S. Texturology in Surface and Nanomolecular Catalysis by ed. R. Richards, Taylor&Francis, Boca Raton, USA, 2006, P. 257—336.

Haensel P.V.N. Ipatieff in Russia // The Chemical bulletin (ACS Chicago Section). 1940. V. 12. N. 4. P. 109—113.

Ipatieff V.N. My life in the United States; the Memoirs of a Chemist. Northwestern University Press, 1959.

Ipatieff V.N. Sesquicentennnial Celebration , Northwestern, Chicago, Sept. 7, 2017.

Ipatieff V.N. Zhizn' odnogo khimika. Vospominaniya (The Life of a Chemist. Memoirs), New York, 1945 [in Russian] (the first Russian reedition: Academician V.N. Ipatieff. In two books. Moscow: Kalvis, 2011); Ipatieff V.N. et al. The Life of a Chemist: Memoirs of Vladimir N. Ipatieff, Stanford: Stanford Univ. Press, 1946

Ipatieff V.N. Kataliticheskie reaktsii pri vysokikh temperaturakh i davleniyakh (Catalytic Reactions at High Temperatures and Pressures), 1900—1933. Moscow, Leningrad: AN SSSR, 1936 [in Russian]; Ipatieff V.N. Catalytic Reactions at High Temperatures and Pressures, Macmillan, 1936

Ipatieff V.N., Sapozhnikov A.V. Kurs neorganicheskoi khimii (A Course in Inorganic Chemistry), 7th ed., Moscow: Mosk. Nauch. Inst., 1920 [in Russian].

Kuznetsov V.I. Vicissitudes of work of Academician Vladimir N. Ipatieff // Repressirovannaya nauka, Leningrad: Nauka, 1991, P. 367—376 [in Russian].

Kuznetsov V.I., Maksimenko A.M. Vladimir Nikolaevich Ipat'ev, 1897—1952, Moscow: Nauka, 1992 [in Russian].

Loktev S.M. Akademik Ipat'ev – khimik novogo veka (Academician Ipatieff: A chemist of the New Century), Moscow: Znanie, 1991 [in Russian].

Morachevskii A.G., Firsova E.G. Life and work of Academician Vladimir N Ipatieff (dedicated to his 150th birthday anniversary) // Nauchno-tekhnicheskie vedomosti SPbPU. Estestvennye i inzhenernye nauki, 2017, V. 23. N 3. P. 165—172 [in Russian].

Orlov N.A. Vladimir Nikolaevich Ipatieff // Priroda. 1927. N 5. P. 330—342 [in Russian].

Razuvaev G.A. Stories without details // Khimiya i zhizn'. 1988. N 2. P. 15—19 [in Russian].

Rideal E.K., Taylor H.S. Catalysis in Theory and Practice, London: Macmillan, 1925.

Sabatier, P. La catalyse en chimie organique, C. Béranger, 1913.

Teleshov S.V. Removing the sands of oblivion (to the 150th birthday anniversary of Academician V.N. Ipatieff) // Kataliticheskii Byulleten'. 2017. V. 84. N 4. P. 20—34 [in Russian].

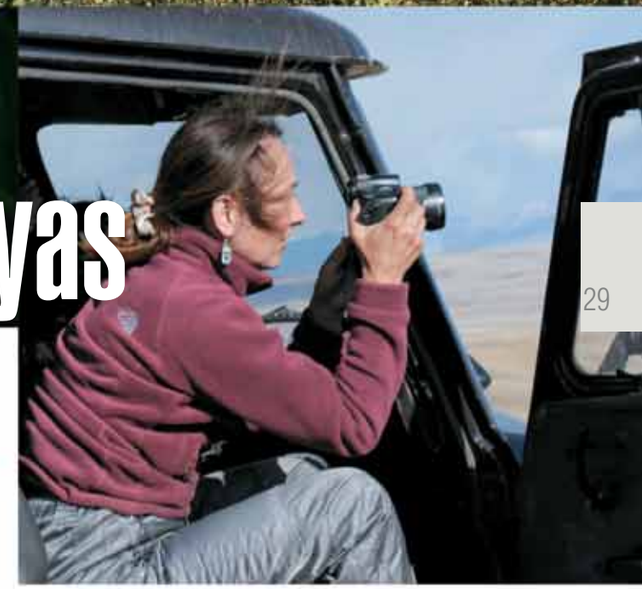
Zal'tsberg M. Portraits: Three lives of Academician Ipatieff // Khimiya i zhisn'. 1992. N 10. P. 78—85, N 11. P. 25—31, N 12. P. 17—25 [in Russian].

The editorial staff of SCIENCE First Hand thanks Dr. Sci. (History) I.V. Tunkina, Acting Director, St. Petersburg Branch, Archive of the Russian Academy of Sciences (SPbB ARAS, St. Petersburg); Cand. Sci. (History) E.N. Gruzdeva, Head of Department and Reading Room, SPbB ARAS; O.S. Bystrova, Director of the Kalvis Publishing House (Moscow); V.V. Agafeev, Director of Honeywell UOP (Moscow); and Chris Nicholas, Engineer / Scientist Principal R & D, Honeywell UOP (Des Plaines, USA) for their invaluable support in preparing the illustrations for this articles

N. V. POLOSMAK

Riders lost in the Himalayas

The Pir Panjal is a mountain range situated in the western part of the Lesser Himalayas extending from the east-southeast to west-northwest across the border of Himachal Pradesh and Jammu and Kashmir. The sights are awesome: lofty peaks rising to the heights of up to 4,000 meters above the sea level, swift-flowing streams and deep-set valleys overgrown with cedars and scattered tiny houses surrounded by little fields. In June 2017, this was the site of a Russian-Indian archaeological expedition launched to find and describe stone horses, enigmatic statues lost in remote mountain areas



Natalia V. POLOSMAK is a Corresponding Member of the Russian Academy of Sciences; Doctor of History; chief researcher with the Institute of Archaeology and Ethnography, Siberian Branch, Russian Academy of Sciences (Novosibirsk, Russia). Awarded the State Prize of the Russian Federation (2004) and Heritage of Generations National Prize. Author and coauthor of over 170 research papers

"Animals don't asleep. In the dark after nightfall
They stand over the world like a stone wall..."
The Horse's Face by N. Zabolotsky

This story began in 2013, when at the entrance to the Archaeology Museum of Srinagar, the administrative center of the Indian state of Jammu and Kashmir, I saw two stone horses with riders. They did not look like anything I had ever seen throughout my career in archaeology. My questions about the origin and owner of these statues took me nowhere, nor did I find any mention of them in scholarly literature. Oddly, the horses were enshrouded in silence and oblivion, which was out of all proportion to what they were. There appeared to be no place for them in the Indian History of Art.

Ever since I had longed to see the locality where these captivating statues came from. It was only in 2017 that my desire became a reality thanks to the financial support of the Gerda Henkel Foundation. An expedition launched to the village of Gool, District Ramban, Jammu Region, Jammu and Kashmir State, India, included, from the Indian side, Dr. Mohammad Ajmal Shah, Assistant Professor-cum-Curator, and Yatoo Mumtaz Ahmad, Assistant Professor (Archaeology), affiliated with the Centre of Central Asian Studies at the University of Kashmir, India.

People living in this area have known all along that the Pir Pajal is home to amazing countless (because nobody has ever counted them) horse statues with riders – undated and found in most unlikely places. One such site near the village of Gool was turned into a sort of open-air museum: some of the statues and slabs that you can see there were brought from the adjacent fields, where they got in the way of planting. Many statues have been broken; their fragments make part of alleys and walling around fields and houses; slabs with depictions were used to make benches. Locals call this site, which is two kilometers from the village of Gool, *Ghoragali, which means* "Horses pass." You can also see statues in streams, where they are used for washing clothes. The local residents do not know anything about their origin: for most of them, the statues are alien and strange. Those who are remotely interested in them consider them to be traffic signs for the caravans that roamed the region in the time of Mahabharata. This, however, is way off the mark.

Strikingly, these outstanding monuments of an unknown culture have not been studied though the locality is on the list of the cultural heritage sites protected by the state. One reason is that the monuments are hard to access; another reason is that they are so original that cannot be unambiguously attributed as belonging to any of the modern cultures or religions. To record and describe the monuments, 3D surface laser scanning was performed by a team from Trimetary Consulting (St Petersburg) led by Mikhail Anikushkin. As of today, this is the most precise technology for recording numerous objects.

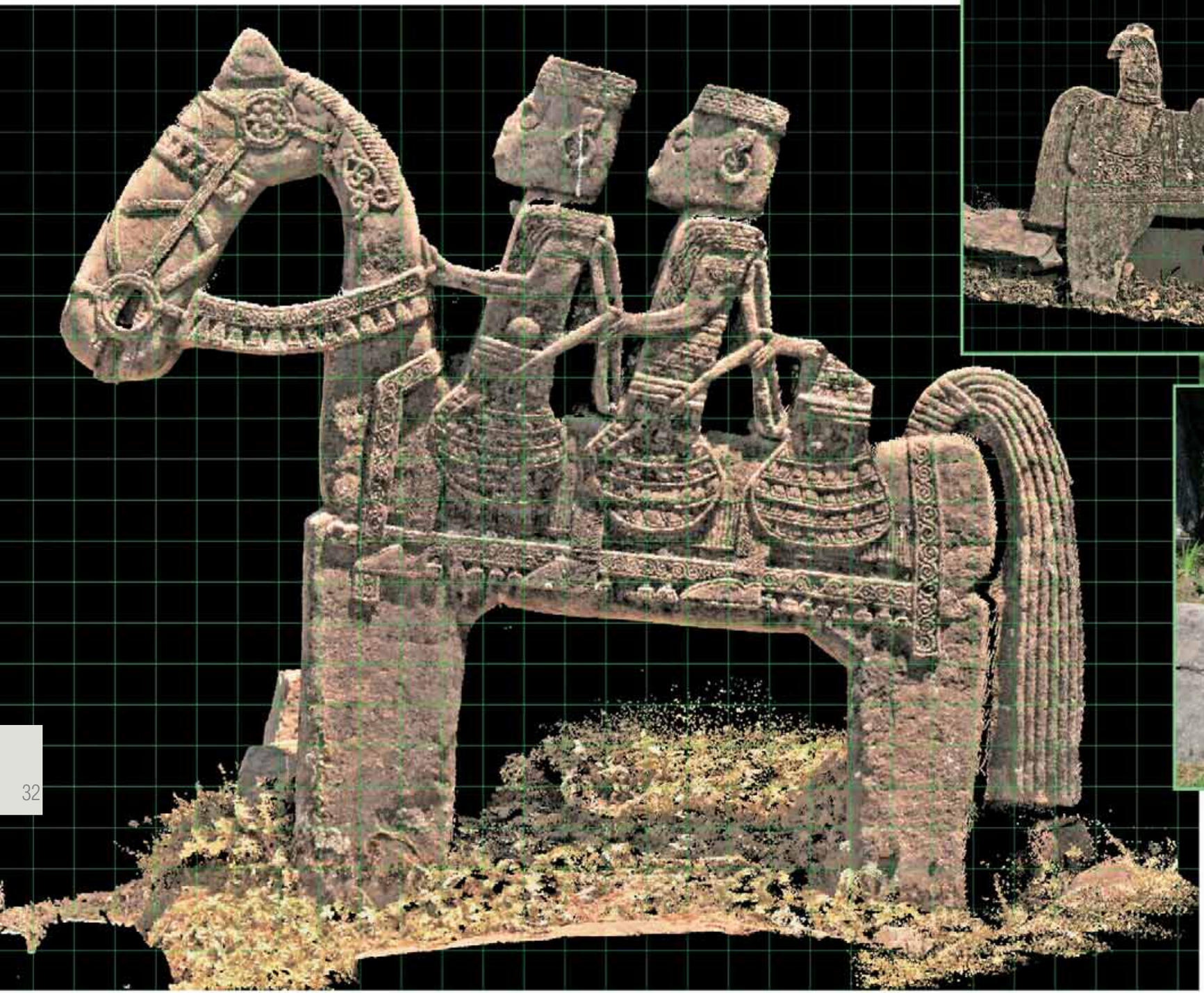
The work was done in two clusters, where the numerous stone sculptures are concentrated, located the height of 1,890 meters and 2,030 meters above the sea level. The area of each cluster is about a hectare. In addition to laser scanning, airborne survey using a quadcopter and survey photography using a digital single-lens reflex camera were performed.

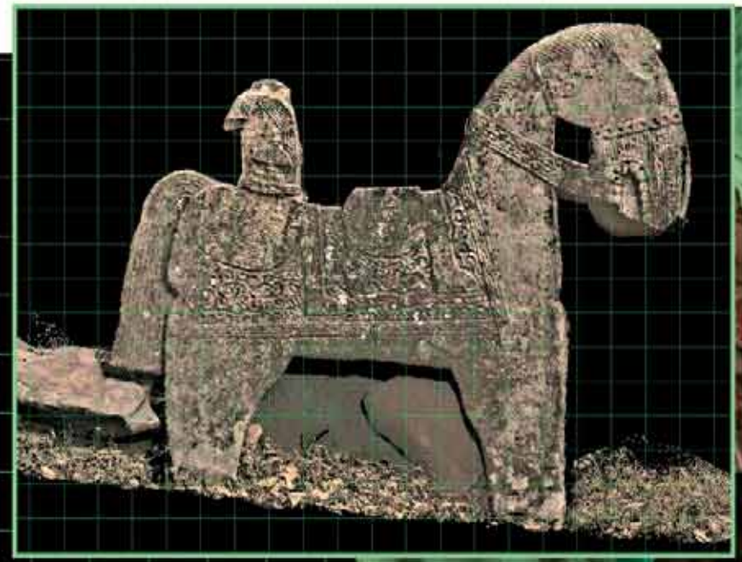
The laser scanning yielded a point cloud containing exhaustive information concerning the geometry of the objects, their spacing and micro-relief of the locality. The data obtained can be used for scientific studies, excavation planning, and visualization of the survey objects. On top of that, they contribute to the conservation of an endangered cultural heritage site, which is under the threat of both human intervention and natural hazards, quite frequent in this region.

In the future, we are planning to create, on the basis the point cloud, a real-world 3D model of the objects and an interactive 3D application. The application can be developed into a virtual reconstruction in several versions, that is, actually, into a virtual museum accessible to the scientific community and broad public.

Key words: archeology, Lesser Himalayas, Jammu and Kashmir, stone sculptures, Hephthalites (Ephthalites), Hunas (Xiongnu), Alchon Huns, laser scanning, cloud of points, 3D object model, virtual reconstruction, interactive application

SCIENCE FIRST HAND https://scfh.ru/en/papers/riders-lost-in-the-himalayas/ May • 2018 • N 1 (43)





The results of the Gool stone riders visualization using laser scanning (a point cloud) and aerial photography. The laser scanning was performed using the Leica ScanStation P20 scanner. To create a geodesic compilation survey, the GNSS-receiver Leica GS14 was used operating in the RTK mode with radio channel correction transfer. Aerial photography was done using the DJI Phantom 3 unmanned drone

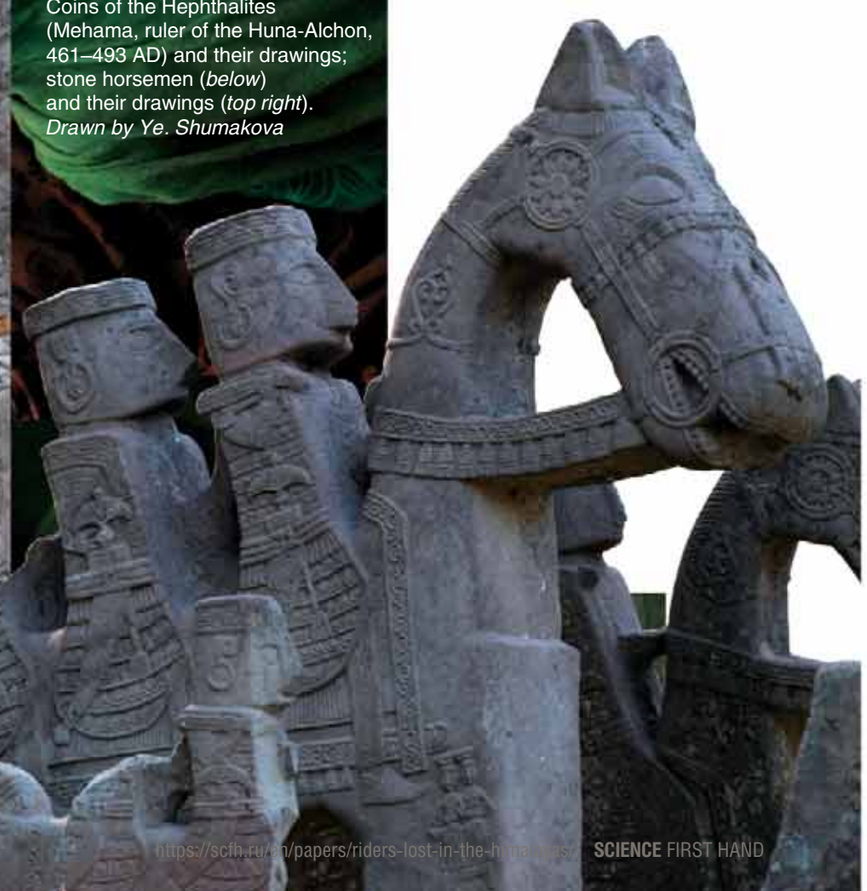
Many riders discovered at the Ghoragali site lost their heads long ago (*below*)

Hephthalite trace?

Undoubtedly, the monuments date from the pre-Muslim period of the region's history though they are neither Buddhist nor Hindu. We are facing an entirely original cultural layer supposedly belonging to a "dark" period of Indian history connected with the Hephthalite conquest and rule (5th to 7th cc.). This ethnicity was as enigmatic as it was powerful and left a detectable trace in the history of both Central Asia and India.

The origin of the Hephthalites is still a subject of scholarly dispute. Opinion is divided: some believe them to be descendants of the Yuezhi, who spoke Iranian

Coins of the Hephthalites (Mehama, ruler of the Huna-Alchon, 461–493 AD) and their drawings; stone horsemen (*below*) and their drawings (*top right*). *Drawn by Ye. Shumakova*



languages, while others argue that they came from the ancient Mongols or Huns, who had assimilated Central-Asian ethnic groups. On top of that, there is a wide variety of hypotheses suggesting that the Hephthalites originate from the Altai Mountains, Northern China, Badakhshan, Aral Sea Region, the Syrdarya, and so on. Summarizing this issue, A. D. Kurbanov writes in his survey of the Hephthalite history that "the Hephthalite period remains to be one of most mysterious in the history of Central Asia. The archaeological data are scarce and information found in narrative sources is intricate, which is a great challenge for the researchers. Only future archaeological findings may help to solve a number of controversial issues of the Hephthalite ethnogenesis" (Kurbanov, 2006).

Indeed, when the potential of analyzing the written sources is exhausted and the matter is not clear, we can only rely on archaeological exploration that may give fresh impetus to an old problem.

There is a hypothesis that the last part of the name of the Hephthalite ruler Mihirakula, "gula," meant a certain rank of a "ruler-warrior." This word must have given name to the Gulot dynasty, whose representatives currently govern Udaipur, the capital of the large province of Mewar, Rajasthan (Uspenskaya, 2000). The settlement located near the site where the horse statues are found is called Gool, which might derive from the name of the Hephthalite tsar-warrior.

Stone army

Horse soldiers would always approach India from the north-west, as did all the conquerors including Alexander the Great. In India, they could not breed horses, so there was no native equestrian culture. It was imported by nomads-conquerors, who would establish their own states within the Indian Territory. In different historical periods, India was attacked by Aryans, Saka, Kushans, Hephthalites, Turks, Mongols... There is, hence, a high probability that so numerous and original depictions of horse riders belong to the people for whom riding was a habitual travel mode and who were used to fighting on horseback.

ON HEPHTHALITES IN INDIA (FROM WRITTEN SOURCES)

The story of the Hephthalite conquest in India began in the second half of the 5th c. AD, circa 470. North-Western India happened to be part of the Hephthalite (Xionite), or White Huns, Empire. Their talented military leader, Toramana, took advantage of the weakening Gupta Empire and took hold of the territory that used to belong to the Kushans, another ethnicity of Central Asian descent, founders of a vast empire that existed from the 1st to 3rd c.

Toramana ruled until 515, and under his power, the indianization of the White Huns (Sveta Huna) was taking place. Toramana's son Mihirakula (the Huna name is Mihirakugula) succeeded his father on the throne and adopted Shaivism, one of the major traditions within Hinduism that worships Shiva. He is reputed to be a cruel ruler, who prosecuted the Buddhists and destroyed quite a number of temples (the latter though is currently questioned). Having lost a few battles to tribal leaders, he returned to Kashmir, where he ruled until 537 and died. His descendants continued to rule Kashmir and the greater part of Punjab for another 150 years.

The last Hephthalite ruler of Kashmir was Toramana's offspring, Lakharna, who governed until 670. Many scientists agree that the Hephthalites contributed a lot to the making of the ethnicities populating the mountain areas of Northwestern India

The tabular napes of all men statues must reflect a typical anthropological feature of the population – the so-called ring, or fronto-occipital deformation. The horse harness features carefully sculpted, good-sized round cheek-pieces with bridle and reins strapped to them and is adorned with round brasses depicting a polypetalous flower (supposedly, the lotus)

In order to explain why we think that the stone statues of horsemen could be attributed to the Hephthalite culture, let us turn to the statues themselves.

The first thing that catches your eye at once is that all the riders have the same face. To convey the image of a warrior, the unknown masters created a character that embodies the warrior host in their entirety by personifying the most typical and marked features. The flatly cut napes of all the men figurines may reflect a typical anthropological trait of the population – the so-called ring, or fronto-occipital deformation. This type of artificial deformation was characteristic of the Central Asian peoples in the early 1st c. This regional tradition was domesticated by the nomads known by the collective name of the Huns, who then spread it around Europe and India.

The coins of the Hephthalite rulers show identical flatly cut napes and a specific shape of the skull. The anthropologists who have compared the coin depictions of the Hephthalite rulers and paleoanthropological materials unequivocally agree that all these skull deformities are of the same type (Trofimova, 1968). The statues of the Himalayan riders show the same deformity; most of all, they remind of the depictions of the Hephthalite rulers shown on the coins with allowances made for the stone sculpture style and design features of the coining die.

In addition, there are some other facial features common to both, the profiles depicted on the Hephthalite coins and faces of the stone horsemen: big straight noses, handlebar moustache and large round earrings.

To sum up, the people depicted on the coins and stone statues look very similar, though this is our own opinion, and it is not that everyone has to agree with it. Surprisingly, modern people populating this high mountain area in Jammu look a lot like the ancient riders. The appearance of the men, women and children now living in the Ramban district suggests the way the people whose anonymous portraits are cast in stone might have looked in real life.

The horse statues with riders were hewn of local slates. According to the research done by L. V. Miroshnichenko in the X-ray laboratory of the Institute of Geology and Minerology, Siberian Branch, Russian Academy of Sciences (Novosibirsk), the rock used to make the statues can be identified as micaceous chloritic quartzite slate, which lends itself easily to carving. Slates were used to make the famous statues and reliefs (1st c. BC – 5th c. AD) found in Gandhara, an ancient kingdom of Northwestern Hindustan, where a distinct style of art was born and perfected during almost 500 years, recognized as an inimitable phenomenon of Indian art culture (Pugachenkova, 1982).

Some of the stone statues show traces of red paint. There is little doubt that the horses and riders used to be painted, as was all ancient stone sculpture from Greece to Mongolian steppes. Shortly we are going to find out how exactly this was done and what dyes or paints were used. The red color – a universal sign of blood – was meant to "reanimate" the statues. The Rajputs are known to have dyed their horses' tails and hooves with henna sap and saffron infusion and put a tika (tilaka) with red paste on their face during the ceremony of preparing horses for the battle (Uspenskaya, 2000)

Drawing of the stone statue
by Ye. Shumakova

The absence of saddles and stirrups on the horse statues does not suggest that this ethnicity did not actually have them, the same as three of four riders on one horse does not mean that this was a common way to travel. Looking at these depictions, we should realize that these are mythical characters, though made after real-life prototypes. Every single object depicted on the statues existed in reality like did people and horses, who changed over to a new condition when they were carved in stone. The depictions are as overloaded with objects and detail, as the horses are overburdened with people…These characteristic features can be attributed to the memorial purpose of these monuments, which were meant to signify so much

As for the carefully sculpted horse harness gear, the first thing that strikes the eye are large round cheek-pieces with bridle and reins strapped to them. Analogs of such cheek-pieces were discovered in the graves of the nomadic peoples populating the East-European and Central Asian steppes in the 5th c., supposedly united for a short time by the European Huns (Ambroz, 1981).

Other interesting and conspicuous details of the horse harness include a variety of strap decorations – horse brasses. The brasses of different size and made of different materials were used to embellish the horse harness from the ancient times to the late medieval period. At times, they were made of precious metals, which indicated the rider's high status.

The horse harness of the stone horsemen is decorated with round brasses depicting a polypetalous flower (supposedly, the lotus). The same brasses decorated the harness gear of the horses carved on bone handicrafts from Bergam (Afghanistan, 1st c.) (Tyulaev, 1988). Sometimes, the brasses display a whirl pattern. Similar ornaments were found in the Sarmatian monuments of the 1st – early 2nd c.; also they occur in more ancient burial sites of the 3rd –2nd cc. BC (Mordvintseva, 2001). Their depictions can be found in Gandhara art. For example, on a relief from Charsadda whirl-pattern brasses decorate the harness of the rams pulling a cart with the youth Siddharth (Pugachenkova, 1982); on the stone sculptures in Palmyra brasses can be seen on the harness of a Parthian rider. Hence the brasses and other embellishments of the stone horsemen's harness refer us to the harness of Eurasian nomads, who brought the equestrian culture to India.

On the way to eternity

The most original part of these monuments ruined by time and people are rock-hewn horses bearing two, three or even four riders. This extraordinary and unrealistic way of collective travel suggests that these are mythological characters: heroes, ancestors heading for the faraway land that every ethnicity fancies in its own way and where everyone complete their earthly existence. These must be monuments to perished warriors. There is something mesmerizing and alarming about this repetition of faces devoid of individuality and solemn postures of the petrified horsemen.

Both the horses and equestrians are depicted in much detail, with carefully sculpted fittings of harness, clothes, ornaments and arms. At the same time, we are looking at a stylized or primitive type of art: all the proportions of the human body are distorted, as well as the proportions of the arms and harness. The horses' backs covered with tasseled carpets, similarly to oriental sofas, easily accommodate two, three or four people. The lookalike horsemen seem to be mythical, fictitious beings that have arrived from an unknown world. The details are redundant, which, for all one knows, may reflect the reality. Every horse deserves a separate description because though all the figurines we have seen and recorded (there are over 100 on just one site) look similar and indicate to a certain canon, each stone sculpture has its special features. The results of laser scanning and phototography will allow creating an electronic catalog describing each statue in detail.

On both sides of the flat statues are finely and precisely carved details of horse harness, costume and arms. The horses' legs, chest and croup bear carved depictions of women. The sculptures are of different size; many are over two meters high due to the long legs supporting them. Interestingly, we have observed that the legs were not dug deep into the ground, which may seem logical. On the contrary, these long legs rose above the surface, making the horses unrealistically tall.

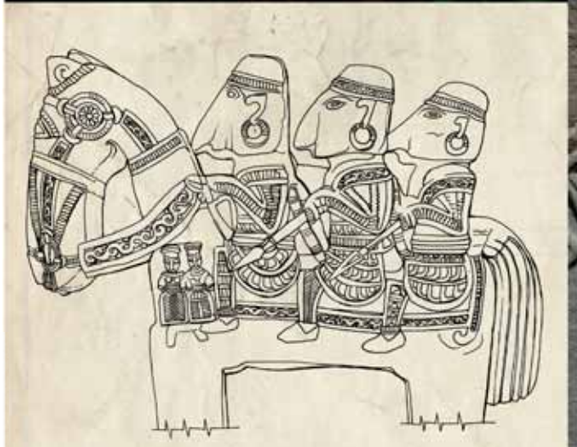
Many of the statues were found fallen down, probably because of the earthquakes and landslides, which are frequent in this area. As for the heads missing from many riders, this is the result of barbarity of the subsequent epochs.

The horses' faces are very expressive. In addition to the details of smart horse harness – big round cheek pieces, plates, nasels and richly tasseled straps – you can see big eyes, often with thick lashes; an open sharp-toothed mouth, often with a protruding tongue with a rolled tip. These long stuck-out tongues of the Himalayan stone horses is a trait indicating their magical nature. Apparently, these are not ordinary horses but supernatural beings connecting the worlds of the living and dead; they know the way to paradise and are taking their riders there…These horses are mythical creatures but the sculptors who created them were well familiar with their real prototypes, which is not true of some other depictions (like the elephant) looking improbable.

The riders' costumes, like the rest, are stylized depictions of real clothes. The stone statues show an ideal warrior whose outfit combined armor and ornamented fabric. The clothes on the arms and legs are closely fitting. The riders are wearing tight-leg calf-length trousers and soft half-boots of varied styles and with various trimmings. Most warriors are dressed in armored jackets and skirts covering thighs. It should be noted that in Northern India scaled (and possibly lamellar) armor and its details appear as early as in the 1st c. BC, when Northern India became part of the Kushan state (Nosov, 2011). On their heads, the riders are wearing not combat helmets but round hats, flat on the top, with an undulated line design along the brim, depicting a stylized rambling branch. Some of the hats display curious details, like strings tied up on the top of the head. Interestingly, this type of headgear is still popular with the residents of the local settlements of Ramban district, along with the turban. A few of the stone horsemen are wearing a different kind of hats that look like short caps. Occasionally, from under them peep out very shortly cut straight hair.

Some riders sitting next to the horse's neck are holding a vessel in their left hand – a goblet shaped like a sand-glass, with its lower part is smaller than the upper. Some of the vessels are richly

ornamented while the others are decorated more modestly. The solemnity with which the rider is holding the vessel in a raised hand suggests that the drink is an offering. The Rajputs are known to have greeted each other or their guests with a goblet of a foamy honey drink and, according to their beliefs, the Apsarases in paradise greeted the warriors who perished in a battle with similar goblets of wine (Uspenskaya, 2000).



Drawing of the stone statue
by Ye. Shumakova

A curved dagger, a straight sword

Before us are noble riders belonging to a caste of warriors, armed with richly adorned prestige weapons.

Bladed weapon testified to a high status of the warriors. This must be the reason why many of the stone riders carry both a dagger and a sword. Thus, with their right hand some of them are grasping the handle of a dagger with a curved blade in a richly decorated scabbard, stuck in a fabric belt. This is chilanum, a typical Indian dagger with characteristically shaped handle: its crossguards and pommel are disc-shaped or look like two curved stalks. The pommel invariably has a nut; the grip is thin, usually with a round thickening. Regrettably, archaeological findings of bladed arms of the early Middle Ages are extremely rare; therefore, the appearance of this kind of daggers cannot be dated accurately (Nosov, 2011).

Another kind of bladed weapons depicted on the reliefs is a sword with a straight broad blade, uniform all along, which the riders carry horizontally on their right shoulder. Apparently, it is impossible to depict the size and shape of the swords realistically as they are too small. What we can see clearly is a large mushroom-shaped pommel with a nut. As it is known, if a warrior carried a sword without a scabbard, the blade had decorative plates attached to it. It could be these or some other marks considered fortunate like the Shiva sign that are depicted on the blades of the swords carried by the stone horsemen (*ibid.*).

By their left hand, all the stone riders hold a small segment-shaped bow with a feathered arrow pointing downwards. Socketed arrowheads with two barbs are outsized. You can see similar bows on Gupta reliefs – at the time they coexisted with the big bows of human scale. The two types of bows continued to be used later (*ibid.*).

The nomads of Central Asia would always carry their scabbards hung on to the belt. In ancient and early medieval India though, the scabbards used to be hung on the back of the right shoulder, as we can see of the Sanchi reliefs as early as in the 1st c. BC. The Himalayan warriors carry their scabbards in exactly the same manner. The Assyrian and Median warriors carried their scabbards behind the back. In India, they began to carry scabbards on the right side following the Central Asian tradition only in the 13th c. (Nosov, 2011).

Just a few of the stone riders have battle axes stuck in belt instead of a dagger. Similar axes with an eye (a hole for the haft) were spread as early as in the end of the 1st c. BC, as illustrated by the findings in Taxila (Ilyin, 1958).

The round decorated shields depicted on the reliefs look inadequately small. Judging by the known pictorial sources, warriors, when off the field, hang their shields behind the back using a special strap or on to the belt on the left side (Nosov, 2011). The small shields of the Pir Panjal riders hang on a braided cord attached to the left forearm. We can see the same kind of shields in the depictions of Sanchi, Ajanta frescoes (5th – 7th cc.), Gupta reliefs and Palmyra reliefs in Syria (Schlumberger, 1985). Small shields were popular with riders in later times too: they are depicted on the Khajuraho statues of the 10th –12th cc. and on the relief showing Rajputs on the Chittor castle gate (15th c.) (Nosov, 2011). To sum up, we can conclude that the full set of weapons depicted on the Pir Panjal statues has a wide chronological framework in Indian culture. Whatever the depicted warriors were, they had been sufficiently "Indianized," were able to use the exceptionally efficient Indian weapons and familiar with the ways to carry them.

Chilanum, an I Indian dagger.
Drawn by Ye. Shumakova.
From: (Nosov, 2011)

Woman's place

Sometimes you can see an equestrienne next to the men and always the last in a row. The women are distinguished by long, past shoulder hair, a diadem, temple pendants along the cheeks and absence of weapons. Nestling behind one equestrienne is a baby. As for the rest, the women look like the men, and their costumes are similar to armor.

We can find the analogs of diadems and temple pendants worn by the stone horsewomen in the adornments discovered in the tombs of the nomads of the East European and Central Asian steppes of the 5th c. (Ambroz, 1981). The set of decorations of these women nomads differs from the men's only by a diadem and temple pendants, similarly to the Himalayan equestriennes.

As a rule, the women are depicted on the surface of the horse's croup, by ones, in pairs or in groups. These are small figurines in long skirts ornamented with a geometrical pattern, tied around the waist with a broad belt made of cloth. Sometimes you can see bare feet peeping out from under the skirts. The upper part of the body seems naked, as you can see breasts: probably, the women were wearing blouses made of transparent fabric. The women have necklaces and a high headgear covering the hair.

As we can see, this women's costume is nowhere near the traditional Indian costume, which is a sari. It is known that long full skirts and blouses were worn, among others, by the Rajput women (Uspenskaya, 2000). Women played a large part in the Rajput society and, most importantly, their help to their husbands had a sacred meaning: the woman had the power to keep her husband among the living or prepone his death by wrongdoing. As a rule, the Rajput women voluntarily parted from this life following their husbands (*ibid.*). Possibly, the mandatory presence of female figurines on the horse statues confirms these ancient customs of the Rajputs and at the same time commemorates the dead women and children.

The female full faces have as long (bird-like) noses as the male. In one hand, the women are holding a lipped jug, and in the other, a ring-shaped object looking very much like a festive garland. Such garlands can be frequently seen in the hands of the dancers depicted on the precious tableware of Iranian grandees dating from the 5th –6th cc. (Lukonin, 1977). Another important function of these garlands in that they were a sign of victory used to crown heroes.

Sacred water

Surprisingly, stone horses with groups of equestrians and occasionally equestriennes are not the only sights of Pir Panjal. The extraordinary stone statues are placed next to a cascade of small basins descending along the mountain slopes. The basins must have been intended for ritual ablution, which links these monuments with Hinduist traditions. Many of the basins are turfed, overgrown with grass and bushes but remain a source of water for local residents.

These small artificial water reservoirs are walled with flagstones of gray shale rock. The flagstones are decorated with big rosettes in the form of open lotuses. Some of the rosettes look more like the Dharma wheel, a Buddhist symbol of learning and transfer of knowledge. Exactly the same depictions can be seen on one of the most ancient Buddhist stupas, Sanchi Stupa (1st c. BC).

The depictions of lotuses occurred in Hindu culture, which lent them to Buddhism. The lotus flower symbolizes spiritual ascension. The basin where the plant grows is a symbol of the world of the uninitiated, where people spend their time pandering to their passions. The leaves spreading out on the water surface signify the revival of consciousness and craving for transfiguration, and the bud opening in sunlight means enlightenment... This might have been what the riders sought when approaching these water pools. The Rajput poems describe a special rite of worshipping a horse before a battle. The rite was performed by the warrior himself, his mother or wife. Before the horses were adorned, they were led to a water reservoir for watering and washing (Uspenskaya, 2000).

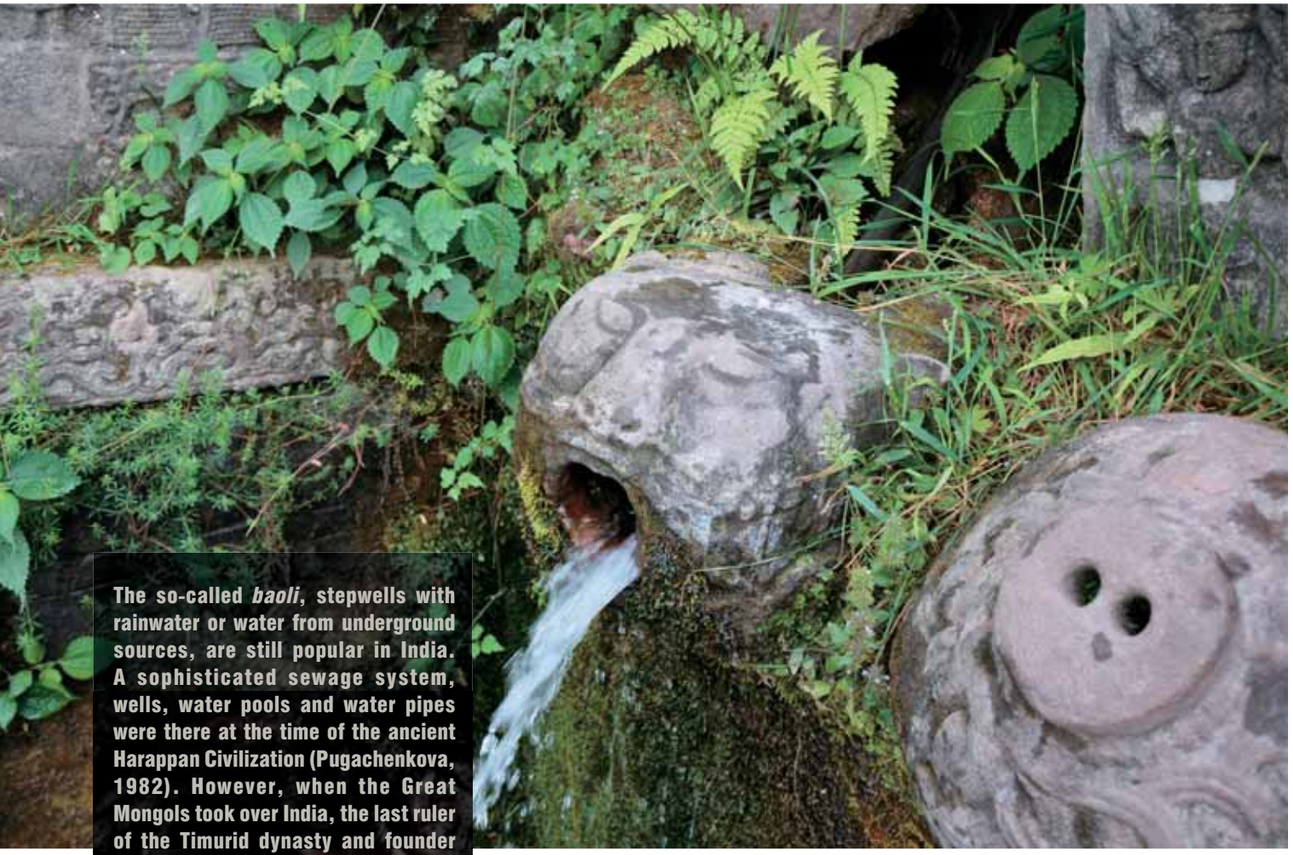
The Pir Panjal basins were filled with the water of mountain brooks flowing in through small round holes in beautiful stone spouts styled after decorated vessels. Sometimes instead of a vessel there is a tiger's head with an open mouth ejecting water.

Similar decoration of sources occurs in Hindu culture until the present day. In the 1960s, Sviatoslav Roerich wrote that in some places of the Kullu Valley at the foot of the Pir Panjal Range in Himachal Pradesh you can still see springs decorated as the heads of lions or makaras, mythical aquatic monsters, and next to the Bashist basin there was quite a large slab decorated with a floral design and depictions of gods. The artist also mentioned a big deserted pond faced with ashlar stone, which used to have some carved details, in Tava near Naggar. By the time the masonwork had mostly crumbled and was used in subsequent construction works (Roerich, 2011).

Much later, in the early 21st c., in another valley of the same state – the Pangi Valley, Chamba district – Indian archaeologists discovered numerous reservoirs having stone slabs with carvings depicting floral and geometric motifs, lotuses, and men and women drinking water. These structures resemble the ones found in Jammu. The researchers date the Hindu temples situated in these parts by 6th –17th cc., making a point though that many of them were built from the stones of more ancient constructions (*Indian Archaeology 2001—02: a review*, 2008).

The stone statues of horses are common in northwestern Iran, East Turkey, Azerbaijan and Armenia. Since the medieval times they can be found on the tombs of warriors; depicted on many of them are different weapons like a bow with arrows, a quiver or a saber. Quite often you can see on the horses croups figurines of hunters with a bird in their hand. The stone horses are always shown fully harnessed, with stirrups and saddle but they never had riders, and this is their fundamental difference from the Himalayan statues. The origin of these stone sculptures is still being discussed (Pchelina, 1932; Efendiev, 1986). There is no consensus on their initial purpose, the time when they were made or the ethnicity of their sculptors. There is little doubt though that these stone horses are monuments to soldier riders like the ones in the Himalayas.

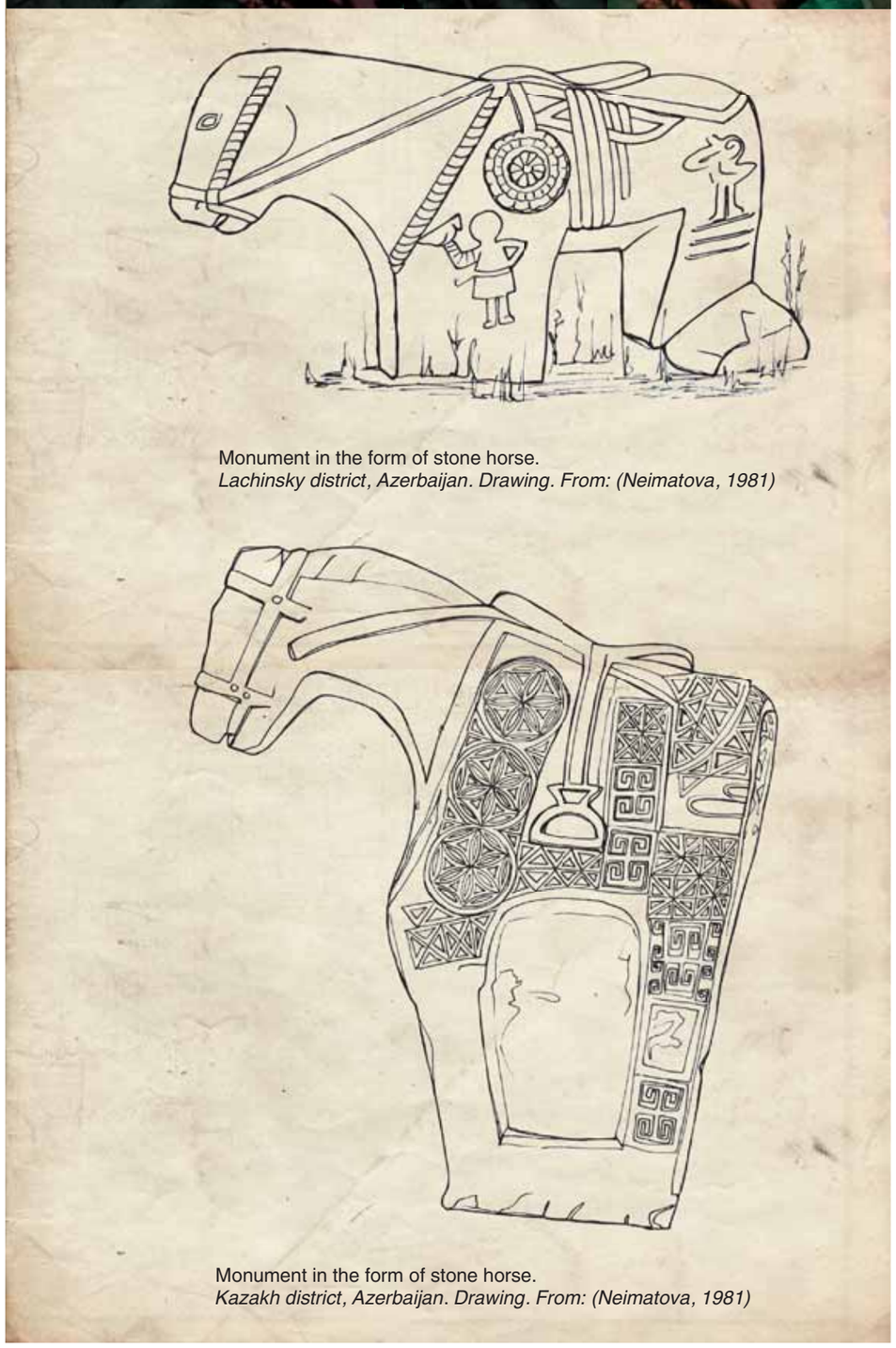
Even an initial investigation of the extraordinary statues from the Inner Himalayas suggests that these monuments belong to the tribes who arrived with the Hephthalites. As is known, there are three Hephthalite tribes that have managed to adjust to the North-Indian ecological and social environment: Rajputs, Gurjars and Jats. Descendants of the belligerent Rajputs are just as belligerent Dogra, the people still populating Jammu and the adjoining areas of Punjab, Himachal Pradesh and northeastern Pakistan. Possibly, these were the ancestors of Rajputs who left these remarkable statues. A well-known researcher of Rajput culture, Ye.N. Uspenskaya wrote, "They were apparently nomads, used to the steppes, horses, bows and arrows, and the martial way of life was as natural for them as, for example, for the Mongols" (Uspenskaya, 2000).



The so-called *baoli*, stepwells with rainwater or water from underground sources, are still popular in India. A sophisticated sewage system, wells, water pools and water pipes were there at the time of the ancient Harappan Civilization (Pugachenkova, 1982). However, when the Great Mongols took over India, the last ruler of the Timurid dynasty and founder of the Babur dynasty wrote in his memoirs, "Apart from rivers and streams running in plains and ravines, there was no other water in gardens and settlements…" (Berensten, 2005). As far as it is known, Babur never took to India. He said that "the towns had no living water at all," and set up gardens with a system of canals and streams (ibid).

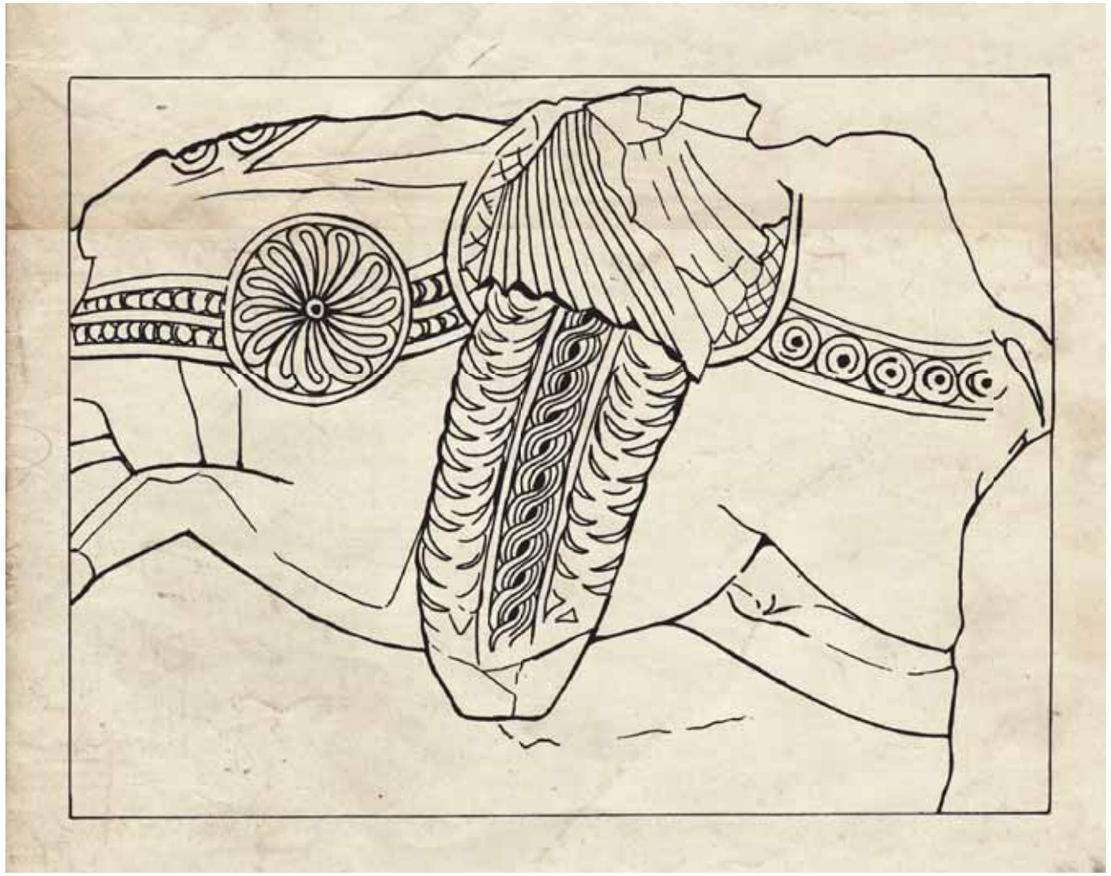
In addition to the statues, stepwells and plates found on the sites, there are some stone pieces of other architectural structures, with their main part buried deep in the ground. However, in order to determine to what particular structures these stone plinths with carving belong, exploratory digging is needed

The object of our study refers to the earlier, possibly, "Hephthalite" history of these tribes on the territory of Northern India. The fully armed riders can be depictions of the heroes who perished in the last battle, in which no one was to survive. As a rule, such a battle came with a very ancient custom of the Rajputs, as of other bellicose tribes – jauhar, or mass self-immolation of the clan's women. This might explain why the monuments were put not to individual warriors but to the warrior host including women and sometimes children. The special features of the religious symbols on the stone statues may also favor their Hephthalite origin since, according to written sources, this ethnicity practiced Buddhism, Hinduism (Shaivism), Zoroastrianism, Manichaeism and even Christianity, alongside some pagan cults (Isomatov, 2009). Hence, the ambiguity of the religious signs on the monuments under study, though they are more like Shaivism symbols than any other.



Monument in the form of stone horse.
Lachinsky district, Azerbaijan. Drawing. From: (Neimatova, 1981)

Monument in the form of stone horse.
Kazakh district, Azerbaijan. Drawing. From: (Neimatova, 1981)



Relief from the Bela palace (Palmyra) depicting a rider in Parthian costume. *Late 1st c. BC. From: (Kaim, 2005)*

In western, central and northern India there are numerous memorial stones – monuments to heroes and sati, their widows who immolated themselves. They are especially many in Gujarat, Rajasthan and Himachal Pradesh. The origins of this tradition – setting up memorial stones – go up to the beliefs of the Vedic Aryans and orthodox Hindu practices, according to some scholars (Patil, 1982), or to early Buddhism and Central Asian influence, according to others (Chattopadnyaya, 1982). The Himalayan stone riders make part of this general phenomenon that has existed within the territory of India for a long time (nobody knows exactly how long). In each district, the memorial stones have their own specific features but there is nothing even slightly resembling the stone equestrians of the Himalayas – they are altogether unique.

The most fascinating part of this story though is that the ethnicity that created these amazing statues did not disappear without leaving a trace: their descendants continue to live in this area not knowing that the stone statues standing in the way of their farming are in fact the memory of their ancestors and traces of their former glory.

References

Kurbanov A.D. Hephthalites: Historical Essays. St Petersburg: Yevropeiski dom, 2006. ISBN 5-8015-0203-3. [In Russian]

Ambroz A.K. East European and Central Asian steppes from the 5th to the first half of the 8th c. // Stepi Evrazii v epokhu srednevekovia. Moscow: Nauka, 1981, P. 10—23. [In Russian]

Roerich S. Art of the Kullu Valley // Indian painting. M.: Roerich International Center, 2011, 440 p. [In Russian]

Berensten V. Empire of the Great Mongols. Moscow: Astrel; AST, 2005, 160 p. [In Russian]

Indian Archaeology 2001–02: a review, New Dehi, 2008. 581 p.

Nosov K.S. Indian Traditional Weapons. Moscow: Eksmo, 2011, 384 c. [In Russian]

Trofimova T.A. Depictions of the Hephthalite rulers on coins and the ancient Central Asian custom of artificial skull deformity // Istoriya, arkheologiya i etnografiya Srednei Azii. Moscow: Nauka, 1968, P. 179—189. [In Russian]

Pugachenkova G.A. The Art of Gandhara. Moscow: Iskusstvo, 1982, 196 p. [In Russian]

Uspenskaya Ye.N. Rajputs: Knights of Medieval India. St Petersburg: Eurazia, 2000, 384 p. [In Russian]

Tulayev S.I. Indian Art of 3rd millennium B.C. to 7th c. BC. Moscow: Iskusstvo, 1988, 344 p. [In Russian]

Efendiev Rasim Samed ogly (Rasim Efendi). Stone Plastic of Azerbaijan. Baku: Ishig, 1986. [In Russian]

Selection of the Best Friend

The experiment on fox domestication, conceived by the outstanding Russian evolutionary geneticist Dmitry Konstantinovich Belyaev and carried out in Novosibirsk Akademgorodok has been recognized as one of the major scientific experiments of the twentieth century. In evolutionary biology the experiment is unprecedented – with over sixty thousand animals, half a century of hard work and the results obtained in the process. Academician Belyaev and his team of enthusiasts, especially his devoted student and follower, Lyudmila Nikolaevna Trut, managed to "turn" the fox into the dog in just fifty years, while it took humans 15 000 years to tame the wolf!

The unique experiment of the Novosibirsk geneticists has been featured in a great number of research papers and popular films. In 2017, the University of Chicago Press published a book, "How to tame a fox (and build a dog)" on the occasion of Belyaev's 100th Anniversary, authored by Lyudmila Trut and Lee Dugatkin, a popular American biologist and science writer. In 2018, the English edition of this book received the American Association for the Advancement of Science Award as the Best Young Adult Science Book. Lyudmila Nikolaevna shares her memories about the times and events at the beginning of the experiment on fox domestication that brought world fame to the Novosibirsk geneticists

Lyudmila N. Trut is Doctor of Biology, professor, and senior researcher of the Institute of Cytology and Genetics, SB RAS (Novosibirsk). Awarded with the Badge of Honor, Silver and Gold Medals of the VDNKh (Exhibition of Achievements of National Economy), and N. I. Vavilov Prize (1982); Honored Science Worker of the Russian Federation (2005)

L. N. Trut with a domesticated fox on the ICG SB RAS experimental fur farm (Novosibirsk). *2012. Photo: V. Koval'*

Key words: Lyudmila Trut, Dmitri Belyaev, evolution, natural selection, destabilizing selection, domestication, fox, dog

Pushinka ("Fluff") was the first fox to live with humans and give birth to a litter of cubs; indeed, she looked like a piece of fluff and was the most affectionate among the thousand foxes on the farm. On a March morning of 1975, she joined Lyudmila Nikolaevna Trut in a small house on the premises of the experimental fox farm in Novosibirsk Akademgorodok, specially equipped for home-sharing of humans and animals. The researchers were very worried: the stress of adapting to a new ecological niche always leaves its marks on the animal.

On the first day at her new home Pushinka was restless. In the wild, expecting vixen mothers usually find a quiet shelter until the cubs arrive. Pushinka got a nest prepared for her in a separate room, but the vixen would not stay still – she did not eat a morsel and kept running and running... Later in the evening, Lyudmila Nikolaevna's daughter dropped in together with her friend, and the girls decided to stay overnight. The only place to sleep was on the floor, and while they were preparing for sleep, the vixen was nervous. But to everyone's surprise – as well as and joy and relief – in the middle of the night, Pushinka crept out of her room, sneaked under the girls' blanket, curled up and fell asleep...

This is just one of many amazing episodes when this incredibly affectionate and friendly vixen demonstrated its dog-like character. For instance, when a new gatekeeper dropped in to greet the newcomers, she met him with abrupt calls very similar to dog barking.

On the night the researchers noticed the tentative signs that the pups were about to be born, Lyudmila Nikolaevna was on the watch. At first, everything was quiet, then she heard the the pups' squeaks. The first thing the vixen did was bring a naked, still wet cub and toss it on the cold floor in front of Lyudmila's feet, where she loved to sit. Lyudmila Nikolaevna was afraid the pup would catch a cold and die: she scolded Pushinka, took the pup and placed it back in the nest – and brought its mother there, too. By that time, the researchers had learned that tame foxes were capable of maternal aggression and did not permit handling the newborns, but the vixen willingly brought the pup!

But after a while, it repeated – again, and again, and again... They tried to reason with the vixen, but in vain. Finally, Lyudmila Nikolaevna put a warm mat near her bed, and Pushinka brought all her cubs there. It was clear that she was struggling with two drives: to be with her young and to stay with the human. As a result, she worked out a new behavioral strategy by combining what would be «incompatible» for a wild animal. It was only then that Pushinka finally settled down and nurtured the pups.

Such experiments on house sharing are necessary to speed up the domestication effect. A fox that spent all its life in an isolated cage with limited contact with humans had to be freed from captivity. A group of researchers headed by Academician D. K. Belyaev decided to house some of the selected individuals directly near humans. The wolf on his way to become the dog was in completely different circumstances: the animals had a choice whether or not to live near the ancient human settlements. Pushinka made her choice.

How it all began

Dmitry Konstantinovich Belyaev was always fascinated by the evolutionary puzzles of domestication. He had an extensive knowledge of fur farming and always compared the fox with its nearest relative – the dog, and wondered: a hungry stray dog bears two litters a year, while a fox on the farm, despite the optimal scientifically developed housing and feeding, gives birth to a single litter in March? How did the wolf, in the process of its evolutionary transformation into the dog, lose its seasonal restrictions on breeding?

It occurred to Belyaev that behavior-based natural selection was what played the main role in the beginning of the transition from the wolf to the dog: only animals that tolerated humans became "domesticated" and began living near humans. More and more tolerant individuals were born with each consecutive generation. Eventually, the initially unconscious artificial selection came into play. It was later replaced by artificial selection consciously directed at specific behavioral traits.

L. N. Trut with a tame fox. *2012. Photo: V. Koval'*

Dmitry Konstantinovich believed it was this sort of behavioral selection that led to the changes not only in the behavior itself, but also in the physiology and morphology of the wolf. However, that idea was nothing but theoretical assumptions, with facts long lost beyond history. What if researchers attempted to recreate the earliest stage of domestication? The idea seemed utopic at first, but the experiment began.

The future Academician began his works on the selection of human-tolerant foxes back in the early 1950s on an Estonian fur farm. In 1958 N. P. Dubinin, the founding director of the Institute of Cytology and Genetics of the SB AS USSR, invited him to the rising Novosibirsk Akademgorodok, where he organized the Department of Animal Genetics and became a deputy director of the Institute.

Back then, even the Institute building was still under construction, not to mention the experimental farms, including the fur farm. But Dmitry Konstantinovich Belyaev did not want to lose time. He understood the immense scale of the task standing before them – compatible with the human lifespan. Altai was close to Akademgorodok: there was a major *zverosovkhoz* (a collective farm specialized on furbearing animals), Lesnoy, where aces of the fur industry worked: director V. A. Chetyrkin and chief livestock technician S. A. Illarionov; both were Honored Workers of Fur Farming. They felt favorably toward the planned experiment and helped Belyaev organize an experimental station of the ICG SB RAS at their fur farm. That is where the first "Estonian" foxes went, eventually joined by friendly animals from other fur farms. Only ten years later, the animals were finally moved to Akademgorodok, when the construction of the fur farm there was finished.

Moscow-Akademgorodok-Altai

Every now and then Belyaev would visit the Chair of Higher Nervous Activity of the MSU Biological Department to discuss with professor L. V. Krushinskiy the budding experiment and the possibility of staffing it with smart and reliable alumni. Back then, he was still working at the Central Research Laboratory of Fur Farming in Moscow and living in the Udelnyi village. That is where two "smart and reliable" students, Lyudmila Trut and her groupmate, Tamara Bondarenko, went to work.

First, Belyaev tested the future scientists: he asked what they knew about foxes; how they were going to select the progenitors of a new tame population among the thousands of animals on the farm, etc. He told the girls about his project and offered to hire them to work at the Institute directly after their graduation. Although they still had to be formally introduced to Dubinin, the final decision was made by Dmitry Konstantinovich.

L. N. Trut with a tame fox. *Photo from the L. N. Trut Archive*

L. N. Trut in the new building of the Institute of Cytology and Genetics SB AS USSR; the construction began only in 1962. *Photo from the ICG SB RAS Archive*

Lyudmila Nikolaevna has been fond of animals, especially dogs, since she was a little child; she always thought her job had to be about animals to be truly enjoyable. That is why she left for Novosibirsk without a second thought – she was sure she was doing the right thing. She believes she was incredibly lucky: she had not even graduated when she got her first scientific task, which predefined her whole life. Her groupmate Tamara, however, found the harsh working environment too challenging and eventually returned to Moscow.

Up until 1967 Lyudmila Nikolaevna spent most of her time at Lesnoy in the Altai mountains, working on a project on the selection of "friendly" foxes. The coldest part of the year – January and February – was the most important: this was the time of selecting breeding pairs and mating, which required continuous attention of the researchers. She constantly had to travel back and forth from Akademgorodok to Altai. The train from Biysk to Tomsk used to stop at the Seyatel' station, but it took time to get from the station to the institute – or home: public transport never kept to the schedule, and on very cold days, sometimes there were no buses in the streets at all. On one of these freezing winter mornings, Lyudmila spent hours waiting for the bus. The professor recalls a haunting thought: if she ever managed to get to the Institute that morning, she would give notice at the very same instant! She was chilled to the marrow! But a car passing by stopped and gave everyone a ride home. Her mom, her daughter and her husband were there – with hot food and tea! The desire to quit evaporated...

The fox domestication experiment started in the dark times for genetics: repressions against the "pseudoscience" continued until the resignation of Khrushchev in 1964; throughout this period, the Institute was on the brink of dismissal. In January 1960, Dubinin was essentially forced to step down, and Academician M. A. Lavrentiev only managed to stand upon his right to pick the new director – and he chose D. K. Belyaev. Their joined effort saved the Institute.

Later, in the turmoil of the post-Perestroika 1990s, when the situation with funding turned dire, the question of closing the experimental fur farm came up. The researchers returned home every evening, not knowing if they would see their pets alive next morning...

When kindness is in the genes

The essence of the experiment lies in selecting the friendliest individuals producing even friendlier offspring, and so forth. Over the past years, about ten thousand animals were used in the experiment, producing at least 50,000 pups.

The researchers were sure that behavioral changes occur at the genetic level; however, hypothetically, other factors could come into play, such as peculiarities of prenatal developement, conditions of the early postnatal period and communication with the mother. To test

On page 57

Domesticated foxes differ from their wild relatives by their dog-like curled tail, piebaldness, short paws and a number of other morphological features. *Photo: V. Koval'*

EVOLUTION ON A FUR FARM

"The domestication syndrome" is a complex of external and internal traits typical for domestic animals regardless of the species and even genus, yet extremely rare in their wild counterparts. This phenomenon discovered by Darwin became a mystery, which did not fit into the theory of artificial selection. For instance, white marks on different parts of the body (such as stars and blazes on the forehead and stockings on the feet of animals): in the wild, fur color and markings often serve the purpose of camouflage, but does a domestic cow have any use for it? Did the humans need floppy ears, pretzel-like tails, shortened snouts and other "baby" features in the appearance and behavior of their domesticated animals? Nevertheless, these "useless" features have persisted through the centuries-old history of spontaneous selection.

But what if all these trait changes are but a side-effect of the selection directed at completely different properties and traits? In the beginning of the unprecedented evolutionary experiment, D. K. Belyaev assumed that all questions concerning the raise of domestic animals could be answered by examining their defining trait – i. e. the absence of fear of humans.

The ancestors of domestic animals, just like the wild animals nowadays, normally fled or attacked when humans approached. At the same time, animals that lived in close contact with humans had a more stable access to food and better protection from predators. In the result, individuals born without aggression to humans gained an advantage and survived.

In other words, this too is natural selection, but with a different vector, aimed at preserving individuals with specific behavioral reactions to the main factor of the new environment – the human. Belyaev assumed that behavioral selection was the moving force of domestication, and genes controlling the behavior had to have very broad ranges of pleiotropic (multiple) influence on various features and traits of the organism (Belyaev, 1969; 1972). A change of the selection pressure vector could result in the activation of "dormant" genes and expression of the previously hidden variability, which pointed at the possibility of domestication going at a much faster rate than the standard interpretation of Darwin's theory implied.

Indeed, selection aimed at friendly behavior toward humans, atypical for wild animals, caused a true explosion of variability of behavioral, physiological and morphological traits in accordance with the "domestication syndrome". It turned out that this variability was based on changes in the major regulatory systems of individual organism development, and most importantly – a decrease in the activity of hypothalamo-pituitary adrenocortical system, the key element in the hormonal regulation of stress responses.

The genetic basis of these coordinated morphological and physiological changes remains an object of study (Trut *et al*., 2013). Their nature may lie in the phenomenon of *genetic linkage*: selection by genes controlling the behavior inevitably affects adjacent genes located on the same chromosome, leading to their linked inheritance over generations. On the other hand, they can be based on gene pleiotropy, just like Belyaev assumed: behavioral genes can be involved in the control of other vital functions. A proof of this hypothesis is the phenomenon of neoteny (arrested development), typical for domestic animals and observed in tame foxes.

In any case, the results of the unique domestication experiment allowed Belyaev to propose a radically new theory of destabilizing selection as a specific form of selection pressure (Belyaev, 1979). In essence, it states that genes responsible for behavior regulate multiple other genes, and behavior-based selection causes, along with changes in the behavior, a destabilization of the animal's individual development and emergence of a whole complex of new traits unrelated to behavior. "Domestication is, in a way, akin to a natural catastrophe. In the context of domestication, the explosion of morphogeny and new evolutionary directions occurs due to the collapse of homeostatic systems created by the preceding evolution; deeply hidden forms of genetic material (dormant genes) are retrieved from the mobilization reserve. <…> The domestication experiment offers an insight into the potential of a species. Science can, if necessary, implement any of these possibilities" (Belyaev, Trut, 1982)

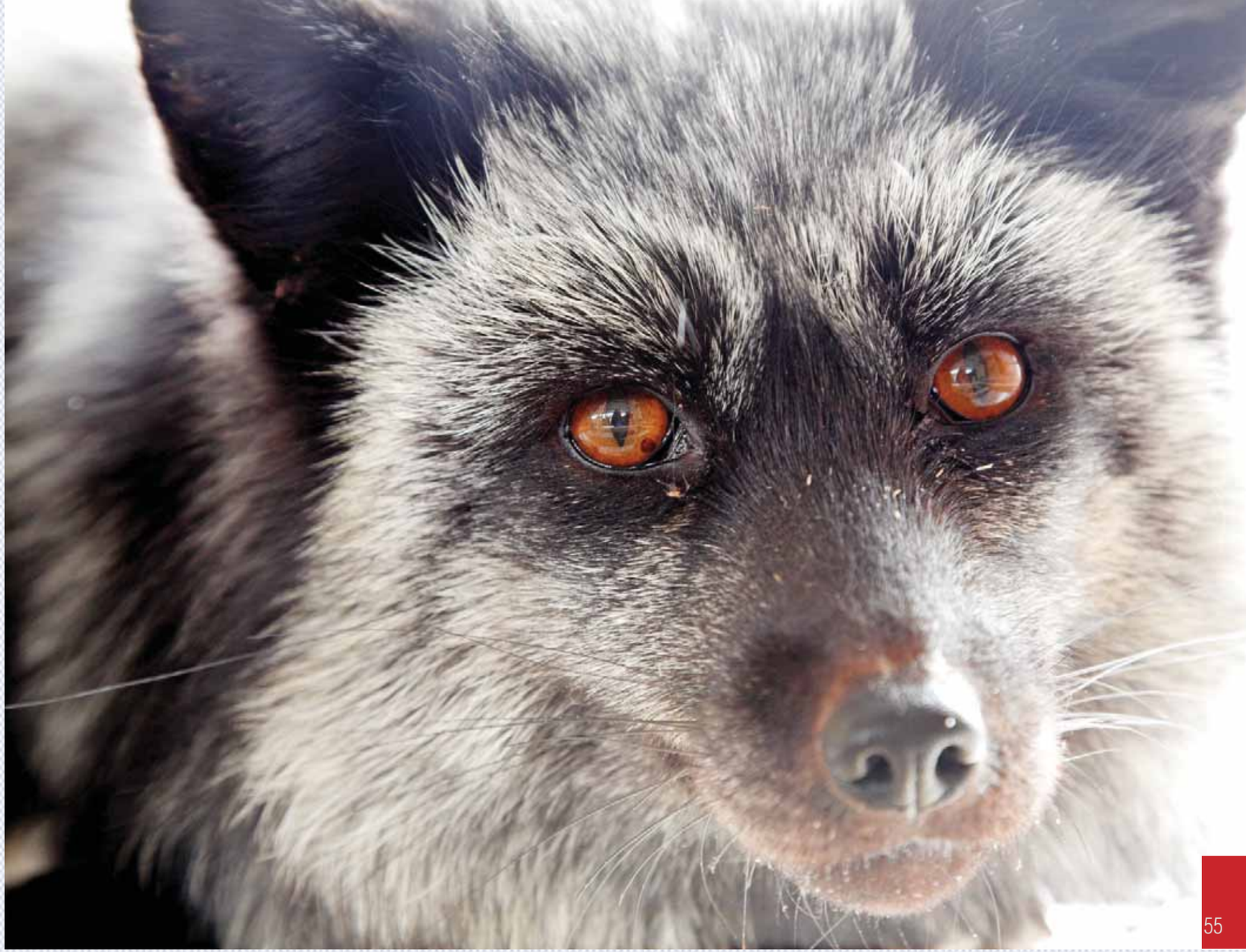
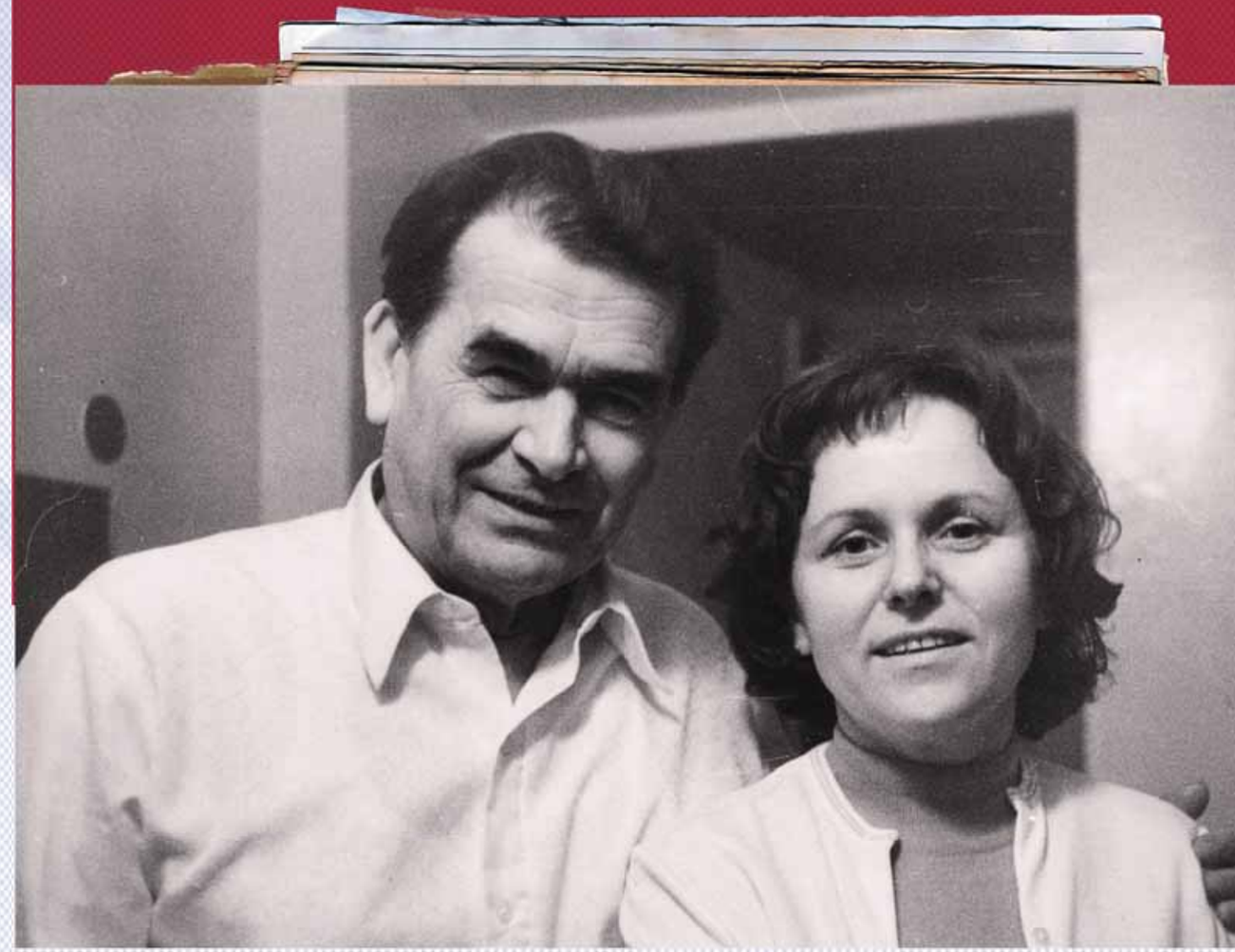


Photo: V. Koval'

Photo: V. Koval'



Academician D. K. Belyaev and L. N. Trut, Doctor of Biology. *Photo from the ICG SB RAS Archive*

some of these assumptions, the researchers decided to transplant blastocysts (i. e. embryos on the earliest stages of development) from a domesticated mother into the womb of a pregnant aggressive vixen (recipient), and vice versa.

Belyaev came to the farm when the aggressive mother vixen had its first mixed litter, and the pups reached the age when they leave the nest and explore the cage. He could not wait to see the pups with genetically different behavioral traits born and raised by the same mother.

Belyaev stopped near the cage where the pups lived, and observed them for a long time. It was a stunning sight, Lyudmila Nikolaevna recalls. First, the colored pups emerged – the true children of the aggressive mother. They were so small they were still staggering, and yet they began avoiding and snapping at the people right away. Then came the "adopted" black pups that grew from the embryos transplanted from a tame mother. They whelped, wagged their tails and tried to come closer. The difference was striking!

Belyaev simply could not take his eyes off the pups. And then he said: "Do you need any more proof that we are seeing a genetic transformation of the behavior of *Vulpes vulpes* (the red fox) into the behavior of *Canis familiaris* (the domestic dog)!"

Can the fox revert to its original state – become aggressive again, if the selection process is reversed? There is no definite answer, although the question got its share of attention. Professor Trut tends to think that the animals are past the point of no return and cannot revert to their original state. Among the foxes used in the experiment, there have always been individuals that did not qualify to be "the elite." however, they were picked for selection by

BEHAVIORAL SELECTION IN HUMANS?

In 2003, an outstanding evolutionary anthropologist R. Wrangham wrote in a letter addressed to L. N. Trut: “Our present concepts of the human evolution are most greatly influenced by your work on domestication of foxes”. Wrangham thinks that the possible human ancestor is a primate phenotypically similar to the bonobo (the dwarf chimpanzee) rather than the chimpanzee – an ape strikingly close to the Australopithecus. The differences between the chimpanzee and the bonobo are surprisingly similar to the differences between the wild and tame foxes. The bonobo has evolved to be more docile, into a kind of a “tame” chimpanzee. It is possible that the early ancestors of bonobos evolved in ecological curcumstances with strong selection pressure against intragroup aggression in favor of peace and cooperation. This could cause the complex of physiological and morphophysiological changes revealed in the bonobo similar to that in the tame foxes. Wrangham believes that ever since the rise of Homo sapiens, our species has been experiencing a decrease in sexual dimorphism, the size of facial bones and thickness of limb bones. Belyaev wrote about this process: “… the change in the central system of neurohumoral regulation necessitated dramatic changes of traits and functions stabilized in the preceding process of evolution. In this sense, selection by features and functions of the brain in the process of evolution caused a similarly extensive variability and boosted the morphogeny in the same way as we observe in the process of domestication”. (Trut, 2007)

On August 7, 2017, on the occasion of Academician D.K. Belyaev 100th Anniversary, a memorial was unveiled. In the center of the memorial, there is a statue of the famous evolutionary geneticist, "shaking hands" with a domesticated fox – the object of his unique evolutionary experiment.
Author of artistic concept: A. Kharkevich (Novosibirsk). Sculpted by K. Zinich (Krasnoyarsk)

important commercial criteria. Still, they remained tame for many generations. Lydmila Nikolaevna believes that the fox preserves the traits acquired in the selection process.

On the day after the arrival of Pushinka's pups, Academician Belyaev came to the farm. He heard the amazing story, slapped his hand on the table and said: "One day, we will write a popular book about all these astonishing phenomena that we observed in our unique experiment." Unfortunately, ten years later Belyaev passed away unexpectedly, and the idea was left dormant.

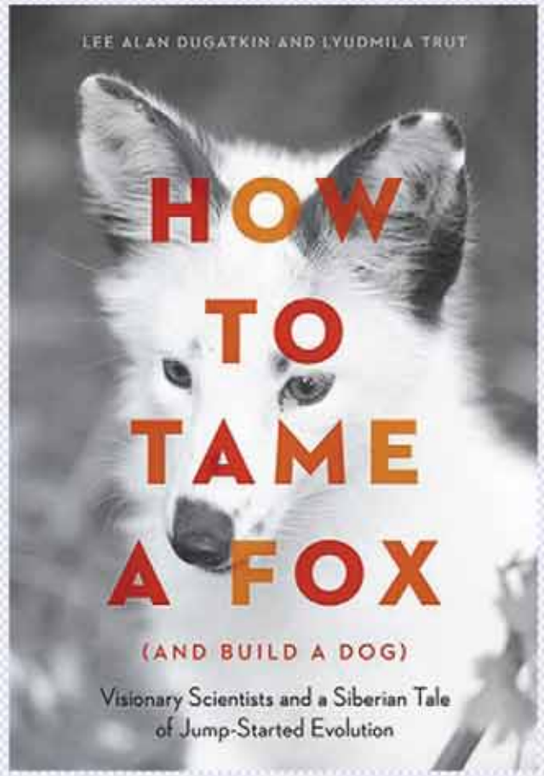
Over three decades later, such a book was published by the University of Chicago Press – the largest academic publishing house in the US. Just like Belyaev wished, it described the key stages of the experiment: what happened and where, and how the attitude of the fox to the human changed. It told about the lives of people intimately connected with this fundamental project, and most importantly, about the difficult life path of its key figure – Dmitry Konstantinovich Belyaev, a visionary scientist, charismatic leader and kind-hearted man.

Naturally, the authors considered publishing the book in Russia, in the SB RAS Press. Professor P.M. Borodin did a lot to make it possible. Unfortunately, so far it has only been possible to do it in the USA, which demonstrates a different attitude to science in this country, where even lay people show a keen interest in scientific progress. On one occasion, several employees of the ICG SB RAS who came to the US to visit a scientific confrence, went on a tour at the museum. Their tour guide was a frail old lady. Not only she knew about the existence of Novosibirsk Akademgorodok, but she knew about the "wonderful tame vixen" that was born there – and she read about it in a research journal!

Over 17,000 copies of *How to tame a fox (and build a dog)* have sold in the US. The American Association for the Advancement of Science (AAAS), the publisher of *Science*, a leading scientific journal, ordered 4000 more copies – they will be distributed among school libraries free of charge.

The experiment that began sixty years ago is still going. The main results of the selection of the "domesticated elite" were achieved by the turn of the millennium, but the fox farm in Akademgorodok still exists. Lyudmila Nikolaevna rarely gets to meet the foxes; nowadays, young specialists work at the farm. The problem is, even despite the fact that there is still some variability observed in the animals' behavior, in terms of the behavioral criteria initially used in the experiment all these foxes are "elite."

New selection criteria are necessary. For further progress, as many animals as possible must be placed into a new ecological niche – i.e. they must live with humans. But in the times of the experiment with Pushinka, scientists from Belyaev's group were willing to spend days at work. In our time, it is virtually impossible to find people willing to work in such a challenging mode...



The full name of the book published in 2017 by the University of Chicago Press is eloquent and informative: *How to Tame a Fox (and Build a Dog): Visionary Scientists and a Siberian Tale of Jump-Started Evolution*

References

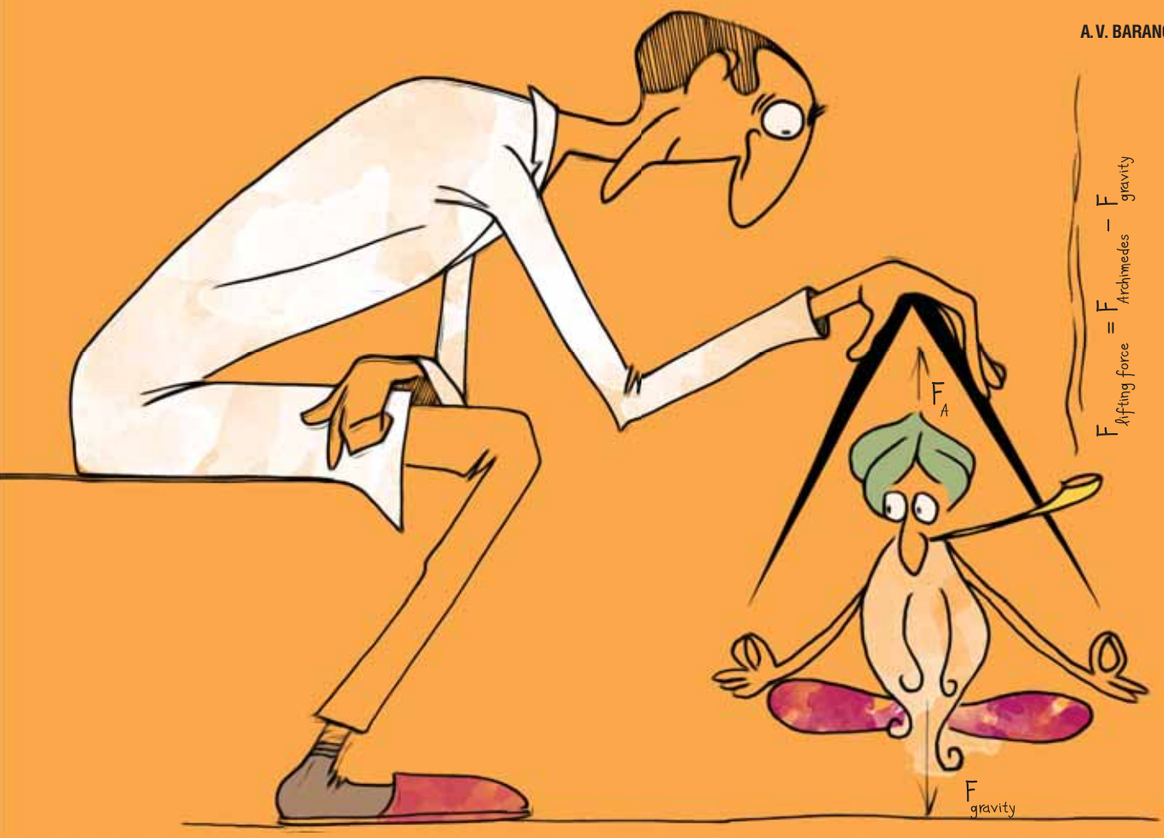
Belyaev D.K., Trut L.N. From natural to artificial selection: the wonders of selection // Science in the USSR. 1982. N. 5. P. 24–29, 60–64 [in Russian].

Belyaev D.K., Trut L.N. The convergent nature of morphogeny and the concept of destabilizing selection / In.: Vavilov's Legacy in Modern Biology. Moscow: Nauka, 1989. P. 155–169. [In Russian]

Belyaev N.D. Dmitriy Konstantinovich Belyaev. Brush strokes in the portrait // SCIENCE First Hand. 2017. V. 47. N. 2/3. P. 110–123.

Trut L.N. An Evolutionary Experiment // SCIENCE First Hand. 2007. V. 14. N. 2. P. 60–63.

A. V. BARANOVA



NULLIUS IN VERBA, or IS YOGA USEFUL

and on the Periodic system of the elements, QUACKERY and the evading research OBJECT

In recent years, the concept of "quackery" has blended into our active vocabulary. When we read about charged water, torsion fields, the influence of moon light on train rails (we're not joking here), cloning humans or, say, living longer using meditation, how do we know if it's the truth, a fake, or a mistake made in earnest? Assessing the authenticity of information can be a challenge unless you are an expert in the specific field; however, anyone who has basic knowledge of the subject can assess the tools that the scientists used and the proof they collected, and use it to draw simple logical conclusions

Ancha V. BARANOVA, Doctor of Biological Sciences, chief researcher of the Laboratory of functional genomics of the Medico-Genetical Center of the Russian Academy of Sciences (Moscow), professor of the School of Systems Biology at George Mason University (Virginia, USA), head of the Center for the Study of Chronic Metabolic and Rare Diseases, scientific director of the Atlas biomedical holding (Moscow); author and co-author of 150 research works and 10 patents

Science is a powerful thing. But what does science mean? As a rule, we use the concept of science intuitively, mixing it into our speech whenever it feels handy. However, each word has a dictionary definition. Let's look it up in the dictionary.

The definitions of science change from one dictionary to another, but they agree in one thing: science is a type of human activity. The goal of science is in acquisition and systematization of objective knowledge of reality. To achieve this goal scientific workers, or scientists, use a system of tools, which has been defined at the dawn of modern science by the Royal Society of London for the Improvement of Natural Knowledge, founded back in 1660.

These tools have not changed much, which means they have stood the trial of time. The slogan of the Royal Society, *Nullius in verba* (Latin «on the word of no one») states that any theory must be based on repeated observations, experiments or mathematical calculations, but not on words of authorities. Hypotheses are proposed to explain observed facts and are to be confirmed experimentally; next, a multitude of hypotheses constituting a theory serves as the foundation for a cause-effect model of the studied object, which allows predicting its behavior in various conditions.

Key words: Yoga, telomeres, aging, science, scientific instrument

«What if I'd been thinking about it for twenty-five years…»

Note that the definition of science as a type of human activity does not imply any limitations on the object of study, however, it does prescribe a certain code of behavior for research workers. In particular, researchers must use scientific tools – but not religious tools, for instance. Even though Dmitry Mendeleev saw his famous periodic table in his sleep, his landmark paper, "On the Correlation between the Properties of the Elements and Their Atomic Weights", published in 1869 in the *Journal of the Russian Chemical Society*, is not a narration of this dream; it is a systematic description of a new consistency.

As we know, Mendeleev has shown that as the atomic mass of chemical elements increases, their properties change periodically rather than monotonously. To prove his theory, Mendeleev provided a number of observations. For instance, potassium is similar to sodium by its chemical properties, even though potassium is heavier; fluoride resembles chlorine, and gold belongs to the same group of elements as silver and copper.

Moreover, Mendeleev bravely faced the potential storm of criticism, using his theory to pinpoint errors in atomic masses and descriptions of some elements. He went even further: in his table, he left blank cells for elements, which were yet to be discovered. Mendeleev's amendments turned out to be correct. The predicted elements were discovered rather quickly. These predictions became a powerful proof of his periodic theory. When asked about his prophetic dream, Mendeleev replied: "I may have been thinking about it for twenty five years, and here you are, assuming: he just sat and wrote it down, a dime a line, a dime a line, done!"

Mendeleev was not alone in tackling the systematics of the chemical elements. A bit earlier, D. A. R. Newlands, a well-known English chemist and musician, proposed his own system. His model was called "the law of octaves" and even superficially resembled the periodic system, however, it lacked a predictive value. Newlands strived to explain the periodic properties by a mystical musical harmony, but failed. Which did not stop him from excelling in another field, just as important as science – the sugar refining business.

Ghosts as a scientific object

Imagine a successful Mendeleev studying the properties of something different – not chemical elements, but, say, ghosts. That may be hard to fancy: we know for sure that there are no ghosts. However, a true worker of science must be indifferent to the choice of the object of study. The more difficult the task, the more enthusiasm it should spark.

The proof of the "absence" of something is an extremely difficult task. The lack of a ghost in a room, just as the lack of black swans in nature, will remain a valid fact until the moment the ghost appears, or until the researcher reaches Australia, where all swans are black. The observation that "there are no ghosts" cannot be proven by any finite number of observations of the room. The scientist will be forever exposed to criticism from enthusiastic spiritists pointing at the "insufficiency" of scientific method as their main argument.

In 1875, ten years after his groundbreaking discovery, Mendeleev, a true scientist and an ace of the scientific method, oblivious to the risk of being branded a nonsense-mongering quack, rolled up his sleeves and created the Commission on the Study of Mediumist Phenomena at the Russian Physico-Chemical Society in response to the blooming Spiritism in the Russian Empire of the day.

The Commission invited well-known foreign mediumists to Russia – the brothers Petti and the infamous madame Claire. Both the spiritism appreciators and members of the Commission were present at their sessions; Mendeleev personally devised a manometric table, which measured the pressure applied to it. Mediums sitting at this table suddenly noticed that the "spirits" refused to communicate with humans: the precise pressure detection provided accurate proof of the mediums' dexterous hands. At the end of its work, the Commission issued a conclusion: "Spiritist phenomena ocur from involuntary movements or intentional deceit, and the teaching of Spiritism is a superstition..."

However, the conclusion of the Mediumist Commission is secondary in relevance; rather, we are interested in the fact that a well-respected scientist, the father of modern chemistry, did not consider Spiritism a simple hoax not worth examining, even though it was beyond his own scientific scope. On the opposite, the scientist took the problem of Spiritism as a challenge and tackled it with a correct application of scientific tools instead of simply brushing ghosts off the table of reality.

No ideology involved!

Once scientists add the scientific method to their arsenal, they cannot use it selectively. If instead of the mediums' cheating Mendeleev's table had recorded true oscillations of the global ether, the scientist would have to acknowledge the existence of ghosts, just as he had to accept the existence of the yet undiscovered chemical elements earlier. However, that did not happen. Or rather, that did not happen that time. Remember the black swans – they did not exist in nature exactly until the moment researchers reached Australia.

Philosophers of science worked out a very important criterion, which allows telling a true scientist from a quack. The quack cannot formulate the conditions which would force him to deny his own theory. A scientist can. "What should happen for you to abandon your hypothesis?" is the very question that the famous philosopher and sociologist Karl Popper asked Marxists. He did not get an answer and applied the falsification criterion, declaring Marxism a quack theory.

Popper's falsification criterion is not ideologically tinted in any way. Had the Marxists given in just a bit and described the horrifying society of victorious capitalism – as theoretically possible, Popper would have given up and accepted the theory of Marx as scientific. This is exactly why Lenin, in his famous statement "The teaching of Marx is omnipotent, because it is correct" essentially shot himself in the foot (Lenin, 1913).

Modern scientists en masse fail to reach the same heights as Mendeleev – for a number of reasons, which are beyond the scope of this discussion; primarily, this is due to the lack of classical education, which does much more than just expand the horizons; it forcefully prescribes the scientist to boldly rely on the power of the scientific method, without limiting oneself to "tried" and "safe" research objects in terms of scientific reputation.

For a real scientist, a reasonable argument for abandoning the study of, say, the effect of the notorious homeopathy would be not the "quackery" of this treatment method but the triteness of the homeopathic problem studied inside out in a multitude of published research works. However, even this argument cannot hold forever.

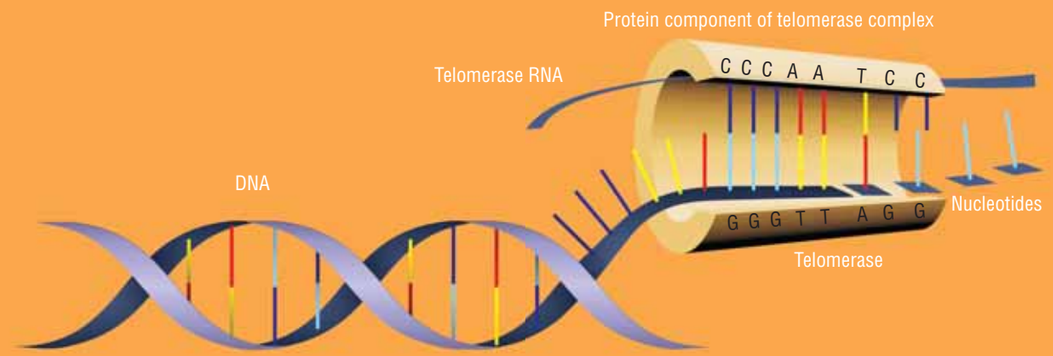
For instance, the study of nonlinear relationships between a dose of a substance and its effect and the phenomenon of hormesis (the stimulating action of low doses of stressors) are not that distant from homeopathy, yet these topics are quite fresh. In contrast to these studies, homeopathy looks like an innocently naïve and a wholeheartedly ineffective attempt to expand a handful of "successful" healings into a universal theory, thoroughly outdated yet alive in the minds of its appreciators, akin to the medieval treatment of leukemia with arsenic preparations, which, by the way, have been reintroduced into the pharmacopeia as differentiating agents to control certain types of acute leucoses.

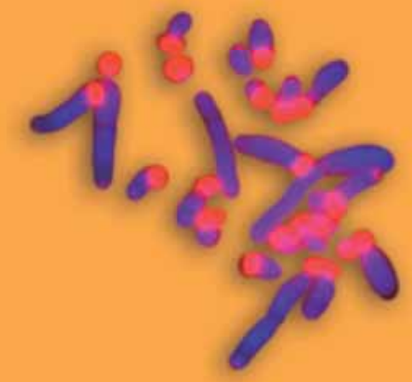
Yoga against aging – why not?

In the past few years, real "no fear, no blame" scientists carried out a series of interesting research projects on the connection between the scientifically proven phenomenon of cell aging and physiological results of esoteric practices, such as yoga.

Cell aging is accompanied by a gradual increase of the oxidative stress and the shortening of telomeres, the terminal regions of chromosomes, which function as "safety lids" at the ends of these very long molecules. Both the oxidative stress and telomere length can be measured, yielding an objective estimate of the intensity of aging of an individual organism and of its biological age.

According to one of the theories, aging happens due to telomere shortening with age due to their incomplete replication during the doubling of the DNA strand. Nowadays we know that the length of telomeres and lifespan are not directly connected, but another factor comes into play here – the telomerase enzyme, which can lengthen the telomere regions of the DNA which shorten spontaneously during cell division. Overall, we can think of the telomere-telomerase balance as one of the quality markers of cell aging; in humans, shorter telomeres are likely to be connected with unfavorable processes in the organism. However, exceedingly long telomeres may signal about a high risk of oncological disease.





The structure of telomerase – an enzyme that "stitches" new nucleotides to the telomere regions of the DNA, which shorten during cell division. Telomerase contains a short RNA molecule complementary to the telomere sequence; this RNA is used as a matrix for the synthesis of the 3'-end of the telomere DNA. Upon finishing building a region, telomerase shifts to repeat the cycle.
The second strand of the DNA is built by DNA-polymerase during the next cell division.
Right: chromosomes of the Iberian shrew (*Sorex granarius*) with telomeres dyed red (fluorescent *in situ* hybridization (FISH)). The telomeres are visibly different at the different ends of the chromosome.
Adapted from (Zhdanova et al., 2007)

Yoga is a religious and philosophical teaching encompassing a system of techniques and exercises performed to control one's psychological and physiological processes to achieve a special spiritual state. One of the techniques, the so-called *meditation*, is used to achieve the state of inner quiet and concentration. Nowadays, however, many people go to "yoga classes" as a set of physical exercises, and "meditative state" is just a way to spend a couple of hours oblivious to everyday problems. No religion or philosophy whatsoever.

But does a complex of physical and breathing exercises and meditative states really improve health and prevent cell aging? Well, why not?

A 2012 review paper summed up the results of 40 years of experiments aimed at understanding whether yoga can help with certain pathologies (Büssing *et al.*, 2012). Researchers focused on psychiatric, cardiovascular and respiratory conditions. A bird's eye view shows that the conclusions of many of these works often contradict each other. Some articles report positive effects of yoga expressed in the decline of stress levels and of manifestations of psychiatric disorders. In other works, authors fail to provide sufficient proof of these hypotheses. Performing a meta-analysis to be able to draw valid conclusions is hampered by the flawed design of these studies; this is especially true for earlier works. Moreover, the works as such are not numerous, and access to research conducted in India is limited. However, the authors stress the potential of this research direction. Yet everything must be done according to the current scientific standards.

When mitochondria do not «leak»

Research published in 2015 has demonstrated that yoga practitioners with at least two years of experience have a higher total antioxidant status and longer telomeres comparing to people living regular lives (Krishna *et al.*, 2015). The overall conclusion was that yoga slows down cell aging; however, the mechanism of this phenomenon remained unknown.

A 2017 overview states more directly that various meditation practices have one thing in common: they all lead to the decrease of activity of the *NF-kappaB* signaling pathway, which is the main conductor of systemic inflammation (Buric *et al.*, 2017). The authors conclude that meditation indeed helps to damp down the acuteness of symptoms of inflammatory diseases.

In another fresh article, researchers scrutinized the effect of practicing yoga on cell aging in about one hundred healthy people (Tolahunase *et al.*, 2017). Training took place five days a week and included both physical and breathing exercises and regular meditation. Throughout the period of study, researchers measured changes in the levels of cell aging biomarkers, such as *8-hydroxy 2'-desoxyguanosine* (*8-OH2dG*) – a marker of oxidative damage of DNA, as well as concentrations of active forms of oxygen, the total antioxidant activity, levels of cortisol, the stress hormone, and some other proteins, length of telomeres and telomerase activity.

They found that after three months of practice the subjects had decreased values of "bad" and increased levels of "good" parameters. The stability of the subjects' genomes and the telomere-telomerase system increased the balance of pro- and antioxidative systems activity and the neuroplasticity improved. However, researchers still refrain from suggesting a possible mechanism of the influence of yoga and limit themselves to abstract speculations on stress in the modern lifestyle and the ability of yoga to reduce that stress, as well as on the role of "regulated mind-body communications" in suppressing subclinical inflammation symptoms.

The reasoning is more or less the same in other recent works: there is likely an effect, but what causes that effect?

For a start, let us have a look at some well-known pathological connections. Indeed, oxidative stress can facilitate premature shortening of telomeres and cell aging – that is a proven fact. Active forms of oxygen facilitate the modification of nitrogenous bases, predominantly forming the potentially dangerous 8-oxoguanine – the predecessor of the mutation of the guanine nucleotide into thymine, i. e. a completely different "letter" of the genetic code. Sequences of the telomere DNA contain many guanine groups, which make telomeres an easy target for the deleterious action of active forms of oxygen.

It is possible that yoga does help against cell aging by lowering the levels of stress in humans, because the stress essentially is active oxygen? If our cells feel uncomfortable, their power plants – the mitochondria – begin "leaking," producing dangerous oxidants, which cripple the cells from the inside. Say, your boss bawls out at you, you take it too close, begin to worry about getting fired and get upset. This upsets your brain cells, too, and damages them – and they get a bit older. If your boss yells at a yoga practitioner,

Telomeres were discovered by two well-known American geneticists: German Muller, who worked with the much loved Drosophila fly, and Barbara McClintock, a winner of the Nobel Prize in physiology and medicine; the research subject was maize, another favorite of selectioners and geneticists. *Public Domain*

he or she will literally blow it off and forget about the problem that has not even happened yet. The yoga practitioner's brain cells will not get upset – and damaged.

This may sound a bit too antropomorphic, but the "upsetting" of cells is based on a well-understood mechanism. The worried state clearly affects the activity patterns of various structures and regions of the brain, with some cells getting "overexcited" and drawing over the resources, affecting the blood flow. Other cells get robbed of oxygen and become prone to self-damage and apoptosis – the cell death. And we know that nerve cells recover very poorly – if at all. Yoga practice supports the total balance of the blood supply to the brain, preventing imbalances in oxygen supply and, consequently, the risk of damage to individual brain cells (Minvaleev *et al.*, 2014).

Let us return to our muttons, i.e. ghosts. Suppose a scientist has been measuring the number of ghosts in a room using, say, a "LED Ghost Counter". A hundred measurements consistently yield zeroes. The conclusion is obvious: there are no ghosts. Later, the observant and tireless scientists hears a story about yoga practicioners occasionally finding ghosts using something called "the third eye."

They say the scientist spends his days in the basement with a solder, building a new contraption for capturing transcendental essences. No one knows neither the working principle of this device nor the results, because the scientist is all too responsible: he is aiming at the Nobel Prize and does not want to reveal "raw data." As soon as his ingenious device becomes functional, and as soon as he accumulates the necessary data, our scientist, an equal of Dmitriy Ivanovich Mendeleev, will publish his groundbreaking research in *Nature* and *Science* – simultaneously. We will read it and rush to report it to you, our dear reader – everything you wanted to know about ghosts (but were afraid to ask)...

References

Buric I., Farias M., Jong J. et al. What is the Molecular Signature of Mind-Body Interventions? A Systematic Review of Gene Expression Changes Induced by Meditation and Related Practices // Front. Immunol. 2017. V. 8., eCollection.

Büssing A.L., Michalsen A., Khalsa S.B. et al. Effects of yoga on mental and physical health: a short summary of reviews // Evid Based Complement Alternat Med. 2012. Epub.

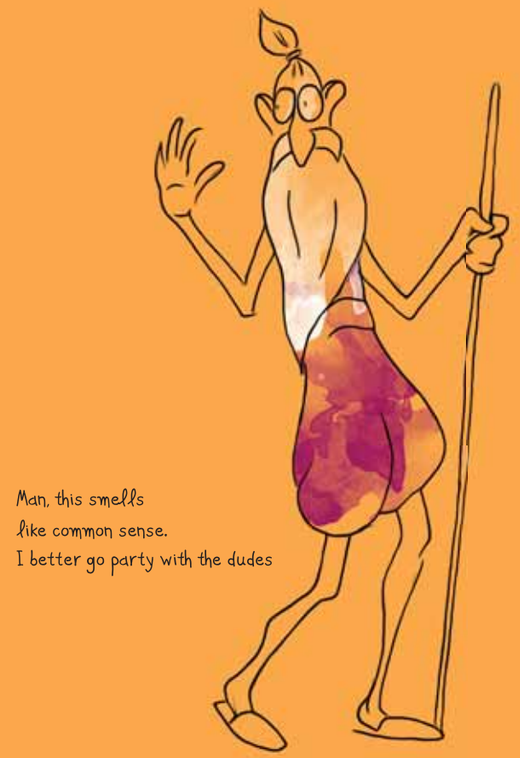
Krishna B.H., Keerthi G.S., Kumar C.K. et al. Association of Leukocyte Telomere Length with Oxidative Stress in Yoga Practitioners // J. Clin. Diagn. Res. 2015. V. 9. N. 3. CC01–CC03.

Minvaleev R.S., Bogdanov A.R., Bogdanov R.R. et al. Hemodynamic observations of tumo yoga practitioners in a Himalayan environment // J. Altern. Complement. Med. 2014. V. 20. N. 4. P. 295–299.

Popper K. The Logic of Scientific Discovery (Russian translation). Moscow: Respublika, 2004. 447 p.

Tolahunase M., Sagar R., Dada R. Impact of Yoga and Meditation on Cellular Aging in Apparently Healthy Individuals: A Prospective, Open-Label Single-Arm Exploratory Study // Oxid. Med. Cell Longev. 2017. Epub.

MEDITATON PRACTITIONER – ON THE MOLECULAR BIOLOGY OF MEDITATION



Margarita V. ROMANENKO, Candidate of Biology,
staff researcher of the Laboratory of biotechnology and virology of Novosibirsk State University. Winner of the first season of the TV series "Scientific Stand-up," a joint project of channel Rossiya K and Science Slam Russia Association (2018).
Teacher of yoga with five years of experience.
Author and co-author of 30 research works and two textbooks

My experience with yoga and meditation is firsthand – I have been practicing them for about 8 years. As a molecular biologist, I could not help taking a closer look at the biological mechanisms underlying their positive influence on the organism.

The phenomenon of cell aging is connected with the shortening of the telomeres, which protect the chromosomes from damage during cell division, and with the reduction of the activity of telomerase, an enzyme that restores the telomeres. Elizabeth Blackburn, an American cytogeneticist, was among the first

researchers to study the connection between these processes and meditation. In 2009, Blackburn together with Jack Szostack and Carol Greider received the Nobel Prize for the discovery of telomerase and research in cell aging.

In one of her recent interviews, Blackburn noted that if she had been told that she would be studying the scientific aspect of meditation, she would not believe it. Today, a number of her works are devoted to the connection between the telomere parts of chromosomes and telomerase activity with stress – and with meditation. Blackburn believes that meditation has a positive effect on these chromosomal parameters, which serve as a kind of a marker of a person's age and longevity. The more you meditate, the stronger the effect. Detailed results of this research are provided in a book she co-authored with Elissa Epel, *The Telomere Effect: A Revolutionary Approach to Living Younger, Healthier, Longer*; it was translated and published in Russian in 2017.

Other researchers came up with similar results. For instance, even a short (12-minute) session of kirtan kriya, a very efficient meditation technique, if practiced regularly, reduces manifestations of depression and anxiety and normalizes carbohydrate metabolism in senior patients (Khalsa, 2015). A remarkable detail: this practice increased their telomerase activity by 43 %! The technique does not require special physical skills; the Internet is full of video tutorials complete with music. There is one requisition, common for all meditative practices – regularity.

As for me, seven years ago, I discovered the dynamic meditation technique, and it turned my life around. It was invented by an Indian mystic and professor of the Jabalpur University, Bhagwan Shree Rajneesh, known as Osho. Unlike the previously described techniques, this one requires considerable physical efforts. There is very little available research on dynamic meditation. However, the available data suggest that practicing dynamic meditation leads to decreased levels of cortisol, the stress hormone, in the bloodstream. (Bansal *et al*., 2016). The technique effectively relieves anxiety (Iqbal *et al*., 2014). Psychotherapists recommend dynamic meditation to patients with depression; Dr. A. Fullham from Harvard University uses it as part of multiple sclerosis complex therapy (Gordon, 2009; Graham, 2010).

Naturally, many people are skeptical about such works, attributing the state of well-being after meditation and long-term preservation of this effect to simple rest. Such skeptics may be interested in the results of a study with two groups: women who had never meditated and experienced meditation practitioners. In the experiment, a half of the first group was "resting" and the other half was meditating for the first time in their lives (Epel *et al*., 2016). Levels of different biomarkers of all participants were measured, including the biomarkers of aging. It turned out that some values, such as reaction to stress and the state of the immune system, improved in all participants, however, only meditation practitioners – both new and experienced – managed to maintain low levels of stress for long periods.

In 2017, I prepared a lecture called "The molecular biology of meditation (how to meditate to lengthen your chromosomes)," which I presented at the "Science Story Night," a scientific barhopping event that took place in October in Novosibirsk Akademgorodok. The title alone subjects us to quackery accusations. But meditation does help us cope with everyday stresses and challenges. For instance, in Canada, the Oncology Center of Calgary University has successfully implemented a program aimed at helping cancer patients, called *Mindfulness-based stress reduction*. It helps patients cope with fear and anxiety and focus on getting better to be able to deal with symptoms and serious side effects of cancer treatment more efficiently.

Photo by M. Bulyonkov

References

Bansal A., Mittal A., Seth V. Osho Dynamic Meditation's Effect on Serum Cortisol Level // J. Clin. Diagn. Res. 2016. V. 10. N. 11. CC05–CC08.

Blackburn E., Epel E. The Telomere Effect: A Revolutionary Approach to Living Younger, Healthier, Longer (Russian translation). Moscow: E, 2017. 384 p.

Epel E. S., Puterman E., Lin J. et al. Meditation and vacation effects have an impact on disease-associated molecular phenotypes // Transl. Psychiatry. 2016. V. 6. N. 8. e880.

Khalsa D. S. Stress, Meditation, and Alzheimer's Disease Prevention: Where The Evidence Stands // J. Alzheimers Dis. 2015. V. 48. N. 1. P. 1–12.

YU. V. OVCHINNIKOV, E. A. KOROLYUK

A Garden Born BY INSPIRATION

Photo by E. Leven

Key words: Central Siberian Botanical Garden, Live Collections, “Park Bonsai”

There are quite a few iconic places in Akademgorodok; one of them is the Central Siberian Botanical Garden. Rain or shine, the locals walk its trails. Couples and jolly crowds of university students, bikers and joggers, moms with bubbly toddlers, elderly people strolling leisurely… On weekends, people come to the Botanical Garden from all around Novosibirsk and its satellite towns, and visitors to our city are always told to check this place out. The joy of picnicking on green lawns or feeding ducks, taking pictures in the gold of fall or walking in the snow and listening to the winter silence is open to everyone. But there are secret nooks and sanctuaries in the Botanical Garden that only a tour guide can show…

Yuriy V. OVCHINNIKOV, chief specialist of the landscaping and phytodesign group of the Central Siberian Botanical Garden, SB RAS (Novosibirsk). The only Siberian expert in the creation of bonsai and niwaki; his work has received high acclaim of the Japanese professionals

Elena A. KOROLYUK, Candidate of Biological Sciences, senior researcher of the Herbarium of the Central Siberian Botanical Garden, SB RAS (Novosibirsk). Author and co-author of over 100 research works

Some fundamental processes and phenomena are sometimes hard to explain to lay people. Yet there are things that seem simple and obvious to absolutely everyone: for instance, edible, medicinal and ornamental plants. This seeming banality and the fact that botany is one of the oldest life sciences explains the often condescending attitude to field botany nowadays.

You don't have to travel far to see this for yourself: in the Novosibirsk Scientific Center, the Botanical Garden is thought of not as a leading research institution but rather as a curiosity, an outdated guild with flower pots and vegetable gardens. But is this fair – or, more importantly, true?

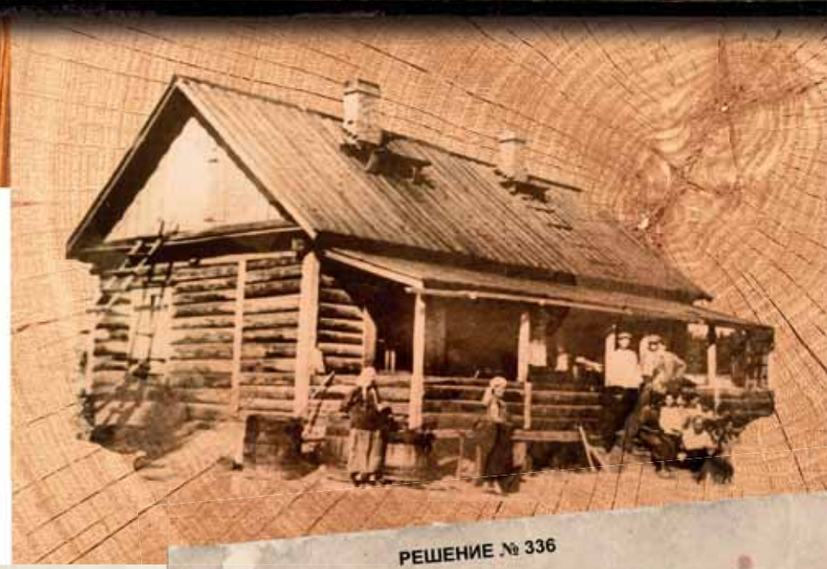
Early sprouts

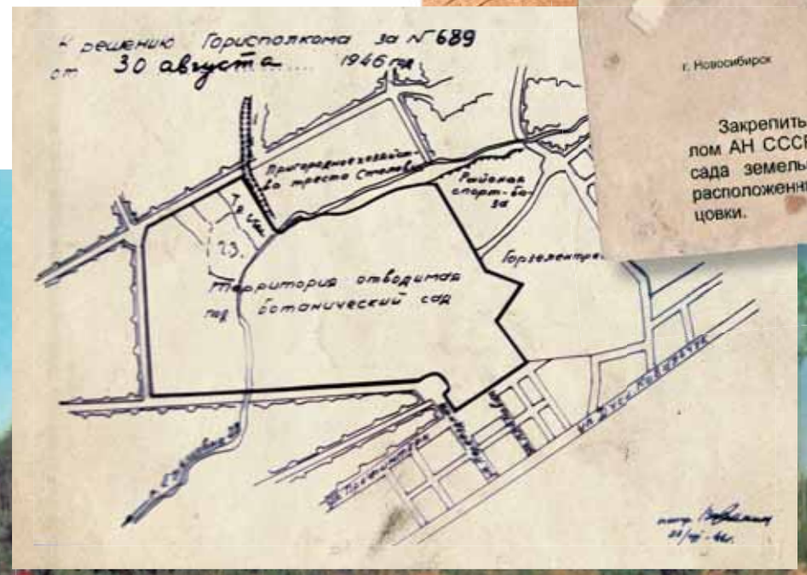
The Central Siberian Botanical Garden of the Siberian Branch of the Russian Academy of Sciences is a complex structure: a real botanical garden and a full-scale research institution. It hosts a range of specialists sharing a common research object – the exceptionally diverse and complex world of plants and fungi. Nowadays we can study it on various levels: from major landscape formations on the global scale to individual populations, from whole organisms to cells and cellular structures. To solve specific botanical problems, researchers study their objects directly in the field and in experimental plots with plant collections. These are the "fenced gardens" that puzzle pedestrian visitors of the Botanical Garden.

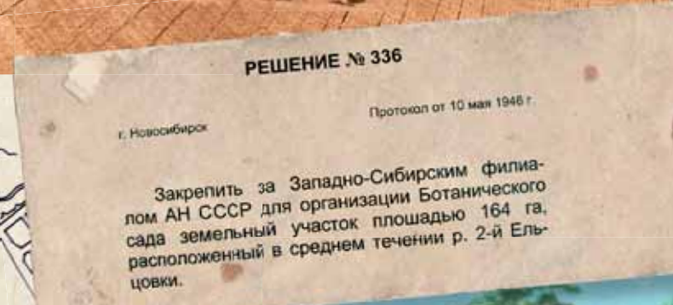
Botanical gardens are created primarily for the purpose of conservation of the global plant diversity. It allows the recovery of species that, for one reason or another, become extinct in the wild. They are a sort of zoos for plants.

It is common knowledge that as humans reclaim new land, they interfere with the nature and disrupt the intimate connections that have been forming for millions of years. Quite often, unique locations are destroyed together with their plants, which we will never even know about. We will never get a chance to register the new organism, study its properties and the potential for its use by humans – it goes extinct, unknown and unnoticed. This happens both on the global scale and within a particular botanical garden

The first area for the botanical garden, a 164-hectare plot, was allocated in the Zayeltsovskiy district of Novosibirsk.
Right – the first log cabin for the Botanical Garden employees; *below* – director L. P. Zubkus and an expert on wild plants of Siberia, E. V. Tyurina, near the collection of ornamental plants in front of the first brick-and-mortar building of the Garden






РЕШЕНИЕ № 336

г. Новосибирск

Протокол от 10 мая 1946 г.

Закрепить за Западно-Сибирским филиалом АН СССР для организации Ботанического сада земельный участок площадью 164 га, расположенный в среднем течении р. 2-й Ельцовки.

Collections of botanical gardens are stocked in many ways: finds of staff researchers during expeditions (for wild plants), exchange with other botanical gardens, including international exchange, and gifts from visitors, as wells as specimens smuggled from abroad by staff researchers (which is, of course, officially illegal)

The main range of the genus Magnolia lies in the tropical and subtropical belts. There are eight species of these iconic southern plants growing in the Botanical Garden – in temperatures as low as –40 °C, but only two of them have bloomed so far, including the Siebold's magnolia (*Magnolia sieboldii* C. Koch), one of the most winter-hardy varieties of our open-ground collections

The history of botanical gardens illustrates vividly the implementation of the concept of "living collections." It all began with "apothecary gardens." When scientific classification of the plant world began to emerge, it led to the creation of the Systematicum, or collections of related plants, both beautiful and informative. This is how the first botanical gardens in Europe in the XV – XVI centuries began: they had the mandatory collection of medicinal plants and the Systematicum, which served as a living collection and had educational value.

In our country, the history of botanical gardens began three and a half centuries ago, also from "apothecary gardens."

Schematic map of the CSBG SB RAS area in the Sovetskiy district of Novosibirsk

Iberan geranium (*Geranium ibericum* Cav.), a native of alpine and subalpine belts of the Caucasus mountains, is considered to be one of the most ornamental wild species of geranium. It has been cultivated since 1802

Varietal water lilies (the genus *Nymphaea*) bloom throughout the summer until the first frosts and winter well in Siberia. The variety Attraction with pink flowers up to 18 cm in diameter was created back in 1910 in France

Round-headed rampion (*Phyteuma orbiculare* L.) from the family *Campanulaceae* is a Mediterranean alpine species preferring calcareous soils (*above left*). This form of Bridal-wreaths, *Spiraea flexuosa* Fisch. ex Cambess cv. Plena, with white polypetal flowers was brought to the Botanical Garden 35 years ago from a station on the Circum-Baikalian Railroad (*above*)

Our Garden is relatively young – it is only 70 years old. It was founded in 1946 together with the creation of the West-Siberian Branch of the USSR Academy of Sciences. In the difficult post-war period, the country was recovering slowly; there was a deficit of specialists and resources. As soon as the Garden got its first hectares of land, instead of display collections it was allocated for practical tasks. Only later the first collections of rare and amazing plants appeared, bearing an inherent value and serving to popularize the biological science.

“The Beauty and the Beast”. *Above* – mayapple (*Podophyllum peltatum* L.), a poisonous plant from Eastern North America, used as a cover-ground plant and a source of anti-tumor substances. *Left* – wild Siberian orchids: the large-flowered cypripedium (*Cypripedium macranthon* Sw. *s.l.*) and the early marsh orchid (*Dactylorhiza incarnata* (L.) Soo). Like many other local orchids, they bloom only on the 11—18th year of life. There are vast numbers of different orchids known from around the world, including the Arctic, but most of them are tropical plants. Over 130 species are registered in Russia (which is no more than 0.4% of the total diversity); a quarter of them are redlisted

Initially, the Botanical Garden as an independent organization had few staff workers; the newly created experimental laboratories focused on the issues of introduction and acclimatization. First, collections of berry shrubs, fruit trees and vegetables appeared, followed by ornamental plants. A year later, the dendrarium was founded. This was the time when the first dissertation theses were defended, based on the results obtained in the experimental plots.

After 10 years, the living collection of the Botanical Garden included 4.2 thousand species, forms and varieties of plants. In 1955, the Botanical Garden was excluded from the Biological Institute of the Siberian Branch of the USSR Academy of Sciences and made into an independent structural unit. When the Siberian Branch of the AS USSR was created, the collections of the Botanical Gardens were gradually transferred to the newly founded Akademgorodok.

The transition was not without losses; some specimens were left in place, much to the delight of the locals – becoming an eternal headache for the city’s officials. The area commonly known as the “Botanical Garden” near the Novosibirsk Zoo testifies to this statement. The name of the nearest bus stop reminds that sixty years ago there was indeed a botanical garden there. Naturally, all collections of herbaceous plants have vanished, and few employees of the Botanical Garden nowadays can name those first plants. But the various trees planted by the first generation of the CSBG researchers are still there.

The 1970s—1980s were the true high noon of the living displays of the Central Siberian Botanical Garden.

The high noon

The transfer of the Botanical Garden to its current location, Akademgorodok ended in 1964. The institute received over a thousand hectares – a giant territory even by the standards of that time, unimaginable nowadays, just steps from the residential areas of Akademgorodok. The vastness of the territory has been a subject of unabated envy of our colleagues from other Russian botanical gardens – and real estate developers cannot get it out of their minds, either...

From the very start, the land was managed smartly. First, the general layout of all buildings and landscaping was designed. The institute was busy working on existing subjects and tackling brand new directions, and the construction was going fast. The influx of young specialists was unprecedented: at no other time in history there were so many young researchers working on the creation of collections hand in hand with seasoned experts.

A bit earlier, in 1958, the Botanical Garden was merged with the local Experimental Forestry Station (Russian: ЛОС – лесозащитная опытная станция). This doubled the duties of our researchers: in addition to theoretical foundation of acclimatization, they had to solve the urgent task of radical improvement of the forests and parklands of the Novosibirsk Scientific Ceneter. This is a good time to remind the reader that the current green image that Akademgorodok takes pride in has been created by the experts of the Botanical Garden.

On page 91

The Rivier's Amorphophallus (*Amorphophallus rivieri* Durieu ex Riviere), an exotic plant from Southeast Asia, has been blooming annually in the CSBG collection for the past 40 years. In early spring, a giant inflorescence sprouts from its roots, reeking of rotten meat; after the flowering, a single large leaf emerges

Nowadays, you can hardly find young people who would be willing to take care of plants with the same knowledgeful love, keep track of everything, and keep everything in order. Maintaining LIVING collections is hard work of titanic scale; this is especially true for plants growing in challenging environments.

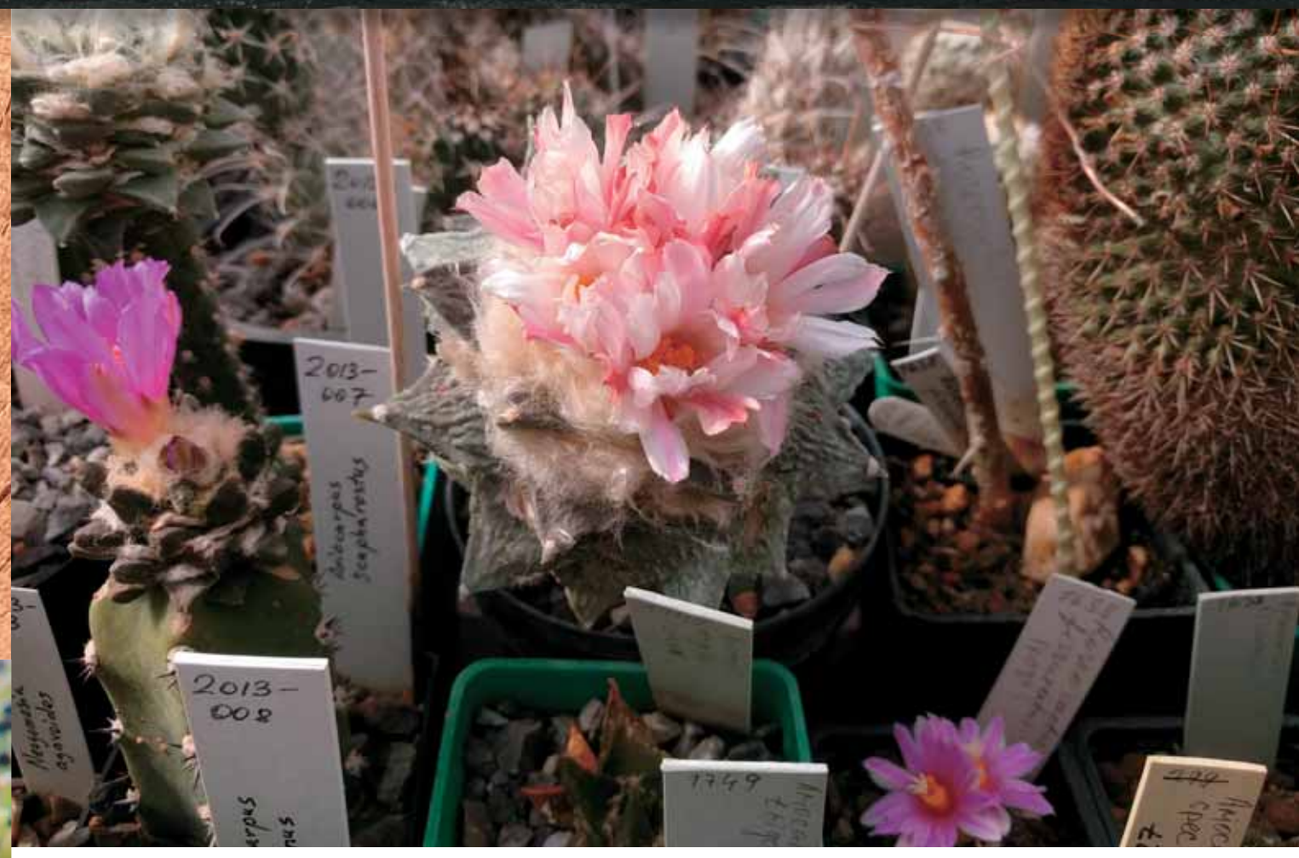
In many ways, such collections are akin to a living organism: they are born, they develop – and they die. Today, there are still a few old school professionals working in our Garden. When they leave, their collections often follow. Collections of art or rare coins are disseminated throughout the world after their owner's death, but they can be restored someday; collections of plants are deprived of such a possibility. The unwritten rules state that a collection "orbits" a single person, the charismatic leader interested in a specific group of plants. If there are successors, the collection will live and grow even after the leader is gone. If not, the plants will perish

Theis epiphytic cactus, *Deamia testudo* (Karw. ex Zucc.) Britton & Rose from tropical Central America blooms in the night; its giant tender flowers reach 20 cm in diameter

In the 1950s, E. L. Kuzmina-Medova inspired and guided the creation of one of the largest collections of varietal dahlias in the country. But when in 1963 the Garden was moved to Akademgorodok, the winter storage for the dahlia tubers had not been built yet, and the collection perished. Much later Evgenia Lvovna headed the Group of Introduction of Tropical and Subtropical Plants – and a new collection appeared which included 1500 species, forms and varieties. The collection is still doing well, and the number of taxa has increased five-fold!

E. L. Kuzmina-Medova, one of the first employees of the CSBG SB AS USSR, with her student, Yu. V. Ovchinnikov. *1985*

Arisaema of the aroid family is called the Cobra Lily for the peculiar shape of its conflorescences. The *Arisaema fargesii* Buchet (*below*) was brought from the banks of the river Yangtze (Southern China) in 2000



Plant collectors are essentially crazy – just like all other gatherers. If they become infatuated with a specific group or form, their collection often becomes the flagship and pride of the whole botanical garden. For instance, we can boast the largest bonsai collection in Siberia and, in terms of content, one of the best collections of succulents with plants from all continents. The latter contains about 2500 taxa

Left – seedlings of *Cereus* cactuses, several weeks old. They can reach the height of 20 meters and live to 300 years

Photo by E. Leven

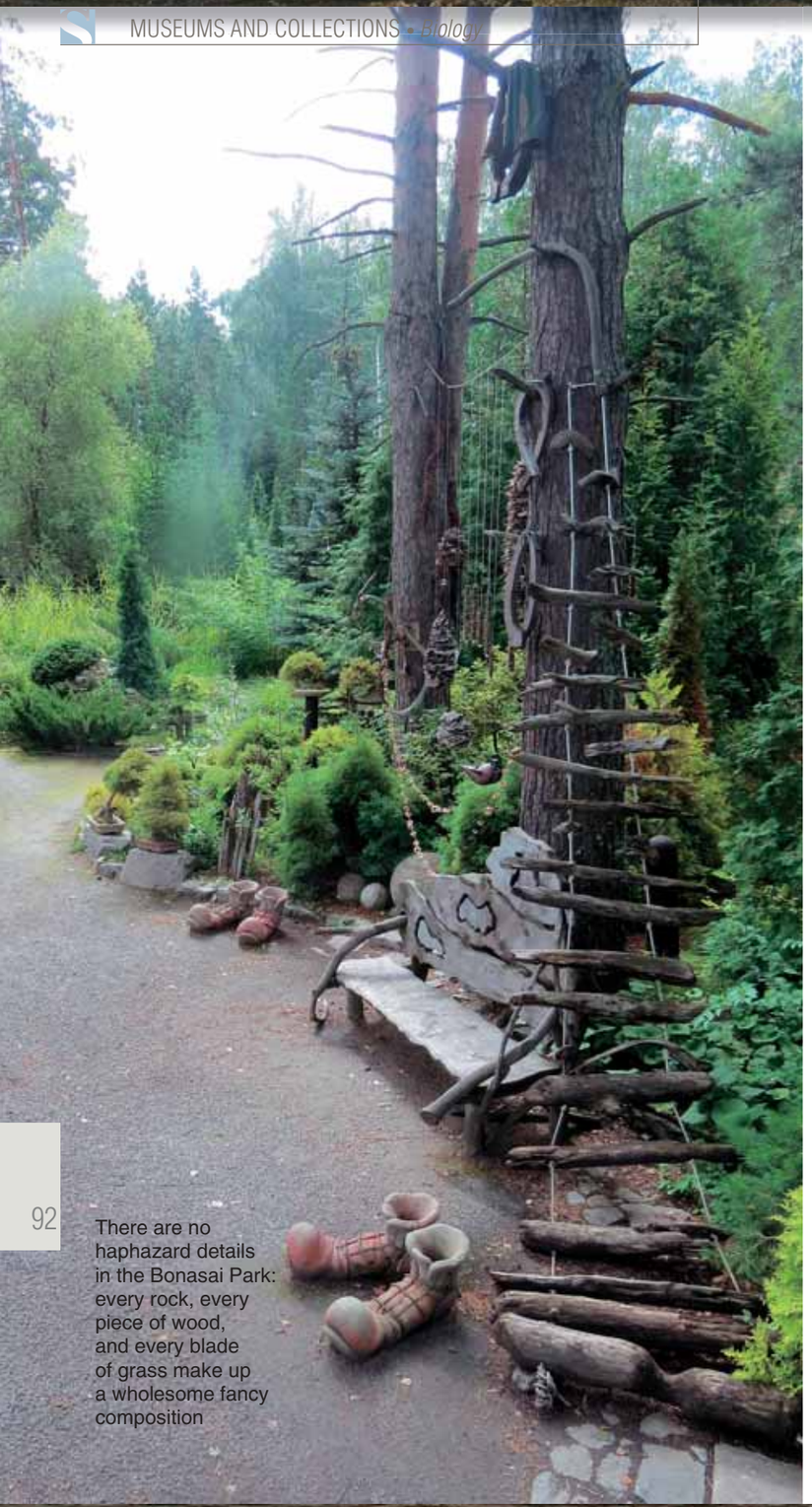
YURIY V. OVCHINNIKOV

"My professional and, in a way, creative path was defined by a trip to Sochi in the 1980s, back when I was a student. At that time, Sochi was the main resort town of the USSR, with a unique charm that it owed, to a big extent, to the dendrologist designer S. I. Venchagov. His parks were the true green "scenery" of the city. The way Venchagov used plants, rocks, terrain and the space itself was amazing. It was literally mind-boggling – Sochi was a fairy-tale town. To me, this incredibly talented man became the icon of the love of beauty, plants and the countless ways to transform the environment creatively.

The Bonsai Park of the CSBG SB RAS is our own attempt to create a similarly enchanted space. The concept appeared back in the late 1990s. In the beginning, we just planned to create and display a collection of temperate-climate arboreal plants grown in containers – the Japanese word bonsai literally means "grown in a tray." But the idea grew, resulting in a plot with about three thousand taxa from East Asia, Far East, European Russsia, Western Europe and North America, distributed according to their geographical origin, including trees, shrubs and herbs. There are bonsai, too, – over three hundred and fifty of them."

No other town in Siberia can boast of the same diversity of tree and shrub species and forms, well-designed landscaping groups and green areas as Akademgorodok. It is the result of hard work and enthusiasm of many people, who put their souls into the creation of the collection of trees, investigating the possibilities of their acclimatization in South Siberia and literally implementing this knowledge into the living and working space of all citizens and guests of Akademgorodok. By 1975, the construction of the garden and new displays on the new territory was mostly complete.

The area was divided into four parts. The largest part was left in primeval state and has stayed like that until the present day. However, it took incredible effort of several generations: Akademgorodok was growing, and beautiful old forest next to residential areas has always been a tasty morsel for the developer industry. In terms of research, this territory was virtually abandoned until the last five years: before that, priorities were different and there were no available resources to study the forests of the Botanical Garden thoroughly and systematically – i. e. create checklists for all groups of the plant kingdom, describe and classify the



There are no haphazard details in the Bonasai Park: every rock, every piece of wood, and every blade of grass make up a wholesome fancy composition

Science, culture and everything about the nurturing and educating the new generation have never been among the priorities of the times of turmoil. Once again, we are seeing the fruit of the "residual principle." All of the botanical gardens in our country are suffering from staff deficit and lack of continuity. There are no special courses for gardeners and botanical collection curators; all the major existing landscaped gardens, such as Gatchina and Peterhof near St. Petersburg, are the heritage of Tzarist Russia. During the Soviet [USSR] period, very little was contributed, and the situation has not changed until the present day

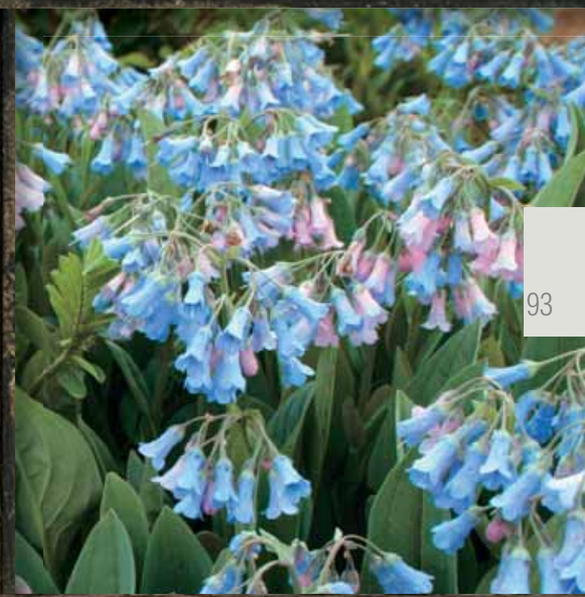
vegetation types, etc. However, this extensive work has finally been done and published – creating a starting point for monitoring programs.

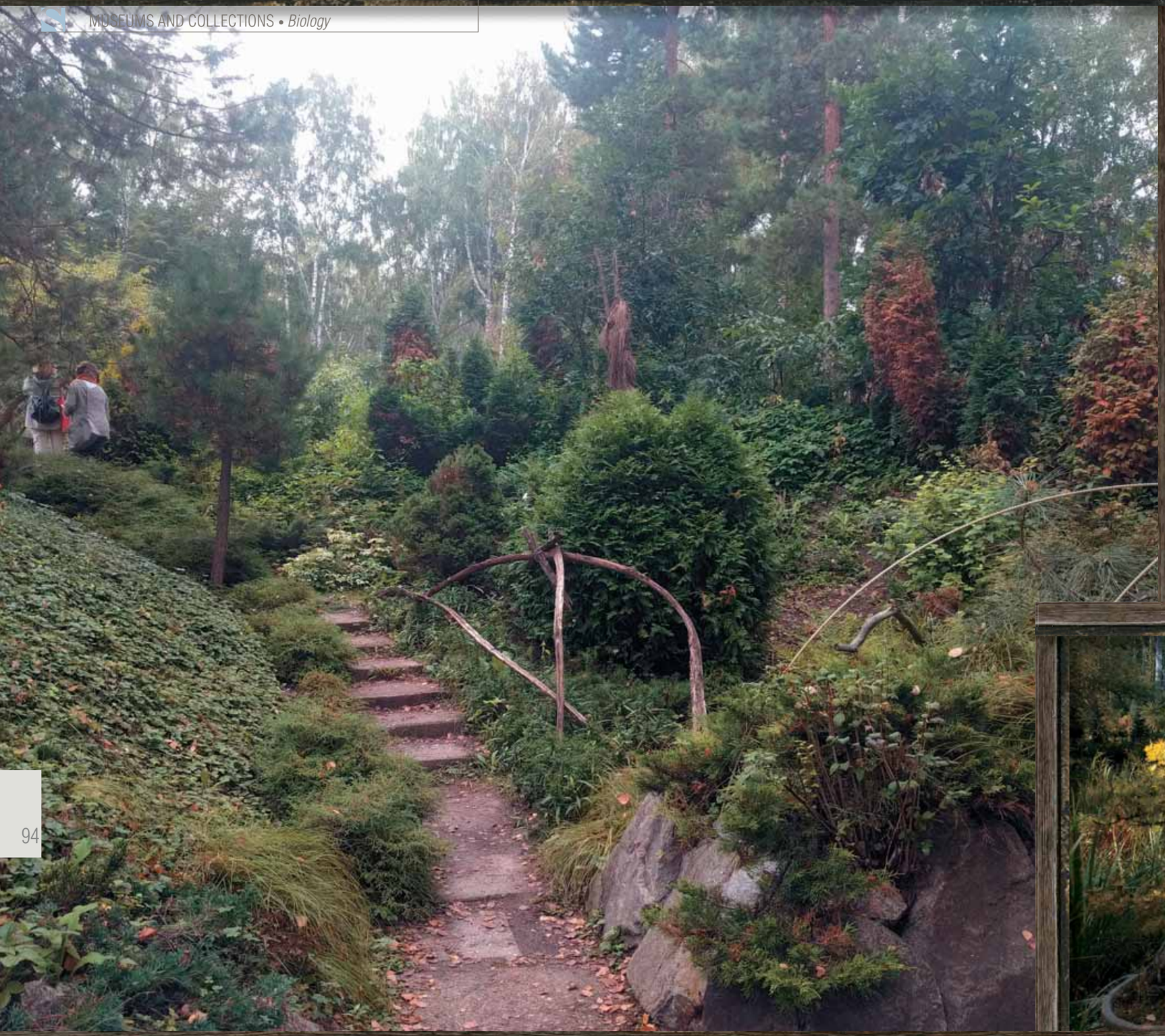
Another big part of the area has been allocated for the displays of arboreal plants, with a network of trails. The Upper and Lower Dendrariums occupied huge areas; the area around the main and experimental buildings of the Botanical Garden was turned into parterre and park zones. The rest

on page 97

The white blossoms of *Sanguinaria canadensis* L. from North America appear as soon as the snow melts. This 15 cm beauty contains a toxic alkaloid with antibacterial effect.

The stately *Mertensia sibirica* (L.) G. Don. fil. has been cultivated in the Bonsai Park for over 10 years; it is an eye-catching plant with attractive foliage and aquamarine-colored flowers





YURIY V. OVCHINNIKOV

“Collections of plants have more than just their intrinsic and scientific value: they must be displayed – to amaze, to spark interest in the surrounding world, to inspire faith in beauty… But this comes at a dear price – especially when it comes to the safety of collections.

For instance, should a collection be divided into parts? A part with plants that will survive being on display and a part containing rare and unique specimens – that only an expert can truly appreciate? Quite often, this is the case. But if all specimens are stored in the same collection, on the same plot, everything must be thoroughly monitored – both what the visitors and the caretakers do.

Force majeure events happen – and plant collectors are not immune. Insects, epiphytotics, power and heating outages, light-fingered visitors – or just guests seduced by rare specimens – are the true plague of any protected-ground collection. Everything must be taken into account. For instance, there is a unique specimen of the common dandelion growing in the Bonsai Park – and every passer-by tries to pluck it out, because people think dandelions are weeds. I found it at the other end of the world – in the Andes! How did it get there? Maybe it was the great German scientist Alexander Humboldt who brought dandelion seeds on the soles of his shoes while studying the flora of South America. And here it is – a spectacular plant, with leaves almost a meter long – doing well in Siberia. It has been plucked on numerous occasions, but half-heartedly: the roots survived and sprouted new growth. It is alive and well, thank God.”

A blooming *Datisca cannabina* L., a perennial dioecious plant up to 2 meters tall, originating from montane parts of Europe. It has tassel-shaped inflorescences up to 30 cm long (*above*). It fruits only when both male and female plants are present

of the area hosted experimental collections, nurseries, seed plots and fields of the experimental research farm of the CSBG.

By the end of the 1980s, the living open ground collections of the Botanical Garden occupied about 300 hectares of land. In addition, there were 8500 square meters of protected ground collections, occupying several mostly plastic film greenhouses.

At that period, most of the open ground displays were true gems of the Botanical Garden collections. They were planned as large-scale projects from the start, with annual additions from the well-organized exchange fund (“the seed cabinet”) and with plants brought from numerous and extensive expeditions to different natural zones of the former USSR. The care for the collection, such as watering and seasonal works, the work of the service yard with gardening equipment and motorized vehicles and, more importantly, the management of human resources was so well-organized that today’s generation of botanists simply refuses to believe that it is even possible.

There were amazing collections of medicinal plants and wild flora of Siberia, which also served as the Systematicum, and the flora of the Far East; collections of fodder and ornamental plants – gladioluses, peonies, roses, chrysanthemiums, lawn grasses, selected forms of pasque flowers and dendranthemiums, rare and redlisted plants, fruit trees and shrubs, vegetables... everything was blooming – a delightful sight for the visitors and a fruitful bough for the researchers. This yielded a rich harvest of publications and results of theoretical and applied research that can be found in reports of that time and in the 1981 “Guide to the Botanical Garden.”

What survived and what has been added? In the post-Perestroika turmoil of the 1990s, when the influx of new people into science skipped a whole generation, it was no longer possible to persuade the state officials that botany was no less important than physics or molecular biology, and supporting the collections on this scale became an unaffordable luxury.

To save the remaining herbaceous plants, the experimental collections had to be transferred directly to the main building of the Institute to provide the necessary care. The collections were dying in agony. People were leaving, funding was decimated, and enthusiasm was trickling down the drain...

The Systematicum in its initial form became a thing of the past; patches with ornamental and edible plants shrunk and withered; the nurseries dying and the collections of fodder plants lost. The collection of medicinal plants is still alive, but in the future, the institute administration is planning to end the studies of pharmacologically

important species, which means an imminent death of the collection. The parks and dendrariums are failing to cope with the increasing recreational stress.

Things are not that bad however. The walking trails in front of the main building are thriving, forming an amazing blooming belt. The Upper and Lower Dendrariums are well-groomed, and the Syringarium is developing well, with a collection of varietal lilacs. The Endless Blooming Garden and the Rock Garden are doing well, too; the latter was the first landscaped garden in the Garden with wild and ornamental plants, created back in the 1970s. In 2017, a new patch appeared, dedicated to topiaries, i.e. trees and shrubs with crowns clipped into ornamental shapes.

The greenhouses are changing, too. The protected ground collection of plants in the CSBG includes 7500 different taxa. The ten greenhouse exhibitions include only a part of the collection: it is in the process of moving, and soon, it will be possible to exhibit more specimens. For instance, the cactus exhibition used to be limited to 20 species, but after the opening of the succulent exhibition, there are now 350 species! The same is true for orchids and ferns – nowadays, we "stock" about 800 species, which have never been shown to the public before; now we have the possibility to do that.

The Bonsai Park is developing as well; it essentially became the New Systematicum, but on a larger scale. At the same time, it serves as a vivid example of the way to turn a boring systematical collection garden into a majestic and enchanted landscaped park.

The blooming of the Giant Granadilla (*Passiflora quadrangularis* L.), a giant vine from the American tropics (*above*) and *Symplocarpus renifolius* Schott ex Tzvel., a poisonous plant from the island of Sakhalin, used in folk medicine

The tiny and tenacious bonsai plants wait for the spring...

Research in experimental botany continues as well. The Edible Plants and Rare and Endangered Plants turned out to be the most tenacious and long-living collections of the CSBG. It was made possible by the continuity of tradition and charisma of our experts, which we cannot but keep mentioning. The Botanical Garden owes its remaining assets to the amazing devotion and motivation of the people who conceived, created and cherished their living collections – and managed to pass them into the caring hands of their successors.

The Central Siberian Botanical Garden has a lot to show to its visitors – for the time being...

Photographs by the authors and from the Botanical Museum of Siberia Archive, Novosibirsk

References

Korolyuk E. A. On the occasion of the Herbarium Anniversary: a FAQ for poets and physicists. SCIENCE First Hand. 2014. V. 56. N. 2. P. 64—87 [In Russian].

Plant diversity of the Central Siberian Botanical Garden of SB RAS / Koropachinskiy I. Yu., Banayev E. V. (eds). Novosibirsk: "Geo" Academic Publishing, 2014, 492 p. [In Russian].

Sedelnikov V. P., Korolyuk A. Yu., Lashchinskiy N. N. A Lost Archipelago: The Altai Krai through the Eyes of a Botanist // SCIENCE First Hand. 2010. V. 25. N. 1. P. 30–45.

The Central Siberian Botanical Garden: A Guide. Novosibirsk: Nauka, Siberian Division, 1981 [In Russian].

The Sakhalin rhodiola (*Rhodiola sachalinensis* Boriss.), an endemic species of the island of Sakhalin and the Kuril islands, is a close relative of the Pink rhodiola (*R. rosea*), the famous medicinal Golden Root

There is no room in ancient history so far for the army of stone horsemen pertified on the slopes of the Pir Panjal mountain range, Himalayas

In June 2017, this was the site of a Russian-Indian archaeological expedition launched to find and describe stone horses, enigmatic statues lost in these remote areas of the western Lesser Himalayas

ISSN 23-10-3000