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Contents

A-I. ASTRONOMY

1. Cleaning up space debris and exploring the moon

Source: Tomsk State Univ

Scientists at the Faculty of Physics of TSU are studying the trajectories of near-earth objects of artificial and natural origin. These include space debris, lunar objects, and near-Earth asteroids.

The laws of orbital evolution and dynamics are studied by scientists using computer modeling and machine data analysis. The results of the study will help to distribute space debris in near-earth space, to solve the problem of the exploration of the Moon and circumlunar space.

“Near-Earth space is being used more and more intensively in the interests of the economic activity of mankind. New satellite systems are being created and deployed in space. Spent objects of these systems, as a rule, remain in near-earth orbits and turn into space debris. Currently, in near-earth space, according to NASA, there are several hundred thousand objects at least 10 centimeters in size. The annual increase is about a thousand fragments, ” says Anna Aleksandrova, project manager, associate professor of the Department of Astronomy and Space Geodesy of the Faculty of Physics of the TSU.

Of the 3,000 spacecraft, only six percent are operational. The researchers note that working in near-earth space requires knowledge of the dynamics of uncontrollable objects. The availability of the obtained data on their trajectory will make it possible to optimize the choice of satellites' locations, as well as to locate the spent objects in the most advantageous way.

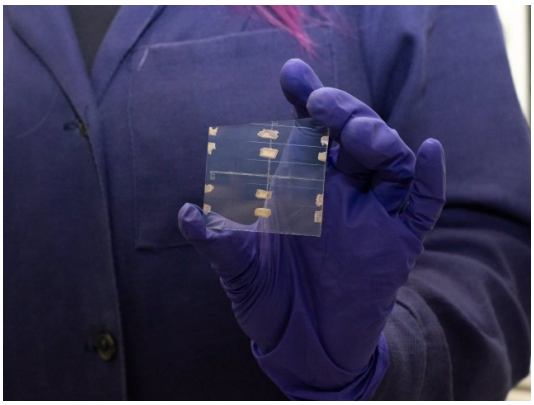
The project manager noted that an equally urgent task is to study the orbital evolution of circumlunar objects. The creation of a more accurate model of the NEA movement will make it possible to better predict the potential hazard:

“The research that we carry out is accompanied by a large volume of calculations, therefore, machine analysis is used to solve the problem. This tool will allow us to predict the movement of tens of thousands of objects and analyze more than a million time series of various dynamic and resonance characteristics,” explained Anna Alexandrova.

To analyze data, researchers use an algorithmic model implemented using artificial neural networks. Physicists have improved the numerical models of the motion of the satellites of the Earth and the Moon. The models have already been implemented at the TSU SKIF Cyberia cluster.

2. Nano particle paste to improve the efficiency of Perovskite solar cells

Source: ITMO Univ



Scientists at ITMO's Novy Phystech have created a paste of silicon and titanium dioxide nanoparticles to increase the generation of photocurrent generation in perovskite solar cells and maximize their efficiency. The result of the researchers' work has been published in the prestigious international journal Nano Energy.

The efficiency of solar cells made of halide perovskites already exceeds 25% at their low cost, which makes them one of the most promising in modern photovoltaics. Two strategies are commonly used to improve efficiency: improving charge collection or increasing light absorption. However, the first method implies the introduction of additional substances into the perovskite structure or the inclusion of 2-d structures, which significantly increases the cost of obtaining devices. Researchers at ITMO University decided to get around this problem - they used one of the most readily available elements in nature - silicon - and, using colloidal chemistry methods, created a paste from nanoparticles based on it to control the distribution of light inside a perovskite solar cell. This made it possible to increase the generation of photocurrent in the structure and to increase the efficiency of solar cells based on the simplest perovskite composition to a maximum.

“This is literally a modernized paste that perovskite cells need to selectively collect charges, to which resonant nanoparticles are simply added in the required amount, and then it is applied during the production of solar cells. At the same time, the technological process itself does not become more complicated, and the cost of silicon particles is low , - explains the first author of the study, a junior researcher at ITMO's New Physics and Technology Institute, Alexandra Furasova . -We also studied the effect of the distance between nanoparticles in the elements on the direction of light scattering by them and changed their concentration in the paste in order to maximize the concentration of all incoming light in the perovskite region. The efficiency of the conversion of light into electricity and all the main photovoltaic parameters directly depend on this. With the help of multiphysics calculations, we found the optimal concentration of nanoparticles and prepared the ideal paste for creating an electron transport layer, where we achieved almost maximum efficiency for this type of solar cells”.

According to the researchers, it was important to optimize the position of silicon nanoparticles within the composition. Especially for this, scientists have built a theoretical model that takes into account the electrophysical and optical properties of all layers and nanoparticles, which makes it possible to calculate the

generation and movement of charges under the influence of external radiation and voltage. This made it possible to determine how the size of nanoparticles affects the optical and electrophysical properties of the structure.

The method proposed by scientists is simple, affordable, universal for use and does not require a significant increase in costs in the production of solar cells.

“In this work, we use the spin coating method, that is, we get uniform thin films by depositing liquids on rotating flat substrates, but other methods can be used to scale up the technology. The resulting paste is a versatile product that can be used to create other types of perovskite solar cells, as well as for the production of photodetectors and other optoelectronic devices based on perovskites. We believe that this will be a demanded solution, ” emphasizes Sergei Makarov, professor at ITMO's New Physics and Technology Institute .

The study was carried out in collaboration with the Center for Hybrid and Organic Solar Energy at the University of Rome Tor Vergata and supported by a grant from the Russian Science Foundation (19-19-00683).

3. Black hole activity: Chronicles recorded in x-rays and radio beams

Source: Institute for Space Studies, RAS

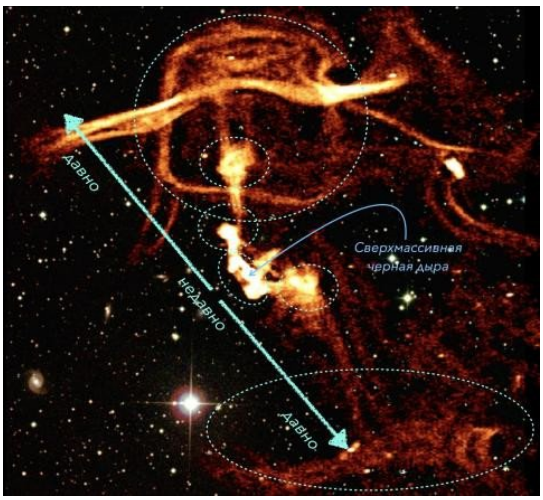
The LOFAR radio interferometer and the SRH / eROSITA telescope are studying impressive traces of supermassive black hole activity hundreds of millions of years ago in a nearby group of galaxies. By combining radio and X-ray images, astrophysicists have investigated a group of galaxies that contains an unusually rich array of radio-bright filaments immersed in an atmosphere of hot X-ray emitting gas. The results of the study are published in the journal Nature Astronomy .

Supermassive black hole in the center of a group of galaxies with hot intergalactic gas as seen by the artist

These filaments were originally formed as a result of the activity of a supermassive black hole several hundred million years ago - around the time when dinosaurs appeared on Earth. Despite their venerable age, the filaments still have clear boundaries and form a strikingly complex web of filaments and geometric shapes, reminiscent of the structures that form when hot clouds of smoke rise in the atmosphere. The lack of complete mixing between X-ray and radio-emitting plasmas is especially interesting for the development of physical models of the influence of supermassive black holes on the environment.

Massive halos in our universe, such as giant elliptical galaxies, galaxy groups and clusters, are mostly composed of dark matter that forms their deep gravitational pits. However, a small part of their mass falls on ordinary matter, that is, baryons, which form a hot (10 or 100 million degrees) gaseous atmosphere that fills the potential well of the halo. This gas emits in the

X-ray range and is studied using modern space observatories such as, for example, Chandra (NASA), XMM-Newton (ESA) and Spektr-RG (GK Roskosmos).



Association of structures of various scales with individual episodes of supermassive black hole activity over hundreds of millions of years. Larger structures are "older" than the more compact and vibrant details closer to the center of the group. Image from article M. Brienza et al, 2021

In the central part of each halo, the gas density is high, and it can cool and condense, providing material for the formation of new stars. However, for some reason this does not happen, and old stars dominate in the center of the halo. This mystery led to the development of a theory about the influence of supermassive black holes in the centers of clusters on the environment - the so-called "feedback" mechanism. According to this theory, as the gas cools, the supermassive black hole increases the accretion rate and begins to release a huge amount of mechanical energy in the form of plasma jets. This energy heats up the gas, preventing it from further cooling.

There are many analytical and numerical models that support this idea. But from first principles it is difficult to say unambiguously which specific physical processes are responsible for heating a relatively cold gas in a halo. These can be waves, turbulence, cosmic rays, viscosity, etc.

To answer these questions, it is necessary to study nearby clusters and groups of galaxies, and preferably in different spectral ranges, since gas of different temperatures emits photons of different energies.

NEST200047 is one of the closest groups of galaxies, about 75 megaparsecs from us (for comparison, the distance from the solar system to the center of our Galaxy is only 8 kiloparsecs). It is one of tens of thousands of similar objects found in galaxy catalogs. It was observed by radio telescopes of the ground-based radio interferometer LOFAR (short for Low Frequency Array, created by the Dutch Institute of Radio Astronomy ASTRON) and the SRH / eROSITA space telescope in radio and X-ray surveys. The characteristic wavelengths of these telescopes differ by about 5 billion times, and the data from the two observatories complement each other perfectly.

X-ray data were obtained during two surveys of the entire sky by the SRG observatory. The effective exposure was 645 seconds.

These observations confirm that the NEST200047 group has a hot gas atmosphere emitting X-rays. At its center is a giant elliptical galaxy, the core of which is a bright radio source. These are typical components for a group of galaxies in which the central black hole plays an important role.

But NEST200047 turned out to be very special. Radio emission comes not only from the center, but also from a rich and complex system of fibers covering an area of more than 200 kiloparsecs. It shows structures that resemble vortex rings. They are similar to those previously found in the famous galaxy M87, but ten times larger. Radio and X-ray images show that the plasma ejected by the supermassive black hole was deformed by complex motions for over a hundred million years, but during this time it has not completely mixed with the surrounding thermal plasma, most likely due to the presence of a dynamically important magnetic fields.

Overall, NEST200047 provides a unique example of an object that can trace the history of a supermassive black hole's activity over hundreds of millions of years. Rising bubbles of relativistic plasma work like a giant spoon, "stirring" the thermal X-ray plasma, preventing it from cooling.

A-II. AGRICULTURE

4. Detecting toxin substances in fruits and vegetables

Source: MEPhI

Scientists of NRNU MEPhI, together with colleagues from Turkey, Saudi Arabia and Iran, have developed a method for detecting the toxic substance thiabendazole in fruits. The advantages of the new technology are simplicity, cost effectiveness and the ability to detect the smallest concentrations of harmful particles.

In Russia and the European Union, the use of thiabendazole for food processing is prohibited. However, it is used in agriculture to control pests, decay and mold. The remains of the toxic substance enter the environment, and then into vegetables and fruits.

“Thiabendazole is toxic to humans. Among the main signs of poisoning: nausea, vomiting, headache, drowsiness, fever. Once in the body, thiabendazole can lead to liver failure, disrupt fetal development in pregnant women, or cause an allergic reaction. The toxic effect of this preservative on living organisms has been recognized as dangerous by the Food and Drug Administration of the European Union and other similar organizations, ”said Konstantin Katin, associate professor at NRNU MEPhI (INTEL).

Scientists have created a special solution that helps to detect thiabendazole in fruits even in the smallest concentration (up to 0.1 mg / liter). The chemical composition was selected using DFT calculations (density functional theory) by comparing the electronic structure of thiabendazole molecules and other substances.

“The task of the DFT calculation was to select a solution composition that would fit thiabendazole 'like a key to a lock.' It was important for us that the resulting solution interacts effectively with a toxic substance even under conditions when there is very little thiabendazole, and there are other contaminants in the food product, ”explained Konstantin Katin.

A suitable molecular complex based on betaine and pyroslimeic acid finds thiabendazole in fruits and "highlights" its presence. The new method is much cheaper and more accessible than the previously known ones. Now experts are working on a similar technology to find toxic substances in cosmetics.

5. Scientists figured out how to improve crops by using less water

Source: Moscow State University

Scientists of the Faculty of CMC, Moscow State University, together with their colleagues, have found optimal scenarios for the irrigation of two crops (potatoes and sugar beets). As a result of mathematical modeling, an increase in yield was demonstrated with a decrease in water consumption.

The objective of the study was not only to increase crop yields, but also to reduce water losses with ineffective irrigation. Reducing water losses during irrigation is necessary, on the one hand, to save water resources, and on the other, to reduce the impact of fertilizer migration to water bodies. With high volumes of irrigation, the efficiency of water use by plants decreases, and the volume of leached mineral fertilizers into groundwater increases.

The work used the mathematical model of yield WOFOST. The WOFOST model is one of the key elements of the European monitoring system for agricultural resources . A significant part of the data on the studied farm located near the river. Oka, was obtained as a result of field experiments. At the exit, after calculations, this model allows you to obtain a quantitative forecast of yield depending on weather conditions, soil properties, farm irrigation strategies, etc.

Using a digital simulator to work out possible scenarios requires incomparably less resources and efforts in comparison with real long-term experiments on the study of yield. “Additionally, the mathematical model allows you to play various qualitative scenarios of yield changes based on data from long-term historical weather observations. Thus, it is possible to assess the long-term effects that may manifest themselves with the constant use of certain strategies for operating the economy,” explained Associate Professor of the Department of Computational Technologies and Modeling, Cand. phys.-mat. Sci. Sergey Matveev.

In the process of searching for the optimal irrigation strategy, the power of the Zhores

supercomputer was used to speed up the calculations using a specialized genetic optimization algorithm NSGA-II.

“It was a nice observation that the actual farm irrigation planning strategies used are very reasonable, and it took us a lot of calculations to make sure that existing scenarios can still be improved within 10-12 percent, which is also a very significant figure. We hope that our recommendations obtained as a result of modeling can be transferred to pilot farms for conducting a large-scale field experiment. At the same time, we are happy even with the fact that we were able to demonstrate once again that the existing irrigation scenarios used in agriculture can still be improved in the direction of reducing the consumption of fresh water," added a senior lecturer at Skoltech, a graduate of the Faculty of Soil Science, Moscow State University, Maria Pukalchik.

The work was carried out jointly with employees from Skoltech and INM RAS.

6. "X-ray barrier" - for rapid assessment of seed suitability

Source: ETU "LETI"

The diagnostic method proposed at LETI with the help of microfocus soft-beam radiography makes it possible to carry out an express assessment of seeds unsuitable for agriculture - infected, without embryos, with hidden germination, enzymomycotic depletion, damaged by insects and with other signs. The technology of operational non-destructive testing is designed to provide Russian agricultural producers with invaluable assistance in determining the further economic suitability of grain crops.

A mobile unit for digital X-ray of seeds was developed by scientists of the Department of Electronic Devices and Devices (EPD) and engineers of ELTECH-Med CJSC. It consists of an X-ray protective camera, a radiation source, a digital image receiver, a device for positioning the research object, as well as original software that automatically detects and classifies seed defects.

The installation is an instrumental support of the national standard GOST R 59603-2021 “Seeds of agricultural crops. Methods of digital radiography", which was developed jointly by scientists from LETI and the Agrophysical Research Institute. The standard describes the procedure for conducting X-ray analysis of seeds and processing the results, requirements for equipment, reagents and samples, as well as for operator qualifications and safety. The document contains photographs from the world's first atlas of X-ray images of vegetable seeds, developed by ETU "LETI" and the Federal

Scientific Center for Vegetable Growing. The document will come into effect on January 1, 2022.

“Russia is heavily dependent on imports of seeds, while their quality is often at a low level. GOST for digital radiography methods and the installation intended for it is the result of more than 30 years of joint work of the LETI and Agrophysical Research Institute teams, which will put an “X-ray barrier” on the way of low-quality imported seeds. GOST is intended to stimulate the production of the domestic seed base, to ensure a steady growth of Russian grain production and to reduce the dependence of our country's agricultural producers on foreign suppliers, ” says Nikolai Potrakhov , head of developers, head of the EPU department.

“In the course of experiments, our employees tested using an X-ray machine seeds of pepper bought in one of the supermarkets - out of ten seeds, only two were suitable for growing ,” says the scientist.

The developers of the national standard plan to extend it to the countries of the Eurasian Economic Community, harmonize it with the existing rules of the International Seed Testing Association (ISTA) and develop an international standard for X-ray analysis of seeds.

At the XXX International Agro-Industrial Exhibition-Fair "Agrorus-2021", the development of ETU "LETI" was awarded a gold medal in the nomination "For Achievement in the Field of Innovations in the Agro-Industrial Complex".

7. Altai scientists developed an economical irrigation technology

Source: Scientific Russia

Scientists of the Scientific and Educational Center of Altaistics and Turkology "Big Altai" of the Altai State University have created a method of resource conservation for the treatment of arid soils. The research was carried out jointly with colleagues from Germany and Kazakhstan.

Arid soils are a big problem for growing crops. Field irrigation is expensive and often causes drainage of natural water bodies. Therefore, the researchers took it upon themselves to reduce the use of water resources and solve the agricultural problem.

“For research, we have deployed in Russia (Altai Territory) and Kazakhstan agrometeorological stations - automatic meteorological stations with sensors installed at three different depths. They measure such parameters as temperature, humidity and the availability of soil moisture for plants, ”said Andrei Bondarovich, Associate Professor of the

Department of Economic Geography and Cartography of Altai State University .

The new development retains moisture without watering the land due to the internal water regime. The stations capture data, broadcast it online, and help researchers analyze soil and quantify water resources. Based on the observation results, it is possible to understand how much water can be saved and how the soil should be cultivated so that the plants use water evenly throughout the season.

“Such elements of precision farming will also improve the training programs for the training of scientific and pedagogical personnel for agricultural production,” added Mukhtor Nasyrov, Vice-Rector for International Cooperation and Academic Affairs of Samarkand State University .

The study is also aimed at uniting scientists to solve common problems in Central Asia. It is planned that the technology will help in the development of agriculture in Uzbekistan.

8. A laboratory for the production of edible bacteria will be built in Russia

The first such complex is planned to be built in 2023 in the Vologda Oblast. In it, scientists will be engaged in the development and cultivation of edible bacteria and microorganisms.

According to the leading expert of the FoodNet working group of the National Technological Initiative (NTI) Mikhail Charny, there are currently no laboratory and technological design complexes in Russia designed for the cultivation of food microorganisms and bacteria, fodder protein, microbial haprin and other dietary supplements.

Meanwhile, their presence is extremely necessary for the implementation of national projects related to strengthening the health of Russians and their treatment. Therefore, at the moment, representatives of the FoodNet working group are actively negotiating with the Ministry of Health, the Ministry of Industry and Trade, the Ministry of Education and Science, the Ministry of Natural Resources and the Ministry of Agriculture in order to develop a roadmap for the implementation of the plan.

“This will allow us to raise funds for the construction of a scientific laboratory in the Vologda region, which will be able not only to issue technology, but also working design documentation, to produce pilot plants, because without such a step it is impossible to prove the market prospects of the product. We are talking about financing in the amount of about 200 million rubles. Taking into account the planned financial support, we plan to open the laboratory in 2023,” said Mikhail Charny.

According to him, a total of 10 such laboratories will need to be built in the country with a total cost of 200-300 million rubles each. As specialists have found out , the use of so-called edible bacteria, for example probiotics contained in fermented milk products, helps to maintain the desired acid balance in the body, thus strengthening human health and improving his psycho-emotional state.

E-I. ELECTRONICS

9. New generation of electronics - Terahertz devices electronics of the future

Source: Moscow Institute of Physics and Technology

Scientists from MIPT have studied new properties of one of the world's most popular materials for the production of magnets. It turned out that this material can be used in a new generation of electronics - terahertz devices.

Terahertz technologies have not yet penetrated into our everyday life, however, due to their rapid development, this day is clearly not far off. Many of us, without knowing it, have already come into contact with terahertz devices, for example, passing through a screening scanner at the airport. This is just one of many examples of terahertz devices. Their field of application covers medicine, telecommunications, information security and many other areas. But what is lacking in promising technologies for sustainable development? The answer is simple - materials. Those very "bricks" from which scientists and engineers build our future with you. And this is where hexaferrites come into play. Despite the unusual name, in fact, hexaferrites are well known to any person who held a bank card in their hands, a key card for a hotel room or a cassette with a magnetic tape. All these things have one thing in common - the magnetic stripes in them are made of hexaferrite. The outwardly nondescript black-brown substance turned out to be a very attractive magnetic material. And the fact that hexaferrites are also quite cheap to manufacture, since they are obtained from waste from metallurgy and mechanical engineering, allowed them to develop in full force on the magnetic market and occupy a good third of it with an annual turnover of billions of dollars. However, the magnetic properties that made hexaferrite famous made them undeservedly forget about its other outstanding qualities. Historically, the scientific study of hexaferrites was rather one-sided: scientists slightly changed the chemical formula and looked at how this would affect the magnetic characteristics. The rest of the research, if carried out,

Scientists from MIPT, in collaboration with Russian and foreign colleagues, were the first to investigate the potential of hexaferrite for terahertz technologies. The result was impressive. One of the desirable characteristics of a material in modern instrumentation is customizability, that is, the ability to purposefully change the properties of a substance. For example, changing the temperature, controlling the transparency of the material, etc. It was the customizability of hexaferrites that delighted the researchers. Lyudmila Alyabyeva and her colleagues investigated barium-lead hexaferrite. It turned out that if lead is added to barium hexaferrite,

this will significantly change its terahertz response, that is, the nature of its interaction with terahertz radiation. By studying how the amount of lead added to hexaferrite affects the ability to absorb terahertz, scientists have found that at a certain concentration of lead, the response changes suddenly and unexpectedly. An absorption band appears in it, which can be moved along the frequency. To displace such a strip, you just need to cool the material - and the hexaferrite will become easily tunable! In principle, the very phenomenon of such moving absorption bands is known in solid state physics and is called "soft modes". However, the soft mode found in hexaferrite posed two riddles to scientists at once: firstly, its very appearance was a complete surprise, and secondly, its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft fashion and its unusual behavior. An absorption band appears in it, which can be moved along the frequency. To displace such a strip, you just need to cool the material - and the hexaferrite will become easily tunable! In principle, the very phenomenon of such moving absorption bands is known in solid state physics and is called "soft modes". However, the soft mode found in hexaferrite posed two riddles to scientists at once: firstly, its very appearance was a complete surprise, and secondly, its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft fashion and its unusual behavior. An absorption band appears in it, which can be moved along the frequency. To displace such a strip, you just need to cool the material - and the hexaferrite will become easily tunable! In principle, the very phenomenon of such moving absorption bands is known in solid state physics and is called "soft modes". However, the soft mode found in hexaferrite posed two riddles to scientists at once: firstly, its very appearance was a complete surprise, and secondly, its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft fashion and its unusual behavior. the very phenomenon of such moving absorption bands is known in solid state physics and is called "soft modes". However, the soft mode found in hexaferrite posed two riddles to scientists at once: firstly, its very appearance was a complete surprise, and secondly, its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft fashion and its unusual behavior. the very phenomenon of such moving absorption bands is known in solid state physics and is called "soft modes". However, the soft mode found in hexaferrite posed two riddles to scientists at once: firstly, its very appearance was a complete surprise, and secondly, its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft fashion and its unusual behavior. its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft

fashion and its unusual behavior. its behavior with decreasing temperature differs from that prescribed by the standard theory. In their work, Lyudmila Alyabyeva et al. Offer an explanation for both phenomena - the unexpected appearance of soft fashion and its unusual behavior.

“In addition to the obvious practical significance, the study also has a purely fundamental interest: we have observed for the first time a soft mode with such exotic temperature behavior. Now we are actively working to find out what physical processes underlie its nature,” says Boris Gorshunov, Ph.D. Sci., Head of the Terahertz Spectroscopy Laboratory, Center for Photonics and Two-Dimensional Materials, MIPT.

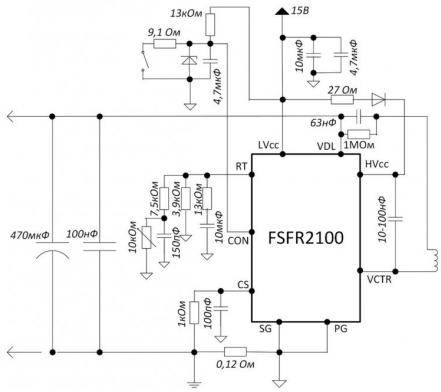
Thus, besides the well-deserved fame in the magnetic field, hexaferrite also has the potential to conquer the heights of terahertz electronics. Low-cost production, chemical stability, non-toxicity and environmental friendliness will also play a role here.

“Of course, there were some problems: for a thorough study of the properties of hexaferrite, we needed large enough crystals, while all well-developed technologies in the world work to obtain small crystals or powders. However, this problem is gradually being overcome. For example, crystals of unique size and quality for this work were grown by our colleagues, the group of Professor Denis Vinnik in Chelyabinsk , "adds Lyudmila Alyabyeva , Ph.D. Sci., senior researcher at the terahertz spectroscopy laboratory of the Moscow Institute of Physics and Technology and the first author of the work.

In addition to the staff of the terahertz spectroscopy laboratory of the Center for Photonics and Two-Dimensional Materials of the Moscow Institute of Physics and Technology, their colleagues from the V.I. A.M. Prokhorov RAS, South Ural State University, Southern Federal University, Institute of Physics of the Czech Academy of Sciences and Charles University (Czech Republic), Stuttgart and Augsburg Universities (Germany), as well as the Institute of Automation and Electrometry SB RAS.

10. Perm polytechnic created a wireless charger for drones, electric cars and robots

Source: Perm Polytechnic



Transmitter schematic diagram

Young researchers from the Perm Polytechnic University have developed a prototype of a platform that will provide wireless power transmission for drones, electric vehicles and robots. The device will significantly increase the duration of their work on a single charge.

The results of the research were published by the developers in the collection of materials of

the IV International Scientific and Practical Conference "Energy and Automation in Modern Society".

- Technologies for wireless transmission of energy are constantly evolving, such "charging" are inexpensive and highly efficient. But these standards are designed for low voltages and are mainly suitable for charging mobile devices. We have proposed a development that will help to increase the operating time of drones, robots and electric vehicles, - says the inventor, a third-year student of the Department of General Scientific Disciplines of the Lysva branch of the Perm Polytechnic University Sergey Sterlyazhnikov .

In many areas, “drones” are used to monitor objects and other purposes, which saves financial and time resources. But drone flights are limited, as a single charge lasts 20 minutes, taking into account photography. Recharging UAVs on special platforms with wireless power transmission systems can significantly increase their operating time, according to researchers from the Perm Polytechnic Institute. Now on the market there are practically no analogs that would provide "power" of rechargeable batteries without returning to a person.

Researchers have developed a device for wireless power transmission based on the FSFR2100 chip. It is distinguished by its high power and a large number of protections. The developers managed to simplify the design, improve the performance and reliability of the device. The maximum "charging" power without using a radiator reaches 200 W, and with a radiator - 450 W. It can operate at temperatures ranging from –40 to +130 degrees.

- Our development consists of two parts: a transmitter and a receiver. The receiver is assembled on the basis of a microcircuit that converts direct current into alternating current with a frequency of 150 kHz. Further, the voltage is transferred to the primary winding of the air transformer. Then, on the receiver winding, the voltage is transferred from the primary to the secondary winding, rectified, stabilized and fed to the BMS controller. Through it, you can charge the battery of the connected device, - explains the inventor.

In addition, the researchers have developed an LLC resonant transmitter that will provide highly efficient charging for drones and robots. The technology can also be used to “power” electric vehicles, as well as in other areas where wireless chargers are used.

11. Scientists of the perm polytechnic will provide intelligent power consumption

Source: Perm Polytechnic

In industrial enterprises, autonomous power plants are often used, but they do not always work accurately. Scientists of the Perm Polytechnic University have developed a program that will allow finding the most promising modes of power supply systems. The choice of the optimal types of equipment will help ensure its long-term and efficient operation and avoid accidents.

Scientists published the results of the study in the Journal of Physics: Conference Series. The development was implemented with the support

of an educational and research grant from the European Erasmus + program (INSPIRE project).

Researchers have developed a software module that models electrical engineering complexes as interconnected structures with complex subsystems. The technique will make it possible to determine in advance how complex modes of autonomous power supply systems based on gas turbine plants will function. The development will help to predict their work, taking into account various technological and field factors, the specifics of the power system, territorial and geological conditions.

- The idea for the development appeared when specialists from one of the industrial enterprises contacted us with a request to analyze the quality of electricity in the autonomous network. Instrumental examination did not show factors that would affect the equipment failure. To conduct a deeper analysis, we have created a model of an electrical complex, - says Dmitry Leizgold, senior lecturer of the Department of Microprocessor Automation Means of Perm Polytechnic University.

According to scientists, an innovative approach will increase the accuracy of process modeling and help solve problems that cannot be identified with instrumental measurements. The development will improve the analysis of the current and future modes of equipment in conditions of uncertainty and incompleteness of information. For example, specialists will be able to find out whether a power transformer will be efficiently used "with a margin", replacing it with a less powerful one when the load decreases.

The development will make it possible to predict the situation when an overvoltage occurs in the external network and will be able to give specialists recommendations on the operation of the equipment. Enterprises will have the opportunity to check the operation of the system at the project stage in order to avoid accidents.

“Unlike other models, our development takes into account non-electrical parameters: equipment maintenance schedules, the results of assessing the technical condition and energy efficiency,” the scientist explains.

Now researchers continue research and development work in the framework of cooperation with the Perm scientific and educational center of the world level "Rational Subsoil Use". Mathematical models of power supply systems and software systems of scientists of the Perm Polytechnic University have already been implemented at several enterprises of the Perm Territory. In particular, the module for assessing the electrical parameters of oil production facilities has been tested at the Ilyichevsk oil and gas field. The developers have confirmed the effectiveness of

the program in an industrial setting using semi-natural models and instrumental surveys.

E-II. ENERGY

12. Scientists developed a coating for energy efficiency of solar panels

Source: ETU "LETI"

Anti-reflective coatings based on nanostructured carbon-containing anodic aluminum oxide will increase the absorption of sunlight by reducing reflection losses.

One of the most important issues of our time is the state of ecology. Alternative energy can reduce the risk of harm to the environment - obtaining energy from renewable sources such as the sun, water and wind. Particularly promising is the direction of solar energy - due to the complete absence of harmful emissions into the atmosphere. Despite its environmental friendliness, this method of energy production has its drawbacks: the coatings used today do not fully absorb sunlight.

To minimize losses caused by the reflection of light from the surfaces of solar collectors, the project is called "Anti-reflective black composite coatings based on nanostructured carbon-containing anodic aluminum oxide", which is being developed by associate professors of the Department of Micro- and Nanoelectronics of ETU "LETI" Ekaterina Muratova and Svetlana Nalimova . “As you know, any coating is capable of reflecting, absorbing and transmitting sunlight. Our coatings are anti-reflective, that is, the proportion of electromagnetic radiation reflected from them is 1-2 orders of magnitude lower than the proportion of transmitted and absorbed. At the same time, the carbon content allows you to regulate the ratio between them, ”explains Ekaterina Muratova.

The creation of antireflection coatings is based on the principle of electrochemical anodization of aluminum substrates - aluminum is immersed in an electrolyte based on oxalic and tartaric acids and a carbon-containing porous coating is formed under the action of an electric current.

“Our technology is the most cost-effective in comparison with technologies for creating analogues of absorbing elements, for example, based on silicon wafers, due to the use of relatively inexpensive materials - aluminum, in the form of a foil or coating, and electrolytes with different concentrations of tartaric and oxalic acids. Also, the process is less energy-consuming and does not require expensive equipment, ” comments Ekaterina Muratova .

According to scientists, the developed technology will allow the use of coatings not

only in the visible, but also in the infrared range of the spectrum. This can form the basis for research into the energy of “smart clothes”, which will be powered by the heat of the human body. At the next stages, it is planned to modify the coatings by forming nanocomposites.

In 2020, the authors of the project won a grant from the President of the Russian Federation for state support of young Russian scientists - candidates of science. The research work is a logical continuation of the studies of the layers of porous anodic aluminum oxide, carried out in the educational and scientific laboratory "Nanomaterials" at ETU "LETI". Several years ago, the project manager, Ekaterina Muratova , presented unique results of studies of the optical properties of porous anodic alumina membranes in a wide wavelength range (from 190 nm to 15 μm). The patterns revealed by scientists served as an occasion for further study of the features of this material.

13. Russian scientists developed a model "standard" of the power system

Source: TPU

Scientists of Tomsk Polytechnic University have created a concept of all-mode verification of calculations of modes and processes in smart power systems, based on information from a model standard. Within the framework of the concept, they formed the accuracy classes of mathematical models of modern devices FACTS, HVDC systems, as well as renewable energy sources. This is necessary for a complete and reliable solution of practical problems in the electric power industry.

Solving the problem of all-mode verification of information obtained as a result of numerical calculations contributes to an increase in the most important indicator of the reliability and efficiency of the functioning of power systems - the accident rate.

“According to the statistics of systemic accidents in the global electric power industry, about half of them are associated with the use of low-reliability calculation results obtained using traditional modeling tools. The situation is aggravated by the current trends towards the complication of power systems due to the introduction of renewable generation, FACTS and HVDC systems, as well as the change and complication of operating modes and processes in power systems, ”explains Aleksey Suvorov, associate professor of the TPU Electricity and Electrical Engineering Department .

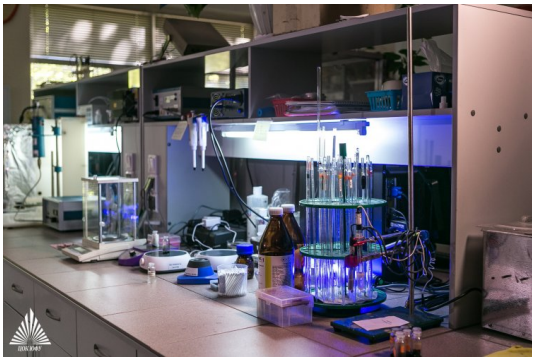
TPU scientists proposed to use a model standard of the power system to increase the completeness and reliability of calculations. It is used as a developed freely configurable multimodular complex for real-time simulation of power systems of any dimension and topology. It was succeeded to create due to the

hybrid approach to modeling complex dynamical systems, proposed and developed at TPU.

The developed concept of verification based on a hybrid model standard is unique and has no analogues in the world energy sector. With the help of it, scientists have already formed the accuracy classes of mathematical models of modern devices FACTS, HVDC systems, as well as renewable energy sources. The work was carried out within the framework of a grant from the Russian Science Foundation.

14. SFEDU scientists create new materials for hydrogen energy

Source: Southern Federal University



In 2021, employees of the Nanostructured Materials for Electrochemical Energy Laboratory published a series of articles in authoritative international journals on the creation of nanocatalysts for hydrogen energy devices. They obtained fundamentally new results.
The papers published in the journals Colloids and Surfaces A : Physicochemical and Engineering Aspects , Beilstein Journal of Nanotechnology , Colloid and Interface Science Communications and the Journal of Applied Electrochemistry, are devoted to the study of the regularities of the course of reactions leading to the formation of platinum nanoparticles, and the search for ways to control the morphology of nanostructured platinum-carbon catalysts are an important component of the new hydrogen energy industry.

SFedU scientists succeeded in developing an original approach, within the framework of which the analysis of the change in the color of the reaction medium was "turned" into an instrument for monitoring the progress of the transformation of a chemical compound into nanoparticles of metallic platinum.

“To understand the laws of the process means to find the key to managing it! As a result of targeted action on the reaction medium or modification of the carbon support, new platinum-carbon catalysts containing ultra-small platinum nanoparticles with a size of about two nanometers were obtained. It is important that we managed to find relatively simple methods of exposure that have demonstrated high efficiency. This means that such methods can be used in real production , not only in test-tube production,” said Vladimir Guterman, chief researcher at the Faculty of Chemistry of SfedU.

The development of a method for visualizing the synthesis of nanomaterials made it possible to understand the role of the main factors affecting the course of chemical reactions and the microstructure of nanomaterials.
Previously, it was believed that catalysts with small nanoparticles are inactive and not sufficiently stable during operation. In this case,

a fundamentally important result was obtained: the catalysts surpassed their commercial counterparts.

“The study opens up new possibilities for reducing the amount of expensive platinum in membrane-electrode assemblies of hydrogen-air fuel cells ,” said Vladimir Guterman .

Today, on the basis of the research laboratory "New materials for electrochemical energy", research is being carried out within the framework of the basic part of the State Assignment of the Russian Federation, two grants from the Russian Science Foundation, four grants from the Russian Foundation for Basic Research and two grants from UMNIK. 12 out of 13 laboratory employees are young scientists. For 10 months of 2021, they published 11 articles in authoritative international scientific journals, indexed in the Scopus and Web of Science databases.

M-I. MATERIAL SCIENCE

15. Scientists developed a universal phosphor for wide-profile sensors

Specialists of the Siberian Federal University (SFU), together with colleagues from China, have created a universal substance - a phosphor for sensor devices used in various areas of the national economy.
A phosphor is a substance that can convert the energy it absorbs into light radiation. However, devices with such radiation have serious drawbacks - they consume a large amount of energy, and also take up a lot of space.

“The existing devices with such radiation - halogen lamps, laser diodes and supercontinuum lasers - are large, consume a lot of energy and have low efficiency. In turn, infrared lamps based on phosphors with LEDs are small in size and efficient, but the problem of thermal stability has not been solved in them, ”explained Maxim Molokeev, associate professor of the basic department of solid state physics and nanotechnology at the Institute of Engineering Physics and Radioelectronics of the Siberian Federal University.

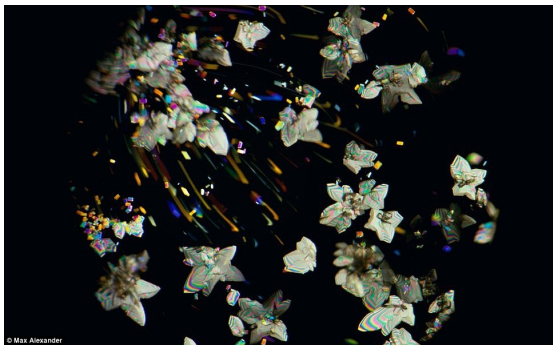
Therefore, scientists from Siberian Federal University, together with specialists from the South China University of Technology Guangzhou and the National Research Center for Synchrotron Radiation of the city of Hsinchu, have developed a phosphor that combines all the advantages of previous generations and at the same time has good thermal stability.

According to the developers, due to its universal characteristics, it can be used in various spheres of life: in medicine, for monitoring the health of

patients, in agriculture for growing plants and in biosensorics.

16. Hard X-rays helped to see the internal structure of crystals

Source: Federal Research Center, Siberia, RAS



Scientists have developed a new method for visualizing the structure of a crystal and examined an element of several hundred microns in it, which no one has seen before. This will allow researchers to understand the mangitoelectric properties of crystals, improve the quality of materials, and create new energy-saving devices for electronics in the future. The research results are presented in the journal Crystals.

Just a few Google searches on the amount of energy expended can boil a liter of water. This example demonstrates the growing need to find ways to reduce the power consumption of computers. NoncentrosyScientists have developed a new method for visualizing the structure of a crystal and examined an element of several hundred microns in it, which no one has seen before. This will allow researchers to understand the mangitoelectric properties of crystals, improve the quality of materials, and create new energy-saving devices for electronics in the future. The research results are presented in the journal Crystals.

Just a few Google searches on the amount of energy expended can boil a liter of water. This example demonstrates the growing need to find ways to reduce the power consumption of computers. Noncentrosymmetric crystal structures with magnetoelectric properties can become one of the solutions. Due to these properties, they are able to control the electrical or magnetic characteristics of a substance under the influence of a magnetic field. Before designing such devices for the future, it is necessary to understand how magnetoelectric effects and crystal organization are related.

Scientists from the Krasnoyarsk Scientific Center of the SB RAS, together with colleagues from Moscow, France and Israel, have developed a new method for visualizing structural characteristics in non-centrosymmetric materials. With its help, scientists were able to examine domains - structural elements of crystals several hundred microns in size, which no one had been able to see before.

A domain is a small part of a crystal that forms its structure and is responsible for orientation. It is known that domains are closely related to the magnetoelectric effect, but little is known about their existence, because it is extremely difficult to observe them. The new technique makes it possible to visualize domains and investigate the principles and features of their formation.

In their approach, scientists have combined two well-known methods: microfocusing X-ray optics and polarized X-ray radiation. The researchers selected radiation at a specific wavelength and focused it with a lens at a specific point in the crystal. By focusing on one point in the sample, the beam can "catch" the domain and transmit data about it through spectral reflection. At the output, scientists receive data on spectra and can judge by them, for example, the size of domains and their other properties.

Scientists have found that domains are typically several hundred microns in size. They tested their method on crystals of samarium ferroborate, which are known for their large magnetoelectric effect and can presumably be effectively used in memory devices. Having illuminated the crystal with a new method, scientists discovered that it is twinned - that is, it represents two crystals connected into one. The domains of these crystals were oriented differently and were mirror images of each other. In accordance with the position of the domains, the structure of crystals formed in a spiral is directed for the first to the right side, and for the second - to the left. As scientists have shown, the twinning of the crystal underestimated the value of its magnetoelectric effect.

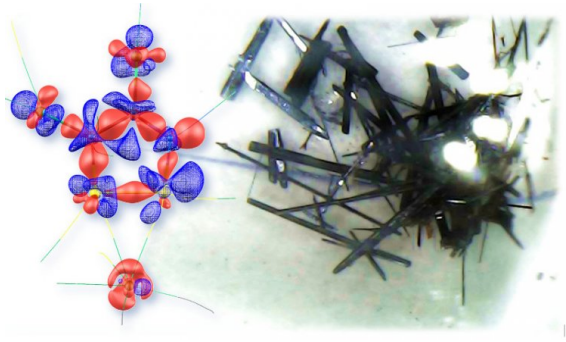
“The developed method is promising for determining the size and spatial distribution of domains in crystals. Our approach also shows good results for multiple twinned crystals or other materials with a complex domain structure, which cannot be studied by other methods. An important advantage of hard X-ray radiation is its high penetrating power, which makes it possible to measure real volumes of samples and investigate the specific properties of an object. This is especially promising for samples with multiple twin domains. The method we have developed can be a powerful tool for improving the quality of materials with non-centrosymmetric structures. In addition, it will help to understand the mechanism of magnetoelectric coupling in various ferromagnetic crystals. If we understand the location of the domains and then, accordingly, learn to control their growth, then it will be possible not only to predict, but to increase and enhance the properties of the material, to achieve new effects that will then be applied in electronics. Moreover, the development of such methods is currently an extremely urgent task, since they will be applied in installations of the class " megascience"Developed in Russia.

For example, the SKIF synchrotron in Novosibirsk, in the creation of which researchers from our center, RIF on Russky Island and SILA in the Moscow Region are also participating,” said Mikhail Platunov , Ph.D. L.V. Kirensky KSC SB RAS.

The scientist also noted that by understanding the laws by which domains are formed, one can learn not only to grow crystals, but also to separate twin samples, creating from them two separate crystals with undisturbed properties.

17. Russian scientists study electron density in crystals of Appel's salt

Source: South Ural State University



Research important for world science was carried out by scientists from South Ural State University (SUSU) together with colleagues from other research institutes. They found salts reasons of stability and in detail described findings in top journal «Acta Crystallographica Section B: Structural Science , Crystal Engineering And Materials» (Q2).

Organic crystals are of active research interest among scientists, because they are widely used in various fields - from organic semiconductors and solar cell components to medicinal chemistry. Experts are studying various properties of crystals; one of the topical areas is to consider the features of the electron density distribution. Thanks to this information, it is possible to predict the physicochemical, photoelectric and other properties of materials, which include the studied molecular compounds.

This work became one of the directions of the project "Towards new hybrid materials: digital modeling of structure and properties from the atomic-molecular level to nanoparticles", carried out by the staff of the South Ural State University together with colleagues from the research institutes of the Russian Academy of Sciences.

“We were the first in the world to study the experimentally obtained distribution of electron density in crystals of Appel's salt, which serves as a precursor in the synthesis of stable radicals ,” says the project manager, Ph.D. Ekaterina Bartashevich .

For the experiment, Ph.D. Oleg Bolshakov synthesized high-quality single crystals, guided by the experience of the group of D.Sc. Oleg Rakitin from the Institute of Organic Chemistry. N. D. Zelinsky (Institute of Organic Chemistry, RAS), studying heterocyclic systems based on substituted dithiazoles. The next step was the collection of X-ray diffraction data under continuous cooling conditions. The laborious experiment was carried out by Mikhail Minyaev from the Institute of Organic Chemistry of the Russian Academy of Sciences and Adam Stash from the Institute of Organoelement Compounds. A.N. Nesmeyanova (INEOS RAS). To build reliable models and interpret the data obtained, we used the facilities of the SUSU Supercomputer Center, in particular, the work was carried out by Ph.D. Irina Yushina . Doctor of Physics and Mathematics ProfessorVladimir Tsirelson , one of the founders of the scientific direction of quantum crystallography, develops a theory that allows you to look at the subatomic level of the structure of multicomponent materials.

The result of the study was an important conclusion: the reasons for the stability of free-

radical salts should be sought at the level of the properties of the electron density distribution. They lie in the peculiarities of the formation of chemical bonds, which are of a multicenter nature.

The scientists will not stop there, they plan to continue research work at the level of modeling and at the level of experimental studies of the structure and electronic properties of organic crystals.

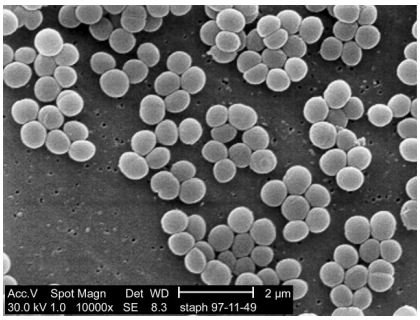
South Ural State University is a university of digital transformations, where innovative research is carried out in most of the priority areas of development of science and technology. In accordance with the strategy of scientific and technological development of the Russian Federation, the university is focused on the development of large scientific interdisciplinary projects in the field of digital industry, materials science and ecology. In the Year of Science and Technology, SUSU won the Priority-2030 competition. The university performs the functions of a regional project office of the Ural interregional world-class scientific and educational center (UMNOTs).

M-II. MEDICAL SCIENCE | LIFE SCIENCE

18. A new method of fighting staphylococcus infections

Scientists from Novosibirsk have found a way to fight staphylococcal infections, which makes it possible to turn off the bacterial DNA repair system.

Often during the treatment of bacterial infections, antibiotic resistance quickly develops, especially during the fight against staphylococci. Scientists from Novosibirsk have improved the treatment mechanism:



"Scientists have selected a group of antibiotics - cephalosporins, which infect bacteria through oxidative stress - a process in which reactive oxygen species damage DNA," the Institute of Chemical Biology and Fundamental Medicine of the SB RAS reports.

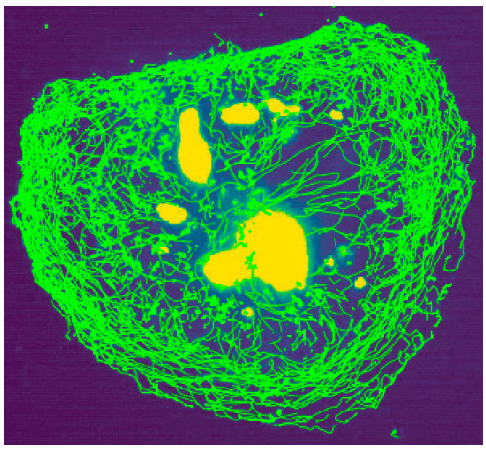
The bacterial DNA repair system can actively resist the action of drugs, it is able to find damaged DNA sections, effectively remove them and restore the integrity of the genetic material. Researchers conducted experiments, studied the GO-system of staphylococcus and learned how to turn it off with an inhibitor.

“Further, the bacterium can already be treated with an antibiotic. Under such a load, it is much more difficult for bacteria to develop resistance to cephalosporin, and it is more likely to die, ”says Anton Endutkin, PhD in Chemistry.

In the future, combined antibiotic therapy will effectively combat bacterial pneumonia, meningitis, tuberculosis and other infectious diseases.

19. Scientists figured out how viruses deceive an infected cell

Source: Moscow State University



A team of scientists from Moscow State University, the Institute of Protein of the Russian Academy of Sciences and other organizations have published a large review of unusual methods by which viruses force an infected cell to synthesize their proteins instead of those that it needs. The article was published in the jubilee collection of the journal "Biochemistry" dedicated to the memory of Academician Alexander Sergeevich Spirin.

Our planet is inhabited by viruses, many of which pose a threat to human health and life. Viruses are molecular parasites, they not only use the resources of an infected cell, but also "rent" many of its parts and mechanisms, instead of paying, they produce thousands of new viral particles.

Viruses are different - some of them have such a large genome that almost all the components necessary for primitive cell life could be encoded in it. However, there is a mechanism, the details of which, apparently, are never presented in their complete set - this is the translational apparatus necessary for protein biosynthesis. Its central component is the ribosome - a complex molecular machine consisting of a large number of diverse parts, ribosomal RNAs and proteins. Perhaps the point here is that the assembly of this machine is so complicated, requires such a huge amount of energy and the coordinated work of such a large number of genes, that “carrying it all with you” is simply impractical: it is much easier to use a ready-made one. However, this makes viruses completely dependent on the cellular translational apparatus, and,

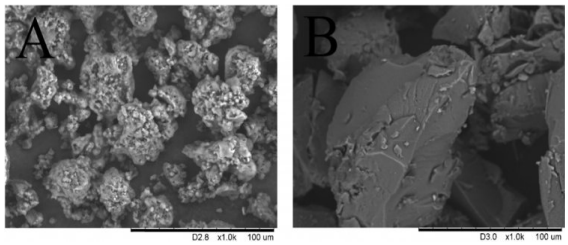
“This is where viruses have to use numerous tricks,” says a junior researcher at the A.N. Belozersky Moscow State University Ivan Sorokin, co-author of the article. “For example, at one end of the cellular mRNA that the ribosome usually binds to, there is a special chemical structure called a cap. One of the main functions of a cap is that it binds to special cellular proteins (cap-binding factors), which then attract the ribosome and thus contribute to the initiation (initiation) of translation. So, the mRNAs of many viruses do not have a cap, but in the course of evolution they have learned to turn this disadvantage into an advantage. So, the poliomyelitis virus encodes a special enzyme - protease, which cuts the cap-binding protein of the cell. It immediately "takes out of the game" cellular mRNA. At the same time, the RNA of the virus itself contains a special region (IRES), which binds the "trim" of this factor - thanks to this, the viral mRNA continues to be translated as if nothing had happened. "

In some viruses, instead of a cap, a small viral protein (VPg) is located at the end, which binds the same factors as the cap. And many plant viruses have special signals (3 'CITE) at the opposite end of the mRNA, but due to the closure of the mRNA molecule in a ring, they also manage to attract the ribosome to the right place. “But the notorious SARS-CoV-2 coronavirus, which caused the current COVID-19 pandemic, uses a completely different“ trick, ”Ivan continues. “It encodes a protein that plugs the ribosome like a plug and prevents it from binding to cellular mRNA. At the same time, all mRNAs of the coronavirus itself contain a special structure that can displace the "plug" during their translation. And there are many such tricks. Here we are considering them in our review. "

“Protein biosynthesis is the Achilles' heel of viruses, since a healthy cell usually does not need to synthesize protein in such large quantities as in a viral infection,” continues the thought of another co-author, head of the department of interaction of viruses with cells at the A.N. Belozersky Moscow State University Sergei Dmitriev... - Many low molecular weight translation suppressors may be potential broad-spectrum antiviral drugs. And understanding these specific translation mechanisms that we are considering in our review can help in the fight against specific viral infections. However, our review also had another goal. By writing it, we wanted to pay tribute to the memory of Academician Spirin, a remarkable scientist who made a huge contribution to the study of protein biosynthesis and who was also involved in research on the translation of viral mRNAs. Our team included students and friends of Alexander Sergeevich, his colleagues, co-authors and employees who worked with him at the Institute of Protein of the Russian Academy of Sciences, at the Faculty of Biology and at the Research Institute of FHB MSU. "

20. Wheat waste could become new medical materials

Source: Federal Research Center, Siberia, RAS



Lignin granules (left) and sulfated lignin granules (right), photo taken with a scanning electron microscope

Krasnoyarsk scientists have developed a method for sulfating lignin obtained from waste wheat. The sulfation process endows lignin with water solubility and anticoagulant activity, which makes it possible to use it in pharmacology. The research results are published in the journal Catalysis Today.

During the deep processing of plant raw materials in the pulp and paper industry, a huge amount of waste is generated, in particular lignin, which must be disposed of. However, lignin is a difficult-to-process product that is practically not used anywhere. At present, scientists are actively developing new, more efficient methods for processing technical lignins into valuable substances and are looking for areas of their application. A promising area of chemical modification of lignins is sulfation,

which allows modifying lignin and endowing it with new properties, in particular pharmacological: anticoagulant activity and solubility in water. The scientists' task was to find the optimal conditions for obtaining sulfated lignins. Krasnoyarsk chemists solved it using harmless reagents.

Scientists from the Federal Research Center "Krasnoyarsk Center SB RAS" and the Siberian Federal University investigated the effect of various solvents and catalysts on the process of sulfation of lignin with sulfamic acid. Based on the studies carried out, a new optimal method for the catalytic sulfation of lignin from wheat straw using sulfamic acid, dioxane ether as a solvent and urea as a catalyst has been proposed. This method has proven to be effective, safe and environmentally friendly. Sulfation has imparted unusual properties to lignin, such as water solubility. Researchers speculate that it could now be used for medical purposes.

“One of the main crop residues among agricultural residues in the world is wheat straw, with a global production of more than five hundred million tons per year. At the same time, wheat straw is 16–25% lignin. The production of sulfated lignin derivatives is a promising area of its processing. We tried to find the most convenient parameters for this process. After the reaction, the presence of a sulfate group in the structure of lignin was confirmed by a complex of physicochemical studies. The inclusion of a sulfate group in the lignin structure increases the solubility and biodegradability of lignin. In addition, sulfated lignin derivatives in the long term can exhibit antiviral and anticoagulant activity, which makes them in demand in pharmaceuticals and medicine.- told about the results of the work Yuri Malyar, candidate of chemical sciences, senior researcher at the Institute of Chemistry and Chemical Technology of the Federal Research Center of the KSC SB RAS.

21. Non coding RNAs in the diagnosis of cancer

Source: Russian Science Foundation

Experts from the Laboratories of Epigenetics and Genome Editing of the Federal State Budgetary Scientific Institution "Medical Genetic Research Center named after Academician N.P. Bochkova” (MGSC) identified a number of new, previously unknown long noncoding RNAs, as well as recently discovered long noncoding RNAs, whose role had not been previously studied in thyroid cancer.

In recent years, more and more new long non-coding RNAs have been discovered; they are not involved in the process of protein synthesis. Accordingly, the question arises as to what functions they perform in the body. It is already known that, first of all, long noncoding RNAs

regulate the work of their target genes. When the concentration of long non-coding RNAs changes, so does the level of expression of individual genes. Including these can be suppressor genes, that is, suppressing the tumor process, or, conversely, genes whose expression triggers carcinogenesis, that is, tumor growth.

It was previously established which of the recently discovered long non-coding RNAs are involved in the development of breast and lung cancer. Experts from the Epigenetics Laboratory of the Moscow State Scientific Center found that these RNAs also play an important role in the development of thyroid cancer.

Valentina Yakushina, Senior Researcher, Laboratory of Epigenetics, Moscow State Scientific Center: “In addition to the fact that we were able to provide one more confirmation of the involvement of some long noncoding RNAs in tumor transformation of thyroid cells, we saw the connection of recently discovered long noncoding RNAs with different subtypes of thyroid cancer”.

Many problems remain in the diagnosis of thyroid neoplasms, the main one being the difference between a benign neoplasm, adenoma, and a malignant, carcinoma. Today, in 60% of cases, after an operation to remove a fragment of the thyroid gland, the neoplasm turns out to be benign.

The diagnosis of cancer is established on the basis of the results of several tests, the main of which is a biopsy, i.e. collection of a tissue sample of the neoplasm.

Vladimir Strelnikov, Head of the Epigenetics Laboratory of the Moscow State Scientific Center, Doctor of Biological Sciences: “Fine-needle biopsy allows taking a very small amount of material, which means that it is difficult to carry out several tests. In some cases, the material is insufficient to accurately determine the type of tumor. Therefore, new methods for classifying a neoplasm before surgery are now in great demand. "

Experts from the Epigenetics Laboratory of the Moscow State Scientific Center put forward a theory that the number of certain long non-coding RNAs in each case can indicate whether a malignant tumor is benign, as well as speak about a specific subtype of malignant neoplasm. In the course of work supported by a grant from the Russian Science Foundation, the researchers showed that the analysis of long noncoding RNAs will not distinguish benign adenoma from malignant follicular carcinoma - even at the molecular level, at the level of gene expression regulation, these tumors are similar. However, it was possible to establish that different types of thyroid cancer have their own set of long non-coding RNAs. In oncology, differentiation of tumors, determination of their subtype are of key importance for the choice of treatment tactics.

Several types of thyroid cancer are distinguished today:
- Papillary cancer. This is the most common malignant neoplasm.
- Follicular cancer. These tumors tend to grow slowly.
- Anaplastic cancer. This is the most aggressive type of thyroid cancer.

Valentina Yakushina, senior researcher at the Epigenetics Laboratory of the Moscow State Scientific Center: “It turned out that the cells of each type of thyroid cancer carry their own, characteristic only of them, a set of long non-coding RNAs. These RNAs can be associated with the features of the clinical course of the disease and the features of metastasis. For doctors in the future, this may be important information, since will help you choose the most effective approach to treatment. However, today our work remains fundamental, it expands the spectrum of knowledge about the role of long non-coding RNAs in the body. It cannot be expected that our results will soon pass into clinical practice. However, it can be expected https://scientificrussia.ru/articles/vyasneno-kakie-dlinnye-nekodiruusie-rnk-mogut-stat-dopolnitelnym-markerom-v-diagnostike-raka-sitovidnoj-zelezythat over time, with the accumulation of a sufficient amount of information confirming the effectiveness, information content of the method, The study of long non-coding RNAs is a global trend in oncogenetics. However, today there is practically no research on their role in the development of thyroid cancer. Laboratory of Epigenetics, Medical Genetic Research Center name after Academician N.P. Bochkova became one of the first in the world who began to study this topic and received significant results.

22. Digital technology will help diagnose heart disease

Source: North Caucasus Federal University

SKFU mathematicians have developed an effective system for recognizing cardiovascular diseases based on ECG signals. The proposed approach has shown a higher accuracy than its counterparts. It improves the quality of early diagnosis of heart problems, which is very important for the prevention of dangerous diseases.

As noted by the scientists, today cardiovascular diseases are the main cause of death in developed countries, and the number of patients seen by a cardiologist is growing every day. An electrocardiogram (ECG) is used to detect heart problems, but doctors, on average, estimate the findings with an accuracy of 65 to 70 percent. In other cases, the information is misinterpreted, which negatively affects the health of patients. SCFU mathematicians have proposed an original approach that improves the accuracy of determining atrial fibrillation (atrial fibrillation), which increases the risk of ischemic stroke.

“We have developed a new architecture with an advanced recurrent neural network structure,” explained Pavel Lyakhov, head of the project, head of the Department of Mathematical Modeling of NCFU and the Department of Modular Computing and Artificial Intelligence of the Regional Scientific and Educational Mathematical Center “North Caucasian Center for Mathematical Research” at the university. -

For a more accurate interpretation of signals, we use digital preprocessing using digital filters, spectral analysis and some other methods. Thanks to this, we were able to significantly reduce the noises of various nature, distorting the signal of the electrocardiogram. As a result, we were able to improve the accuracy of data interpretation up to 87.5 percent. For the best foreign counterparts, this figure reaches 79-83 percent.

To train the neural network, the open base of cardiogram signals "PhysioNet Computing in Cardiology Challenge" (CinC Challenge) was used. During the first simulation, the network examined data from 976 ECGs, and during the second, it was offered 5754 ECGs.

“Our approach does not require any specialized technical means,” noted Ulyana Lyakhova, a postgraduate student, research associate of the Department of Mathematical Modeling of NCFU. - The solution we have proposed can be implemented in the form of a special program that will receive a cardiogram signal at the input, and issue a verdict at the output whether a person needs treatment or prevention of cardiovascular diseases. In the future, we want to generalize our approach and apply it to the processing of other biomedical signals received from the human body. Processing of cerebral signals by electroencephalogram is of great interest to us. Such research is now very relevant for the development of a brain-computer interface that allows you to control the computer using your thoughts without mice and keyboards.

23. LETI scientists have developed a "smart patch" for drug administration

Source: ETU "LETI"

Researchers at ETU "LETI" have developed and began to implement the concept of creating a "smart patch", which is able, based on data from monitoring the state of the body and unfavorable environmental conditions, to carry out a minimally invasive injection of drugs into the human body through the skin.

One of the promising directions in the development of medicine is aimed at providing a person with medical care without the need to visit a medical institution, without the need to change the rhythm of his professional activity or rest. Such help may be needed by people suffering from chronic diseases or working in conditions associated with the possibility of severe poisoning.

“We have developed the concept of a conformal system for monitoring and correcting the human condition that is fixed on the skin. Depending on the purpose, the system is completed with the necessary set of miniature devices, in which only the reservoir for storing the drug and the array of microneedles that ensure its transdermal delivery remain unchanged, ”explains Viktor Luchinin, head of the Department of Micro- and Nanoelectronics at ETU“ LETI ”.

The production of the monitoring and control system is based on the use of modern technologies for micro-processing and printing of flexible electronics. In addition to the mandatory modules, the product can include sensors for monitoring the state of a person, a

radio communication module designed to control the device in the event of an emergency (the appearance of toxic substances), as well as a micropump that provides the required rate of introduction of the substance. In one embodiment, the device can be placed on a person's wrist, similar to a wristwatch.

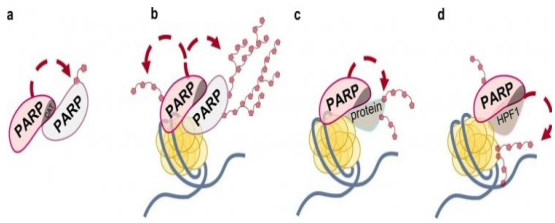
“So far, the current prototype of the“ smart patch ”is aimed at solving pharmacological problems that ensure the transportation of drugs into the human body or the extraction of interstitial fluid for subsequent analysis of biomarkers. In the future, we plan to explore the possibility of using our technical solutions for non-pharmacological correction of the state of the body, for example, transdermal transfer of the energy of the electromagnetic field, ”says Victor Luchinin.

The project is based on the achievements of LETI scientists of recent decades in the field of "smart" technologies for use in various spheres of life. So, in 2008, clothes with built-in interfaces were created and patented . The first generation of such clothing is a T-shirt and shorts with integrated sensors for heart rate, blood pressure and oxygen saturation, a pedometer, and orientation and navigation devices that record data in real time.

The development of the "smart patch" is carried out in line with one of the priority R&D directions of ETU "LETI" "Biointerface", and is also supported by a grant from the Russian Science Foundation .

24. New discoveries in DNA repair

Source: SB RAS



Variants of PARP enzyme activity: a - basal (DNA-independent) activity; b - DNA-dependent self-modification, which is assumed to occur in cis and transvariants; c - DNA-dependent heteromodification of the target protein; d - HPF1-induced histone heteromodification

The vital activity of the human body largely depends on the stability of its genome and the correct reproduction of the information stored in it in the form of DNA. In turn, genome stability is determined by the cell's ability to respond to DNA damage. The key mechanism of regulation of this process is poly-ADP-ribosylation of proteins involved in DNA repair. Fundamental research in this direction is carried out by employees of the Laboratory of Bioorganic Chemistry of Enzymes of the Institute of Chemical Biology and Fundamental Medicine of the Siberian Branch of the Russian Academy of Sciences under the leadership of Academician Olga Ivanovna Lavrik. They recently published their findings in the prestigious Communications Biology journal .

A DNA molecule is a library that contains information about the functioning of a cell. It is well known that the structure of DNA is protected from damage by a repair system consisting of protein complexes. Dynamic repair

processes in chromatin require the participation of regulatory enzymes. Today, the most relevant fundamental research is related to ADP-ribosylation, an intracellular reaction that regulates many processes, including replication, transcription, and DNA repair. As a result of this reaction, carried out by the enzymes poly (ADP-ribose) -polymerases, poly (ADP-ribose) is formed - a specific polymer that performs the most important function, namely, attracts "repair teams" of repair enzymes to breaks in DNA molecules to restore them.

Head of the Laboratory of Bioorganic Chemistry of Enzymes (LBCP) of the ICBFM SB RAS, Academician Olga Ivanovna Lavrik: “The study of the processes occurring in human cells is impossible without understanding the mechanism of ADP-ribosylation. In the cell nucleus, this process is catalyzed by the enzymes poly (ADP-ribose) -polymerase 1 and 2 (PARP1 and PARP2), which, in essence, regulate all important cellular systems, maintaining the stability and fidelity of the genome. "

PARP1 is the most important enzyme. It regulates key processes, catalyzing the synthesis of poly (ADP-ribose), which is called the third nucleic acid along with DNA and RNA, during DNA damage. The study of such a fundamental reaction is necessary for the most important medical problems, namely, for the search for targets that must be inhibited in order to kill a cancer cell.

PARP1 and PARP2 are members of the poly (ADP-ribose) polymerase (PARPs) family of 18 proteins. The functions of many of them are still unclear and are the subject of active research. The first of the discovered proteins of this family, PARP1, is responsible for detecting DNA breaks that occur during genotoxic stress. By binding to breaks in DNA, the enzyme uses NAD +(coenzyme of vitamin B3, vital for every cell of the human body) for the synthesis of a branched negatively charged polymer - poly (ADP-ribose), the very "third nucleic acid". During the synthesis of poly (ADP-ribose), PARP1 covalently attaches this negatively charged polymer to itself in order to more easily leave the breaks in DNA, which is also negatively charged, and PARP1 can attach this polymer to other proteins, regulating their interaction with DNA. At the same time, poly (ADP-ribose) can assemble proteins into functional complexes, concentrating them near DNA damage. The synthesis of poly (ADP-ribose) has an important signaling function, namely, it informs the cellular systems about the damage to DNA that has occurred, in the same wPARP1 and PARP2 are members of the poly (ADP-ribose) polymerase (PARPs) family of 18 proteins. The functions of many of them are still unclear and are the subject of active research. The first of the discovered proteins of this family, PARP1, is responsible for detecting DNA breaks that occur during genotoxic stress. By binding to breaks in DNA, the enzyme uses NAD +(coenzyme of vitamin B3, vital for every cell of the human body) for the synthesis of a branched negatively charged polymer - poly (ADP-ribose), the very "third nucleic acid". During the synthesis of poly (ADP-ribose), PARP1 covalently attaches this negatively charged polymer to itself in order to more easily leave the breaks in DNA, which is also negatively charged, and PARP1 can attach this polymer to other proteins, regulating their interaction with DNA. At the same time, poly

(ADP-ribose) can assemble proteins into functional complexes, concentrating them near DNA damage. The synthesis of poly (ADP-ribose) has an important signaling function, namely, it informs the cellular systems about the damage to DNA that has occurred, in the same way as a column of smoke is a signal that a fire has begun. Thus,

Another member of the PARP family, PARP2, is considered to be a less active PARP1 analog. It actually has less activity in the poly (ADP-ribose) synthesis reaction when compared to PARP1. Nevertheless, it was found that intact cells, in which there is no PARP1 at all, continue to function fully. It turns out that PARP2 is quite capable of supporting the vital processes of the cell, but how this is possible at a much lower level of poly (ADP-ribose) synthesis remained unknown.

Given the key roles of PARP1 and PARP2 in repairing DNA damage, understanding their mechanisms of action is of great medical importance. Enzymes in this family of proteins are excellent therapeutic targets. PARP1 inhibitors inhibit DNA repair in cancer cells and are used as anticancer drugs for the treatment of breast, ovarian, and several other diseases. It was found that PARP1 is involved in the development of inflammatory processes. For example, "hyperactivation" of PARP1, coupled with the consumption of NAD + and a decrease in the energy balance of the cell, is responsible for an increase in the number of lesions in stroke, myocardial infarction, and sepsis. This suggests that PARP1 inhibitors can also be used for the treatment of non-cancer diseases.

The PARP1 enzyme was discovered back in the 60s of the last century, but for decades scientists did not suspect that it interacts with a certain cofactor, a helper protein, with which it forms a single active center. This protein was discovered only in 2016 and was named histone PARylation factor 1 (HPF1). It is HPF1 that regulates the attachment of the synthesized ADP-ribose polymer to histones in chromatin.

Tatyana Andreevna Kurgina, postgraduate student of Novosibirsk State University, employee of the laboratory of bioorganic chemistry of enzymes at the ICBFM SB RAS: “This is extremely important for the repair processes, and here's why: DNA is tightly packed in the cell nucleus as part of chromatin. The very first level of compaction is nucleosomes, DNA-protein complexes, where DNA is wound on a histone nucleus, consisting of proteins. In such a structure, some parts of DNA, including those containing damage, are screened by histones, and poly-ADP-ribosylation of histones leads to relaxation of this structure, making the hidden areas available for repair machines. "

Research by researchers at the Laboratory of Bioorganic Chemistry of Enzymes of the ICBFM SB RAS showed that HPF1 is able to stimulate the early stages of ADP-ribosylation and inhibit the late ones. That is, under certain conditions, this coenzyme is able to increase the amount of the synthesized poly (ADP-ribose) polymer. “At first glance, it might seem that HPF1 interacts with PARP1 and PARP2 extremely inefficiently. It is necessary to add a very large excess of HPF1 over PARP1 or PARP2 to see the formation of their complexes with HPF1. The first studies due to this

seemingly poor interaction were carried out at high concentrations of HPF1. Research results have shown that this factor prevents PARP1 from synthesizing poly (ADP-ribose), reduces the amount and length of synthesized polymers. " However, as it was established by the LBHF staff, these data are not entirely correct. The fact is that HPF1 forms a complex with PARP1 much more efficiently when this enzyme is already activated. When PARP1 binds damaged DNA and NAD+ , he goes on alert and his structure changes - HPF1 gets the opportunity to contact him, as the site opens for his landing. In a cell, it is unlikely that HPF1 will be greater than PARP1, as shown by relevant studies. Experiments carried out under conditions closest to those of a cell showed that HPF1, on the contrary, stimulates the activity of PARP1, and it was also found for the first time that this protein stimulates the activity of PARP2. As a result, in the presence of HPF1, the PARP1 “substitute”, namely PARP2, becomes truly active. This is a very important observation that clarifies the mystery of the low activity of the second PARP in the absence of HPF1.

The role of NAD + is also extremely important, because this molecule supplies energy for many cellular processes and acts as a cofactor for enzymes. To waste it is wasteful and harmful. If PARP1 is strongly activated and has spent all NAD + on synthesis, then the cell may die. In the work of LBHF employees, it was shown that HPF1 can prevent PARP1 "hyperactivation" so that it does not use all the NAD + , which is also needed for other processes. At low NAD + concentration, HPF1 will, on the contrary, stimulate PARP1 and PARP2 to maintain the signal of DNA damage, initiating the process of repairing these damage. Thus, HPF1 normalizes PARP1 and PARP2 activity by regulating energy expenditure.

Another important result of the work is as follows. It turned out that HPF1 has a much greater effect on PARP2 compared to PARP1. Unlike PARP1, this enzyme predominantly modifies histones in the presence of HPF1. That is, it participates not only in creating a signal of DNA damage, but also creates conditions for its repair at the chromatin level. Poly-ADP-ribosylated histones interact worse with DNA and do not interfere with the repair process. Thus, it was found that HPF1 is especially required in the cell for the performance of PARP2 functions, since without this factor PARP2 has a low level of activity. We can say that the long-standing mystery has been solved!

“The study of enzymes in the PARP family undoubtedly holds great promise, even including areas such as combating COVID-19. After all, ADP-ribosylation is a process involved in the penetration of the coronavirus into the host cell. Our laboratory is the leading laboratory in Russia in studies of the functions of proteins of the PARP family. The world's leading laboratories are actively involved in these enzymes. Conferences dedicated only to these enzymes are held annually, due to the importance of these studies for the treatment of cancer and neurodegenerative diseases. I would like to point out that serious fundamental research is absolutely necessary in order to develop optimal methods of treatment. Only fundamental research can create the necessary foothold for the further development of medicine,” commented Olga Lavrik.

25. Russia has developed a unique drug for the treatment of alzheimer's disease

Source: RIA

Russian developer of a unique peptide drug for the treatment of Alzheimer's plans to apply for permission to conduct its clinical trials since 2022, told RIA Novosti director of the St. Petersburg Institute of Bio-regulation and Gerontology, chief researcher at the Institute of Physiology named after IP Pavlova of the Russian Academy of Sciences , Corresponding Member of the Russian Academy of Sciences, Professor Vladimir Khavinson .

"These developments have been going on for about 8 years ... Experimental studies were carried out in mice in a model of Alzheimer's disease. Currently, the development of unique peptides that can effectively combat memory loss is at the final stage of preclinical studies. At the next stage, documents will be submitted to the Ministry of Health of the Russian Federation to obtain permission to conduct clinical trials on humans. These documents are planned to be submitted after 2022, "he said.

According to the scientist, experimental studies have shown that the use of peptides contributed to an increase in the number of dendritic spines in the brain in rodents, which are responsible for the formation of memory, that is, there was a complete restoration of brain functions in Alzheimer's disease in mice.

"Over the next year, research on animals will continue, in particular, the effect on memory processes. And also there is a study of the effect on the activity of genes that are associated with Alzheimer's disease," - said Khavinson.

He noted that the results of this long-term work in 2021 were published by the leading scientific journal Pharmaceuticals (Switzerland, 2021, Vol. 14, No. 6).

“What we got in the experiment, in fact, is a complete restoration of the neural network to normal. This is not described in the literature. And the fact that it is published in one of the best scientific European journals is an examination. An examination is carried out - how competently it was done, how it was all introduced, etc. The fact that the research results are published in this journal shows that we have passed the examination and the Western world believed it, "Khavinson said.

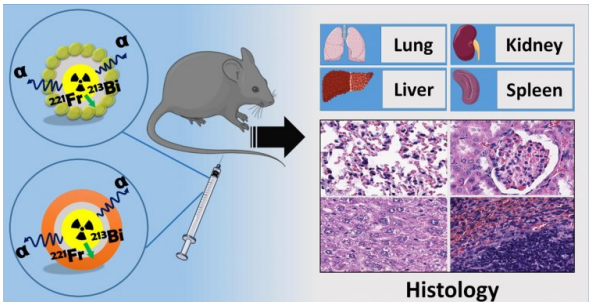
He also said that the unique peptide drug is safe and has no side effects. "This is an extremely important point. The advantage of this development is the restoration of brain functions with the complete absence of side effects," the scientist said.

Russian scientists from St. Petersburg published in the Swiss scientific journal Pharmaceuticals

the results of an experiment to study the effect of EDR and KED peptides on the development of Alzheimer's disease. The experiment was carried out on mice with genes for Alzheimer's disease, in which the number of dendritic spines responsible for the formation of memory was reduced, the introduction of peptides helped to increase their number.

26. Radiation therapy for cancer safer

Source: Russian Science Foundation



Experiment scheme. Source: Karpov et al. / Journal of Colloid and Interface Science

Radionuclide radiation therapy is one of the most effective methods of treating malignant tumors. With this effect, the neoplasm is destroyed due to the fact that radionuclides are injected into the patient's blood - unstable atoms, which decay and emit ionizing radiation. Russian scientists have developed a delivery system that will help minimize the effects of radiation on healthy tissues and protect them from destruction. The results of the study, supported by a grant from the Presidential Program of the Russian Science Foundation (RSF), are published in the Journal of Colloid and Interface Science.

According to the International Agency for Research on Cancer (IARC), more than twelve million new cases of cancer and about six million deaths from them are registered in the world every year.

Today, there are three main treatments for tumors: chemotherapy, surgical removal, and radiation therapy. The first two methods are not always effective, since cancer cells eventually acquire resistance to drugs, and all metastases that have spread throughout the body can be impossible to identify and remove. The third method kills tumors without fail: it is impossible to acquire resistance to ionizing radiation. During treatment, radionuclides are injected into the patient's blood - unstable atoms, the nuclei of which decay and form ionizing particles. They carry a large amount of energy that damages tumor cells: destroys their membrane, DNA, changes the biochemical reactions taking place inside them.

A significant drawback of the described approach is that until the radioactive isotope reaches the tumor, it will damage healthy tissues of the body due to the emission of ionizing radiation during radioactive decay. Therefore, scientists are developing special carriers that help to "hold" the radionuclide and its daughter isotopes - the atoms into which it decays - until they are delivered to cancer cells. For this, peptides (short protein molecules), artificial membrane bubbles, as well as nanoparticles from inorganic compounds are used. But the best of them retain a maximum of 84% of radionuclides, and the remaining 16% still infect healthy tissues.

A research group from the Russian Scientific Center for Radiology and Surgical Technologies named after Academician A.M. Granova (St. Petersburg), Peter the Great St. Petersburg Polytechnic University (St. Petersburg), National Research University ITMO (St. Petersburg) and National Research Tomsk Polytechnic University (Tomsk) developed a delivery system for the radionuclide actinium-225 (225 Ac), which keeps more than 98% of these isotopes within its structure. Scientists have chosen radionuclide 225 as a therapeutic agentAc, because during its radioactive decay, four alpha particles are formed with a large amount of energy, sufficient for an effective destructive effect on the tumor. In addition, this isotope, unlike others, has a relatively long half-life, that is, the time during which its activity will be halved. The half-life of 225 Ac is ten days, which gives an advantage in its production, storage and transport to medical centers.

As carriers of the 225 Ac radionuclide, scientists have developed and synthesized nanoparticles consisting of silicon dioxide. Then, radionuclides were chemically attached to the nanoparticles and covered with a film of gold or a titanium-containing organic compound on top. It was these additional layers that were supposed to prevent the detachment of 225 Ac from the carrier particles and its chaotic circulation throughout the body, leading to damage to healthy tissues and organs.

To test whether the nanoparticles were actually capable of retaining the radionuclide, biologists injected samples as a suspension into the tail vein of mice. On the first, third and tenth days after the therapy, the animals were painlessly sacrificed, and their organs were examined for radioactivity, which was a sign of the decay of 225 Ac. As a control group, the researchers used mice that were injected with pure 225 Ac without nanoparticles-carriers or with nanoparticles, but without a gold or titanium coating.

It turned out that in all control variants already on the third day the radionuclide accumulated in the liver, spleen and lungs, leading to the death of the cells of these organs. On the contrary, nanoparticles with 225 Ac, additionally coated with a layer of gold or titanium, practically did not harm healthy tissues even after ten days.

“Our development will allow the safe delivery of radionuclides to tumors without harming healthy tissues of the body. In addition to experiments on animals, we conducted in vitro studies - "in vitro" - which proved that the particles we synthesized keep 225 Ac in a stable state for thirty days. The next phase of the study - a modification of the surface of the nanoparticles by means of special molecular "tags" that allow developed n th contact components directed to migrate to cancer cells and thereby provide selective treatment ", - says Timothy Karpov, group employee nanopharmacology laboratory genetic engineering of the Russian Scientific Radiology Center and surgical technologies named after academician A.M. Granova .

27. Chemists of MSU figured out the intricacies of toxic substances on the body

Source: Moscow State Univ

Loading samples into a gas chromatography-mass spectrometer

Employees of the Department of Analytical Chemistry, Faculty of Chemistry, Moscow State University discovered a set of markers - significant metabolites, the presence of which in the body can be associated with poisoning with potent substances. The identified metabolites make it possible to understand the detailed mechanism of the effect of toxic substances on animals and humans and to treat patients more correctly. The work was published in the journal Analytical and Bioanalytical Chemistry.

Biological samples are the most difficult objects for research, as they contain a huge amount of organic and inorganic substances. And sometimes not only health, but also life depends on correct, high-quality and quick analysis. Therefore, chemists are constantly looking for new methods for studying biological fluids. Recently, the so-called metabolome analysis, an analytical approach based on the use of mass spectrometry, has become popular. One of the tasks of metabolomic analysis is the identification of new metabolites for various pathological conditions.

“Previously, we were able to gain quite a lot of experience in metabolomic studies related to the identification of potential metabolites for various diseases, for example, bladder cancer,” said the head of the study, professor, Ph.D. Igor Rodin . “Also, our laboratory has accumulated extensive experience in the field of analytical toxicology: the analysis of biomaterials of organisms exposed to toxic substances.”

Initially, the study authors trained to find known metabolites resulting from poisoning. The experience gained made it possible to expand the work: scientists began to look for new substances associated with one or another effect on the body. The first option is much simpler, because it is carried out using methods pre-configured for specific connections and ignoring others as much as possible. In the second case, on the contrary, it is necessary to identify as many substances as possible. This approach is many times more complicated, because substances begin to interfere with the definition of each other.

“As part of this work, using high-resolution liquid chromatography-mass spectrometry methodology, we were able to analyze biomaterial samples obtained from laboratory animals,” explained Igor Rodin. "The technology used allows you to measure the content of organic substances and identify them in complex objects."

To process the data obtained, chemists used the methods of statistics and chemometrics. In large

amounts of data, they made it possible to identify significant changes that occurred after the poisoning of organisms with potent substances.

“Since the initially obtained data are quite complex, my part of the work consisted in their preliminary processing,” said the participant of the study, a 5th year student of the Faculty of Chemistry of Moscow State University, Yuri Ihalainen.

“After the preprocessing of a large data set, all available information was analyzed statistically, including by machine learning methods,” added Ivan Plushenko , co-author of the study, an employee of the laboratory of mass spectrometry of the Faculty of Chemistry of Moscow State University . “As a result, we were able to track the changes associated with the effects of the toxicant on the body.”

New markers showed that the effects of toxic substances were much wider than previously thought. The toxicant blocked several enzymes at once, which caused a whole chain of new disorders in metabolism, endogenous metabolism and much more. The results obtained made it possible to understand the mechanism of action of a wide class of toxic substances. Based on the biomarkers found, in the future it will be possible to draw conclusions about poisoning, damaged body mechanisms and correctly prescribe treatment.

28. Algorithm to simplify the analysis of the genome of pathogenic bacteria

Source: ITMO University

ITMO scientists have developed an algorithm for analyzing bacterial genomes. The method allows in less than a minute to automatically recognize changes in the genomes that are responsible for the evolution of bacteria, including those causing human diseases. The tool will simplify the study of the evolutionary mechanisms of bacterial genomes. It has already been tested on strains of streptococcus - the causative agent of pneumonia - and Escherichia coli.

Comparative genomics makes it possible to study the history of the origin of the genomes of living things, their variability in order to identify evolutionary scenarios and the molecular mechanisms that implement them.

The PaReBrick algorithm, developed by ITMO bioinformatics specialists and employees of the Institute of Science and Technology in Austria, automatically identifies parallel rearrangements in bacterial populations. First, the tool examines

a collection of strains, represented as a sequence of common blocks in the genomes of various living organisms, and their phylogenetic tree, which demonstrates the evolutionary relationships between them. Then he determines the rearrangements in the genome and visualizes the information on a phylogenetic tree displaying the desired trait, for example, the presence of a certain gene.

The algorithm was tested on a dataset of about 200 strains of streptococcus, the bacteria that causes pneumonia.

According to the main author of the study, a graduate student of the Faculty of Information Technologies and Programming at ITMO Alexei Zabelkin , the project was prompted by the work of colleagues at the Institute of Industrial and Geophysics of the Russian Academy of Sciences, who described a previously unknown evolutionary mechanism of antigenic variation that allows the pathogen to remain invisible to the human immune system. Comparing the genomes of different strains of streptococcus, they found that the same evolutionary event (change in the order of genes and their fragments in the genome) occurs in different strains independently, significantly changing the properties of this pathogen. But usually such studies are carried out manually and take a lot of time, but now the method of ITMO scientists will help automate this process.

“Our method is able to analyze a phylogenetic tree built for bacterial strains, study similar regions in genomes, automatically find the traits we need and color the strains on the phylogenetic tree in a certain color depending on the state of the trait (for example, there was an inversion or not). This is a visual display of information about the genome in the form of graphs , ”explains Alexey.

The method proposed by scientists is universal and can be used to analyze various bacterial strains of streptococcus and other bacteria.

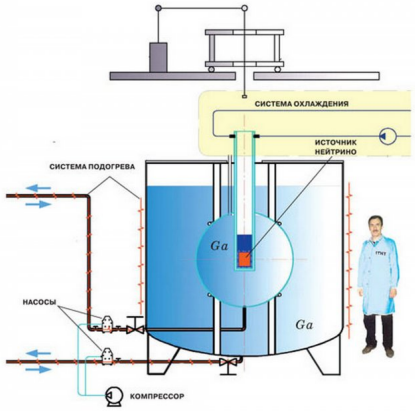
“Few people have done such a systematic analysis from the point of view of bioinformatics, construction of trees and the study of the evolution of sequences of a large number of strains. Usually people find similar phenomena “in a test tube”. Let's say a biologist discovered some patterns in one particular strain and then described them. Our project solves this problem by analyzing data from many strains of the same species and comparing them, ”the researcher concludes.

The algorithm can be used in medicine, genetic engineering, agricultural and basic biological research. For example, studying the evolutionary mechanisms of bacteria allows us to find out the potential causes of their resistance to antibiotics and their evolutionary strategies - all this can significantly simplify the work of doctors, bioinformatics, and biologists.

P. PHYSICS

29. Unique experiments in Neutrino Physics

Source: Institute for Nuclear Research, RAS



BEST installation diagram. Two zones (targets) filled with liquid gallium are located inside the tank. Heating systems keep gallium liquid

Investigations of the mutual transitions of electron and sterile neutrinos were performed at the gallium-germanium neutrino telescope at the Baksan Neutrino Observatory of the Institute for Nuclear Research, Russian Academy of Sciences. The telescope is located at a depth of 4 km in the Andyrchi mountain in the Baksan gorge (Kabardino-Balkaria).

In 2019-2021, a unique world-class experiment BEST (Baksan Experiment on Sterile Transitions) was carried out at the Baksan Neutrino Observatory of the Institute for Nuclear Research of the Russian Academy of Sciences under the leadership of RAS Corresponding Member Vladimir Gavrin. An article with the results of the experiment was sent to the journal Physical Review Letters.

The purpose of the BEST experiment is to search for transitions of an electron neutrino to a sterile state. For the BEST experiment, a compact source of electron neutrinos based on the Cr-51 isotope with a record intensity of 3.4 MCi was specially developed and created with the participation of the State Atomic Energy Corporation Rosatom and the support of the Ministry of Education and Science of the Russian Federation. Experiments with such a high neutrino intensity have not been carried out either before or since. The source was installed in the center of two gallium targets placed one inside the other. In the course of the experiment, 10 gallium extractions were carried out from both targets and 20 measurements were made of the rates of formation of germanium atoms as a result of the interaction of neutrinos with the nuclei of a gallium atom in targets located at different distances from the source. Unique radiochemical technology developed at INR RAS,The results obtained in the two gallium targets turned out to be very close and at the same time 20-24% lower than expected. This deficit in the number of neutrinos observed in previous gallium experiments is called the gallium anomaly. It can be interpreted as evidence of oscillations between electronic and sterile neutrino states. The BEST experiment was the first to reliably establish the existence of a gallium anomaly. The BEST results are consistent with transitions of electron neutrinos to sterile states.

Russia is one of the world leaders in neutrino physics due to its unique infrastructure. BNO INR RAS is the world's first unique underground observatory built for this purpose in the bowels of Mount Andyrchi in the North Caucasus in the Elbrus region. In this

observatory, a gallium-germanium neutrino telescope was created, where breakthrough results in neutrino physics were obtained: it was proved that the source of the Sun's energy is a giant thermonuclear reactor located in its center; made a key contribution to the discovery of neutrino oscillations (mutual transitions of these particles from one state to another).

30. Altai State University help in solving ecological problems of the planet

Source: AltSU

Scientists of Altai State University, within the framework of the work of the Center for Space Monitoring of Altai State University, are engaged in tasks that contribute to solving the global problem of climate change on the planet.

Today it is well known that oil production at each field is accompanied by the release of associated petroleum gas, part of which is burned in flares at the oil production sites, as well as at other stages of its processing.

According to the National Oceanic and Atmospheric Administration of the United States, in 2015, there were 13,605 flare installations in 88 countries around the world, where about 140 billion cubic meters of gas are burned annually, which leads to the emission of about 300 million tons of CO 2 .

It should be noted that the flaring of associated petroleum gas leads to emissions into the atmosphere in addition to CO 2 and methane, nitrogen oxide, sulfur dioxide, soot and other toxic components, as well as to thermal effects on the underlying surface in the area of flare installations. These emissions have an impact on climate, environment and human health, both regionally and globally.

Scientists from the Altai Territory supporting university are working on solving these problems based on data received from satellites and processed at the Center for Space Monitoring of Altai State University. They conduct regular monitoring of flares and greenhouse gas emissions over a large area of Western Siberia thanks to the satellite technology they have developed for estimating the volume of associated petroleum gas flared in flares.

The implemented satellite technology makes it possible to remotely determine a number of characteristics of flare units: temperature of the combusted mixture, the area of the flame, the power of the thermal radiation source and the volume of associated petroleum gas flared.

Monitoring is carried out at night in the visible and near / thermal infrared ranges. Director of the Center for Space Monitoring of Altai State University, Professor Anatoly Alekseevich Lagutin, called the advantage of the new

technology its easy applicability for comparative analysis of a large number of emission sources simultaneously in large areas, including in remote areas.

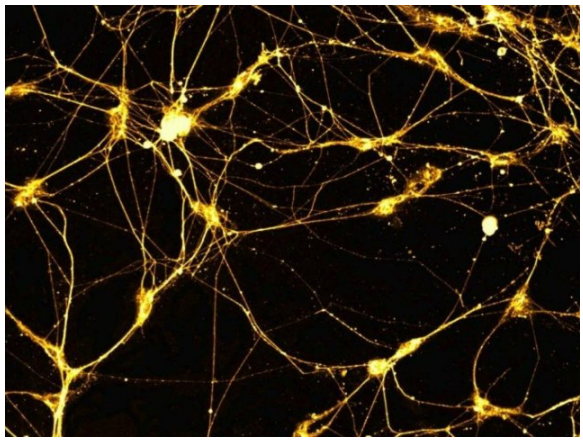
According to the researchers, this technology is of interest to both oil and gas companies in Russia and government authorities, whose competence includes issues of state regulation of greenhouse gas emissions.

Currently, the technology developed by the specialists of the Altai State University Space Monitoring Center is used to implement a project to assess greenhouse gas emissions by oil industry enterprises in Western Siberia. The data from this project will help to understand how and to what extent greenhouse gas emissions should be reduced, and will also become an information base for the Center's chemical transport model, which makes it possible to predict the content of greenhouse gases in the atmosphere of the region in the next two decades under several scenarios of the evolution of the global climate system.

31. Physicists created a model of a superconducting Neuron

Source: UNN

Experts from the laboratory of the theory of nanostructures of the Scientific Research Institute of Physics and Technology of the Nizhny Novgorod State University named after N.I. Lobachevsky (NIPT NNSU) together with colleagues from Moscow State University named after M.V. Lomonosov and the Moscow Technical University of Communications and Informatics have developed a model of a superconducting neuron. The research results are published in the journal Symmetry.



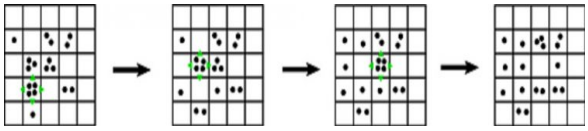
The proposed prototype is based on macroscopic quantum effects in nanostructures made of superconducting materials. Thanks to the use of superconducting adiabatic logic, a neuron spends a hundred times less energy than its semiconductor counterparts, while at the same time processing data at a speed of 10-100 times higher. In addition, it takes up much less space than the semiconductor version.

“Prototypes for classical and quantum neural networks are now being proposed, quantum intelligence is being developed, and our scheme has good prospects in this direction. Superconducting solutions have already shown themselves excellently as the basic blocks of quantum computers, and the superconducting adiabatic logic used in our work works and is applied to quantum systems, ”explained Marina Bastrakova, head of the Theory of Nanostructures Laboratory at NIPT NNSU, author of the study.

MISCELLANEOUS

32. HSE scientists explain the behavior of chaotic systems

Source: Higher School of Economics



Sand heap collapse cascade illustration

Researchers at the HSE Research and Training Laboratory for Modeling and Control of Complex Systems have proposed the missing component of the self-organized criticality mechanism, which makes it possible to reproduce the power laws observed in the real world. According to scientists, this brings us closer to understanding how earthquakes occur, forest fires spread, financial markets and social networks work. The research results are published in Scientific Reports . The research was carried out with the support of the Russian Science Foundation.

Complex systems surround us everywhere. From processes at microscopic distances in the human brain to large-scale flows of water in the oceans, science can describe the state of each individual piece of a system, but it is much more difficult to describe its behavior as a whole. In complex systems, the interaction of individual substructures with each other turns out to be so complex that the system as a whole acquires completely new and unexpected properties that cannot be reduced to the properties of individual parts.

By controlling parameters such as temperature or magnetization, it is possible to guide a complex system through a critical point - to carry out a phase transition. During a phase transition, the basic properties of the system fundamentally change: for example, water passes from a liquid state to vapor, and the metal melts and turns into a liquid. The critical point itself is characterized by power laws. However, there are various examples of processes and systems that are characterized by power laws that arose without any adjustment: seismic activity with destructive earthquakes, neural and social networks, financial markets, forest fires, etc.

In 1987, scientists Bak, Tang, and Wiesenfeld discovered the phenomenon of self-organized criticality by constructing a mechanism that explains how a system reaches a critical state without tuning any parameters. Their model, which is called the "sandpile" or BTV model, is implemented on a square lattice on which grains of sand fall. As soon as a locally large pile of grains of sand is created, an avalanche occurs: grains of sand fill the "pits" and fall out of the grate when they reach the edge. In this case, regardless of the order of the landslides, the system arrives at the same final state. The picture shows an avalanche that starts when four grains of sand appear in a cell, which are transferred to four neighboring cells - one to each of the neighbors. Then new "fours" are distributed according to the same rule.

Of course, you can offer as many implementations of the BTW mechanism as you like. However, among a wide class of models, it is possible to achieve only a small number of power laws arising in the critical state. This

amazing robustness of exponents of power laws makes it difficult to apply self-organized criticality models to real-world problems.

In a paper published in the journal Scientific Reports , researchers at the Scientific and Educational Laboratory for Modeling and Control of Complex Systems managed to propose a mechanism that allows you to change the exponent of power laws, in particular, to make it equal to one.

“The indicator equal to one has long attracted the attention of researchers for its simplicity, bordering on grace. A certain hunt was conducted on him, which finally ended. The proposed mechanism implements a fundamental property of the observed systems - the clustering of events in space and time. Therefore, it is natural to think that it turns out to be in demand in applications, laying the foundation for future research, ”commented Alexander Shapoval , one of the co-authors of the work, professor at the HSE Faculty of Computer Science.

33. Scientists of BIP SB RAS developed heat-resistant polymers for 4d printing

Source: SB RAS

Employees of the Baikal Institute of Nature Management SB RAS (Ulan-Ude) have developed mechanically strong and heat-resistant polymeric materials with shape memory effect. They can be used in 4D printing of structures for the aerospace industry. The research results are published in Advanced Materials Technologies .

4D printing is different in that it uses materials that can change their shape depending on the impact of some external stimulus. Scientists of BIP SB RAS have developed new materials for DLP-printing technology. Its advantage is that it allows you to shape products with very high precision and high resolution. This is achieved through a minimum single layer thickness of only 50 microns.

However, most of the currently known heat-sensitive shape memory polymers suitable for DLP printing lack mechanical strength and thermal stability. This limits the potential applications of the technology.

The development of Siberian scientists will make it possible to overcome this barrier. “We used two types of heat-resistant polymers - aromatic polyamide and polybenzimidazole. Thanks to their introduction into specific photosensitive compositions, we managed to obtain materials that not only combine heat resistance and mechanical strength, but also have a shape memory effect, ”says Bato Chingisovich Kholkhoev, senior researcher at BIP SB RAS, Candidate of Chemical Sciences.

The shape memory effect is that the material can be bent and modified, and then, under the influence of an external stimulus, it returns to its previous state. In this case, temperature acts as an external stimulus.

The materials obtained by the scientists demonstrate excellent shape memory characteristics at transition temperatures above 100 ° C. Therefore, they are promising for use in the aerospace industry. For example, for the development of deployable structures that are

used in low-earth orbit. In addition, such polymers have great potential in robotics and sensorics.

The study was supported by a grant from the Russian Science Foundation. In addition to the BIP SB RAS, specialists from the Federal Research Center "Crystallography and Photonics" of the Russian Academy of Sciences (Moscow) and the First Moscow State Medical University. THEM. Sechenov (Moscow).

34. A device for effective air purification in a car

Source: TSU

Maria Chernykh, a postgraduate student at the Faculty of Chemistry, Tomsk State University (TSU), has developed a universal catalyst capable of effectively removing volatile organic compounds, bacteria and viruses from the air in a passenger carriage. The cleaning procedure is safe for passengers and can be carried out in their presence.

According to Maria Chernykh, the air is currently being purified using ozone, which is dangerous to humans, the remains of which must be removed after the entire procedure is completed. This is usually done using coal, thermal and catalytic decomposition, and other methods. But coal is poorly compatible with ozone, and thermal decomposition requires high temperatures - from +400 degrees Celsius. In addition, such systems contain platinum and palladium, which makes them expensive to manufacture.

The advantage of the device, developed by Tomsk specialists, is that it uses mixtures of transition metal oxides as an active composition. This allows you to seriously reduce its cost, as well as remove problems with the sale or transfer, since in this case it will not fall under the existing restrictions on the turnover of precious metals.

“The catalyst will not have the usual base in the form of cellular metal materials, but a cordierite block. Such blocks are much cheaper than metal structures due to their simpler manufacture. The cell size in the cordierite block is smaller, which will significantly increase the catalyst's efficiency, ”explains Grigory Mamontov, senior researcher at the TSU Catalytic Research Laboratory.

In addition to air purification, the new device will be able to reduce the risks of the spread of diseases transmitted by airborne droplets.

In case of successful passing of approbation in real conditions, its scope can be expanded to other enclosed spaces: airplanes, shops, cinemas, underground parking lots, submarines and other similar objects.

35. Aircraft for intercontinental flights in the stratosphere

Source: RIA Novosti

Scientists from the Tupolev Kazan National Research Technical University (KAI) have developed a supersonic aircraft for intercontinental flights in the stratosphere. The relevant documents are published on the Rospatent website .

The design of the stratoplane includes a fuselage with wings, horizontal control surfaces in front and behind, a combined rocket or air-rocket engine running on oxygen and an upper stage, to which two gas turbine engines and a fuselage engine fairing will be attached. The unit includes an oval wing attached via two fuel tanks to the ends of the fenders.

From its closest foreign counterpart, the British reusable unmanned spacecraft Skylon by Reaction Engines Limited, the domestic stratoplane is distinguished by an increased payload and a reduced take-off time. According to the designers, this became possible thanks to the two-stage flight principle, due to which the volume of fuel in the last stage is reduced and the payload is increased. And the oval shape of the wing of the booster block will provide a greater angle of attack, thus giving additional lift. Accordingly, the take-off time will be reduced.

The presence of similar developments in this area was announced by the Kronstadt group and the Zhukovsky Central Aerohydrodynamic Institute.

36. Innovative welding method in bridge construction

Source: SPbPU

Scientists from Peter the Great St. Petersburg Polytechnic University (SPbPU) were the first in Russia to develop a friction stir welding (FSR) technology of a new aluminum alloy for a lightweight pedestrian bridge. The engineers intend to implement an innovative scientific development on the basis of the university: they plan to weld the elements, and then connect them into a bridge at the construction site of the facility.

Using friction stir welding technology

The aluminum pedestrian bridge will be located in the town of Bor in the Nizhny Novgorod region. This is already the tenth aluminum pedestrian bridge in Russia, but the new alloy and STP technology will be used in bridge construction for the first time. Scientists work in conjunction with the SGR aluminum structures plant in St. Petersburg, and the project itself is supervised by the Aluminum Association of Russia.

Recall that in the period 2017-2020. Eight aluminum pedestrian bridges have been erected in Russia: two in the Nizhny Novgorod Region, three in Krasnoyarsk, two in Moscow over the

Yauza River and one in Tula. More than 20 bridge designs using aluminum structures are currently in the works. Experts believe that the development of aluminum bridge construction in Russia was facilitated by the approval by the Ministry of Construction in 2019 of the Code of Rules “Bridges with structures made of aluminum alloys. Design rules ".

In the laboratory of light materials and structures of the Institute of Mechanical Engineering, Materials and Transport of SPbPU, engineers will connect about 20 parts 8 m long and 16 mm thick sheet made of aluminum-magnesium alloy 1565chm. According to scientists, this new alloy has recently become available for widespread use, and all work on the design and construction of a bridge from this alloy is pioneering.

“The bridge is large-sized, there are many types of connections,” explained Anton Naumov, associate professor of the Research and Modeling Materials Research Center at SPbPU, adding that the research group is developing a technology for STP butt joining of aluminum plates on both sides in a straight plane. The joint made with this technology, he said, will surpass arc welding in quality.

The scientist also noted that it is economically more profitable to weld a thick aluminum sheet in this way, since a number of additional manipulations must be carried out with the material during arc welding (for example, arc welding is carried out in several passes in order to fill the entire thickness of the seam with filler material). In addition, STP is a "green" technology, when it is used there is no release of aerosols or luminescence! “Although aluminum is inferior to steel in strength, the structure will be much lighter in weight than steel. Therefore, aluminum bridges are gaining more and more popularity both abroad and in Russia, ”Anton Naumov emphasized.

Scientists have applied an innovative welding method in bridge construction

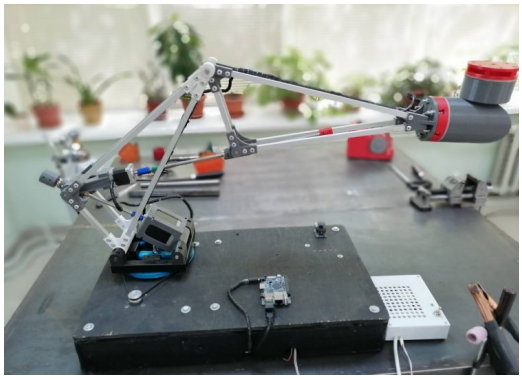
As part of their work, the laboratory staff will develop a welding technology, with strict adherence to which the bridge parts will be welded. Then the quality control of the welded joints will be carried out to ensure the safety of the entire structure.

“The innovative technology of friction stir welding is already used in aluminum bridge construction: the Sespel plant (Cheboksary) uses it to join the components of orthotropic plates from the well-known 6082 T6 aluminum alloy. But the peculiarity of the bridge, in the creation of which colleagues from SPbPU are involved, is that it will be the first in our country, made using STP technology for the new alloy 1565chm, ”stressed Evgeny Vasiliev, head of the transport infrastructure department of the Aluminum Association. According to him, this is a responsible task and a real technological breakthrough.

The researchers plan to complete their part of the project by the end of September. The bridge itself, which has a length along the axes of 121 m, is planned to be commissioned by 2022.

37. PPU will help future machine builders improve their skills

Source: Perm Polytechnic Univ (PPU)



Desktop Robot Arm

On the last Sunday of September, Russia and some other CIS countries celebrate the Day of the Machine Builder. Young researchers from the Perm Polytechnic University have developed a robot that will help future specialists in this field to better master the work with modern equipment. Its advantage over its counterparts is its low cost and availability for educational institutions.

- Future machine builders do not always have the opportunity to learn how to control industrial manipulators. During practice at enterprises, students work with expensive equipment and do not have access to its software. The cost of repairing and maintaining such robots is also high, and it is not always suitable for more “creative” tasks. Cheaper counterparts are not of high quality and break down quickly. Therefore, our goal was to create a high-quality and versatile robot manipulator, - says the author of the development, student of the electrical engineering faculty of the Perm Polytechnic Institute Alexei Dukhanin .

The "training" robot will allow students to gain experience that will be useful in their future work at the enterprise. In addition to educational institutions, the product can be used for training in small laboratories and robotics circles. Among the tasks that students and schoolchildren will be able to perform with the help of development are the study of artificial intelligence algorithms, the creation of web interfaces, programming and solving inverse kinematics problems.

The product can already be introduced into the educational process. The production time for one robot is 1-2 weeks. It can be implemented as a tabletop equipment, equipped with a mobile stand or a self-propelled platform. This will expand the scope of study of educational programs, - explains the scientific supervisor of the developer, associate professor of the Department of Information Technologies and Automated Systems of the Electrical Engineering Faculty of the Perm Polytechnic Institute, Candidate of Technical Sciences Daniil Kurushin .

Young researchers presented the previous model of the manipulator at the Optimal Grip competition of the Quantoriade 2019 (Moscow) together with the Perm Technopark Quantorium Photonics and became laureates.

38. "ROSEHIP": Digital signature will change in the post-quantum era

Source: NPK Kryptonite

Modern cryptography is built on the computational complexity of a number of mathematical problems described in number theory. In particular, in asymmetric electronic signature schemes, such problems include factorization (decomposition of large numbers into prime factors) and discrete logarithm (the inverse operation of raising an integer to a power modulo a prime number).

To solve these problems, there are currently no known fast algorithms - that is, those in which the complexity of the solution polynomially depends on the length of the input data. On the contrary, all existing approaches are exponentially dependent. This means that when using large enough primes, the key selection will require performing an exponentially growing (as the size of the input data increases) the number of bit operations and / or the amount of memory. In other words, such algorithms cannot be executed in a reasonable time even on powerful computers of classical architecture.

However, now there is intensive development of quantum processors that could use fundamentally different algorithms. Their appearance can make many cryptographic systems unstable, as Peter Shor showed back in 1994.

In the nineties, this was only a hypothetical threat, since quantum computers then existed only on paper. That changed in 2001 when IBM built a prototype of a seven-qubit quantum processor and experimentally tested Shor's algorithm on it.

Today, more than a dozen large companies have presented their versions of quantum processors, and the number of qubits is growing every year. There is a real need to pave the way for the transition to post-quantum cryptography, that is, to develop protocols, attacks on which will remain computationally difficult even for quantum computers.

The problem of EDS

Security Post-quantum electronic digital signatures (EDS) are cryptographic schemes on lattices, multidimensional polynomials, hash functions and error-correcting codes. Nevertheless, proofs of the robustness of most of the described schemes are based on mathematical problems that are not proven to be difficult.

The first electronic signature scheme, whose security is based on the complexity of the problem of decoding error-correcting code, appeared at the very beginning of the nineties of the last century. However, she proved to be vulnerable. A number of modifications to this scheme have appeared over the decade, but all of them have also been attacked within a few months of their inception. At some point, doubts arose in the cryptographic community that building an EDS using error-correcting codes is generally possible.

In 2001, a universal approach was applied to build a code signature, which is also used to build a classic RSA signature. The idea is to

encrypt the hash value of an open message with the sender's secret key. For verification, the recipient decrypts the received value using the sender's public key and compares the result with a self-calculated hash.

This approach has spawned a large number of code schemes. However, the proof of their robustness is based on the assumption that the base code is indistinguishable from the random one, which in practice often turns out to be incorrect. In this case, the use of the structure of the code allows you to build effective attacks.

Another successful method for synthesizing EDS, which was successfully applied to error-correcting codes, is the application of the Fiat-Shamir transformation to the identification scheme. If the scheme has the property of zero knowledge, then the resulting signature will be tamper-resistant. Signatures of this type are built on a random linear code, which makes it possible not to make any additional assumptions when justifying their strength.

Prospective digital signature schemes ended

On November 30, 2017Call for applications from the US National Institute of Standards and Technology (NIST) competition for new post-quantum algorithms. All schemes in the competition were presented in two directions: encryption and key encapsulation algorithms and digital signature algorithms. Since then, there has been an active analysis and comparison of the submitted schemes. As of autumn 2021, the third round of the competition is in progress.

In parallel with NIST, the working group on post-quantum mechanisms of the Technical Committee for Standardization "Cryptographic Information Security" (TC26) is developing its own cryptography algorithms for the future. As part of the work of the group, the "Rosehip" electronic signature scheme is being developed, built by applying the Fiat-Shamir transformation to the Stern identification protocol (with zero knowledge). The algorithm for choosing signature parameters is based on the use of the theory of provable security.

Viktoria Vysotskaya, a research specialist at the Cryptonite Research and Production Complex, and one of the co-authors of this EDS scheme, tells in more detail.

-Why is your digital signature scheme called "Rosehip" and for what purpose was it created?

- Our scheme was written within the framework of the TK26 working group on post-quantum mechanisms. This group works for the future: develops cryptographic schemes that will be strong even if there is a sufficiently powerful quantum computer. We gave our scheme the name - "Rosehip", as we wanted to emphasize the connection with the Stern scheme (hence the letter "Ш" at the beginning). Well, then the tradition of our working group was simply followed, in which the schemes have “plant” names - “Gooseberry”, “Forsythia”, etc.

- Have such schemes been considered at the NIST competition?

- There were no close analogs to our scheme in NIST. However, NIST plans to announce a new competition for EDS schemes, among which, most likely, there will be schemes built on the basis of the Fiat-Shamir approach, like ours.

- What level of firmness does Rosehip provide?

- In the current version of the draft standard, we propose a set of parameters that make it possible to obtain a provable security equal to 80 bits (this means that such a scheme cannot be attacked with a complexity of less than 280 bit

operations). However, we believe that the real resistance greatly exceeds this value, since the current estimate gives a rather large error. Thus, the best classic attack on Rosehip known at the moment requires 2,256 bit operations, and the best quantum attack -2,170.

- What are the chances that "Rosehip" will become the Russian standard?

- Now we are at the final stage of preparing the draft standard. We plan to send the package of documents on Rosehip to TK26 in early December. Further we will look at the comments. We do not yet know what will be standardized: our scheme or some other proposed within the framework of the working group. It is also possible that several options are standardized at once. At the moment, together with “Rosehip”, “Gooseberry” is at the final stage - the signature scheme on the grates. In addition, the development of a signature on hash functions is underway.

- What are the advantages of Rosehip over Gooseberry?

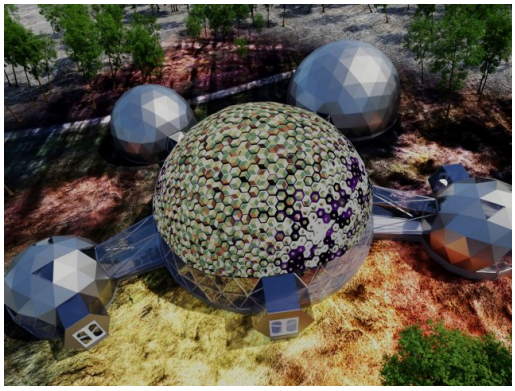
- Grids are one of the most promising areas, which can be traced even in the composition of the third round of the NIST competition, where two such schemes are presented. However, if we compare "Rosehip" and "Gooseberry", then we win in terms of the size of keys and the speed of their generation. In addition, the resistance of our scheme to counterfeiting is based on the complexity of the problem of syndromic decoding of a random code, which is proved to be NP-hard, while the resistance of the scheme on lattices is reduced, among other things, to the problem of learning with rounding, for which such a result is absent.

It should be noted that the competition between the schemes is not entirely appropriate, since at the moment the Russian cryptographic community has no plans to leave only one post-quantum EDS scheme. The main interest now is aimed at developing the largest possible number of areas that could hedge each other in the event of new attacks. The fact is that the post-quantum direction in cryptography is relatively young, and it is not yet known which of the schemes will pass the test of time and which will not.

NEW INITIATIVES

39. The space pavilion will be built at the Crimean Federal University

Source: KFU



The space pavilion is planned to be built at the Crimean Federal University. The facility will be located in the Botanical Garden, on the basis of which the University is creating Science Park. This was announced by the rector of the university, Andrei Falaleev.

Funding for the project at the moment is 80 million rubles.

“The space pavilion is one of the projects of the Priority 2030 program and the first step towards the creation of a large Science Park on the basis

of our Botanical Garden. We have chosen the theme of space because it is interesting and informative. Space is innovative technologies and the most modern science. Working in space is associated with extreme conditions, and all high scientific technologies were originally intended for this industry, and only after some of them became part of our life, ”said the rector of the Crimean Federal University Andrey Falaleev.

According to him, the space pavilion is planned to be launched in 2022. The facility will be designed to demonstrate scientific achievements and technologies to students and schoolchildren.

“There will definitely be a planetarium in the pavilion, and as for the overall saturation of the project, it will depend on the scientific tasks facing our scientists. On these issues, we consult with ITMO, the Russian Academy of Sciences, experts, in particular Oleg Valerievich Kotov - pilot-cosmonaut, Hero of Russia and Honorary Professor of the Crimean Federal University. In general, Science Park will become a popular science platform with exhibition complexes, interactive laboratories and cultural heritage sites. At the same time, it is not planned to build capital buildings on the territory in order to maximally preserve the natural potential of such a unique biological object as a botanical garden, "added Andrey Falaleev.

Science Park of the Crimean Federal University is an innovative scientific and educational complex, the purpose of which will be to popularize science and technology. The main idea of the park is to create experimental sites with the maximum use of natural resources based on innovative technologies. Within the framework of the project, it is planned to build new infrastructural and exhibition facilities on the territory of the Botanical Garden.

40. End-to-end technologies of STI - "molecular engineering in life sciences"

Source: Federal Research Center of Biotechnology RAS

FRC Biotechnology RAS headed the consortium, which became the winner in the competition for the creation of cross-cutting competence centers of the National Technology Initiative in the field of "Molecular Engineering in Life Sciences". The project will begin this year.

Molecular engineering as a subject area is the basis of engineering biology - a system of approaches for the directed design of living systems at all levels - from molecules to cells and organisms. Scientific and technological solutions in this area will have a huge impact on a wide range of industries and markets - from healthcare and chemical industries to food and processing industries, agriculture and energy. In addition to ready-to-implement cost-effective technologies, these markets should also be provided with professional personnel and, which

is especially important in the sciences of living systems, with a well-developed regulatory framework that meets both basic ethical principles and the current level of development of scientific knowledge. All these tasks should be solved on the basis of the systematic work of specialists from scientific, university, expert and business community. The NTI Competence Center based on the Federal Research Center of Biotechnology of the Russian Academy of Sciences will become such an association.

The consortium of the center includes both leading federal classical universities and strong industry universities: Sirius University, Higher School of Economics, University. Kant, Perm State Agrarian Technical University. On their basis, specialists will be trained to work in interdisciplinary research projects and in high-tech industries. The modern world dictates the introduction of new approaches to personnel training, the creation of new educational programs and the formation of new professions, such as, for example, bioinformatics-bioengineer, bioeconomist, engineer-microbiology. These professions of the future will develop on the basis of the center.

The consortium also brings together 15 industrial companies from the food and processing industry, pharmaceuticals, agriculture, veterinary medicine and green chemistry. Companies such as JSC EFKO, JSC UCC Uralchem, JSC Generium, LLC Geropharm, and others are interested in the developments that will be carried out by the center - in the context of rapidly changing markets, the accelerated introduction of advanced scientific developments into production is becoming one of the key competitive advantages at the global level. In the process of implementing the center's program, the number of industrial customers will expand.

“In today's world, the development of humanity's ability to overcome the crisis caused by the global pandemic, the consequences of climate change, the excessive use of natural resources and irresponsible waste production comes to the forefront of the international scientific, technological, business and political agenda. The basis for concrete steps here is the modern scientific developments of the 6th technological wave, including molecular engineering. We are sure that the NTI Cross-cutting Competence Center, which is being created today in this area, will allow working not only in step with the times, but also ahead of schedule and will provide Russia with a worthy place in the technological world of the future ", - comments Alexey Fedorov, Doctor of Biological Sciences, Director of the Federal Research Center of Biotechnology RAS.

An important area of the center's work will also be expert and analytical work aimed at creating a decision support system in emerging markets: mapping technological landscapes, independent scientific and technological expertise, organizing network interaction among industry participants. Here, the key partner will be the BioTech2030 Technological Platform, which has been bringing together participants of the country's biotechnology market on the principle of associative work for more than 10 years.
It is worth mentioning separately that molecular engineering, as well as genomic and post-genomic technologies, and synthetic biology in general, not only in Russia, but also in the world

now, is the cutting edge of development, around which a clear outline of legal registration has not yet been built. Legal regulation, codification, standardization of new products do not keep pace with the level of development of scientific and technological developments and the pace of their introduction into the market. This is becoming a serious obstacle both for the development of the industry and for building a consistent state policy to support innovative industries. The NTI Center sets itself the task of consistently carrying out this work, concentrating the required competencies on its basis.

“Developments in the field of molecular engineering touch on many topics that are very sensitive for society - ecology, medicine, nutrition, the way of household consumption, even the global political agenda. The natural tendency to manipulate public opinion in this area should be compensated by the presence of a specialized independent expert and analytical center. Even now, as FITs, we are actively engaged in educational work, the popularization of science. Now we are preparing for the opening of the Center for Modern Biotechnology and the BIOTECH Museum at VDNKh. The launch of the NTI center for us is a logical and natural development of the work already done, ”notes Elchin Sadikhov, Deputy Director of the Federal Research Center for Biotechnology of the Russian Academy of Sciences.

The total funding for the implementation of the center's program will amount to more than RUB 1.4 billion. for 5 years and will include both budgetary and private investments. The creation of the NTI End-to-End Technologies Center "Molecular Engineering in Life Sciences" will allow to continue existing projects in the field of biotechnology at a new, higher quality level, as well as initiate complex interdisciplinary projects, create more effective technological solutions, and form new niches in the global market of the future.

41. Leading Russian scientists discuss issues of genetics, breeding, seed production and plant reproduction

Conference Participants

The VII All-Russian Scientific and Practical Conference "Biological and Technological Foundations of Breeding, Seed Production, Reproduction and Protection of Agricultural and Forest Woody Plants" was held at the Federal State Budgetary Scientific Institution - National Scientific Center of the Russian Academy of Sciences" from September 7 to 11. This traditional forum is held under the auspices of the Russian Academy of Sciences, the Ministry of Science and Higher Education of the Russian Federation, the Ministry of Agriculture of the

Russian Federation, NBS-NSC, Federal State Budgetary Institution Rosselkhoztsentr, Federal State Budgetary Institution Roslesozashchita, the Ministry of Agriculture of the Republic of Crimea and the Kuban State Agrarian University.

The event was opened by Academician-Secretary of the RAS Department of Agricultural Sciences, Academician of the RAS, a well-known scientist, a prominent specialist in the field of technologies and means of agricultural mechanization, Chairman of the conference organizing committee Yuri Fedorovich Lachuga... He noted that the knowledge that the NBS gives is priceless, it has been polished and honed over the centuries. Even today, scientific life is in full swing here, and we all work for the future. 2021, declared by the President of the Russian Federation as the Year of Science and Technology, is extremely important. For all of us, its main task is to further implement the country's food security doctrine, within the framework of which the most important draft federal law on seed production is being considered in both chambers of the RF Parliament. "

The requirements for science in the RF today are as high as ever. Scientists are at the forefront today. The same Crimea has the highest, colossal natural potential, but at the same time, nature is not always gentle here, various crops cultivated on the peninsula (and there are about two hundred of them) must be drought-resistant. For the same grain crops over the past seven years, Crimea has a plus as a result. How does this first success compare? With that very ski track, probably, which the first skier needs to kick in the snow .

Today we have a very powerful tool - well-equipped laboratories. It is necessary to go further into the depths, to achieve using engineering methods to create those varieties that will give the highest yields and will not be afraid of drought .

He noted that, the days of lone scientists like Vernadsky are passing. The ability to work in a team is becoming very popular and extremely important in the design of future varieties.

I often remember the words of one of my teachers myself: "We need to deal with dark evenings and bright Sundays ...". It is he that the whole week should be devoted to science - that's the only way, all 24 hours a day, this is all your precious time.

Then the result will not be long in coming. What do I think about when your magnificent flower exhibitions - chrysanthemums, roses, and tulips - are shown on television all over Russia? .. And what about essential oil and medicinal crops? All this is also created by you, the gardeners and scientists of Nikitsky Garden, all these are your unique varieties, your skill that requires tremendous knowledge, new approaches, perseverance, perseverance, tirelessness in your scientific experiments.

Therefore, never, under any circumstances, give up. Analyze endlessly. Look for answers to your main question. Approach your only true option with each step. Read as much as possible and stay in the lab. And success will come to you.

On the opening day of the conference, the director of the NBS-NSC, Corresponding Member RAS Yuri Vladimirovich Plugar. He

warmly thanked all those involved for the fact that immediately after the Crimean spring the scientific community supported the initiative of their Crimean colleagues: “The decision to hold conferences on the development of seed production at the NBS was made seven years ago. And in the very first year, the highest bar was set. Over the past years, our conference has become a real all-Russian platform for solving the most pressing and painful problems of the country. It is also important that already at the first conference we established the School of Young Scientists, which traditionally opens each of our meetings now. Young people have the opportunity to compare their developments with the areas that the leading scientists of the country present at the conference in their reports. After such sessions, interest in the problems of innovative areas of breeding, seed production, genetics among young scientists grows many times over. "

At the plenary session on the first day of the conference, the tasks of scientists for the further development of breeding and seed production in the Russian Federation were considered; issues of scientific support of plant growing in the country; current state and ways of development of domestic breeding and seed production; application of genetic technologies in breeding and seed production; the complexity of the legal regulation of genetic engineering activities.

Director of the Federal State Budgetary Scientific Institution "Research Institute of Agriculture of Crimea", Doctor of Agricultural Sciences Vladimir Stepanovich Pashtetsky , speaking at the plenary session, announced important news: the Government's decree No. 2409-r dated August 31, 2021 expanded the List of agricultural products, production, the primary and subsequent (industrial) processing of which agricultural producers, as well as scientific organizations, educational organizations of higher education in the process of their scientific, scientific and technical or educational activities. This List was supplemented by essential oil and medicinal crops.

“This will become a huge stimulus for the development of the essential oil industry in Crimea and beyond,” V.S. Pashtetsky. “New perspectives are opening up for the selection and seed-growing work of scientists.”

Within the framework of the "Club of Discussion Problems", the difficulties and prospects of using GMOs in pest control were discussed.

Planetary topics aroused great interest: what are the prospects and development risks of the global seed market, how to quickly and cheaply feed humanity.