55 “Moscow is my Motherland and will remain so forever: I was born there and there I suffered a lot and there I was too happy.” These are the words written by our great poet Mikhail Lermontov about the years spent in the old capital—a short but very significant period for his creative work.

37 It is believed that to preserve purity of water it is sufficient not to discharge contaminants into reservoirs in the quantities exceeding the limits of the permissible level. Studies carried on by scientists from the Moscow State University show that these priorities are insufficient for securing ecological safety of water supply sources.

75 In the 1760s-1770s a group of scientists headed by Peter Simon Pallas carried on a project unprecedented by the scale of works and involved territory—described a great number of Russian regions, including geological, mineralogical, animal and plant resources, historical, socio-economic and ethnographic peculiarities.

SCIENCE IN RUSSIA

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According to archeological findings approximately 30-35 thous. years ago hunting tribes reached Arctic latitudes of Siberia. Extreme natural conditions made people actively search for new means of procuring food. As a result they could pay attention to wolves, who, as is well known, use group driving-in hunting for animals. Presumably primitive man managed to domesticate the wolf, thus acquiring a reliable friend and perfect assistant—a dog. The contemporary Yakut Eskimo dog (photo on the first page of the cover), a venturesome, universal, rather hardy and clever hunter, has even today a lot of characteristics of his remote ancestor.

CONTENTS

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On June 7, 1954, in a village of Obninskoye, Kaluga Region, at the Institute of Physics and Power Engineering named after A. Leipunsky (Laboratory "V"), was implemented starting of the first in the world atomic electric power station, equipped with uranium-graphite channel reactor with a water heat carrying agent of 5 MW capacity. This opened for Mankind a way to peaceful use of one of the most powerful sources of energy, based on reactions of fission of atomic nuclei. For the past 60 years from the historical event atomic power engineering has turned into an independent large-scale field of production.

MAGNETOHYDRODYNAMICS: FROM GALAXIES TO PROBLEMS OF METALLURGY

by Pyotr FRIK, Dr. Sc. (Phys. & Math.),
Head of Physical Hydrodynamics Laboratory,
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RAS Ural Branch (Perm)

When Academician of the Latvian Academy of Sciences Igor Kirko came to Perm in 1972, the spectrum of conducted studies was expanded by magnetohydrodynamics (MHD), a section of mechanics which studies flows of electroconducting liquids and their interaction with magnetic fields. Today the physical hydrodynamics laboratory of the Institute of Continuum Mechanics is perhaps the only scientific division in Russia which carries out theoretical and experimental work on practically all problems in this area of knowledge, from galactic magnetic fields, stellar and planetary magnetism to applied problems associated with formation and monitoring of liquid metal flows in production conditions.

BIRTH OF A NEW SCIENCE

As far as magnetohydrodynamics is concerned, non-expert can imply a range of phenomena which have no direct relationship with man's life and the environment. But it is not the case. The natural magnetic fields not only exist in many cosmic objects—from planets and stars to pulsars and galaxies but also largely determine their evolution. And if magnetic fields of galaxies, quasars, accretion disks and neutron stars excite interest in a relatively small circle of astrophysical scientists and astronomy enthusiasts, the similar fields of the Sun and the Earth have a direct effect on human life. The Solar magnetic field which is largely responsible for flashes causing bombardment of our planet by particle flows, complies with the eleven-year cycle of activity changing its direction to the opposite one every time upon its

Galaxy M31 (Andromeda Nebula), as many others, has its own magnetic field whose origin is possible only due to the MHD dynamo effect.

completion. But the Earth's magnetic field which protects it from dangerous cosmic particles seems to be constant and unchanged. In reality it is not so, and its manifestations bear a lot of mystery. According to specialists during a whole period of history of our planet's existence, its magnetic field "turned over" several hundreds of times. The instances of these "turns" follow randomly one after another, and the interval between them varies from 10,000 to 100 mln years. During a polarity reversal, which can last for centuries, the magnetic field disappears (hence "the shield" disappears also), and it is impossible to predict them up to date.

Of course, the facts are interesting, but what hydrodynamics and conducting liquids do here? The point is that magnetic fields of celestial bodies and our planet are created by fluxes of conducting liquid which is in the form of a liquid metal in the outer core of the Earth and plasma in the convective shell of the Sun. It is interesting to note that the very problem of the origin of cosmic fields was a topmost incentive for development of magnetohydrodynamics. The Solar magnetic field was the first puzzle, and to interpret its nature the Irish physicist and mathematician, Professor of the Cambridge University Joseph Larmor was the first who in 1919 advanced a hypothesis on its possible generation by a moving conducting plasma in the convective shell of the star.

It was long assumed that the interstellar medium was vacuum. Sure enough, density of its substance makes up only from 0.1 to 1,000 atoms per cubic centimeter. When in 1937 the pioneer of research in the MHD theory Swedish scientist and specialist in plasma physics Hannes Alfven voiced for the first time a hypothesis that the interstellar medium was filled with ionized gas, the scientific community did not accept it. He supposed that if plasma filled the Universe, it was capable to conduct electrical currents but the latter gave rise to a galactic magnetic field which in its turn worked on passage of cosmic rays. Later these ideas were confirmed and are now universally recognized. Hannes Alfven has a number of other discoveries and hypotheses which form the basis of a new science, namely magnetohydrodynamics, i.e. discovery of a new type of wave motion of conducting medium in magnetic field (later named the Alfven waves), attempts to explain the formation of protuberances, solar spots, magnetic storms and aurora polaris. In 1970 the scientist was awarded the Nobel Prize, and in 1971 the USSR Academy of Sciences noted his services with its top award the Great Golden Medal named after Lomonosov.

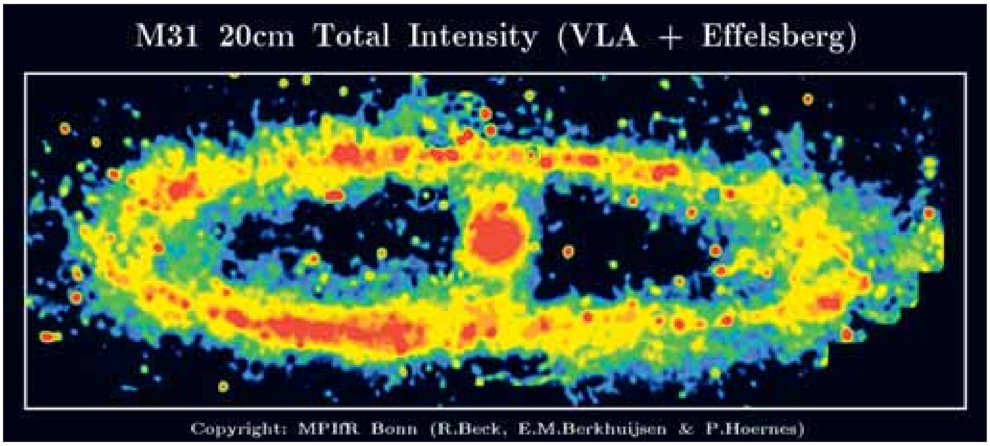
At about the same time with the appearance of Alfven's ideas, Julius Hartmann (Denmark) carried out the first experiments in MHD, namely, studies of mercury flow resistance in the pipe under action of a lateral magnetic field.

The above-mentioned Acad. Igor Kirko was one of the founders of magnetohydrodynamics (MHD) in the Soviet Union, the initiator of scientific schools in Riga and Perm, the founder of the *Magnetohydrodynamics* journal. He headed the physical hydrodynamics laboratory in our institute from 1972 to 1986 and played a significant role in selection of the studied problems.

MHD-DYNAMO

The process of magnetic field generation by conducting liquid (gas) flows was named MHD-dynamo. This scientific problem formulated almost a century ago remains one of the most intriguing in modern fundamental science, first of all in hydrodynamics and astrophysics. The first self-consistent model describing the nature of solar dynamo was suggested by the American astrophysicist Eugene Parker in 1955. In the next decade a number of fundamental steps were taken for understanding of the dynamo process. Without specifying all important results of this period we shall mention the famous "Zeldovich's eight"* which he demonstrated at a conference by means of a belt taken from one of the participants and explained in general terms how a liquid

*Yakov Zeldovich—Soviet physicist, one of the creators of atomic and hydrogen bombs in the USSR.—*Ed.*



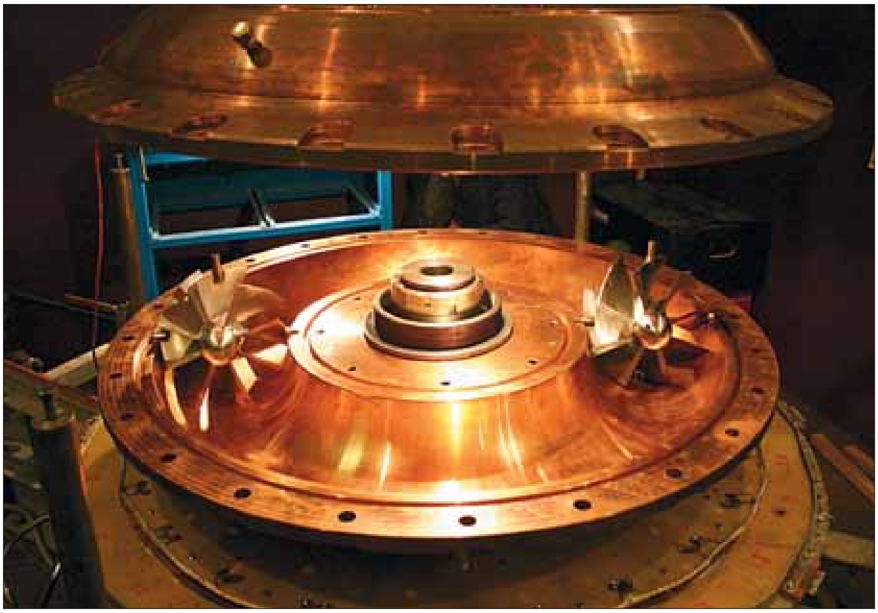
Polarized radio emission of galaxy M31, which is indicative of the existence of its regular magnetic field.

flow could transform into a magnetic loop to strengthen a magnetic flux. We must also mention the research of German physicists Max Steenbeck, Friedrich Krause and Karl-Heinz Radler, who proved that the key dynamo problem, i.e. positive feedback in induction equation, could be solved at a level of small-scale turbulence (the required electromotive force was created not by an ordered motion of liquid but a collective attack of chaotic small-scale vortexes). It is just the above works which were followed by rapid development of the MHD dynamo theory but exhaustive comprehension of this extremely complex nonlinear phenomenon was still a long way off. As it is impossible to perform a total mathematical modelling of the MHD dynamo up to date (statistics of interactions at different scales is required, which needs a gigantic calculation time even using supercomputers), while space observations are limited with hopes put on laboratory experiments.

But experiments are also not an easy matter. Just a few fluxes are known (and all of them have a rather complex structure) which can provide the dynamo operation, and in each such case the dynamo-effect can arise only on achieving certain “threshold” modes. Real values of critical parameters are such that the desired phenomenon can arise only in large quantities of liquid at its sufficiently rapid movement and fair electrical conductivity. Lower conductivity can be compensated by still greater sizes or velocities.

In conditions of cosmic scales the sizes and velocities are so great that dynamo works even at a very low conductivity of the medium. But under the laboratory conditions it is difficult to achieve dynamo mode. Liquid sodium is the most suitable material for such experiments. It is a dangerous material but has two great advantages, i.e. it has good electrical conductivity and is very light, its density and viscosity are similar to those of water. To reach critical parameters it is necessary to achieve the flow sizes of about a meter and velocity of about 10 m/s. The existing plants pump through tons of liquid sodium with velocities close to the designed value, which stipulates a high cost of such plants and an immense amount of consumed energy. But the listed conditions are not enough. The origin of dynamo requires a movement of a special type, i.e. liquid must move in helical trajectories.

The laboratory dynamo experiments have long remained a dream of specialists though the first attempt to realize them was made as early as the 1980s by researchers from the Institute of Physics (Riga) and Yefremov Research Institute of Electrophysical Equipment (Leningrad). The attempt ended in failure because the laboratory plant broke down in the process of approaching sought for regimes. At the end of the 1990s a new series of experimental research started all over the world. Two competitive large teams in the laboratories of Riga and Karlsruhe (Germany) succeeded in achieving the MHD dynamo effect at an interval of literally one month. Since then almost fifteen years have passed. But despite a hard work of a number of research teams only one new example of generation of a large-scale magnetic field moving by means of liquid metal appeared in all these years. The successful experiment was carried out in Cadarach (France). But not all specialists appraise it identically as dynamo was obtained only after solid magnetic particles, more precisely ferromagnetic parts, were introduced into the flux. Properly speaking, scientists have not managed yet to create a direct analog of the natural dynamo as in all three mentioned experiments solid metal parts played a key role (electric conductivity of walls in the Riga plant, guide tubes of a complex form in Karlsruhe, and ferromagnetic parts in Cadarach), which however by no means diminishes results of these experiments in development of magnetothermodynamics.



Channel of an experimental dynamo facility. It is filled with liquid sodium and brought to rotation to 2,000 rpm. Sudden braking of the channel causes in it a helical flow of liquid metal, which should provide a magnetic-field generation effect.

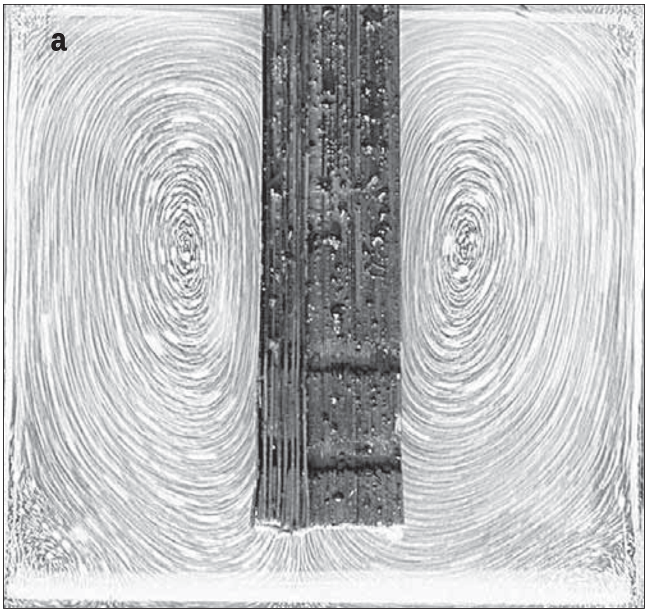
About fifteen years ago the physical hydrodynamics laboratory of the Institute of Continuum Mechanics (Perm) decided to participate in a “world race” for discovering MHD dynamo effect. (Let us point out here that at the same time preparations for dynamo-experiments were started, apart from the above-mentioned research institutions, in Los Alamos and in the universities of Madison and Maryland, USA.) Such decision was anything but simple as science at that time was financed in Russia on the “leftover” principle, which placed us on an unequal footing with our competitors. The desire to rally the research team round the “super-mission”, which was in the traditions of the laboratory, won the day. We did not possess even a tenth of the financial resources available to foreign researchers and therefore strived for a great result at low expenses.

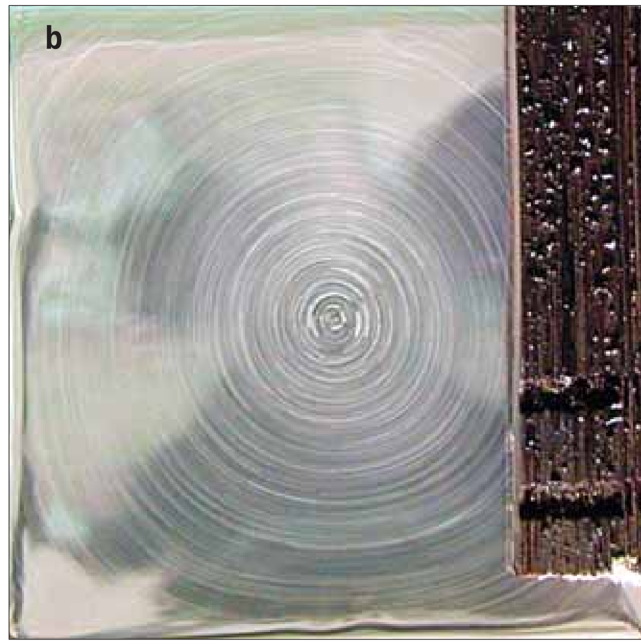
An original method was suggested in Perm, which meant abandoning the idea of dynamo realization in a stable metal flow. Instead they advanced an idea of achieving the desired effect in conditions of a pulse mode. What is it in practice? Liquid sodium is placed in a toroidal channel which gathers momentum to high speeds thus accumulating substantial reserves of kinetic energy. After acceleration the channel stops dead, and inertia forces make run liquid metal through special impeller diverters and provide intense flow with the prescribed geometry in the channel. Substantial advantages of such scheme of the experiment include a sharp drop in the volume of required liquid sodium (about 100 kg instead of several tons) and reduction of engine power (by an order of magnitude). The disadvantage lies in the fact that the scheme can realize only pulse (nonstationary) helical flow which secures the dynamo mode during a short period of time (about 1 s). But even this relatively simple configuration of the plant required long preliminary studies and theoretical works.

The idea of creation of an intense pulse flow of liquid metal in a fast-rotating channel by its sudden braking proved to be fruitful for laboratory studies of MHD-flows with moderate and high magnetic Reynolds numbers*, but it is not brought up yet to the dynamo effect. As of today the plant has already produced a number of fundamentally important results. In particular, the so-called alpha-effect was first recorded in a pulse flow of liquid sodium, which provides excitation of electromotive force in a turbulent flow directed along the magnetic field. The beta-effect was also quantitatively studied at the same plant, i.e. direct measurements of effective conductance of liquid metal in a turbulent flow (conductivity in which differs from conductivity of an immovable or slow-flowing analog). The alpha- and beta-effects are two key turbulent constituents in the dynamo theory of mean fields, on the basis of which all realistic models of cosmic dynamo are created.

Studies of spontaneous occurrence effect of the magnetic field can find quite a practical application. For example, liquid sodium has more and more widespread application as coolant in some atomic reactors. With an increase in capacity of these plants, the volumes of liquid metal increase which possesses high conductance

*Magnetic Reynolds number is a criterion in magnetohydrodynamics which determines the role of hydrodynamic effects in a magnetic field induction and is an analog of the known Reynolds’ criterion, named after the British physicist and engineer Osborne Reynolds.—*Ed.*





Electroturbulent flows of liquid metal in laboratory facilities. The flow is conditioned by interaction of the current passing through metal and its magnetic field distorted by ferromagnetic bars located centrally (a) and sideways of a dish (b).

and moves at a high speed. As a consequence, a magnetic field can originate spontaneously, which can change a process of heat and mass transfer in the reactor. We must foresee and prevent such possibility.

COSMIC MAGNETIC FIELDS

The problem of cosmic magnetic fields is attractive for hydrodynamics not only in the context of revealing physical mechanisms of magnetic field generation (which is a prime objective of laboratory experiments). Of no less interest are they for specialists in turbulence as the very astrophysical objects set examples of turbulent fluxes with the highest values of the Raynolds' number, a parameter responsible for a "degree of turbulization" of the flux. Besides, as applied to astrophysics it is mainly MHD turbulence in which velocity (vortex) and magnetic fields interact.

The turbulence models for limit modes not accessible for direct numerical simulation are another longstanding preoccupation of the laboratory workers. They made it possible to study in detail the behavior of a spiral MHD turbulence which is usual in cosmic systems. These models were used also in the process of computer reproduction of galactic dynamo for correct description of contribution of interstellar medium turbulence supported by supernova explosions.

It should be noted that the laboratory workers came to the problems of cosmic magnetic fields quite suddenly. For many years engaged in modelling of turbulent flows and analyzing signals generated by them, the laboratory specialists actively used a mathematical apparatus called the wavelet analysis. At the very beginning of its formation (1995), a specialized seminar on the wavelet analysis was organized within the framework of the continuum mechanics school at our institute. Among the seminar participants there were also astrophysicists, representatives of the school of Acad. Yakov Zeldovich, namely Dmitry Sokolov from the Lomonosov Moscow State University and Anvar Shukurov from the Institute of Terrestrial Magnetism and Radiowave Propagation (Troitsk), who evaluated the means of the method and suggested taking up the subject related to an analysis of magnetic fields in outer space. The tasks appeared to be of interest and resulted in close cooperation which is still in progress. An analysis of data on the solar activity was carried out in cooperation with astronomers from

Channel of MHD pump.

the observatories of Paris and Nice, and a set of research work on the activity of solar stars was conducted in partnership with the colleagues from the Harvard University. The most productive cooperation was established with a research team of Rainer Beck from the Institute of Radioastronomy (Bonn, Germany) specializing in observations of polarized radio emission, a major source of information on galactic magnetic fields.

The data analysis provided a conclusion on the magnetic field structure both of the external galaxies and also our galaxy, i.e. the Milky Way. All of them are gigantic and at the same time compact physical systems in whose evolution the well-known natural phenomena manifest themselves. Magnetism occupies a special place among them. Magnetic fields play a key role in the formation of new stars and the cosmic climate in the already existing planetary systems. Luminescence of clusters of stars creates a bright spiral design well known from astronomical pictures. Less known is a fact that magnetic fields also form spiral structures. Among the last important results obtained by the laboratory workers together with scientists from the Lomonosov Moscow State University, the University of Manchester and the Institute of Radioastronomy in Bonn, is a multiscale model of a galactic magnetic field generation which predicts the origin of inversions of a large-scale magnetic field and formation of spiral arms. Magnetic arms are not “tied” to gas arms, they can interpenetrate. Therefore in the process of evolution the planetary systems will enter and come out of magnetic arms. If the latter have a periodic structure, it will lead to a “seasonal” (hundreds of millions of years duration) change of the cosmic climate around planets.

APPLIED STUDIES

Despite cosmic motivation of its development magnetohydrodynamics has numerous terrestrial applications especially topical in metallurgy. The point is that electromagnetic field exerts influence on liquid metal. By changing its value and also the value of electric current passing through liquid metal we can control its flows. Scientifically the cosmic dynamo and MHD generators occupy two extreme regions in magnetohydrodynamics, where dynamo is a limit of enormous scales and heavy flows leading to generation of a field, and MHD generators are a limit of immense electric currents and strong magnetic fields which form metal flows and provide their control.

Introduction of MHD technologies to metallurgical production provides transition to pumps which are reliable and simple to control and service, raise labor efficiency and improve quality of cast metal and working conditions of the founder. Magnetohydrodynamic mixers for metals and alloys are designed for crystallization front levelling and grain refining in ingots, provide even distribution of an admixture in them, accelerate the process of alloy preparation and a higher quality of ingots.

The laboratory is carrying on works for studies and practical application of the so-called vortex flows in electroconducting liquid. The phenomenon lies in the fact that electric current passing through liquid conduc-

MHD mixer for production of cylindrical semicontinuous aluminum and its alloy ingots and aluminum-based composite materials. The mixer handles separate controlled mixing of metal in two planes.

tor causes forces in the latter which are conditioned by interaction of the latter and its own magnetic field. In case of sufficiently strong electric currents electromagnetic forces can generate different flows of liquid metal through which this current passes.

Based on the conducted studies of vortex flows, the Institute of Continuum Mechanics worked out different MHD pumps and separators for transfer, mixing and refining of liquid metals. The absence of special electric coils for creation of a magnetic field which are sensitive to the influence of different aggressive factors of foundry production is an advantage of this equipment. Besides, due to the absence of coils such pumps can be lowered below the liquid metal level thus making them submerged. They are convenient in service as they do not need vacuum pumping during preliminary filling of the channel with metal. MHD facility with a corresponding pump has no moving parts; therefore metal does not mix with bottom sediments and is delivered cleaner to the conveyer. Besides, MHD facility provides simple control of the ingot pouring process and maximum isolation of metal from outer atmosphere, thus avoiding harmful gases in the atmosphere of the foundry shop and reducing the risk of occupational diseases.

The physical hydrodynamics laboratory worked out a new class of vortex pumps for transfer of nonferrous metals. This equipment passed experimental operation at the Berezniki Titano-Magnesium Integrated Plant and Solikamsk Magnesium Plant. The liquid aluminum mixer for preparation of semicontinuous ingots developed and manufactured in our laboratory found application at the All-Russia Aluminum-Magnesium Institute (St. Petersburg), Kamensk-Uralsky Metallurgical Works, Rossendorf Research Center (Germany) and Cidaut company (Spain).

The research works carried out in our laboratory are reflected in publications both of leading foreign periodicals (more than 10 per year in the *Web of Science* journals) and also national periodicals (more than 10 per year in the Russian Science Citation Index). And also survey articles published in the *Uspekhi fizicheskikh nauk* (Russia) and the *Physical Reports* (the Netherlands). Two specialized conferences were held in Perm "Perm Dynamo Days" and "Russian Magnetohydrodynamics". They aroused great interest in the Russian and international fellowship.

Today the physical hydrodynamics laboratory represents a sufficiently young team, which includes above 20 scientists. Annually new postgraduates join the team, and many of them continue their work with the laboratory even after taking a degree.

Apart from studies in the sphere of magnetohydrodynamics, the laboratory workers participate in research related to nonconducting liquid dynamics, medicine, mathematical methods of signal processing and geophysical flows.

Illustrations supplied by the author

PREDATOR AS A UNIVERSAL BREEDER

by Alexei SEVERTSOV, Dr. Sc. (Biol.),
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Why this or that animal falls prey to predator? The observations in natural environment show that it is rather difficult to estimate reasons why the particular animal becomes the prey. Predators are unable to catch any animal suitable for them in size, not each potential object is available. Consequently, there exists, as specialists say, the "selective removal", which means the natural selection, accomplished by predators.

WHO IS LUCKIER THAN A CHEETAH?

Field studies are associated with numerous challenges. Besides, classical field methods are rather inefficient. The first problem for the scientists is estimation of the predator's hunting success. In other words, you should know an exact number of pursuits and their results. Normally, such observations are carried out in winter by tracking in snow, i.e., by way of studying attacks by traces left by the animal. It is a labor-intensive and arduous task, since predators are able to run some tens of kilometers daily, including places difficult of access, while a biologist needs to count all attempts to catch the prey to get reliable biological data. In addition, winter is the hard time for herbivorous animals, when they can become totally helpless. That's why, there is a probability of incorrect interpretation of real elimination reasons. Often it is impossible to use technical devices—predators could be afraid of snowtractors following their

Leopard among antelopes. Photo from the web-site http://firstwall.ru/dl/23.

tracks: active observations may affect their behavior and spatial distribution. Therefore, assessment of hunt success is usually rough. It has been established that efficient pursuits occasionally reach 50 percent of the total number of attempts. For instance, a cheetah—the fastest of big predators—succeeds only in 25-26 percent of all attempts. A team hunting organized by wolves and African wild dogs is considered most productive: they catch the prey in 40-46 percent of all attempts. But, before the start of the chase, wild predators watch probable victims and often cut off the hunt. It is considered that wild Canids assess chances before chasing a potential victim.

The second problem is that it is extremely difficult, if ever possible in wild nature, to assess reasons that make this or that animal a victim. First, predators eat the prey, and then come vultures, the remains are decomposed in destructive food chains. That is why selectivity in terms of classical field studies is assessed only in rough figures.

There is a number of wide-spread approaches to studies of remains of dead animals. The general state (conditions) is assessed proceeding from the share of bone marrow fat in tubular bones of dead animals—they are preserved better. If the part is down to 50 percent, this means the starving animal is without subcutaneous and abdominal fat. Due to this method, scientists established that spotted hyenas catch gnu antelopes mainly with a low fat index, but not those which are about to die.

There are data evidencing that wild predators selectively remove the youngest and oldest animals, as well as animals in a poor state (in bad conditions, injured, sick, behaving inadequately, etc.). These facts confirm selectivity, but fail to elucidate neither its degree nor mechanisms which determine the accessibility of the potential prey. To determine the degree of selectivity, it is necessary to examine not remains, but the fresh prey, which is hardly possible in wild nature.

THE WILD PREDATOR MODEL— WINDHOUNDS

To get the opportunity to study characteristics of the prey and repeated play of the process of search, pursuit, attack and capture, we elaborated the model of wild Canids hunt. Windhounds (sighthounds) were used as the predator. They are the unique group of domestic dogs capable of game capture without human assistance and without weapons. It is commonly believed that these very fast dogs hold down animals which they descry (get sight of) in the field or steppe. In such a way, windhounds simulate the hunt in hijacking (“driving away”)—the chase-form typical of wolves, jackals, cheetahs, hyenas, and other terrestrial predators. The model has a number of advantages. First, pursuit is in the open space, which facilitates observations. Secondly, irrespective of different groups of windhounds (breeds, genetic groups), there is

As a rule, a "scene" of pursuit quickly moves away from the observer.

a commonly accepted system to describe their "work" adopted for field studies. Finally, the researcher gets the whole bag (prey body), not only its remains. It is true that the model has its shortcomings: centuries-old selection of windhounds was aimed to select the dogs pursuing any game without preliminary assessment of expediency of hunt.

Windhounds are used to hunt hares and foxes, wolves and jackals, small and medium antelopes. Hence, windhounds are able to run a little bit faster. Special high-frequency GPS recording units were designed to study how the speed affects hunt success and quantitatively describe behavior of chasers. Devices were fixed on dog collars during field trainings and trials in chase with free-living European hare. With the help of second-by-second registration of coordinates was determined location, speed and direction of movement of conventional predators and their victims. It was established that the speed of pursuit depends on many factors: the relief and microrelief, soil and vegetation properties, weather, etc. Sometimes predators and prey fail to gain maximal speed due to natural conditions. GPS recording data enabled scientists to identify a number of important factors.

The speed of windhounds, which is higher than that of European hares, is not so high as it may seem. It varies from 7.43 to 16.9 m/s, i.e. does not exceed 17 m/s. This complies with the data obtained at English greyhound racings and indicators on thoroughbred racehorses and cheetahs established by similar methods.

Speaking of English racehorses, the gallop speed varies from 7 to 20 m/s, while cheetahs in the nature usually run at a speed of 10-18 m/s and almost never reach 26 m/s. Diversity of natural conditions affects the changes of pursuit speed of windhounds every several seconds: even a flat surface of a wheat field has areas of different thickness and density, various height vegetation types, micro- and micro depressions and elevations.

Windhounds pursue European hare for a distance from 389 to 2,674 m, which is much more, as compared with a cheetah (average distance is 173 m, maximal distance—559 m). No doubt, such criteria as speed, duration and distance of pursuit are important, however this is not the whole story—the capture takes place in different speed ranges, at different distances and duration of pursuits.

Windhounds often detect hares before they become visible (get up to run away, start moving), i.e. can smell them. This was proved during field observations and data fixed by GPS recording units—active search may start long (tens of seconds) before the hare flashes.

Sometimes windhounds stop pursuit after a number of approaches to the prey, i.e. irrespective of marked superiority in speed. In other cases they pursue a hare for a kilometer or more and then catch it, though not always.

Second-by-second GPS registration makes it possible to determine location and parameters of the pursuit.

In other words, in the process of pursuing dogs assess its prospects, albeit incorrectly.

It must be emphasized that ethical restrictions are an integral element of our experiments. Field tests were carried out in the late autumn—early winter to eliminate any risks of poor health of wild animals due to hunger or other adverse factors. In this period there are no young animals, pregnant females, etc. We carried out tests in the regions where the state of prey species was characterized as safe, i.e. withdrawal of animals for studies would not have a negative effect on the well-being of populations. For comparison we used animals killed by local hunters within the same period and in the same areas.

SELECTIVITY OF CHOICE

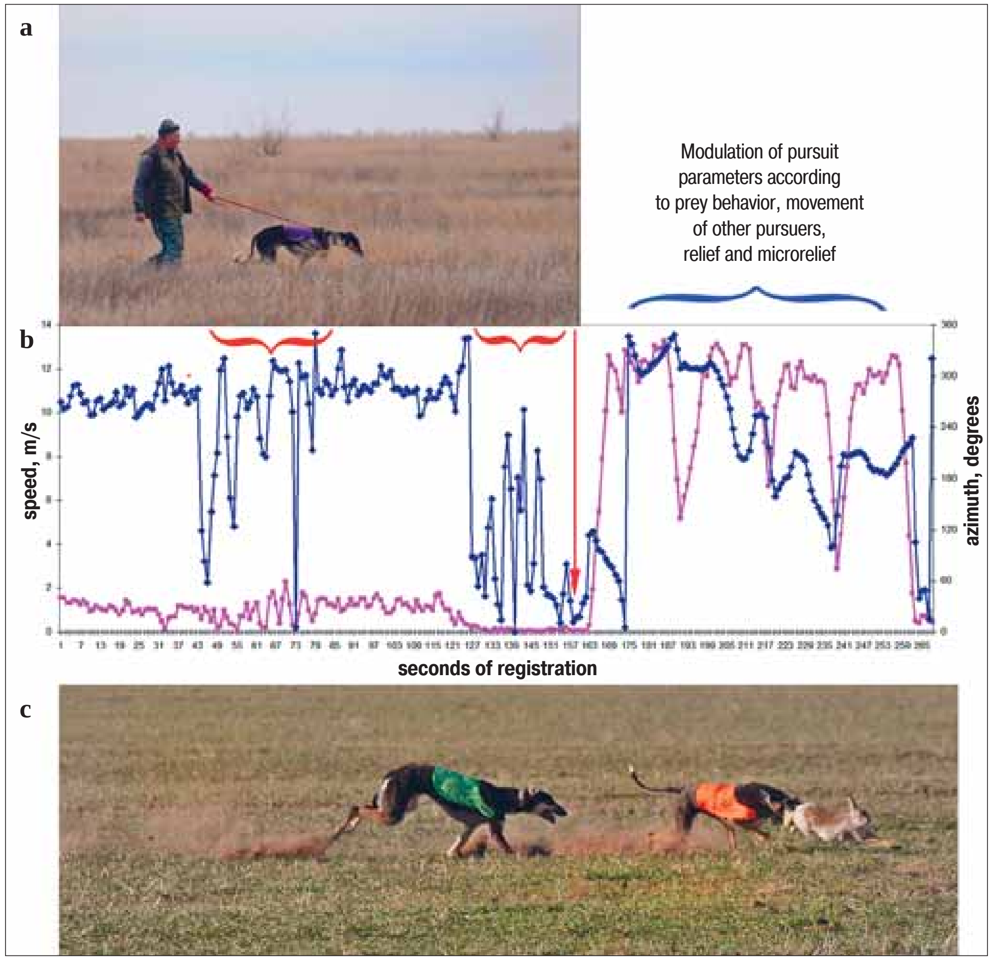
The highest selectivity of windhounds hunt was established while studying saiga chase as early as in the 1980s. This was a starting point to initiate interaction between a predator and a prey on the individual level.

For 2 field seasons in Kalmykia (in the period of abundance of saiga antelope in the region) scientists studied the animals which were pursued by the windhounds. All in all, they caught 38 animals. Concurrently, employees of the State Hunting Supervision Service shot allegedly 40 sick saigas. Each of these 78 animals were subjected to complete pathologoanatomical examination by veterinary surgeons who took part in the expeditions. It turned out that all antelopes caught by windhounds were far from being healthy. As for the shot animals, the share of sick ones was much less—only 33 percent. Thus, the dogs were very precise in choosing sick animals, unlike human specialists. Most pathologies found in saigas were visceral (heart, leaver, lungs, etc.) disorders. We should point out that such abnormalities cannot be identified by remains of the victims caught by wolves and other predators (first of all they eat internal organs).

In the course of 30 seasons, we were studying hunting of windhounds for European hares in steppe regions, comparing animals caught by dogs and shot by local hunters. Outwardly and by average weight, the hares were almost identical, all differences were revealed only in the course of pathologoanatomical studies, when we compared conditions by the state of adipose capsules of kidneys (kidney fat index). Finally, it was found out that the hares caught by windhounds were in a worse condition than the animals shot by the hunters.

The microbiological research enabling to measure the stress level not connected with the moment of capture turned out to be rather promising. The quantity of microflora on the surface of noses of the hares caught by windhounds was higher than in the shot animals. According to the results of immobilization stress tests (hares were put into narrow cages for 3 days), the hares had almost the same number of microorganisms as the hares caught by the dogs. This means that windhounds catch animals existing in a long stress.

The predator shows itself as the very strict breeder—it eliminates the animals with different health disorders. In addition, high selectivity of actions of predators combines with low efficiency of hunting.



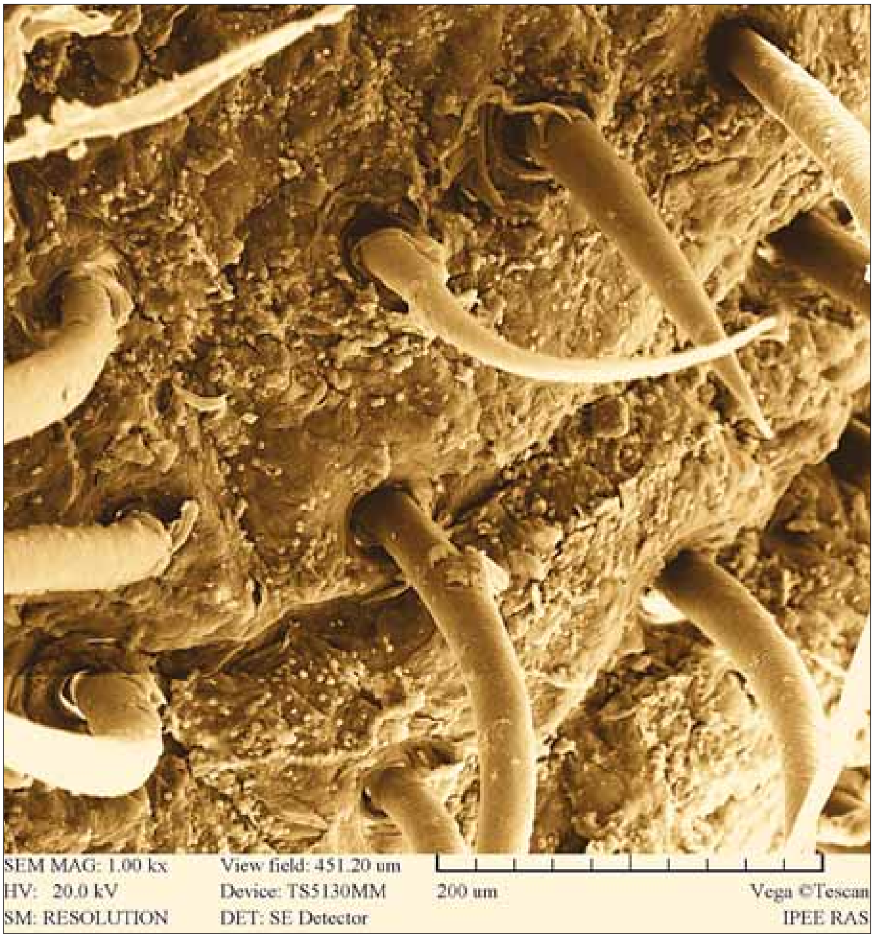
Activation of search behavior, when a hare is neither heard, nor yet seen—a; often search behavior is activated (red brackets) long before the prey starts rising (arrow)—b; speed of pursuit varies: trying to catch a hare, the dog in orange cloth is slowing down, and the other dog in the green cloth has to slow down too not to run into the former—c.

HUNTING SUCCESS

Speaking of saiga hunting, on average 27 percent of windhound pursuits were successful. As for hare hunting, the number of successful chases was from 0 to 70 percent, depending on the day and season. During trials—dogs were let out in groups of 2-3 at least 25 m away from a victim—the hunting success made up 12 percent of the number of pursuits (596 windhounds caught 35 hares in 282 attempts). This complies with the results obtained in the UK, when the fastest dogs (greyhounds) caught 15 percent of hares released from the cages. The hunt of domestic dogs is less successful as compared with wild animals, but their hunt success also varies, depending on the season and prey species. In case of exact registration of all hunts made by wild animals, the result would not be so high. Let's remind you that only 26 percent out of 367 pursuits were successful for cheetahs.

The choice of prey is affected by a number of factors: for example, when hunting for rodents, a feathered predator attacks an animal differing from the majority. Possibly some of the victims have distinctive parameters of movement choosing a wrong strategy to escape, or perhaps are late to get away from the predator, etc. But such animals amount is insufficient to feed predators—at least in autumn, in the period of tests. Observers were able to predict capture of saigas only in 5 cases out of 210 documented pursuits (2 percent). As for the hares, humans are not able to make reliable predictions. This means that visually distinguished signs, as a rule, are not enough to say exactly whether the animal will be caught or not.

The predator uses any circumstances to facilitate hunting. As a rule, it eliminates animals with health disorders. This disparity brings up a problem of making difference between available (sick) and unavailable (healthy) animals. In theory there are only two mechanisms enabling to determine availability of the prey in advance remotely: visual and olfactory. The latter implies changes of smell of attacked sick animals in comparison with healthy ones. The mechanism of such change was initially registered in laboratory and open air cage animals during tests led by the biologist Acad. Vladimir Sokolov in the early 1990s.



Microorganisms on the hare's nose (preparation by E. Naumova and G. Zharova).

SIGNIFICANCE OF MICROFLORA

Cavities and surface of a human body and animals are full of numerous microorganisms—mutualists, commensals, pathogens, and simply symbionts, including bacteria and yeast forms. Their number and composition are constantly changing: both diseases and any deterioration of the state of the macroorganism results in an increase of the number of microflora on the body surface in 2-3 days.

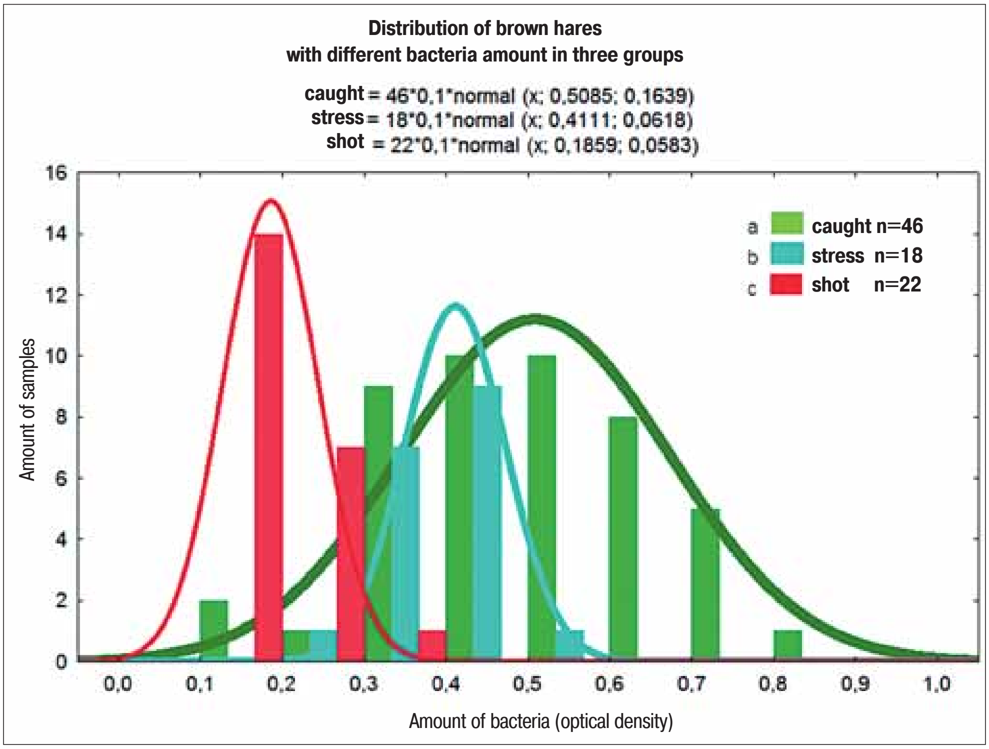
The number of microbes is 10 times greater than the number of cells of the macroorganism (established for a human being), while their number and even composition vary depending on the physiological condition of a carrier, for example, in case of fever. This is a result of the universal generalized adaptation syndrome, known as a stress. The microflora in cavities and on the surface of a body is processing and mediating all excretions of animals and man—i.e. the smell of any macroorganism is a result of bacterial processing (which is widely used in perfume and deodorant industry). Odor intensity depends on the number and composition of microorganisms.

According to our field observations, windhounds are attracted both by the smell of caught hares and bacterial imprints from their noses. The experiments showed that the smell of bacteria is sufficient to change the direction and rhythm of their motion—dogs move towards the source of the smell. This smell is a unique modulator of metazoans' behavior. For example, the smell of bacterial population (imprints from the skin surface) from the people suffering from malaria is enough to change the direction of movement of malaria carriers, mosquitoes of *Anopheles* genus.

Thus, in the course of experiments carried out with participation of windhounds, we determined one of the mechanisms used by the predators to assess accessibility or non-accessibility of a potential victim. No doubt, it is not ideal, since spreading of smell depends on many factors: from meteorological to biotopic conditions, and, of course, from the distance.

WHAT'S HAPPENING IN PREDATOR—PREY INTERACTION?

The welfare level vary among animals and also for each of them for life. These variations determine changes in



Frequency of incidence of hares with a varying number of bacteria caught by windhounds (a), in a stress (b), shot by hunters (c).

the microflora, therefore microbiota is one of the indicators of the state of metazoans. In their turn, microbiota changes, induced by the state of a host organism, modify individual odor, which enables the predator to identify the available prey. Disorders of different origin become key characteristics of the prey increasing the probability of its capture. It is marked by the body surface microflora change, which affects the animal odor.

Among animals caught by predators predominate those with physiological disorders, i.e. changed or increased microbiota. It implements a mediator function in predator-prey relations. The use of smell increases the selectivity of elimination. In other words, participation of microbiota explains one of the mechanisms of natural selection by predators.

Not only a long-term stress, but also any temporal reduced adaptability can trigger the prey removal (or elimination). Predators have an influence on the number of animals, but do not regulate it. Removing the sick animals, they improve a qualitative composition of populations. High selectivity of elimination means survival of the fittest. The main value of the selection performed by predators is stabilization of the population norm and increase of the number of phenotypes possessing a sense of adaptability to the integral effect of the environment.

We should acknowledge that the predator is in fact a universal breeder. Co-evolution in food-chains will never ensure complete protection of the 1st order consumers (plant-eating) or an absolute success of the 2nd order consumers (predators). Selectively eliminating all and any insufficiently adapted animals, predators act as strict and tough breeders. However, since natural selection is implemented simultaneously according to numerous and diverse features, it is almost inefficient by each of them. At the same time, it is difficult to overestimate its significance for existence of prey-species populations. The only comparison we can offer is a purifying selection at a molecular level through elimination of any harmful mutations. At an individual level, selection carried on by predators stabilizes not separate factors, but an organism in its integrity.

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Illustrations supplied by the authors

THE SECRET OF THE NINETEENTH LAYER: LISTVENKA SITE

by Yelena AKIMOVA, Cand. Sc. (Hist.),
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The late Paleolithic multilayer site Listvenka is located in the vicinity of the town of Divnogorsk, 40 km away from Krasnoyarsk. Its age is estimated within 16.5-10 thous. years. The site was discovered in 1982 by the schoolboy Alexei Guryanov and Director of the Divnogorsk Museum Konstantin Zyryanov. In 1983 archeological excavations of the site were commenced by a group from the Krasnoyarsk State Pedagogical Institute (later—university) led by Nikolai Drozdov (1983-1986), Cand. Sc. (Hist.), Head of the Chair of National History (KSPU), Manager of the Laboratory of Archeology and Paleogeography of Central Siberia, RAS SB Institute of Archeology and Ethnography, and the author of this article (1987-1997). For the years of excavation works Listvenka became widely known for unique findings of stone and bone utensils and household complexes: fireplaces, workshops, and dwellings. This article deals with a specific, 19th cultivated layer of the site that revealed unique and quite surprising artifacts.

Excavation site in 1996.

HOW IT ALL BEGAN

A scientific article might have started like this: "In 1996-1997, in the 19th cultivated layer of Listvenka site, about 7 m deep from the daylight surface, a household complex, interpreted as a dwelling-workshop, was discovered and studied...". In fact, the story began in August 1992 when our small group, mostly composed of students of the Krasnoyarsk Pedagogical Institute, was preparing Listvenka site for an international academic conference. It was required to clear out all huge terraced walls of the site containing fragments of cultivated layers to show them to the visitors. Perhaps we could have considered ourselves constructors of a sand castle if Listvenka site and all immense excavated soils anyhow resembled a sand-box...

Somewhere in the early August I asked Sergei Volkov, a physicist seconded to us, to dig a trench "from beginning to end", since I was sure nothing interesting could be found at this depth, and went to Divnogorsk for a couple of hours. When I got back, I was astonished to find a rich soot-colored horizon in the trench wall. Numerous soot pieces covered the dump surface; nearby I found scattered stone instruments on small fragments and plates, nuclei on fine pebbles, pieces of mammoth tusk—the things I never supposed to discover there. Quite upset, we sifted the dump and collected around twenty items... It was the 19th layer. It was known since 1987, when we found bones of a young mammoth and a number of inexpressive flakes at the very bottom of the dig. And all this in the area of approximately 300 square meters! Who could imagine that in 1992 everything would thus change?

In late August, after the scientific conference was over, we completed digging of the prepared area. In a small area of about 10 m^2 we found over 2,000 stone and mammoth tusk artifacts. They were located close to each other, in a thick ash-sooty layer, in a form of one conglomeration. There were a few intact bones, while a combination of mammoth's large spinal bones and split hare and willow grouse bones was unusual. Hare bones were especially numerous. When examining them at home, I was astonished to realize that one of the bones was not in fact hare's. What I mechanically attributed to hare remains, turned out to be an odd job from the mammoth tusk, fine and elegant, with two "heads". According to ethnographic materials, it was very much like a button (later on, the Irkutsk ethnographer Mikhail Turov, Cand. Sc. (Hist.), said: "Write down a 'pin' "), the button of a special type—a "pin".

There was another thing that attracted my attention. Our trench touched an edge of a pit with 3 spinal bones of a mammoth in it. One more bone was found above, near the pit. No coal, no soot, no flakes in it, except for an occasional pair. Nothing was so simple as it seemed—no accidental conglomeration of objects.

As it turned out soon, this trench was dug along the edge of a land plot that somehow survived after construction of the Krasnoyarsk Hydro-Electric Power Station, a bridge across the Listvenka River, power transmission line towers, and, finally, levelling of a site for a race track of a college of the Voluntary Association for Assistance to Army, Air Force and Navy. We carefully examined a tiny piece of land we "inherited", and a secret of the 19th layer of Listvenka site was created to a large extent due to an excavator bucket.

A year later, we finished excavations of the site adjacent to the bedrock outcrops, but it did not meet our expecta-

After cleaning up the "floor" of the dwelling in 1997. Almost completed phase of the work.

tions. The discovered artifacts were few and extraordinary situations were absent.

It sometimes so happens that years later you have to carry out excavations in the place you once worked but it remained a mystery for you. Three years later, in 1996, we returned to the 19th layer. By the mid-season, almost all participants of the expedition left the place, we spent all money, and had to decide whether to give up and leave or stay and try to find reasons for further excavations at the site. In other words, we were looking for any chance to wriggle out and find some money or products. We began to open a half of the excavation site and, as it turned out, missed the point for half a meter...

Stones, stones... Large and average-size stones, they stood out of the layer, making an uneven dashed line. To the north of the stones, in the ash layer, we found some artifacts: flakes, plates, small bones. There was nothing of the kind to the south of the stones: not a single ash inset indicating presence of man. Finally, we found the spine of a mammoth, then another one, a large bone fragment, and no colored horizon at all. There was no sense in digging deeper. Anyway, we were sure that nothing interesting would come out, since the stones expressly marked the boundary. Did that mean that...

But northwards we found another stone that did not look like a fragment of rock: flat on top with polished ribs... Around it, there were numerous finds... Here is an empty place: twenty centimeters eastwards there is an oval spot clean of ashes and stone splinters. Next to it, a large elongated pebble-hammer, a nucleus used probably to produce plates by this same hammer, numerous big chips obtained mostly from one stone... If you sit down on this stone and try to clean the layer, that oval spot would be located exactly at arms' length... Or perhaps this really is a seat of the master, who in the old times used to split stones, who left a hammer and a nucleus there, obviously one of the many. But why is there a spot? Let us assume that there could lie something, pinned down to the ground that did not let waste and colored ash leak under it... A large oval stone? Skin?.. Staggering! Once I was happy to find an imprint of an ancient bedding in the layer and deplored that it was made in France, and now we found something similar in our country!

Where is the second wall, I wonder? It should exist! Somewhere here, in these squares. Several minutes later, from sandy loam cleaned literally at a depth of 2 centimeters, there shows up a protruding edge of a large stone. Why does the stone stick out from a frost fissure cutting through the excavation site? Could it fall through it?.. No, it could not, but if the second wall could be calculated logically, no doubt—a mythical idea of an early man dwelling is materializing before our eyes!

Here is another strange concentration of stones. Crushed stones are closely laid in a circle leaving an empty area of up to 20 cm in diameter inside the circle. The analogy is striking—a pillar supporting the construction arch. But could this be a pillar of such thickness?! Besides, if it is a pillar, the soil in between the stones would be broken. Another thing that might be expected is a coal-like lens—a remainder of the singed for endurance

Fragments of the cultivated layer, cleaning up of 1996.

The pit was hidden under this very mammoth bone.

base. But we have to wait: it is not allowed to rummage in the stones. Meanwhile, we can only clear the surface, trying not to miss details. Nearby, there are some more stones lying in the form of a comma. Two small fragments are lying on each other with a large mammoth tusk piece in between them. After we removed the upper stone and cleared it of the sand, we saw an oval tool with a solid handle—a kind of a shovel-scraper to process skin. One of the ancient dwellers tacked it away near the wall at the foot of the pillar and covered it with a stone.

Here is the mammoth at last! A tiny bone under the knife gradually turns into a huge fragment of the ulna with a massive epiphysis. But it lies somehow strangely—inclined... Yes, it lies in a wide rather shallow pit. Nearby there are some pieces of tusk, a broken rib and a fragment of the spine, single flakes... In general, the findings are few, less than outside of the pit. There is a point vertically looking out near the bone epiphysis edge. We can clearly see that it is made of the tusk, even polished... It is clear that it was stuck intentionally, but what for?.. We carefully take it out... It is a fragment of an artifact with a conic blunted edge and a thoroughly chosen groove smoothly tapering from the edge to the base. Once it was a splendid thing, but unfortunately now we have in our hands only a piece of it. One more fragment was found 1 m to the east, but it was of little help for us. But for all that why was it stuck?

SCIENTIFIC HYPOTHESES AND ASSUMPTIONS

Thus, one more depression to the north-west of the pit. The artifact is not stuck, it is laid down. Nearby lies a stone blade with a totally worn out cutting edge. It is most likely that this yet impersonal item made from the tusk, half-cleared, in the sand, with a lime crust on top, will turn out to be a blank. Yes, perhaps... The fine elongated form with a light bend, uneven shallow narrow grooves totally useless in terms of any functionality. But

"The pit with holes." 1997.

A "head" made of the mammoth tusk.

I feel something is missing... No head. If it existed, it would explain everything: flexures in the spine and knees, and the inguinal region emphasized by an oblique cut... If the guess is true, this find is a real success, since no anthropomorphic figurines made of mammoth tusk were found along the Yenisei so far! If only we could find the head...

Surprisingly enough, but we found the head soon... It was absolutely identical to the "pin" we discovered in 1992 except for the size. Unfortunately, it did not match the "body". So, was it another "pin"?

The problem lies in the pit. Generally speaking, it could be used for a camp-fire. But we found no traces of it. Could it be a pit-pantry? Maybe this mammoth bone had much meat? But why is the pit so shallow, with irregular sides and bottom? Why is the article from the tusk unfinished and moreover, why is it stuck into the ground? Not to let it dry up? Dried-up tusk requires soaking to be

An unfinished article made of mammoth tusk resembling a female figure.

A fragment of the cultivated layer ("master's place"), cleaning up of 1996.

processed... And why not use this pit for water covering its sides and bottom with a skin beforehand? This could explain why it is so shallow and irregular. However, it is the only argument. If only the pit contained many tusk fragments... all doubts would be superfluous...

At the southern edge of the excavation site, there is a stone fence. But one of the stones stands out high... No, it is where it should be, in the circle, but something is wrong about it... I make a decision to go deep into the ground with a knife near its base... It turns out to be from somewhere else, rolled down from the rock much later, after the dwelling was constructed. No doubt, this was to be expected given native outcrops nearby.

So, we can summarize. The stone fence in the southern part, though not as solid as you'd like to, but this changes almost nothing. The stone facing that had fallen into the crack in the northern part of the site. In the center, there is a strange pit and a stone seat obviously for an ancient master. Only a hearth is missing, but, in general, it is simply a classical variant: round ancient dwelling of about 4 m in diameter. I suppose, there was something similar discovered in 1992, but as the stone line was not so well-proportioned, the dwelling most probably was destroyed and abandoned. We could be proud of our achievements and get down to writing a sophisticated scientific article.

Meanwhile, we did not have enough time to complete excavation works in August: we had to make an additional piece in the direction of the rock, and then, after getting a complete picture, to dismantle the laying and clean up the "floor". We had to postpone the works till the next summer.

A year full of hopes, expectations, and discussions passed... A pillar, a pit, and a stone so comfortable to sit on... What is in store for us? Next summer, we continued digging the area left, elaborated a plan of excavations, corrected it, and started to classify the stones. Soon we got to the round wall... Where was the pillar believed to support the roof? Nothing left: the soil is intact and no signs of a butt. But what was then the reason to lay the stones? If the pillar had nothing to do with the roof, and the stones supported something else, for example, an item with a wide rounded bottom? At that time no ceramic items existed; vessels could be made of skin, wood, wattled with twigs

A "pin".

The view of an excavation site in 1997. The bridge was built to let a locomotive pass to the dam of the Krasnoyarsk hydro-electric power station under construction. All bearings are located at the place of the early site.

and clayey. It is impossible to check the hypothesis; traces of such materials are not usually preserved...

Where is that spot near the stone-seat? It would seem it is here..., but it is getting smaller and smaller with each movement of the knife, there appear flakes, small bones, and ashes... That means, no spot was ever there... Consequently no seat ever existed? But they had to sit somewhere, and that stone was simply "born" for this role!

There is one more stone located above the "floor" level; nearby there is a concentration of flakes and tiny bones pressed down by another stone... We took the setting to pieces, made photos of stones, reference cleanups trying to notice every detail and to comprehend. Besides, it turned out that we kept moving around the same central pit, gradually tightening the circle. And the moment came when it was no sense in gaining time—in the middle of the excavation site there stood the only outlier covered with a film... I carefully cleaned the sides of the pit covered with a thin ash layer.... I do not know what I was waiting for. Perhaps, it was something that could stop an unavoidable series of new sections and final destruction of the pit, our last chance to make a discovery... To my utter amazement, my knife reached small round dark-grey spots clearly seen in the light-brown sand. They were located on the sides of the pit, slightly higher or lower of the middle. 9, 11, 13 spots! 13 round spots of 2 cm in diameter! What does this all mean?

I start quietly collecting the contents of the spot—grey sandy soil is going deep down as a narrow long cone... They were pegs! 13 wooden pegs were once stuck into the pit to the depth from 4 to 9 cm! What for? What does this mean?

It is clear what stones were installed by man and what stones later rolled down from the rock.

And, in general, if you look at the outline formed by the pegs from above, it resembles... the skin of a small animal (hare or polar fox) stretched on a concave surface. So, I might assume that the skin was really stretched in the pit pressed down to the soil. By the way, that same biggest bone of a mammoth was there too, but what for?

THE SENSE OF THE UNIQUE FIND

So, what was the purpose of this pit with the mammoth bone, traces of wooden pegs, scarce archeological material inside and no signs of a fire? Nearby numerous small pieces of the cut tusk, the whole and broken items made of the tusk: a blank of a strange (could this be anthropomorphic?) item, and stone tools for processing tusks. In the vicinity a mass of stone splinters, but they are of no use in solving a puzzle connected with the mammoth tusk. Perhaps our guess made a year earlier is in keeping with the truth? The pegs were used to press the skin down to the ground, forming a reservoir to pour water necessary for processing a tusk. Nobody has ever found anything like this. It is widely known that Paleolithic people used to process tusks at stopping places, but to find such a "basin"?!

After the works had been completed, I repeatedly examined my own records and photos and suddenly was struck by a phrase in my diary—"stuck perpendicular to the pit sides". Something very familiar. What else was "stuck perpendicularly"?.. A fragment of the polished tip made of the tusk in 1996. It was the tip that stuck out vertically at the epiphysis of the mammoth bone in the uppermost part of the pit. Moreover, it was stuck not with a point (quite blunt, in fact), but with a sharp broken end. Is it possible that it is the fourteenth peg? Why not to use a fragment of the object for such an ordinary thing? What luck it was not wooden and has survived till our days. But what was that bone for? Was it gradually sliding down to the pit or was put there intentionally—to press down a protruding edge? Who can say now...

Well, what do we have in the end? A dwelling? On the one side—a relatively distinct wall, on the other side—a single large fragment. During a control cleaning of the "floor", the stone began to go deep into the soil and all our attempts to find its base ended in a failure. It transformed into an acute-angled rock protuberance cutting our layer from below. So, no stones were found on this side. Actually, they were not so obligatory: it's enough to press stakes down and to draw covers made of skin tight on them from the windward side, the more so as the other side looks onto the rock. It is all OK, but... What did we have in 1992? I take out my plans, diaries, and a report. A pre-conference fever, nasty days of September, a camera lost in the rain... Forget about the camera! If only I could begin all over again, examine the site differently, pay attention to details I missed at that time! Many archeologists experienced this feeling of angry disappointment and injury when you are ready to give any thing to have a chance to look once again at the things you once fecklessly missed, failing to assess this present of fate! Time goes by, and you get smarter, experienced, but what is the use of it today, if you are unable to make up for lost time and correct your mistakes! In 1992 we witnessed a compact accumulation of material: magnificent series of cutters, retouched plates, nuclei, punctures and screws! Let alone tusk items! Sharp points, a "pin"... Stop... No doubt, all these things were made by one and the save man—that same "pin" and "head", which are identical even in their asymmetry. The distance between them—6 m. Is that accidental? Taking from one nucleus—what is area scattering? Perhaps this is a single complex?

Thus, in 1992 we discovered an area rich in archeological findings; in 1996 we found another one. These areas are located at a distance of about 1.5-2 m, where compactness of finds was lower. The first and the second areas are characterized by a similar composition of artifacts plus the same stone flakes and cut tusk pieces, and a relatively few bones of animals (in any case early people did not have to butcher animals there) and a thick soot layer. Between these two areas—flakes, plates, retouched microplates, scrapers... Why no scrapers were found in the rich areas, why were they concentrated almost in one square? Could this fact be explained by an assumption that this very area was used to process skins? What about a "shovel" made of a mammoth tusk hidden under a crushed stone piece near the concentric laying? It is absolutely clear that it was designed (and used!) to process soft materials. This means that our structure is composed of three parts, two of them absolutely identical, and only one that pit with pegs... But there is a pit in other case too! But it looks a little bit different: it contained mammoth's vertebrae and nothing more. We did not examine its bottom—the soil was so clean, without ash. If only we could get back to 1992 and examine this pit once more. But at that time we found no spots-pegs there! And no other variants except for a small pit-pantry, could arise. One thing remained unclear: why was there no "mud" on its sides (if it was open), and on the surface (if it was filled up)? It could appear only if at the time of its origin, the site was already abandoned by people. They could leave for another territory, i.e. "production zone moved to the south-east", while the pit with hidden mammoth vertebrae remained. But why did they store them if not for meat?

A DWELLING OR A WORKSHOP?

Was there a dwelling? By the way, what does a dwelling mean? A place to eat and sleep? If a dwelling is only a functionally neutral term, it is worth thinking about a roofed workshop that was used in a cold season where people worked in the light of a primitive light stand? But where is the hearth then? It should be; I believe we could have found it, if it had not been for construction of a hydro-electric power station, power transmission line, a bridge across Listvenka. It hardly was a simple hearth—a place for a fire. Perhaps, compared with a discovery ahead, a pit with pegs inside would have been perceived by us as nothing serious...

Well, once again: a fragment of a stone wall (western part destroyed by excavators), two very similar production areas, a place for processing of skins... Was there any building? Indeed, it could be a closed structure or a structure with a single wind wall—reliable and compact, not letting wastes pass from these "premises". From the opposite side, the rock served as a natural shield, at the foot of which a workshop of mammoth hunters was located. Somehow imperceptibly, everything became focused on the layout of this building, as if it was the most important thing. But the most important artifacts, in paper packages and polyethylene sacks, were samples of unique stone and bone industry, which remained where they were originally, untouched by water or sand. A similar method of bone and tusk processing was opened in late 1920s in the Baikal Region, which changed all existing scientific ideas on the Late Paleolithic in Siberia (35-10.3 thous. years ago). In the past decades, they were found also near a number of sites on the Yenisei... But never before the discovered items were in places and in the position they had been left by early people—hidden under the stones, half-dug or stuck into the soil. We discovered intact stone and tusk instruments, perhaps still necessary for someone, untouched vertebrae once certainly with meat on them, a "basin" with pegs... What had happened? Where did the people go? Why did they go leaving behind the things they could have taken?.. Generally speaking, these issues are out of competence of an archeologist. Our regular problem is to answer such questions as "how did these artifacts get at this geological body?".. History is gradually becoming a matter for regional ethnographers and journalists carried away by popular science, while we remain specialists in material culture, like many other experts in quaternary geology, soils, flora and fauna, and we feel ill at ease to put such unprofessional amateurish question: what has happened with these people, mammoth hunters, capable of constructing SUCH structures and processing stone and tusk SO skilfully? We are making attempts to decode the remains of their activities. Sometimes, we succeed (or it only seems that we succeed), sometimes we feel disappointed challenging numerous problems we are unable to solve.

For six thousand years, people settled at the foot of the rock on the bank of the Listvenka rivulet over twenty times. They were already different: they hunted for bisons, produced different stone and reindeer horn instruments, constructed dwellings. They left behind hearths, instruments, animal bones, which we cleaned, described, took photos of, but, it seems, as if I never again felt the sense of "fixed moment", as during excavations of the 19th cultivated layer...

They never returned to Listvenka.

Illustrations supplied by the author

KOMPLEKS AVERTS ACCIDENTS

The Novosibirsk scientists develop new methods and instruments for optical diagnostics of processes in different branches of industry, on transport and in power engineering. Dmitry Markovich, deputy director in scientific work of the Kutateladze Institute of Thermal Physics, corresponding member of the RAS Siberian Branch told about the made progress to Firyuza Yanchilina, correspondent of the *Poisk* newspaper. He stressed that apart from his team the following research bodies took part in the said research headed by Vladimir Meledin, chief research assistant of the same institute, Oleg Potaturkin, deputy director in scientific work of the Institute of Automatics and Electrometry of the RAS Siberian Branch, Yuri Chuguy, director of the Technological Institute of Scientific Instrumentation of the RAS Siberian Branch (all Drs Sc. (Tech.)). Due to the instrumentation developed by them it has become possible to efficiently control multiphase and reactive flows of liquids and gases in scientific and industrial plants, parameters of cold- and hot-rolled mill products in metallurgy and even to monitor mounted wheels in railway transport on a real-time basis. What are the suggested design works in substance and what are their performance capabilities?

Markovich explained: "Optical instruments which we are developing make use of electromagnetic emission in different wave ranges from infrared to ultraviolet and even X-ray for determination of the studied object parameters.

Elements of the "Kompleks" system.

High-speed software-algorithmic complex of digital tracer visualization for studies of cavitation flows.

The main physical principles are based on the scattering laws working on tracers either artificially brought into the flow or on natural ones. We managed to create tomographic measuring systems which enabled us to achieve high-precision spatial distribution of velocities and structures of liquid and gas flows. Image processing by the software-and-algorithmic complexes of digital tracer visualization requires enormous datasets and application of parallel computing technologies and supercomputers, but on the other hand the received experimental physical information is significant and unique."

Another class of the suggested optical methods is based on molecular tracers. Owing to them it becomes possible to determine a wide set of values including a chemical composition and temperature distribution in liquid and gas flows which is important both in scientific studies and in industrial production.

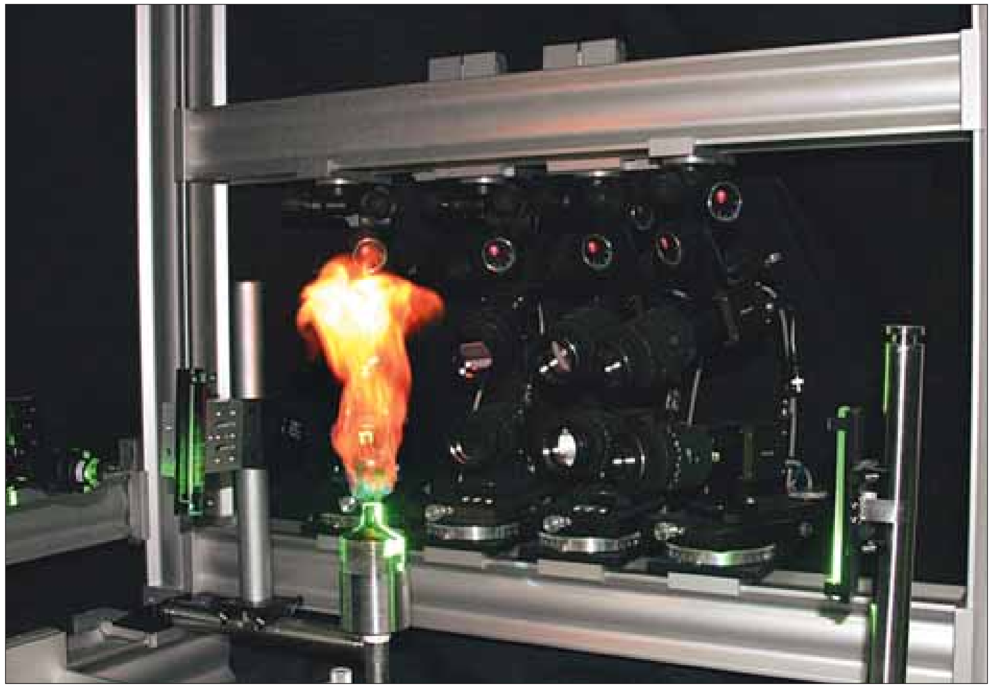
All these approaches are realized by the joint research team in the form of various instruments for contactless and exact optical diagnostics. The measuring systems of the series POLIS, LAD-0 and Korvet for diagnostics of kinematics and structure of flows are used in creation of new technologies in power engineering, aerospace industry and for the needs of fundamental metrology in the national primary standard of the air-flow rate unit. They are introduced into a number of enterprises, research institutes and universities.

As regards power engineering, when diagnosing the processes of hydrocarbon fuel combustion we manage to provide fuel saving and reduce polluting emissions. Recording and analysis of important physical parameters allowed on-line and selective control of combustion modes and substantial increase of efficiency, ecological properties and safety of technologies.

Markovich continued: "In cooperation with the Moscow Power Institute we first in the world equipped large-scale laboratory plants and simulation processes in steam turbines with control devices. Discussions on introduction of similar diagnostic systems at enterprises producing such turbines is under way now. It is a highly difficult technical problem. To deal successfully with this problem one should carry out a long chain of laboratory research, mathematical modelling, manufacture of prototypes and tests on a semi-industrial scale followed by realization and implementation. No single link can be withdrawn from this chain. Complex and large-scale physical effects forming the basis of industrial technologies often prevent from a direct transfer of laboratory experiment results to them.

Hydropower engineering is a case in point. Laboratory models of hydroturbines equipped with advanced diagnostic facilities can provide information on different processes, phenomena and regularities such as, for example, initiation of cavitation which destroys turbines. It makes possible to assess basic characteristics of non-stationary turbulent flows and verify mathematical models and computer codes."

With reference to hydropower engineering Markovich told of his plans for restoration of a high-pressure laboratory at the Krasnoyarsk hydroelectric power plant. It is a unique construction put in operation in the 1970s, which includes several hydrodynamic channels in which liquid moves under action of natural water differential



Tomographic measuring system with 8 chambers for studies of combustion processes.

(about 100 m).The laboratory potentialities are vast, and in case of its repeated creation there will start a real-time modelling of processes for the needs of not only hydroelectric engineering but also defense applications.

Transport is an individual topic. Optical methods are irreplaceable for diagnostics of processes in combustion chambers of gas-turbine and internal-combustion engines. The control of flow of blades in power and transport turbine plants and optimization of work processes using mathematical modelling provide increase of engine efficiency and substantial reduction of the hazardous emission level and acoustic noise of turbines and airplanes.

As we have mentioned above, diagnostics of wheel pairs of railway cars is an important part of the work of the research team. The method of contactless diagnostics of moving three-dimensional object geometry was a breakthrough in practical application of science intensive optical-and-information methods and technologies realized for the first time by specialists of the Design and Technological Institute of Scientific Instrument Manufacture and the Institute of Thermal Physics. In cooperation with the Western Siberian Railway Administration they created on its basis and brought to full-scale production the all-weather laser system *Kompleks* for automatic control of geometric parameters of wheel pairs of freight cars of a train moving a speed of 60 km/h. Non-observance of the said parameters is a serious risk factor of train derailing. Abrasion of even one wheel threatens with a catastrophe. Until recently hand control and measuring equipment of the contact type on the basis of templates or clamps was used for solving this problem. Such method is subjective and unproductive; it requires a lot of time for setting-up of the measuring instrument and does not allow to control train wheels in motion. The research team created brand new contactless and automatic equipment of dimensional control providing diagnostics during movement of the train, moreover with a high accuracy, i.e. the error is below 0.5 mm.

Software records parameters of each wheel, and at the next station the railway personnel receives accurate instructions in which car which wheel pair should be replaced. *Kompleks* is adapted to severe climatic conditions of Russia. Contrary to foreign analogs it is stable in heat and frost, in snow drifts and in rain. For more than 10 years the equipment of this system is successfully used on all railways of Russia, thus preventing accidents and providing safe railway traffic. Economic effect is assessed at many milliards of rubles.

With reference to competition at the world market, there, of course, similar products are available. But the systems from Novosibirsk, created on a fundamental scientific basis and oriented to specifics of particular industry and the climatic characteristics of Russia, surpass the best foreign analogs by a number of parameters.

Firyuza Yanchilina, *Are Accidents Cancelled? Original Works of Siberian Scientists Help Prevent Accidents,— "Poisk" newspaper, No. 25, 2014*

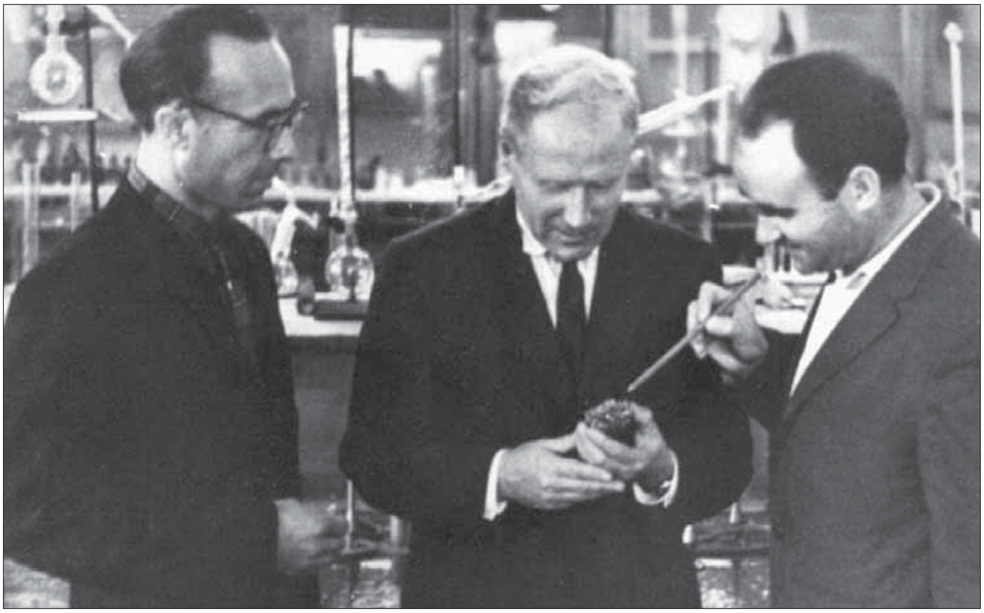
Photo supplied by Dmitry Markovich

Prepared by Sergei MAKAROV

FROM THE INFRARED REGION TO TERAHERTZES

by Vladimir SHIRYAEV, Dr. Sc. (Chem.),
leading research assistant of the Institute of Chemistry
of High-Purity Substances named after G. Devyatykh
(Nizhni Novgorod)

High-purity substances are a basis for many sections of modern materials science. They form a basis for materials required for new industry sectors such as micro- and nanoelectronics, fiber and power optics, optoelectronics. Since 1988 the Devyatykh Institute of Chemistry of High-Purity Substances is a leading center for production and analysis of such substances in our country. It develops science-intensive optical materials and functional units on their basis in cooperation with the Moscow Scientific Center for Fiber Optics and the largest laboratories in the world. The research findings of the institute have been marked with the RF Government Award in the field of science and technology for 1998, diplomas and medals of national and international exhibitions. In 2014 the institute joined the European Consortium for development and creation of infrared fiber lasers and coherent sources of emission.



Founder of the Institute of Chemistry of High-Purity Substances Acad. Grigory Devyatykh (in the center) and his colleagues.

Fiber-optic communication facilities based on quartz glass lightguides became an integral part of our life. But in a spectral wavelength range above 2.5 µm these facilities are nontransparent. Therefore specialists follow the line of a wider mastery of different ranges of the optical spectrum including the infrared and even terahertz regions.

Medium infrared radiation range of 3-25 µm wavelength bears information on presence and temperature of hot bodies and is a convenient form of energy for processing of materials and biological tissues. It provides an opportunity for application of infrared fiber lightguides in laser surgery and chemical technology. Vibration frequencies of different chemical bonds and functional groups are also in the medium infrared region. Therefore, application of optic systems of this spectrum allows making of a remote quality and quantity analysis of gases, vapors and liquids and also the environmental control.

Chalcogenide and fluoride glasses compare favorably with medium infrared range materials designed for production of optic lightguides. The first of them, most commonly encountered in the last 30 years, are divided conventionally into three main families, i.e. sulphide, selenide and telluride groups. As, P, Si, Tl, Ge act as glass-forming cations in these families. Antimony, gallium, bismuth and some other elements serve as a grid modifier and stabilizer. Anion-based compounds such as sulfo-selenides and selenic tellurides are also well-known. Changed properties of chalcogenide glasses also change introduction of alloying additive. For example, selenium atoms are replaced partially with tellurium or halogen atoms (I, Cl, Br) for reduction of multi-background absorption. Gallium, indium or iodine is introduced into a glass matrix for improvement of rare-earth element solubility.

The potential advantages of such elements for application in fiber optics are as follows: transparence and small optic losses in a medium infrared region, low photon energy, slight tendency to crystallization, high value of a nonlinear refraction index, chemical stability and possibility of receiving lightguides of different length. Therefore optical devices made of chalcogenide glasses are promising for transmission of a powerful laser emission of a medium infrared range, thermal monitoring, analytical remote spectroscopy and creation of new elements and systems of nonlinear and integral optics such as infrared fiber-optic lasers, amplifiers, high-speed switches, frequency convertors and supercontinuum generators (coherent electromagnetic emission with an extra-wide spectrum).

Chalcogenide glasses are known since the 19th century. Good transmission in auripigment (mineral of a sulphide class with the chemical formula As_2S_3) was first described in 1870. But only after the repeated discovery in 1950 by the American chemist Kester Freriks of As_2S_3 glass and production of the first specimens of optical lightguides they were considered materials for fiber optics. They displayed good transparency in a medium infrared region. But optical losses in the first lightguides remained high, therefore Freriks was first to note an admixture sensitive feature of chalcogenide glasses.

The building of the Institute of Chemistry of High-Purity Substances named after G. Devyatykh in Nizhni Novgorod.

From the mid-1950s this subject became a research issue of numerous laboratories in all developed countries. The research boom was connected first of all with semiconductor properties of this material.

A substantial contribution to studies of different compounds of chalcogenide glasses and their optical properties was made in the 1950s-1960s by workers of the Ioffe Physico-Technical Institute and the Vavilov State Optical Institute (both in Leningrad). Leadership of the Russian scientists in this field was indubitable. At that time specialists developed methods of chalcogen cleaning from metal impurities and studied the production methods and basic physical and chemical properties of a majority of glass-forming compounds.

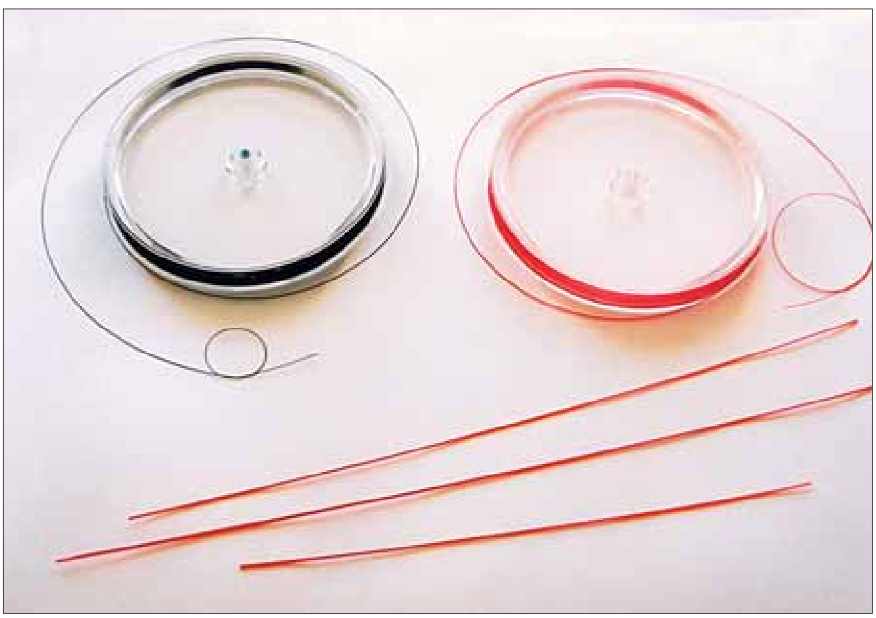
The achievement of optical losses in quartz lightguides at a level of 1-5 dB/km by Corning Glass Company (USA) early in the 1970s gave an impetus to rapid development of fiber-optic communication systems on their basis and active search for other substances of high purity for waveguides with new promising properties required in telecommunication and optoelectronics. For example, in 1974 in the glass and ceramics laboratory of the University of Rennes (France) Professor Jacques Luc and his team developed a new class of materials, i.e. fluoride glasses which consist of chemical compounds of zirconium, barium, aluminum, sodium and other elements. Their emission band extended from ultraviolet to medium infrared regions, and solubility of rare-earth elements opened a way for development of fiber lasers and amplifiers. According to Russian and American physicists the theoretical estimates of optical losses in chalcogenide and fluoride lightguides were by two orders below than in quartz-based ones, and they fell on the medium infrared region.

At that time, early in the 1980s, there was an increased interest in studies of such glasses for production of lightguides with the lowest feasible optical losses. Development of the first promising materials started in laboratories of the USA, France, Japan, Germany, Czechia and many national institutes. The methods of glass synthesis and cleaning were not developed yet, therefore industrial elements were used as basic substances. But such lightguides contained a great amount of limiting impurities (oxygen, hydrogen, carbon), which resulted in substantial optical losses, i.e. above 500dB/km.

At the end of the 1970s the problem of chalcogenide glass production and devices based on such glasses was handled by Professor (today Academician) Mikhail Churbanov's team at the USSR AS Institute of Chemistry (today the RAS Institute of Chemistry of High-Purity Substances, Nizhni Novgorod). His research workers managed to achieve high results in fine cleaning of chalcogens (1965-1980) and in technology of quartz fiber lightguides with small optical losses (1972-1989). Further studies of these glasses as a material for fiber optics was initiated by academicians Grigory Devyatykh, Alexander Prokhorov and Yevgeny Dianov*; the latter headed the Scientific Center for Fiber Optics in

* *See*: A. Prokhorov, Ye. Dianov, "Fiber Optics: Problems and Prospects", *Science in Russia*, No. 1, 2001.—*Ed.*

Chalcogenide lightguides.



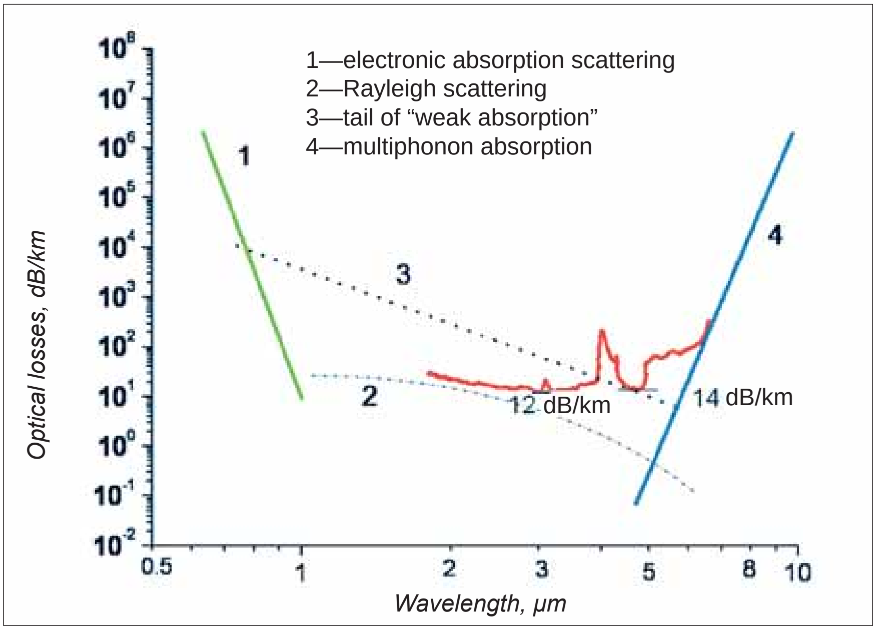
Chalcogenide lightguides made of arsenic selenide (left) and arsenic sulfide.

1994. Since then our institute works in a close cooperation with this institution known in our country and abroad for a pioneer development of a technology of special fiber lightguides, lasers and amplifiers*.

By the 1980s the Nizhni Novgorod specialists studied thoroughly the cleaning methods of chalcogens (S, Se and Te), therefore for synthesis of proper glasses they used not commercial but high-purity basic elements. But by the 1990s they already mastered the methods of their production based on arsenic sulphide and selenide, which opened a way for creation of lightguides with minimum optical losses, i.e. 23-100 dB/km, and later, in 2008, even 12 dB/km in the medium infrared region. Our laboratory came out to leading positions as far as purity of produced glasses and a level of optical losses in lightguides are concerned. Therefore, the work of Russian scientists drew more and more attention of foreign researchers.

I got acquainted with chalcogenide glasses in 1981 when I was preparing a course paper and a degree work. As a student of the Lobachevsky State University (city of Gorky) I implemented them at the laboratory of chemistry of high-purity oxygen-free glasses of the Institute of Chemistry of High-Purity Substances under guidance of Professor Mikhail Churbanov, and in 1985 I got a regular work there. At the laboratory one group was engaged in the work with chalcogenide glasses, and another group—in fluoride glasses and lightguides. The institute was visited by leading scientists in fiber optics such as Jacques Luc and Jean-Luc Adam from France, James Harrington, Eeshwar Aggarwal and Jasbinder Sangera from the USA, Angela Seddon from Great Britain and

*See: Ye. Dianov, “On the Way to Peta Era”, *Science in Russia*, No. 3, 2014.—*Ed.*



Minimal losses in hyaline arsenic sulfide.

High-purity chalcogenide glass of the As-S system.

Philip Russel from Germany. The foreign colleagues were greatly impressed by our advances in cleaning of basic components and production of high-purity samples of glasses and lightguides with small optical losses.

Early in the 1990s the interest in fluoride glass devices declined in the world as the maximum possible results in reduction of their relaying losses were achieved. Therefore, the research area of our laboratory and most of foreign centers was focused on chalcogenide glasses which had great opportunities for emission transfer of medium infrared range waves. They opened up new horizons in development of fiber optics and optoelectronics, in creation of laser devices and amplifiers on their basis.

Our foreign contacts were also strengthening. We used to meet our colleagues at international conferences and visited laboratories in France, Brazil, Great Britain and other countries where we carried out joint experiments. Foreign specialists always took a sustained interest in our research work. The national technologies of receiving high-purity substances and also chalcogenide glasses and optical lightguides were of interest to institutes and universities of the USA, Great Britain, France, Canada, Germany, China, Brazil, South Korea and Australia. We established long-standing partnership relations with a number of foreign scientific groups. For example, in 1995 our laboratory entered into contract with the Chinese Institute of Semi-Conductor Materials from the city of Tianjin for production and studies of chalcogenide lightguides. For two years the Chinese specialists worked at our institute. During this time we gained a unique

Vladimir Shiryaev, Dr. Sc. (Chem.), (right) and Marcelo Nalin, Professor of the University of Sao Paolo (Brazil) at the International Conference for Noncrystalline Solids in Brazil. 2005.

The research findings of the staff members of the Institute of Chemistry of High-Purity Substances were awarded a Diploma and a medal of the EUREKA-2005 International Exhibition in Brussels.

experience in scientific and informal communication.

For more than 20 years Astrium and A.R.T. Photonics companies from Germany are our regular customers. They use chalcogenide lightguides for production of cables and regular cable strands for systems of infrared emission and image transfer.

For many years we maintain good relations with the glass and ceramics laboratory of the University of Rennes (France). It is one of the leading organizations in the world established in the 1970s by the fellow of the French Academy of Sciences Jacques Luc for creation and study of infrared glasses and glass-ceramic materials. Here in 1974 fluoride glasses were created and later, in 1986, also chalcogenide glasses transparent in the spectral range of 1-25 μm. The laboratory equipped with qualified personnel and a wide range of technological and analytical equipment makes a search for and all-embracing studies of new materials for fiber optics, synthesizes high-purity chalcogenide glasses and glass-ceramics, carries on drawing out of lightguides by the

At the laboratory of the University of Nottingham, Great Britain. 2011.

"small bar-pipe" method* and studies their optical, mechanical, thermal and luminescent properties.

Under the joint research program with the University of Rennes for creation and studies of fluoride and chalcogenide glasses, which started back in the 1980s, our institute entered into a number of long-term international projects. Their main objectives are as follows: studies of crystallization kinetics of fluoride and chalcogenide glasses, production of chalcogenide lightguides based on As-Se-Te and Ge-Sb-S glasses with small optical losses, creation on their basis of remote chemical sensors for an analysis and control of the composition of different biological and technical objects and media, and also development of single-mode lightguides with a transmission band 2-16 μm for an interference telescope. It is intended to be used within the framework of the DARWIN project launched by the European Space Agency designed for search of life on other planets. In the course of the Russian-French cooperation interesting and important results were obtained and more than a dozen of articles and two monographs on photon glasses were published.

In cooperation with the infrared glass laboratory headed by Professor Angela Seddon from the University of Nottingham (Great Britain) we are creating fundamentals and methods of obtaining high-purity materials alloyed with rare-earth ions for fiber lasers and studying nonlinear and luminescent properties of chalcogenide glasses. A group of scientists from the University of Nottingham visited our institute, and I had a great pleasure to visit them twice as an invited professor. The British laboratory is developing chalcogenide lightguides for sensors and lasers of the medium infrared range. Here they are developing methods of getting chalcogenide glasses alloyed and non-alloyed with rare-earth ions and make preforms for double-layer and microstructured lightguides using the extrusion method (through a forming device). In the course of mutual work we obtained new original results and infrared materials with the assigned functional properties and published several papers. The chalcogenide cone-shaped lightguides developed at our institute were used as end pieces in a scanning infrared microscope with synchrotron radiation, which increased substantially its resolution.

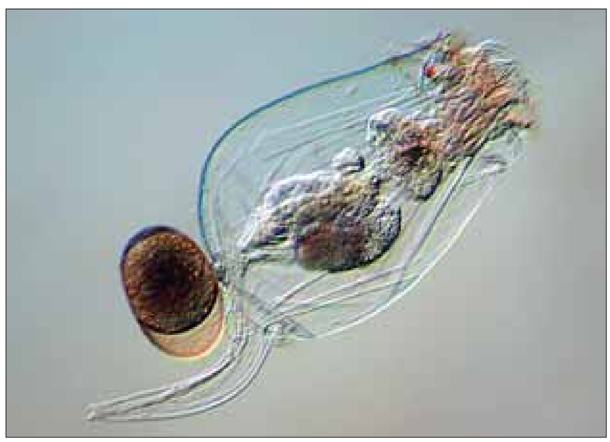
It should be noted that the main advantage of international cooperation is its striving to gain results and practical application of the obtained materials in different systems of the industrial scale. It implies first of all instruments for medical examinations, environmental control, determination of a chemical composition of substances and also other devices using infrared emission.

Lately specialists of Germany and Canada take an increased interest in development of terahertz lightguides based on chalcogenide glasses. The frequency spectrum of terahertz emission is located between the infrared and superhigh-frequency ranges in the wavelength region of 3-0.03 μm. In contradistinction to X-ray radiation, the said emission does not harm a human organism, therefore with the development of terahertz spectroscopy it has become widely used in some sectors of national economy and everyday life, for example, in safety systems for scanning of luggage and people, noncontact inspection and in medical tomography. Waveguides in the form of hollow capillaries or microstructures made of sapphire, metal or plastic are used for channeled transfer of terahertz emission. Application of chalcogenide glasses as a structural material for production of such lightguides is a promising business. Cooperation in this field with German and Canadian scientists will make it possible to create optical devices with a wide transmission spectrum, i.e. from 5 to 200 μm.

Illustrations supplied by the author

* The idea of the "small bar-pipe" method lies in the fact that a bar made of core glass is put in a pipe made of casing glass. During the process of drawing out the bar glass fuses together with the pipe glass thus forming a fiber consisting of a core and a casing.—*Ed.*

QUALITY OF WATER: NEW CRITERIA



by Sergei OSTROUMOV, Dr. Sc. (Biol.),
Department of Biology, Moscow State University

Life cycle of water ecosystems involves numerous physical, biological, and chemical processes. Up to a certain point, natural self-purification processes successfully cope with the problem of water purification. However, in the past decades, anthropogenic impact on the natural environment has increased insomuch that these natural mechanisms are sometimes unable to meet the challenge and even "break down". According to the results of multiyear studies, present-day priorities in the sphere of preservation of water quality and environmental security of water-supply sources are already insufficient and should be supplemented and reconsidered.

Planktonic wheel animalcules (Brachionus calyciflorus).

Fresh-water mollusk—pearl shell (UNIO sp.).

Specimen of marine bivalve mollusk species—Crenomytilus grayanus.

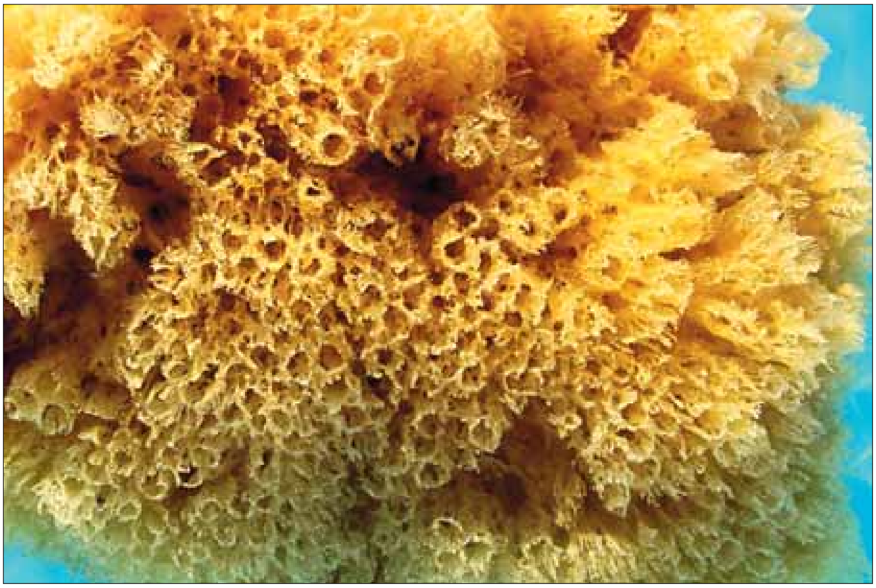
BIOLOGICAL FACTORS

Many physical and chemical processes of self-purification of water are regulated by biological factors or essentially depend on them*. For example, sorption of pollutants on sedimenting particles of suspended matter depends on the concentration of phytoplankton cells. Photochemical processes depend on water transparency, water transparency—on filtration capacity of aquatic organisms. Free radical processes of decomposition of pollutants (substances of anthropogenic origin polluting habitats of living organisms) depend on fixation of metal ions by dissolved ligands—organic molecules of biological origin. Consequently, biotic (biological) factors are the central point of the whole water self-purification system. Oxidation of organic substance and filtration of water by aquatic organisms, as the key factors, have been studied by scientists in every detail.

Oxidation of organic substance is typical of many hydrobionts (aquatic organisms), while bacteria play a special role in this process. It gets involved almost all representatives of main groups of bacteria. It is believed that about 60-70 percent of the overall heterotrophic decomposition (i.e. biological oxidation of organic substances) in the world ocean fall on bacteria. Eukaryotic microorganisms (single-cell organisms characterized by a higher cell organization compared with bacteria, in particular,

* *See:* S. Ostroumov, "Biological Filters Are an Important Part of the Biosphere", *Science in Russia,* No. 2, 2009.—*Ed.*

Ascidiacea.
Halocinthia aurantium.

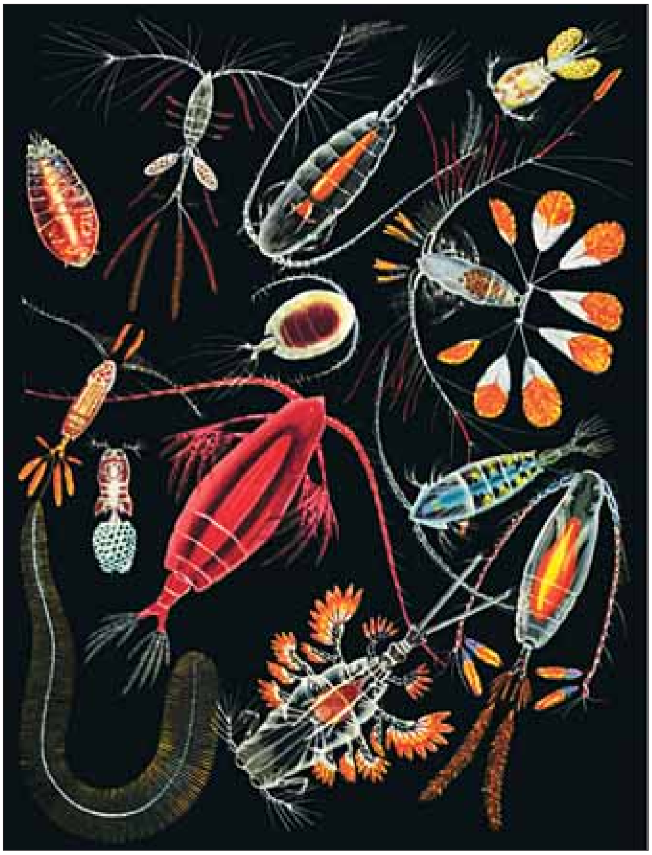


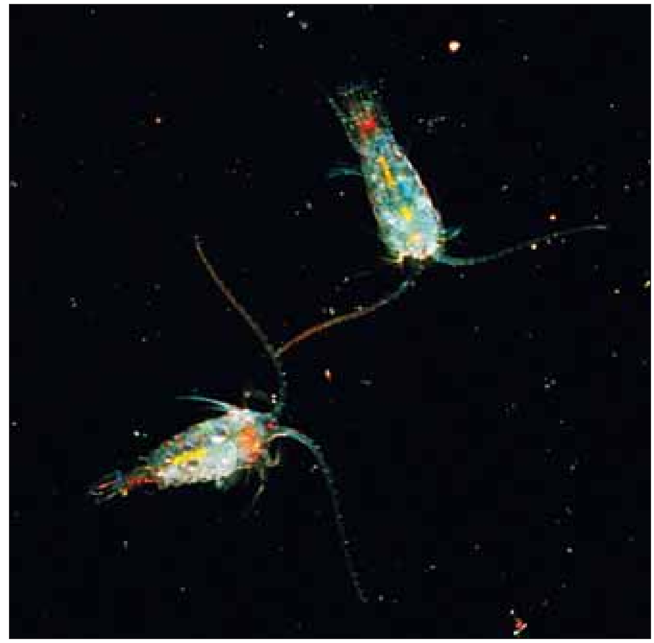
Polifera

diplomonads, ameboflagellates, infusorias, flagellates, etc.) are another important element in self-purification of water ecosystems. Moreover, these very single-cell plankton organisms produce a steady positive effect on stability of ecosystems since they also act as consumers* of bacteria. In such a way, they "rejuvenate" bacterial community and stimulate decomposition of organic matter by bacteria.

Studies of filtration capacity of separate groups of aquatic organisms (for instance, ascidia, barnacles, bryozoans, echinoderms, bivalve molluscs, gastropods, polychaetes, sponges) showed that they are able to filter 1-8.8 liters of water per hour for 1g of salt-free dry body weight of these invertebrates. According to the results of more detailed analysis, it was established that an overall filtration capacity of water by communities of macro-invertebrates (such relatively large organisms as molluscs, ascidia and polychaetes) is assessed in the range from 1 to 10 m^3 per 1 m^2 of the bottom area daily. Here are some specific examples. In the Uchinskoye reservoir (part of the Moscow water-supply system), molluscs filter at least two volumes of all water per annum. In the Volgograd reservoir, they filter 840 billion tons of water a year, i.e. the whole water body is filtered 24 times. In Lake Baikal filtering sponges purify coastal waters for 1.2 days. These figures show grandiose scale of the work of natural "laundry".

* Consumers—organisms consuming ready-to-eat organic substances—*Ed.*





Copepoda.
The drawing to the left from the book
Life of Animals, Vol. 2
(M., Prosveshcheniye, 1968).

THEORY OF SELF-PURIFICATION

Our analysis of ecosystems resulted in establishing three key structural-functional blocks covering almost all hydrobiological mechanisms of self-purification of water bodies. First, the block in charge of filtration. It is composed of a number of groups of living organisms, in particular: invertebrate aquatic organisms-filter feeders; a group of littoral plants (macrophytes) catching a part of nutrients and pollutants getting to the ecosystem from the adjacent territory; benthos (organisms inhabiting the bottom of a water body) consuming a part of biogenes (nitrogen, phosphorus) and pollutants migrating along the borderline of water bottom sediments; a group of microorganisms, attaching to fine particles suspended in water and extracting dissolved organic substances and biogenes from water. Secondly, the block of mechanisms of transmission, pumping over chemical substances from one section or part of the ecosystem (compartment) to another (from one medium to another), in other words, "pumps" as a part of self-purification mechanisms. In this block, some processes assist in transferring pollutants from the depth of water to bottom sediments, others from the depth of water to atmosphere through evaporation. Finally, the third block is responsible for disintegration of pollutant molecules—a kind of a "mill" grinding pollutants.

What are the power-supply sources for biotic mechanisms of self-purification of aqueous ecosystems? The key sources are: photosynthesis, oxidation of autochthonous (i.e. produced within the ecosystem) and allochthonous (i.e. imported from outside) organic matter, as well as other oxidation-reduction reactions. It is worth pointing out that power supply is partially ensured by oxidation of the components (dissolved and suspended organic matter) the system is getting rid of. In other words, nature employs a kind of power-saving "technologies".

Traditionally, self-purification is mainly associated with oxidation of organic substances by aerobic (oxygen consuming) organisms. Anaerobic (without participation of oxygen) processes the efficiency of which is ensured by transmission of electrons to acceptor molecules different from oxygen are no less important. Anaerobic energy ensures metabolism in microorganisms of different communities: methanogenic community (decomposing organic matter "produces" methane), sulphidogenic community (decomposition of organic matter results in the formation of hydrogen sulphide, hydrogen and methane), anoxygenic phototrophic (photosynthesizing) community (producing anion SO_4^{2-}, hydrogen dioxide, hydrogen and methane). It is worth mentioning that products produced by organisms of the abovementioned communities are further used as oxidation substrates by other communi-

Planktonic organisms, Doliolidae order, Thaliacea class, Tunicata type.

ties, including organisms from the "bacterial oxidizing filter" group. The latter is already functioning in aerobic conditions and oxidizes hydrogen (hydrogen bacteria), methane (methanotrophs), hydrogen sulphide (sulphur bacteria), etc. High efficiency of microbial communities of bottom sediments, producing and consuming gases, was proved in the course of studies of geochemical composition of sediments of the World Ocean. Thus, these blocks of the self-purification system operate according to the principle of waste-free technology.

What kind of taxons (systematic groups of organisms) participate in self-purification of water ecosystems? Microorganisms, taxons of phytoplankton, higher plants, invertebrate animals, fishes, and other groups of organisms are among basic groups. Each group plays its own role and is engaged in more than one or two processes.

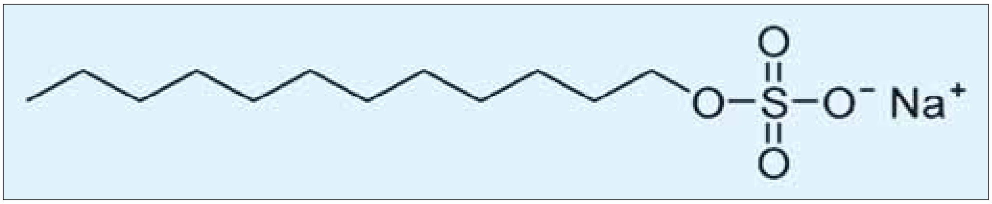
The process of filtration important for the water self-purification process is implemented by representatives of numerous taxons. For example, speaking of haloplankton, the finction of fine filter-feeders-nanophages is carried out by invertebrates such as *Appendicularia, Doliolidae, Calanoida*, meroplankton (larvae), and other animals; the function of coarse filter feeders-euryphages is effected by *Oithona, Oncaea*, etc., i.e. omnivorous microorganisms.

Quantitative parameters characterizing the role of concrete processes vary from one ecosystem to another. For example, this is how different groups of organisms behave while extracting hydrogen from the ecosystem in the course of breathing (in percents of total breathing) of the community inhabiting the central part of the Sea of Okhotsk for a minimal population of phytoplankton in summer: macrophytes (large aqueous plants)—0.3 percent, phytoplankton—8.9 percent, bacteria—55.6 percent, microzooplankton—7.7 percent, peaceful zooplankton—12.2 percent, predatory zooplankton—4.45 percent, zoobenthos—8.3 percent, fishes—2.5 percent, mammals and birds—0.05 percent. In other regions these figures may vary. Thus, from 5 to 30 percent of the total production and total breathing of the heterotrophic (non-photosynthesizing) plankton inhabiting fresh and sea water, including bacteria, falls on protozoans.

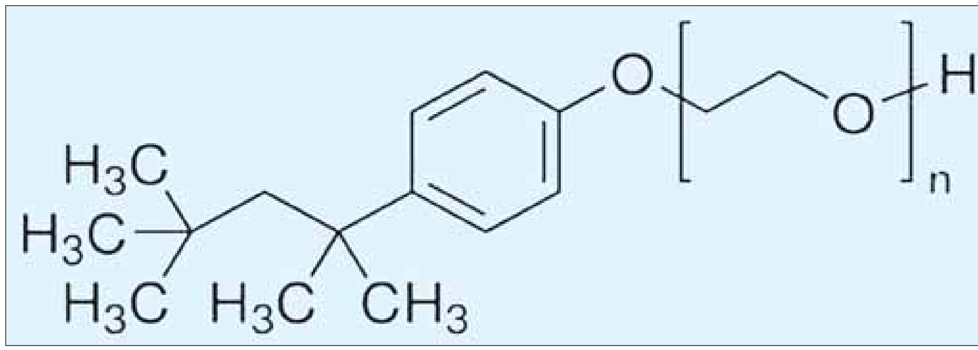
Thus, to ensure efficient functioning of the self-purification process, almost all groups of organisms (pertaining to prokaryotes and eukaryotes) are useful, which confirms the generalization proposed by Acad. Vladimir Vernadsky: practically no group of organisms separated from the community is able to exist for a long time.

"REPARATION" MECHANISMS

How does nature ensure reliability of the self-purification system? As you know, regular operation of sophisticated mechanisms is provided by way of duplicating many of its elements. The same principle has been identified in the course of functional analysis of water ecosystems. For instance, the filtration activity of hydrobionts (aqueous organisms) is duplicated in such a way that it is carried out by two big groups of organisms—plankton (dwelling in the water column) and benthos (dwelling in the soil and in the soil of the bottom of reservoirs). Both groups filter water at a high speed. Besides, benthos additionally duplicates functions of planktonic organisms permanently living in the pelagic zone (a sea or ocean zone located somewhere not in close vicinity to the bottom) due to the fact that larvae of many benthic filter feeders lead a planktonic way of life. The plankton consists of two big groups of multicellular invertebrate filter feeders—crustaceans and rotifers—duplicating each other. But, in this case, nature has provided for one more additional "actor": this role has been assigned to a big group of organisms (Pro-



Surface-active substance dodecylsodium sulfate.



Surface-active substance "Triton X-100".

tozoa) characterized by somewhat different type of nutrition, as compared with crustaceans and rotifers.

The processes of fermentative decomposition of pollutants is partially duplicated by bacteria and fungi. The function of oxidation of dissolved organic matter is duplicated by almost all hydrobionts, more or less adapted to absorption and oxidation of the dissolved organic matter.

It should be noted that stability of any ecosystem is ensured by its self-regulation through interaction of relatively independent structural components. That is why we have reason to consider that self-regulating biota is one of the essential elements of reliability of the self-purification mechanism. Almost all organisms engaged in these processes are under a double control of the organisms of the preceding and subsequent trophic links of the nutrition chain. Different forms of signal systems, including chemical substances—carriers of information or regulatory signals—play an important role too. The author of this article proposed to call such substances natural chemoregulators and ecological chemomediators.

So, we can conclude that there are two important factors necessary to ensure reliability and stability of the water self-purification system in the ecosystem: plurality of constituent processes implemented to some exent at the same time and well-developed system of regulation and self-regulation of biota. In addition, by itself purification of water and steady regeneration of its quality are an important element of self-maintenance of stability of the whole water ecosystem. This contributes to continuous regeneration of normal conditions of natural habitats of plant and animal species. It is necessary to bear in mind that contamination of water is not only due to organic pollutants. For example, the amount of precipitating phosphorus is estimated to a considerable extent per 1 unit of water surface a year. That is why self-purification of water has the same importance for the ecosystem as DNA reparation (current repair of molecules of genetic material by cell enzymes) for heredity systems.

UNSAFE CHEMISTRY

In this context, it is expedient to point out that the reliability margin of self-purification mechanisms is limited. Based on the results of our experiments, we revealed a significant element of lability (instability) of one of them—filtration of water by invertebrate hydrobionts (molluscs, rotifers). It was established that these processes were inhibited under influence of sublethal concentrations of such anthropogenic pollutants as surfactants, contained in many detergents. For example, we established deterioration in the filtering capacity of *Crassostrea gigas* oysters under action of cationic surfactant tetradecyltrimethylammonium bromide in concentrations of 0.5 mg/l and higher and anionic surfactant sodium dodecyl-sulphate in the same concentrations. In our other works we showed that nonionogenic surfactant Triton X-100 also (in concentrations of 0.5 mg/l and higher) reduced filtration capacity of *Mytilus edulis* mussels. It should be noted that anionic and nonionogenic surfactants form part of most popular household detergents—washing powders, liquid detergents, and shampoos.

It was established that surfactants and surfactant-containing mixed preparations can inhibit activity not only of filter feeders but also of invertebrates with different type of nutrition. Thus, *Lymnaea stagnalis* molluscs play a significant role in ecosystems, since they eat hydrophytes and excrete considerable quantity of non-assimilated organic matter. It rapidly sinks to the bottom, which accelerates the process of transfer of organic matter from upper layers of water to bottom sediments. It turned out that under the action of tetradecyltrimethylammonium bromide (2 mg/l), trophic activity (nutrition rate) of molluscs was inhibited by 27.9-70.9 percent. We also registered inhibition of mollusc activity by other pollutants, including, inter alia, not only powder detergents, dishwashing liquids, and shampoos, but also toxic chemicals, oil components, and heavy metals.

All these and other numerous data prove that chemical pollution of reservoirs and streams deteriorates self-purification mechanisms of water.

Our works have demonstrated that present-day priorities focused on preservation of water quality and ecological safety of water-supply sources are insufficient and already inadequate for the current situation. They should be revised and supplemented. What are disadvantages of the present approaches?

INADEQUACY OF PRESENT-DAY PRIORITIES

The main challenge declared today is to prevent discharge of pollutants to water in excess of the limits established by the list of maximum permissible concentrations (MPC). They were determined according to the methods worked out earlier and approved by relevant legal acts (including, for example, in the EU countries). If the discharge is within set limits, the target is hit, and water quality is supposed to be good. In fact, such priorities create a false sense of wishful thinking. Let me explain why.

The current danger criteria are based on three types of assessment: toxicity of a pollutant (heavy metal, toxic chemical, etc.) for planktonic algae, water fleas, fish; bioaccumulation capacity (accumulation of pollutants in the organism of water dwellers); biodecomposition capacity.

What do we mean by inadequacy of these goals? First, toxicity is assessed by the mortality rate of three groups of organisms (above-mentioned algae, water fleas, and fish). The threat of sublethal impacts (when no deaths are registered) is underestimated. Underestimated or ignored is also a negative impact on other organisms not related to these three groups.

The second problem is associated with bioaccumulation. It is stated that if a chemical substance is not accumulated in a body, it is practically not dangerous or relatively dangerous. But this approach fails to rightly assess a negative impact of such substance on cell receptors. It is possible even without accumulation in the body.

The third problem is biodecomposition of pollutants. It is assumed that if a pollutant is subject to rapid biodecomposition, it is not dangerous. But let's see how experts assess this capacity. Tests are carried out in laboratory conditions using retorts filled with microorganisms on the so called rockingchairs enabling cells to get more oxygen from water. In practice, biodecomposition is a result of oxidation of the pollutant by oxygen inside bacteria cells. In case of rapid oxidation (this seems to be good) the oxygen contained in water is also rapidly consumed, which is accompanied by an accelerated reduction of its concentration in water (which is already bad). This produces a negative impact on all aquatic organisms. Under such conditions, some aquatic bacteria start producing hydrogen sulphide. Accelerated decomposition of the pollutant leads to rottening of water. That means that finally all three estimates are inadequate.

Quality of water depends not only on getting of pollutants into the reservoir, but also on the efficiency of self-purification. As has been mentioned above, many anthropogenic pollutants have a negative impact on the capacity of organisms to filter water thus causing lowering of the quality of water. It is widely accepted that low concentrations of surfactants in water are admissible as they do not kill test organisms. But, according to our experiments, ecological peril still exists.

NEW DANGER CRITERIA

What measures should be taken to ensure in practice purity of water resources? To our point of view, in order to assess the danger level of this or that substance, it is necessary to assess not only three test groups (algae, water fleas, and fish), but also benthic organisms-filter feeders (molluscs). It is necessary to register the death rate of test organisms and decrease of activity of organisms to filter water. As for the criteria of assessment of the state of aquatic ecosystems, in addition to concentration of pollutants it is necessary to assess one more important factor—availability and biological activity of organisms in charge of water filtering. Clean water is a result of joint work of all aquatic organisms.

Present-day priorities focused on safety of water reserves is comparable with the attempts to treat a HIV patent from pneumonia with no regard to his immune system. It is an attempt doomed to failure. This is what we see—water quality is worsening everywhere irrespective of all attempts to reduce discharge of pollutants. If we want to keep water clean, we should take care of aquatic organisms.

Illustrations supplied by the author

"GREAT TURNING POINT IN THE LIFE OF MANKIND"

"We are approaching a great turning point in the life of mankind which cannot be compared with anything experienced before. Time is not far off when man will take into his own hands atomic energy, a source of such power which will enable him to organize his life as he wishes. This may happen centuries later. But it is clear that this should happen. Will man succeed in taking advantage of this power and direct it to the good and not to self-destruction? Is he old enough to use skilfully the power which will inevitably be given to him by science?"

Acad. Vladimir Vernadsky, 1922

"Power engineering has entered a new epoch. This happened on June 27, 1954. The mankind is still far from grasping the importance of this new epoch."

Acad. Anatoly Alexandrov

"The design and creation of a reactor facility of the first in the world nuclear power plant was probably the most significant achievement in the field of nuclear power engineering. Its startup proved and demonstrated feasibility of production of electric power at a nuclear power plant."

Acad. Nikolai Dollezhal

"The small nuclear power plant in Obninsk as a pathfinder opened a wide highway for large-scale nuclear power engineering."

Andranik Petrosyants,
Chairman of the State Committee
for Nuclear Power Use

MISSION OF THE FIRST ATOMIC ELECTRIC POWER STATION

by Marina KHALIZEVA,
observer of the *Science in Russia* magazine

More than 60 years ago, on June 27, 1954, the Soviet physicists accomplished starting up of a nuclear power plant of 5 MW capacity at the Laboratory "V", today the Physics and Power Engineering Institute named after A. Leipunsky, situated in a small settlement of Obninskoye, Kaluga Region. It was the first in the world atomic power plant connected to external electric networks. The world got to know that nuclear reaction could not only destroy but also create thus changing radically the life of mankind. Since that date peaceful use of nuclear energy has started.

LONG BEFORE TESTS OF ATOMIC WEAPONS

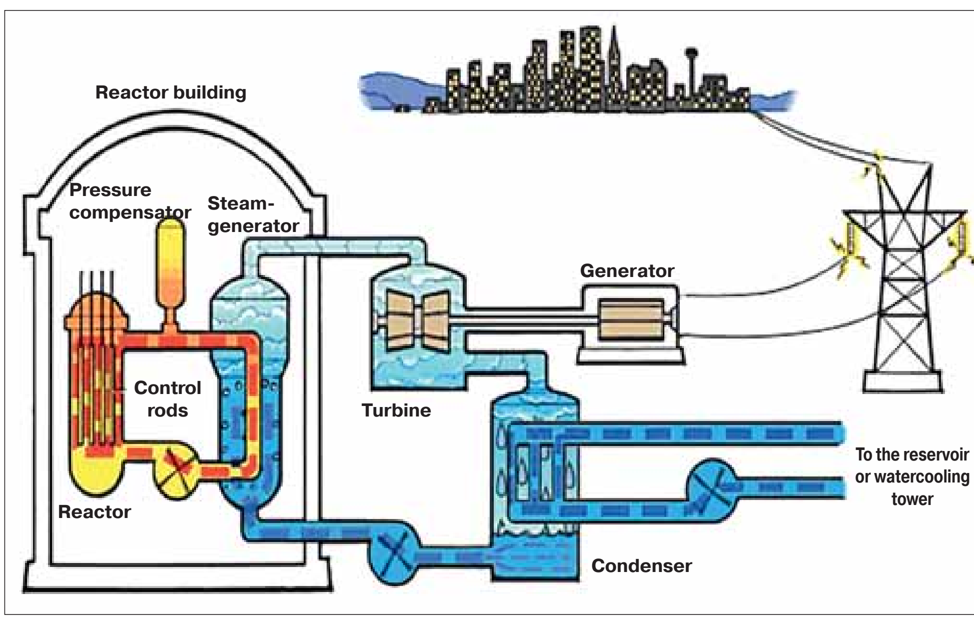
The idea of creation of an atomic power plant belonged to Acad. Igor Kurchatov*. According to documents from the archives, in the autumn of 1942, when Kurchatov headed the national uranium project, he drew attention of the government to prospects for introduction of atomic energy into national economy. Proceeding to implementing the basic task, i.e. creation of a bomb, he expressed himself definitely saying that it should be solved in organic unity with peaceful use of the energy of atom. Therefore early in 1946, i.e. well before the test of atomic weapons (August of 1949), he drew up a program of possible applications of nuclear technologies in science and modern branches of industry. He wrote: "No doubt that atomic energy and radioactive substances, which will be produced in atomic facilities, will find various applications in engineering, biology and medicine in the near future. Possibilities will probably arise for transformation of energy not only to thermal but also to other kinds of energy (electrical and chemical), and designs of uranium-based engines will be developed. It is already time now to start working in these directions."

In the spring of 1947, Kurchatov turned to Lavrenty Beria, who supervised national development of nuclear weapons and rocket technology, with a proposal to use power plants in aviation, navy and construction of electric power plants and also expressed readiness to start immediately design works.

By the autumn of 1949, a circumstantial memorandum "Atomic Energy for Industrial Purposes" was prepared in Kurchatov's Laboratory No. 2 (today the Research Center

* *See*: Ye. Velikhov, "Pride of Russian Science"; V. Sidorenko, "Pioneer of Soviet Atomic Power Engineering"; Yu. Sivintsev, "A Few Unforgettable Meetings"; R. Kuznetsova, V. Popov, "Scientific Heritage of Academician Kurchatov", *Science in Russia*, No. 6, 2012.—*Ed.*

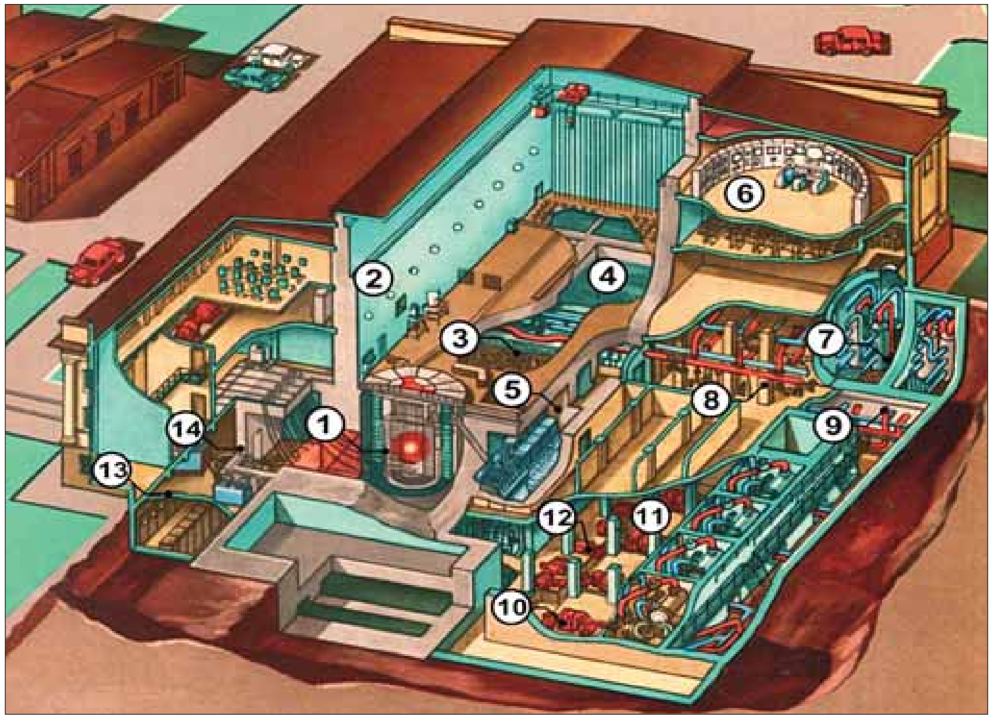
Building of the Obninsk atomic power plant.



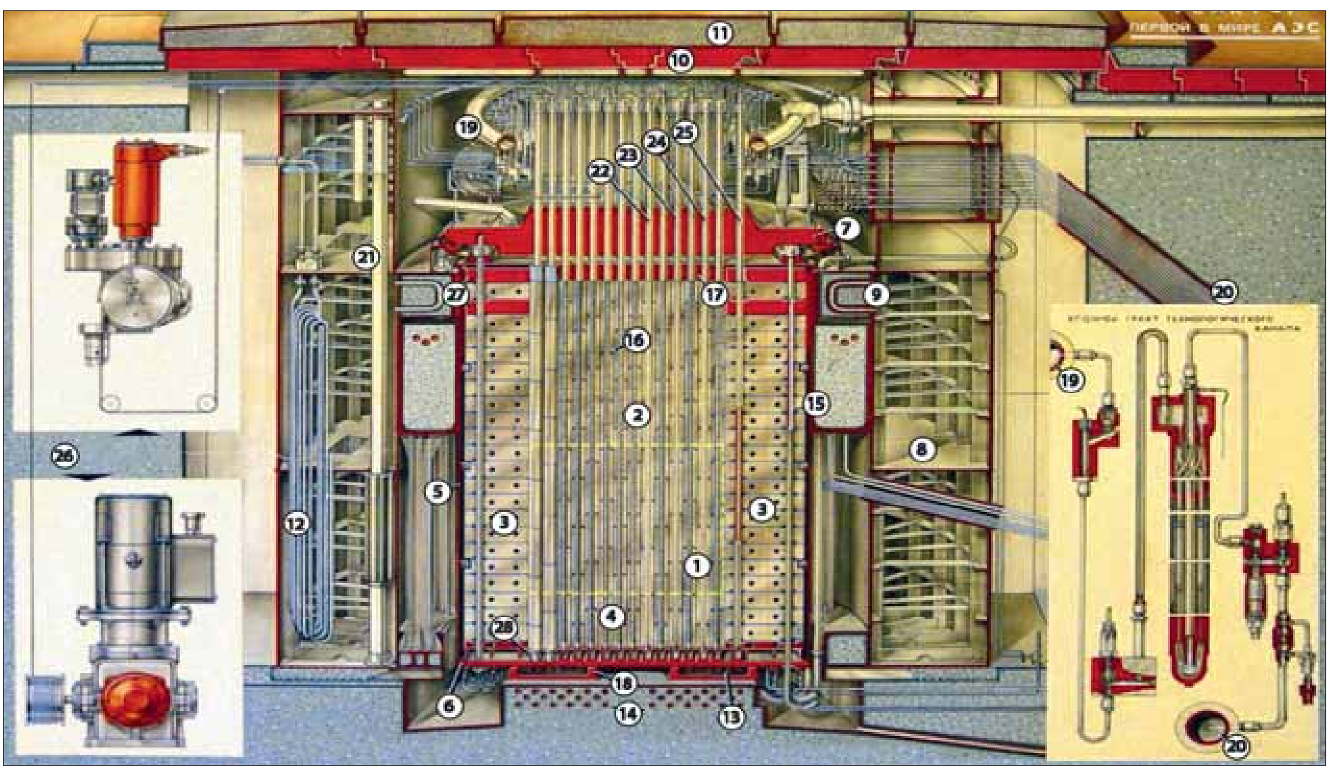
Plan of the work of the atomic electric power-station using two-circuit water-moderate water cooled power reactor.

"Kurchatov Institute")* and submitted by Savely Feinberg, Dr. Sc. (Phys. & Math.), a leading specialist in nuclear reactor industry, to the First Main Department under the USSR Government. In particular, the memorandum laid down considerations of possible practical application of graphite reactor producing plutonium for electrical energy production. A year later Kurchatov and Nikolai Dollezhal, director of Research Institute of Chemical Engineering (NII Khimmash) reported the results of research studies and design works for different versions of atomic power plant at a meeting at the First Main Department. Soon after a government regulation was released on creation of the first atomic power plant in our country. Kurchatov was appointed a research manager of the project, Savely Feinberg as estimator of physical parameters of the reactor, heating engineer Nikolai Dollezhal as chief designer of uranium reactor and the Leningrad All-Union Design and Research Institute of Complex Power Technology (director Alexander Gutov) as designer of atomic power plant. The Laboratory "V" established in May of 1946, 100 km from Moscow and 15 years later named "Physics and Power Engineering Institute" was chosen as a construction site. At

**See*: A. Gagarinsky, Ye. Yatsishina, "From a Secret Laboratory to a National Research Center", *Science in Russia*, No. 2, 2013.—*Ed.*



Design of the first in the world atomic power plant:
1—reactor;
2—central hall;
3—servo control rods;
4—cooling pool;
5—header of primary cooling circuit;
6—central control panel;
7—steam generator;
8—valve actuator of the primary cooling circuit;
9—supply lines corridor;
10—circulation;
11—pumping unit;
12—boost pump of the primary cooling circuit;
13—physics laboratory;
14—isotopic laboratory.



Channel-type uranium-graphite water-cooled reactor of the first in the world atomic power plant:
1—reactor core; 2—top reflector; 3—side reflector; 4—lower reflector; 5—reactor casing; 6—lower plate; 7—top plate; 8—water shielding; 9—top concrete shielding; 10—lower row of shielding plates; 11—top row of shielding plates; 12 —cooling of concrete bed; 13—cooling of lower plate; 14—cooling of concrete bed; 15—tower of reflector cooling system; 16—neutron shield; 17—cast iron blocks; 18—base ring; 19—outlet header; 20—pressure header; 21—ion chamber channel; 22—process channel; 23—emergency shutdown system; 24—shim rod channel; 25—channel of automatic control rod; 26—servo-drives.

First specialists of the station.

that time it was headed by Dmitry Blokhintsev, a known specialist in quantum mechanics and nuclear physics and Corresponding Member of the USSR Academy of Sciences. In 1951 Kurchatov handed over to him scientific management of development, construction and startup of the first atomic power plant as he himself concentrated on problems of creation of a hydrogen bomb or a "superbomb". But Kurchatov did not forget the project and supervised it. He was interested in everything that was going on at the laboratory and the construction site. In the last months before the startup he stayed long in the village and inspected personally the main work places comparing them with drawings and on-site.

HEAT TRANSFER SYSTEM AT THE ATOMIC POWER PLANT

The planned capacity of the power plant (5,000 KW) was determined casually in many ways. After writing off the completely efficient turbo-generator (5,000 KW capacity), first Moscow electric power-station named after Smidovich, transferred it to Obninsk. It was decided to tune up the experimental plant to the said turbo-generator.

Already at the project development stage the Technical Council of the Ministry of Medium Mechanical Engineering discussed options of a power plant and took a decision guided by principle, i.e. to construct a channel-type uranium-graphite water coolant reactor. It went down to history as the acronym AM (atom for peace).

To provide safe operation of the reactor block under possible emergency situations it was decided to use in Obninsk a two circuit heat transfer system by separating structurally a heat carrying agent (water) and a working body (vapor converting heat energy to electrical energy). An active zone in the form of ~170 cm high graphite stack pierced with channels was located in the middle of the reactor cylindrical shell of about 1.5 m diameter. Some channels were designed for nuclear fuel and others for rods absorbing excess neutrons which maintained reaction at the given level. The energy released during uranium nuclei fission was transferred to the heat carrying agent of the first contour. The circulating radioactive water heated there but did not boil twining into vapor as it was under pressure of ~100 atmospheres. Then it reached a heat exchanger (steam generator) where it heated water of the secondary contour, nonradioactive and safe for nearby environment to a temperature of about 260-270 ^{o}C. Steam formed during water boiling under pressure of 12.5 atmospheres got into a turbine with 5 MW electrical generator installed on its shaft. After this useful work, it cooled in a condenser and, turning into water headed again for the steam generator.

The designers maintained that application of a two circuit heat transfer system excluded possibility of radioactive water getting into the turbine and its supply lines. Thanks to this fact servicing of the equipment did not differ from service at thermal power stations and did not require creation of biological protection devices.

THROUGH DOZENS OF PROBLEMS

The operating principle of the reactor passed an operational trial on the first commercial boiler for production of plutonium for arms. It was just put at the rated capacity (in 1948) in the city of Chelyabinsk-40*. The NII Khimmash acted as the engineering design developer of

**See*: M. Khalizeva, "No Hit-or-Miss Chance", *Science in Russia*, No. 4, 2008.—*Ed.*

Reactor of the First Atomic Power Plant. View from the observation platform.

both plants, which undoubtedly reduced the risk of the origin of errors in construction of a new power plant.

But as compared with a commercial reactor the Obninsk prototype had at least two fundamental distinctions. In the former case water served only as a coolant. But in the second case it acted as energy carrier. Another important feature consists in using of fuel elements instead of uranium rods in the reactor core. They had a circular design formed by two pipes, inner (bearing) and outer (cover). Spacing between them was filled with uranium. Water ran along the internal channel (under such design it is easier to heat it to the required temperature). During the plant operation it was necessary to provide a relatively low temperature of nuclear fuel and restrict its “swelling”.

The production process of a main structural component of the reactor core proved a very hard case. First of all, it was necessary to determine the fuel composition. It resulted not only in successful running of the chain reaction but also in favorable conditions for heat transfer to water running along the internal channel of the pipe.

The Ministry of Medium Mechanical Engineering enlisted the services of four groups of physicists for working out of fuel elements, namely: from the Instrumentation Laboratory of the USSR Academy of Sciences (today the Scientific Center “Kurchatov Institute”), Research Institute-9 (Bochvar High-Technology Research Institute of Inorganic Materials), Kharkov Institute of Physics and Technology, and Laboratory “V” where the reactor was under construction. For one and a half years the specialists developed 9 options of fuel elements. The designs suggested by the first three research teams failed to pass the benchmark and reactor trials. Only the fuel composition of a disperse type based on uranium-molybdenum alloy in a magnesium matrix created in Obninsk under guidance of the talented technologist Vladimir Malykh managed to meet the specifications. The experiments proved that the fuel elements with such “filling” were highly reliable and could provide high fuel rating under considerable thermal loads.

But not only was the nuclear component a stumbling block. The problem of fuel casing also was solved with difficulty. It had to face strict requirements to strength, anticorrosion resistance and ability to maintain properties under long action of radiation. At that time metallurgists could suggest only stainless steel (zirconium alloys with properties fit for operation at a temperature of ~300 ^{o}C did not exist yet). But though it deeply absorbed neutrons, which required increased enrichment of uranium fuel, there was nothing left but to work with this metal.

The internal pipe of a fuel element was to be thicker than the external one in order to hold hot water under the pressure of 100 atmospheres. The basic service properties of fuel elements depended on pipe welding. Taking into account that there were a total of 128 fuel elements in a reactor, many hundreds of seams had to be welded. Moreover, science imposed uncompromising requirements on seal tightness. A contact of even a water drop not only with uranium but also with graphite was excluded. But at that time our industry could not boast of skill in welding of stainless steel. As always, cooperation with the national research institutes helped out, due to which specialists managed to master this process and develop a test method for seal tightness.

The full-scale test of the whole assembly was carried out at the Instrumentation Laboratory on a research

Operator at the reactor control panel.

Reactor hall.

reactor MR. The results were encouraging: the fuel elements were slightly subjected to deformation and "swelling" under irradiation at rather deep burnup of nuclear fuel. At the end of 1953 the commercial-scale production of fuel elements started at the Mechanical Engineering Works in the city of Elektrostal (Moscow Region). The first batch of fuel assemblies was delivered to the Obninsk atomic power plant early in 1954

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ENJOY GOOD STEAM!

By the end of 1953 the specialists had already executed the main scope of construction and assembly works, i.e. they built up a reactor casing and a turbogenerator building, installed metal structures of the reactor, steam generators, pipework and a turbine. The construction project achieved status of prime importance at the Ministry of Medium Mechanical Engineering, and was supervised by the Minister Yefim Slavsky.

The personnel was recruited and trained actively at the atomic power plant. A large group of engineers and technicians came to Obninsk from Chelyabinsk-40 early in the startup period, including the power engineer Nikolai Nikolayev, director of a commercial reactor, who was later appointed head of the First Atomic Power Plant.

Maintenance of the new equipment required good academic training, engineering intuition and ability to make prompt decisions. Therefore, highly skilled specialists were sent to Obninsk. By the way, many of those who were trained at the reactor school received later major posts in engineering, scientific and management structures of the atomic power plant.

By the completion time of installation works, on March 3, 1954, compliance of the physical characteristics of the reactor with the estimated data were checked on a physical test bench (full-scale assembly of the reactor core). As a matter of fact, it was then that the Russian specialists accomplished for the first time a chain reaction of uranium fission at a minimally controlled, the so-called "zero" power, which was not accompanied by isolating of radioactivity.

It is symbolical that loading of the active region of the object AM started on May 9, 1954. By coincidence the first physical starting of the atomic power plant was scheduled just on that day. The State Commission members came to Obninsk including such founders of the atomic sector as Acad. Igor Kurchatov, Anatoly Alexandrov* and Albert Alikhanov. The startup team of Laboratory "V" specialists was headed by Boris Dubovsky, a disciple of Kurchatov with whom he participated in the startup of the first in our country experimental reactor F-1** in 1946. By the evening of that day, after about 60 fuel assemblies were charged into the active region, the reactor reached a critical state. Nikolai Dollezhal described the situation: "The chain reaction started! Operators checked the reactor operation at a low power. Then they started increasing it steadily. At last near the generator building there appeared hissing clouds of steam—yet too weak to rotate the turbine rotor but still it was steam produced by atomic energy for the first time in the history of mankind. We were overcome by delightful feelings. It has come off! The event is not so effective as a nuclear explosion but by its significance it is quite comparable with it. And by its size of contribution to the money-box of human progress it is much superior."

Only several weeks later, on June 26, 1954, the energy startup took place after inspection of manual and automatic control of the reactor, studies of the plant units in conditions close to the operational and elimination of the first production problems. Laboratory "V" head Dmitry Blokhintsev wrote in the summary log: "The time is 5.45 p.m. Steam is delivered to the turbine." Kurchatov and Alexandrov congratulated the event participants by Russian custom: "Enjoy good steam!". On June 27, the first in the world atomic power plant was synchronized with the Mosenergo electric system. In several days the *Pravda* newspaper published the TASS statement: "The atomic electric power-station is put into operation and produced electric power for industry and agriculture of the adjacent areas."

After the energy startup, weekdays seemed filled with anxious and sometimes dramatic events. The main difficulties of the first months were: low quality of fuel channels and numerous leaks of water to the reactor graphite laying red-hot to 700 °C causing a sharp increase in the content of radiolytic gas (mixture of oxygen and hydrogen), which created an explosion danger of the latter. The control instrumentation sometimes failed too. As a consequence, the numerous "false" stops took place. It took about four months for finalizing and improvements, which resulted in stabilizing all reactor functions. By October of 1954 the atomic power plant was up and running at full capacity. Its electric power was sufficient to satisfy requirements of a city with a population of 30-40 thous. people.

The new perspective line in power engineering was highly appreciated at the First International Scientific and Technical Conference on Peaceful Use of Atomic Energy (Geneva, 1955). The report by Dmitry Blokhintsev created a real furore. The Europeans usually reserved during business events burst into stormy applause after the report. It was a triumph and recognition of our country's priority in peaceful use of atomic energy. In 1957 Dmitry Blokhintsev, Nikolai Dollezhal, Andrei Krasin (director of Laboratory "V" in 1956-1959) and Vladimir Malykh were awarded Lenin Prize for participation in development, startup and mastery of the first atomic power plant. A large group of developers and operating engineers were awarded the USSR orders and medals.

AMPLE OPPORTUNITIES

Since 1956 the atomic plant operation was oriented not so much to production of energy but to science. Slavsky believed that it was required to power industry for creation of following generations of reactor plants. Indeed, the First Atomic Power Plant became a laboratory for testing of materials and equipment and also operating modes of future power plants. Here were tested engineering solutions which were used as substantiation for the projects of Beloyarsk and Novovoronezh atomic power plants and Bilibino nuclear cogeneration plant, reactors for transportation, space facilities *Topaz* first guided into orbit on February 2, 1987 as a part of the experimental apparatus *Plazma-A*.

From the first days the reactor produced isotope products for medical purposes. Apart from experimental plants envisaged by the project, 17 special devices or reactor loops* were put into operation here, which expanded the range of the considered problems in the fields of

* *See*: N. Ponomarev-Stepnoi, "At the Head of the Nuclear Branch", *Science in Russia*, No. 2, 2003; Ye. Velikhov, "Unable to Live Otherwise"; M. Mokulsky, "Rebirth of the Nation's Genetics"; V. Popov, "Scientific Works of Academician Alexandrov", *Science in Russia*, No. 1, 2013.—*Ed.*

** *See*: N. Chernoplekov, "At the Dawn of Atomic Energetics", *Science in Russia*, No. 6, 2006.—*Ed.*

* Reactor loop is an independent flow circuit of the reactor designed for experimental purposes and consisting of one or several channels.—*Ed.*

First cosmonaut of the planet Yuri Gagarin visiting nuclear physicists. 1966.

nuclear physics, physics of reactors and radiation protection, thermal physics and hydraulics, corrosion of structural materials, radiation materials science, technology of liquid-metal coolants, chemistry and radiochemistry.

The atomic power plant became a kind of a training school of personnel for emerging atomic industry. A majority of specialists of the first industrial giants made use of it as a natural simulator. It was important for the history of the national atomic fleet. Here not only shipborne nuclear power plants were upgraded but also nuclear submarine crews were trained. Specialists from the GDR, China, Romania and Czechoslovakia came to Obninsk for a period of probation.

In the 1950s the first atomic power plant in Obninsk was followed by experimental power plants in Great Britain, the USA and France. As the experience was accumulating in the USSR and Western Europe, their governments adopted programs for construction of prototype models of commercial atomic power plants.

According to the data of the International Atomic Energy Agency today 437 nuclear units operate in the world, which produce ~373.3 hectowatt of electric power. In Russia alone 33 blocks operate at 10 atomic power plants. They produce ~16 percent of all generated electric power.

48 YEARS AFTER

The Obninsk atomic power plant operated for 48 years including 18 years in excess of the design lifetime. On April 29, 2002, an emergency protection button on the control board worked, which announced the reactor shutdown. In September of the same year the last fuel assembly was unloaded from the reactor. After that the nuclear facility should be brought to a safe state. The procedure is time- and cost-consuming but compulsory. Both the national and foreign experience in this field is very limited. Therefore, operation of the Obninsk atomic power plant is considered an important stage in formation of standard procedures which will be used later in putting out of action of other research and nuclear power reactors.

Nevertheless, the legendary first-born of peaceful nuclear industry gets along as a memorial complex. The complex displays an exposition of curious chapters in the history of development of atomic industry and the power plant proper. Some time ago, especially in the first years, the atomic power plant was a place of pilgrimage. Hundreds of well-known scientists and outstanding statesmen from all over the world rushed to the small town near Moscow. For the first 20 years its main point of interest was visited by ~60 thous. men from 2,200 thous. delegations, including 6,770 foreigners from 85 countries. In due time scientists of world repute visited this place, namely, Frederic Joliot-Curie and Francis Perrin (France), Glenn Seaborg (USA), great military leader marshal Georgy Zhukov, the first cosmonaut of the planet Yuri Gagarin, foreign political and public figures such as the leader of the Indian National Liberation Movement Jawaharlal Nehru and Prime-Minister of India Indira Gandhi, President of Indonesia Dr. Soekarno, “the last king of the Balkans” Josip Broz Tito and dozens of other known personalities. The plant is open for the public even today.

Illustrations
from the Internet sources

AUTONOMOUS HYBRID MINI POWER SYSTEM

Staff members of the Innovation Center of the Physical Institute named after P. Lebedev, RAS (FIAN), under support of the Fund of Assistance to Development of small forms of enterprises in scientific-technical sphere have worked out an autonomous hybrid mini power system MIP-SK, which can provide with electric energy small economic and social objects: villages, settlements, small enterprises and individual residential houses. Andrei Chervyakov, Cand. Sc. (Tech.), a specialist in FIAN commercialization, told about a concluding phase of the project to the Agency of Scientific Information “FIAN-Inform”.

The necessity of such sources is most acutely felt by owners of buildings, which are located rather far from basic energy mains. Connection of the house to the general transmission line is a process involving much trouble for owners, while for energy suppliers it results in significant expenses. The matter is that consumption of electricity by population has a vividly expressed “peak” character. Each inhabitant of Russia on average spends approximately 2 kWh of electric energy a day, while in working evening hours almost 10 times more than other time. It turns out that the energy supply company must provide each house with, say, 10 kW electric energy for each inhabitant to be able to use it to fully only twice a day. Such uneven rhythm of consumption tells badly on the service term of the equipment of electric power stations, as in peak hours it functions in maximum modes and so it wears out more rapidly, while for the rest of time the figure is 10 percent.

It is certainly possible to obtain an autonomous electrogenerator, set in motion by an internal-combustion engine. But its functioning under uneven loading is also uneconomical. Besides, parameters of noisiness of such aggregate are, as a rule, rather critical.

There exist advocates of “green technologies”, who propagate use of wind generators and solar batteries. However, the former producing electric energy, let out unacceptable noises, especially unpleasant in the infrasound part of the spectrum. Besides, they can be use only in mountains or near the sea, where the wind is constantly blowing. The latter possess low efficiency and also completely depend on weather conditions. Consequently both sources lack stability.

According to Chervyakov, a good example of stable energy supply can become an autonomous hybrid system MIP-SK. “Such installation,—he explained,—can provide electric energy for remote places, without exposing the owners to extreme conditions of life near it. In addition we tried to solve a problem of effective use of resources: the system should produce exactly so much energy as it is required for the consumer in the given moment to avoid charging, say, a mobile phone using the power necessary for the refrigerator, microwave oven and a washing machine in the aggregate.”

MIP-SK is designed according to the block-module principle and consists of a direct current accumulator battery with a voltage of 24 V and from 100 to 1,000 A/h capacity (depending on the needs of the consumer)—it is the “nucleus” of electrosupply of the object, 9.9 kW generator of electric energy, actuated by a modernized double-cylinder four-cycle engine of internal combustion air cooling Honda GX-610 with 6.6 horsepower capacity and heavy-current (9 kW) multifunctional inverter.

The main generating force of MIP-SK is a multifuel engine of internal combustion. “It is our pride,—said Chervyakov.—If the existing in the market multifuel power systems really require replacement of one type of fuel by another, depending on its availability, our engine is “omnivorous”. It can work using both gasoline and gas

MIP-SK diagram.

MIP-SK model at the exhibition “Development of the Infrastructure of the South of Russia—2012”.

(main or balloon). Besides, according to the results of trials, transfer to balloon gas takes place without a loss of engine capacity as compared with gasoline regime, while transfer to main gas results in power drop by not more than 20 percent. For comparison: a majority of standard engines show in some cases a power drop by 50 percent and more.

Management of the work of energy resources is carried out by means of a controller. “If, for example, for some reason, delivery of main gas is terminated,—explained Chervyakov,—the system automatically transfers the engine to balloon gas. If gas has finished in the balloon (or it is out), the system will automatically passes to gasoline. And backwards—as soon as reserves of balloon gas are refilled or delivery of main gas is renewed, the engine will return to economically advantageous variant of fuel.”

Such “omnivorous” character of MIP-SK increases reliability of providing objects with electric energy in case of arising of emergency situations.

The systems of control and management worked out by the staff members of the Innovation Center are today solving a pressing problem of effective use of electric energy and allow to additionally lower fuel consumption. MIP-SK automatically follows consumed power at the exit of energy system. If the load is light, the system works using storage batteries. When the load increases and the battery capacity is not enough, the engine is triggered. When the resource of the storage battery is exhausted, the system automatically sets it to be charged and starts the engine. So, the owner of such equipment will never find himself in a deenergized house.

At the expense of periodization of the engine work and giving up the idea of its constant functioning, its resource is “expanded” and ecological safety of its exploitation is increased. Besides, due to the intellectual and accumulating principle of the unit, it can become a base for use of additional energy sources—the same wind generators or solar batteries. But they will be not main, but auxiliary resources expanding the potentialities of energy system. This will result in maximum decrease of their negative characteristics and will accentuate their indubitable advantages—getting “free” energy, literally from the air.

MIP-SK, weighing ~140-160 kg, has rather modest parameters: 700×600×1,200 mm, i.e. it is a quite mobile module, not requiring special means of delivery. It can be exploited at a temperature from $-40\ ^{\circ}C$ to $+45\ ^{\circ}C$.

At present the inspection of efficiency of the existing mockup of the unit is in progress, which will be followed by field trials. The developers are at the same time solving a problem of cleaning up of the worked out fuel, in order to make its characteristics and composition meet the requirements of the standards of Euro-4 and Euro-5. This will increase ecological safety of the aggregate.

In 2012 the Hybrid Mini Power System was highly assessed at the International Industrial Exhibition “Development of the Infrastructure of the South of Russia—IDES”.

***Ye. Lyubchenko**, Energy to Order.— Scientific Information Agency “FIAN-Inform”, May 2014*

Illustrations from the site of FIAN and other Internet sources

Prepared by Marina KHALIZEVA

“MOSCOW, MY HOMELAND...”

View of the Red Gates, the Food Storage Palace and the Church of Three Prelates. Engraving. 1856.

by Olga BAZANOVA,
observer of the *Science in Russia* magazine

The earthly life of Mikhail Lermontov (1814-1841), one of the greatest national masters of the word, was too short; therefore every “grain” of information about his life is valuable. From the incomplete twenty-seven years he was destined to live he spent only a total of six years in Moscow but he regarded it as his homeland and loved it “strongly, ardently and tenderly as a son and a Russian!”

Not far from the Moscow historical center, in the Red Gates Square, there is an administrative and residential high-rise building (from among seven skyscrapers which beautified Moscow in late 1940s-early 1950s)*. The memorial plate with a portrait of our celebrated townsman on its wall has an inscription: “Here stood a house, where on October 3(15), 1814, the great Russian poet Mikhail Lermontov was born.” We mean the mansion of major-general Fyodor Tol, which was situated in early 19th century just here opposite the Red Gates, the

**See*: A. Firsova, “The Empire Style in Soviet Architecture”, *Science in Russia*, No. 3, 2010.—*Ed.*

Building of the Moscow University in the Mokhovaya Street. Architect, Matvei Kazakov. 1782.

Lermontov Museum in Moscow.

first national triumphal arch built in honor of our victory in the Battle of Poltava in the course of the Great Northern War*.

The initial version of this pompous construction was wooden thereby it suffered from fires not once, and in 1753 baroque architect** Dmitry Ukhtomsky reproduced it in stone. The scarlet Red Gates decorated with rich snow-white fretwork, bronze gilded figures and colorful painting appeared before the eyes of the poet's parents who arrived in Moscow from his mother's family estate in Tarkhany Village, Chembarsky District, Penza Province just on the eve of his birth. Unfortunately, the majestic arch has not remained intact to the present day (as well as the neighboring Church of Three Prelates, where small Mikhail was christened a week after his birth). The Red Gates Square is now in this very place opposite the Lermontov Square with a monument to the poet erected in its center in 1965 (sculptor, Issac Brodsky).

As soon as frosty days were over, the young family returned to Tarkhany in the spring of 1815. But its life was neither happy nor long. In 1817 the poet's mother died of consumption, and her mother Yelizaveta Arsenyeva devoted herself to Mikhail's upbringing. She was a clever, strong-willed, energetic and well-to-do person, who was fond of her beloved grandson, "the light of her eyes". Her son-in-law whom she never loved and even considered him guilty in her daughter's death, received from his mother-in-law (according to a number of authors of memoirs) a bill of exchange for a big sum of money and left for his own estate near the city of Tula.

* *See*: V. Artamonov, "If Only Russia Lived in Glory and Welfare...", *Science in Russia*, No. 4, 2009.—*Ed.*

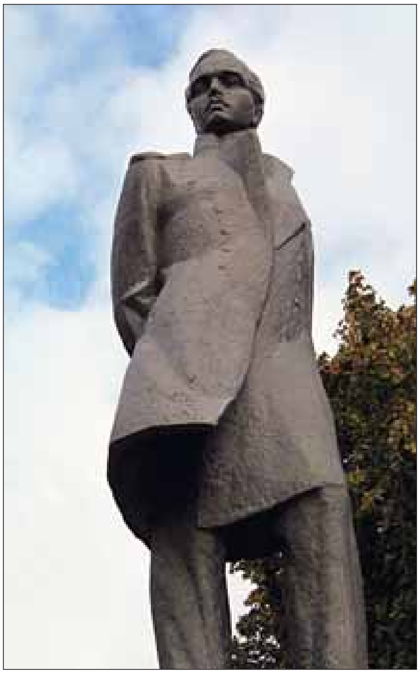
** *See*: I. Terekhova, "Russian Baroque", *Science in Russia*, No. 2, 2009.—*Ed.*

However, Yelizaveta Arsenyeva allowed her son-in-law to carry on correspondence with and visit his son, and, of course, she lavished attentions on her favorite child and provided with everything required by the family status. Nevertheless, orphanhood with a live farther and a feeling of his difference from others deeply wounded his young soul and gave rise to a feeling of loneliness among people and striving to fly away to the dreamland with fascinating virgin nature and fervent noble hearts ...

In the autumn of 1827 she went with young Mikhail from Tarkhany to Moscow (their first address was a mansion of Kostomarova, wife of a Guards' ensign in the Povarskaya Street) to send him to the University Noble Boarding School*. In contradistinction to high schools and universities the said school (like the Imperial Lyceum in Tsarskoye Selo near Petersburg—*alma mater* of our great poet Alexander Pushkin) admitted only children of the nobility to prepare them for "important sectors of the government service". The lessons were conducted under individual programs which included a wide range of subjects such as jurisprudence, theology, military art, mathematics, physics, geography, natural science, drawing, music, dancing, practical farming, etc., but the Russian language and literature were the main subjects.

In Tarkhany Lermontov under supervision of the hired teachers studied history, literature, music, Greek, Latin, German and French languages. It enabled him to read the books of foreign authors in original available in the excellent home library and at the same time national journals and books. In order to prepare him thoroughly for entering such privileged educational establishment his grandmother invited experienced pedagogues including Alexander

**See*: Ye. Sysoyeva, "The Torch of Learning", *Science in Russia*, No. 3, 2007.—*Ed.*



Monument to Lermontov.

Portrait of Lermontov at the age of 3-4 years. Unknown painter. State Literary Museum.

Zinovyev who worked at the said school. The latter gave lessons to him in Latin and Russian languages, general history, geography and took him frequently for interesting cognitive walks in the center of Moscow.

Lermontov entered the fourth form of the boarding school right away (there was a total of six forms), was an ardent student and made great advances. There he received comprehensive education, which allowed him to become not only a real master of the word, but also a wonderful painter and a musician, which is due to his remarkable teachers (in higher forms there were mainly professors of the Moscow University). Apart from Zinovyev one should mention Semyon Raich (Amfiteatrov), at that time a known poet in the country who headed practical studies in Russian and established a society of lovers of Russian philology at the school, where the students (including the future great poet) read and discussed their fictional experiments.

Rhetoric, Russian and Latin languages were taught by Dmitry Dubensky, a lecturer at the Moscow University, a writer, "an enthusiast of folk poetry" and an expert in "The Lay of Igor's Warfare". A course of lectures in literature was given by Professor Alexei Merzlyakov, a poet and the author of the poem "Amidst the Flat Valley" (1810) set to a folk music, which later became a popular romance. He was also Lermontov' private tutor. It should be stressed that the teachers possessed high erudition and progressive views. They were respectful towards their students and did not practice corporal punishment. Instead, for assiduity and advances in studies, they always awarded them with either a book or selection of a student's good work for an exhibition, or even a medal. Friendship and mutual assistance prevailed also among the students.

All these seeds of good deeds got into a beneficial soil, and a responsive poetic soul absorbed all obtained from the tutors. As Zinovyev put it about his student, "he read brilliantly pieces of Zhukovsky's poetry devoted to the sea and deserved a loud applause. He was good at drawing, was fond of fencing, riding, dancing, and he was not clumsy at all: he was a thickset youth promising to become a strong and healthy man in maturity". In a word, the moral atmosphere at the school was extremely benevolent, which contributed to successful comprehension of sciences, training in arts, cognition of the environment and in addition penetration of freethinking ideas. It is no mere chance that quite a number of graduates of this school happened to be among the participants of the Decembrist Revolt of 1825. That same year Emperor Nicholas I deprived this "hot-bed of freethinking" of many privileges and reorganized it into a public high school in 1830, as a result, a lot of students including Lermontov filed a resignation.

In the course of two years at the school, the young poet wrote about 60 poems (four handwritten notebooks kept today at the Institute of Russian Literature—Pushkin House*, St. Petersburg), in particular *The Prayer, Bed-of-Honor, To Caucasia, Autumn, Complains of the Turk, Monologue, Corsair,* the play *Spaniards*, etc. Besides, he was among Moscow theater-goers, was passionately drawing, moulded using wax, made new friends including such close friends as Alexandra Vereshchagina, Alexei, Mariya and Varvara Lopukhins. Lermontov was in love with Varvara; moreover, despite other objects of passion, "his feeling towards her... was inexplicable but true and deep,

**See*: Ye. Bogatyryov, "Literary Pantheon", *Science in Russia*, No. 6, 2005.—*Ed.*

Portrait of Lermontov's mother. Unknown painter. State Literary Museum.

Portrait of Lermontov's grandmother. Unknown painter. State Literary Museum.

and he remained faithful to her almost to his last days", as his relative and close friend Akim Shan-Girey recalled later. Lermontov dedicated a number of poems to her: *She With Her Not Proud Beauty, Forget Vain Troubles, Fate Brought Us Together by Chance* (1832), *Really, I Am Writing to You by Accident, Indeed* (1840), *In a Midday Heat in a Valley of Dagestan* (1841).

In the autumn of 1830 Lermontov became a student of the Moscow University. Initially he attended lectures at the moral and political department, later on he left it for the department of philology but stayed there altogether for less than two years. Well-informed in excess of the education program he often did not know the lecture material, which caused tensions with professors, and finally the ambitious youth left the university. Instead, social life, such as different receptions, balls, masked balls, etc. became a real school of life and a rich material for studies of human nature for the future author of the first Russian psychological novel *The Hero of Our Time*.

It is not accidental that literary critics call the university period the most fruitful in Lermontov's creative work. In those years he created several lyrical cycles, cast by ardent love affairs and search for an ideal (*To N.F.I..., Romance, To K..., Tired out by Depression and Ailment, Sonnet*, etc.) and poems *The Circassians, The Caucasian Captive* which reflected his own childhood experiences of the stay in Caucasia*. The discord between the most loved persons, i.e. his grandmother and his "dear daddy", responded with acute pain in the poet's soul. Later on he took his father's untimely death hard in 1831. He dedicated some verses to this sad event in his life: *Awful Fate of the Father and His Son, Epitaph (Forgive me! Shall I be Seeing You Again?), I Saw a Shadow of Blessing; but Quite..., Let me be in Love with Somebody...,* drama *A Queer Customer,* etc.

**See*: O. Bazanova, "...Caucasia, His Poetic Cradle...", *Science in Russia*, No. 2, 2014.—*Ed.*

From August of 1829 to late May of 1832 Lermontov and his grandmother lived in a small one-storeyed wooden mansion with a penthouse in the Malaya Molchanovka Street. Built by the merchant Pyotr Chernov in 1814-1817, the mansion is the only building in Moscow whose walls remember the great poet, and since 1979 it houses a department of the State Museum of Literature*. The original interior and everyday life items of the 19th century have unfortunately not preserved. To reconstruct the atmosphere of that period the exposition organizers referred to pictorial graphics, documentary and epistolary sources.

Meanwhile, the main wealth of the memorial mansion includes autographs, manuscripts, 15 paintings and drawings of our great compatriot created in 1837-1841 (views of Caucasia, self-portrait, etc.) and portraits of his relatives depicted by unknown serf painters. For example, on the writing desk in his grandmother's room we can see an almanac *Cepheus* of 1829 of the Moscow University Noble Boarding School with the first publication of the young author, a textbook *Course in Mathematics by Bezout* with the author's dedication, and Lermontov's application to enrol him in the Moscow University.

On the writing desk in the small drawing room there is a title page of the tale *Angel of Death*, which the poet dedicated to his good friend Alexandra Vereshchagina. His water-color drawings are placed on the wall, such as an illustration to his drama *Spaniards*—a portrait of Varvara Lopukhina as a nun, *Landscape with Horsemen, The Spaniard with a Dagger* and a portrait of his father made after his sudden death. On an oval table there is a

* *See*: L. Morozova, "A Guest Invited or Guest Sudden, He's Visited this Wondrous World...", *Science in Russia*, No. 3, 2005.—*Ed.*

Ivan the Great Bell Tower. Engraving. 1872.

copy of *Book of Fates* made by Lermontov as an attribute of an astrologer's costume for a New Year's masked ball at the Noble Assembly. It contained holiday addresses to the guests.

The fascinating impression is produced by a portrait in the large drawing room, which is made by a serf painter, as if foreseeing the fate of a genius: little Mikhail is depicted with a sheet of paper in one hand and a brush in another. Nearby are portraits of his mother and grandmother perhaps made by the same painter. There are exquisite basreliefs by the remarkable sculptor Fyodor Tolstoi dedicated to the Patriotic War of 1812 on the opposite wall. The adjacent room displays picturesque and graphic works by Lermontov. They include first of all his self-portrait of 1837 well known to admirers of his creative work and presented by the author to Varvara Lopukhina (the portrait remained in Germany for many years and only in 1962 was returned to Russia); a portrait of his friend Svyatoslav Rayevsky in a costume of a Kurd; drawings of galloping horses and landscapes.

Lermontov's study in the penthouse is the holy of holies of the mansion. There are books of the most respected historians, philosophers and writers, goose quill, homemade copybooks, abstracts of lectures, engraving with a view of the Ivan the Great Bell Tower (which he visited often with his tutor Zinovyev) in the Moscow Kremlin, which aroused his pride and reference. Such was the poet's "cell", who wrote about himself: "From the very first days of my life I was fond of gloomy solitude, where I sought shelter in myself, fearing that unable to hide my sadness, I will arouse human regret…"

With a view to continue his education at the Petersburg University, Lermontov and his grandmother moved to the northern capital in the autumn of 1832. But he spent summer as before (previous three years) in Serednikovo*, an estate of his grandmother's brother. A spacious park and estate ensemble of the late 18th century (the author is supposedly one of the founders of Russian classicism** Ivan Starov) on a high bank of the Goretovka rivulet with a system of ponds is even today an unusually picturesque and romantic place near Moscow.

The elegance and harmony of architectural solutions are in full conformity with delicate lyricism of the surrounding Russian nature. The manorial two-storeyed mansion is connected by a roofed colonnade with four side wings, and all five constructions are topped with identical small turrets. One of the side façades of the main building overlooks the broad stairs, which go down to a picturesque pond and is laid with massive stone plates once used by the great poet. The dilapidated bridges here and there in the park also remember Lermontov. These traits of Moscow landscape are recognizable in his works, and some poems of the early 1830s are even marked with notes "Serednikovo. At night at the window" or "Serednikovo. Evening on the belvedere. July 29".

In 1992 the National Lermontov Center was set up at the estate, which initiated its restoration in line with the old drawings. This process is now under way as a vast territory (almost 120 hectares) is to be put in order. Fortunately such valuable object of cultural heritage of the federal importance is one of the best well-preserved park and estate complexes of the Moscow Region. Suffice it to say that all 16 constructions existing here the century before last (including household outbuildings such as cattle-yards and stables, manège, several greenhouses, coach-house, etc.) are preserved to this day. Now many interiors are restored, and the manorial mansion houses an exposition related to the life and creative work of our great compatriot.

The remarkable fact is that a part of décor of the early 20th century (fragments of curtains of window openings, a

* *See*: O. Bazanova, "At the Crossroads of Fates and Roads", *Science in Russia,* No. 2, 2010.—*Ed.*

***See*: Z. Zolotnitskaya, "Lofty Simplicity and Dignity", *Science in Russia,* No. 3, 2009.—*Ed.*

Serednikovo estate. Bird's-eye view.

In the park of Serednikovo.

mirror with marble tabletop, doors and earthenware tile floor) is almost intact in the entrance hall of the main building. But owing to the skill of the restorers everything looks here now just like in those years. We go up the stairs decorated with wood carving and lighted by four stained-glass windows of the late 19th century and get to the second floor. The main marble (or oval) hall served often as a music saloon to the owners. In 1890 on order of the estate

Interiors of the main building of the Serednikovo estate.

owner Vera Firsanova its shade was decorated by the painter Victor Shtember with the fresco *Demon and Angel carrying away Tamara's soul* based on Lermontov's poem *Demon*, which we see today.

There is a library in an adjacent room with ancient books, and the Serednikovo "chronicle" is reproduced in photos in the next room. One hall on the second floor is dedicated to Vera Firsanova who did much for memorizing the poet's stay in Serednikovo and also for public education. Here are restored items belonging to her, which are at least 100 years old, such as a wardrobe with a mirror, a kiot (small box for icons), etc. and also modern tapestries with portraits of Lermontov and his grandmother.

A special section of the exposition deals with the history of the Lermontov family which begins from the Scottish singer and prophet of the 13th century Thomas Learmonth (the family name is known since the 11th century). One of his descendants served in the Polish army, was taken prisoner by Russians near Smolensk* in 1613. He became member of the Orthodox Church and signed up to tsar Mikhail Fyodorovich—this is how a branch of this genealogical tree appeared in our country. Among elegant carved oak furniture the museum visitors will see the colors with the family emblem and photos of his contemporary representatives, ancient Scottish castles, etc.

In the year of centenary of the poet's birth, a stele was installed near the main mansion with the following inscription on one side: "Mikhail Lermontov. 1914. This obelisk is erected in memory of his stay in Serednikovo in 1830-1831" and on the other side: "To the singer of sadness and love...". Besides, the then mistress of the estate Vera Firsanova ordered in Paris his bronze bust after a plaster model made by the sculptor Anna Golubkina in 1900.

The poet abandoned forever this wonderful place of repose and a "refuge of thoughtful dryads" in the autumn of 1832 and started for Petersburg hoping to enroll in the third year of studies at the Petersburg University after two years at the Moscow University. There he was offered to begin studies from scratch but under influence of his relatives and to the joy of his grandmother Lermontov enlisted in the School of Guards' Sub-Lieutenants and Cavalry Junkers. But, the newly made cadet's soul was far from the Neva banks. He wrote to Mariya Lopukhina in those days: "Moscow is my homeland, and it will be such forever. It is where I was born, suffered so much and was too happy as well."

Probably it is not accidental that only in separation from his favorite ancient capital the poet created an impassioned hymn dedicated to Moscow. In 1834 on the instructions of the teacher from the junker school Vasily Plaksin (who highly estimated the literary talent of his student) Lermontov wrote a composition "Moscow Pan-

* The siege of Smolensk in 1613-1617, an episode of the Russo-Polish War of 1609-1618.—*Ed.*

Emblem of the Lermontov family.

Petrovsky Roadside Palace, last refuge of Lermontov in Moscow.

orama". He endowed the city, dear to his heart and often observed by him in his childhood from the Ivan the Great Bell Tower, with "soul, thought and language", here "every... stone keeps inscription made by time and fate, inscription unintelligible for a crowd but rich and abundant in thoughts, feeling and inspiration for the scientist, patriot and poet!.."

The poet dedicated particularly eloquent lines to "heart of Moscow": "What can be compared with this Kremlin, which surrounded by toothed walls and shining with golden cupolas of cathedrals, rests on a high hill like a sovereign wreath on the brow of a terrible master?.. It is an altar of Russia where many sacrifices worthy of the homeland should be made and are already made..."

After 1832 Lermontov happened to be in his home city only in passing. But eight years later on his way from Petersburg to the Caucasian exile (punished for duel with a son of the French envoy Ernest de Barante) he lived almost a month in Moscow. Here he gained numerous pleasant impressions, in particular, he heard a lot of enthusiastic comments after he read the new poem *The Novice* on the Saint Nicholas Day (May 9) in the mansion of the historian, collector, publicist and publisher Acad. Mikhail Pogodin on the name-day celebration party of the writer Nikolai Gogol, where he met a lot of well-known Moscow men of letters of the day. In those days he became friends with the first-string Slavophils*, namely, publicists and philosophers Yuri Samarin and Alexei Khomyakov (Corresponding Member of the Petersburg Academy of Sciences) related to him by love of Motherland, conviction in national cultural identity, resorting to history and popular arts, belief in a special mission of Russia.

Of interest may be Samarin's words about the poet: "I often met Lermontov during his stay in Moscow. He has an extremely artistic nature, elusive and giving no way to any external influence owing to his power of observation and a significant dose of indifferentism. Even before you start speaking to him, he already sees through you; he takes note of everything; he has a heavy look, and it is tiresome to feel this look...This man never listens to what you are saying, he just listens and watches..."

During his last visit to Moscow in the spring of 1941 on his way from Petersburg to Caucasia Lermontov stayed there only for five days but he thought of them later with great warmth. He stayed at the Petrovsky Roadside Palace in the apartment of Dmitri Rozen, his fellow soldier in the Life Guards' Hussar Regiment. He took part in folk festivities, met his friends, in particular Samarin, who already after the poet's death as if experienced parting with him over and over again: "I shall never forget our... meeting... half an hour before his departure. When parting he gave me his last verses. All this comes back to me with striking clearness...

He told me about his future and his literary projects, and among all other things he let fall a few words about his impending death which I took as a joke on his part. I was the last person who shook hands with him in Moscow."

* Slavophilism—a literary and philosophical movement in Russia in the middle of the 19th century, oriented to substantiation of its identity and a special type of culture differing from the Western European way, which originated on the base of orthodoxy.—*Ed.*

Illustrations supplied by the author

"THE COUNTRY WHICH COULD HAVE BEEN A PARADISE BECAME A DEN OF FIRE..."

by Alexander MAKARYCHEV,
Kaliningrad Regional Museum of History and Arts

At the end of 2013 in anticipation of the 100th anniversary of the outbreak of World War I of 1914-1918 which is marked in 2014 the Kaliningrad Regional Museum of History and Arts sponsored a set of exhibitions devoted to this event. Assistance in replenishment of exhibitions was provided by the Russian State Archives of the Navy, Central Naval Museum, Military Historical Museum of Artillery, Engineers and Signal Corps (St. Petersburg), Archives of Foreign Policy of the Russian Empire (RF MFA) and State Central Museum of Modern History of Russia (Moscow).

After the Great Patriotic War of 1941-1945 was over, an exhibition of the captured weaponry and combat equipment was arranged in the Kaliningrad Region (the northern part of East Prussia which then joined the USSR), and in 1946 on its basis the Regional Museum of Local Lore, History and Economy was established. In 1977 the museum achieved status of a historical and arts museum, and in 1991 it settled in the Stadthalle (city concert hall), a fine three-storeyed building built in 1912 by the Berlin architect Richard Seel (monument of architecture of the 20th century). Its collection of artifacts numbers above 120,000 storage units and describes history and nature of this Baltic region.

The permanent display of the museum includes unique archeological findings, decorations, coins of different years, weaponry and household items, engravings, portraits, rare books, etc. and allows to trace formation and development of the region from antiquity to our days. Temporary exhibitions acquaint visitors with works of local, Russian and foreign artists. A special section deals with World War I which left an indelible trace in East Prussia*. The showcases and stands display photos of military commanders, operation maps, national and German awards, cold steel and fire arms, soldiers' letters, front-line items, posters of Russian and

* *See*: A. Makarychev, "From Königsberg to Kaliningrad", *Science in Russia*, No. 3, 2014.—*Ed.*

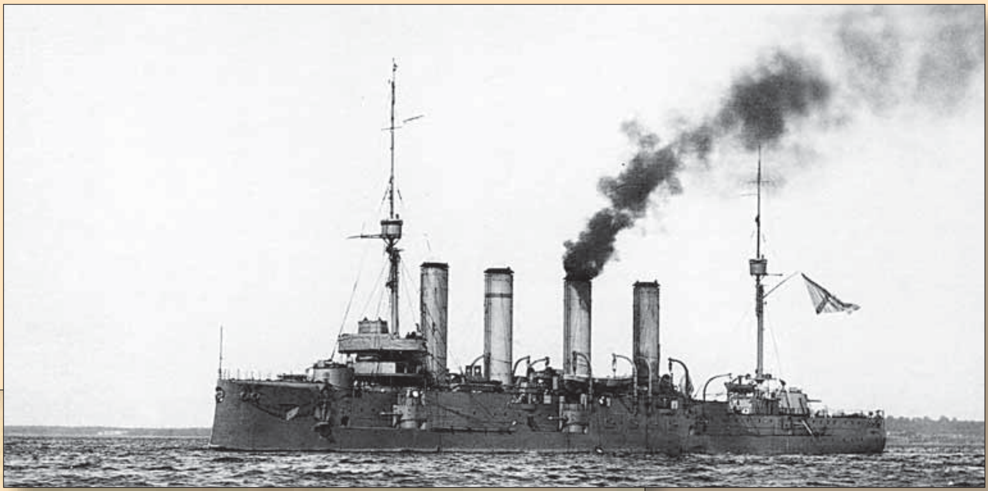
Kaliningrad Regional Museum of History and Arts.

Section of a permanent exposition devoted to World War I.

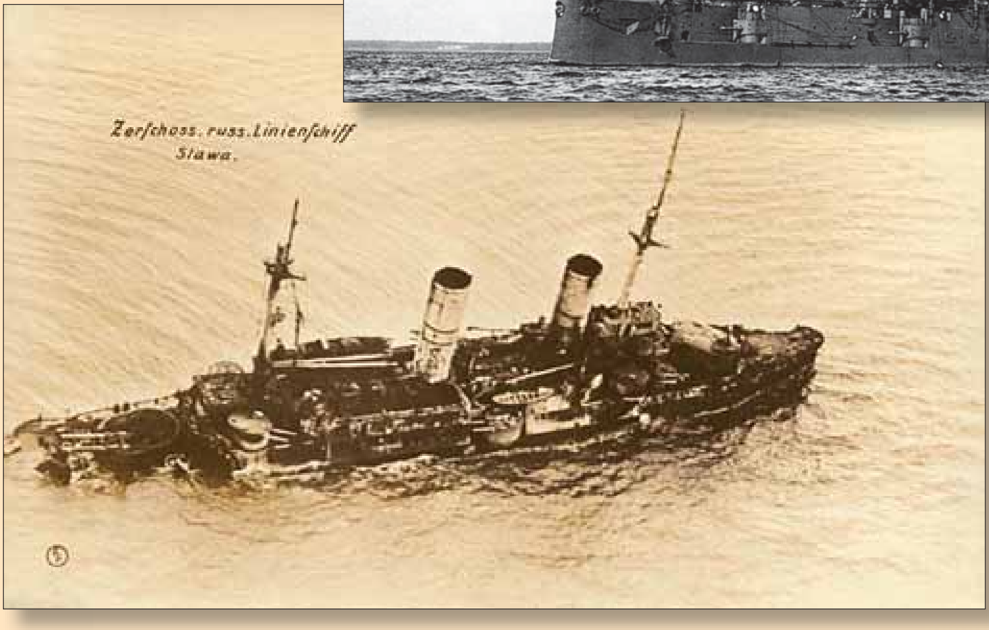
German artists, photos of local cities damaged by shelling, etc.

On the eve of the 100th anniversary of the outbreak of World War I, the museum organized a number of exhibitions devoted to this event. It is important to point out that the Kaliningrad Region is the only place in the present territory of Russia where combat operations took place at that time. Here on August 7*, 1914, the first battle near Gumbinnen (today the city of Gusev) was conducted at the Eastern Front, which resulted in the victory of our troops. Practically simultaneously in this region an important event took place also at the theater of naval (Baltic) operations. The Russian cruisers *Bogatyr* and *Pallada* captured the German light cruiser *Magdeburg*, which ran around in the Gulf of Finland near the Osmussaar Island (today Estonia). One of its signal-books was handed over to the British Admiralty, which helped decipher the German naval

* All dates are given in Old Style.—*Ed.*



The armored cruiser ADMIRAL MAKAROV—a participant of the Battle of Moonzund. 1917.



The blown up battleship SLAVA lying on the ground. 1917.

code (used for transmission of secret documents by signals) and in the end promoted victory of the Entente.

When the operations started, the Baltic Fleet (4 battleships, 6 armored and 4 light cruisers, 13 destroyers, 50 torpedo-boats, 6 minelayers, 13 submarines and 6 gunboats) was replenished with 4 new dreadnoughts of the *Sevastopol* type and also destroyers of the *Novik* project and submarines of the *Bars* series, noted for high combat characteristics. To prevent an enemy breakthrough to the Gulf of Finland, the Russian Command created the Central Mine-and-Artillery Position (above 2,000 mines were installed between the Nargen Island and the Porkkala Udd Peninsula*) and another 3 positions for defense of the Gulf of Riga. Our seamen conducted systematic military operations also near the enemy seacoasts and on its naval communications including in the area of ports Danzig (Gdansk, Poland), Pillau (Baltiysk), Memel (Klaipeda, Lithuania), and Libava (Liepaja, Latvia).

* Nargen Island (today Naissaar, Estonia); Porkkala Udd Peninsula in Finland.—*Ed.*

In the summer of 1915, a force of cruisers *Bayan*, *Admiral Makarov*, *Oleg* and *Bogatyr* conducted a successful battle near the Gotland Island (Sweden) against the German cruisers *Augsburg*, *Bremen* and *Roon*. Meanwhile, the naval forces of the Gulf of Riga (battleship *Slava*, destroyers *Novik* and *Amur* and several torpedo-boats) repelled the enemy attempt to break through the minefield in the Irbensky Strait (between the Gulf of Riga and the Baltic Sea). Our seamen put up a good fight. For example, near the Kynö Island (Kihnu, Estonia) the gunboat *Sivuch II* together with *Koreyets*, a ship of the same class, joined unequal battle with the German cruiser *Augsburg* and two torpedo-boats, joined by battleships *Pozen* and *Nassau*, but it was sunk and for this act of heroism it was called the Baltic "*Varyag*"*.

The Russian submariners more than once intercepted the German ships which carried iron ore from neutral countries and sank them in the Gulf of Bothnia. The

* In the course of Russo-Japanese War of 1904-1905, after an unequal battle with the enemy squadron our armored cruiser *Varyag* was considerably damaged by enemy shells but it did not surrender to the enemy and was sunk by its crew.—*Ed.*

World War I posters.

The ensign of the 10th Finland infantry regiment Afanasyev. Painter, Vladimir Poyarkov. 1916-1917. Military Historical Museum of Artillery, Engineers and Signal Corps. St. Petersburg.

The sergeant-major of the 1st Life-Guards artillery brigade Shchelkunov. Painter, Vladimir Poyarkov. 1916-1917. Military Historical Museum of Artillery, Engineers and Signal Corps. St. Petersburg.

surface ships rendered substantial assistance to the ground troops which defended the coastal area of the Gulf of Riga by systematic shelling of the German positions and making landings.

When in the autumn of 1917 our ships and coastal artillery held back the superior enemy forces near the Moonzund Archipelago, they wiped out 10 enemy destroyers and 6 mine-sweepers, damaged 3 battleships and 13 destroyers and torpedo-boats. It was the last battle of the Russian seamen in World War I and after that they left the Gulf of Riga. But the German Command also stopped their offensive operations and withdrew its ships from that area. Thus, the Baltic Fleet prevented the German supremacy in the sea and retained fighting efficiency up to the end of operations. In total our losses made up 36 ships while Germany lost 102.

The visitors can be acquainted with these events at the exhibition *War on the Baltic Sea* prepared by the Kaliningrad Museum in cooperation with the Russian State

Senior non-commissioned officer of the Life-Guards Finland regiment Glumov. Painter, Vladimir Poyarkov.1916-1917. Military Historical Museum of Artillery, Engineers and Signal Corps. St. Petersburg.

Medal "For Services in Excellent Execution of General Mobilization of 1914". 1915. Kaliningrad Regional Museum of History and Arts.

Archives of the Navy and Central Naval Museum (St. Petersburg). The exposition displays a report to the Minister of the Navy Admiral Ivan Grigorovich with a list of documents found on board of the cruiser *Magdeburg* captured by our seamen in 1914. There are also cables to the naval department of the Supreme Command General Headquarters which informed about a loss of the cruiser *Pallada* of the Baltic Fleet in the same year (probably the enemy shell got into its bomb or mine cellar) and the gunboat *Sivuch II* sunk by the enemy in 1915.

Displayed here is also a report on the last battle of the battleship *Slava* on October 17, 1917 in the Moonzund Strait as well as photos of the battle. On that day during an artillery "duel" with the German dreadnoughts *König* and *Kronprinz Wilhelm*, the fore gunturret of the Russian ship broke down for technical reasons, and a bow draught reached 10 m. The chief of naval forces of the Gulf of Riga Vice-Admiral Mikhail Bakhirev ordered to scuttle the ship (and thus to block the seaway) and then to torpedo it from the destroyer *Turkmenets-Stavropolsky.*

The photos of the Russian surface ships, submarines and national aircraft, the documents on operations of the British submarines in the Baltic Sea help perceive the atmosphere of heroic everyday life of our seamen in those stormy days. Interesting specialized exhibitions on the same subject were also sponsored on the basis of private collections. Personal badges and articles of uniform were displayed at one of the exhibitions, while the main awards of the Russian officers and seamen of the period of World War I were demonstrated at another exhibition.

Based on the materials of the Foreign Policy Archives of the Russian Empire now at the disposal of the Russian Ministry of Foreign Affairs the Kaliningrad Museum organized an exhibition "From the History of Diplomacy of World War I of 1914-1918". The exhibition gave an insight into the relations which developed at that time between Russia, Germany, France, Great Britain, Serbia and Austro-Hungary. Copies of secret cables to the Minister of Foreign Affairs Sergei Sazonov were among the most interesting exhibits. For example, the cable from the Russian Ambassador in Vienna Nikolai Shebeko informed about assassination of the successor to the Austro-Hungarian throne archduke Franz Ferdinand and his spouse duchess Gogenberg by Serbian Gavrilo Princip. Another cable from the Russian charge d'affairs in Serbia Vasily Shtrandtman dealt with an address of Serbian prince-regent Alexander to Emperor Nicholas II. The young monarch asked for assistance in view of an ultimatum of Austro-Hungary with a request to investigate the crime with its participation and punish the guilty. The tsar left a curious note on the cable: "It is a very modest and worthy cable. What reply shall I give to him?".

The copy of Sazonov's report (September 7, 1914) to the tsar on a conversation of the Russian Ambassador to London Alexander Benkendorf with the King Georg V of Great Britain is of great historical importance. The question was that making peace with Germany was inadmissible until "the might of the latter was not broken down completely". Nicholas II wrote on the margins: "I share every idea of the King. I ask count Benkendorf to categorically assure His Imperial Majesty of the fact that despite any obstacles or losses Russia will fight against its enemies to the end."

The exposition gives a chance to trace development of diplomatic, political and military relations between the Entente states and the German bloc, and a process of transition from negotiations to "the language of guns". The exhibition visitors can also clearly visualize personal attitude of the Russian ruling circles, first of all, of the Emperor Nicholas II, to the positional or trench warfare. The latter implied the tactics which the fighting armies for the first time in history were forced to use in 1914 at the Western Front (and in 1915 at the Eastern Front) due to a gross lag in technology of offensive arms from means of defense. Under such conditions the warring parties tried mainly to hold their positions as active operations proved to be ineffective. At that time the

Medal-like badge "Supreme Commander-in-Chief General Brusilov". Not before 1916. Kaliningrad Regional Museum of History and Arts.

German leadership hoped that it deprived our army of ability to conduct major offensive operations. But the tsarist government assured the allies of a firm intention of Russia to continue the war to the victorious end.

The exhibition "The Last War of the Russian Empire" was based on the collections of the Kaliningrad Regional Museum which included household items, documents, uniform, ammunition, weaponry, artworks and posters of those years. The exposition "gem" was a set of documents devoted to one of the best performers of folk songs and romances of that time Nadezhda Plevitskaya. In November of 1914 she accompanied her husband, lieutenant of the Cuirassier regiment Vladimir Shangin, to the front, and she got a job as a nurse in a field hospital of the city where his military unit was located.

The singer's unique voice helped a lot of wounded soldiers to recover. Her recollections "My Life With a Song" win over by simplicity and sincerity: "Sometimes my songs worked as a medicine. Once a nurse came from the officers' department and asked me to help her soothe a seriously wounded patient who was apathetic even to morphine. Sitting on his bedside I hummed quietly songs and he fell asleep. I sat for a long time motionless as he held tightly my hand...". The central place in the exposition belongs to a gramophone of the end of the 19th century and records of songs of Plevitskaya which allow to better understand the Russian spiritual life of that time including its musical culture.

The photo exhibition "Belarus in World War I" which showed events of that period through the eyes of participants and witnesses was compiled by our staff members from copies of the photos provided by the Belorussian National Historical Museum (Minsk), other collections and individual collectors. In the autumn of 1915 the enemy tried to penetrate deep into the country and occupied a substantial part of this region where above 2 mln people found themselves under German occupation. But due to staunchness of Russian soldiers, the enemy was stopped on the military line Dvinsk-Postavy-Smorgon-Baranovichi-Pinsk. This frontline was preserved until the end of the war in 1918.

The exposition materials were grouped into the following four sections: the burden and hardships of people left on the pavement and forced to abandon their homes; army life in a rare lull in fighting; hospital physicians and attendants facing an unprecedented number of the wounded; battlefields, burnt down houses and graves of soldiers. Nobody could have remained indifferent to photos of exploded ground, a village on fire, a woman crying at a cemetery, a group of refugees with children...

The visitors got interested in small displays, rather complexes of unique items, provided temporarily for viewing by citizens of the Kaliningrad Region whose forefathers participated in operations in the territory of Eastern Prussia such as photos, decorations, documents and personal effects carefully kept in family archives.

"The World War I in Posters" impressive exhibition was prepared on the basis of museum pieces of the State Central Museum of Modern History of Russia (Moscow), which possessed one of the largest collections of works of such genre in the world. The global military conflict of 1914-1918 called into being a powerful revival of this perhaps the most popular kind of graphic art. In our country the following prominent painters were engaged in the work on wall graphic art: Viktor and Apollinary Vasnetsov, Leonid Pasternak, Ivan Bilibin, Konstantin Korovin*, Valentin Serov, Lev Bakst, Konstantin Somov, Mikhail Vrubel and Mstislav Dobuzhinsky.

The displayed wartime posters provided with clear images and an easy to memorize energetic text possess an enormous emotional impact. Their subject is rather diverse and always patriotic: support of morale among civil population, army and navy; representation of feats of arms of our soldiers; unmasking of the enemy intentions; caricatures of its rulers and commanders; appeal to the country citizens for assistance to the front.

**See*: L. Lyashenko, "Music of Color", *Science in Russia*, No. 2, 2011.—*Ed.*

Bas-relief of the field-marshal-general Gindenburg. Germany. The first half of the 20th century. Kaliningrad Regional Museum of History and Arts.

Even today's visitors are greatly impressed by Pasternak's poster "Help to War Victims" (1914), which depicts a wounded soldier weary of war in heavy ammunition. The same appeal to their contemporaries was also made by Viktor Vasnetsov, who reproduced the folklore stories known to us from our childhood, for example, about a hero fighting against the three-headed serpent, and Korovin who used the image of the great commander prince Dmitry Donskoi, the first Moscow ruler who had started fighting for liberation of the motherland from the Golden Horde.

The exhibition of water-color drawings from the collection of the Military Historical Museum of Artillery, Engineers and Signal Corps (St. Petersburg) represents a gallery of portraits of holders of the St. George Cross of the World War I period. These works were implemented on the decree of Emperor Nicholas II by an artistic team of five students of the outstanding painter of battle scenes Nikolai Samokish for a commission on captured items in 1916-1917. It was created in 1917 (on the basis of two previously existing similar galleries) for description of acts of bravery of our soldiers, trophies, old national and captured enemy colors, insignia and other artifacts for the whole period of the Russian army existence.

Among these paintings let's single out realistic portraits of the ensign of the 10th Finland infantry regiment Afanasyev, sergeant-major of the 7th Finland infantry regiment Dudnikov, sergeant-major of the 1st Life-guards artillery brigade Shchelkunov, senior non-commissioned officer of the Life-guards Finland regiment Glumov and other holders of the St. George Cross, created by the gifted painter Vladimir Poyarkov.

The Kaliningrad Museum organized also an exhibition devoted to participation of the well-known representative of the Silver Age literature in World War I Nikolai Gumilyov (1886-1921) who fought in Eastern Prussia. "The country which could have been a paradise became a den of fire," he wrote in 1914, when he got to be called up to the front, though he was exempt from military service due to his bad eye sight. The poet was enrolled in the Life-Guards His Imperial Majesty Uhlan Regiment and on October 17, 1914, took baptism of fire in the battle of Vladislavov (today Kudirkos-Naumestis, Lithuania).

Thereafter Gumilyov participated in battles near the settlements of Shillenen (today Pobedino), Schirwindt (Kuruzovo), Pillkallen (Dobrovolsk) and the city of Lazdenen (Krasnoznamensk) in the territory of the present Kaliningrad Region and later described his frontline impressions in *Memoirs of Cavalryman* and a series of poems. He showed himself to be an expert rifleman and a brave soldier, was decorated with the St. George Cross of the 4th and 3rd degrees (1914 and 1915) and the St. Stanislaus Order of the 3rd degree with swords and bow (1917). The outstanding writer Alexander Kuprin noted: "It is not enough that he went to the present war as volunteer, he, and only he; could have poetized it. Yes, it is true that he was not devoid of... love for his country, of a sense of duty to it and a sense of personal honor. And so... he was always ready to pay at the price of his own life."

The exposition displays unique materials from collections of the Russian State Archives of Literature and Arts (Moscow) and the Museum of Anna Akhmatova in the Fountain House (St. Petersburg), connected with Gumilyov's biography and creative work in the war years. They include copies of the manuscript "Memoirs of the Cavalryman", poems, letters, addressed to his wife Anna Akhmatova in 1910-1918, rare photos, etc.

The abovementioned Kaliningrad exhibitions naturally reflect regional aspects of such scale event of the early 20th century as World War I, but they also help understand the role of Russia in the developments of those years and better learn national history.

Illustrations supplied
by the Kaliningrad Regional Museum
of History and Arts

THE 10TH CENTURY FAMILY PORTRAIT

by Vladimir KULAKOV, Dr. Sc. (Hist.),
Institute of Archeology, RAS

The summer of 2013 on the southern coast of the Baltic Sea was hot, though intense heat was hardly felt under the crowns of ancient trees, which covered one of the heights in the environs of Zelenogradsk (Kaliningrad region). Under this natural "umbrella" is actively working an international archeological expedition, organized on the base of the Baltic Federal University named after Immanuil Kant (Kaliningrad) within the framework of the international project "Cross-Roads 2.0". Young scientists and students from Russia, Lithuania and Poland carried out here excavations of the Prussian burial ground Minor Kaup. One of the findings turned out to be unique.

Excavation near Zelenogradsk.
In the foreground-location of the burial ground K70.

Expedition participants on the Kaup burial ground at the background of the project banner.

Cleared horse's skeleton in the burial ground K70.

The story about the finding I would like to begin from afar, touching upon the sources of such notion as a family portrait, which we connect with a high organization form of the society.

One of the first portrayals of the family—the most important social cell, a base of civilizations, including a contemporary one—is known through frescos of Pompeii. This small town, located on the slope of Vesuvius, in the center of the Apennine Peninsula, was buried under the volcanic ashes in 79 A.D. The excavations connected with this town promoted formation of archeology as science in the 18th century. There are found a great number of monuments of ancient art in Pompeii and neighboring Herculaneum. Among them a special place belongs to the fresco representing, according to specialists, a family portrait. United by love for versification (this is evident due to objects for writing in the hands of the man and woman on the fresco), young people demonstrate spiritual community, which points to the unity of their views on the environment.

Undoubtedly, earthly love plays a significant role in the family. This unalterable truth is illustrated by another

Portrait of a husband and wife. Fresco from Pompeii. 1st cent. A.D.

pair portrait of the 1st century A.D., originating from El Fayum in the Nile delta.

According to the presented artistic data we can assume that the family portrait originated at the apogee of the development of ancient civilization, in the epoch of the early Roman Empire. In the years of the rule of Emperor Octavian August and his closest heirs Roman society preserved purity and simplicity of ancient customs, reflected in respect for the family as an important social phenomenon. This respect is characteristic also of the Renaissance, when the family portrait was an important component of European fine arts. We can assert that it has not lost its significance even today, in the postindustrial epoch.

But what about family relations in Baltic region in the epoch of Vikings? This we found out during excavations near Zelenogradsk.

... That August day began as usual. Each of the expedition participant was engaged in his work. One of them, Roman, was clearing a rather solid filling of the burial ground under the code name K70. Finally his work was completed and we saw a horse's skeleton lying at the bottom of the grave. The clearing was a success: all details were well seen, among bones there showed up darkly like a cinder iron objects (bit, buckles, and stirrups). These findings allowed us to date the burial ground by the late 10th century. By the way, there is nothing surprising in the fact that the main find on the burial ground were horses' skeletons, as Prussians regarded these animals as the best "messengers" between the sky and the earth. Each burial starting from the 5th century A.D. was accompanied by sacrificing the horse.

Examining the findings Roman handed me over a rather unusual rectangular fragment. It's hard to imagine our surprise, when after its clearing, on the carefully scraped out right side we saw a woman's figure in a long skirt cut by a fine engraving tool. Her head and lifted up hands (this gesture means a prayer addressed to Gods), if you looked closely, formed a kind of a trident. The woman's face, framed by curly hair, was only marked by a chisel, but, nevertheless, it staggered. Unfortunately, the angles of the object, which turned out to be bone brackets, did not preserve. They were damaged by iron nails, which were used to fasten it to the wooden saddle pommel.

"Here are some more brackets,"—Roman showed me other bone fragments, lying among horses' vertebrae. After recording all this sudden wealth we started clearing other findings. It turned out that a pair of them, in size smaller than the woman's figure, portrayed figures of two children, wrapped in a kind of felt cloak. Their heads, damaged due to nail corrosion, did not preserve, but fingers hidden in the "cloak" cut, were seen well enough as well as soles of feet, marked, like the woman's figure, with an ornament made by dividers. It seems as if the bracket with the woman's figure was in the center of the saddle pommel, while the figures of teenagers (?) were fastened to its sides.

Thus, we faced the family portrait. Evidently the faithful wife placed her portrait surrounded by two children's figures on the saddle pommel of her husband carefully preparing him for a journey beyond the clouds. Her gesture symbolizing a prayer is turned to Prussian Gods with a request to spare a deserved place in the other world to the deceased. It is noteworthy that we could not find any weapons in the burial ground. Perhaps, the unknown inhabitant of the ancient land of Sambia (this was the name of the present-day Kaliningrad Peninsula in the 10th-13th centuries) did not accompany merchant caravans along the Neman to Kiev and even further, to Constantinople, fully armed, but led a settled way of life, possessed a workshop, where worked masters bone-cutters. As our excavations show a lot of Prussians decorated their saddles with carved bone. But the finding in the burial ground K70 surpassed all others by its splendor. The saddle edges were decorated with rectangular brackets, overlaid with curved and wattled ornaments. Besides, the latter according to its outlines resembled small snakes. Such associations are not accidental as it is a well known fact that Prussians and their neighbors worshipped grass-snakes, regarded as inhabitants of the other, underground world.

Bone brackets and the family portrait from the burial ground K70 (width of the big bracket 3.7 cm).

Brackets framing the saddle pommel from the burial ground K70.

Our finding demonstrates not only a high level of applied arts of the inhabitants of Baltic region of the epoch of Vikings, their means of bone processing and ability for portrayal of symmetric ornamental compositions. The discovered draft family portrait leads us to the main conclusion: in the 10th century the family in Prussia already proved to be a cell of the society, the kin with its leaders lost its significance and there began to form a structure of the society based, first of all, on individual contacts of its ordinary members. The discovered images represent important testimonies to prove the existence of Prussian culture. As was considered earlier it was completely destroyed by the Teutonic order founded in late 13th century, wiped off the face of the earth by settlers from Germany. But we should not forget that these settlers were strangers in the land, which was a possession of forbears of the Prussians for thousands of years.

Illustrations supplied by the author

MAJOR ACADEMIC EXPEDITIONS

by Nikolai VEKHOV, Cand. Sc. (Biol.),
Likhachev Russian Research Institute
of Cultural and Natural Heritage

In 1767 Empress Catherine the Great who took a keen interest in the organization and wealth of her possessions travelled along the Volga from Tver to Simbirsk. The Empress was not only delighted with the beauty of the great river but also went ashore in cities and villages and gathered information on the state of business, trade, factories and crafts. Everything she saw during her trip roused her to conceive a project unprecedented in range of works and involved territory, i.e. to form an authentic presentation of Russia, including geological, mineralogical, animal and plant resources, historical, socio-economic and ethnographic features of different regions.

The Empress ordered to sponsor several expeditions with a view to gather and publish necessary information to realize a grandiose scheme for studies of her state in naturalistic and historical aspects. Only eminent encyclopedic scientists were able to solve such important task. But as Russia lacked its own specialists in this sphere at that time (the national Academy of Sciences was founded just recently, in 1724), the European, mainly German, scientists were invited for participation in the forthcoming project.

The following specialists came from Germany: natural scientists Samuel George Gmelin junior, Johann Anton Güldenstädt and Johann Gottlieb Georgi and also the father of many trends of natural science Peter Simon Pallas, all of them were elected later fellows of the Petersburg Academy of Sciences. Johann Peter Falk, a famous botanist of that time and a disciple of the founder of biological sciences and outstanding biologist Carolus Linnaeus, came from Sweden. The prominent scientists were a base of leadership of field parties, and Pallas headed the whole

European Russia. Winter landscape. From the book: Pallas P. S., Bemerkungen auf einer Reise in die südlichen Statthalterschaften des Russischen Reichs in den Jahren 1793 und 1794.

project. When they came to the Russian capital, the preparation for its implementation was in full swing. It became clear that full-scale geographical studies were the main objective of the coming trip. It is no mere chance that this project is known in the history of formation of national science as "Major Academic Expeditions".

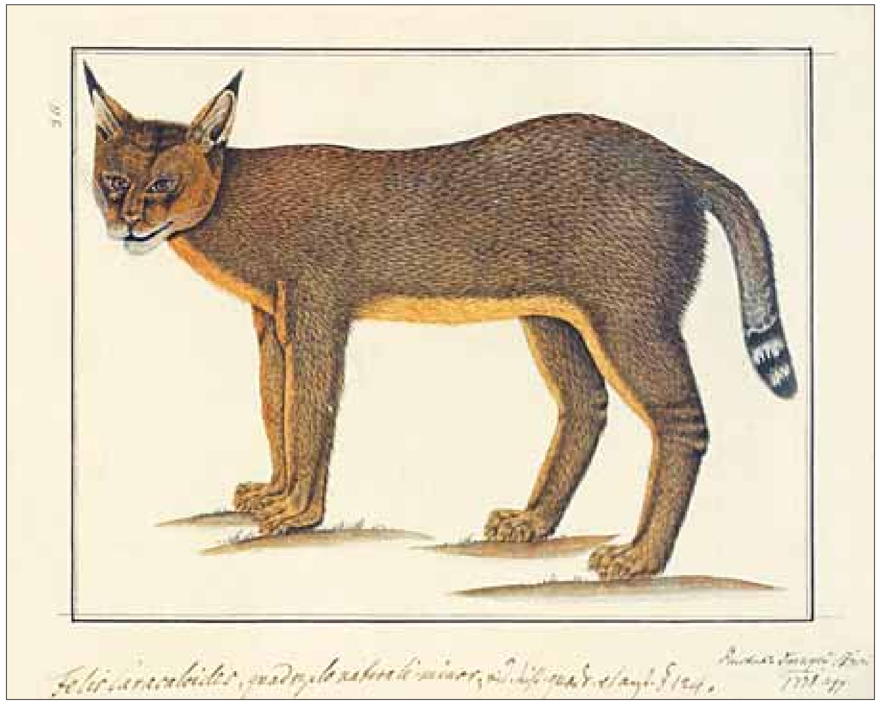
The elaboration of research routes and plans designed for a period of 1768-1774 was a responsibility of all national institutions interested in obtaining of up-to-date data including the Geographical Department of the Petersburg Academy of Sciences, Free Economic Society, Collegium of Medicine, Collegium of Mining and Collegium of Commerce. A special program was worked out for the expedition which included "observations... of the nature of lands and waters, populated localities, their advantages and disadvantages, growth and improvement of livestock farms, especially those producing wool; methods of fishing, wild animal trading, mineral coal, peat and ore signs; and also half-metals which are important for commerce. Besides, the Academy hopes that the travelers will note diligently everything which can provide explanation of... geography, describe social manners, spiritual ceremonies and ancient stories of peoples living in a country which they will visit and also pay attention to the encountered antiquities and examine ruins and remains of ancient places."

In the spring of 1768 the expedition parties were formed including six astronomical parties for Venus observation, three geographical parties to the Orenburg province and two parties to the Astrakhan province. The expedition was equipped with all necessary tools and instruments, appliances and laboratory equipment and a vast reference library. But their path was not strewed with roses. They moved in carts and mail coaches which broke down time after time, moved frequently in high winds, rainstorms and thunderstorms from which they sometimes could not find shelter. The surveying parties were not welcomed anywhere, and they were not always given the required help and came across sabotage in many cases despite the government instructions for the provincial authorities to assist them in such affair of national importance.

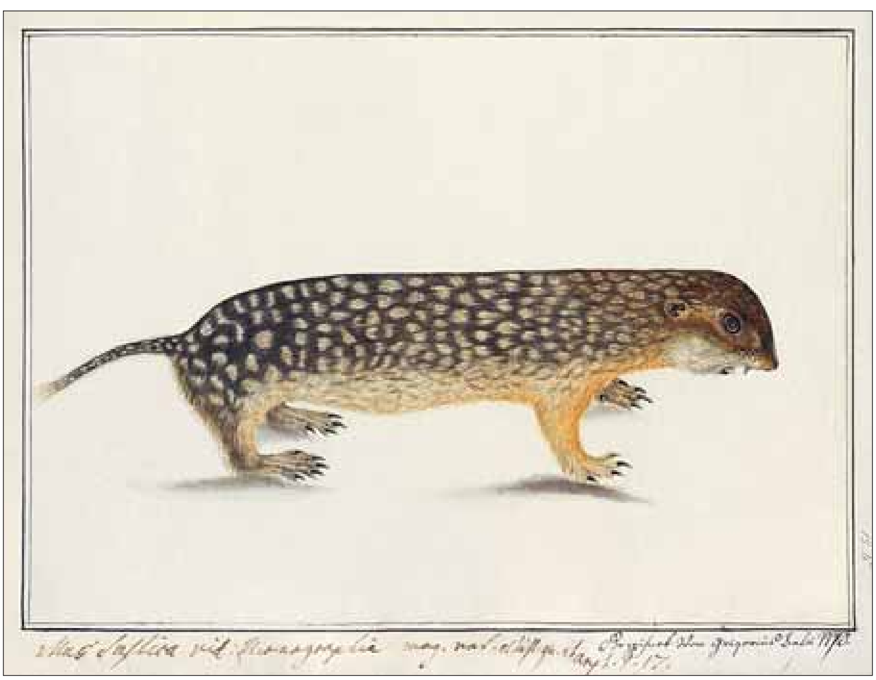
But it was not the most tragic thing. For six years that the travelers went about Russia, the draughtsman Ivan Borisov, naturalist Mikhail Kotov and academic students Boris Zryakovsky and Yakov Klyucharev died of diseases. Gmelin's death was a timeless and irreplaceable loss for the whole business. On his way back from Persia (Iran) in 1772 he was robbed and seized as hostage by the highlander in Dagestan who tried to get ransom for the foreigner, and two years later he fell ill from hardships of every kind and died in captivity at the age of 30.

The gifted botanist Falk during his wandering about Russia became an opium-addict and susceptible to hypohondria and depression, which interfered with his work, he wrote in his letter to Count Vladimir Orlov, the then director of the Academy of Sciences, who held him in high respect: "Gout, headache and hypohondria have exhausted me all over and I feel unhappy about it... But I feel unhappy most of all about the thought that with all my zeal but to the detriment of the Academy and my own shame I cannot discharge my duties." As a result, on March 31, 1774, the naturalist committed suicide. Even Pallas, who was a young man of 27 in his prime when he set off on a multi-year trip, returned from the expedition at the age of 33 grizzled and affected with ophthalmia and scurvy.

Only in the 20th century our contemporaries appraised worthily the selfless activity of the foreigners in Russian



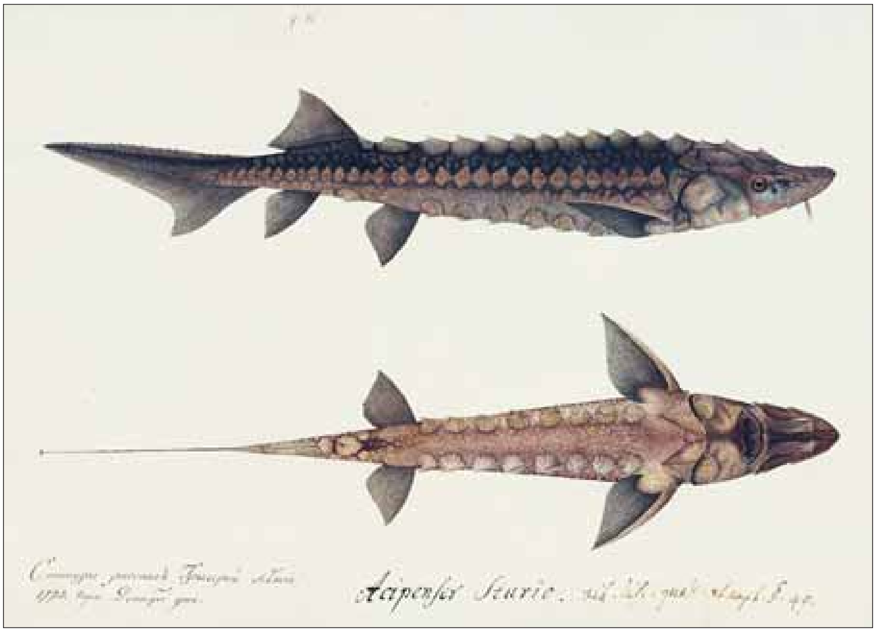
Caracal lynx.
From the book: Güldenstädt J. A., Reisen durch Russland und im Caucasischen Gebürge.



Spotted souslik.
From the book: Güldenstädt J. A., Reisen durch Russland und im Caucasischen Gebürge.

service. This is what Acad. Vladimir Vernadsky wrote about Pallas (*Studies in the History of the Academy*, 1988): his works "underlie up to now our knowledge of nature and people of Russia. They are inevitably referred to as to a living source by a geographer and ethnographer, a zoologist and botanist, a geologist and mineralogist, statistician, archeologist and linguist... His travels are in his presentation... an inexhaustible source of very diverse significant and negligible but always scientifically exact data."

Not belittling erudition and qualification of other researchers, it cannot be denied that the main and most diverse information was obtained just by Pallas and his colleagues. He headed the 1st party of the Orenburg expedition whose activity lasted from June 21, 1768 to June 30, 1774. Under the general instructions this party was entrusted with the following: "To study properties of waters, soils, tillage methods, farming conditions, frequent diseases of people and animals and seek out reme-



Atlantic sturgeon.
From the book: Güldenstädt J. A. ,
Reisen durch Russland
und im Caucasischen Gebürge.

Glass-snake.
From the book: Ivan Lepekhin,
Daily Notes of Travels in Different Provinces
of the Russian State in 1768-1772.

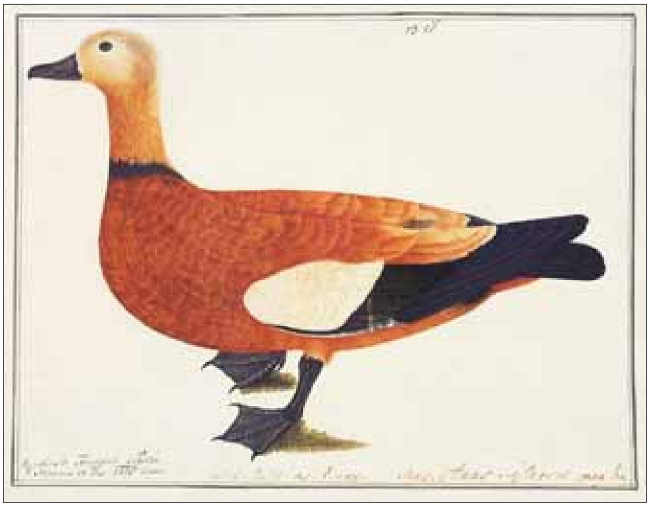
dies to cure and prevent them, and study bee-keeping, sericulture, cattle-breeding, especially sheep-breeding. Then pay attention to mineral resources and mineral waters, arts, crafts and trades of every province, plants and animals, form and interior of mountains, and, finally, all branches of natural science... To carry out geographical and meteorological observations, astronomic reckoning of main territories and gather all information related to manners, customs, faith, legends, monuments and various antiquities."

In 1768 Pallas' party started taking a route of Petersburg, Veliky Novgorod, Tver, Klin, Moscow, Vladimir, Kasimov, Murom, Arzamas and Penza, came to Simbirsk (today Ulyanovsk) where it stayed for winter. In March of 1769 the researchers moved to Samara, then to Syzran and Serny town (Sernovodsk). Back to Samara they travelled to Orenburg via Borsk (village of Borskoye, Samara Region) and therefrom to the Yaitsky town (Uralsk), reached Guryev along the Ural River and then Ufa through the steppe. Here the party waited through the cold months, and its head finished the first volume of *Travels to Different Provinces of the Russian State* (published in Petersburg in 1771).

To execute the Empress' order, in the summer of 1770 Pallas described almost 40 large and small Ural plants, including iron foundry, copper-smelting and steel works. Many of them such as Nizhne- and Verkhne-Tagilskiye, Saldinskiye, Bogoslovsky, Yuryuzansky, Vyksunsky, Turyinskiye, Nevyansky and Petropavlovsky works are operating up to now. The scientist described the methods of mining mineral resources, their reserves, transportation routes of raw materials and products, provision of water and manpower, ore content in rocks, distance to main industrial centers and many others, which was in essence the first evaluation of Ural as a main strategic region of Russia at that time.

In winter Pallas stayed in Chelyabinsk wherefrom visited Tobolsk and Tyumen. In May of 1771 he and his party went to Omsk, then moved southwards and visited the Altai region and reached Tomsk. He spent winter in Krasnoyarsk where he completed the second volume of his *Travels to Different Provinces of the Russian State*. Then he planned to go to China but due to his ill health he had to give up the idea of such long trip.

In March of 1772, the researchers proceeded to Irkutsk, crossed Lake Baikal, reached Selenginsk (today Novoselenginsk) and made a journey to Kyakhta (town in Buryatia in a border zone with Mongolia). After that they visited the Transbaikalia and returned to Krasnoyarsk where they stayed until January of 1773. From this geo-



Ruddy sheldrake.
From the book: Güldenstädt J. A., Reisen durch Russland und im Caucasischen Gebürge.

Ruff, male in a nuptial attire.
From the book: Ivan Lepekhin, Daily Notes of Travels in Different Provinces of the Russian State in 1768-1772.

graphical point which became the extreme eastern point in Pallas' trip the party moved to the European Russia. On the way to Petersburg the scientist stayed in Tsaritsyn (today Volgograd) wherefrom he several times visited Astrakhan.

The route of Pallas' party made in total about 28,000 km, which looks almost impossible even today when researchers have at their disposal various transport facilities and communication services. The many-year travels were connected with great difficulties and risks to life and required enormous efforts. Besides, as natives of Central Europe they faced an unfamiliar sharply continental climate. The expedition head was frequently ill, had frostbitten heels and chronic ophthalmia. They often had to stay overnight in abandoned winter huts and dug-outs and sometimes in the open air. The roads presented a lot of trouble, and it was difficult to get good horses. In wintertime they traveled by sledges and in summertime by carts and sometimes by water. On their way they met new regions of Russia where nomadic tribes did not shun robberies and plunder.

Meanwhile the expedition results exceeded all expectations: the invaluable data on zoology, botany, paleontology, geology, physical geography, economy, history, ethnography, culture and way of life of Russian peoples have become the basis for collections of the Kunstkammer*. Many of them are still kept in the museums of the Russian Academy of Sciences*, and a part of them got into the Berlin University. Pallas made also a number of discoveries. For example, he revealed and described several hundreds of the then unknown to biologists species of plants, insects, mammals, birds, fish and marine animals (including lancelet), studied the fossilized remains of the bull and representatives of the so-called hipparion fauna (mammals which lived 2-12 mln years ago in the Central Eurasia, where herbaceous forest steppes prevailed in that period), i.e. mammoth and woolly rhinoceros.

In 1772 in the Krasnoyarsk region the scientist saw a 680 kg block, the largest siderolite ever found in Russia, i.e. aerosiderolite or pallasite. The "celestial wanderer" given the name "Krasnoyarsk" (or "Pallas' iron") was sent to Petersburg and now is exhibited at the meteorite section of the RAS Mineralogical Museum. The expedition was also of paramount practical importance as it gathered data on unique natural wealth of Eastern Siberia and the Altai almost unknown till then and on the needs of the peoples living there. Of eternal value is also the fact that it was managed to describe fields, steppes, forests, rivers, lakes and mountains in a condition when they did not yet experience anthropogenic influence and were populated in plenty by animal species many of which disappeared already in several decades as, for example, tarpan.

* *See*: A. Teryukov, A. Salmin, "Kunstkammer and Its Collections", *Science in Russia*, No. 1, 2014.—*Ed.*

**See*: L. Pavlinskaya, "Formation of Ethnographic Science in Russia", *Science in Russia*, No. 2, 2014.—*Ed.*

Young Cossack girl in a holiday head-dress from the Terek. From the book: Güldenstädt J. A., Reisen durch Russland und im Caucasischen Gebürge.

Results of the travellers' scientific achievement were summed up in Pallas' numerous works published in Latin, German and Russian in Petersburg and then in English in Edinburgh and London and in French in Paris. These works were highly appreciated by the then international scientific fellowship and became a source of invaluable and detailed information on resources of our country.

The results of activities of other parties of the expedition also proved to be very impressive. For example, Johann Peter Falk and his assistants focused on the south of Russia, i.e. the Volga Region, Astrakhan and Kalmykia, and the steppe area of Western Siberia. The extreme points which he reached were Barnaul and Altai mines. The researchers gathered a vast botanical material and also plenty of ethnographic material related to the way of life and traditions of the Russian, Tatar, Bashkir and Kalmyk peoples.

Falk's notebook contains a large quantity of specific and sometimes minutest details about the nature and population of the visited places. In particular, he described thoroughly the "traces" of an ancient river connecting the Aral and Caspian seas in the geological past, i.e. dried-up river-bed, wells, springs, etc. Besides, the scientist studied the salty soils and springs in the Kuma (Kalmykia) and Kirghiz steppes, where he measured brine concentration by hydrometer, and also reservoirs of the Iset steppe (Eastern Ural) dividing them into fresh, licorice (brakish), bitter and empty (i.e. drying up and freezing).

Alas! The untimely death prevented the outstanding botanist from polishing his diaries, and it was done by Georgi who was familiar with his handwriting. *The traveller's Notes* by Falk were published first in German (1785-1787) and then in Russian as a part of *Collected Works on Scholarly Travels in Russia* (1818-1825).

Another member of the expedition, Johann Anton Güldenstädt, who started for the south of Russia in 1769 focused on the steppe regions from Voronezh and Tambov to Northern Caucasia and Georgia inclusive and then moved to Kiev via Poltava. His party undertook the longest trips and returned to Petersburg only in 1775. For seven years of travels which passed often in places where the foot of man had never stepped he managed to gather a great deal of valuable information on the natural conditions, the animal and vegetation world, minerals, resources, population of the territory under study, its way of life, economy and trade.

Güldenstädt is rightfully considered the father of Caucasian studies. In particular, it was just he who put into scientific use a rich factual material about the highland

Lapp.
From the book: Johann Georgi, Description of All Peoples Living in the Russian State and Also Their Life Ceremonies, Beliefs, Customs, Lodging, Clothes and Other Peculiarities.

Valdai girl.
From the book: Johann Georgi, Description of All Peoples Living in the Russian State and Also Their Life Ceremonies, Beliefs, Customs, Lodging, Clothes and Other Peculiarities.

separating the Black Sea from the Caspian Sea, which made a basis for studies of the local nature, first of all, rivers and lakes, salt and mineral waters, oil and thermal springs.

Ivan Lepekhin, one of the first Russian academicians (from 1768), also gathered unique information. The party headed by him studied a vast territory stretching from the White Sea to the hot steppe (approximately to the Elton Lake, Volgograd Region) but he gave special priority to Cisural and Ural, where he, like Pallas with his assistants, visited many production units. The scientist brought to the capital comprehensive collections of insects, herbarium, animals preserved in alcohol, stuffed birds, skins of big game, and bones of fossilized inhabitants of the territory under study, minerals and various remains.

In Solikamsk Lepekhin drew up a plant catalog of the Demidov Botanical Gardens founded in 1731 by one of the representatives of this dynasty of businessmen well known in Russia. He counted 422 flora species there (or 525 by other sources), and among them were not only those typical of Ural and Siberia but also thermophilic plants, including those from tropical and subtropical zones of the planet, such as coffee, cactus, aloe, amaryllis, canna, hyacinth, pineapple, oleander, laurel, myrtle, lemon and banana.

Lepekhin gathered essential information on useful plants, methods of plant cultivation and use, attentively scrutinized the process of forest regeneration after fires. He outlined in his travel notes his considerations regarding the means and methods of fruit tree protection in frost and the influence of the environment on the nature of flora. In the territory of the Volgograd Region the traveller found several lakes with a high content of salt much like Glauber's salt (sodium sulphate) and advanced an idea of possible production of this substance important for industry and medicine from wastes of salt-works.

A significant place in Lepekhin's party activity belongs to acquaintance with mines, mining, leather-dressing and other productions of Ural. Even at that time he noticed cases of clogging of rivers with production wastes. Having examined the local enterprises the scientist gave thought to improvement of methods and conditions of resource development. Besides he gathered a great deal of data on lodging, customs, ceremonies, clothes, hairstyles and ornaments of Mordovians, Chuvash, Komi-Permyak and other inhabitants of the visited places, on their languages, origin of the names of mountains, rivers and backwoods; on diseases and popular remedies; on ancient settlements and fortifications, and others. All this invaluable material was included into *Daily Notes of Travels in Different Provinces of the Russian State in 1768-1772* published first in Russian in Petersburg, in German in Altenburg and in French in Lausanne and then reprinted in *Collected Works on Scholarly Travels*.

The route of another notable researcher Samuel Gottlieb Gmelin included the southern direction strategically important for Russia which threatened with raids of nomadic tribes. Proceeding to the steppe regions he vis-

Kamchadal woman. From the book: Johann Georgi, Description of All Peoples Living in the Russian State and Also Their Life Ceremonies, Beliefs, Customs, Lodging, Clothes and Other Peculiarities.

Merchant from Kaluga. From the book: Johann Georgi, Description of All Peoples Living in the Russian State and Also Their Life Ceremonies, Beliefs, Customs, Lodging, Clothes and Other Peculiarities.

ited Azov and Tsimlyansk, reached the Lower Volga river, travelled throughout the whole territory of Eastern Caucasia, reached Northern Persia, put out to the Caspian Sea and reached Astrabad and Enzeli Bays but he could have done more had he not fallen prisoner and died in captivity.

Gmelin attentively studied the animal and vegetation world of the visited places. He was the first to describe big-eared hedgehog, Persian squirrel and Asiatic mouflon, he characterized saiga, a little-known species of the Central Asian antelope. His diaries give detailed account of the Lower Volga region and Azov steppes, especially the Kuma steppe, fishing practices in the northern shores of Azov and Caspian seas, local navigation, and manners and customs of peoples inhabiting the regions under study including Persians. The scientist prepared a map of Astrakhan salt lakes and suggested classification of salt lakes* according to their chemical composition. His works were published in Petersburg first in German and then in Russian.

In conclusion we would like to tell you about yet another wonderful participant of the expedition—Johann Gottlieb Georgi. Right away upon arrival in Russia in 1770 he started field studies of the Kalmyk steppe as a member of the Falk party, but due to the illness of the latter he and Alexei Pushkarev went over to the Pallas party and received a task to examine Lake Baikal and its environs. In 1773 the scientist inspected the works in Tara (today a town in the Omsk Region) and Tobolsk, made observations in the Chusovaya river basin and the next year devoted to studies of the Volga Region. On his way to Petersburg he learnt about Falk's death and took his manuscripts in Kazan, which he later on prepared for publication.

Together with Pushkarev Georgi prepared the first authentic map of the "Sea of Baikal". "Description of all peoples living in the Russian state and also their life ceremonies, beliefs, customs, lodging, clothes and other peculiarities" was a major result of his activities and was published first in German and then in Russian (1776-1780). This fundamental work in four volumes with a great number of colored engravings, watercolors and black-and-white pictures generalizing the results of ethnographic studies of the national scientists is not only the first composite richly illustrated description of different sides of culture and way of life of the Russian peoples but also a standard of ethnographic studies recognized by the world scientific fellowship.

Illustrations supplied by the author

* Salt lakes are characterized by so high salt concentration that salt can crystallize and precipitate to the bottom.—*Ed.*

WAYS OF OPENING UP THE USSURI TAIGA

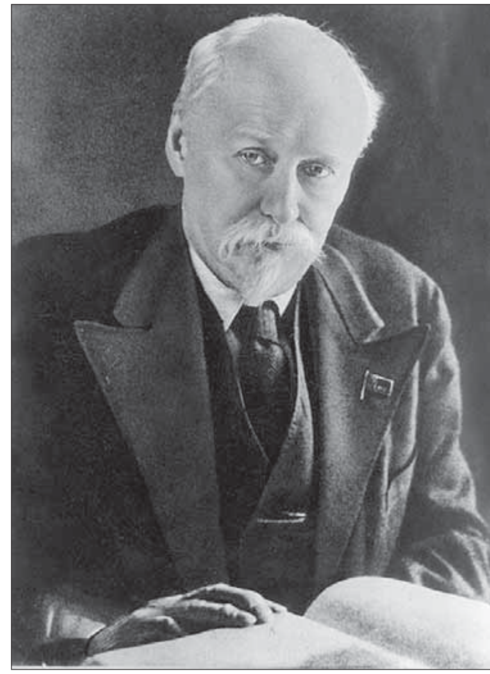
by Svetlana FISENKO, Cand. Sc. (Agr.),
senior research assistant of Gornotayezhnaya station
named after V. Komarov, RAS Far-Eastern Branch
(village of Gornotayezhnoe, Primorski Krai)

On the western slopes of the Przhevalsk Mountains, a part of the Sikhote Alin system, 25 km away from the town of Ussuriisk, on the area of 4,747 hectares, there is located a Gornotayezhnaya station of RAS Far-Eastern Branch, the first academic research institution in the Far East, named after the outstanding botanist and geographer, President of the USSR Academy of Sciences (1936-1945) Acad. Vladimir Komarov. Founded in 1932 on his initiative and under his active support, it became a center of collective use and a base for experimental and scientific studies of national and foreign specialists, who are engaged in problems of reproduction, rational use and protection of resources of Primorski Krai.

Almost all academic institutions in early 20th century, except for experimental and regional stations, were concentrated in Moscow and Leningrad. However, the state interests required creation of research bases in other big industrial areas as well. In 1916, after opening of the Southern Ussuri Branch of the Amur Department of the Russian Geographical Society, they were set up in north-western outskirts of Russia: in Vladivostok, Khabarovsk and Nikolsk-Ussuriisk (today Ussuriisk), where a permanently acting Botanical Study was opened in 1918. In 1929, it was transformed into a Southern Ussuri Branch of the Far-Eastern regional research institute and in two years into the Institute for Studies of the Far-Eastern Flora; then in 1932 on its basis was formed the aforesaid Gornotayezhnaya Station (GTS).

Its creation is closely connected with the name of Acad. Vladimir Komarov. He suggested to organize per-

Sign post with an emblem and the building of Gornotayezhnaya station, RAS Far-Eastern Branch—the first academic research institution in the Far East.



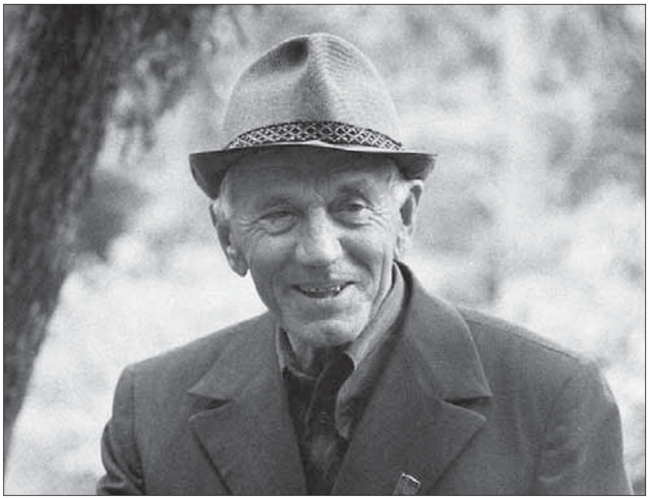
Acad. Vladimir Komarov.

manent branches of the Academy of Sciences in remote regions of our country, including the Far East, when he was Vice-President of the USSR Academy of Sciences (1930-1936). In 1913 the outstanding naturalist thoroughly studied the Southern Ussuri territory. The unique flora in the upper reaches of the Suputinka river, diversity of forest communities, not damaged by fires and anthropogenic activities, all this became a motive force for the scientist to take a decision on creation of a reserve there. But hard times in Russia hampered realization of these plans. Only in 1931 Komarov managed to initiate a resolution of the Presidium of the USSR AS on organization of the Far-Eastern Gornotayezhnaya Station with a Suputinka (today Ussuri) reserve as its component part. In 1932, after its incorporation into the Far-Eastern Branch of the USSR AS, it became the first regional academic institution in the Far East.

The tasks were grandiose: to study mountain and taiga areas of Primorski Krai and offer ways of their reasonable and rational use. Its first director (1932-1934) was Alexander Fedorov, one of the initiators of creation of the Southern Ussuri Branch of the Russian Geographical Society—an outstanding personality, talented organizer, close friend of the famous geographer, ethnographer and researcher of the Far East Vladimir Arsenyev (1872-1930). It was also headed by Tit Samoilov for more than 30 years (1945-1979). Under his guidance the station carried out functions of an experimental permanent base for biological subdivisions of the Far-Eastern Branch of the Academy of Sciences, conducted independent studies and assisted in the development of horticulture, potato-keeping, bee-keeping and other spheres of agriculture in the territory. At present the station is headed by Pyotr Zorikov, Dr. Sc. (Biol.), who is interested in studies of medicinal herbs of Primorski Krai, biological activity of extracts from Far-Eastern and introduced plants.

Acad. Komarov closely cooperated with the station for many years, supervised studies in the sphere of plant taxonomy—most important in the first and very difficult years of its formation. In 1931 and 1932 there was published in Leningrad a two-volume book by Komarov *Guide to Plants of the Far-Eastern Territory*, which he wrote in collaboration with the botanist Yevgeniya Klobukova-Alisova. It presents ~2,000 species of the local flora. The book gained popularity at once and became a bibliographical rarity. At the same time there was carried out inventorying of the Ussuri reserve vegetation, taxonomy of Far-Eastern poplars, lindens, buckthorns, actinidias, grasses and sedges.

In the initial period specialists paid close attention to groups of plants which had economic significance. Observations carried on by Zinaida Gutnikova, Cand. Sc. (Biol.), for many years, allowed to reveal composition and study phenology of forest honey plants in the south of Primorski Krai. The object of studies were fodder crops (more than 9,000 local and introduced species of herbs used in animal husbandry were tested at the nursery) as well as medicinal wild plants, including ginseng. Not far from the Suputinka reserve (today the Ussuri reserve named after V. Komarov) the staff member of the station Anna Skibinskaya laid the first planta-



Tit Samoilov—director of Gornotayezhnaya station, RAS Far-Eastern Branch.

Taisia Samoilova, head of Dendrology Laboratory.

tion of ginseng (200 plants). This served as a base for creation (in 1961) of Primorski specialized state farm "Ginseng"(village of Starovarvarovka, Anuchinsk district). The famous Far-Eastern geobotanist Galina Kurentsova described characteristics and use of more than 250 Far-Eastern medicinal plants.

In 1935 a dendrological nursery was organized on the experimental plot "Krivoi Klyuch", the place of the present-day station, in the picturesque spurs of the Przhevalsky ridge. Works connected with its laying and looking after plants were managed by Taisia Samoilova, head of the dendrological laboratory. For the first 10 years she and her colleagues tested more than 6,000 species of seeds of arboreal and frutescent plants of various origin. The grown material was planted in the arboretum.

Among biochemical works of the period of formation of the station we must mention works of Dmitry Balandin on studies of lemon tree, predominating in Primorski Krai, mainly in areas adjacent to the Ussuri river. In 1941 there was published the scientist's monograph with convincing proofs of pharmacological characteristics of liana. He isolated for the first time a new stimulating substance from the plant fruits—schizandrin (from Latin name of lemon tree) and described it.

From late 1930s our specialists studied methods of economical use of mountain slopes for agriculture and timber industry, laid new experimental plots for studies of erosion processes in soils and fodder-grass cultivation.

In 1940 the GTS was named after Acad. V. Komarov. Three years later due to the organization in Ussuriisk of the Far-Eastern base of the USSR Academy of Sciences, which in 1949 was transformed into the Far-Eastern Branch of the USSR AS, a majority of its leading specialists began work there, while at the station proper research activities were gradually abating. Only in 1953 the work team was strengthened by academic specialists. At the same time there was set up a station of Solar Service for continuous tracking of active processes on the Sun; in 1981 the station turned into an independent organization—the Ussuri Astrophysical Observatory of the RAS Far-Eastern Branch.

The 1960s are one of the brightest decades in the GTS history. The group of Antonin Titlyanov studied anatomy of seeds of lemon tree and Actinidia, as well as methods of their accelerated reproduction. Nikolai Suprunov and Pyotr Zorikov with colleagues carried out biochemical studies of plants of the ginseng family for medicinal purposes, worked out technologies of getting extracts from them. Yelena Nechayeva with colleagues analyzed peculiarities of formation of forest soils in mountain and taiga areas and worked out recommendations for their practical application.

From 1961 the works were resumed in the arboretum, which had been terminated in 1942. The main objective was to create an uterine park in the territory of the station—in fact it was a live museum with arboreal-frutes-

Botanical and Entomological expedition of Gornotayezhnaya station.

Guests on the porch of the house of the Samoilov family. In the center—the writer Konstantin Simonov.

Visit of Acad. Victor Spitsin to Gornotayezhnaya station.

cent, suffruticose and liana plants of different origin. The group of Taisia Samoilova, studying a possibility of introduction and acclimatization of plants in the conditions of Primorski Krai, created on the area of 10 hectares sites for expositions and collections of botanical and geographical landscapes of North America, Eastern Asia, Europe, Siberia and Far East. By 1978 the arboretum had a collection of almost 1,360 species of trees, shrubs, lianas of various origin. Some introduced cultures (American mountain ash, Canadian wayfaring tree, shadbush, nine-barks, box elder, etc.) turned out to be more viable and productive as compared with local aboriginal plants. A significant part of plants managed to acclimatize successfully—they flower, bear fruit, are self-sown and can serve as an initial material for further reproduction. A lot of introduced leafy plants are wide-

In the arboretum of Gornotayezhnaya station yesterday and today.

Amur adonis.

Japanese ruince.

ly used in cities and villages of Primorski Krai to make them green and beautiful.

Scientific and practical significance presents one of the biggest collections of Coniferales, rhododendrons and lianas in Russia, as well as a complete collection of relict species of the ginseng family. On the base of the nursery there is implemented reproduction of economically valuable, rare and endemic plant species, an insectarium is created for breeding and upkeep of disappearing species of insects, registered in the Red Data Book of Russia.

In the 1960s the problem of potato-growing was completely abandoned in Primorski Krai, its yields were very low. The cause—general spread of viral diseases and a low level of seed-growing. The infection-affected tuberiform herbaceous plant was "degenerating" (was losing quality characteristics). The solution of this problem consisted in working out agrotechnical methods of growing of high-grade seed potato on a virus-free

Actinidia—frutescent liana, rising to the height of 25 m.

Winter landscape.

Red mountain ash brome.

Weymouth pine alley.

base. Yevgeniya Lebedeva, Cand. Sc. (Agr.), decided to find them.

I happened to work under her guidance for 15 years, study weed-infested plants, take part in expeditions to Primorski Krai and Khabarovsk Territory with other staff members of the laboratory. At last we managed to find main causes of affection of the culture by viral diseases and on the basis of studies of many years (in cooperation with the Biological and Soil Institute on Vladivostok) to work out methods of potato-growing on a virus-free base. The most rational of them was creation of closed areas for seed-growing. Ecological and climatic analyses based on materials of studies of 20 meteostations demonstrated: the best place for organization of farms to produce healthy élite in Primorski Krai was a plot in Chuguevsk district, where are located two villages—Sokolovka and Bulyga-Fadeevo. In 1971, by the government decision there were organized areas of closed potato seed-growing, one of the first in our country. Due to GTS works its growing in the farms of Primorski Krai became rather profitable.

Thus, by early 1970s there were formed 3 research groups—of dendrology, phytovirusology and medicinal herbs, reorganized into corresponding laboratories (later on 2 more groups were created—insect ecology and forest monitoring). In 1986, by order of the USSR AS, the station was granted status equal to that of research institutes. Together with the arboretum it is a center for collective use and an experimental base for national and foreign laboratories. Our main partners are institutions of RAS Far-Eastern Branch: Biological and Soil Institute, Botanical Garden-Institute, Far-Eastern Geological Institute, Pacific Institute of Geography, Pacific Institute of Bioorganic Chemistry and other leading centers of Primorye.

Illustrations supplied by the author

MOSCOW STATE UNIVERSITY BOTANICAL GARDENS

by Vladimir NOVIKOV, Dr. Sc. (Biol.),
Director of the Botanical Gardens under the Department of Biology,
Lomonosov Moscow State University;
Sergei YEFIMOV, Cand. Sc. (Biol.),
Academic Secretary of the same scientific institution

The Botanical Gardens of the Moscow State University named after M. Lomonosov, the oldest botanical scientific institution in Russia— was established on the basis of the "Moscow Pharmaceutical Kitchen-Garden", set up back in 1706 by order of the Emperor Peter I. During its first years, there were planted only medicinal plants for drugstores and hospitals, but by the early 19th century it turned into the Botanical Gardens with rich and diverse plant collections.

CREATION AND DEVELOPMENT OF THE GARDENS

In 1805 the "Moscow Pharmaceutical Garden" was acquired by the university. The botanist Georg Franz Hoffmann who headed the Chair of Botany was appointed its first director. At that time abundant plant collections of the Gardens were a research ground to carry out complex botanical, including biological, studies. There worked such botanists and biologists of different epochs as Mikhail Maximovich, a natural scientist, first rector

Vorobyovy Hills. A collection of lilacs.

Subtropical hothouse (19th cent.) and a crystal channel in front of it in the branch of the Botanical Gardens.

of the Kiev University, Corresponding Member of the St. Petersburg AS (from 1871); Alexander Fischer von Waldheim, a naturalist, Professor of the Moscow University and President of the Moscow Society of Natural Scientists; Nikolai Kaufman, one of the first botanical geographers in the Russian Empire; Ivan Chistyakov*, Full Professor of the Moscow University at the Chair of Plant Anatomy and Physiology; Ivan Gorozhankin, founder of the scientific school of plant morphology and comparative embryology in national botany; Mikhail Golenkin, a botanist, Honored Scientist of the RSFSR, Professor of the Moscow University at the Chair of Plant Taxonomy and Morphology; Mikhail Navashin, a renowned cytologist and cytogeneticist; Carl von Meyer, a botanist-systemizer, Corresponding Member of the USSR AS (from 1932); Boris Kozo-Polyansky, a botanist, author of the original phylogenetic system of higher plants; Yevgeny Wulf, a botanist, florist and biogeographer, specialist in historical geography; Vasily Alyokhin, a Soviet geobotanist, founder of the Moscow scientific school, Professor of the Moscow State University (from 1918), author of the textbook *Plant Geography*, and many other experts who left an appreciable trace in national science.

Little by little, the Gardens expanded its territory. On October 6, 1950, Rector of the Moscow State University, Academician (from 1943) Alexander Nesmeyanov, prominent organic chemist of the 20th century, President of the USSR Academy of Sciences (1951-1961), issued an order to lay a new garden territory in Vorobyovy Hills (over 30 ha), while its former territory got a status of a branch, and under the decision of the Moscow City Council of May 31, 1973, was acknowledged as a monument of history and culture of Moscow.

Development of the new territory of the Gardens was guided by Nina Bazilevskaya Dr. Sc. (Biol.), a Russian and Soviet botanist, systemizer, Moscow State University Professor, Director of the Botanical Gardens from 1952 to 1964. Together with the architect Vera Kolpakova, she took part in the development of the layout project for the territory in Vorobyovy Hills. From 1965 the Gardens were managed by the morphologist-ecologist Igor Kultiasov, Cand. Sc. (Biol.), from 1967—by Vadim Tikhomirov, a botanist, USSR AS Corresponding Member (from 1987), author of studies in morphology and taxonomy of flowering plants, floristics, and environmental protection. At present the Gardens are led by the botanist florist Vladimir Novikov, Dr. Sc. (Biol.).

Today the Botanical Gardens are a training and research base of the Department of Biology, Moscow State University. Since establishment, the gardens have become one of the leading scientific units of the Department of Biology and other botanical centers in Russia. Such conventional research areas as taxonomy, floristry, gene pool protection, breeding, and plant introduction, as well as scientific schools of floristic and morphological-taxonomic studies of plants are being developed there. These works are carried out under the guidance of Vladimir Novikov and Mikhail Pimenov, head of the Department of Plant Taxonomy and Geography.

*Ivan Chistyakov was one of the first Russian scientists to study embryology and cytology of plants. In 1874 he described indirect division of a plant cell for the first time ever.—*Ed.*

Pharmaceutical kitchen-garden.
Tree nursery.

A series of floristic studies carried out by employees of the Botanical Gardens in cooperation with specialists in higher plants and geobotany from different univesitites became widely known. They described over 100 taxons* of higher plants unknown to science before (in particular, from the *Umbelliferae, Juncaceae*** and *Poaceae* families of the flora of Russia and CIS countries) and a number of insect species; they have grown tens of new sorts and forms of decorative and small-fruit and berry plants, got over 30 invention patents. In addition, our specialists are members of various scientific associations, Russian and international societies. The Garden as an important research institution is headed by the regional Board of Botanical Gardens of the central European part of our country.

THE GARDEN STRUCTURE AND COLLECTIONS

The Gardens are divided into a number of zones: sections of taxonomy and geography of plants, flora and gene pool protection, dendrology, garden plants, tropical and subtropical cultures. Currently, the collection of the Gardens consists of 6,000 species, varieties, and forms of cultures grown on the main research and exposition plots.

In the tree nursery, the main plot of the Botanical Gardens, there are about 1,150 species and forms of woody plants and over 40 species of herbs; in the alpine gardens—about 700 species, mostly herbs; in the plots assigned for scientific taxonomy—around over 500 species, useful plants—over 500 species and sorts; flora of the central part of Russia is represented by about 200 species; decorative plants are represented by 157 species and 1,360 sorts and forms; in the fruit garden there are over 400 sorts of fruit and berry cultures. There are about 100 species of birds in the Botanical Gardens.

The scientific-historical collection of the Botanical Gardens established in 1706 is located in the zone of tropical and subtropical plants of its branch. It is represented mainly by hothouse plants, tropical and subtropical flora representatives (about 1,000 species and varieties).

Meanwhile, present-day scientific studies and intensive selection projects resulted in creation of specialized enlarged collections of *Umbelliferae*, wild species of apple trees, sea buckthorn, peony, new expositions—a segment of collection lilac and flora attributed to the central part of Russia, etc. Scientific achievements of the past and present have been awarded state and branch prizes. For example, in 1989 the chief research officer of the RAS MBG Alexei Skvortsov, Dr. Sc. (Biol.) (worked at the MGU BG from 1952 to 1971) was awarded the USSR State Prize, in 2002 he got the RAS Award named after V. Komarov*; in 2011 the chief research officer of the MGU Botanical Gardens Mikhail Pimenov, Dr.Sc. (Biol.), was also awarded the RAS Award named after V. Komarov.

*Taxon—according to the International Code of Botanical Literature (Vienna Code, 2006), a taxonomic group of any rank.—*Ed.*

** Juncaceae—a plant family of the *Poales* order.—*Ed.*

* RAS Award named after V. Komarov was set up in 1944 by the USSR Academy of Sciences for outstanding achievements in botany in the field of taxonomy, anatomy and morphology of plants, botanical geography, and paleobotany.—*Ed.*

Vorobyovy Hills.
Show of modes of decorative design.

Today the Botanical Gardens is a research and testing ground for 10 chairs and laboratories of the Department of Biology specializing in botany and zoology. In cooperation with the Chair of Higher Plants they regularly hold All-Russia and international conferences on taxonomy, phylogeny, floristic studies, and environmental protection. Everyday visitors of the Garden are offered survey and thematic excursions: around 120,000 visitors enjoy them there annually.

For 308 years of existence, the Botanical Gardens left a noticeable trace in the history of the Moscow University and national botanical science. Our main achievements were published in numerous monographs and popular science articles. For the last 10-15 years, many of these achievements received universal recognition in Russia and abroad.

Our specialists issued the first full description of vegetation of the capital *The Flora of Moscow*, incorporating over 1,600 species, timed for the 850th anniversary of Moscow (in 1997); for this vast research work, the team of its authors was awarded the Moscow Government Award for Ecology Studies.

EXPEDITIONS AND EDUCATIONAL PROGRAMS

Currently the Botanical Gardens together with other national scientific centers are organizing expeditions to different regions of Russia (most of them—to the European part of Russia and Caucasia), and also to neighboring and remote foreign countries (Central and Eastern Asia, South Africa, etc.). Thus, since 1987 employees of the Botanical Gardens has been studying flora of Solovki Islands with the assistance of the Solovki Branch of the White Sea Biological Station named after N. Pertsov under the MGU Department of Biology.

The Garden is cooperating with a number of foreign organizations: International Council of Botanical Gardens for Plant Protection (BGCI, UK), Anadolu University (Eskişehir, Turkey), Johannesburg University (RSA), Meilland company (France), etc.

The Garden's branch keeps a vast library (about 40 thous. books), representing unique samples of botanical editions from the 16th-17th centuries till our days.

It is also worth saying that the ecological-educational program of the Botanical Gardens was initiated in 1998, when the Club for Young Ecologists for children and youth was established. Under this program, schoolchildren are offered the thematic course "Lessons in the Botanical Gardens", while elementary school teachers and teachers of ecology can visit methodical courses and thematic consultations. To support ecological education, our employees organize conferences, seminars, and training courses for their colleagues from regional botanical gardens and school teachers. Schoolchildren can take part in annual educational ecological games timed to coincide with the Spring Flower Festival and the Day of the Botanical Gardens (April 1).

Illustrations supplied by the authors

KOLA PENINSULA IN TERMS OF GEOBOTANY

by Natalya KOROLYOVA, Cand. Sc. (Biol.),
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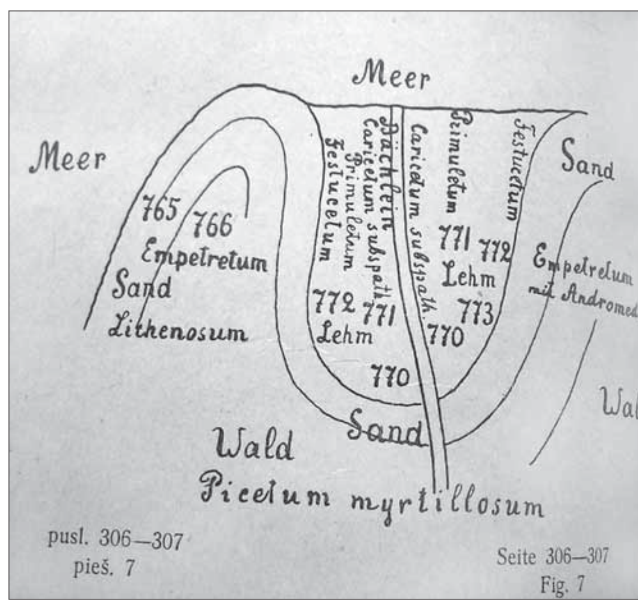
Geobotany, a science on vegetable cover, is fundamental for any natural research. The root "geo" in this word goes back to the Greek goddess of the Earth Gaea who, as the legend has, was the first to appear from the Chaos and gave birth to all flesh on the planet. When studying vegetation, specialists conceive its structural regularities and dynamics influenced by environmental and anthropogenic factors, try to renew the past and forecast future development of ecosystems. Flora and vegetation of the Kola Peninsula have been studied since the late 13th century; however, the territory has not been studied evenly. Next to well-studied areas, there are blank spots waiting for pioneer explorers. This article is dedicated to the history, present-day state, and problems of geobotany in the Murmansk Region.

Geobotanical description— one of the main methods of a field geobotanical research.

Vegetation plan of the Pirya Guba Bay coastline, Kandalaksha Gulf, White Sea, made by Karl Regel in the course of the expedition across the Kola Peninsula in the early 20th century.



ORIGIN

Geobotany, a mixture of biological and geographical sciences, is relatively young, as compared with these "classical" disciplines. Theoretical principles of this science were first formed and developed by the great German natural scientist Alexander Humboldt (1767-1835). In Russia, it separated from other botanical sciences in the late 19th century. As for the official recognition of this science and its terminology, this took place at the Brussels International Botanical Congress in 1910.

Studies of vegetation of the Kola Territory as a part of the Arctic is one of the striking pages in the history of Russian science. In the 1830s-1840s, one of the first geographical expeditions organized by the St. Petersburg AS headed by Acad. Karl Ernst von Baer, one of the founders of the Russian Geographical Society, forefather of embryology and comparative animal anatomy, was sent to the Kola Lapland. Many leading scientists worked there: the pioneer of permafrost studies, geographer, zoologist, botanist and natural scientist, Academician and permanent secretary of the Petersburg AS Alexander Middendorf, Assistant Professor in mineralogy at the Tartu University Alexander Shrenk, prominent botanist-systemizer and florist, founder of the Russian genetic geography of plants Franz Ruprecht. The first major geobotanical monograph was written upon request of the St. Petersburg Society of Natural Scientists by Karl Regel, Professor of the Tartu University, who in 1911-1914 studied the coastline of the Barents and White seas, Khibini and Lovozersk Mountains, valleys of Varzuga, Tuloma, Umba, Ponoya rivers, and many other regions that are difficult of access even today. Finnish botanists actively examined the Kola Peninsula in the 19th-early 20th centuries, when parts of its terri-

Outstanding explorer of the North Yuri Tsinzerling (1894-1939).

tory and Karelia formed part of the Great Duchy of Finland in the composition of the Russian Empire. It has much in common with the Finnish territory in terms of geological structure and vegetation; that is why local natural scientists considered it their national duty to study the nature of the peninsula.

In the 20th century, studies of vegetation in the northern outskirts of the USSR were stimulated by first steps in exploration of natural wealth of the Arctic. In the 1920s-1930s, the prominent geobotanist Yuri Tsinzerling worked there as a participant of several expeditions. His fixed-route studies of the north-eastern part of the Kola Peninsula, including data on the Tersky coastline and the central part of the Murmansk Region, were used to make a map, review and botanical-geographical zoning of vegetation of the north-west of the European part of our country.

In the 1930s, vast tundra territories of the USSR were studied in terms of land development, map making, and inventory of deer pastures. At that time, geobotanists described in detail not only plant communities, but also geomorphological peculiarities of the locality, geological structure and soils, made vegetation maps as a source for reindeer-breeding. From 1929 to 1949 the territory was twice covered by geobotanical surveying. The obtained materials were used to make the Map of the Kola Peninsula in the scale of 1:1,000,000 (1953) by the employee of the Polar-Alpine Botanical Gardens-Institute of the USSR AS Kola Branch Yevgeny Chernov. The explanatory text offered a detailed analysis of floristic and geobotanical studies in the Murmansk Region from the late 18th century to the mid-20th century, a description and illustrations of the main types of plant communities, a review of geobotanical areas specified by the author. This work is still the most complete and reliable regional cartographic piece.

Another major monograph of geobotanical and floristic studies of two neighboring regions was an analytical review of the flora of the Murmansk Region and Karelia by Marianna Ramenskaya, Dr. Sc. (Biol.), who was employed at the Polar-Alpine Botanical Gardens of the Kola Branch of the USSR AS from 1964 to 1976. She focused her attention on environmental protection, cultivation of apatite-nephelinic dumps, plant biochemistry, and restoration of forests. The most well-known works by Ramenskaya (co-author Valentina Andreeva) are the *Classifier of Higher Plants of the Murmansk Region and Karelia* (1982) and the *Analysis of Flora of the Murmansk Region and Karelia* (1983). Brief geobotanical characteristics of natural zones and landscape provinces are still most cited in the printed works dedicated to the local nature.

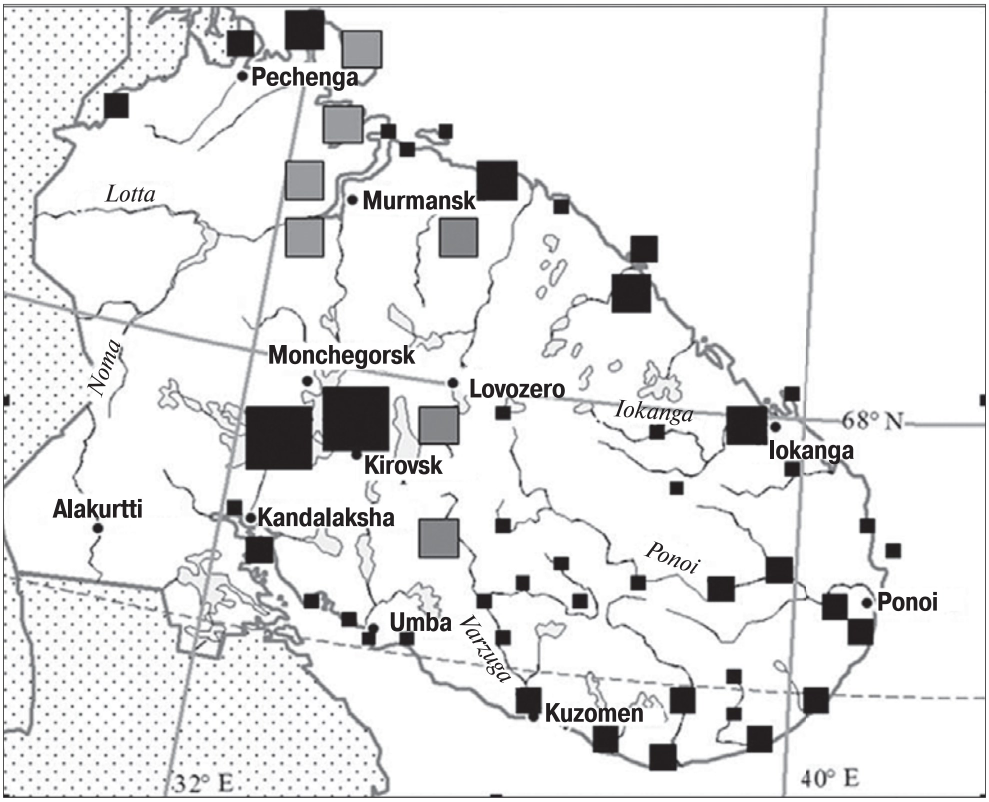
PRESENT-DAY ACHIEVEMENTS, PROBLEMS, AND PERSPECTIVES

Currently, continuous geobotanical surveys are carried out by employees of the Polar-Alpine Botanical Gardens-Institute named after N. Avrorin, Institute for Problems of Industrial Environment of the North, Kola Scientific Center, RAS, Kola Center for Protection of Nature (Apatity), local natural reserves, and specialized scientific centers in Moscow, St. Petersburg and Petrozavodsk.

So far, the syntaxonomic* diversity of zonal and mountain tundras as well as forest tundra of the Murmansk Region have been studied; scientists made a prodromus** of associations, multiyear studies of vegetation in specially protected areas are carried out. In order to preserve the population of wild reindeer and local geographical landscape, scientists described basic forest associations, mountain and tundra vegetation growing in the Lapland State Natural Biosphere Reserve, one of the oldest reserves in our county founded in 1930. In-depth

*Syntaxonomy—a section of geobotany specializing in classification of plant communities and development of standards of phytocenological nomenclature.—*Ed.*

** Prodromus (from Greek *prodromos*—precursor)—a list of plant syntaxons specifying distinctive features and substantiating their hierarchy.—*Ed.*



Geobotanical knowledge of the Murmansk Region:
■—areas where separate types of vegetation are described (less than 25 geobotanical descriptions for one or several types of vegetation);
■—areas where vegetation diversity is revealed to a considerable extent (from 25 to 100 descriptions of all main types of vegetation);
■—areas where vegetation diversity has been described almost fully (over 100 descriptions for practically all types of vegetation).
Black squares—published geobotanical descriptions, grey squares—descriptions to be published.

studies and a large-scale mapping of maritime and ornithogenic vegetation in the Kandalaksha Natural Reserve established to protect habitats of marine, water and periaquatic fowl (first of all, eider) were implemented. The survey of natural territorial habitats was completed and a landscape map of the State Natural Reserve *Pasvik* set up in 1992 in the remote north-west of the Kola Peninsula was prepared.

The bibliography of studies of the central part of the Murmansk Region in the districts of technogenic influence counts more than 1,000 sources. In the area where *Severonikel* industrial complex is located (a major producer of non-ferrous metals established in 1938 near Monchegorsk), specialists registered deterioration of pine forests, studied resistance and processes of recovery of phytocenoses. Besides, scientists studied dynamics of changing status of vegetation exposed to a constant air pollution and a catastrophic event valid for one time only (forest fires), developed methods of forest restoration in terms of different anthropogenic impacts. On the basis of results of multiyear observations, including observations made from the American remote sensing satellites *Landsat*, scientists made some conclusions on the changing structure of vegetation in the forests and mountain tundras in the area of Monchegorsk, Zapolyarny and Nikel.

Mapping is one of the main lines of the present-day geobotany. You might as well say it is a connecting unit for all geosciences. The geobotanical map is a complex work integrating all characteristics of vegetation and representing its floristic composition and structure, dynamic state, ecological and geographical links. Typological geobotanical mapping of the Kola Peninsula is both a result and a method of cognizing of the most important regional regularities of the structure and state of the plant cover. Among considerable achievements in the field of cartography, we can name *Map of Vegetation of the Central Part of the Murmansk Region* (1:100,000) compiled in 2011 on the basis of an analysis of ground and remote data aerophoto- and cosmic pictures, covering most of the Lapland Natural Reserve, Khibini Mountains and technologically transformed suburbs of *Severonikel* iron and steel works.

The analysis of "behavior" of the local plant communities listed in the regional Red Data Book and identification of the most valuable biotops contributed a lot to theoretical substantiation of the steps taken to protect the local nature. As a result, scientists established a coenotic conjugation between rare species of vascular plants and bryophytes and their links with rare types of phytocenoses, as well as coenotic dependence of groups of rare species of bryophytes, linchens, and cyanoprocaryotes (blue-green algae).

In 2011, the joint Russian-Finnish project aimed to take an inventory of species most valuable for preserva-

Lapland paintbrush listed in the Red Data Book of the Murmansk Region.

Lapland poppy listed in the Red Data Book of the Murmansk Region.

tion of biological diversity in the territory of Archangelsk, Vologda, Leningrad, and Murmansk regions, Karelia and St. Petersburg with the participation of scientific institutions, local management bodies, and non-government organizations was completed. The results of this project are reflected in the book *Preservation of Valuable Natural Habitats in the North-West of Russia*. It is worth saying that the present-day state of vegetation was assessed through a single technique using remote sounding data, which helped obtain the most reliable and up-to-date results.

Current geobotanical studies in the Murmansk Region are diverse and in line with the applicable international standards; however their "compactness" is rather uneven. The central forest part is the most studied region, while vegetation in the eastern and north-eastern parts is poorly studied, since this territory is difficult of access. Bogs, predominant in area and diversity of

Arctic thyme listed in the Red Data Book of the Murmansk Region.

Alpine butterwort—a predator plant found in damp habitats.

plant species, are still little known. Another task is to make an updated vegetation map on the basis of field data and remote information, since the currently used map was compiled over 50 years ago and a few large-scale maps cover only a small part of the territory under consideration.

Further socio-economic development of the region is connected with exploration, sustainable and long-term use of its natural resources accompanied by preservation of local biological diversity. That's why this region is in need of highly qualified ecologists, bachelors and holders of a master's degree, capable of solving pressing problems of natural wealth (including vegetation) inventory, ecological examination and monitoring of the results of anthropogenic influence on the ground phytobiota.

There are three educational institutions in the Murmansk Region offering "Ecology" and "Ecology and Environmental Protection" programs; however, the subject "geobotany" is not included in the training module, which means that our students have no access even to the basic level of geobotanical knowledge. Unfortunately, such situation is typical of some other biological disciplines. In particular, there are no specialists actively engaged in protection of the ground phytodiversity of the region at the branches of Petrozavodsk University and Murmansk Technical University. Geobotanical knowledge is not called for and absence of continuity in getting this knowledge can have irreversible consequences. Young professionals—ecologists and biologists—have a vague notion about vegetation in the Murmansk Region and Russia in general. To ensure a real integration of science and higher education into the program of departments of biology and ecology, it is necessary to introduce a course of geobotany and employ qualified practitioners from the institutes of the Academy of Sciences.

Illustrations supplied by the author

ARTIFICIAL CLIMATE STATION IN IRKUTSK

by Maxim RACHENKO, Cand. Sc. (Biol.),
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Tatyana KULAKOVA,
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Siberian Institute of Plant Physiology and Chemistry,
RAS SB (Irkutsk)

The Siberian Institute of Plant Physiology and Chemistry, RAS SB (set up in 1961) is one of the leading national research centers specializing in plant physiology, molecular biology, and ecology of plant organisms. It was there that in 1969 the first national phytotron, an artificial climate station designed to study effects produced by environmental factors on plant organisms, was installed. Intended as a tool of common use, the station has significantly expanded experimental capacities of the institute laboratories and turned out to be the main support in implementation of exploratory studies by specialists of different scientific institutions under the All-Union Lenin Academy of Agricultural Sciences, Irkutsk State University, Institute of Agriculture, scientific center, and scientists from Novosibirsk, Krasnoyarsk, Yakutsk, Bulgarian Academy of Sciences, and Mongolia.

FROM THE HISTORY OF WINTER GARDENS

Before speaking about the unique complex of stationary chambers in Irkutsk enabling scientists to simulate various climates and develop state-of-the-art technologies in greenhouses, let's turn to the history of indoor and tub plants. Everything began in the Ancient Egypt. On picturesque images, which are 3,000 years old, one can see small trees and bushes in stone vases and boxes. The winter garden of flowers (roses, violets, lilies) and grasses, decorated with statutes and encircled by a colonnade, was an integral element of a rich patrician house.

The art of bonsai ("grown in a tray" in Japanese) counts some thousands of years; it originated in China and became a frequent practice in Japan.

Excursion in the greenhouse of tropical plants.

In the 16th century, bitter-orange greenhouses intended to grow citrus plants became popular in Europe. In the late 18th-early 19th centuries, the custom of growing of orange and lemon trees gave way to cultivation of tropical plants brought from remote countries by sailors and travelers. It was a difficult task: enthusiasts knew almost nothing about countries of origin of these plants, let alone their growing conditions.

In the 19th century, the situation changed after the Englishman Nathaniel Word, a collector of rare plant species, in 1829 invented a device of seemingly little importance. He noticed that his favorite plants slowed down growing due to the London smog and dust. He then decided to cover the plants with a glass box, arranged ventilation and watering. This device, named "Word's box", quickly gained popularity. The boxes were further improved: there appeared glass roofs and greenhouses attached to residential buildings. Step by step, these structures began to occupy one of the main places at the estate. In addition to plants, the place was adorned with sculptures, pictures, chill-out areas, artificial waterfalls and grottoes. Such gardens became a standard practice in Europe in the second half of the 20th century expanding living space of the house by way of translucent glass structures.

The fashion of glass structures penetrated the Russian province, including the outskirts of Siberia. There is a documentary evidence that one of the most successful gold prospectors of that time merchant Gavrila Masharov from the town of Kansk (Krasnoyarsk Territory) in 1836 "already lived in the taiga in a big house with attached glass galleries, roofed passageways, and a pineapple greenhouse". There were also people in Irkutsk who took a fancy to grow and enjoy the "American fruit". As it appears from documents, in due time the famous Decembrist Sergei Trubetskoi acquired pineapple greenhouses from the Governor of Irkutsk Ivan Seidler (1777-1853).

ARTIFICIAL ECOSYSTEMS

Artificial climate stations (phytotrons*) designed to carry our scientific research were first assembled in 1949 in California (USA). The first similar station was built in our country at the Moscow Institute of Plant Physiology named after K. Timiryazev, the USSR AS (1949-1957). Later on, such station was installed at the department of biology of the Moscow State University. In the 1960s, the experimental station was arranged at the Siberian Institute of Plant Physiology and Chemistry, USSR AS SB.

Arkady Korovin, Dr. Sc. (Biol.), and Vladimir Kurets, certified engineer, afterwards Dr. Sc. (Biol.), stood at the sources of phytotron (1959-1961). The latter was a chief designer of an artificial climate station. Before Irkutsk, both scientists worked at the USSR Academy of Sciences Karelian Branch Institute of Biology. In a close cooperation with biologists, Vladimir Kurets developed thermal greenhouses and devices to study the effect of low-temperature soils on mineral nutrition of plants and the effect of summer frosts on their productivity and resistance. Through the ef-

*Phytotron (from Greek phyton—a plant and thronos—location)—a chamber or a complex of chambers to grow plants in the controllable artificial environment.—*Ed.*

Growth chambers (left),
BINDER climatic chambers (right),
CLF Plant Climatics (straight).

Interior equipment of the BINDER climatic growth chambers.

forts taken by Kurets, the Agrobiological Station was equipped with the than modern artificial climate units. The gifted engineer, he together with Korovin formulated principles of organization of studies connected with the effect of extreme environmental factors on the plants grown in artificial conditions. A special report delivered at the USSR AS SB impressed the Siberians. It was not by chance that in 1963 Vladimir Kurets and Arkady Korovin were invited to design a phytotron in Irkutsk. The station was built using only serial national devices in 1969.

Biologists used the artificial climate station with the area of almost 3,000 m^2 for many years; after a multistage overhaul it was transformed into the main experimental plant of the Siberian Institute of Plant Physiology and Chemistry. It has been designed to maintain controllable lighting, humidity and temperature conditions, thus enabling scientists to work with experimental, including transgenic plants, all year round.

The phytotron has two 2.7×2.7×2.5 m chambers, equipped as plant cultivation rooms: they are furnished with daylight lamps of different power and air conditioners. There are also experimental mini-greenhouses with natural lighting, additional lamps, and a big greenhouse with supporting lighting and hydroponic units.

In 2011, the station was upgraded with modern equipment: 16 mobile chambers manufactured by BINDER (Germany) are controlled by original software. Plant cultivation rooms with the capacity from 240 to 720 liters are able to maintain the temperature from 0 up to +70 °C without lighting and from +5 to +60 °C with 100 percent lighting intensity. The experimental chambers of 240 liters operate in the temperature from –70 to +180 °C.

In addition, there are two climate chambers designed by CLF PlantClimatics (Germany) aimed to develop new therapies on the basis of state-of-the-art biotechnological methods for cultivation of plants, mushrooms and microorganisms, studies of genetic and physiological-biochemical mechanisms of growth and stability of plants, studies of plant-microbe interactions in terms of biotic and abiotic stresses, genetic control of functions of intracellular structures, selection, creation of quickly growing plants by way of methods of genetic engineering.

The station makes it possible to study physiological and biochemical reactions of transgenic plants, including soft wheat, bred at the *Plant Master* climate chamber under the set lighting, air humidity and temperature parameters. The chamber is spacious enough to grow concurrently up to 40-45 lines of cereals and carry out experiments irrespective of the season.

Specialists of the institute carry out experiments intended to select highly stable varieties and forms of fruit trees and bushes to be cultivated in Siberia, proceeding from their frost and winter resistance. Speaking

CLF Plant Climatics chamber.

CLF Plant Climatics chamber from inside.

of perennial bushes, the main problem here is a long period between getting hybrid seeds and the first crop allowing to carry on initial assessment of received fruits. Plant cultivation chambers reduce the selection period twofold: you can get the first crop in two-three years and, accordingly, assess obtained results.

Employees of our institute are working in cooperation with academic scientists. Experts and students study problems of winter injuries of seed, stone and soft fruit cultures and develop methods of efficient use of the closed soil in severe conditions of the Baikal Region.

TROPICS IN SIBERIA

The greenhouse of the Siberian Institute of Plant Physiology and Biochemistry, RAS SB, was arranged in the 1970s by the well-known local dendrologist Antonina Telpukhovskaya. She actively promoted gardening of Academgorodok with wood species unusual for that time—blue spruces, lindens, Ussuri pear trees, and decorative bushes. The all-year-round green oasis in our latitudes, located in the climatic zone characterized by a long winter and off-season period turned out to be a bright event, an urban and regional object of note. Since 2013, this unique green corner has become a part of the phytotron.

The area of the greenhouse is 561 m^2. It took some years to form the plant collection. Most of the large plants that have survived till our days were planted in the first years of development of the artificial ecosystem. The staff members brought plant material from the botanical gardens of various Russian cities. That time, every profile institution considered it an honor to offer plant cuttings for the Siberian greenhouse. Employees of the institute carefully delivered them to Irkutsk and planted in the earth.

Today, about 400 varieties of heat-loving plants are growing under the glass roof. Most of them are from Africa, South-Eastern Asia, and Australia. In our climate they can survive only in artificial environment with all-the-year-round above-zero temperature and necessary humidity level. The heating system along the perimeter and in the soil maintains the required temperature. Even when the outside temperature is −30 °C, it is still above zero in the greenhouse. Humidity level is maintained through a small reservoir in the center of the complex.

Visitors of the greenhouse are offered a beautiful collection of different species of roses. In winter this regal flower is “sleeping” to show itself in all its glory the next year. The first buds start emerging in late February and begins flowering which lasts till November or December. Weaving roses, classical tea roses, cluster-flowered roses, small-flowered roses, classical English roses and other varieties, all under one roof, attract visitors with diversity of smells and colors. Wintering roses which can withstand even −40 °C temperatures are most popular among the Siberians.

Irkutsk lemons cultivated by the local breeder Vladimir Borishchuk are pride of the greenhouse.

The collection of citrus fruits occupies a special place in the greenhouse.

In the collection apple tree garden.

It was a hard task to form the tropical collection: in the 1970s plants from Holland or China were a rarity. They were brought from other cities, exchanged with Moscow and St. Petersburg greenhouses, some of them were brought from the Far East.

Bamboo, one of the oldest plants in the collection, is notable for durability and rapid growth in the first weeks of development. The collection of cacti has been enriched since the first days of the greenhouse: we are proud of opuntia used to produce wine and agave used

***Strelitzia reginae*—a South African flower that conquered the world by its exotic form.**

***Stanhopea* from Latin America.**

Water hyacinth (*Eichornia crassipes*) from tropical regions of America.


Banana plant.


Cactus hillock.

to produce tequila—a strong spirit made mainly in the neighborhood of the town of Tequila in the west of the Mexican state Halisco.

Citrus cultures play a special part in our greenhouse. We are proud of Irkutsk lemons grown by the local plant-breeder Vladimir Borishchuk. The tree is not tall, its leaves are big and coriaceous. It blossoms twice a year—in spring and autumn—and bears fruit on the second year. Lemons are big, ~700 g, sometimes even 1.5 kg, and are characterized by an increased concentration of vitamin C. The peel is of average thickness, slightly grumous. *Budda's hand* is another unique plant in our greenhouse. It differs from standard lemons and oranges by its strange form, resembling man's hand. It was a mere chance that this plant appeared in the greenhouse. It was brought there almost dried up to be cured. First specialists took it for a common lemon but in the end after treatment they got a new unique plant. The collection also incorporates small hybrid bushes: calamondins, cumquats, citrofortunella, Meyer's lemon covered with yellow and orange fruits.

It is hard to imagine that you would see a palm "fish tail" of the form of a leaf resembling a fish fin somewhere else. It is also called wine palm, since its fruits are used to produce wine. No less interesting is thatch palm—its marrow is used to make a salad, most expensive salad in the world. The ginkgo biloba tree is actively used in medicine; *Bougainville spp.* is known for its bright and rich color called "fiery". All these species are only a small part of the wealth of our greenhouse.

In addition to the greenhouse, we have also a garden of fruit and decorative cultures with dominating apple trees of different forms and varieties.

Employees of the institute are engaged in both scientific and educational programs. The annual number of visitors of the greenhouse is about 3,000, most of them are residents of Irkutsk, Irkutsk Region and Buryatia. During excursions, they get visual information on the structure of biosphere, principles of functioning of ecosystems of different types. In addition, biologists carry out consultations on flower-growing, vegetable-growing, and horticulture. They can design, transplant and provide recommendations on management and maintenance of a country garden or a winter garden. Such services are in great demand in the city, which makes local specialists think about establishing a special center, where enthusiasts can get valuable information.

Photos by A. Raikevich

RELIABLE ASSISTANTS IN DEVELOPING ARCTIC REGIONS

by Pyotr KOLOSOV, Dr. Sc. (Geol. & Mineral.),
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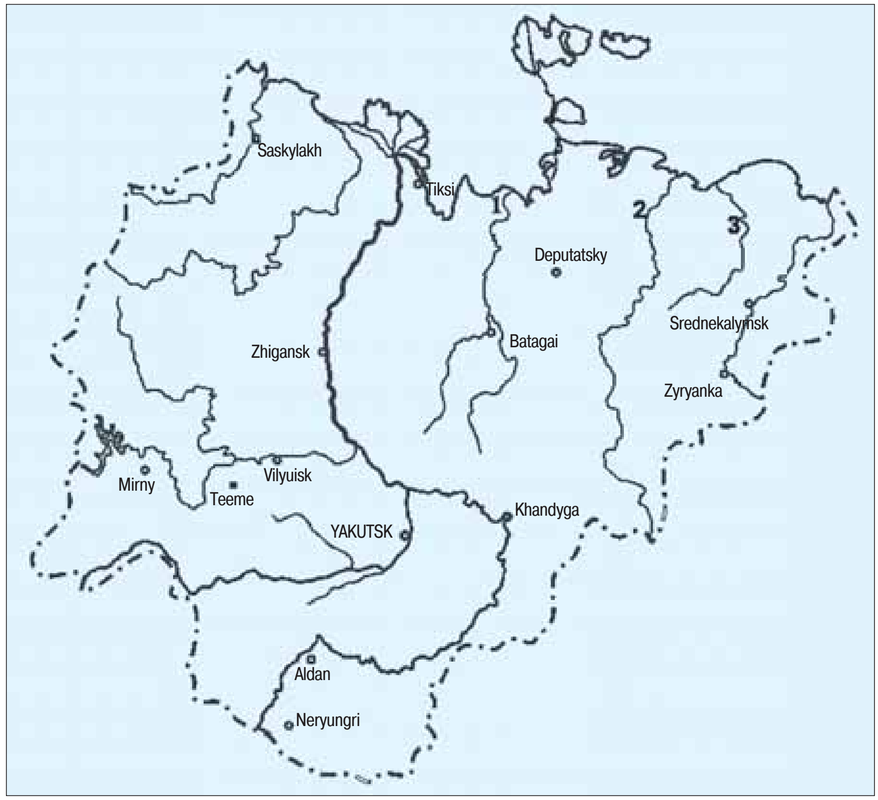
of Diamond and Precious Metals (Yakutsk),
German ARBUGAEV and Maxim LYUBAVIN,
participants of the dog team expedition

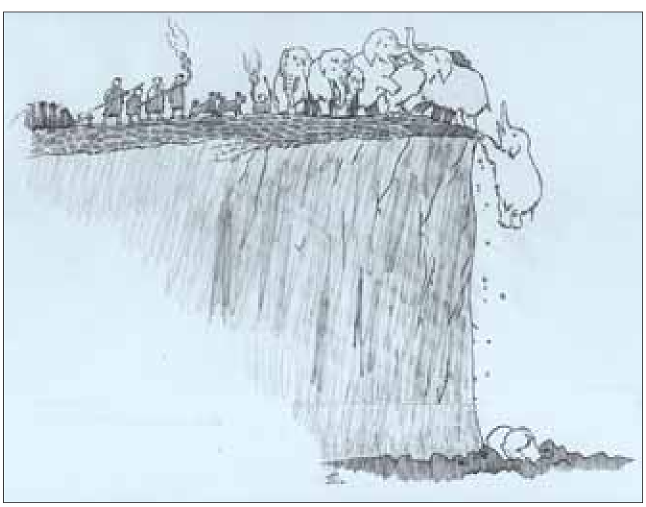
Presence of mammoths, bisons, tarpans, and other mammals of the Pleistocene (2.6-0.011 mln years ago) and skillful gaming practices with the assistance of domesticated wolves (hunting laikas) approximately 30 thous. years ago enabled primitive hunters to survive in the extreme climatic conditions of the polar regions in the north-east of Asia and marked the beginning of development of the Arctic.

Through endless Artic regions in a dog sledge.



Map of Yakutia. Sites: 1—stopping place of man in the estuary of Yana River; 2—Berelekhsky mammoth "cemetery" in the basin of Indigirka River; 3—dog skull site in the Yeadonian strata (age 25-30 thous. years) along Rassokha River. The expedition of Yukagir route passed on dog-teams from the settlement to the Cape of Anisiy on Kotelny Island and is marked by dotted lines.

Mammoth hunt scene (artist, Ye. Nesterova).



THE ARCTIC YEAR IN YAKUTIA

As a constituent part of Russia, the north-eastern region of the Arctic is among top priorities of national policy. This severe climatic region accommodates enormous natural wealth; in particular, according to some estimates, in the continental outskirts of the Arctic Ocean, the extracted hydrocarbon resources make up about 110 bln tons of the conventional fuel. In 2013, the RF President Vladimir Putin approved the *Strategy for Developing the Russian Arctic and Protecting National Security till 2020*. A relevant program complying with the provisions of this document is being developed in the Republic of Sakha (Yakutia), 13 districts of which are located in the Polar regions. Local residents are engaged mainly in reindeer-breeding, fishing and hunting; they also participate in mining. It is appropriate here to note that as early as in 1925-1930 the USSR AS organized the first large-scale expedition to study development of local productive forces in this territory. Today, scientists are discussing a possibility of arranging a similar expedition in 2016 using the resources of the RAS, focused on the polar zone.

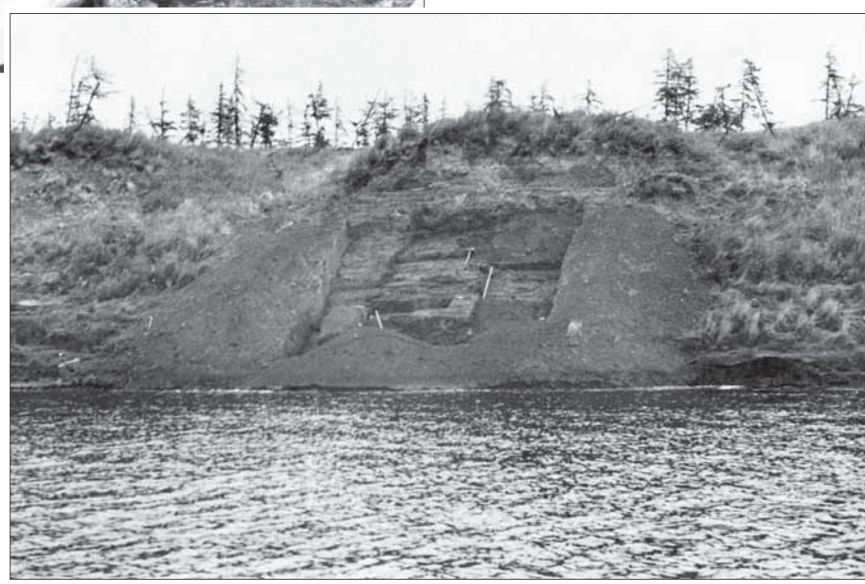
The year of 2014 was declared the Arctic Year, during which new approaches to the formation of a complex program for socio-economic development of the Arctic and Northern regions for 2014-2016 and up to 2022 have been proposed. But these are problems of today or tomorrow. In this article we'll try to scan the remote past and study in detail the process of populating the Northern territories.

TWO HUNTERS

About 30-35 thous. years ago, tribes of hunters reached the Arctic latitudes in Siberia, which is evidenced by artifacts found at a Paleolithic site in the estuary of the Yana River in the north-east of Asia*.

* *See*: A. Tikhonov, Yu. Burlakov, "Causes of Northern Giants' Extinction", *Science in Russia*, No. 2, 2008.—*Ed.*

Berelekhsky mammoth "cemetery".



Primitive man's site located near the Berelekhsky mammoth "cemetery".

The extreme environmental conditions made primitive man to actively develop new means of food procuring. It makes sense to assume that he had problems with hunting big thick-skinned, fast animals such as mammoths, bisons, tarpans, etc., with no reliable hunting means. He had to "design" it (it is well known that struggle for a piece of bread is a good teacher). Finally, people took notice of wolves, who side by side with them used to hunt in groups. In addition, man and wolf time and again ran into each other, especially near the bag.

Ancient man was able to assess such characteristics of this animal as intellect, caution, observation, well developed hearing, vision, and sense of smell. The wolf can lay an ambush, wait for the right time for attack, run fast (up to 65 km/h), is hardy and knows productivity of group hunting. He can see well in darkness and survive without food for many days running.

For centuries tribes of hunters took wolf-cubs to bring them up (this sometimes happens even in our days). The cubs growing together with the children of hunters, tried to imitate man's voice and, after centuries, learnt to bark. In the extreme conditions, grown in captivity and then set free, in fact already half-domesticated wolves had difficulties in surviving. They could not compete with wild animals for food, since in the wild life cubs ate taught to procure food in a very early age. The half-domesticated free and hungry wolves lived in a cold territory and could adapt themselves to man, get used to his smell, and win his confidence. Centuries later, such wolves could "give birth" to a new species *Canis familiaris* (domestic dog).

THE WOLF BECOMES A GUN-DOG

Proceeding from the scientific data, we can come to a conclusion that in the present-day Arctic zone of Yaku-

Dog-teams running northwards between ice toroses.

A stop on the way near the ice fields of the Laptev Sea.

tia, a territory of the most severe climate in Eastern Asia, tribes of hunters and predators (semi-domesticated wolves) had to fight for survival, as compared with people and animals living in more favorable environmental conditions. Probably it was there that primitive man domesticated the wolf and got a reliable friend and perfect assistant—a dog. First, the domesticated wolf turned into a gun-dog, not a watchdog, a rescuer or a shepherd. She helped find mammoths, bisons, and other animals, together they encircled a prey, and in general was very helpful for driving-in hunting. In severe climatic conditions, only a dog, presumably a Yakut laika, could help primitive man to survive: venturesome, universal, rather hardy and clever hunter, the dog has preserved many skills of the wolf. Early domestic dogs apparently resembled wolves in many ways.

This hypothesis is proved first by two dog skulls found in the Rossokha River, left tributary of Alazea (for further details see the book *Giants of the Ice Age* by N. Guryev, P. Lazarev, and P. Kolosov, Yakutsk, 2011). The artifacts were found in the Yeadonian suit layers of the Karginsky Period, are around 25-35 thous. years old. Secondly, based on the fact that genetic composition of the Eastern Asian dogs differ greatly, which took much time to form, geneticists of Sweden, USA, and Australia made a conclusion that dogs as domesticated animals have been existing in this very region longer than in any other place. Thirdly, the most ancient (20.9 thous. years) in the world authentic finding of bones of a domesticated dog was discovered in Siberia near Krasnoyarsk, while in other regions the earliest findings are dated by a lesser age: 14 thous. years (Germany), 11 thous. years (Kamchatka), and 10.4 thous. years (North America). There are other findings of dog remains too. Apparently man domesticated wolves on several continents at different time.

Two "dog power".

Assisted by dogs during hunting, primitive man procured food, which helped him survive in the severe climatic conditions and start settling in the Arctic. Finally, a circumpolar (related to one of the polar zones of the Earth) culture was forming. Descendants of hunting tribes of the Late Paleolithic (35-11 thous. years ago), well adapted to the Arctic environment, are represented by native minorities of the North-East of Asia (Evens, Yukagirs, Chukchi, etc.). In the severe taiga conditions of Yakutia, these tribes managed to survive due to their perfect hunting skills and laikas. Even today Yakut hunters go hunting together with their dogs: a talented dog means a rich bag. As for draught-dogs, they were replaced by snowmobiles, though they were the only means of transport there for centuries). A good team of dogs was as necessary as a rifle or fire in a yurt. Laikas were indeed indispensable: in hunting, in guarding, and what is most important—as a means of conveyance. In any weather, in fog or snow-storm, they helped hunters get to their traps or nomad camps, served as a reliable compass capable of finding a right way.

THROUGH THE ARCTIC ON DOG TEAMS

To some extent, evolution of a circumpolar culture is attributed to breeding of draught-dogs. It is not by chance that a monument to the dog named Balto, a leader of the dog team in Alaska, has been installed in New York. The stuffed figure of another dog named Togo is exhibited at the Museum of Draught-Dogs in the suburb of Anchorage. Both these dogs are laikas known in North America as Siberian husky. Representatives of this breed took part in the tragic Russian polar expedition in the early 20th century.

...The year of 1902. The Arctic coast of the Laptev Sea. Eduard Toll, famous researcher and discoverer, headed a regular expedition in search of a mysterious Sannikov Land*. His ship *Zarya* got stuck in the gulf between the islands of Belkovsky and Bolshoi Kotelny. It seemed as if his attempt to find a phantom island was in vain. However, Toll obsessed by the idea, made violent efforts to continue the expedition. Together with his three companions—astronomer Friedrich Seeberg and two guides Yakut Vasily Gorokhov and Tungus Nikolai Dyakonov—he arranged a dog team, left the ship and set towards Bennett Island of the De Long archipelago. Today it is hardly possible to imagine how brave and at the same time reckless these people were as a success was not so easy to attain, while at stake were their lives.

In 1903, the future Admiral Alexander Kolchak, as a member of this expedition onboard of *Zarya*, organized a rescue operation to find Eduard Toll and his friends. He was one of those who believed that they were alive, had reached Bennett Island, and were in need of help. Kolchak realized that after they reached the Great Siberian Polynia, the most difficult natural barrier on the way to Toll's supposed wintering site (Bennett Island), they would have to drag the ship by ice and land. The only transport he could use were dogs, more than a hundred of them. The rescue party set towards

* *See*: V. Glushkov, "Sannikov Land: Fact or Fiction?", *Science in Russia*, No. 2, 2004.—*Ed.*

After work.

the northern edge of Kotelny Island—the cape of Anisiy...

Since then 110 years have passed. A small expedition led by one of the co-authors of this article German Arbugaev, composed of five enthusiasts (including the other co-author Maxim Lyubavin) repeated the route of Kolchak from April 16 to May 17, 2013, with 22 laikas. It was a risky trip, but all participants relied on one another and believed in endurance of the draught-dogs. Everyone worked hard to get ready for the trip: they trained the dogs not only in the suburb of Yakutsk, but even reached the natural park *Lenskiye Stolby** located 240 km away from the city.

From the starting point—the village of Yukagir (north of Yakutia)—we set to the northern edge of the archipelago, the cape of Anisiy, which was the final point of the expedition led by Kolchak. Another thing we were interested in was to see if it was possible to reach Bennett Island where in 1903 Toll's personal belongings and diary had been found. The expedition was organized under the auspices of the Government of Yakutia, sponsored by *Purina* fodder production company, Polar Airlines, and the Yakut Branch of the Russian Geographical Society.

TRAVEL NOTES

Each of us, driving the sledges for hours, had a feeling of sailing in the endless Arctic "vacuum". The dogs gave the only hope that we would not be lost. They turned into "our brothers". It had nothing in common with a simple trip to an unknown place. Draught-dogs never show weakness. No matter how tired they are, they never growl or grin at a dog-team driver. They bear any emotional splash and take any behavior for granted. Laikas cannot feel aggrieved for a long time and are happy to notice any cordial gesture of man. They are faithful friends and industrious animals. You will be astonished to feel so much will and strength in a small fluffy animal. They are totally committed to man, which is above all praise.

On April 17 we set up the first camp. We tie dogs to stakeouts (a kind of fastening in the form of a peg to tie a dog), and feed them. Then we inspect their legs, and slightly pet them expressing tenderness. After having a bite we go to our sleeping-bags.

The next day we continue our way. The expedition steadily moves forward until we face a challenging obstacle... Toroses, toroses and again toroses of the Laptev Sea. A chaotic wall of rampant ice giants. The first serious test on the way. We realize that we are unable to bridge the obstacle straightforward. The dogs enjoy unplanned rest; we climb by turns the ice rocks to find any loophole in this confused mass of ice and snow. It is difficult to imagine the rumble when these toroses were formed in Sannikov Strait. No way out. All attempts are in vain ...We open the map and consult.

The decision is made—we'll walk along the wall until we find a way out. In the worst case, we'll make an overnight stop on the ice and then keep moving ahead. We finally find narrow passage ways. Each time we hope to

* *See*: P. Kolosov, "Natural Treasure on the Lena", *Science in Russia*, No. 2, 2013.—*Ed*.

see a flat ice behind the wall. However, ice walls change one another. The sledges move unsteadily as if they are small boats in a ten-point storm: going up or down.

It takes 7 hours to pass through the toroses. Dogs and people are extremely tired. However, the sledges keep moving. It is there that we realize the advantages of this mode of transport, as compared with modern motor vehicles. Dog sledges are able to overcome obstacles impassable for snowmobiles. Finally we realize: we can search for passage ways for miles and miles on and make a decision: to cut a path through by axes and spades. After ten hours of active work, sharply deviating from the route and going deep into the Laptev Sea, we find ourselves on a flat ice and decide to make an overnight stop.

April 19. We are facing another problem—a piercing Arctic night cold: the temperature goes down to –45 ºC. Until we kept moving, no one felt it. As soon as we stopped, we got into a cold trap. Snap hooks got frozen, and we had to warm them with our breathing. As luck would have it, a metal gear for dog sledges broke down, so we had to repair it with bare hands. Frost-bitten fingers are painful and do not bend. Gusty wind "plays" with the tents, we have to fix them deeply in the ice and cover ten flaps with snow. Finally, we prepare dinner. Salty boiling water gets cold in seconds. Metal spoons stick to the tongue. People are too tired and cold to talk. The sea wind penetrates through heavy clothes and makes us feel chilled to the marrow—the only wish is to hide in the sleeping-bag, reindeer fur coats get warm, and fall asleep.

April 20. The expedition reaches the island of Bolshoi Lyakhovsky. In 1903 the hunter Alexei Gorokhov found a skeleton of mammoth *Mammuthus primigenius* (Blumenbach, 1799), who died 49 thous. years ago there. In the winter of 1909-1910 it was taken away in dog sledges. Today, it is exhibited at the Paleontological Gallery of the National Museum of Natural History in Paris.

Sometimes the dogs are running half in the snow. On rare occasions, on bare stones. They get hurt rubbing their feet to bloody wounds. Nevertheless, they kept running day and night, wagging fluffy tails. The animals did not even eat the second fish in order to run easily. It is true their life was more difficult than that of the people.

The weather offers us another "surprise"—there starts a snow-storm. The snow desert of Kotelny Island comes to life and everything around begins chaotic motion. The snow-storm now calms down now intensifies. We have to stay where we are and observe powerful and unpredictable Arctic weather. It has no pity to the nature or man, can mix all colors and deprive a traveler of ear and eyesight, hide any guiding lines and strike panic and fear into anybody. And only dogs... perhaps, only dogs are not subject to its charms. Finally the snow-storm abates, and, irrespective of leaden-colored clouds, snow and fog, the expedition continues its advance to the final point—the cape of Anisiy. The fog becomes thicker and dog-teams try to be close to each other, constantly changing the leader. We all feel the breathing of the Arctic Ocean. The more we move forward, the colder the weather becomes. Hoar-frost covers our clothes, sledges, faces of peoples and dogs. For the whole period of the expedition we had to stop all in all for 10 days due to snow-storms.

May 10. The sledges reach the Cape of Anisiy on the northern edge of Kotelny Island. The weather suddenly changes and the fog disappears. We can see an endless dark open water (clear evidence of reducing Arctic ice area due to global warming). No way for us ahead.

Deviating from the topic of this article, we have regrettably to share our sad impressions: the regions of the Arctic we visited were polluted by man: fuel tanks, polyethylene packing materials, other wastes, etc. You can hardly imagine the size of this problem unless you see and feel it...

May 17. We passed 1,549 km using dog-teams. The longer we ran, the better we understood that dogs got a second breath. At the end of our journey it was easier for them to pass large distances. This means they could run and run. One day we covered 125 km in 18 hours. The expedition crossed the Laptev Strait through endless ice toroses, passed Lyakhov Islands, crossed the Sannikov Strait, then Kotelny Island, and finally reached the Cape of Anisiy. After all, we successfully returned to the settlement of Yukagir from where we had left in the mid-April.

...We completed our expedition in the tracks of the pioneer explorers in the year of the centenary of the Russian Geographical Society and 110th anniversary of rescue expedition headed by Alexander Kolchak to save the lost team of baron Toll. Thus, we once again confirmed the reliability of traditional transport—draught-dogs—in severe conditions of the Arctic.

Photos of the expedition by Ye. Arbugaeva,
other illustrations supplied by P. Kolosov