

NATIONAL ACADEMY OF SCIENCES OF UKRAINE

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Main Results



B. E. Paton,
President of the Academy

2015 was not an easy year for the Academy. Yet, in spite of all difficulties, scholars of the National Academy of Sciences (NAS) continued their extensive scientific research and obtained quite a lot of important results.

Among fundamental achievements of mathematicians were new numerical methods for solving systems of differential equations generated in investigating the impacts of natural disasters. Physicists obtained new two-dimensional structures of microporous silicon that are promising for producing compact nondestructive testing devices. For the first time, the thorium potential of Ukraine's geological structures was determined. Another achievement of our geologists is a new scheme of the phase-geochemical zoning of naphthide genesis in the Earth's interior. It radically changes scientific ideas about the hydrocarbon potential of great and super-great depths. Significant results were achieved in investigating the chemistry of two-dimensional structures with unique functional properties, namely, graphene and its oxides, molybdenum sulfide, oxides of transition metals with hierarchical structure etc. Highly active low-toxicity analgesic and anti-inflammatory substances were synthesized; the most active and safest of them were selected for preclinical testing. In life sciences, researchers obtained novel data on the emergence mechanisms and nature of certain mutations that determine the development of hereditary diseases. Further developed was molecular breeding of wheat, which is a new direction of plant genetic improvement in Ukraine.

Last year, the long-term fundamental study towards a full-scale reconstruction of the demographic dynamics of Ukraine in its current borders from the late 18th to the early 21st century was completed. Relying on it, NAS scholars gave the first-ever scientifically validated estimate of Ukraine's human losses due to social calamities in the first half of the 20th century. In particular, according to their estimates, direct and indirect losses resulting from the Holodomor (the Ukraine Genocide Famine) amounted to nearly 4.5 million people. Academy's scholars in humanities continued their fundamental publishing projects, encyclopedic ones included: they published the next volumes of «Collected Works by Mykhailo Hrushevsky», «Encyclopedia of Modern Ukraine», «Encyclopedia of International Law», «Dictionary of the Ukrainian Language».

Among the positive outcomes of the previous year was a rather high level of Academy institutions' pub-

lishing activities. They published 560 academic books, including 400 monographs. Of those, 80 scientific monographs were issued by foreign publishers. Scientific research was summarized in 21,250 papers and articles in journals; 5,780 of them were published in foreign ones.

A lot of concern was given to practical applications of innovative research results. Scientists in metal physics developed a technology for obtaining high-strength, corrosion-resistant, super-light titanium alloy and sent it to 'Antonov' state enterprise to be implemented there. The technology of growing optical germanium with novel alloying additives was brought to the series manufacturing stage. The material has already been purchased by companies of the USA and a number of European countries to be used in the manufacturing of lenses and other optical elements. The operation and extension of the network of NAS seismic stations was supported. Their observation data are necessary, in particular, for evaluating quantitative parameters of the maximum predictable seismic vibrations at construction sites in seismic areas of the country. In February 2015, the national drinking water standard proposed by our specialists was enforced and implemented at numerous Ukrainian agencies and water-supply enterprises. For the first time, Academy researchers implemented the whole production cycle of finished pharmaceutical drugs in the form of pills, taking into account the requirements of the EU Good Manufacturing Practice. Continued was the manufacture of substances and dosage forms of original medicines (Phenazepam, Amixin, Guidazepam, Levana), which are badly needed by patients.

One of the main priorities of NAS activities in 2015 was scientific back-up to basic branches of the national economy and high-tech manufacturing businesses. A good example of that is the involvement of Academy scientists in addressing the problem of extending the operation lives of 4 out of 15 operating power units of Ukrainian NPPs, which allowed their decommissioning and construction of new facilities to be delayed for 10–20 years (for 30 years in the long term). According to estimates of 'NAEC 'Energoatom' state company, the economic benefit of extending the operation life of just one power unit for a year amounts to nearly \$1.5bn.

Among major developments in the interest of power industry one should also mention the automated system for electricity accounting with control of its quality ratings at all stages of its generation, transmission and consumption. Since 2013 the economic benefit due to its introduction at the 'NEC 'Ukrenergo' state company has been in excess of UAH 1bn. In 2015, NAS scientists solved another difficult problem: they developed procedures and produced composite fuel (a lean coal analog) based on anthracite with adding 35–40% of domestic gas coal. Successful burning of the first trial batch at Zmiivska thermal power plant enabled its specialists to diversify fuel sources of this power plant and increase their number by 40%, getting rid of the dependence on imported fuel.

Developments of Academy institutions also facilitate the growth and improvement of Ukraine's transport infrastructure. For example, the E.O. Paton Electric Welding Institute, in collaboration with Kakhovka-based Electric Welding Equipment Plant, developed a technology and organized the manufacturing of machines for butt resistance welding of high-strength steel rails. Now, relying on the equipment produced, 5,000 km of the so-called "velvet" railway track in Ukraine and 11,000 km in People's Republic of China have been laid. The technology allowed the speed of Ukrainian trains to reach 160 km/hr. The total economic benefit from the implementation of this development amounted to UAH 2.6 bn.

Food security was also in the focus of our scientist's attention. In recent years, over 145 new crop varieties and hybrids have been registered. In 2015 alone, 8 winter wheat varieties suitable for cultivation in Ukraine were introduced in the Register of Plant Varieties and 10 more varieties were being tested. Now, the total area of arable land where new wheat varieties are sown is over 1.7m hectares. The yield harvested from that area meets the needs of Ukraine in food grain almost in full.

Recently we again witnessed the ability of NAS scientists to channel their efforts into dealing with the most pressing challenges the nation is faced with. In 2015, the NAS targeted ST program 'R&D for strengthening the defense potential and security of the state' was launched, and the implementation of the most promising projects selected through competition was started. There is also an arrangement on closer collaboration between NAS and 'Ukroboronprom' State Concern. Quite a number of new developments of our scientists are already used for military needs, in the anti-terrorist operation zone as well. Those are, for example, hemostatic and fire-protection means, self-contained flameless heat generators, a number of powerful information and communication systems. Undoubtedly, a major achievement of Academy's R&D researchers is the technology for mass manufacturing of mosaic polymer-ceramic armor elements that relies on reaction sintering of ceramic materials.

It should be noted that meetings of scientists with Ukraine's President P.O. Poroshenko, held on 18 June and 25 December 2015, were of major importance for increasing the efficiency of scientific research and improving the interaction of science and business. There the head of state repeatedly stressed that Ukraine placed great hopes on science, and the disuse of its scientific potential resulted in a technological gap between our state and developed countries. Special emphasis was placed on providing efficient mechanisms to implement innovative developments and technologies. The President of Ukraine also stressed the necessity of engaging young people in science.

Indeed, one of the most acute problems of the science sphere is ageing of research personnel, so guiding young people, engaging them in research work is an important focus of Academy's work. For a long time we have been using the state system of targeted support to young scientists which is provided through grants, prizes and scholarships. The NAS of Ukraine has also introduced its own forms of encouraging young scholars. Primarily, one should mention the

financial support for research works provided to young scientists on a competitive basis. The winners of the regular competition in 2015 were 100 research projects, which received financing of 45–135 thousand for 18 months. Since 1994, the Academy has also awarded special scholarships to young researchers.

Meetings of Academy Presidium regularly listen to the best research presentations of young scholars. According to their results, researchers get an opportunity to open an additional NAS research project and head it. Last year, we heard 9 such reports covering a variety of subjects. Under Academy publishing project 'Academic Book. Young Scholars', 5 monographs were issued in 2015, 10 more won the competition to be published this year.

Of considerable importance is the fact that the work for establishing Councils of Young Scholars has been completed in all 14 NAS Departments. Those councils have already held a number of popular science events, 'Science Days' in particular, which were held twice last year.

Still, despite all the measures taken, in the last four years we have been witnessing a disturbing trend towards continuous decline in the number of young researchers. And the cardinal solution of this problem requires urgent actions of the national scope which would ensure a rise in the prestige of research work and better social security of scientists.

The election of 12 new NAS Academicians and 51 NAS Corresponding Members, as well as its new Presidium, which zeroed in on scientific support to addressing current needs of the nation, first and foremost, on the innovative development of economy, improved management and efficiency of research.

International scientific and R&D collaboration had been and remained a most important area of Academy's activities last year. That was promoted by over 120 international collaboration agreements with science organizations of 50 countries of Europe, Africa, Asia, North and South America. Fruitful co-operation of our scientists with foreign partners under various scientific programs of the EU, NATO, UNESCO, IAAS, the European Center for Nuclear Research (CERN), Ukrainian Science and Technology Center, and numerous other international organizations was continued.

Lately, a special emphasis has been placed on establishing regular contacts with partners from European Union member states and associated countries. Those are based on 27 agreements concluded with academies and leading science centers of Europe. In particular, in June 2015 in the framework of collaboration between the NAS of Ukraine and the National Center for Scientific Research (CNRS, France), we signed an agreement on setting up an associated international laboratory for high energy physics, with a view to developing equipment for accelerator experiments and acceleration methods.

Of the utmost importance for the whole academic community of Ukraine was the signing of the Agreement on the Associated Membership of Ukraine in the EU Framework Program 'Horizon-2020' last year. Undoubtedly, that opened up new opportunities for our country's accession to the European research

area. To share information on 'Horizon-2020' competitions and provide advice, 9 national contact points in certain thematic areas of the program were organized within the Academy.

As far as the financial provision and logistic support of scientific research in the Academy is concerned, it was and remains grossly inadequate due to many factors, crisis phenomena in the economy included. Ukrainian science is now in a rather difficult situation, which, unfortunately, can become even worse. That results from the Law of Ukraine 'On the 2016 State Budget' providing for a significant, as compared to the previous year, reduction in the financing of the science sphere, NAS in particular, to about UAH 2,054 million, which is 26% less than its minimum needs.

The reduced funding, which already was unsatisfactory, may have disastrous impacts, as it could lead to inevitable phasing out of research in many priority areas (including that addressing important national issues), considerable staff redundancies in Academy institutions, and introducing part-time employment regime. Due to severely limited allocations from the general fund of the state budget, last year two thirds of our institutes had to introduce short-time working.

In general, it is very hurting and bitter to state that in all the years of Ukraine independence its science has been financed on the leftover principle and has not been considered as one of the state priorities. As a result – today in this country the number of R&D researchers per 1 thousand of wage earners is twice as low as in the countries of the European Union, which we strive for so much. No less sad is the amount of the state budget expenditures per one Ukrainian researcher: they are several dozen times as low as those in developed countries.

The new Law of Ukraine 'On Science and Scientific and Technological Activities', adopted last year, in our view, provides an effective legal framework for the future advancement of science in Ukraine, turning it into a driving force of nation's innovative progress. It envisages radically new ways for restructuring research management on the basis of generally recognized European criteria – an independent assessment of results, grant financing through the newly established National Research Foundation, science sphere coordination through the National Council for the Development of Science and Technologies etc.

The law contains legislative fixation of progressive elements of the science infrastructure that were once introduced in the NAS of Ukraine. Those are centers for the shared use of scientific equipment and state-supported key laboratories. A significant stimulus for intensified innovation activity (that in our Academy as well) are legal norms on granting scientific institutions the right to transfer their own earnings to special registered accounts opened in state-owned banks, and also be cofounders of businesses with the purpose of exploiting the objects of intellectual property rights.

An important role will also be played by those provisions of the new version of the Law of Ukraine 'On Science and Scientific and Technological Activities' that directly concern the NAS of Ukraine and are aimed at the democratization of its inner life. I'll emphasize several important points. First, in compli-

ance with the law, in future the time of continuance in Academy's executive offices will be limited to two 5-year terms. Second, the Law envisages that delegated representatives of NAS institutes' scientific teams will take part in NAS general meetings with the right to vote.

It should be noted that a number of measures for increasing the efficiency of scientific research is already implemented by the Academy itself in accordance with the Concept of NAS Development for 2014–2023. In particular, our specialists, guided by European standards, have prepared and started to introduce a new procedure to assess the efficiency of research institutions' work. The procedure is based on the main principles of the assessment system used by the Leibniz Association in Germany.

So, the new Law of Ukraine 'On Science and Scientific and Technological Activities' will also be instrumental in the democratization of the Academy life, facilitate a more transparent finance distribution and increase the efficiency of research institutions' work. And – which is the most important thing – it gives us certain hopes for improving the situation in science in the near future. That will stimulate research teams of the National Academy of Sciences of Ukraine to spare no effort for further advancement and extension of research, scientific support to concrete positive changes in our country.

High-Efficiency S&T Developments of NAS Institutions for Economy Branches



**A. G. Naumovets,
First Vice-President
of the Academy**

Scientific research and practical developments based on them are now the main driving force of economic progress and the most important factor in competition. These very ideas were the main topics of discussions at this year's World Economic Forum in Davos, which was concerned with the Fourth Industrial Revolution awaiting mankind. The global trend towards the rates of investments in science exceeding the increase in the gross product was featured in the 'UNESCO Science Report: Towards 2030'.

Although science in Ukraine, unfortunately, is funded at the level of about 0.2% of the GDP, its positive impact on the domestic economy is significant and of utmost importance for the nation.

The most telling example of the efficiency of Academy specialists' activities is their involvement in the work on extending the operation life of Ukrainian NPPs. Novel technologies which they developed and implemented, first and foremost, the diagnostics of reactor shells, allowed the design operational life of 4 out of 15 now operating nuclear power units to be extended by 10–20 years. The cost of constructing a new 1000 MW power unit is currently estimated at \$ 5bn, while the extension of its operation life costs less than 1bn. Besides, the construction of a new power unit takes 5–6 years.

In the interest of nuclear power industry, NAS scientists are carrying out tests of and scientific support to the exploitation of fuel elements produced by the 'Westinghouse' American company. Relying on the test results, the 'NAEC 'Energoatom' state company has concluded an agreement on supplying an alternative nuclear fuel for Ukrainian NPPs, which is a powerful lever for setting a fair market price of nuclear fuel, whose annual deliveries amount to over \$ 600 million. According to the Ministry for Energy and Coal Industry, in 2016 about 40% of nuclear fuel supplies to Ukraine will be in Westinghouse fuel assemblies, which will save UAH 1.3bn in 2015–2016.

NAS institutions also help diversify fuel supplies for thermal power stations. The problem resulted from the failure to supply the necessary amounts of coal from Donbas. In particular, our energy engineers have developed technological procedures of effective burning of coal imported from the South African Republic, as its characteristics differ significantly from those designed for boilers of domestic thermal power plants and cogeneration plants. That permitted them to fully use the purchased coal and secure the

2014–2015 heating season.

The 'NPC 'Ukrenergo' state enterprise engaged our scientists in the development and deployment of the automated system for accounting electrical power, which provides for control of its quality characteristics at all levels of generation, transmission and consumption. Since the beginning of this system exploitation, the economic benefit of its implementation at the 'NPC 'Ukrenergo' has been in excess of UAH 1bn.

For railway transport, NAS specialists, in collaboration with the Kakhovka Plant of Electric Welding Equipment, organized manufacturing of machines for butt resistance welding of rails. Using this equipment, 5 thousand kilometers of the so-called "velvet" railway track have already been laid in Ukraine, which allowed the speed of trains to be increased to 160 kilometers per hour and day-time passenger trains to be introduced. Over 11 thousand kilometers of railways have also been built in China. The manufacturing plant has exported such welding equipment for \$ 228m to 11 countries.

IT specialists of the NAS of Ukraine developed 'HART' and 'Arkan' systems intended for improving the protection of the state borders of Ukraine, fighting organized crime and restricting illegal migration, controlling travels from the zone of anti-terrorist operation. In 2014 alone, the use of these systems helped detect over 28 thousand offences, detain 2708 illegal migrants, and over 9,000 potential migrants were banned from crossing the state border.

Of the most recent developments, very promising is the technology for producing magnetically soft amorphous and nanocrystalline alloys, as well as using those for manufacturing magnetic cores with high thermal stability of properties. The wide use of the nanotechnology developed opens the way to a significant energy saving, and a multiple reduction in the mass and dimensions of electric equipment.

The aforementioned examples of successful implementation of our results convincingly demonstrate that funding of R&D is the most efficient way to develop high-tech manufacturing. Undoubtedly, this should be done not only by the state but by industrial and investment companies as well, which, in turn, requires a radical improvement of the investment climate in the country.

Applied Research and Developments of NAS Institutions for State Companies and Design Offices



**V.P. Gorbulin,
First Vice-President
of the Academy**

In 2015, scientific institutions of the NAS of Ukraine conducted applied research and carried out development work in the interests of state companies and design offices both under the agreements concluded by the Academy on scientific and technical cooperation and by direct contracts, in particular, those with the 'Pivdenne' State Design Office, the 'Antonov State Company', the 'Lvchenko-Progress' State Company, the State Space Agency, the 'Ukroboronprom' State Concern etc.

This form of practical cooperation between state companies and design offices with NAS scientific institutions proved highly efficient. For example, in 2015, the contract work for over UAH 16m was performed for the 'Pivdenne' State Design Office alone. In particular, developed were:

- a technique to investigate the characteristics of composite materials samples, which allowed specialists to reproduce or model thermal force loads occurring in the manufacture and operation of spacecraft structure elements;
- a technology and equipment for laser welding of large nozzle blocks of liquid rocket engines made of stainless steels and titanium alloys;
- a technology for producing solid fuel binders for rocket engines on the basis of low-molecular-weight rubber with carboxyl end groups;
- scientific, technological and methodological fundamentals for developing the equipment and component parts of spacecraft with the reduced level of magnetic field;
- physical and mathematical models as well as an algorithm to calculate parameters of the two-phase supersonic stream of combustion products, with account being taken of water drops evaporation.

In 2015, NAS institutions, in collaboration with the 'Antonov' State Company, carried out joint research in the interest of the company.

An efficient technology was worked out for diagnostics of different types of damage (cracks, stratification and thinning of the material resulting from its partial destruction) in the elements of aircraft structures made of composite materials in industrial conditions at the 'Antonov' State Company.

Specialists introduced a technique for determining the opening angle of the crack tip at the stage of sheet metal equilibrium failure, alongside with mutually agreed determination of the deformation and energy characteristics of crack resistance under general yield

conditions during the uniaxial stretching of a rectangular plate with the central hole. The experimental technique developed was a part of the new approach to engineering estimates of the integrity and the residual strength of aircraft structures.

New technologies were developed and deployed to manufacture high-strength parts of the BT22 titanium alloy for detachable joints with extended service life.

A system for diagnostics of the aircraft structure condition that allowed impact damage to be registered was developed at the request of the 'Antonov' State Company.

Last year, NAS institutions also investigated performances of promising zirconium diboride-based ceramic materials with high oxidation resistance for the 'Lvchenko-Progress' State Company; the materials were intended for combustion chambers and turbines.

Software for scientific and methodological support to the numerical solution of the inverse problems of the transonic compressor stages of aircraft gas turbine engines was introduced at the 'Lvchenko-Progress' State Company in 2015. That enabled specialists to: carry out dynamic designing of compressor blade rings for modern aircraft gas turbine engines; improve aerodynamic perfection of the interblade channels of blade rings; reduce the cost of aircraft experimental research.

In the reporting year, onboard equipment for diagnostics of the parameters of neutral and charged components of the ionospheric plasma was developed and manufactured for the State Space Agency of Ukraine. This equipment is included in the payload of the 'Sich-2-1' to be launched in 2017. The main purpose of the equipment is to monitor the ionospheric plasma and identify sources of natural and man-made disturbances in the sub-satellite path.

Besides, Academy institutions carried out applied R&D under targeted NAS research programs for the 'Arsenal' Special Instrumentation Design Office, the 'Impuls' State S&T Complex, the State 'Kharkiv Morozov Machine Building Company', the State 'Kvant' Research Institute, RPA 'H.Petrovskiy Kyiv Automatics Plant' PJSC, the 'Photoprylad' State Research and Production Complex, the State-Owned 'Izium Plant for Optical Instruments and Devices' etc.

In the short term, NAS institutions will be involved in the work towards replacing imported materials and components used by domestic companies in the manufacture of rocket-and-space, aircraft and special-purposed equipment. Given the fact that a number of research projects are performed by Academy institutions on their own initiative and with their own resources, scientific councils of the targeted integrated research programs should support the investigations which address the most pressing R&D problems the companies of the state sector of the Ukrainian economy are faced with.

Development of Scientific Fundamentals for Creating Drugs for Medicine at NAS Institutions



**V.G. Koshechko,
Vice-President
of the Academy**

Health protection is one of major fields in the state, and pharmaceutical industry plays a decisive role there. Still, there is significant domination of expensive medicines of foreign production in the pharmaceutical market of Ukraine (over 70% in monetary terms), so the development of Ukraine's own pharmaceutical industry, provision of affordable domestic preparations and drugs for citizens is a social concern of national importance, its solution being impossible without cutting-edge scientific research.

Scientists of the National Academy of Sciences of Ukraine have been giving continuous attention to scientific research in medicine, biology and chemistry, which, in fact, covers key areas of modern medicine (diagnostics, treatment, prevention). In the last 10–15 years alone, institutions of the Academy created dozens of preparations for the prevention and treatment of cardiovascular, gastrointestinal, neurologic, infectious, oncologic diseases, and immune system disorders. In particular, those drugs include Kalmivid, Corectin, Mebifon, Nicorandil, Nimodipine, Foridon, Flokalin, Corvitin, Neo-Corvitin, Amitozin, Blasten, Mikoton, Biosporin, Izatizon, Lorameksin, Subalin, Teobonditiomikotsid, Batumin, Tomerzol, Filomek, Namacyt, Cyklofosfan, Myelosan, etc.

According to the forecasts of specialists, a number of innovative technologies will make a significant contribution to extending drug production in the near future. In particular, these technologies include biotechnologies based on synthetic genomes for producing complex medical preparations, technologies for selective transport and exact identification of targets for medical preparations, use of stem cells for preventing diseases at early stages, biomarkers for more reliable diagnostics of diseases, etc.

In recent years, in accordance with the abovementioned trends, NAS institutions have been carrying out extensive fundamental research, they have also started new research areas, in particular:

- molecular and cellular pathobiology in determining predictive and prognostic markers in oncology;
- nanomedicine, nanobiotechnology, nanopharmacology;
- biopharmaceutical informatics, which in conjunction with chemo- and bio-informatics, enables researchers to forecast physico-chemical and pharmacological properties of various compounds;
- the development of new cryotechnologies, methods and medicines based on fundamental research, and a number of other promising areas that are of no less importance.

This enabled Academy scientists to obtain a number of significant fundamental and applied results in the field of medicine. Only some of them will be mentioned.

Methods of DNA analysis for early diagnostics of severe hereditary diseases were developed and implemented at the institutions of the National Academy of Medical Sciences of Ukraine. Besides, a test-system was produced for diagnostics of different types of lacteal gland tumors in humans for personalized therapy used at the National Cancer Institute.

Diagnostic procedures and separate components of test-systems were developed for DNA analysis of mutant genes that cause the development of the most common mono-gene hereditary diseases in Ukraine and determine predisposition to cardiovascular, reproductive, inflammatory and endocrine pathologies. A novel technology was worked out for producing combined anti-tumor vaccine based on autologous tumor cells enriched with heat-shock proteins.

Fundamental research in cryobiology was used as a basis for creating several immunologic drugs for the treatment of various diseases (diabetes mellitus, heart ischemia, hypertension etc.). Novel anti-virus drug 'Cryocell-Haemocord', based on human cord blood, was produced.

Original hypnotic and anxiolytic drug Levana® IC (Cinazepam) was formulated, registered and introduced to the State Register of Medical Preparations of Ukraine; the manufacture of the medical form of the drug was organized at industrial facilities of 'InterChem' Additional Liability Company.

'Alkotest', 'Lactatest' and 'Diagluk' diagnostic sets were produced; they are 3–4 times as cheap as their foreign analogs. For the first time in Ukraine, new promising anti-tumor drug 'Feroplast' was developed. It contains nanoparticles of magnetic liquid and cisplatin, its performances being better than those of the standard platinum preparation.

Novel combined vitamin drug 'Metovitan', immunodiagnostic drugs for determining anti-diphtheria immunity and threat of clot formation in humans, as well as immunochromatographic tests for tuberculosis diagnostics, which rely on *Mycobacterium* recombinant proteins, were proposed for industrial deployment.

The effect of structure on properties was studied for more than two thousand compounds; for this purpose a hierarchic QSAR technology, aimed at optimizing the formulation of new efficient biologically-active compounds, was developed.

A number of other new drugs for medical needs are under development.

The NAS Section of Biochemistry, Physiology and Molecular Biology initiated the preparation of generalized printed edition «National Academy of Sciences of Ukraine for Medicine». The publication of such a book will be an evidence of Academy's significant contribution to health protection and will also facilitate popularization and commercialization of the drugs developed.

Development of Social Sciences and Humanities in the National Academy of Sciences of Ukraine



**S.I. Pyrozhevsky,
Vice-President
of the Academy**

In 2015, the activities of the NAS Section of Social Sciences and Humanities were aimed at implementing research projects and preparing integrated analytical and prognostic materials in major areas of economic, social and cultural development of Ukraine. That concerned, primarily, the issues of consolidating the Ukrainian society, ways of strengthening the integration of Ukraine's regions and Ukrainian identity.

According to the practice of preparing annual national reports, started by the NAS of Ukraine, specialists of the Economics Department prepared the National Report 'Innovative Ukraine – 2020', which stressed the need for immediate conversion of the national economy to the innovative model. The specific feature of this National Report is that it was developed by specialists of the NAS Section of Social Sciences and Humanities in collaboration with numerous experts in nearly all areas of natural sciences. Scientists confirmed that the implementation of the innovative model of Ukraine's economic development is the only effective way to overcome the impacts of the financial and economic crisis and achieve social progress.

In order to implement the Decree of the President of Ukraine №514 of 26 August 2015 'On the Decision of the National Security and Defense Council of Ukraine of 20 July 2015 'On Implementing Measures to Protect Property Rights and Interests of Ukraine in Connection with the Temporary Occupation of a Part of the Territory of Ukraine', scholars of the Section prepared the analytical report 'Revival of Donbas: Assessment of Social and Economic Losses, and Priority Trends of the State Policy'. In it, NAS specialists proposed mechanisms to restore social and economic potential of Donbas through the development of public and private partnership, decentralization and deregulation, creation of technology-deployment and industrial-investment zone, introduction of a special regime of governing and targeted socio-economic programs, protection of citizens' and businesses' rights according to the requirements of the Association Agreement between Ukraine and the EU.

Specialists of the institutions of the NAS Department of History, Philosophy and Law prepared an electronic version of the 16th and 17th volumes of the «Encyclopaedia of Modern Ukraine», published the sociological monitoring materials «Ukrainian Society. 1992–2015. Status and Dynamics of Changes», new volumes of the multi-volume collection of works by M. Hrushevsky (vol. 10, books 1 and 2; vol. 22; vol. 46, books 1 and 2), collections of docu-

ments and materials «Ukrainian State (April – December 1918)» in 2 volumes, and «Ukrainian Identity and Language Issue in Russian Empire: an Attempt at State Regulation (1847–1914)».

Scholars of the Department made proposals to amend the Constitution of Ukraine on issues of state power decentralization and development of local self-government and reforms of the judicial system of Ukraine. NAS specialists enlarged the database of the victims of political repressions of the Soviet period with the information on more than 207 thousand repressed citizens.

Scientists of the NAS Department of Literature, Language and Art Criticism worked efficiently in preparing such fundamental publications as «History of Ukrainian Literature» in 12 volumes (the 3rd volume of this edition is being edited now), «Dictionary of Ukrainian Language» in 20 volumes (the 6th volume was published), «History of Decorative Arts of Ukraine» in 5 volumes (the last volume is in the publishing house), «Ukrainian Music Encyclopedia» in 7 volumes (the 4th volume is going to be published), «History of Ukrainian Theatre» in 3 volumes (the 1st volume is to be published), «Ukrainian Sacred Arts of 10th–21st Centuries» in 3 volumes (the 3rd volume was prepared for printing).

In the year under review the Section completed the implementation of such targeted NAS integrated research programs as: 'Modernization of Ukrainian Society and Economics in the Context of the 21st Century's Challenges', 'Humanitarian Technologies as Means of Social Transformations in Ukraine', 'Civil Society, Individual and State: National Experience and Potential Co-Operation', 'Modernization of the Social and Cultural Segments in Europe and Ukraine'. In the framework of those projects, Academy's scholars prepared detailed proposals for modernizing the production sector and regulating investment processes. They developed recommendations on the ways to reform the political system of Ukraine and mechanisms in public policy to promote the development of civil society and facilitate the resolution of regional, interethnic and inter-confessional conflicts, combating separatism and anti-Ukrainian propaganda.

Considerable attention was paid to implementing the results of socio-humanitarian research. For example, in 2015 the institutions of the Section prepared over 930 analytical studies, expert conclusions, proposals and recommendations to state authorities, ministries and departments.

In the short-term period the efforts of the scholars of the NAS Section of Social Sciences and Humanities will be focused on further research into topical issues of state development, social and economic progress of Ukraine. In particular, special emphasis will be placed on conceptual principles and strategies for realizing the civilizational choice of Ukraine, integrating Donbas and the Crimea into political, legal, and sociocultural spheres of Ukraine, modernizing the national government and public institutions in accordance with European and international standards.

Environment Research at the NAS of Ukraine: National and International Aspects



**A.G. Zagorodny,
Vice-President
of the Academy**

In 2015, scientists' efforts were focused on studying regional problems of environment conservation and restoration, increasing the biota and landscape diversity in Ukraine under global environmental change, developing scientific fundamentals to achieve energy independence of Ukraine, as well as creating safe and man-friendly environment.

In the reporting period, Academy scientists carried out studies and research management activities in the framework of the State Program for forming the national ecological network of Ukraine in 2000–2015, the State targeted program of water industry development and the Dnieper basin rehabilitation for the period till 2021, as well as NAS targeted integrated research programs. Taking into account the successful implementation of the NAS targeted integrated interdisciplinary scientific research program for sustainable development, rational nature management and environment preservation, the Academy Presidium launched a NAS targeted integrated interdisciplinary program to elaborate scientific fundamentals for the rational use of natural-resource potential and sustainable development scheduled for 2015–2019.

A number of draft resolutions and orders of the Cabinet of Ministers of Ukraine were analyzed and coordinated. An Action Plan to implement the Concept of managing the risks of the onset of technological and natural disasters was approved by the respective Cabinet order of 25 March 2015 #419.

NAS specialists were engaged in preparing science-based proposals to address various nature-protection issues in Ukraine, particularly those concerned with the draft of intended nationally determined contributions of Ukraine to the new global climate agreement, the elaboration of the international Convention on UNESCO Biosphere Reserves, initiated in UNESCO by Ukraine, the feasibility of connecting the Sasyk lake with the Black Sea etc.

The period under review generated a number of important scientific results. Concepts and principles were substantiated to build up an organization and stewardship system of nature management, alongside with economic aspects of using natural resources under decentralization of authority. A new system of forming and assessing the territories of nature-conservation sites was proposed. Road maps for the development of renewable energy were worked out for the period till 2020; an energy-efficient technology for thermal disposal of the sludge of urban sewage-treatment facilities was proposed and tested. An assess-

ment of the current status of climate in Ukraine was made and trends in its change determined; methodological principles were elaborated to forecast the effects of air temperature, precipitation and vaporization on the formation of water resources.

A special focus was given to co-operation with UNESCO. In particular, NAS specialists were actively involved in the work of the National Committee of Ukraine for UNESCO. An inter-agency commission was set up to implement the International Hydrological Program of UNESCO and the Hydrology and Water Resources Programme of the World Meteorological Organization.

NAS scientists also participated in the work of the 38th session of UNESCO General Conference, the 27th session of the International Co-ordination Council of the UNESCO 'The Man and the Biosphere' (MAB) Programme. Relying on the results of the work of the Strategic group for the Action Plan to implement the Strategy of developing UNESCO MAB Programme for 2016–2025, a draft Action Plan was worked out and approved. It is to be adopted at the 28th session of the International Coordination Council of the MAB Programme (March 2016, Lima (Peru)).

NAS specialists were active participants in the realization of numerous projects and programs, in particular, of the regional project of the European Commission 'Consolidation of the network of protected natural areas for biodiversity preservation and sustainable development of the Danube Delta and Lower Prut areas – PAN Nature', the European endangered animal species programme, the EU programme 'Preservation of transboundary Polissia water and wetland areas in Belarus, Russia and Ukraine', the project of Poland–Belarus–Ukraine transborder cooperation in the framework of the European Neighbourhood Policy etc.

Besides, close collaboration of the interdisciplinary team consisting of several groups of scientists representing different NAS institutions with the International Institute for Applied Systems Analysis (IIASA) resulted in the development of a systemic methodology for integrated safety management that relies on a set of interrelated models of water, agrarian and energy resources. These models enabled scientists to assess environmental, social and economic risks of the national and regional scope. The methodology was successfully tested in China.

The Institute for Space Research, operating under NAS and SSA of Ukraine, is involved in 'SIGMA' and 'ERA-PLANET' projects of the EU FP-7 and FP-8 'Horizon-2020'. Those programs tackle important sustainable development issues and are aimed at setting up Earth monitoring services.

In the short term, NAS scientists will focus on implementing the main ideas of the UN Declaration on Millennium Development Goals, documents of the International Conference 'Rio+20: The Future We Want', the new Lima Strategy of the MAB Programme development for 2016–2025 and the relevant action plan.

Activities of NAS General Meeting and Presidium



**V.L. Bogdanov,
Chief Scientific Secretary
of the Academy**

In 2015 the main focus of the General Meeting and Presidium of the NAS of Ukraine was on advancing top-priority areas of fundamental and applied research, implementing its results, providing scientific support to the solution of major problems facing the state and society, promoting international collaboration, improving Academy's work.

Four sessions of the NAS General Meetings were convened last year. On 6 March, the session of the General Meeting elected new Academy members – 12 NAS academicians and 51 NAS corresponding members.

The reporting session of the General Meeting held on 15 April considered main results of Academy's activities in 2009–2014, set guidelines for its further work, determined nationwide problems requiring the involvement of scientific potential.

The session of the General Meeting on 16–17 April elected NAS Academician B.E. Paton the President of the Academy. A new body of the NAS Presidium was also elected.

On 30 October 2015 a jubilee session of the NAS General Meeting was held to commemorate the 130th anniversary of Academician O.V. Palladin – an outstanding Ukrainian scientist, one of the founders of the Ukrainian biochemistry school, a renowned public and political figure, a former President of the Academy of Sciences.

NAS Presidium paid a lot of attention to the scientific support for dealing with current challenges of national importance. In the year under review, it heard the results of implementing the state targeted S&T program 'Nanotechnologies and nanomaterials', which was an interdisciplinary one and involved scientists of 43 research institutions of 9 NAS Departments. The Presidium stated that the results obtained in this cutting-edge area were of great scientific relevance and held great promise for introduction in various branches of industry and medicine. To increase the defense potential of the country, the Academy launched its targeted program that would facilitate the solution of S&T problems related to the modernization and development of Ukraine's defense industry.

Special focus was given to the current situation in Donbas. Considered were both scientific aspects of reviving the region and the issues of retaining the research potential of respective Academy institutions, first and foremost, evacuating them from the zone of anti-terrorist operation and facilitating their work in

the new places.

NAS Presidium approved of the National Report 'Innovative Ukraine', which substantiated the necessity of creating conditions for the efficient use of innovative and S&T potentials of the state, and to economic development scenarios worked out through situation scale modelling. Of great significance for ensuring energy supplies was the discussion of energy balance optimization, which is necessary for the efficient functioning of the economy and satisfying energy needs of citizens, as well as the preparation to launching the state-of-the-art and powerful neutron source based on the sub-critical assembly.

A joint session of NAS Presidium and the Board of the Ministry for Science and Education of Ukraine discussed various aspects of their co-operation, participation of Ukrainian scientists in the EU program of scientific research and innovation 'Horizon-2020', collaboration with CERN, coordination of marine research. Jointly with the State Space Agency of Ukraine, the NAS of Ukraine determined areas of collaboration in space exploration and exploitation.

Meetings of NAS Presidium thoroughly analyzed the work of Academy sections in 2009–2014. They stressed the successful organization of measures to address highly relevant interdisciplinary problems, high standards of basic and applied studies, and the international level of research in some areas.

Special emphasis was placed on the promotion of research financing based on principles of targeted programs and competition. NAS Presidium gave high appraisals to reports on the implementation of 8 integrated targeted programs.

Over 50 research presentations were heard. Their discussions demonstrated the importance of the research outcomes considered for the progress of cutting-edge science areas, as well as their prospects for introduction in different branches of economy and Ukrainian culture. In particular, NAS Presidium noted that the results of research into dark matter, neutrino properties, double β -decay of atomic nuclei corresponded to the world science level. Significant results were achieved in introducing nanotechnologies in materials science, biology and medicine, in optimizing the operation regime of gas-transport systems, implementing technologies based on renewable energy etc.

NAS Presidium also focused on legal and normative framework of Academy's functioning. It approved the draft NAS Statute and draft Law of Ukraine 'On the National Academy of Sciences of Ukraine'. Main provisions of the draft Law of Ukraine 'On Scientific and S&T Activities' were discussed as well.

A significant place in the work of NAS Presidium was also taken by various aspects of implementing the Concept of Academy Development, improving the management of scientific research, supporting the studies carried out by young scholars, popularizing science etc.

Mathematics



**A.M. Samoilenko,
Academician-Secretary
of the Department**

In 2015, significant outcomes of researchers of the NAS Department of Mathematics resulted from the development of integrated and interdisciplinary areas of fundamental and applied studies in the fields of mathematics that are of high relevance for the world science. Some of those were produced through extensive international collaboration.

In the field of differential equations and dynamical systems, Department's scientists studied the parabolic equation describing the phenomenological model of gasless combustion on a cylindrical surface and, in particular, investigated the problem of the existence of asymptotic shape and stability of running waves, as well as the pattern of their stabilization and loss of stability. The conditions of unique solvability were established for both mixed and inverse problems of a weakly nonlinear ultraparabolic equation, which enabled researchers to study the processes of diffusion with inertia in the theory of binary electrolytes, in models of population sizes, and in the theory of options.

In the field of mathematical physics and functional analysis, it is necessary to mention the classification of Schrödinger equations with position-dependent mass which admit second-order integrals of motion. It was proved that all such equations are superintegrable and exactly solvable. Moreover, the algorithm of their integration was presented. The structure of algebras of operators in Banach spaces over a non-Archimedean field generated by regular representations of discrete groups was investigated with the aim of subsequent creation of the general theory of non-Archimedean operator algebras as a working tool of the quantum statistical mechanics and for describing the dynamics of protein molecules in biophysics. A universal method was developed to investigate fluctuations of linear statistics of eigenvalues for matrices with independent elements, which enables one to get new results for banded matrices and significantly simplify the well-known proofs of the central limit theorems for fluctuations of linear statistics. Methods of the theory of averaging were used to study the asymptotic behavior of an elastic system of point masses with nonlocal interaction and to construct a nonlocal model of continuous elastic medium. Analytic expressions for the advanced and retarded solutions of the Maxwell equations in special Riemannian spaces were obtained, which opens up new possibilities of discovering subtle properties of black holes. The complete description of scattering data was obtained for Dirac systems on the semiaxis, and a solution algorithm for the corresponding inverse scattering prob-

lem was proposed, which enables one to study the inverse scattering problems for a broad class of Schrödinger equations with energy-dependent potentials.

In the theory of probability and mathematical statistics, Department's mathematicians completed the investigation of the problem of large deviations in the scheme of asymptotically small diffusion with lumping of a Markov random medium. For potentials of a simple layer related to a class of pseudodifferential equations generated by symmetric stable processes, they proved an analog of the classical theorem on the jump of normal or conormal derivative of the simple-layer potential, which is quite promising for various applications in mathematical physics.

In the theory of functions, our researchers established the exact-order estimates for the entropy numbers and Kolmogorov widths of the Nikolskii–Besov classes of periodic functions of many variables in the uniform metric, which can be used in the information theory. The problem of existence of the solutions of classical boundary-value problems of the theory of quasiconformal mappings was solved in Jordan domains with measurable boundary data. That opened up new ways for investigating mathematical models of natural sciences posed in media with complex structures.

In the fields of algebra, geometry, and topology, one is to mention the development of the theory of quasihereditary noncommutative schemes for which the estimates of the global dimension and the Rouquier dimension of derived categories were obtained and the semiorthogonal decompositions of derived categories were constructed. This allowed the estimates for the Rouquier dimension of the derived categories of singular curves to be established.

In mathematical problems of mechanics, new algebraic criteria of the existence of static and dynamic regulators were established. These criteria guarantee the asymptotic stability of the equilibrium state and the required level of damping of external perturbations in control systems, which can be used for constructing highly reliable controlled engineering objects. To investigate the strength and reliability of multilayer structures of various shapes operating under conditions of high-temperature heating with the simultaneous action of force loads, a method was developed for the analytic determination of their thermal stressed state. It proves to be quite promising for the application in rocket and space technology as it takes into account the distribution of temperature and mass forces in the layers of structures, force loads, as well as functional dependences of various characteristics of layers on temperature.

In mathematical modeling, numerical and applied mathematics, the exact analytic solutions of a series of spectral problems for the Schrödinger operators with polynomial potentials were obtained for the first time by the functional-discrete method, relying on computer algebra. These solutions can be used in theoretical physics.

Information Science



P.I. Andon,
Academician-Secretary of
the Department

In 2015 the work of scientists of the NAS Department of Information Science was focused on important fundamental and applied issues in the field of intelligent information technologies and systems, information protection and security, etc.

In particular, in the field of mathematical modeling and analysis of complex systems, Department's researchers developed mathematical tools for advanced analysis of mathematical model sets for nonlinear control processes and fields of various natures, on conditions which do not violate the adequacy of models and allow consideration of various kinds of effects that are natural to the processes investigated. It enabled them to build highly accurate algorithms for long-term forecasts of processes and phenomena occurring in superconductivity, chemical kinetics, hydrodynamics, bioinformatics and economics.

Mathematical methods were created for assessing the vulnerability risk of a complex stochastic system and for determining the weight of each of its components. For the first time this permitted scientists to simulate and evaluate it, relying on the notion of systemic risk measuring. Using these methods, they developed and tested through actual observations new mathematical models of agricultural production; that enabled them to compare needs for different production factors (capital assets, human resources, energy and water supply) among all regions of Ukraine and to assess the role of weather and climate factors.

Mathematical methods, an information technology, the structure and composition of information-analytical system of prompt content-monitoring of Internet were developed to support decision-making in conflict situations and in those that are difficult to formalize. The results obtained were aimed at providing effective support to processes of decision-making at different levels: from analytical support to situation centers functioning to strategic planning objectives at the levels of local or state authorities.

In the field of intelligent information technologies (IIT) and systems, Department's scientists developed the fundamental basis for constructing new IIT classes of figurative thinking that operate on the basis of precise definition of target requirements. This approach opens up new ways to effectively address a wide class of problems.

New methods were worked out to synthesize reference images for correlating-and-extreme guidance systems with infrared and radar sensors which can

detect signs of steady informative indicators that weakly depend on use conditions.

An algorithm of satellite image processing was proposed to improve the accuracy and speed of rapid analysis of farmlands. Its testing and computer simulation of model's optimal parameters were performed.

In the field of information security, specialists developed the Analytical report for the Annual Address of the President of Ukraine to the Verkhovna Rada, National Security Strategy of Ukraine and several other documents of national importance that provide for protection of national interests.

For the first time in Ukraine, models of attacks on stream ciphers were developed, which could significantly speed up their cryptanalysis. These results provide the protection of information in communications systems, electronic document workflow systems in governmental institutions and departments of Ukraine, in particular, in defense and security agencies.

A spectral steganographic algorithm that is by 10% more tamper-resistant as compared to the existing ones was developed. A composite steganographic system combining the use of CAPTCHA technology with existing steganographic methods was created, which ensures the user-defined steganographic stability and bandwidth of stegananalysis.

A unified game-theoretic approach to the analysis of Internet-networks was proposed. Within it, models and methods were developed to analyze distributed systems in the presence of users' competition for system's resources, a conflict interaction between users and malicious user's actions aimed at system disruption – denial of service attacks.

A portable hardware-software electrocardiography complex was produced. It was used in the Mykola Pyrogov First Voluntary Mobile Hospital for medical examination of military personnel in the area of the anti-terrorist operation and for population screening in Khmelnytska oblast, covering 22 thousand persons from 565 settlements. Its advantages as compared to the existing hardware are portability, improved performance, 4th-generation diagnostic algorithms and automated diagnostic report.

In the clinical setting, comprehensive studies of promising technologies of digital medicine in regular physical examinations as well as dispensary treatment were carried out. Their results confirmed the high accuracy of diagnosis and examination in both hidden and manifested cardiovascular and neurological diseases.

In the interest of national defense, the development of and scientific support to several projects was provided on a voluntary basis. One of the projects concerned the development of an automated centralized system of command and control for the Armed Forces of Ukraine to replace obsolete equipment and improve the quality and efficiency of command and control in the armed forces.

Mechanics



A.F. Bulat,
Academician-Secretary of
the Department

In 2015, scientists of the Mechanics Department of the NAS of Ukraine continued fundamental and applied research in priority areas of science and technology. They obtained a number of new important theoretical and experimental results; some of those were honored with awards.

Algorithms were developed for calculating the thermo-elastoplastic deformation of shells and bodies of revolution in the process of re-loading, with account being taken of the stress-state dependent and secondary plastic deformations. Those will be used to develop methods for predicting the strength of thin-walled and thick-walled elements of space reentry vehicles.

For non-linear equations of perturbed motion, new boundaries were determined for the solution norms; their applications were shown for a class of affine systems and in the problem of the synchronization of movements. A new approach based on the theory of mixed volumes was proposed for the qualitative analysis of sets of mechanical systems trajectories.

The exact analytical solution was obtained for the problem on the stress-strain state of an elastic half-plane with mixed boundary conditions under arbitrary non-stationary loading. Non-stationary displacements of non-closed spherical electro-elastic bimorph shell were determined and their optimization path proposed.

A mathematical model was formulated for numerical simulation of gas-dynamic and thermophysical parameters of a viscous non-equilibrium chemically-reacting non-isobarometric immersed jet of the end products of the combustion of rocket propellant fuel, taking into account its mixing with air and the delivery of a drop phase (water) into the jet body; the respective algorithm and calculation program were developed. Special features of the effects of water evaporation and jet afterburning on its parameters were found. The data obtained concerning the jet chemical composition, the degree of its temperature and velocity reduction, depending on the point and techniques of water supply, should be used in selecting ways of damage effect mitigation for a supersonic high-temperature jet of a rocket engine on streamlined surfaces.

A procedure was developed to determine fatigue crack size and the number of cycles to fracture that corresponds to the transition from non-localized to localized fatigue damage. The analysis of crack sizes and the number of loading cycles corresponding to

this transition was made for various metals and alloys. It was shown that under high-cycle fatigue conditions the size of such a crack decreases with increased stress amplitude and varies over a wide range for different materials.

In order to protect military targets, civilian objects and personnel, engineering solutions were proposed to develop basic transparent elements optimized with respect to the level of stability during a ballistic attack. They allow the creation of high-reliability modular systems, including the possibility of fast and efficient recovery of the damaged transparent parts of the module.

Modification of the existing energy criterion of fracture mechanics of a brittle body was made; relying on it, a new model of marginal zone of mine working was developed. This differs in that it takes into account the impact of rheology properties of the material on the formation and development of cracks in the marginal array of mine working. The model for the first time enables specialists to describe the process of accounting for the effect of crack constant creep, which provides a more accurate and adequate picture of the stress-strain state of mine workings over time. It permits a more accurate prediction of crack formation and rock breaking in the marginal array of mine working, with a view to a significant improvement in the quality of their maintenance under intensive mining.

Features of feedback in sound generation by a flow of fluid were established, and an algorithm to estimate sound field characteristics was elaborated.

Calculation methods were developed to characterize the processes of waste treatment in aerotanks with biocenosis suspended (free-floating) and attached to auxiliary structures. Novel methods for estimating the parameters of radial drainage and numerical simulation of water filtration for different types of salinization of suffusive soil were proposed.

A generalization of the classical Lipschitz condition was proposed; in particular, it allowed scientists to consider systems with discontinuous nonlinearities that are often found in problems of mechanics and control. For numerous nonlinear differential equations of any order that satisfy the specified condition the exact upper limits of amplitude-frequency characteristics were found.

The effect of certain geometric characteristics of the Darrieus rotor on the energy efficiency of the vertical-axis windmill was determined. The dependences of power factor of the vertical-axis wind power plant with a Darrieus rotor on specific speed, filling and the Reynolds number were obtained. Using the engineering method developed for calculating natural frequencies of H-Darrieus rotor blades, the dependence of rotor design parameters was investigated at different ratios of blade stiffness and transverse parameters.

Physics and Astronomy



V. M. Loktev,
Academician-Secretary of
the Department

Research in physics and astronomy was carried out at 16 institutions of the NAS Department of Physics and Astronomy and in a number of higher educational institutions. Focusing on fundamental research, scientists of the Department also directed their efforts to obtaining, on its base, the results oriented towards practical use and development of new technologies.

In the field of fundamental interactions and microscopic structure of matter, researchers of the M.M. Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine proposed models describing collisions of heavy nuclei. The previsions made are widely applied to interpret the data obtained with the Large Hadron Collider at CERN (Geneva, Switzerland).

In solid-state physics, a record high (higher than by a factor of 45) magnetoresistive effect in textured polycrystals of $\text{Bi}_{93.99}\text{Mn}_2\text{Fe}_{0.01}$ was discovered in magnetic fields of up to 14 T. It was shown that in the case of a field normal to the current this effect is 10 times as high as that for the longitudinal field, which holds a high promise for the spintronic devices.

In the field of low and super low temperatures, a new type of the superconductive quantum magnetometer was introduced. Its characteristics were calculated, proving that it exhibits extra capabilities for the super accurate detection of a weak magnetic field, as well as for the sensory diagnostics of superconductor properties.

In optics and laser physics, the spectra of microresonator magnetic photonic crystals were investigated. The temperature stability of the frequencies of optical transmission and magnetic rotation of the light polarization area was found, which can be used in the formation of crystals with controlled optical characteristics.

In nanophysics and nanotechnologies, predicted was the formation of submicron structures of atoms and molecules in a trap generated by the field of two collinear standing waves with different frequencies. It was found that cooling of the particles down to a temperature corresponding to the Doppler line occurs simultaneously with their retention in the trap.

In radio physics and electronics, produced was an automated system for remote video surveillance in special security areas, thus allowing the detection of various objects hidden from direct observation.

In soft matter physics, the effect of metal-phthalocyanines and clathrochelates on human protein aggregation products was investigated. The results obtained make it possible to consider the corresponding complexes as agents capable of producing significant impacts on the processes occurring in living

organisms, thus opening up ways to treating the Alzheimer's and Parkinson's diseases.

In physics of plasma processes, the method of renewable disturbances was employed to describe electrostatic modes in the presence of ion temperature gradients, and it was shown that liquid resonances play the main role in the excitation of zone flows. This mechanism causes a displacement of the line of such flows generation and facilitates plasma confinement.

In astronomy, astrophysics and radio astronomy, the complete survey of star clusters in our Galaxy, covering 3210 of those, was carried out for the first time ever. Besides, the lowest-frequency (20–30 MHz) carbon lines amounting to about 100 for the record-high principal quantum numbers of 683–1105 were detected for Cassiopeia A. This shows that atom as a single system exists below boundary excitation levels, which opens up ways for ultrasensitive diagnostics of space plasma.

It is worth noting that a number of the results obtained by scientists of the Department were duly appreciated. The State Prize of Ukraine in Science and Technology was awarded to associates of the Main Astronomical Observatory of the NAS of Ukraine P.P. Bertsyk, I.B. Vavilova, V.Yu. Karachevtseva, Ya.V. Pavlenko and L.S. Pilyugin, and associate of the Institute of Radio Astronomy of the NAS of Ukraine A.O. Minakov. Three teams got prizes named after distinguished NAS scientists, and a number of scientists received awards of the NAS of Ukraine. The Honorary Diploma of the Verkhovna Rada of Ukraine was conferred on B.I. Lev, NAS Corresponding Member, and Diplomas of the Verkhovna Rada of Ukraine – on L.S. Bryzhyk, M.I. Gorenshstein, O.O. Yeremko, V.O. Biloshenko and Ya.Yu. Beigelzimer. Research associate of the NAS Institute of Electron Physics O.V. Snigursky was awarded the Order of the Polish Republic 'Bronze Cross of Merit'. The Medal of the National Academy of Pedagogical Sciences of Ukraine 'Grigory Skovoroda' was conferred on NAS Academician I.R. Yukhnovsky.

Institutions of the Department gave much consideration to the training of research personnel. In 2015, 13 theses for doctor's degree and 59 theses for the candidate's degree were defended, and 16 textbooks were prepared. Yet, the scientific cadre of the Department is growing old, this being caused by the loss of scientist's prestige in Ukraine. Besides, inadequate financing leads to the wear of physical research equipment, which was produced back in 1970–1980. The centers for shared use of research equipment are in a difficult situation as well, as now neither consumables nor spares are provided for it.

All this taken together is a sign of a deep crisis the Ukrainian science is suffering now. Nevertheless, scientists of the Department, together with their colleagues from other departments and universities, do not lose optimism and aim their efforts at improving the conditions for research and attracting talented young people to it.

Earth Sciences



**O.M. Ponomarenko,
Academician-Secretary of
the Department**

In 2015, scientists of the NAS Department of Earth Science obtained a number of significant fundamental and applied results, some of which won awards and prizes. Some specific examples are to be mentioned.

The State Prize of Ukraine in Science and Technology was awarded to V.M. Shuman and P.G. Pigulevskyi, researchers of the S.I. Subbotin Institute of Geophysics, for their work 'Geochemical, petrological and geophysical criteria for forecasting mineral deposits of the Ukrainian Shield'.

NAS Academician V.I. Starostenko, NAS Corresponding Member O.B. Gintov, G.M. Drogytska were awarded the NAS S.I. Subbotin Prize for their book «Kirovohrad Ore Area. Deep Structure. Tectonophysical Analysis. Ore Deposits».

It was stated for the first time that the construction of realistic models of the geological environment which take into account rapid migration zones and detailed 3d filtration modeling enabled scientists to determine a significant (more than 15-fold) increase in infiltration supply and, therefore, nearly a 2.5-fold rise in groundwater resources. Allowance for the existence of rapid migration zones (depressions and lineaments) to estimate groundwater resources in specific areas is a pioneering research and is unique both in Ukraine and the whole world (NAS Academician V.M. Shestopalov, V.M. Bublyas, A.S. Boguslavsky, I.P. Onyschenko, I.M. Romanyuk).

The 'Isohypse' program was worked out and tested; it was intended for automated interactive processing of geophysical object images for rectangular and spherical coordinate systems in calculating the 3d density model of the Ukrainian Shield, the Dnieper-Donets basin and the Black Sea area (NAS Academician V.I. Starostenko, O.V. Lehostayeva, I.B. Makarenko, O.S. Savchenko, P.Ya. Kupriyenko).

In the framework of prospecting for hydrocarbons, it was discovered that the central parts of oil and gas basins with anomalous thicknesses of sedimentary cover are characterized by current deep petrophysical, geothermodynamic and fluid-dynamic zonation. It was shown that at the depths greater than 5–6 km large segments of oil and gas basins acquire signs of common oil and gas mega reservoirs that are currently being formed and are an inexhaustible source of hydrocarbons (NAS Academician O.Yu. Lukin).

A new satellite technology was elaborated to detect anomalous decreases in sea surface temperatures which result from the efflux of cold bottom waters from the seabed by methane flows associated with hydrocarbon migration from deep deposits. This tech-

nology permits an increase in the efficiency of detecting methane discharges from the seabed (NAS Academician V.I. Lyalko, A.I. Vorobyov, A.M. Heyhman).

An integrated mapping database was compiled for the comprehensive analysis of huge volumes of data available on the geology and distribution of mineral deposits in the Black Sea region. The database was created in GIS in the real coordinate system, which permitted scientists to combine different types of information, namely, to superimpose geophysical anomalies, fault zones, lithological and geochemical characteristics of rocks of different ages, development fields of marine and alluvial deposits etc. on actual topography (NAS Academician Ye.F. Shnyukov, I.E. Lomakin, N.V. Shafranska).

Geodynamic processes in the deep seismogenic Vrancea zone were studied relying on mechanisms of 80 earthquake foci according to deep seismic sounding and seismic tomography (NAS Corresponding Member O.B. Gintov, T.P. Yehorova, T.A. Tsvyetkova, I.V. Buhayenko, H.V. Murovska).

An atlas-guidebook of the nature reserve fund of the Kyiv oblast was prepared and published in both paper and interactive versions (NAS Academician L.H. Rudenko, K.A. Polyvach, S.O. Zapadnyuk, V.S. Chabanyuk).

In order to enhance navigation and hydrographic support to the Navy and Merchant Marine of Ukraine, new methods were developed for improving the detection and estimation of nautical object motion parameters, as well as recognition of low-profile moving marine objects. These methods are based on the analysis of indirect optical signs of a moving marine facility, which is of particular relevance due to the wide introduction of stealth technologies for marine facilities (NAS Corresponding Member O.D. Fedorovskyy, M.O. Popov, S.A. Stankevych, V.H. Yakymchuk, A.I. Vorobyov et al.).

A model of pollutants transport and transformation in the atmosphere was developed; it was tested in calculating the distribution of gas-aerosol cloud formed by a fire on the BRSM-Nafta oil tank farm near the Kriachky village of the Vasylkivskiy district (NAS Corresponding Member V.I. Osadchy, O.Ya. Skrynyk).

In the coming years, research efforts will be focused on the advancement of basic and applied research in priority areas of geological sciences. The Department will give particular attention to coordinating the research that best corresponds to the new realities and ensures a more efficient use of budget allocations and facilities of its institutions, developing scientific principles of the multidisciplinary approach to and evaluation of mineral deposits exploitation, to prospects of the development and commercialization of mineral resources, upgrading technological aspects of exploring promising mineral resources, and geo-ecological studies in order to stabilize and improve the environment in Ukraine.

Physical and Technical Problems of Materials Science



L.M. Lobanov,
Academician-Secretary of
the Department

In 2015, the work of scientists of the NAS Department of Physical and Technical Problems of Materials Science was focused on advancing priority investigations in modern materials science. Some significant research results of both fundamental and applied nature were obtained.

Over 100 experiments in high-frequency welding of nerve and tendon tissues were conducted. Welding parameters were optimized to obtain quality joints of epineurium of nerves and tendons using the designed mock-ups of tools with different electrode geometries. For the first time ever, welded joints of nerve tissues of live rodents (rats) and tendon tissues of the pig (bio imitators) were produced. The results indicate that as compared to the conventional (suture) procedure of joining such tissues a significant (within 20–40%) increase in the speed of recovery of sciatic nerve functions in rats is observed, which guarantees similar positive results in surgical procedures in hospitals.

Experimental studies allowed determining the optimal parameters of the optical scheme of shearography interferometer and thermal load which are used in the non-destructive quality control of aircraft structural elements manufactured of composite materials with defects. It was proved that shearography technology permits the detection of all defective areas present in the specimens. A technology was developed for diagnostics of different types of damages (cracks, delamination and thinning of material due to partial destruction) in the elements of aircraft structures manufactured of composite materials. According to the results of the shearography diagnostic procedure developed, recommendations for its industrial application at the 'Antonov' ASTC were worked out.

Using the method of reaction high-power mechanical grinding in hydrogen environment, Department's scientists synthesized a series of alloys and composites based on magnesium with additives of transition metals (Ti, Fe, Ni) and aluminium. The materials produced possess high defectiveness, are nanostructured and demonstrate increased hydrogen-sorption characteristics. They could be recommended for application in stationary hydrogen storage systems.

Under high pressures (up to 9.5 GPa) and temperatures (1950°C), by solid-phase sintering of homogeneous mixtures in the $\text{Nb}_{0.33}\text{Cr}_{0.66}\text{C}_{0.92} - \text{C}_{\text{ALM}}$ and $\text{Ta}_{0.33}\text{Cr}_{0.66}\text{C}_{0.92} - \text{C}_{\text{ALM}}$ systems, superhard composite materials with high physical and mechanical characteristics and a significant heat resistance were produced. It was proved that the high heat resistance

(~1250°C) of materials results from the significant chemical inertness of double carbides, as well as the pattern of microparticle distribution in the structure.

A method was proposed for reconstructing the scatterer shape; it relies on the solution of the inverse diffraction problem on condition that the scattered field is recorded at many frequencies at different observation angles by a single receiver that is combined with the radiating antenna. The method is featured by an increased resolution that was achieved by specifying the solution of the diffraction problem obtained in the Born approximation for quasi-static measurements.

On the basis of fundamental research into thermal, physico-chemical, hydrodynamic and magneto-hydrodynamic processes, a technology was developed to manufacture ingots of aluminium alloys intended for aircraft industry. It relies on casting under regulated electromagnetic pressure into a sand-clay mould, which can significantly upgrade the cast products, save energy and improve the environmental parameters of manufacture. The materials were sent to the 'Antonov' State Company for testing.

The first national specimens of transparent armour to protect against modern firearms were developed. The main element of the armour is crystalline sapphire plates. In general, the armour consists of a special multilayer package of 490x256x38 mm of sapphire and tempered glass plates whose thickness is nearly one third of the standard of armoured glass design. This domestic product meets the NATO standards and is intended for defence enterprises of Ukraine.

Fundamentals of the theory of microminiaturization of thermoelectric energy converters were created. Patterns of changes in the efficiency of such converters with a decrease in their thickness from 1 mm to 50 μm were determined. It was found that the increase in the quality factor due to size effects does not exceed 5% as compared to massive structures. A significant 1.5–2-fold increase in the quality factor on condition of reducing the optimum additives concentration by 10–20% is only possible in the layers 1–10 μm thick. These research outcomes are promising for the development of optimized miniature structures of the metal–thermoelectric material–metal type for coolers and generators. The results obtained are a scientific basis for mass application of thermoelectrics due to the possibility of decreasing the need in scarce materials, primarily Te, by dozens of times, and respectively, of a significant reduction in the cost of thermoelectric energy converters.

Physical and Technical Problems of Power Engineering



O.V. Kyrylenko,
Academician-Secretary of
the Department

In 2015, scientists of the NAS Department of Physical and Technical Problems of Power Engineering addressed the most important scientific and technical problems of power engineering. Issues of ensuring the transition of the United Energy System (UES) of Ukraine to synchronous operation with the Association of European Power Systems were given special concern. The development of novel energy-saving and efficient power engineering technologies, including dual-use ones, were also attended to.

Department's scientists carried out integrated research intended for: the reconstruction of gaseous masut boilers of the Vuhlehirsk Thermal Power Plant (TPP) and Trypilska TPP for transition to coal fuel; cost-effective transition of anthracite-coal TPP 200- and 300-megawatt boilers to coal gas fuel; testing the safe burning of fuel mixtures based on anthracite coal and coal gas mixtures in TPP boilers.

For the first time in Ukraine a system of multilevel interconsistent dynamic simulation and optimizing models was elaborated. The system modelled the development of the structure of generating capacities of the national power engineering with integer and stochastic variables under market conditions. It was implemented in the 'Pyramid-V' program-information complex, which provides a search for the optimal trajectory of the national power engineering development and evaluates the robustness of the solution found.

A technology for manufacturing granular composite peat fuel was worked out. It allows an up to 25% increase in the caloric content of granules, up to 22% – in density and a reduction in the energy consumption for granulation. Specifications for granulated fuel based on peat, plant raw materials and their mixtures were approved by the Ukrmetrteststandart of Ukraine.

Theoretical basics for constructing electromechanical systems with adjustable electric drives were developed further. A radically new concept of vector control without sensors of mechanical displacements as a basis for producing new-generation systems was proposed and implemented. Determined were their unified structures, whose precision was nearly the same as that of the systems with angular velocity meters but whose economic performances are significantly better. The systems were deployed at the 'Azovstal' JSC.

Department's scientists carried out systemic research that allowed them to obtain stable nano-liquids using carbon nano-tubes, thermographenite and Ukrainian aluminosilicates. They found that thermal conductivity of nano-liquids is 20–30% higher, so their

use in systems with boiling heat-transfer agent allows a 2–3.5-fold increase of the critical heat flow.

Relying on the fundamental results obtained our specialists developed novel schemes of external cooling of gas turbine blades intended for energy engineering and aviation, which allows the efficiency of turbine cooling to be increased by 10–15%. The results obtained were sent to 'Zoria'–'Mashproekt' and 'Ivchenko – Progress' state companies to be used there.

Carried out was comprehensive research into the operation efficiency and reliability of the UES of Ukraine under its parallel operation with the Association of European Power Systems in compliance with ENTSO-E requirements. A structure of the system for automatic regulation of the frequency and power of the UES of Ukraine was proposed; a model of such a system was developed for conditions when a significant share of generation was based on renewable energy. Practical recommendations were implemented at the 'NEC 'Ukrenergo' state enterprise.

A new effective method was developed for shielding the man-made magnetic field of three-phase cable lines on local sites adjacent to residential and public areas. It was implemented through local passive contour screens with ferromagnetic rods and allowed a more than 5-fold reduction in the magnetic field of cable lines.

It was shown that dust-generating capacity of radioactive fuel-containing materials in the 'Ukryttia' ('Shelter') facility for the period before their controlled storage or processing decreased 5–7-fold in 2015 as compared to 2010. This result was based on studying the physico-chemical processes that caused the degradation of fuel-containing materials.

Department's researchers proposed a new mathematical model to determine hydro energy potentials of small rivers, which, unlike the existing criteria, took into account the environmental values of the territories involved and the probabilistic distribution of runoffs. It enabled them to allow for environmental restrictions on the amounts of water used for electricity production.

A number of works carried out with the participation of our scientists were highly acknowledged by the state.

NAS Corresponding Member A.V. Nosovsky, T.V. Gablaya, V.M. Kolikhanov, Yu.O. Komarov, V.I. Skalozubov, V.M. Shcherbin won the 2015 State Prize of Ukraine in Science and Technology.

NAS Corresponding Member A.O. Avramenko was awarded the 2015 State Prize of Ukraine in Science and Technology as a member of research team.

NAS Academician I.M. Karp, Ye.Ye. Nikitin and K.Ye. Pyanykch won NAS V.I. Tolubinsky Prize.

For courage and heroism shown in defending the sovereignty and territorial integrity of Ukraine, A.O. Nazarenko was awarded with the Order 'For Courage' III Class.

Nuclear Physics and Power Engineering



M.F. Shulga,
Academician-Secretary of
the Department

In 2015, scientists of the NAS Department of Nuclear Physics and Power Engineering produced new significant scientific results.

On the basis of the experimental data obtained with the CMS detector of the Large Hadron Collider having the proton energy of 13 TeV, scientists identified the processes of inclusive production of Z^0 -bosons by their decays into $\mu^+\mu^-$, and the processes of hadron jet production.

A new theory of collective motion in nuclei was developed to establish the relationship between memory effects and the dynamic perturbation of the Fermi surface. Its consideration leads to an essential increase in the nuclear fission time and influences the spectrum of neutrons and gamma-quanta that accompany nuclear fission.

Developed was a new concept of critical phenomena and phase transformations that is based on the response to spontaneous violation of symmetry.

For the first time, the geoneutrino flux was measured to the highest precision, and a new, stricter, electron lifetime limitation equal to $\tau_e > 6.6 \times 10^{28}$ years was determined.

A kinetic theory of many-particle dissipative systems in the external stochastic field of arbitrary nature was constructed.

Relying on the theoretical analysis and numerical computations, Department's scientists solved the problem of torque transfer from the magnetic systems of resonant disturbances (nowadays employed in tokamaks and to be used in the ITER) to the confined plasma.

Data were obtained on the effect of the defect microstructure of materials on the volume distributions and accumulation of implanted gas impurities which change physical and mechanical properties of nuclear reactor structural elements.

The concept of the multibunch wakefield accelerator was developed; it provides the acceleration rate which is several orders of magnitude higher than the rates in the existing charged particle accelerators. This opens up the prospect for an essential reduction in the sizes and costs of both the accelerators intended for many applied programs and the lepton/hadron colliders designed for solving fundamental problems of high-energy physics.

The nuclear fuel qualification project for domestic NPPs was completed. Validated were alternative supplies of 'Westinghouse'-produced nuclear fuel for WWER-1000 reactors, as well as its operating safety

and operability under conditions of mixed core loading.

Feasibility study was carried out to organize the domestic production of neutron-absorbing elements and rods of control and protection systems with increased operational life for 13 reactors of the WWER-1000 type in Ukraine. The economic benefit of the replacement of those with domestic neutron-absorbing elements and rods is expected to reach about \$2 million a year.

Investigations of the templates cut out from the main circulation pipeline of the Pivdennoukrainsk NPP Unit 1 after 100 000 and 200 000 service hours permitted the pipeline service life to be extended till 2031.

For scientific and technological arguments in support of extending the accident-free service life of the Pivdennoukrainsk NPP Unit 2 over the period of its design value, fast neutron fluencies bombarding the supporting elements of the reactor vessel were determined. Engineering documentation was developed to assess the environmental impact of the Pivdennoukrainsk NPP.

Health and safety of people in Kyiv under radiation accident that had emerged at the Kyiv 'Radon' Association was validated experimentally. Over the period from 2011 to 2015, owing to measures taken to minimize the radiation accident, the ingress of 1×10^{13} Bq of tritium into underground waters was prevented.

Innovative radiation monitoring equipment was produced. It has a wide range of applications, such as: uranium ore mining and processing plants; geological explorations and regular radiological surveys; countering nuclear-radiation terrorism; detection of radioactive materials, in particular, those in the Exclusion Zone.

The total thorium metallogenic potential of the Ukrainian Shield crystalline rocks was estimated for the first time, and the prospects of its development for the needs of nuclear-power industry were evaluated. It was found that Ukraine can fully meet its domestic thorium needs for many years ahead.

The NAS D.V. Volkov Prize was awarded to scientists of the National Science Center 'Kharkiv Institute of Physics & Technology' G.I. Gakh, O.O. Isaiev, O.V. Shebeko for the series of works 'New approaches in the theory of nuclear forces, electromagnetic interactions with atomic nuclei, and astrophysics'.

The Award of the Verkhovna Rada of Ukraine for the most talented young scientists working in basic and applied research, and R&D works was given to O.P. Novak, a scientist of the NAS Institute of Applied Physics, for his work 'Generation of radiation and electron-positron pairs in a strong magnetic field'.

Chemistry



M.T. Kartel,
Academician-Secretary of
the Department

In 2015 the work of scholars of the NAS Chemistry Department and its Bureau was focused on fundamental research into integrated problems of chemistry development, use of the results obtained in various sectors of the economy, improvement of scientific and organizational activities, training of young researchers.

A number of important fundamental scientific results corresponding to the international standards were obtained.

For the first time shown was the possibility of environmentally friendly mechano-chemical production of graphene while modifying its external borders by nitrogen-containing functional groups that allow achieving high concentration and stability of dispersions of such graphene in water (NAS Academician V.D. Pokhodenko).

It was demonstrated that the processes of electrochemical activation of C-2 freons on nanostructured Cu/Cu_xO electrodes was characterized by much higher currents and a shift of peak current potentials toward less negative region. The electrochemical reduction of C-2 freons on such electrodes in the presence of carbon dioxide resulted in the efficient single-stage formation of important fluorine-containing propionic acids under soft conditions (NAS Academician V.G. Koshechko).

Basic patterns of photo-activity changes were found for a number of phthalocyanine metal complexes, namely, the values of fluorescence quantum yield and lifetimes of the excited states of complexes decreased in the series: Mg(II) > Zn(II) > Ti(IV) > Zr(IV) > Hf(IV), and out-of-plane ligands, depending on their composition, strengthened or weakened this effect (NAS Academician S.V. Volkov).

In the framework of joint scientific research of the NAS of Ukraine and 'Pivdenne' Design Bureau, binders were developed for special-purpose materials for the aerospace industry (NAS Academician E.V. Lebedev).

It was found that peroxo-solvates can be used as a stable and convenient source of hydrogen peroxide in the development of systems for oxidation of organic sulfides in various media (NAS Academician A.F. Popov).

Based on comprehensive studies of the properties of water depending on its isotopic composition, it was found that light water (D/H = 4.2 ppm, ¹⁸O/¹⁶O = 910 ppm) froze at positive temperature $0.3 \pm 0.1^\circ\text{C}$, and the formation of the solid phase began only in

supercooled metastable state. The freezing process with heavy water began at $(-3.0) - (-4.0) \pm 0.1^\circ\text{C}$ and corresponded to the reference value $3.9 \pm 0.1^\circ\text{C}$ (NAS Academician V.V. Goncharuk).

Relying on studies of the dependence of biological activity of N-(aryl-piperazynil) alkyl-pyrimidines on their structure, Department's scientists carried out the molecular design and synthesis of ligands of a new type 5NT_{1A} of serotonin receptors, which are effective anxiolytic remedies and actoprotectors (NAS Academician S.A. Andronati).

A technology for synthesizing composite sorbents based on lingo-cellulosic matrix and incorporated nanoclusters of some d-metal ferrocyanides was worked out; those materials possess high selective action to capture and remove radiocesium (distribution coefficient $K_d \sim 10^5 - 10^6$ ml/g) from complex liquid media (NAS Academician M.T. Kartel).

Methods were developed to synthesize 3-polyfluoro-alkyl- and 3,3-difluoro-amino-oily acids – new fluorinated analogs of natural neuromediator and 2-amino-4-(trifluoro-methoxy) butane acid – a new OCF₃-containing analog of natural hydrophobic amino acids such as leucine, valine, isoleucine (NAS Academician V.P. Kukhar).

For the first time ever, using quantum chemistry methods, the correctness of carbon nanomaterials modeling through graphene clusters with open electronic shells was validated. The molecular structure and energy parameters of graphene modified by heteroatoms were determined, which enabled researchers to interpret the mechanisms of heteroatoms effect on the process of carbon nanostructure formation and the effect of heteroatoms on the catalytic, photo-catalytic and redox properties of activated carbons (NAS Academician V.V. Strelko).

For the first time the mechanism of energy losses in systems based on super paramagnetic nanoparticles of Fe₃O₄, CoFe₂O₄, (La,Sr)MnO₃ exposed to external alternating magnetic field was revealed; this permitted scientists to optimize the conditions for obtaining stable and non-toxic magnetic nanoparticle dispersions which were heated up quickly and efficiently by magnetic field (NAS Academician A.G. Bilous).

It was found that the kinetics of the interaction of acetone with glycerol in the presence of acid-modified samples of natural clinoptilolite and bentonite were satisfactorily described by Michaelis–Menten model. At practical equality of KM constants for both groups of catalysts the values V_{max} were significantly higher for bentonite-based samples (NAS Academician G.L. Kamalov).

The new reaction product – triethyl-ammonia salt of bis (2,1-1H-benzotiazin-4(3H)-on 2,2-dioxide) – to be refined and the mechanism of three-component interaction to be extended. Methods of synthesizing new 6-azolotieno [2,3-d] pyrimidines that exhibited anticancer and antimicrobial activity were developed (NAS Academician V.P. Chernykh).

Biochemistry, Physiology and Molecular Biology



S.V. Komisarenko,
Academician-Secretary of
the Department

The activities of the Department of Biochemistry, Physiology and Molecular Biology of the NAS of Ukraine in 2015 were aimed at basic research in the highest priority areas of biology, medicine and ecology. Considerable attention was paid to the development of new biotechnologies, issues of fundamental and practical medicine, the creation of medicines and means to enhance the defense potential of the nation. A number of important scientific results of the international level were obtained.

Palladin Institute of Biochemistry found new unspecific effects of positive allosteric modulator of GABAB receptors rac-BHFF. The modulator affected transporter-mediated accumulation of GABA and caused dissipation of the proton gradient of synaptic vesicles that masked its specific receptor-mediated effects in brain nerve terminals. These data are an essential contribution to the strategy for the development of new pharmacological modulators of GABAergic neurotransmission.

Scientists of Bogomolets Institute of Physiology established that R2H3-knotted ganglia neuron currents reversibly inhibited leyenkefalinom, depending on the dose and time, like similar currents in DSH neurons. In both types of neurons, naloxone – the competitive antagonist of opioid receptors – abolished the leyenkefalin effect. These results are important for further elucidation of the fundamental differences in the molecular mechanisms of the inhibition of somatic and visceral pain.

Zabolotny Institute of Microbiology and Virology established that the joint cultivation of ethanol-forming yeast culture with active amylolytics in the medium containing starch and lactose significantly increased the growth of yeast biomass and starch assimilation. Oxygen modes of cultivation also affected the growth of mixed yeast cultures and ethanol production.

The Institute of Molecular Biology and Genetics obtained and characterized recombinant individual subunits of the human eEF1B translation elongation factor complex. Reconstruction of full eEF1B complex as well as mini complexes, which are its constituents, was achieved. This creates the necessary basis for understanding the complete molecular organization of the complex, which is the key to protein biosynthesis.

Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology proved that lactoferrin was involved in the formation of molecular and pro/antioxidant profiles of human breast cancer cells. It was established that substantial inhibition of lacto-

ferrin expression was observed in receptor negative breast cancer cells (MDA-MB-231, MDA-MB-468). This inhibition correlated with the reduced adhesion and increased invasive characteristics of these cancer cells.

Scientists of the Institute of Cryobiology and Cryomedicine found that penetrating cryoprotectant DMSO caused an increase in the number of nucleus-containing cord blood cells with an excessive content of reactive oxygen species. This happened before and especially after the cryopreservation. The pronounced antioxidant and cytoprotective N-acetyl-L-cysteine effect was established, allowing a 15–20% increase in the number of preserved and viable cells.

The Institute of Cell Biology designed a cassette with SEF1 gene flanking sequences to produce strains of *Candida famata* yeast with this gene deletion (gene flanking sequences were separated by a selective marker – the LEU2 gene). The presence of deletion in *C. famata* transformants was confirmed by PCR and Southern hybridization.

The International Centre of Molecular Physiology established that saturated N-stearoyl ethanolamine and mono-unsaturated N-oleylethanolamine had an effect on potential-dependent activation, inactivation and INa kinetics that could, at least partially, cause the reduction in cardiomyocyte excitability under the influence of these lipids in health and disease.

In the area of medical research it was found that the most reliable prognostic indicator of the prostate cancer progress is the level of immunohistochemical marker Ki-67 expression in the tumor tissue; a new surgical tactics was developed for patients with the acute rupture of the interventricular septum; stem cell technologies were developed and improved for various experimental pathologies; new experimental data were obtained on phenomena and mechanisms of neuroendocrine disorders in reproductive system and hormonal adaptation.

An important focus of the Department in 2015 was on organizing the education and raising the awareness in the field of biosafety and biosecurity among life scientists. In the framework of the implementation of the STCU project 'The spread of education and consciousness (on biosafety) in Ukraine', in co-operation with the Ukrainian Biosafety Association, a number of international and national educational activities were held.

Amongst priorities for the Department institutions in 2016 will be the research aimed at solving the problems of the most relevant areas of biochemistry, physiology, molecular biology, microbiology, genetics, oncology, cryobiology and cryomedicine that are concerned with the major challenges of modern biology and medicine. In 2015 the Department started to review and systematize the results of the research conducted by NAS institutes in the interest of medicine in former years, and this work will continue in 2016.

General Biology



V.V. Morgun,
Academician-Secretary of
the Department

Despite the grim economic situation in Ukraine in 2015, institutions of the Department of General Biology continued their work and focused on studies of molecular, cellular and physiological fundamentals of living systems functioning. Faunistic, floristic and mycological studies went on, as well as research in ecology and bioindication. Department's scientists gave ever increasing attention to genetics, genomics, genetic improvement of plants, biotechnology, nanobiotechnology, biosafety, etc.

For example, geneticists and plant breeders demonstrated the efficiency of using the DNA markers for selection of valuable genotypes resistant to abiotic stressors. Molecular markers for cereals genotyping were developed, alongside with *in planta* and *in vitro* systems for *Agrobacterium*-mediated genetic transformation of soft wheat. Molecular, genetic, physiological and biochemical peculiarities of the functioning of symbiotic legumes were studied, and tools to improve their effectiveness were developed. In the reporting year, as many as 27 new plant varieties were registered and received respective certificates.

A new approach was proposed to ensure the expression of genes transferred into transgenic plants without using previously known promoters. It was shown that the treatment of human tumor cell with extracts of interferon-expressing biotech plants leads to a significant reduction in the accumulation of the reparative enzyme that protects malignant tumors from the action of chemotherapy drugs.

Radiobiologists discovered that, due to the activation of microevolution processes in the Chernobyl exclusion zone, the balance between vascular plants and phytopathogenic bacteria and fungi was disrupted, which was accompanied by a drastic fall in the biological productivity of higher plants.

Scientists of the Department gave a lot of attention to studying climate change on the global scale and the responses of plants and animals to those. Results of the studies of anthropogenic transformation of mountain ecosystems were generalized, and a typological classification of the Ukrainian Carpathians forests was developed. The levels of phytobiotic contamination by alien plant species in protected areas of the forest-steppe zone of Ukraine were determined.

The list of recent and fossil animal species of Ukraine was extended. Using molecular genetic methods, researchers investigated dominant mite species and found a number of microorganism pathogens dangerous to humans. Scientists of the Department, collaborating with the international team, successfully

completed their long-term work on the Red List of the International Union for Conservation of Nature (IUCN Red List) of all species of pollinator insects in Europe. In 2015, our botanists and zoologists described as new for science a total of nearly 120 taxa of plants, fungi and animals representing modern and fossil flora and fauna.

Hydrobiologists developed a conceptual model of the functioning of mountain and lowland rivers of Ukraine as a basis for developing a river-basin management plan under Ukraine's commitments in the implementation of the EU water directives. Recommendations for improving aquatic ecosystems and living conditions of aquatic organisms were proposed. Scientists also summarized the results of long-term studies of contour habitats and their inhabitants (contourbiont organisms), which play the key role in the functioning of marine ecosystems and could be used as strategic indicators in ecological monitoring of the aquatic environment.

Relying on high-throughput molecular screening tools within the framework of CSLabGrid virtual organization, researchers selected 136 promising tubulin inhibitors, which, according to their calculations, can depolymerize microtubules of parasitic worms. Our scientists discovered and tested new anticancer compounds of the imidazole group acting through direct inhibition of the molecules of α - and β -subunits of human tubulin.

A biotechnology for microclonal breeding of the *Lysimachia* genus lines was developed to obtain a highly efficient bactericidal drug characterized by a high content of aliphatic compounds and terpenoids.

Results of the studies of structural and functional adaptation of tropical orchids in hothouse and *in vitro* culture will contribute to their long life in artificial conditions. On the basis of organic material and silicon-containing minerals, compositions were formulated and implemented to restore soil fertility, reduce soil fatigue, and improve plant resistance to abiotic and biotic stresses.

The importance of scientific achievements of Department's scholars was confirmed by awarding one State Prize of Ukraine in Science and Technology, the election of one researcher an associate member of the French Academy of Agriculture (Academie d'Agriculture de France), and a number of government and Academy awards and distinctions.

In 2015 our scientific institutions received 43 patents for their R&D. Simultaneously, scientific support of nearly 3 000 licensing agreements was carried out for the cultivation of innovative wheat varieties in agricultural production. The annual economic benefit due to the introduction of scientific developments (cultivars and technologies) by plant physiologists and geneticists in agricultural production amounted to UAH 6.7bn, which is a significant contribution to the food security of Ukraine.

Today's situation would require a revision of research areas, the identification of institutions' priority research, optimization of the organizational structure and personnel of the Department.

Economics



E. M. Libanova,
Academician-Secretary of
the Department

In 2015, the efforts of researchers of the NAS Economics Department were aimed, primarily, at determining the main areas and mechanisms of correcting institutional transformations, substantiating the content of economic policy in terms of its instruments for the state regulation of the economy, substantiating the ways to improve the state policy for the recovery of both public and real economy finance, of the banking system, grounding the peculiarities and promising trends of the state innovation policy.

A number of important results were obtained. Researchers revealed the formation of preconditions for the transition to a reconstructive type of reproductive dynamics which combines simple, narrowed and expanded reproduction of various components of the economic system and changes the measure of and criteria for socio-economic development. That boosts the potential of employing such negative forms of economic dynamics as crisis, depression, destructive growth for the qualitative renovation of the economic structure.

New approaches to substantiating the concept of unbalanced human development and considering it as a global social process were determined, which enabled researchers to identify the determinants of unbalanced human development at the global level. Indicators of their assessment and quantitative parameters for interregional comparisons were also proposed.

Dominants and contradictions of the monetary development of small resource-based transitional economies were revealed, factors and features of the monetary component of the economic crisis were determined, the basic concepts of modernizing the monetary mechanism in Ukraine in the context of challenges and risks resulting from the global financial imbalances were substantiated.

Economics scholars determined the strategic ways of consolidating public finances that are crucial under conditions of a high degree of Ukraine's financial system dependence on external debt and the necessity to reduce the debt burden.

They also estimated the effect of the liberalization of trade regimes during the period of Ukraine's membership in the WTO and the potential impact of further liberalization of trade regimes in the FTA with the EU on the structure of the domestic market of Ukraine and some commodity markets. The main lines of state protectionist policies towards accelerated structural changes in the domestic commodity production were determined.

Formulated were proposals for and comments on particular articles of the Association Agreement between Ukraine and the EU, with a view to broader replacement of the markets of real economy products, and improvements in the legal provision of state aid within the integration processes with the EU.

The impact of labor migration on the long-term demographic developments and long-term labour market development in Ukraine was estimated. Recommendations towards minimizing the negative impacts of labour migrations and obtaining maximum effect from the positive ones were provided. Migration losses of Ukraine's population in general and those of particular areas of Donbas as a result of the military conflict were estimated.

Basic approaches to formalizing and accounting for the principles of economic equity, maximum coverage, solvency, targeting etc. in the development and evaluation of measures on the taxation of the population were determined. Methodological approaches to the evaluation of socio-economic effects of introducing a new model of social standards and guarantees were determined.

The impact of the hostilities in Donbas on the level and quality of life in the affected areas and Ukraine in general was studied, and potential risks of its further decline due to the deteriorating socio-economic situation in the country and its regions were determined.

A mechanism was developed to activate the innovative interaction component of the labour market and the education system on the basis of transformational change; it involves the formation and development of the national qualifications system towards a better institutional interaction among the subjects of establishing, approving and implementing professional and educational standards.

A scientific methodological approach to the greening of production in the context of neo industrial development based on the principles of eco-technological determinism, group environmental loyalty, cyber evolutionism, and the theory of constraints was elaborated.

Approaches to introducing modern organizational and economic mechanisms for the implementation of high technologies in Ukraine's economy under the Association Agreement with the EU were grounded. Possibilities to assess the level of country's innovative development according to EU standards were analyzed.

In the short term, the efforts of economists will be focused on: identifying the main guidelines and institutional mechanisms to overcome reproductive disparities, with a view to improving the stability of Ukraine's socio-economic system; fundamental concepts for institutional modernization of its financial sector; determining the characteristics of the domestic high-tech production in the implementation of the economic part of the Association Agreement between Ukraine and the EU; development of theoretical and methodological approaches to determining the risk of human development in socio-economic terms.

History, Philosophy and Law



V.A. Smolii,
Academician-Secretary of
the Department

In 2015, scholars of Department's institutions obtained significant theoretical results in comprehensive interdisciplinary research for the preservation of the integrity of the Ukrainian State and national identity, the support of ethno-political and information security, as well as to the development of political and legal mechanisms for counteracting disintegration of the State and improving the public dialogue as a tool for resolving social conflicts.

The main focus was on citizens' assessment of the social processes happening in economic, political, social, spiritual and cultural spheres. That allowed researchers to reveal people's attitudes to state institutions, local self-government bodies and civil society institutions, as well as record prevailing emotional states and moods in the society that were caused by events in Donbas.

Issues of information security during information war were investigated. The ways to address them alongside with methodological and practical guidelines for using social networks as a tool for society democratization were developed.

The NAS Institute of the History of Ukraine published fundamental studies concerned with the history of the East and South of Ukraine, such as: «Donetsk and Luhansk Regions in 17th–21st Centuries: Historical Factors and Political Techniques of Forming the Particular and the General in Regional Area»; «Southern Ukraine at Civilization Frontier» (NAS Academician V.A. Smolii, L.D. Yakubova, S.V. Kulchytskyi, Ya.V. Vermenych). In the series of publications (started in 2014) entitled «Studies of Regional History of Ukraine: the Steppe Ukraine» 12 works were published, among them being «Donetsk and Luhansk Regions – Cossack Lands of Ukraine (16th–18th Centuries)»; «Donbas as Frontier Region: Territorial Dimension»; «Donbas in the System of Social, Demographic and Economic Processes (19th–Early 20th Centuries)»; «Holodomor 1932–1933 in Donbas»; «'Novorossiia Project' and Current Russian–Ukrainian War» (Ya.V. Vermenych, S.V. Kulchytskyi, V.I. Marochko, V.B. Molchanov, F.H. Turchenko, T.V. Chukhlib, L.D. Yakubova et al.), reference book «History of Crimea in Questions and Answers» (NAS Academician V.A. Smolii, NAS Corresponding Member H.V. Boriak, T.B. Bykova, O.I. Halenko, S.V. Kulchytskyi et al.).

Scholars of the NAS Institute of Sociology published their study «Ukrainian Society: Monitoring of Social Changes. 1992–2015» (NAS Academician V.M. Vorona, NAS Corresponding Member M.O.

Shulha et al.). NAS Institute of Encyclopedic Studies prepared volumes 16 and 17 of the «Encyclopedia of Modern Ukraine»; its researchers also made the contents of volumes 1–17 available online (M.H. Zhelezniak et al.). M. Hrushevsky Institute of Ukrainian Archeography and Source Studies of the National Academy of Science of Ukraine published volumes 10, 22 and 46 of Mykhailo Hrushevsky's Collected Works in 50 volumes (G.V. Papakin, M.M. Kapral, I.B. Hrych et al.).

To implement the Decree of the President of Ukraine №169 of 26 March 2015 'Measures towards the 70th anniversary of the Victory Day and the 70th anniversary of the end of World War II', scholars of V.M. Koretsky Institute of State and Law of the NAS of Ukraine prepared the commemorative jubilee edition «Victory is One for All: to 70th Anniversary of Victory in World War II» (edited by NAS Academician Yu.S. Shemshuchenko).

Leading scholars of the Department prepared profound analytical materials, expert conclusions, proposals and guidelines concerning the risks and dangers resulting from events in Donbas and preventing Ukrainian society from consolidation; social protection as a factor of social order in the country; the role of Ukrainian science in modernizing the society; foreign-policy attitudes of Ukrainian people; formation of effective local communities in Ukraine; cultural risks in Ukrainian society during crisis; typological criteria of Ukraine's historical regions; prospects of Polish–Ukrainian academic collaboration in humanities; modern interpretations of state-development practices for Donetsk and Luhansk regions.

Experts of the Department sent their remarks and proposals on the draft Strategy of national security of Ukraine, alongside with proposals towards improving draft Labor Code of Ukraine, Laws of Ukraine 'On the principles of national security of Ukraine', 'On the fundamentals of home and foreign policy'; remarks and proposals to the draft Laws of Ukraine 'On the National Academy of Sciences of Ukraine', 'On amendments to the Law of Ukraine 'On national minorities in Ukraine'' to various bodies of state power.

In 2016, all institutions of the Department will focus on comprehensive studies of state-development issues, historical experience and current status of administrative regulation of inter-ethnic relations in Eastern Ukraine and the Crimea, as well as on developing and intensifying the processes of decentralization and mechanisms to cope with social inequality and ensure adaptation of different strata of Ukrainian society under crisis.

Philology Studies, Art Criticism, Ethnology



**M.H. Zhulinsky,
Academician-Secretary of
the Department**

In the year under review, scholars of the NAS Department of Literature, Language and Art Studies focused their research efforts on studying fundamental and applied issues of the development of literature, language, arts, every-day culture and computer linguistics; they addressed numerous challenges of the scholarly backup to the national and cultural revival of Ukraine, provided the unbiased analysis of various stages in the development of Ukrainian spiritual culture in the past and in the context of globalization processes of the early 21st century.

The practical outcome of the abovementioned tasks was the publication of 88 individual and co-authored monographs and collections of writings, 5 study textbooks and manuals for university students and schoolchildren, 24 reference books and dictionaries, 33 academically treated and commented belles-lettres texts, over 1600 articles in research proceedings and periodicals.

The high academic level of Department's research is proved by the election of literature scholar Ye.K. Nakhlic a NAS corresponding member, awarding the 2015 NAS O.O. Potebnia Prize to linguistics scholar V.V. Luchyk and 2015 F.I. Schmit Prize to art scholars L.O. Parkhomenko and N.B. Kalutska. In the reporting year the President of Ukraine signed Ordinance №686 'On awarding 2014 State Prizes of Ukraine in Science and Technology', according to which this prize went to NAS Academicians M.H. Zhulinsky and H.A. Skrypnyk, Doctor of Art Studies V.V. Ruban and Candidate of Philology M.P. Bondar for their work «History of Ukrainian Culture» in 5 volumes (9 books).

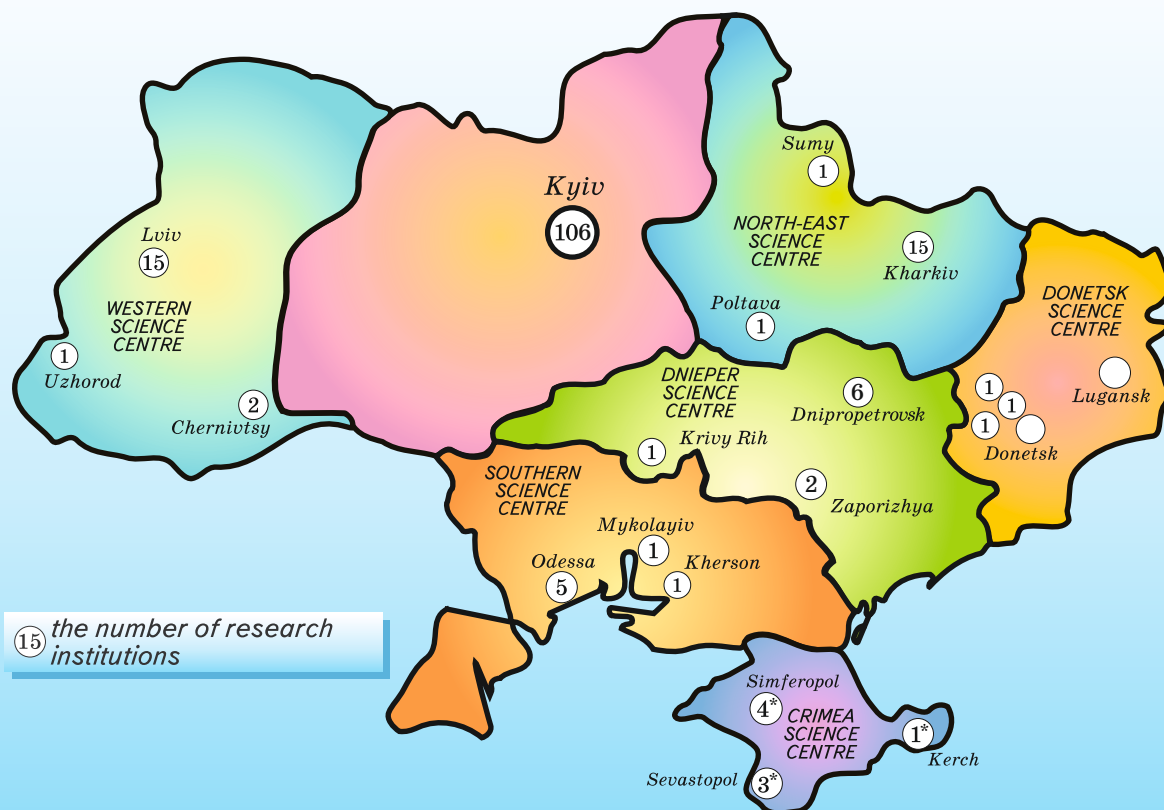
Literature scholars of the Department carried out research in literature theory, the history of Ukrainian and foreign literatures, comparative literary studies, the present functioning of belles-lettres, they prepared encyclopedic editions and academic publications of artistic heritage. Analyzed was the status and trends in the development of Ukrainian and world literatures in the early 21st century as well as issues of textological studies of the Ukrainian classical literature works. Published were a number of co-authored and individual writings, among them being «Word on Guard of Nation. Literary and Critical Articles, Reminiscences, Memoirs» (by NAS Academician M.H. Zhulinsky), «In the Literature and Around it» (by NAS Academician I.M. Dziuba), «Turned World of Ivan Kotliarevsky: Text – Intertext – Context» (by NAS Corresponding Member Ye.K. Nakhlik), «History of Text, Source Studies and Textological Aspects of the Creative Work of P.H. Tychyna, V.M. Sosiura and Ostap

Vyshnia» (by S.A. Halchenko, «Poet and His Prose: Genesis, Semantics and Reception of Shevchenko's Creative Work» (by O.V. Boron), «Apology of Personality (Articles about Lesia Ukrainka)» (by L.I. Skupeyko), a number of collected academic writings, commented editions of selected works by M. Smotrytsky, M. Drakhmara, V. Vynnychenko et. al. Prepared for publication were next volumes of the 12-volume fundamental academic «History of Ukrainian Literature».

Linguistic scholars of the Department carried out research in the areas of theoretical and general linguistics, Slavic etymology, comparative and structural-and-mathematical linguistics, the current functioning of the Ukrainian language and its practical introduction in all spheres of social life. They published 3 dictionaries, including the next – the 6th – volume of the fundamental academic «Dictionary of the Ukrainian Language» in 20 volumes, such fundamental works as «Slavic Linguistic History Studies. Selected Works» (by NAS Corresponding Member H.P. Pivtorak), «Ukrainian Menology of 1489» (by NAS Corresponding Member V.V. Nimchuk, «Actualized Models in the Word-Formation System of Modern Ukrainian (Late 20th – 21st Centuries)» (by O.O. Taranenko), «Essays in Proto-Slavic Anthroponyms» (part 2) (by V.P. Shulhach), «Text Corpus Data in Linguistic Research», «Paradigmatic and Categorical Basics of Applied Linguistics», and a number of collected scholarly writings. Also published was the book «Ukrainian Language of the 10th – 13th Centuries: Reading Book» (by NAS Corresponding Member V.V. Nimchuk) etc. Relying on the theory of lexicographic systems and the methodology of creating virtual lexicographic laboratories they constructed a conceptual model and produced software for the virtual lexicographic laboratory «Ukrainian–Crimean Tatar Dictionary», created the experimental zone (web-site) of the Virtual Lexicographic Laboratory «Ukrainian–Crimean Tatar Dictionary».

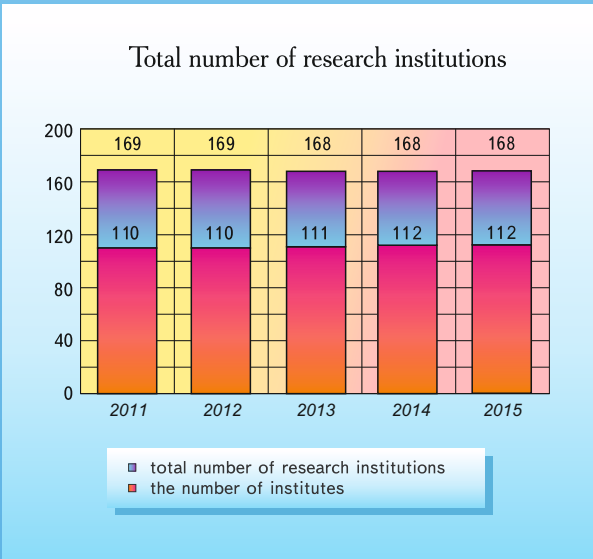
Art scholars, folklorists and ethnologists of the Department published 36 co-authored and individual monographic works addressing the history and methodology of research in these areas, individual folklore genres and art forms, rituals, outstanding cultural landmarks and prominent personalities who had contributed to their creation, conservation and popularization. Those include, in particular, «Ukrainian Ethnology in Personalities» (by NAS Academician H.A. Skrypnyk), «Ritual Musical Folklore of the Middle Dnieper Area. Genre and Regional Anthology» (by NAS Corresponding Member A.I. Ivanytskyi), «Mykola Budnyk and Kobzar Art» (by M.Yo. Khail), «Volodymyrsky Cathedral: History. Architecture. Paintings» (by D.V. Stepovyk), «Melodic Basis of Ukrainian Folk Epic Songs» (by S.Yo. Hrytsa), «Ukrainian Folklore Studies: Methodology Issues» (by M.K. Dmytrenko), «Family Rituals of Ukrainians of the 20th – Early 21st Centuries» (by V.K. Borysenko), «Folk Architecture of Starosambir Area of the 19th – First Half of the 20th Century (Housing and Utility Complex)» (by R.B. Radovych). A number of folklorist and ethnographic expeditions to 11 oblasts of Ukraine and to Poland and Bulgaria were organized.

Regional Structure of the National Academy of Sciences of Ukraine



* The status of NAS institutions situated in the Crimea AR is determined by the law of Ukraine
'On ensuring the rights and freedoms of citizens and the legal regime on the temporarily occupied territory of Ukraine'

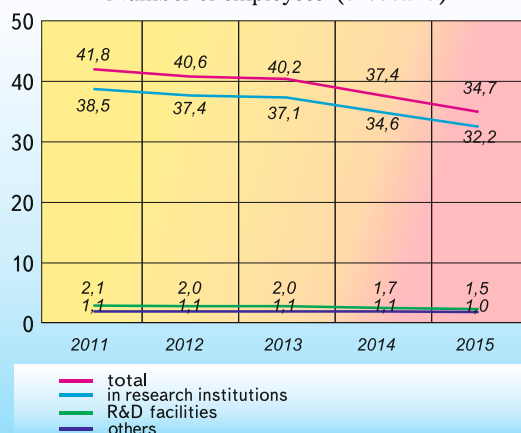
- Newly Formed:
Interdepartmental Coordination Council of the National Academy of Sciences of Ukraine on Marine Research and Improvement of the System of Training, Retraining and Professional Development of Scientific Personnel in the Field of Marine Sciences
Commission of the NAS of Ukraine for European Integration.



NAS of Ukraine 2015

Total number of employees, including those:	34617
in research institutions	32183
in R&D organizations	1463
others	971

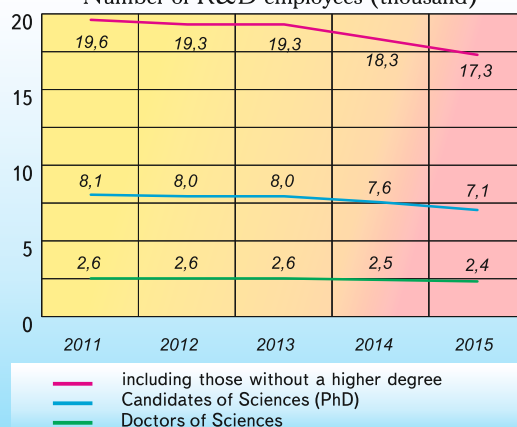
Number of employees (thousand)



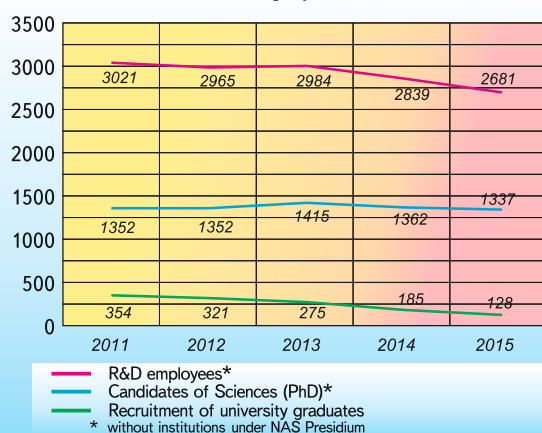
Statistics

R&D employees including:	17289
Doctors of Sciences	2434
Candidates of Sciences (PhD)	7092

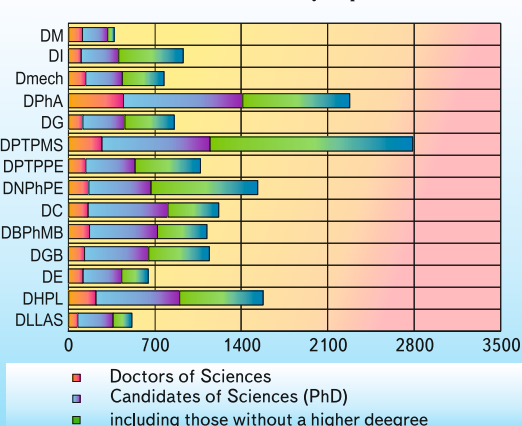
Number of R&D employees (thousand)



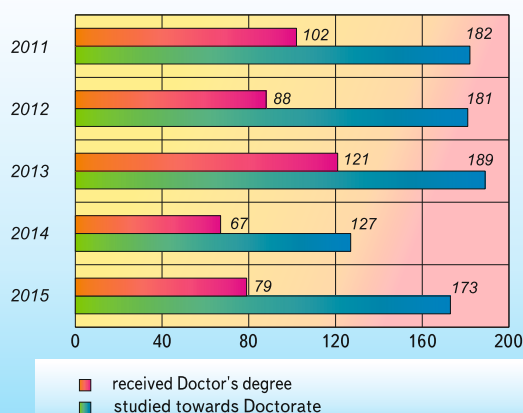
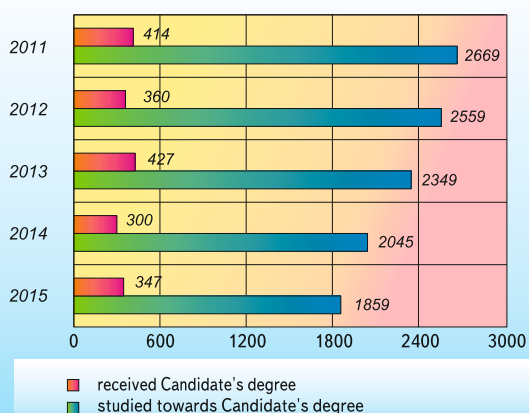
Number of employees under 35



Distribution of scientists by departments

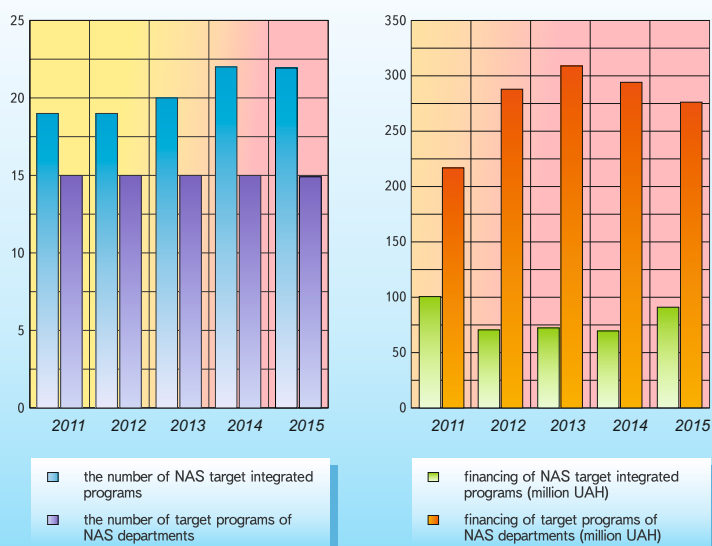


Training of research personnel

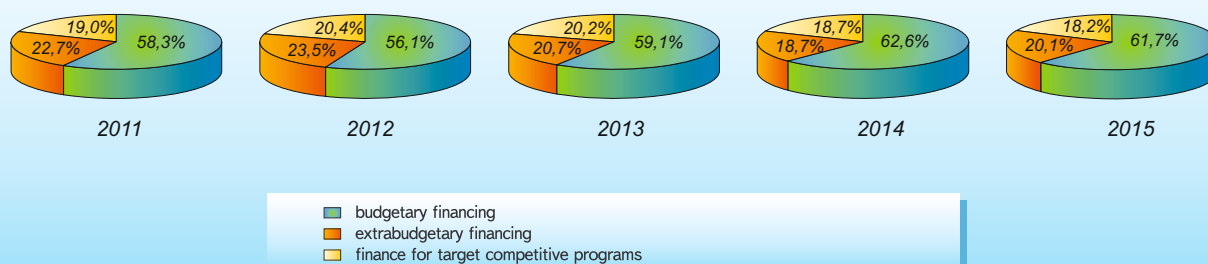


Budget	thousand UAH
Total financing	2925633,8
General fund of the state budget	2337864,3
Basic funding from the State budget	1758697,2
Target programs finance	533532,8
Budget finance for personnel training	8271,1
Budget finance for health protection	37363,2
Extrabudgetary revenues	587769,5
Total expenditures	2899263,7
Expenditures on wages	2182188,6
Expenditures on equipment and instruments	47618,2
Expenditures on capital construction and reconstruction	3087,9
Expenditures on utilities	233024,3
Other expenditures	433344,7

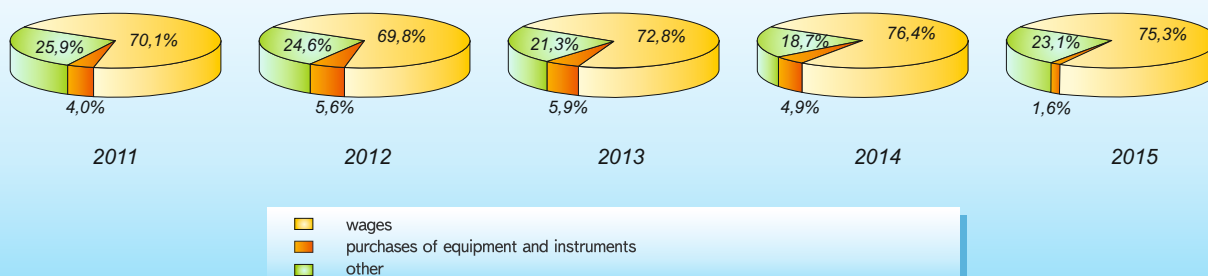
Target program subjects



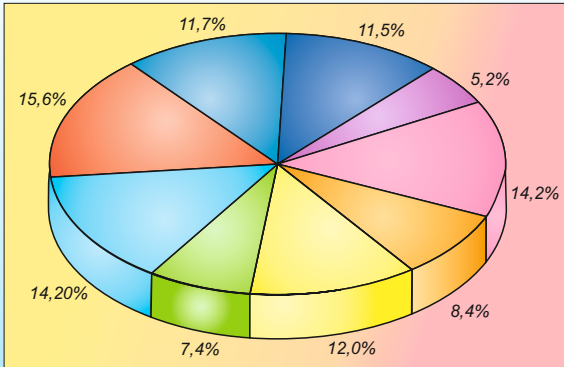
Distribution of finance by sources



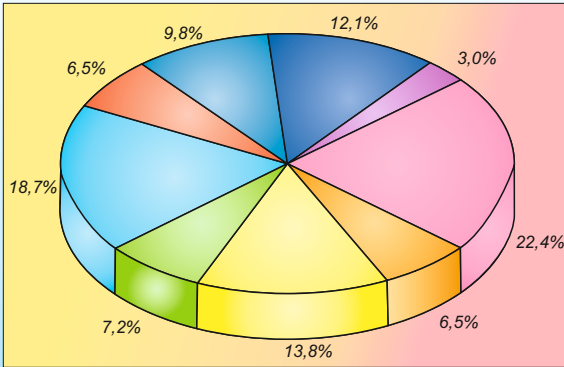
Distribution of expenditures by principal items



Distribution of basic budgetary finance

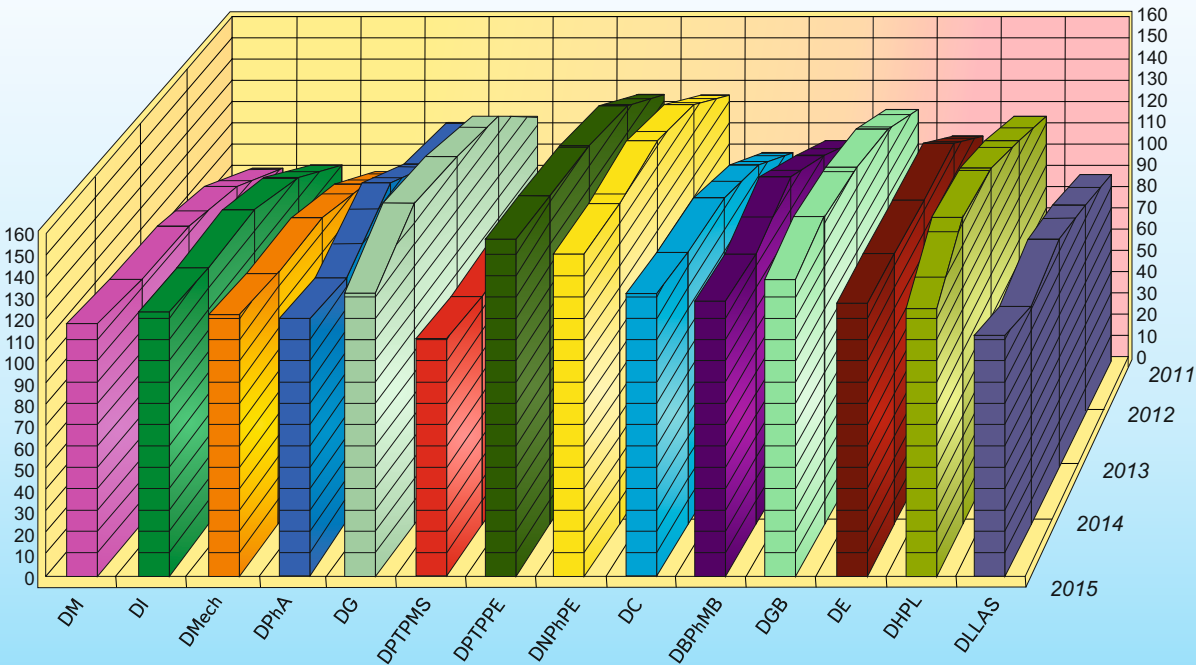


Distribution of extrabudgetary finance



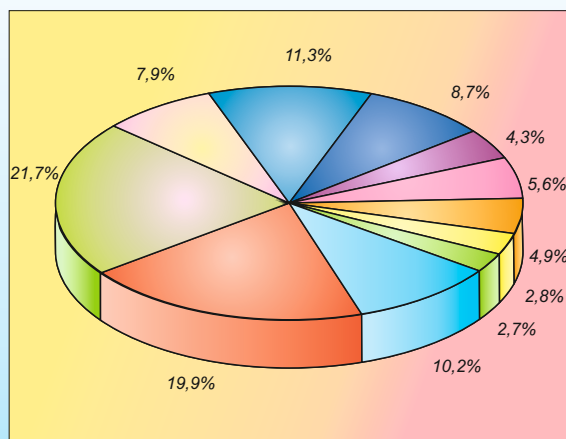
- Mathematics, Mechanics, Informatics
- Earth Sciences
- Power Engineering
- Chemistry
- Social Sciences and Humanities
- Physics and Astronomy
- Materials Sciences
- Nuclear Physics and Power Engineering
- Biological Sciences

Distribution of budget finance per 1 researcher among Departments (thousand UAH)

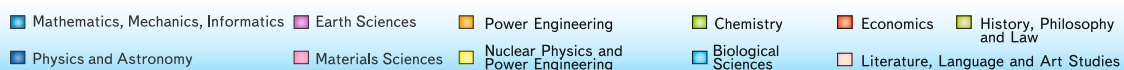
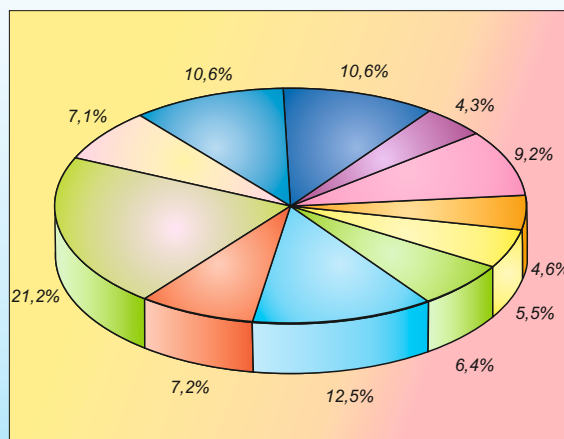


Publication of Academic Materials

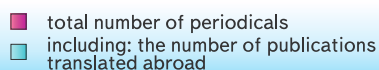
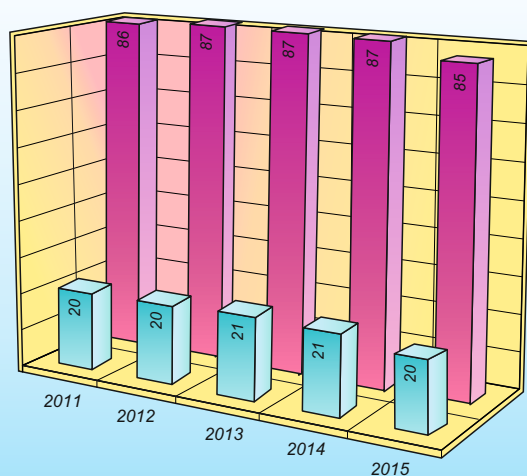
Monographs



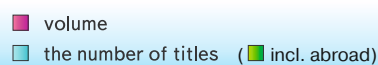
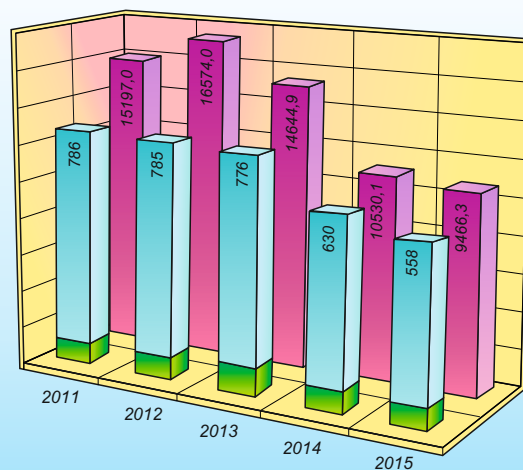
Papers



Academic Periodicals



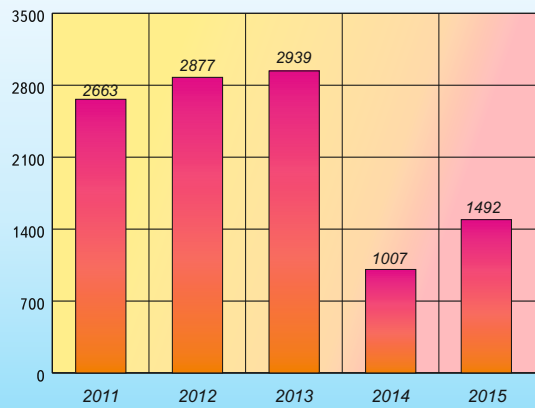
Publication of Academic Books



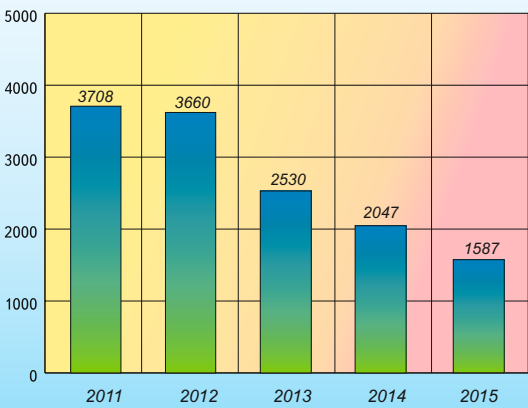
International Contacts of the National Academy of Sciences of Ukraine with Foreign Institutions



Foreign Scientists Received in Ukraine



Ukrainian Scientists Sent on Mission Abroad



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