

NATIONAL ACADEMY OF SCIENCES OF UKRAINE

BRIEF ANNUAL REPORT

2013

Main Results



B. E. Paton,
President of the Academy

2013 was marked by a jubilee of the National Academy of Sciences of Ukraine – the 95th anniversary of its establishment. It was accompanied by quite a number of celebration events – numerous science conferences, symposia, seminars, readings, and a grand session; jubilee editions were prepared and published, exhibitions of scientific achievements were held.

Academy scientists welcomed its jubilee with significant research achievements. They fruitfully worked to ensure socio-economic, scientific, technological and cultural progress of Ukraine. A number of radically new results in highly relevant areas of mathematics, information science and mechanics were obtained. Theoretical and experimental studies in physics and astronomy made a significant contribution to the advancement of modern ideas as to the nature of physical phenomena and the universe. A number of major studies in the Earth sciences, physical and engineering problems of materials science and energy were carried out. Scientific results of the international scope were produced in some areas of chemistry and life sciences.

In the sphere of social and humanitarian studies, a large amount of basic research was carried out in economics, in socio-political, ethno-national and cultural development of the Ukrainian society. It is on the basis of these studies that numerous analytical and prognostic data for state power bodies were prepared, in particular, a draft National Report "State and Society in Ukraine: History and Today". That was the fifth fundamental generalizing study of the national report series, which deals with establishing effective interaction mechanisms between state power bodies and civil society institutions.

Significant success was also achieved in implementing large-scale academic publishing projects. The work on creating a multi-volume «Comprehensive Ukrainian Encyclopedia» was started. It involves scholars of all Academy departments without exception. The publication of the «History of Ukrainian Culture», «History of Ukrainian Art», «History of Decorative Art of Ukraine» and «Russian-Ukrainian Dictionary» was completed. On the basis of sociological monitoring results, published was the work «Ukrainian Society. 1992–2013. Status and Change Dynamics»; it describes the development of Ukrainian society in all the years of independence.

In total, in 2013, Academy scholars prepared nearly 600 monographs, 400 textbooks, reference

books and encyclopedia, over 27,000 papers and articles. The presence of NAS academic publications in the international information space greatly increased, which was shown in respective databases and systems of academic referencing. Foreign publishers issued 90 monographs by our scientists, this being the maximum number in the last 15 years. 21 journals, i.e. one fourth of NAS scientific periodicals, are re-issued in English by foreign publishing companies, 10 more are issued in English in Ukraine. It is worth noting that the Scopus database now indexes over 40 of them, and the impact factor is calculated for 18 Academy journals.

As before, the top priority in Academy's activities was increasing the effect of R&D results on the innovative progress of the nation, active involvement of science in dealing with major challenges of the country.

Among such major challenges is the improvement of energy efficiency and energy saving. The Government is now forming an integrated program of efficient energy use. One of its elements is the state program of developing and deploying energy-efficient LED light sources and lighting systems based on them. Scientific back-up to the program is provided by NAS institutions. Pilot projects for introducing energy-efficient LED light sources are now underway in Kyiv, Kharkiv, Donetsk, Simferopol and Zhitomir.

Besides, the Cabinet of Ministers has approved a program for updating heating systems in Ukraine, which was developed by scientists working in the field of power engineering. It provides for a reduction of natural gas consumption in the community power sector by a factor of two due to the substitution of obsolete facilities with more energy-efficient ones, e.g., with boilers for community power supplies with the efficiency of up to 98%, which is twice as high as that of the obsolete boilers. Such boilers were developed by Academy specialists. Production of those boilers has been started in Kharkiv, which would allow a re-equipment of Ukrainian community power sector.

In addition to those developments for power industry, NAS scientists have important and interesting applications of their research outcomes in numerous other spheres – aero-space, aviation and coal-mining industries, agriculture, in ecology and environment protection etc.

Academy scholars also made a significant contribution to ensuring food security of the nation. As we all know, in 2013 Ukraine harvested a record-setting amount of grain – over 60 million tons. Not the least role in this achievement belonged to our scientists, who every year created new highly productive wheat varieties and maize hybrids. Last year those crops were grown on nearly 1.8 million ha, which is practically one fifth of arable lands in Ukraine covered with grain cultures.

In recent years the whole world has been giving a lot of attention to research in health protection and medicine. Numerous NAS institutions successfully

work in this area. Last year, scientists synthesized new hetero- and macro-cyclic compounds that are promising for the development of anti-diabetes drugs on their basis. A basic set of novel information technologies was developed; they are intended for mass diagnostics, prevention and treatment of some most common grave heart diseases, strokes, diabetes mellitus etc. They form the basis for industrial manufacturing of devices that are efficiently employed in medical institutions of Ukraine.

Continued was the research into improving and extending the use of live tissue welding in surgery. Unique results were obtained in the application of this technology in general, thoracic and children's surgery, in neurosurgery, urology, gynecology, ophthalmology, and treatment of inner organ injuries. In the future, scientists plan to weld nerves, tendons, scleromeninx and even bones.

An important factor of the significant achievements of NAS scientists in health protection is their close co-operation with specialists of practical medicine and other specialized national academies of sciences. Last summer a joint session of the presidiums of our Academy and the National Academy of Medical Sciences was held. It analyzed the current state and prospects of the development and domestic production of radio pharmacological preparations, accelerators and diagnostic equipment for the advancement of nuclear medicine in Ukraine. The session adopted the decision on forming an inter-academy integrated research program, which would focus on novel ground-breaking areas of nuclear medicine that would include systems for targeted delivery of radio pharmacological preparations, a new generation of tomographers, small-sized neutron sources, biophysical and medico-biological research at the cell and sub-cell levels.

One should notice that the Academy of Sciences of Ukraine has already accumulated a significant and successful experience of implementing targeted integrated research programs and holding research project competitions, including those implemented in collaboration with science centers of other countries. Last year, the targeted and competitive research projects amounted to nearly 40% of their total number, and their financing – to 25% of the total amount of research finance. Currently, 20 all-Academy programs are being implemented, and I'd like to stress that they enabled scientists to achieve truly impressive research outcomes, which contributed to progress in priority areas of science and technology and to solving major economic tasks. In particular, this concerns such integrated programs as "Fundamental problems of nanostructured systems, nanomaterials and nanotechnologies", "Sensor systems for medical, ecological, industrial and technological needs", "R&D support to the progress of nuclear energy and application of radiation technologies in industries".

Constant attention was given to a most important task – the improvement of human resources in science and involvement of youth to research activities. The Academy gives every support to the participation of young researchers in various competitions organized by central state power bodies. In 2013, young NAS scholars won 15 prizes of the President

of Ukraine, 4 prizes of the Cabinet of Ministers, 18 grants of the President of Ukraine. Young scholars of the Academy also took an active part in competitions for Verkhovna Rada prizes, whose results are not known yet.

Measures to support young researchers are also taken by the Academy. One of them is the publishing project "Academic book. Young scientists". According to it, young scholars compete for the right to issue a monograph in 'Naukova Dumka' – the leading academic publishing house of Ukraine. Last year, five works were selected for publication under this project. Besides, among the measures taken by the Academy is the awarding of annual prizes and provision of grants to the best young researchers, listening to their scientific presentations at NAS Presidium sessions, with further additional targeted financing of respective research.

Yet, such major problems of young scientists as provision of housing, purchase of novel research equipment, raising salaries remain very acute and demand cardinal solution at the government level.

Successive steps were taken towards further integration into the world research area. An important event for the Academy and the nation as a whole was granting to Ukraine the status of an associate member of the European Organization for Nuclear Research (CERN), which is the leading international center in high energy and elementary particle physics. One should note that the signing of the Agreement was preceded by many years of fruitful collaboration of NAS institutions with CERN. Our scientists have been involved and are taking part in developing research programs and upgrading the equipment of the Large Hadron Collider as well as conducting experiments on it.

Lately, the role of electronic information exchange networks has increased significantly, so the Academy has given great efforts to take its place in such networks. Recently the NAS of Ukraine, on behalf of the Ukrainian National Grid, joined the NorduGrid collaboration, which provides for joining the potentials of national grids. A memorandum on mutual understanding was also signed with the European grid-infrastructure; it provides for interaction at the technical level of the national grid (that including 8 NAS institutions and 3 universities) with the abovementioned institution.

Last year was also marked with further extension of academic ties with research organizations of CIS countries. September saw the 20th anniversary of establishing the International Association of Academies of Sciences (IAAS). In early December an IAAS session was held in Kyiv to mark the event. It was attended by the delegations of Azerbaijan, Belarus, Armenia, Georgia, Kazakhstan, Moldova, Russia and Tajikistan. Some major results of Association's activities were discussed and lines of its work in the near future determined. In particular, IAAS will continue to focus on furthering the collaboration of the national academies of the CIS countries, on forming and implementing inter-state research programs.

In the period under review, persistent efforts were taken for finance and material provision of the

Academy. The law of Ukraine 'On the 2013 State Budget' provided financing of the National Academy of Sciences of Ukraine at UAH 2,662.0 million, which only exceeded by 5.4% the financing of the Academy in the previous year. However, the rise in the salaries due to increases in the minimum wages amounted to 6.5%. Besides, considering additional salaries for academic degrees and titles in the full as mandatory resulted in the total rise of the salaries fund by UAH 217.3 million, which was nearly twice as much as the increase in Academy financing from the general fund of the State Budget.

Given that, last year every fourth state-supported NAS institution had to introduce part-time regime, and their employees were given unpaid leaves. The renewal of unique research equipment, which is absolutely necessary for maintaining advanced level of research, nearly stopped, all available finance being channeled for the support of the operating equipment and purchase of the necessary consumables, chemicals etc. Financing of urgent repair works in the premises of the Academy, the emergency ones included, was reduced to minimum.

Unfortunately, the financing of the National Academy of Sciences of Ukraine in 2014 from the general fund of the State Budget is provided, in fact, within the limits of the previous year. No doubt, this will cause even more acute problems in providing the statutory activities of the Academy and its institutions. So, the top priority task must be the maximum raising of extra-budgetary finance, first of all, through contracted research works, orders for ready-to-use R&D products, and grants. Ever more important is becoming participation in international research programs, implementation of joint science projects with foreign partners; that in particular, provides opportunities to use state-of-the-art research equipment.

The response to modern challenges facing Ukrainian science, society and the nation was the development and approval last December of the Concept of the development of the National Academy of Sciences of Ukraine in 2014–2023. The essence of the prospective changes proposed by the Concept is the improvement and advancement of NAS activities but without ruining time-tested traditions and achievements. The academy-based system of science organization has proved its great efficiency over the 95 years of Academy's existence.

National academies of sciences in the whole world are immense cultural and scientific assets. It is for this very reason that the events related to reforming the Russian Academy of Sciences caused deep concern of the scholarly community. I am convinced that in these hard times scientists must not spare efforts to defend academic freedoms and preserve fundamental science in Russia.

The Concept of NAS development determines tasks and means aimed at increasing the contribution of science to the progress of the economy, social and cultural spheres, of the nation in general. Our institutions have significant experience, a large amount of research results and high potential for preparing analytical materials, expert conclusions and recommendations for state power bodies. It is for this reason that the Academy strives to promote

its co-operation with state structures, to become the leading institution of the country in the scholarly expertise and research-based prognostication.

The Concept provides for measures to establish competitive and targeted-program principles of R&D organization, to increase the competition in financing the research and promote international scientific collaboration. A lot of attention is also given to strengthening human resources, improving Academy's structure, integrating science and education etc.

I am sure that the implementation of the Concept of NAS development will improve the creative potential of the Academy, strengthen its position as the leading science center, and increase its contribution to the innovative progress of our country.

New Results of Basic Research of the Institutions of the Section of Physical, Engineering, and Mathematical Sciences

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

The advancement of science is the determining factor in the progress of society, improving human welfare, the spiritual and intellectual development of people. The decisive role in this belongs to basic research.

In 2013, scientists of the Section of Physical, Engineering, and Mathematical Sciences (hereinafter Section) produced outstanding basic results in both traditional and advanced science fields, such as information and communication technologies, nanotechnology, etc.

In particular, mathematicians developed a theory of existence and nonexistence of supersingular and "large" solutions of semilinear elliptic equations with absorption potentials which degenerate at different manifolds. The theory will provide a number of significant results in solving various important complex problems of modern mathematical analysis.

Using the ideas of global equilibrium search, specialists in information science developed and investigated an approximate algorithm to solve the problem of maximum weight set packing. The problem occurs in the scheduling of trains, planes and ships, in brokering activities, in work tasks distribution etc.

Scientists also designed and experimentally implemented a method to compensate optical anisotropy in focusing optical radiation through single-crystal sapphire substrate in optical long-term data storage disks.

Specialists in the field of mechanics investigated the peculiarities of the effect of jet supply and hydrogen combustion on turbulent supersonic flow braking. It was found that the flow nonuniformity at the channel outlet can be significantly reduced by choosing the parameters and location of the jets. The result is of practical importance in designing gas-dynamic paths of air-jet engines and solving the problem of rational hydrocarbon fuel combustion.

Our Earth scientists, taking into account the international experience of exploration and exploitation of shale gas deposits, found that gas mega traps of large stratigraphic range that emerged in black-shale formations of the Euxine type exist in all oil- and gas-bearing regions of Ukraine. New promising exploratory objects associated with hydrocarbon traps were discovered in the Upper Devonian, Carboniferous and Lower Permian reef carbonate complexes of the Dnieper-Donets Basin and Donbas. Recommendations on exploration works and the order of performing seismic exploration and well-boring were prepared.

Materials scientists developed a theoretical model and experimentally determined the effect of plastic and elastic deformation on hydrogen redistribution in metal welds of structural steel and the generation of cold cracks in them. The results obtained can be used in developing methods for joining materials and in evaluating the service life of welded metal structures.

Specialists of the Department of Physics and Astronomy, advancing such a new field as spintronics, in which the control parameter is not the electron charge but the magnetic moment, proved that the magnetic polarizability of current may reach record-high values in superconductors. Also significant is the contribution of experimental physicists to substantiating the mechanism of high-temperature superconductivity, which is basically different from the conventional one.

In the December 2013 issue of «Science», one of the world's most prestigious journals, our physicists published a communication about a special nature of the Brownian motion of particles in liquid crystals, which opens up prospects for controlling this process in living cells.

Academy's astronomers conducted observations in the framework of the 'Radioastron' project, with the use the RT-70 antenna. During measurements on 40 space radio sources a very high resolution was achieved; it amounted to tens of angular microseconds and allowed the determination of galactic objects' cosmological parameters.

Researchers in the field of physical and technical problems of power engineering developed new methods for obtaining carbon nanomaterials and nanofluids to be used in heat transfer. Their application allows the critical heat flux value to be almost tripled. This result keeps promise for application in nuclear power, metallurgy, chemical and oil refining industries.

Our nuclear physicists, relying on their analysis of data on proton-proton collisions obtained in the LHCb experiment at the Large Hadron Collider of the European Center for Nuclear Research, determined with the highest accuracy in the world the oscillation frequency of β -mesons with various quark structures. These frequencies characterize the unique physical phenomenon of mixing the particles and antiparticles during the evolution of matter and antimatter, due to the difference in their masses.

The abovementioned results demonstrate that institutions of our Section plan and implement their basic research within novel global trends. At the same time, considerable attention is given to targeted fundamental studies that are the source of new knowledge for innovative developments.

Development of Scientific Research on Inventories and Conservation of Biodiversity at the National Academy of Sciences of Ukraine



**V. D. Pokhodenko,
Vice-President
of the Academy**

The issue of biodiversity conservation, i.e. the preservation of the whole diversity of all living things on Earth at different levels of their organization, is becoming increasingly relevant due to growing concern of both professionals and the whole mankind.

However, according to UN assessments, which declared one of the recent years the 'Year of Biodiversity', in the 21st century the rate of species extinction due to human activities is 50–100 times higher than the natural 'background extinction' rates.

Biological institutions and experts of the National Academy of Sciences of Ukraine (NAS) pay a lot of attention to comprehensive studies of biodiversity.

Every year, NAS biologists detect and describe as new dozens of plant, fungus and animal species; in particular, in 2013 they described 80 such species that were previously unknown to science. Botanical gardens and arboreta of the Academy implement research projects aimed at reproduction of rare and threatened plant species *ex situ* and subsequent restoration of biodiversity through repatriation (re-introduction) of such species into natural habitats.

Through preparing relevant scientific justifications, NAS scientists established numerous new components of the network of protected areas in Ukraine. Within the system of the NAS of Ukraine, there are now 2 biosphere reserves and 3 nature reserves, 3 botanical gardens, 3 arboreta, and one park landmark of gardening and landscape architecture, which are important elements of the existing ecological corridors and constituent parts of the National Ecological Network (EcoNet).

The majority of Academy research institutions working in the field of biology have unique scientific collections representing a significant portion of biodiversity of Ukraine and the world. They are recognized as National Heritage units and are scientific bases and resources for research and conservation of our planet's biodiversity.

Some NAS institutions accumulate germplasm collections, seed banks, banks of cell lines etc. that include over 7 000 specimens of rare, endangered and endemic plants, thus safeguarding against losing these species forever.

Such studies are of utmost importance especially given the adverse changes that affected Ukraine's biodiversity over the past 50–70 years.

Among the consequences of these changes are new cases of immigration of alien species, especially invasive ones. Those are species of animals, plants

and fungi that were not registered in Ukraine before but have been accidentally or deliberately introduced, then adapted to the new environment and are actively dispersed. They include numerous species that are dangerous pests, the taxa displacing and destroying native representatives of the flora and fauna, changing natural ecosystems, or even threatening human health. According to the latest data, the number of alien plant species registered to date in Ukraine has already exceeded 800.

NAS institutions also give a lot of attention to research coordination and further development of international collaboration. Specifically, the NAS of Ukraine, represented by the National Committee of Ukraine for UNESCO 'Man and Biosphere' program, for 40 years has been the coordinator of the international research program mentioned. The National Commission on the Red Data Book of Ukraine also operates under the NAS of Ukraine; the Commission is legally responsible for a number of functions, in particular, identification of species in need of conservation, as well as preparation of new official editions of the Red Data Book of Ukraine.

The National Ecological Network (see above) is integrated into the global and Pan-European ecological networks. The latter, being a physical network of natural or semi-natural areas of European importance, is among the primary focuses of the Pan-European Biological and Landscape Diversity Strategy, adopted at the 3rd Ministerial Conference 'An Environment for Europe' held in 1995 in Sofia, Bulgaria. For example, the NAS Danube Biosphere Reserve is the Ukrainian part of the transboundary (Romania/Ukraine) UNESCO Danube Delta Biosphere Reserve.

Important aspects of the activities of NAS scientists and institutions in this field are publishing and conferences. Based on research results, hundreds of papers and dozens of books are published each year; they reveal and discuss various aspects of biological systems at different levels of their integration (from individual organisms to species populations and biotic communities of various ecosystems). Many years' results of hard work for biodiversity research are generalized in multi-volume series «Flora of the Ukrainian SSR» and «Fauna of Ukraine».

Overcoming some negative trends observed in the present state of biodiversity in Ukraine requires joint and concerted efforts of scientists from many institutions and agencies, which can be implemented through a relevant program. It would be feasible to appeal to the government authorities for launching such an integrated program. At the same time, NAS research institutions should strengthen their comprehensive research, fieldwork included, aimed at studies of the flora and fauna in order to identify the changes occurring in the environment and to minimize their negative impacts. Having that in mind and taking into account the limited finance of biological research institutions, we think it would be useful to initiate a targeted all-Academy program of fundamental biodiversity research and conservation.

Democratization of Relations between State and Society in Ukraine: Socio-Humanitarian Dimension



**V. M. Heyets,
Vice-President
of the Academy**

In 2013, efforts of scholars of the NAS Section of Social studies and Humanities were focused on integrated interdisciplinary research into the interrelations of the person, state and society as one of the main indicators of the development of the state and its socium, on searching for mechanisms to provide the social consensus as to the national interests in implementing the state's socio-humanitarian policy, and on substantiating the necessity of institutions and values transformations in the context of democratization of the state-society relations.

Relying on the results of studying interrelations in the 'person-society-state' triad in Ukraine in historical retrospective and at present as one of the major indicators of the development of the state and its society, the Section prepared the NAS National Report "State and Society in Ukraine: History and Contemporaneity". Of great practical importance is the presented analysis of possible transition in the interrelations between the state and society in Ukraine to the partnership model, as well as recommendations provided to state power bodies and civil society institutions concerning the its implementation.

Scholars of the NAS Department of Economics determined special features of the effect of country's socio-economic development indexes on social structure changes and the formation of new social mobility vectors, substantiated the role of socio-political, institutional, natural-resource factors leading to the substitution of the economic growth paradigm with the sustainable development one in the Ukrainian economic science, revealed the essence and meaning of socio-humanitarian processes, forms of their existence, their prerequisites and formation, determined their role in the reproduction of social processes.

Of major practical importance are recommendations on the improvement and development of the state policy, with a view to adapting to new demographic realia, determining the effect of socio-humanitarian processes on the development, formation and functioning of social infrastructure, the set of macro-economic, normative-and-legal, institutional and political prerequisites for the effective formation of public-private relations to ensure the balance of interests among the investor, state and civil society.

Scholars of the Department of History, Philosophy and Law substantiated the necessity of improving the national legislation and legal practice in the sphere of public control over unconditional conforming of the state power and local government bodies to the Constitution, the laws of Ukraine and other normative

legal acts. They prepared proposals and recommendations to improve political and legal principles of Ukrainian society's ethno-cultural consolidation. Researchers carried out a national-scale sociological monitoring of the level of civil activity in Ukraine, which allowed them to reveal social factors and peculiarities of the effect of social context on the establishment of civil society in the country. Section's researchers determined ways of the efficient use of global information resources in the interests of social progress in Ukraine and produced recommendations towards adopting successful experience and preventing negative trends in the sphere of information exchange in the system of social communications.

Of great theoretical and applied importance is the research carried out by Department's specialists into socio-humanitarian factors of modernizing the Ukrainian society, the social potential of Ukraine's innovative development, regulatory functions of the social capital in transformation processes in Ukraine, electoral behavior of Ukrainian population, socio-cultural trends in today's Ukrainian society. A fundamental publication – «Glossary of Comprehensive Ukrainian Encyclopedia» was prepared with the involvement of leading scholars, and the publication of the 10-volume «Encyclopedia of the History of Ukraine» and «History of Religion in Ukraine» was completed.

An important achievement of Section's researchers is the Draft Concept of amendments and additions to the current Constitution of Ukraine, which was worked out in the framework of scholarly back-up to the Constitutional Assembly activities.

A major practical outcome of the research done by scholars of the Department of Literature, Language and Art Studies is the completion and publication of fundamental works «History of Ukrainian Culture» in 5 volumes, 9 books and «History of Decorative Art of Ukraine» in 5 volumes, the publication of the 3rd and 4th volumes of the national-scope 6-volume project «Shevchenko Encyclopedia», 7 new-generation dictionaries, including the 4-volume «Russian-Ukrainian Dictionary» and 7-volume «Etymological Dictionary of the Ukrainian Language» (vol.6).

In the near future the efforts of scholars of the NAS Section of Social Sciences and Humanities will be centered on further research into the processes of democratization of the state-society relations in the context of current modernization processes in the world, identifying the principal trends and mechanisms of improving the institutional structure of the socio-economic system of Ukraine, forming strategic lines of developing public-private partnership in Ukraine on the background of the globalization of institutions of socio-economic sphere management.

Academy Programs and International Cooperation: Interrelation, Current State and Prospects



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

International cooperation – an important and essential task of Academy's statute – is at the same time both a supplement to and a development stimulus for numerous scientific programs and projects supported by the Academy. These are not only closely related to more than 300 bilateral collaboration projects of NAS institutions and their partners from other countries, moreover, they lay the topical foundations for the participation of Academy's researchers in multilateral projects of international scientific programs.

These projects are mainly selected through competition; they correspond to the high-priority topical fields approved by the Ukrainian government and coordinated with foreign partner institutions to meet mutual aims.

In particular, the projects of the program "Fundamental Problems of Nanosystems, Nanomaterials and Nanotechnologies" are supplemented by several dozens of related international projects, including bilateral ones performed under inter-academy agreements with research institutions of the CIS and EU countries, as well as those implemented under the Seventh Framework Program of the European Commission and through a joint competition with the Science and Technology Center in Ukraine.

The Academy program of space research includes projects implemented within the Ukrainian-Russian collaboration program of exploration and peaceful use of space for 2012–2016, in particular, experiments in the Russian segment of the International Space Station.

International institutions provide considerable financial support to the targeted integrated NAS programs, such as "Fundamentals of Molecular and Cellular Biotechnologies" and "Sensor Devices for Medical, Ecological, Industrial and Technological Purposes: Metrological Support and Experimental Use". 109 projects of these programs are implemented by institutions of six NAS departments and financed by the state budget of Ukraine; other 52 projects of relevant topics are carried out jointly with partners from France, Russia, Poland, the Czech Republic, Turkey and Hungary.

An important contribution to the promotion of international co-operation was made by Academy institutes involved in the State Program on the Implementation and Application of GRID-Technologies for 2009–2013. In particular, the formation of the GRID-infrastructure enabled Ukrainian scientists to take part in the experiments performed on CERN's

Large Hadron Collider (this fact was recognized in the press release of CERN Director General after signing the agreement on association membership of Ukraine in CERN). Eight institutes and three universities of Ukraine could enter the international GRID collaboration and thus employ the computational resource of their foreign partners due to the technical-level cooperation with the European GRID Initiative (EGI).

The targeted integrated program on sustainable development, rational nature use and environment protection for 2010–2014 involves collaboration with scientists of the academies of sciences of Poland, the Czech Republic and Slovakia in studying species biodiversity, and with partners from the Hungarian Academy of Sciences in the comparative studies of ecosystems of Hungary and Ukraine, which allows them to deal with comprehensive problems of environment protection. This program is closely related to the results of the project "Integrated modeling of food, energy and water safety management for sustainable social, economic and environmental development", implemented jointly with the International Institute of Applied Systems Analysis.

This approach is most helpful in the high-level research; in particular, it allows scientists to employ their partners' advanced facilities, to publish collaborative papers in high-rating journals, to present their research results at international conferences and exhibitions. One should also note the role of infrastructure and communication projects of the European Commission. The interrelation of Academy programs and international co-operation produces a positive effect on the commercialization of research outcomes as well, which is confirmed by a considerable number and range of NAS foreign-economic contracts.

The prospects of further combination and coordination of Academy programs with the topics of international collaboration could include the initiation of mutual topical programs similar to the joint NAS and RAS research program "The Black Sea as a Simulation Model of the Ocean", the targeted program of NAS collaboration with CERN and JINR, or joint research of the NAS of Ukraine and EISCAT. It should also be reasonable to propose a special-purpose project for the scientific support to the implementation of the European Union Strategy for the Danube Region in Ukraine, which the Academy is trusted with. The implementation of the NAS targeted program "Prospective Research in Plasma Physics, Controlled Fusion, and Plasma Technologies" will promote co-operation with EURATOM. Further on, such programs will make a foundation for the coordinated topical competitions of Ukraine and European Commission, such as the newly started "Horizon 2020" program.

Activities of NAS General Meeting and Presidium



**V.F. Machulin,
Chief Scientific
Secretary of the Academy**

In 2013, which was a jubilee year for the National Academy of Sciences of Ukraine, managing bodies of the Academy focused on improving its activities as the highest scientific institution of the country, coordinating and maintaining fundamental and applied studies in priority areas of science, deploying their outcomes in practical work, informing the society about scholars' achievements, and on further integration of scientists to the international research area.

The annual session of the NAS General Meeting held on 18 April 2013, summarized Academy's activities in 2012, major research outcomes and examples of extensive deployment of R&D results, outlined top-priority tasks of the Academy for the near future. Of great importance was the discussion and adoption by the General Meeting of the new version of NAS Statute, which reflected changes in the legal framework and new socio-economic conditions of NAS activities.

The jubilee session of the NAS General Meeting commemorating the 90th anniversary of V.M. Glushkov, an outstanding scientist and science manager, the founder of Ukrainian cybernetics, was held on 12 September 2013. On 6 December 2013 a joint jubilee session of the general meetings of the National Academy of Sciences and the National Academy of Medical Sciences of Ukraine marked the 100th anniversary of M.M. Amosov, a world-renowned scientist, famous surgeon, the founder of science schools in cardio-vascular surgery and medical cybernetics.

In the year under review, the meetings of the NAS Presidium, as usual, gave a lot of attention to the current state and future prospects of the advancement of some cutting-edge research fields. Highly appraised were results of studies in controlled thermonuclear fusion, plasma physics and technologies, nanostructured oxide magnetism as an important element of spintronics – one of the state-of-the-art areas of solid state physics, dynamics of prospective spacecraft, and using marine biological resources. To improve the coordination of scientific research and its efficient planning, the list of principal research areas and major problems of NAS fundamental research was approved for 2014–2018.

The Presidium also considered important issues of the national scope, in particular, those of improving the reliability of the Ukrainian gas-transport system operation, the legal framework of the constitutional reform, measures towards preparing the fundamental academic edition – the Comprehensive Ukrainian Encyclopedia, creating the 'Taras Shevchenko' research and educational portal. An Academy Presidium meeting,

attended by the social policy minister, discussed and approved the National Report 'Sustainable Human Development: Ensuring Equity', where NAS scholars made a comprehensive inter-disciplinary analysis of a range of issues related to ensuring social equity, outlined an integrated system of sustainable human development priorities. A joint session of the NAS and NAMS presidiums, attended by the Health Minister, considered the development of a most advanced research area in Ukraine – that of nuclear medicine – and discussed a joint action plan to implement the Concept of nuclear medicine advancement till 2017. Jointly with representatives of the Donbas Fuel and Energy Company the NAS Presidium discussed further participation of Academy science in dealing with the problems of coal mining industry, in particular, deploying the advanced technology of mine developments support anchoring, which significantly improves coal mining safety.

A positive appraisal was given to the results of implementing the Academy-initiated targeted S&T programs on developing and introducing energy-saving LED light sources and lighting systems based on them, as well as deployment and application of grid technologies in scientific research, education, medicine and environment monitoring.

In the reporting year the Presidium considered a number of issues for improving the current NAS activities. It approved the Concept of the Law of Ukraine 'On the National Academy of Sciences of Ukraine', which is to define the place and role of the Academy in the progress of the Ukrainian society and specify its legal status. The NAS Presidium adopted the Concept of Academy development in 2014–2023, which is a broad program of NAS modernization taking into account current challenges and the best academic traditions tested by many years of practice. In order to optimize the Academy structure, decisions were made on transforming the Research Center of Ecomonitoring and Megalopolis Biodiversity into the NAS Institute of Evolutionary Ecology and of the NAS R&D Center of Technical Objects Magnetism – into the NAS Institute of Engineering Problems of Magnetism; the Institute of World Economy and International Relations was liquidated. The current state and future prospects of Academy's academic publishing were considered alongside with providing the centralized access of its institutions to foreign databases of scientific information and broader representation of NAS periodicals in leading scientometric databases.

In 2013 the NAS Presidium also kept an eye on developing young scientists' research. In particular, earmarked finance and grant support was provided for the most promising studies. Continuous attention was given to promoting the international collaboration, to the organizational and financial provision of the implementation of international agreements and joint research projects with matched financing, to the participation in international scientific programs, extending ties with academies of sciences and research centers that are members of the International Association of the Academies of Sciences.

Mathematics



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

In 2013, efforts of the researchers of the NAS Department of Mathematics were directed towards new achievements in fundamental investigations in various branches of mathematical sciences. A number of major scientific results were obtained.

Experts in the field of differential equations and dynamical systems performed the analysis of the phenomenological model of gasless combustion on the surface of a cylinder of radius r . For the model investigated, the conditions of existence of running waves and their properties were investigated. In particular, their asymptotic was established and the nature of acquiring and loss of their stability analyzed. The theory of solvability of linear normally solvable operator equations in Banach spaces was constructed. The theory of existence and nonexistence of supersingular and "large" solutions of semilinear elliptic equations with absorption potential degenerating on various manifolds was developed. Well-posedness of the problem with time integral conditions was studied for equations with constant coefficients hyperbolic in the sense of Garding. The problem of discrete data assimilation was analyzed for three-dimensional primitive equations with viscosity, simulating the dynamics of ocean currents.

In mathematical physics and functional analysis, a countable sequence of superintegrable models of neutral particles with arbitrary spin and hidden Fock symmetry was constructed. New criteria of the exponential stability of solutions were established for parabolic differential equations in Banach spaces. The structure of indecomposable pairs of operators connected by a quadratic relation was investigated. Numerous theorems were proved on the existence of correspondence of a definite form between the Witten spinor method and the Nester tensor method in the problem of gravitational energy positivity. L-matrices specifying oscillations of a mechanical system in the vicinity of stable equilibrium and characterized by the masses and potential energy of particles interactions with each other and with the external field were studied. Relationships between asymptotic relations for orthogonal polynomials with variable weight and the corresponding Riemann–Gilbert problems with spectral properties of finite-zone Jacobi matrices were established and analyzed. The Cauchy problem was solved for the modified Korteweg–de Vries vector equation. A new method was proposed to investigate beta-models in the theory of random matrices. It enables one to study both global and local modes for beta-models by using a simple change of variables.

In the theory of functions, the existence of a point of local homeomorphism was proved for continuous mappings of two manifolds whose set of countable levels is not of the first category. Exact order estimates were established for the best orthogonal and bilinear approximations of the Nikolskii–Besov periodic functions of many variables. The theorems on the existence of solutions with isolated singularities were proved for the general Beltrami equations with degeneration. Obtained were conditions under which the generalized Lebesgue constants of Fourier–Jacobi sums are bounded.

In the probability theory and mathematical statistics, the problem of large deviations was investigated for random evolutions with asymptotically weak diffusion in the scheme of double phase lumping. A new formula was obtained for the characteristic function of the squared Hilbert norm of the Ornstein–Uhlenbeck process path. It generalizes the well-known Cameron–Martin result for the Wiener process. Limit theorems of the averaging, principle of large deviations, and law of iterated logarithm types were proved for the solutions of stochastic Ito equations, stochastic equations with local time, and functionals of these solutions.

In algebra, geometry and topology, necessary and sufficient conditions for the topological equivalence of harmonic polynomials were established. The structure of unitary mappings of the general position was determined for linear groups over tame piecewise-hereditary algebras. The known problem of semiscalar equivalence of polynomial matrices was solved for their fairly broad classes. The geometry of submanifolds constructed with the help of wave functions of electrons in hydrogen-like atoms was investigated and the relationship between the geometric properties and quantum numbers was established.

In the field of mathematical problems of mechanics, nonlinear boundary-value problems of the dynamics of bounded volumes of liquid were formulated in the Riemannian space in the tensor form. Variational methods were proposed for their solution. The method of additional functions was generalized to the nonautonomous case. Sufficient conditions were established for the asymptotic stability and instability of functions with derivatives of constant sign. A nonclassical statement of the problem and a method for its solution were proposed for axially symmetric problems of stationary heat conduction and thermal elasticity with partially determined boundary conditions for bodies with heat releasing or thermally insulated disk inclusions. A procedure to determine thermoelastic steady state was developed for multilayer structures subjected to high-temperature heating by internal heat sources under complex heat exchange with the environment through bounding surfaces.

In mathematical modeling, computer science and applied mathematics, an exponentially convergent FD-method was developed and substantiated for solving Sturm–Liouville problems with singular Legendre operator and singular potential.

Information Science



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

In 2013, scientists of the institutions under the NAS Information Science Department produced a number of significant fundamental and applied results.

Fundamental results in the theory of matrices were obtained in mathematical modeling and in methods of computer mathematics, which resulted in novel efficient procedures for solving a number of ill-posed problems of linear algebra.

An approximate algorithm to solve the problem of the set cover with maximum capacity occurring in trains, planes and ships scheduling was constructed. The known records for all the 64 test tasks of large dimension were obtained, with 40 solutions of these tasks being accurate. A new record for one task was found. The comparison of the results obtained with other algorithms performances showed that the algorithm developed is better than speed options in nearly all cases.

A mathematical model to describe the state of human face and algorithms for solving the problems of its emotional state recognition were produced. The abovementioned software program was realized.

New classes of models were proposed in the field of intellectual information technologies and systems creation. Those models are focused on the development of rational information technologies in perception, recognition and meaningful interpretation of environmental objects.

A semantic management technology was worked out for allocated low-structured informational resources of arbitrary formats. Networking tools and portal solutions were constructed for elaborating, filling and presenting information resources based on this technology. Electronic platforms for studying T.H. Shevchenko artistic heritage were created.

Methods and algorithms to guide linear multidimensional objects with incomplete a priori information as to options in arbitrary sending of this object were created for the first time. They provide acceptable characteristics of controlling system's performances under nonstandard conditions.

A probabilistic model of functioning was built for periodically generalized Laktosh-type systems and the ergodic theorem was proved. Statistic models of transport systems controlling the processes of plane landing and car motion on the closely tied crossroads were constructed.

Methods were developed to determine ellipsoidal and interval estimates of the minimum amount of recovery tasks of vector state and a broad class of

nonlinear dynamic systems in making measurements with the bounded obstacles for up-to-date spacecrafts control systems.

An efficient numerical analytical tool was produced for long-term prediction of the functioning of nonlinear, non-autonomous controlled fields of various natures. It is based on the theory of evenly attracting sets for m-semi-threads in infinite-dimensional developed spaces.

In the area of programming theory and techniques, conceptual models of service-oriented software engineering and their components, as well as the technology platform and software-development environment, were worked out.

In the field of special computer systems and facilities, specialists experimentally proved the efficiency of the proposed method to compensate optical anisotropy in focusing optical radiation through the single crystal sapphire substrates of a long-term visual cover for data collecting.

An information technology for contactless research of the magnetic properties of medical and engineering materials was developed. In particular, scientists for the first time provided an experimental proof of the relation between the efficiency of drugs used in oncology (exemplified by doxorubicin) and their magnetic properties. They also found a change in the magnetic state of coal substance in places of natural shear layers.

A complex of novel machine-learning models was created for solving problems of computer processing within natural language texts and methods of factorization of large text cases' bodies for pithy analysis of immense volumes of information. New classes of information technologies were created; they significantly accelerate the processes of knowledge obtaining and utilization in education, culture and social infrastructure of knowledge-based society. The respective resolutions of Ukraine for the final documents of the 37th General Conference of UNESCO were prepared and adopted.

Created were theoretical foundations of a new class of knowledge-based information systems in terms of ontology-driven architecture that implements comprehensive IT computer processing of domain-specific knowledge.

Mechanics



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

In 2013, scientists of the NAS Mechanics Department were involved in fundamental and applied research in priority areas of the development of science and technology. They obtained a number of new important theoretical and experimental results, some of which were honored with awards.

Analytical solutions of plane dynamic problems for bodies with initial stresses on the perturbation of the multilayer foundation surface by a load moving with constant speed were obtained. A technique of constructing mathematical models for composite materials with internal structures of the micro- and nano-level was developed. Efficient discrete-continual approaches to studying stationary deformations of anisotropic shells of modern materials were refined. The effect of the main parameters on the mechanical behavior of shell structures was analyzed.

A technique was developed for numerical investigation of the stress-strain state and strength of structural elements in the form of revolution solids under thermal and force loading, taking into account the third invariant of stress deviator and material damage. A method to analyze a set of trajectories of impulse systems with aftereffect was worked out relying on the comparison technique and generalized direct Lyapunov method. Conditions of Lyapunov stability and stability with respect to two measures were determined. Effective numerically analytical approaches were created; on their basis, solutions of some problems on control of axisymmetric oscillations of thin-walled closed and unclosed spherical electro-elastic shells were found.

Mathematical models were developed to determine dynamic characteristics of oxidizer and fuel supply lines for liquid-fuel rocket engine. Calculation analysis of dynamic characteristics of supply lines and a flexible body of the launch vehicle demonstrated that conditions for POGO-stability loss can occur both in the oxidizer line and in the fuel one at the active leg of the launch vehicle flight. To prevent POGO-stability loss, gas-liquid dampers were proposed for supply lines. Main design parameters of dampers and their operation conditions were determined.

Mechanisms of the generation of vibrations of regular vibration system with a closing fatigue crack in one of the rods were determined. For this rod, new analytical dependencies of vibrodiagnostic parameters on the parameter of vibrations nonlinearity were obtained. It was shown that under subharmonic reso-

nance conditions, as well as in the case of an isolated rod, the relation between amplitudes of the first and second harmonics of vibrations with the in-phase mode of system vibrations can be used as a vibrodiagnostic parameter for this crack. As a result of elastic coupling between rods, the vibrodiagnostic parameter for a damaged beam in the system is lower than that for the isolated rod; moreover, it decreases with an increase of the elastic coupling stiffness factor.

Parameters of the coal-rock massive properties that facilitate release, migration, accumulation and preservation of methane masses were validated. It was found that the main parameter that determines the state of the molecular system of coal substance is the value of the potential of the accumulated free energy. Through calculations, it was shown that if account is taken only of mechanical impact on the molecular system of coal substance, the energy potential of small quantities is sufficient to activate gas-generation processes.

An algorithm to evaluate parameters of sound fields generated by flows in channels with deformable walls was developed and applied. New laws of the unsteady behavior of artificial ventilating supercavities which close on the body were established. The existence of circulating currents within the cavity was discovered.

An unsteady mathematical model was developed for a geothermal system (environment – thermal pump), with account being taken of the space-time variability of temperature field and energy characteristics of the thermal pump. A multi-hull hydrodynamic scheme of high-speed ship was developed and scientifically validated.

The stability of a system of differential equations with lumped and distributed varying delays and norm limited non-linear terms was investigated. Sufficient conditions for exponential stability and upper bounds for the Lyapunov exponents were found. In contrast to the known results of this kind, which require solving the Riccati equations or constructing Lyapunov functions, the obtained conditions for stability are determined directly by system coefficients.

The problems of increasing the efficiency of wind flow concentrators through the elimination of high pressure areas in the lee sectors of wind turbines were investigated. A wind turbine with a multi-channel wind energy converging concentrator was designed; it relies on the re-acceleration of exhausted air streams.

Physics and Astronomy



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

In the reporting year, scientists of the institutions under the NAS Department of Physics and Astronomy were active in solving both fundamental and applied problems. Research was carried out in the following areas: fundamental interactions and microscopic structure of the matter, solid state physics, low- and ultralow-temperature physics, optics and laser physics, radio physics and electronics, soft matter physics, physics of plasma processes, as well as astrophysics, astronomy and radio astronomy. World-level results were obtained in all these research areas.

In the area of fundamental interactions and microscopic structure of the matter, the effective cross section of the $p+p \rightarrow n+D$ recharging reactions for energies of RHIC, JLab and SPS accelerators was estimated, which is necessary for analysing experiments conducted at the Large Hadron Collider.

In solid-state physics, sensors that demonstrate response to the gas expired by humans were made; hydrogen-resistant steel which can be used in hydrogen accumulators was developed.

In low and ultralow-temperature physics, a heat treatment technology was developed to improve wear resistance of versatile metal products, and the respective cryogenic equipment corresponding to the world-best analogues was transferred to Ukrainian enterprises to be applied.

In optics and laser physics, methods were proposed for synthesizing materials whose optical parameters are close to the day light, i.e. a step was made towards upgrading the systems for artificial lighting.

In nanophysics and nanotechnologies, ordered monolayers of derivative diariletilens with controllable properties were created; those can be used in optics, sensors and tribology; materials meeting international requirements to medical materials were made by synthesizing nanoparticles with specially doped surfaces.

In radiophysics and electronics, the problem of transient radiation of electromagnetic waves by an electron that crosses the dielectric-superconductor interface was solved; and production of piezoelectric ceramic elements for medicine was arranged.

In soft matter physics, a model describing abnormal diffusion of colloidal particles was proposed for the liquid nematic-colloid system, this holding promise for biology.

In physics of plasma processes, a high-power plasma source of concentrated energy was developed, which can be applied for treatment of surfaces of various materials.

In astrophysics, astronomy and radio astronomy, 254 sessions of measurements for 40 space sources were carried out within the frames of the 'RadioAstron' International Project, that allowing a high-accuracy determination of galactic objects parameters.

Institutions of the Department participated in completion of projects of the State Target R&D Programs: 'Nanotechnologies and Nanomaterials', 'Introduction and Application of Grid-Technologies', 'Development and Application of Energy-Saving LED Sources and Lighting Systems Based on Them', as well as projects of joint competitions with the Ukrainian Science and Technology Centre, Russian Foundation for Basic Research, Siberian Division of the Russian Academy of Sciences, National Science Centre of France, etc.

In 2013, the Department successfully held over 50 scientific forums (international conferences, symposia, seminars, schools, etc.). Scientists of the Department defended 13 theses for doctor-of-science degree and 61 theses for candidate-of-science degree, published over 2500 research papers and 27 monographs. A number of fundamental results were duly appreciated.

The cycle of works "Non-linear Waves and Solitons in Condensed State Physics" by research associates of the NAS M.M. Bogolyubov Institute for Theoretical Physics, Institute of Magnetism of NAS and MES, NAS B.I. Verkin Institute for Low Temperature Physics and Engineering, and NAS O.Ya. Usikov Institute of Radio Physics and Electronics, as well as the work "Ensuring Technogenic and Ecological Safety in Development of Coal and Gas Fields" by associates of the NAS Institute for Physics of Mining Processes were awarded the State Prizes of Ukraine in Science and Technology.

The Prizes of the President of Ukraine for young scientists were presented to associates of the V.E. Lashkarov Institute of Semiconductor Physics and M.M. Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine.

A number of scientists of the Department received high state awards: the order 'For Merits' II Class went to Yu.G. Ptushinsky, NAS Corresponding Member; and the titles of honoured Science and Technology Worker of Ukraine were received by B.I. Lev and F.F. Sizov, NAS Corresponding Members.

A.G. Naumovets, NAS Academician, was awarded a high decoration of the French Republic – the Diploma of the French Academic Palms Order Officer.

Yet, scientists of the Department are concerned with the fact that science and education in the country continue to stagnate. Research equipment is becoming obsolete, and young scientists again are inclined to move abroad. This situation, when science and education are financed on leftovers and have no appropriate support from the governing bodies of the country, is very dangerous and threatening not only with a loss of leading positions in some areas of physics, but also with a technological decline of the country as a whole. Physicists and astronomers appeal to the scientists of the NAS of Ukraine to express their disagreement with this policy of the State and demand that its governing bodies take immediate measures to restore and save the national science and education.

Earth Sciences



**V. M. Shestopalov,
Academician-Secretar
of the Department**

In 2013 the efforts of scientists of the NAS Earth Sciences Department and its institutions were focused on further development of research related to the build-up of mineral resources, improving the efficiency of their use, environmental safety, using the results obtained in various sectors of the economy, improving science management activities. Some major basic-science and applied achievements won prizes and awards.

The State Prize of Ukraine in Science and Technology was awarded to Prof. L.V. Cherkesov, NAS Corresponding Member, an employee of NAS Marine Hydrophysical Institute, and co-authors for a series of papers "Regularities of Wave-Vortex Processes in a Continuous Medium".

The NAS P.A. Tutkovsky Prize was awarded to O.S. Vialova and V.M. Paliy for their monograph «Oleg Stepanovich Vialov. Essays on His Life and Work».

Within the framework of international co-operation under bilateral agreements with geological, geophysical, oceanographic institutions of the CIS and other foreign countries, leading scientists of the Department served as members of many international committees, editorial boards, etc., took an active part in international meetings and symposia of various scopes.

Under the Program of Joint Ukrainian-Japanese Cooperation Committee for Emergencies at Nuclear Power Plants, the contract 'Classification of vegetation within the territory of the Fukushima-1 on the basis of satellite data for Earth's surface survey' was signed by the NAS IGS Centre for Aerospace Research and the Research Center for Advanced Science and Technology, University of Tokyo.

The NAS Departments of Marine Geology and Sediment Ore Formation and the Institute of Geology of the National Academy of Sciences of Azerbaijan concluded a scientific collaboration agreement to pool their research potentials in addressing fundamental and applied problems of geology in the Azov-Black Sea and Caucasus regions. A respective research program 'Modern ideas about mud volcanoes of the Azov-Black Sea and Caucasus regions, including the Black Sea and Caspian aquatic areas' was drawn up and approved.

Leading experts of research institutions of the Department developed the scientific and technological project 'Strategic evaluation of possible gas production from reservoirs operated in Ukraine and envi-

ronmental exploratory survey of priority areas', which, along with the prospects of hydrocarbon gas in conventional traps, proposes to investigate gas-bearing carbonate rocks, promising sediments at depths over 5 km, shale gas, gas-compacted sandstone etc. Its implementation would produce concrete results concerning the types of the most promising gas fields in priority exploration areas, and help determine exploration stages and distribution of promising resources. In addition, the works proposed are intended to minimize the risk of negative environmental impact of processes associated with hydraulic fracturing for promising Yuzivska and Oleska shale gas sites.

The final version of the next Sixth National Report of Ukraine on Climate Change was prepared; it was approved at a meeting of the Interdepartmental Commission for Implementation of the UN Framework Convention on Climate Change and submitted to the UNFCCC Secretariat. The results were used to develop national and regional plans of action on adaptation to climate change.

Activities were substantiated for the Draft National Action Plan for Ukraine's transition to sustainable development with objectives of socio-humanitarian development vector. In collaboration with experts of the Institute of Market Problems and Economic-and-Ecological Research and the Institute of Natural Resources Management and Ecology, the elaboration of scientific principles of design strategies for sustainable development in Ukraine was completed.

Progressive shortage of certain types of domestic raw materials, largely due to insufficient structural, geological, geophysical and geochemical research, can lead to a dangerously low level of the protection of Ukraine's national interests. It is, therefore, of vital importance to provide a comprehensive description of patterns of mineral deposits formation and distribution, performed at modern scientific level, prospecting geophysical and geochemical features of their manifestation in rocks of geological complexes of Ukraine, classification and analysis of the available information on all mineral species and varieties registered in Ukraine. It is critically important to upgrade various studies on environmental safety on land and at sea, integrated mining, marine, geographic, remote sensing and other research for more rational and safe use of various resources of this country. Dealing with these tasks of utmost importance will be the focus of Department's scientists in 2014.

Physical and Technical Problems of Materials Science



**I. K. Pokhodnya,
Academician-Secretar
of the Department**

In 2013, scientists of the NAS Department of Physical and Technical Problems of Materials Science obtained a number of important fundamental and applied results, which are of great importance for the economy.

A concept, technical assignment and designing documentation of a new generation of electron beam tools for manual and mechanized welding in site and repair-restoration works in the open space were worked out, which will improve the convenience of the operator's work in performing welding and related technologies. The equipment designed will have the capacity of up to 2.5 kW, which is twice that of the 'Universal' equipment and will also be able to focus the electron beam and deflect it with preset program, enabling the thickness of materials welded to be increased 3.5–4.0 times (aluminium, stainless steel, titanium). The research done showed that the chamber evacuation at a continuous blowing with ultra-pure helium during pumping provides the highest sterility and stability of high vacuum in the melting chamber during melting, thus increasing the specific electric resistance of silicon by 5 times.

Works were carried out to develop a model of hydrogen diffusion with account for its redistribution in the presence of plastic deformation and elastic stresses. The effect of plastic deformation and elastic stresses on hydrogen redistribution in weld metal of structural steels was experimentally determined. The experimental-and-calculation modeling of the effect of hydrogen redistribution in a technological sample on cold crack formation was made. It was found that application of elastic stresses of the value $\sigma = 0,8\sigma_{0,2}$ leads to hydrogen redistribution in the metal between the crystal lattice and dislocations formed as a result of microplastic deformation of steel. For the first time, complete experimental data were obtained concerning the thermodynamics and kinetics of reaction diffusion in 'solid molybdenum – liquid alloys of copper and tin with cobalt' system. The equilibrium composition of three-component melts in contact with Mo and intermetallic Mo_6Co_7 was established. Significant differences were found in the growth rate and microstructure of intermetallic layers, depending on the neutral base of the melt (copper or tin). The results obtained are basic for developing a new generation of pseudo-alloys on the base of molybdenum, which are intended for electrical equipment.

Using the method of tunnel microscopy, polycrystalline graphene coatings on substrates of materials that have BCC crystalline lattice were investigated.

For the first time, it was shown that the graphene coating of an important functional purpose has an island structure with crystallites of elliptical shape. The width of the boundary of delaying the growth of islands was calculated, depending on the substrate type. It was: 1.59 nm for the substrate of ultra-dispersed diamonds; 1.35 nm – for the substrate of cBN, and 2.22 nm – for quartz substrate.

A calculation model for evaluating the operation of tribojoints was formulated and new contact two-dimensional problems were solved for bodies with edge and near-surface cracks, with account being taken for the presence of friction under loads; those are necessary for the realization of the abovementioned model. These solutions were used for investigating the peculiarities of formation of the initial phase of crack propagation during contact-fatigue damages of tribojoints, such as pitting, delamination and fragmentation of the contact surface of rolling bodies. Diagrams of contact fatigue prediction were plotted for elements of wheel-rail system and support rolls of rolling mills.

It was proved that the equation of state of the perfect gas depends on boundary properties. The new equation of state of the perfect gas was obtained, which takes into account this effect. This fundamental result is important as applied to nanosystems, since the relation of surface and volume in them is increased in favor of the surface. Respectively, the deviation of equation of state of the perfect gas or quasi-particles in these systems should be taken into consideration.

Large-sized YSO:Ce, LYSO:Ce, LGSO:Ce crystals of up to 48mm diameter and up to 250 mm length were produced. In collaboration with JINR (Dubna, Russia) the suitability of LGSO:Ce crystals for experiments of recording the heavy electron conversion in high-energy physics was validated.

Regularities of dissipation of current and phonon carriers in micro-miniature layers and powders of thermoelectric materials were established, and their effect on parameters of thermoelectric energy converters was also investigated. Scientists determined optimum thicknesses and sizes of nanoparticles at which the quality of thermoelectric materials increases 1.2–1.7 times as compared to single crystals, which can be used for developing novel nanostructured materials of increased quality.

B.E. Paton, the President of the National Academy of Sciences of Ukraine, L.M. Lobanov and B.V. Grinev, NAS Academicians, were awarded the order 'For Merits' I Class.

The high title 'Honored Worker of Science and Technology of Ukraine' was awarded to G.G. Gnesin, NAS Corresponding Member, and to A.I. Vovchenko and V.R. Skalsky, doctors of technical sciences.

Physical and Technical Problems of Power Engineering



**B. S. Stogniy,
Academician-Secretar
of the Department**

In 2013, scientists of the NAS Department of Physical and Technical Problems of Power Engineering addressed major scientific and technical problems of power engineering in Ukraine.

They continued research work on the implementation of integrated NAS research programs: 'Association -2', 'Resource', 'Biofuels', 'Development and Production of Science-Intensive Sensor Products' and 'Fundamental Problems of Hydrogen Energy'.

In 2013, scientists of the Department obtained a number of significant results of fundamental and applied research.

Relying on the outcomes of experimental and theoretical studies of two promising schemes of oscillating film cooling, specialists proved their efficiency, which exceeds the performances of conventional film cooling schemes by 50–80%. Those results were used in developing cooling systems of blades of high-temperature gas turbines at 'Zoria-Mashproekt' Plant (Mykolayiv).

A new procedure was developed to evaluate crack development in power machine elements under various cyclic loads and creep. With the use of three-dimensional models, the development of primary creep damage was investigated in the areas of discharge openings and the axial channel of high-temperature turbine rotor. The results were used to construct systems for vibration diagnostics.

For the first time, analyzed was the problem of controlling regimes of electric power systems of Ukraine, which was due to the commissioning of new powerful renewable energy sources. Basic principles concerning the feasibility of possible involvement of solar power stations (SPS) in the automatic frequency control were formulated. The structure of the subsystem frequency control within automatic control systems at substations of powerful SPS was proposed and their involvement in automatic frequency control was investigated. Practical advice and research results were submitted to 'Ukrenergo' National Power Company.

Relying on mathematical methods and advanced computer modeling tools, software was developed for designing measurement and control systems of the new generation of test benches for power sources in power engineering and transport. The software is an active computer database of a new information technology.

Fundamentals of the theory of adaptive automatic load-frequency control system (ALFCS) in interconnec-

tions, synthesized on the basis of passive regulator consumers as heat pump systems, were developed; that allows a nearly threefold increase in their performance as compared to the conventional ALFCS proportional-integral-differential controller.

Technologies were developed to produce carbon nanomaterials and nanofluid for heat-physics on their basis. The possibility of a 2.5–3.5-times increase in the critical heat fluxes due to the use of nanofluids was shown, which is important for nuclear power engineering, for the functioning of critically loaded equipment in metallurgy, chemical and oil-processing industries, in electronic equipment, superinventions included.

On the basis of the averaged environmental theory, using the finite element method, scientists determined the relations of averaged thermal and electrical conductivities of composite heat sinks in photothermal modules intended for combined production of electricity and heat.

A CFD model of burner and coal boiler with tangential coal burning for TP-10 boiler was worked out, relying on the ANSYS-FLUENT software package. Model calculations were carried out; they showed a decrease in nitrogen oxides emissions by almost a third due to tangential secondary air supply. A pilot version of the burner for the TP-10 boiler was designed for Dobrotvirska heat-and-power plant.

On the basis on atmospheric transportation models, specialists created and implemented the Chernobyl informational-and-analytical system for estimating and projecting the radiation situation within the Chernobyl Exclusion Zone (CEZ) to provide operational support to decision-making on the introduction of countermeasures to protect personnel working on the territory of CEZ. The system is designed for calculating volumetric activity of the main current dose-forming nuclides ^{137}Cs , ^{90}Sr , $^{239}+^{240}\text{Pu}$, ^{241}Am in the air and on the ground surface within CEZ, the doses of external and internal exposure of its workers and the population outside.

Scientific fundamentals and novel procedures of precision bench testing of domestic spacecraft concerning their magnetic characteristics were developed. Their implementation in the space industry allowed precise orientation of domestic 'EgyptSat-1' and 'Sich-2' satellites in the Earth orbit, which is a scientific basis for producing high-resolution remote sensing satellites in Ukraine that would be competitive in the world market.

A number of R&D works carried out with the participation of Department's scientists received high state appraisal.

A 2013 State Prize of Ukraine in Science and Technology was awarded to I.Ya. Sigal (as a member of a research team). A.E. Antonov, V.G. Kireev, I.S. Petukhov were awarded the NAS V.N. Khrushchov Prize. NAS Academician Yu.I. Yakimenko was awarded the Order 'For Merits' I Class. NAS Corresponding Member N.M. Mkchitaryan was awarded the Order of Yaroslav the Wise V Class.

Nuclear Physics and Power Engineering



**I. M. Nekludov,
Academician-Secretar
of the Department**

In 2013, scientists of the Nuclear Physics and Power Engineering Department of the National Academy of Sciences of Ukraine obtained new significant research results.

In cooperation with a large international team of researchers in the Large Hadron Collider experiments (CERN, Switzerland), NAS scientists established the existence of the Higgs boson, thereby confirming the Standard Model of elementary particle physics. From the analysis of the data obtained at proton-proton collisions for energies of 7 and 8 TeV, oscillation frequencies of quark-structure-B-mesons were determined with the world highest degree of accuracy.

In the context of joint studies with the HESR under the FAIR Megaproject on the problem of electron cooling of antiprotons, energy losses by antiprotons in magnetized electron gas with anisotropic temperature were determined.

Experimentally found was the main physical mechanism that is responsible for plasma production and heating in all phases of the RF discharge in the 'Uragan-3M' facility, namely, ionization of molecular hydrogen coming from a large buffer volume.

A high-power plasma accelerator was used as a base to start up a new experimental test bench devised to investigate radiation-beam impact on the materials of nuclear/thermonuclear power engineering. For the needs of space industry enterprises of Ukraine and Russia, a test area was created for simulation testing of protective properties of metallic and composite materials.

Model experiments aimed at creating a fusion reactor (ITER) revealed the existence of an additional metal surface shielding for a combined carbon-tungsten divertor configuration that substantially reduces heat load on the structural elements exposed to plasma.

As a result of a comparative analysis of the radiation effect on structural-phase transformations in nanoparticle-alloyed ferrite-13%Cr steels in ferritic-martensitic state, the role of the structural state and the basic factors that must be taken into account when creating new radiation-resistant ferritic-class steels were established for the first time.

A computer program was developed to consider the state of the fuel assemblies charged into the reactor. The software makes it possible to improve the reliability and safety of NPP operation, and besides, to visualize refueling at Ukrainian NPPs.

Defect-free nanostructured radiation-resistant coatings showing high mechanical and corrosive

characteristics were created. They will ensure endurance and integrity of fuel cladding both under operating conditions and in an emergency with heating of up to 1100° C.

Scientific fundamentals were presented to justify the possibility of extending the service life of nuclear unit #1 of Pivdennoukrainsk NPP in excess of the established time limit for the following 10 years (licensed by the State Nuclear Regulatory Inspectorate of Ukraine), and nuclear unit #2 of Zaporizhzhya NPP till 2047.

To carry out examination of nuclear and other radioactive materials withdrawn from nuclear trafficking, a nuclear-criminalistic laboratory equipped with modern radiometric and dosimetric instruments, alpha-, gamma- and mass-spectrometers was created.

The use of the ^{179}Ta isotope in nuclear medicine was proposed for bone loss diagnostics for the first time; principal physics for its manufacturing were developed.

In collaboration with specialists of the National Academy of Medical Sciences of Ukraine and the Ministry of Health of Ukraine, the Concept of nuclear medicine development for the period till 2017 was worked out. It was approved by the Ordinance of the Cabinet of Ministers of Ukraine of 13 March, 2013, #130-p.

Relying on the metallogenic analysis of pre-Cambrian crystalline rocks of the Ukrainian Shield, thorium-bearing, ore-bearing and ore formations of thorium were determined; ages and periods of its buildup were established.

The Cabinet of Ministers of Ukraine awarded I.M. Vishnevsky, NAS Academician, the Certificate of Honor. Honorary Mention by the Prime Minister of Ukraine went to V.I. Miroshnichenko, NAS Corresponding Member.

The team of contributors of the National Science Center 'Kharkiv Institute of Physics and Technology' of the NAS of Ukraine, namely, NAS Corresponding Member A.N. Dovbnya, V.B. Ganenko, A.A. Grinenko, V.I. Kasilov, G.D. Kovalenko, N.I. Maslov, V.L. Morokhovskiy, V.I. Truten, S.P. Fomin, B.I. Shramenko, won the State Prize of Ukraine in Science and Technology for the series of works "Dynamics of high-energy particle beams in crystalline structures, control over beam parameters and gamma-radiation characteristics".

The NAS K.D. Sinelnikov Prize was awarded to the research scientists of the NAS Institute of Electrophysics and Radiation Technologies: NAS Corresponding Member V.F. Klepikov, Yu.A. Kasatkin, and V.V. Litvinenko for the series of works "Electrophysical processes in nuclear systems and condensing media under irradiation".

Chemistry



V. V. Goncharuk,
Academician-Secretar
of the Department

In 2013, scientists of the NAS Chemistry Department and its Bureau zeroed in on fundamental research into integrated issues of chemistry development, application of the results obtained in various spheres of the national economy, improvement of science-management activities, and training of young generation of scientists.

A series of important fundamental scientific results satisfying international requirements were obtained:

The possibility of nano-structures formation as nano-tracks 100 nm wide and tens micrometers long that consist of single-layer nano-particles of graphene or its inorganic analog – molybdenum disulphide – during controlled evaporation of their suspensions was shown for the first time ever (NAS Academician V.D. Pokhodenko).

The possibility of activation and dehalogenation of heminal and vicinal C-2 freons under the action of sulfur dioxide in the processes of their joint electrochemical conversion yielding commercially important fluoroethylenes or fluoroalkylsulfonic acids was proved for the first time. It was found that SO_2 may be used both as a catalyst in such processes – the mediator of electron transport – and as a reagent allowing these reactions to be conducted in mild, energy-saving conditions (NAS Academician V.G. Koshechko).

New approaches to the synthesis of clathrochelates with carbonyl substituents in edge fragments were developed, a high-spin type of clathrochelates containing lacuna complexes (pirazoloximborates Fe, Co, Mn, Zn) was produced, which is promising for application as paramagnetic probes for structural studies of biological objects (NAS Academician S.V. Volkov).

Principal laws of the effect of chemical structure and content of oxides, salts and disperse metals on polymerization process and formation of organo-inorganic systems based on urethane, epoxy and inorganic components were discovered, which makes them promising for industrial use (NAS Academician E.V. Lebedev).

A new water-soluble supramolecular sensor system on the basis of surfactants containing boronic acid functional group was developed. It is characterized by effective binding of mono-sugars and allows a 3–10- time more effective identification of d-glucose and d-fructose in water solutions (NAS Academician A.F. Popov).

New mutagenic forms of microorganisms resistant to chlorine and temperature during water and equip-

ment disinfection were separated for the first time. These results require a basic revision of drinking water treatment technology in the whole world. Ceramic membranes of natural clay materials for water treatment were produced. A method for applying catalytically active phase coating on ceramic blocks and tube filters was proposed; it was used in devices and technology of catalytic treatment of waste containing organic eco-toxicants (NAS Academician V.V. Goncharuk).

A series of new ligands of $\alpha\text{IIb}\beta\text{3}$ integrins – RGD-peptidomimetics containing 6-amino-2,3-dihydroindoline fragment and residues of carbonic acids as substitutes of arginine fragment were synthesized. Correlations between molecular docking and mimetics affinity to $\alpha\text{IIb}\beta\text{3}$ integrin and their anti-aggregation properties were found. A good correspondence between molecular docking results and structures of especially active compounds was shown by X-Ray method (NAS Academician S.A. Andronati).

The reactivity of graphene-containing carbonic nano-structures showing defects of vacancy type and heteroatoms of oxygen and nitrogen was studied; a high catalytic (enzyme-like) activity of some structures (nano-tubes, graphenes) in model fermentative reactions of reductase and hydrolase type was found. Relying on spin probes, a method of quantitative evaluation of carbon nano-tubes cytotoxicity for cell organelles (mitochondria) of some tissues and organs of experimental animals was proposed (NAS Academician M.T. Kartel).

Synthetic approaches were elaborated and derivatives of cyclames containing difluoromethylphosphonate groups bound with macrocyclic skeleton were obtained for the first time; a preliminary study of their activity towards proteintyrozinephosphatases was carried out. High effectiveness and selectivity of some compounds of this series opens up the opportunity to create ground-breaking inhibitors of proteintyrozinephosphatases as potential medical preparations (NAS Academician V.P. Kukhar).

A concept of creating and using combined carbon and inorganic sorbents that enable the control over the electrolytic composition of human organism and processes of oxidative stress, as well as the level of dangerous toxicants was elaborated (NAS Academician V.V. Strelko).

It was shown for the first time that solid solutions $(1-x)\text{BaTiO}_3-x\text{Li}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ ($0 \leq x \leq 0.6$) are characterized by high positive temperature resistance factor, their working temperature rises when concentration of $\text{Li}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ increases, which could be used in producing thermo-stable heating elements (NAS Academician A.G. Bilous).

Relying on the 2D-QSPR approach, adequate, highly prognostic PLS models relating structure and catalytic properties of over 60 homo- and hetero-ligand carboxylate and carboxylat-pirazolate, mono- and poly-nuclear complexes of 3d metals in liquid-phase oxidation of dibenzene ether were obtained (NAS Academician G.L. Kamalov).

Biochemistry, Physiology and Molecular Biology



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

In 2013 the activities of institutions of the NAS Department of Biochemistry, Physiology and Molecular Biology were aimed at fundamental and applied research into molecular, biochemical, morphological and physiological basis of human diseases; at the research of living organisms' genome, proteome and metabolome, as well as at the development of state-of-the-art technologies and nanobiotechnologies for medicine, veterinary medicine and pharmaceuticals.

In the Palladin Institute of Biochemistry of the NAS of Ukraine the study of nicotinic acetylcholine receptors (nAChRs) showed that nAChRs control the induction of regulatory B cells and the formation of mitochondrial pores. Antibodies specific to nAChR $\alpha 7$ subunit cause in brain an effect similar to chronic inflammation and contribute to the accumulation of β -amyloid. Molecular mechanisms of calixarenes interactions with proteins of blood coagulation system as well as with Mg-dependent Ca-transporting ATP-hydrolase were studied. This paves the way for using calixarenes as platforms for novel drugs development.

Scientists of the Bogomolets Institute of Physiology of the NAS of Ukraine showed that the block of hydrogen sulfide synthesis using DL-Propargyl Glycine – a specific inhibitor of cystathionine- γ -lyase – by its intraperitoneal administration in rats lead to some stimulation of the heart functional state. During the ischemia-reperfusion the cardioprotective effect was minimal under the cystathionine- γ -lyase blockade. In the absence of endogenous glutathione production the infringements of heart reperfusion contractile function significantly increased.

Scientists of the Zabolotnyi Institute of Microbiology and Virology of the NAS of Ukraine, from the soils of different places in Ukraine, isolated strains of streptomycetes – antibiotics producers that inhibit the growth of pathogenic bacteria. The antibiotics were purified by thin layer chromatography and assigned to different groups of chemical compounds.

Studies conducted at the Institute of Molecular Biology and Genetics of the NAS of Ukraine revealed structural tRNA-dependent (pre-transfer) editing of errors in aminoacyl-tRNA synthetases of the 2nd structural class by *Enterococcus faecalis* prolyl-tRNA synthetase. Based on the data obtained by molecular dynamics methods, quantum-chemical calculations and mutagenesis of *Thermus thermophilus* leucyl-tRNA synthetase and tRNA^{Leu}, the tRNA - assisted mechanism of post-transfer editing for prokaryote leucyl-tRNA synthetase were proposed.

Researchers of Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the NAS of Ukraine found that in human breast cancer cells of the most aggressive basic subtype (MDA-MB-231 and MDA-MB-468) there is a significant down regulation of expression of microRNA 133a and 200b, which are involved in the regulation of ferritin heavy and light chains expression. These data can lay the basis for using microRNAs 133a and 200b as markers of breast cancer prognosis.

Scientists of the Institute of Problems of Cryobiology and Cryomedicine of the NAS of Ukraine, studying the mechanisms of "graft versus host" disease (after allogeneic bone marrow transplantation), found a reduction of T-regulatory cells and their gene *foxp3* expression level as compared to the recipients of syngeneic bone marrow. They also showed that T-regulatory cells suppression activity correlated with gene *foxp3* expression.

The Institute of Cell Biology of the NAS of Ukraine obtained the improved yeast ethanol producers from xylose by insertion mutagenesis and selection of strains resistant to inhibitors of glycolysis. Its scientists found that *ATG13* gene, which is involved in autophagy regulation, also serves as regulation factor of xylose metabolism and its alcoholic fermentation.

In the field of medicine: methods were developed to optimize surgical interventions for intra cerebral tumors of cerebral hemispheres; the mechanisms of symptomatic myocardial ischemia of hemodynamic origin were investigated; an optimal method of mitral valve plastic surgery at ischemic cardiomyopathy was elaborated; the neuroprotective effect of transplanted stem cells of various origins was investigated; research was carried out into the pathogenesis of diabetes chronic complications; an algorithm of diabetes early diagnosis and treatment was developed.

Collaboration with home and/or foreign institutions in the field of medicine and biology continued. E.g., the IAAS Scientific Council for Biomedicine and Biotechnology was founded. In 2013, in Jerusalem a landmark event was held – the 9th Parnas Conference on Biochemistry and Molecular Biology 'Proteins: from Birth to Death', organized by Israeli, Ukrainian and Polish Biochemical Societies. The Interagency Seminar 'Molecular Medicine' was operating.

The tasks under State targeted research programs and integrated NAS programs were successfully continued. The institutes and the Department Bureau worked out measures to implement the Concept of NAS development for 2014–2023.

General Biology



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

In the reporting year, biologists of the National Academy of Sciences of Ukraine focused their efforts on studies of physico-chemical, structural and functional fundamentals of biological systems, research and conservation of the flora and fauna, as well as applications of biotechnology methods in various fields of science.

In particular, geneticists and plant breeders developed methodological principles of using molecular markers in wheat breeding for high quality of grain, productivity, soil and climatic adaptability. These studies initiate a new direction of genetic improvement of plants in Ukraine – molecular breeding.

A method was worked out to modify useful agronomic traits by applying agrobacterial aerosol suspensions for transient gene expression; it does not cause the appearance of transgenes. Coding sequences of the SHP1 gene isolated from Antarctic mosses was cloned; this gene is responsible for resistance to adverse environmental factors.

Cell biologists developed techniques for obtaining non-antibiotic antimicrobial compounds in plants; these techniques are safe for human and animal health. Genetic vectors were developed for highly efficient production of pharmaceutical proteins and breeding lines of some vegetables and forage plants that accumulate immunogenic antigens (ESAT6 and Ag85b) or human leukocyte interferon and can be used as “edible vaccine” for preventing various diseases of viral etiology.

Radiobiological studies of wild plants from the Chernobyl Nuclear Power Plant's Exclusion Zone showed the increase of their resistance to radiation due to certain changes in the cell epigenome. It was proved that this zone turned into a hotbed of highly hazardous pathogens dangerous to crops and other plants, due to intensified processes of microevolution resulting from radionuclide contamination of the environment.

Botanists, phycologists, mycologists and zoologists described over 80 taxa of animals, plants, fungi, and protists that are new to science.

In the framework of the International Union for Conservation of Nature, which acts under the UN, zoologists were directly involved in the preparation of the European Red List and Atlas Hymenoptera (Atlas of hymenopterous insects of Europe). Parasitologists for the first time confirmed the possibility of transovarial transmission of pathogens of borreliosis, anaplasmosis and babesiosis by hard-bodied ticks (*Ixodes*; *Ixodidae*).

Research data on the emergence and spread of invasive species suggest that every year the number and harmfulness of such species is growing, even within the natural protected areas in Ukraine.

Researchers of botanical gardens and arboreta developed a protocol for predicting the adaptive capacity of introduced exotic plants, based on physiological, biochemical and genetic assessment methods. In particular, it was found that species with high contents of phenolic compounds are promising for introduction.

Hydrobiologists discovered in the Kiev Reservoir the processes of spatial redistribution of bottom sediments that contain and actively accumulate radionuclides and other contaminants. In addition, climate change-induced effects of oxygen deficiency in the near-bottom layers of water contribute to their secondary pollution by toxicants.

Integrated research in plant physiology, soil science, and allelopathy showed a positive effect of allelochemicals, including cinnamic, salicylic and ascorbic acids, on the antioxidant activity of plants at the early stages of their development, which increases their drought resistance. Involvement of silicon minerals in the inhibition of nitrification processes and more efficient use of nitrogen fertilizers was demonstrated for the first time. It was also found that adding active silicon compounds to soil can improve the drought tolerance of plants and reduce the use of water for irrigation by more than one-third.

Last year, the work on development and breeding of new cultivars resulted in 24 certificates of state registration of plant varieties and patents for these cultivars. Moreover, 27 applications for new varieties of plants were submitted. Innovative varieties of winter wheat were recognized as a considerable achievement of plant breeding in Ukraine, Russia and Moldova. 2785 license agreements for cultivation of crops in production are implemented, ensured and put under scientific support, which is a significant contribution to ensuring food resources in our country. In addition, in order to further increase the implementation of agrotechnologies, representative offices of the NAS Institute of Plant Physiology and Genetics were opened in Russia and other CIS countries.

Through the combined efforts of scientists and producers, the work has been completed on the production cycle for obtaining biodiesel components from new Camelina (false-flax) varieties with high oil content; a pilot industrial unit with complete cycle was developed.

It is particularly rewarding to note that in the year of the 95th anniversary of the NAS of Ukraine two research projects actively contributed by scientists of our Department were recommended by the Committee on the State Prizes in Science and Technology of Ukraine for being awarded the State Prizes of Ukraine. There is no doubt that the results of basic and applied research obtained by our scientists in 2013 will also be highly appraised by the scientific community and the nation.

Economics



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

In 2013, the efforts of researchers of the NAS Economics Department were aimed at determining the essence and forecasting the consequences of inner institutional transformations of the socio-economic system of Ukraine in their interconnections with the risks stemming from the prospects of country's international integration associations, at studying the elimination of structural economy imbalances, human development, and identifying the priority areas of the economy and society modernization.

A number of significant results were obtained. The necessity of institutional transformations in the context of overcoming the consumer society and the welfare state crisis was grounded, and the importance of the ethical component of the regulatory mechanism of social and political interaction was shown.

Revealed were the logic of historical evolution and the essence of the relationships of the state and market institutions as complementary foundations of today's economy, which are the basis for resolving basic contradictions and overcoming disparities in the economic system of Ukraine.

The internal logic of the genesis of scientific approaches to and practical philosophy of ensuring the balance of education with other state functions was determined and the principles of their implementation completeness were found. A model was developed to determine the intergenerational consistency of price and value of the current ways of implementing the state's educational function.

The factors of gaps formation in the macroeconomic balance, which can lead to a rapid spreading of destructive processes, the emergence of destructive deficits and approaching to the default were determined and analyzed in detail.

Tools to analyze and assess risks or public finance in terms of hidden direct liabilities (income losses) of the government, related to peculiarities of tax laws and financial situations of businesses, were developed.

The advantages of transition from industry branch-based management to the state regulation of economic development relying on legally defined national priorities and approved innovative-investment projects were substantiated.

A set of legal, institutional, political, macroeconomic prerequisites to enable effective formation of public-private relations in attracting foreign investment with ensuring a balance of investors', government's and civil society's interests was grounded.

Scientific and practical approaches to forming a system of administrative services by public authorities in Ukraine were substantiated, and measures to improve this process were developed. Proposals towards improving legal, organizational and economic principles of state regulatory policy were determined.

The main risks and benefits of signing the Association Agreement between Ukraine, on the one hand, and the European Union and its member states, on the other, were estimated. A number of recommendations towards avoiding the most acute contradictions and inconsistencies in implementing Ukraine's integration aspirations and declared major areas of cooperation both with individual countries and integrative structures were provided.

The problem of the loss of state control over strategically important enterprises of basic industries that ensure the economic sovereignty of Ukraine was emphasized. The necessity of constitutional and legal securing of retention of high-priority assets in the ownership of the state and local communities was founded.

The estimation of demographic losses due to Ukraine Famine of 1932–1934 was made, which amounted to 4.5 million, including 3.9 million through excess mortality and 0.6 million through loss of the unborn.

Theoretical and methodological principles of the "green" economy doctrine as a necessary lever for sustainable development of Ukraine were formed. Conceptual principles of achieving environmental security of Ukraine and its border regions under European integration were substantiated.

A draft Concept of the administrative-territorial reform in Ukraine, which provides the decentralization and separation of the functions of government at various levels on the principle of subsidiarity and regulation of the system of administrative units, was worked out.

Economic scientists developed political and economic approaches to studying international processes of regional integration and they found that these processes are rather specific, subordinated only to a small number of fundamental patterns that determine their logic of evolution as systemic processes. Methodological approaches to assess the impact of free trade zones on the welfare and economic growth of the nation were formulated.

In the short term the efforts of economists will be focused on: determining the principal lines and mechanisms of the adjustment of institutional transformations; substantiating the essence of economic policy concerning the system of tools for state regulation of the economy; validating the ways of improving state policy in financial recovery of enterprises of the real economy sector; on developing methodological principles of modeling current demographic, social and socio-economic processes.

History, Philosophy and Law



**O. S. Onyschenko,
Academician-Secretar
of the Department**

In 2013, scholars of the Department achieved good results in developing theoretical interdisciplinary studies of integrated relationships in the 'personality–society–state' triad. This research, which takes into account the historical aspect, is aimed at creating a system of proposals on developing modern Ukrainian civil society, optimizing its members' relations in searching the ways to ensure public consensus in preserving national interests in implementing state's social and humanitarian policy.

Significant results were obtained in the implementation of numerous large-scale research and publishing projects. E.g., scholars of the NAS I.F. Kuras Institute of Political and Ethnic Studies jointly with scholars from the other institutions of the Department and the Section of Social Sciences and Humanities developed a draft NAS "State and Society in Ukraine: History and Contemporaneity" (by NAS Acad. V.M. Heyets, NAS Acad. O.S. Onyschenko, NAS Acad. Yu.A. Levenets, O.M. Mayboroda et al.).

The NAS Institute of the History of Ukraine published the collective monograph «Government and Society in Ukraine. Historical Context» (by NAS Acad. V.A. Smolii, NAS Corr. Memb. O.P. Tolochko, S.V. Kulchitskyy et al.), vol.10 of the «Encyclopaedia of the History of Ukraine» (by NAS Acad. V.A. Smolii, NAS Corr. Memb. H.V. Boryak, S.V. Kulchitskyy et al.).

The staff of NAS Institute of Encyclopedic Research published the 13th volume of the «Encyclopaedia of Modern Ukraine» (by NAS Acad. I.M. Dzuvuba and M.H. Zheleznyak). Scholars of the Department prepared for publishing «The Glossary of the Comprehensive Encyclopaedia of Ukraine» (by Yu.I. Shapoval, M.H. Zheleznyak et al.).

Sociological monitoring data «Ukrainian society. 1992–2013. Current State and Change Dynamics» (by NAS Acad. V.M. Vorona, NAS Corr. Memb. M.O. Shulha et al.) were published by the NAS Institute of Sociology.

Researchers from the NAS M.S. Hrushevsky Institute of Ukrainian Archeography and Source Studies published the 2nd part of vol. 4 of the 50-volume edition of M.S. Hrushevsky's works (NAS Corr. Memb. P.S. Sokhan, O.O. Mavrin, I.B. Hyrych, S.M. Pankova et al.).

To the 200th anniversary of Taras Shevchenko, specialists of V.I. Vernadsky National Library of Ukraine prepared «T.H. Shevchenko's works bibliography. 1840–2014» (V.Yu. Omelchuk, K.V. Lobuzina).

Scholars of the Department of Religion Studies

within the NAS H.S. Skovoroda Institute of Philosophy published the final part of the 10-volume «History of Religion in Ukraine» (A.M. Kolodnyi, L.O. Fylypovych, V.V. Klymov et al.).

A number of fundamental works to honour the 95th anniversary of the Academy were published by Department's researchers. Scholars of the NAS V.M. Koretsky Institute of State and Law prepared the collective monograph «Legal Status of the National Academy of Sciences of Ukraine: Past and Present» (NAS Acad. Yu.S. Shemshuchenko, V.P. Nahrebelnyi et al.). Scholars of the V.I. Vernadsky National Library of Ukraine published a collection of documents and materials «History of the NAS of Ukraine. 1951–1955» in 2 vol. (NAS Acad. O.S. Onyschenko, L.M. Yaremenko, S.V. Starovoyt, H.V. Indychenko). In the NAS Institute of the History of Ukraine a documentary edition «The Patons: Historical and Genealogical Research» (by NAS Acad. V.A. Smolii, M.F. Dmytriyenko, V.V. Tomozov) was issued..

Leading scholars of the Department participated in preparing the work «A.P. Aleksandrov and Ukrainian Science: to the 110th Anniversary of the Scientist» (by NAS Acad. A.H. Zahorodny, NAS Acad. O.S. Onyschenko, L.M. Yaremenko, H.V. Indychenko et al.).

For the state authorities, Department's institutions prepared proposals and recommendations for commemorating the 1025th anniversary of Kiev Rus' Baptizing. Scholars of the Department were involved in developing the "Program of Ukrainian and Russian Co operation in Social and Human Sciences for 2013–2014", the "Concept of Ukraine's CIS Presidency in 2014".

Institutions of the Department prepared amendments and proposals to the draft Laws of Ukraine 'On the Concept of National Ethnic Policy', 'On Ethnic Minorities in Ukraine', 'On Amendments to Some Legislative Acts (on increasing the responsibility for violations of public social and labour warranties, on implementing the recommendations of the European Commission on anti-corruption state policy)'.

Leading experts of the Department were engaged in preparing draft Law of Ukraine 'On the National Academy of Sciences of Ukraine', aimed at legislative regulation of the complex relations between the State and the Academy.

Participating in the Constitutional Assembly, scholars of the NAS V.M. Koretsky Institute of State and Law prepared a draft 'Concept of Amendments and Additions to the Constitution of Ukraine'.

In 2014 the efforts of the Bureau and institutions of the Department will be focused on complex interdisciplinary studies of the issues of consolidation of the Ukrainian society, democratization and reformation of the political system of Ukraine, development of legal mechanisms of conflict-free resolution of social and political contradictions, strengthening the values of civil peace, solidarity and responsibility in the Ukrainian society.

Philology Studies, Art Criticism, Ethnology

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

In the year under review, scholars of the NAS Department of Literature, Language and Art Studies continued to focus their research efforts on fundamental and applied issues of the development of literature, language, art studies, traditional every-day culture, computer linguistics; they addressed major challenges of the scholarly back-up to the national and cultural revival of Ukraine, 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 by Department's scholars of 86 monographs and collections of writings, 10 study textbooks and manuals for university students and schoolchildren, 15 reference books and dictionaries, 26 academically treated and commented belles-lettres texts, nearly 1500 publications in academic proceedings and periodicals.

The high academic relevance of Department's research was proved by awarding the 2013 NAS I.Ya. Franko Prize to literature scholar O.A. Kaminchuk for her work «Artistic Discourse of Ukrainian Poetry of Late 19th – Early 20th Century», the 2013 annual Prize of the President of Ukraine to arts scholar O.M. Poshvyvailo for the work «Opishne Painted Bowls of the Second Half of the 19th – Early 20th Century». For his outstanding services to the advancement of Ukrainian science, V.V. Starynets, deputy director of the NAS O.O. Potebnia Institute of Linguistics, received the Honour Diploma of the Cabinet of Ministers of Ukraine, art scholar Z.A. Chehusova was honoured with the Order of Princess Olha III Class, and NAS Corresponding Member V.I. Naulko – with the Order 'For Merits'.

Literature scholars of the Department provided a comprehensive analysis of the status and trends in the development of Ukrainian and world literatures in the early 21st century. Besides, relying on the achievements of today's literature studies and novel methodological approaches, they reviewed the creative heritage of the leading figures in the history of Ukrainian belles-lettres – T.Shevchenko, I.Franko, Lesya Ukrainka – and its place in the international cultural context. A number of fundamental works were published: «On Three Continents» (Book 1) (by NAS Academician I.M. Dziuba), «Transit Culture: Symptoms of Post-Colonial Trauma» (by NAS Corresponding Member T.I. Hundorova), «Story of Time: Discourse of 1960th Movement in Ukrainian Literature of 20th Century» (by L.B. Tarnashynska), «Semio-

sphere of Mykola Bazhan: Thoughts over Master's Creative Work» (M.P. Kodak), profound collective scholarly writings «Shevchenko's World» (issue 5), «Gogol Studies» (issue 20), «Heritage» (issue 7), commented editions of literary works by T.Shevchenko, O.Dovzhenko, O.Senatovych, V.Vysotskyi et al. Volumes 3 and 4 of the national-scale edition – the 6-volume «Shevchenko Encyclopedia» – were published. Prepared for publishing were volumes 6–8 of the «History of Ukrainian Literature» in 12 volumes, its volumes 1, 2 and 5 were published.

Linguistic scholars of the Department studied in comparative historical and typological aspects the spatial and temporal dynamics of the of the Ukrainian language functioning in the early 21st century, the development of Ukrainian oikonymicon and terminology, and the evolution of vocabularies of Romance, Germanic and Baltic languages. To implement the Decree of the President of Ukraine 'On the Development of the National Dictionary Base', Department's scholars worked out and put to operation the virtual terminological laboratory on the 'Mechanics' subject area, and the first electronic «Welding» Ukrainian – Russian – English terminological dictionary on laser disk was issued. 7 new-generation dictionaries were published, including vol.6 of the 7-volume «Etymological Dictionary of the Ukrainian Language» and vol. 4 of the 20-volume «Dictionary of the Ukrainian Language». Also published were such fundamental works as «Indo-European Heritage in Vocabularies of Slavic, Baltic, Germanic and Romance Languages», «Language Issue as Object of Manipulative Strategies in Today's Political Discourse» (by O.H. Ruda), «Introduction to Slavic Philology» (by V.V. Luchyk), «Literary Norm and Speech Practice», collected academic works «Speech Culture» (issues 78 and 79), «Ukrainian Onomastics» etc.

Art scholars, folklorists and ethnologists of the Department completed the publication of the fundamental studies – «History of Decorative Art of Ukraine» in 5 volumes and 9 books, as well as «History of Decorative Art of Ukraine» in 5 volumes. All in all, the studies of diversified phenomena of traditional culture resulted in the publication of 60 collective and individual works: «Rusyn Ukrainians: Ethno-Linguistic and Ethno-Cultural Processes in Historical Evolution», «Ethnic Composition of the Population of Ukraine and Adjacent Lands» (by S.M. Chorny), «Folklore of Ukrainian-Hungarian Borderline Territories» (by L.H. Mushketyk) etc.

Principal research-management activities of the Department in the year under review focused on developing new scholarly concepts and programs, national-scale and Academy work to implement presidential decrees and government's assignments, on preparing and holding 52 international and all-Ukrainian academic conferences, the XV Congress of Slavic Scholars in Minsk (the Republic of Belarus) and the VIII International Congress of Ukrainian Scholars in Kyiv.

Coordination of Research-and-Publishing Activities of the NAS of Ukraine



Ya.S. Yatskiv,
Member of the Academy
Presidium

In 2013, the scientific community of Ukraine celebrated several prominent anniversaries: the 95th anniversary of founding the National Academy of Sciences of Ukraine (NAS of Ukraine) and the 95th birthday of Academician Borys Evgenievych Paton, the President of the NAS of Ukraine for more than 50 years; the 150th anniversary of Volodymyr Ivanovych Vernadsky, outstanding scientist and the first President of the Academy; the 110th anniversary of Academician Anatolii Petrovich Aleksandrov, the President of the Academy of Sciences of the USSR (in 1975–1986); the 100th anniversary of Academician Mykola Mykhailovych Amosov, famous scientist and the founder of thoracic and cardiovascular surgery in Ukraine; the 90th anniversary of Academician Volodymyr Mykhailovych Glushkov, the pioneer of Ukrainian cybernetics; the 20th anniversary of founding the International Association of the Academies of Sciences, as well as anniversaries of other famous scientists and renowned scientific institutions. So, the year was marked by publishing new highly informative books and conducting scientific search, by preparing interesting articles, producing documentaries and feature films, and by holding celebration conferences and presentations.

The book «M.M. Amosov. 100th Anniversary», published by NAS 'Akademperiodyka' PH, is worth special mentioning. In addition to articles about the bright life and incessant work of M.M. Amosov, it contains the full text of one of his best books «Thoughts and Heart». M.M. Amosov is widely known as a scientist and surgeon, science manager and the founder of the science school of biological and medical cybernetics. As well as the director of the Institute of Cardiovascular Surgery, he was an active public figure and a deputy of the USSR Supreme Soviet, a philosopher and writer. M.M. Amosov carried out one of the first studies of the current state of the Ukrainian society and gave a clear statement of the national idea of the independent Ukraine. He proposed his vision of the ideological development of Ukraine and the concept of its reconstruction. Back in the mid-1990-ies he stressed that a promising path for our country is the path towards European democratic values and economic models.

In the reporting year, NAS 'Naukova Dumka' PH issued 45 books (over 13 700 copies) having in total about 1000 printer's sheets. 'Akademperiodyka' PH issued 15 books (about 11 400 copies) having in total about 700 printer's sheets. So, in 2013, the number of books published at the State order amounted to nearly 8 per cent of the total number of books issued by the Academy.

In general, research-and-publishing activities of the NAS of Ukraine in 2013 can be considered as successful. Its institutions issued about 600 scientific monographs and 200 books of collected research papers, nearly 400 educational, reference and popular science editions. Foreign publishers issued 90 scientific monographs prepared by NAS scientists in 2013. It is the largest number in the last 15 years. One should note the publication of the 1st volume of the «History of Ukrainian Literature» and the completion of the fundamental encyclopedic projects: «History of Ukrainian Culture», «Encyclopedia of the History of Ukraine» and «Shevchenko Encyclopedia».

The NAS Research-and-Publishing Council (RPC) coordinates research and publishing activities of NAS institutions, prepares state-order publication plans and checks their fulfillment. It initiated a series of measures towards re-issuing NAS scientific journals by foreign publishers and other related matters concerning references in the articles prepared in English or Russian etc.

Practical aspects of the representation of Ukrainian scientific publications in the world's leading scientometric databases was discussed at the annual conference 'Scientific periodicals: traditions and innovations', which was initiated by the NAS 'Akademperiodyka' PH, and at working meetings, attended by representatives of corporations, in particular, by integrators of Elsevier, EBSCO, Springer scientific information databases.

Scientific publishing activities are among the major tasks of the Academy that are aimed at disseminating the outcomes of scientific research and forming the strategic line of its further development.

The global trend in these activities is a gradual increase in the number of titles accompanied by a decrease in their total circulations as well as a shift towards producing electronic editions. In the most general terms, changes in the scientific-and-publication activities of the NAS of Ukraine are associated with changes of the economic situation in the state. The desired increase in the number of scientific publications is slowed down by the lack of beneficial economic conditions for and legal support to the whole publishing and book-trading industry in the country.

Besides, the further progress of the NAS publishing activities depends on the development of printing and publishing potential of the NAS of Ukraine and organizing the complete publishing cycle within the Academy facilities.

One of the strategic tasks of the NAS of Ukraine should be a broad representation of the results of national scientific research in the modern forms that are accessible for the world scientific community. To deal with this challenge, Ukrainian scientists are to be motivated and stimulated both for foreign publications and for more active use of foreign languages in preparing scientific publications. Furthermore, organizational and financial support is to be provided to the NAS Research-and-Publishing Council for foreign publications.

Regional Structure of the National Academy of Sciences of Ukraine



• Liquidated:

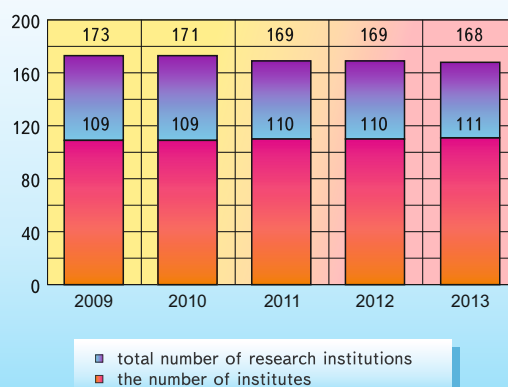
Institute of World Economy and International Relations

• Reorganized:

R&D Center of Magnetism of Technical Objects
into Institute of Technical Problems of Magnetism

Center for Megalopolis Ecomonitoring and Biodiversity Research
into Institute for Evolutionary Ecology

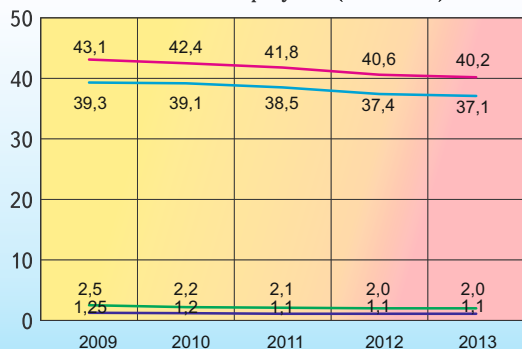
Total number of research institutions



NAS of Ukraine 2013

Total number of employees including:	40211
in research institutions	37128
in R&D organizations	1970
in service organizations	1109

Number of employees (thousand)

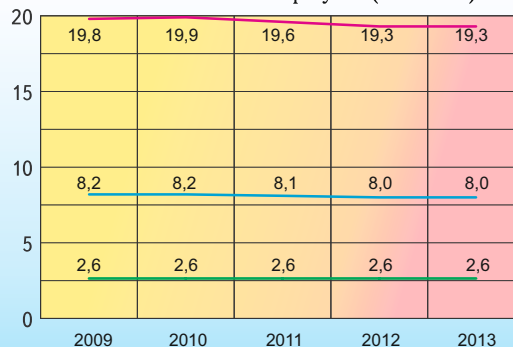


total
in research institutions
R&D facilities
in servicing

Statistics

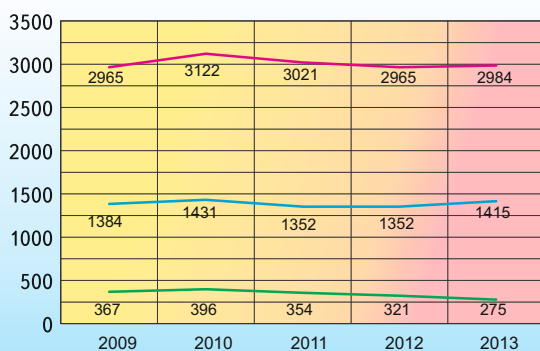
R&D employees including:	19292
Doctors of Sciences	2610
Candidates of Sciences (PhD)	8007

Number of R&D employees (thousand)



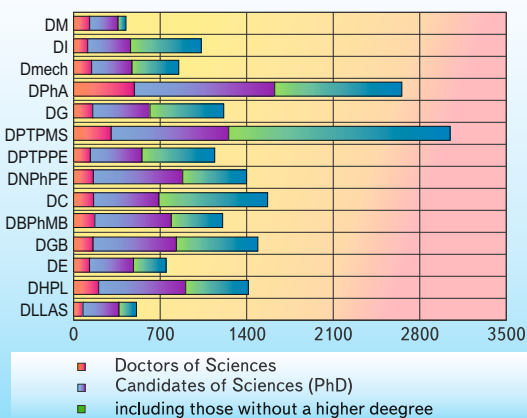
including those without a higher degree
Candidates of Sciences (PhD)
Doctors of Sciences

Number of employees under 35



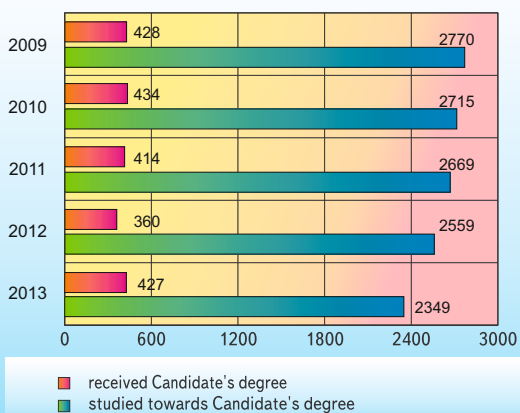
R&D employees*
Candidates of Sciences (PhD)*
Recruitment of university graduates
* without institutions under NAS Presidium

Distribution of scientists by departments

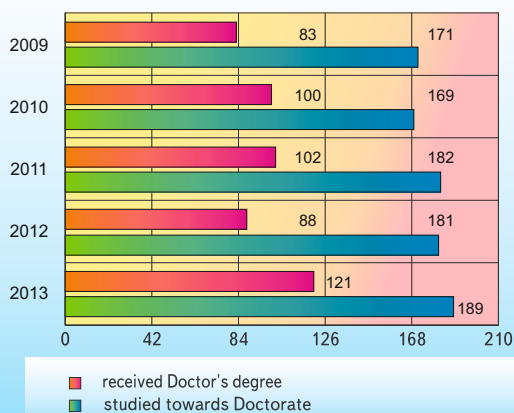


Doctors of Sciences
Candidates of Sciences (PhD)
including those without a higher degree

Training of research personnel



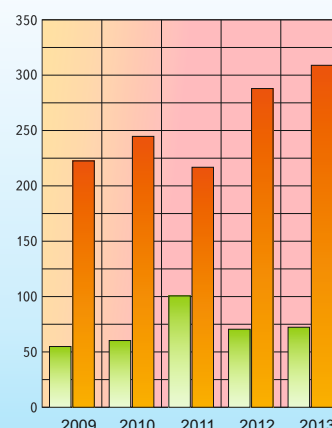
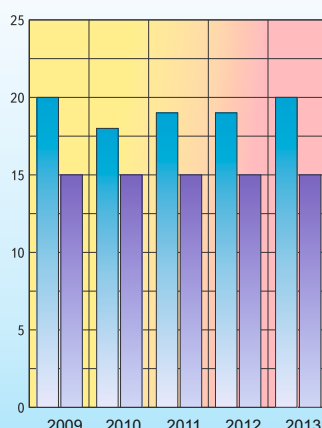
received Candidate's degree
studied towards Candidate's degree



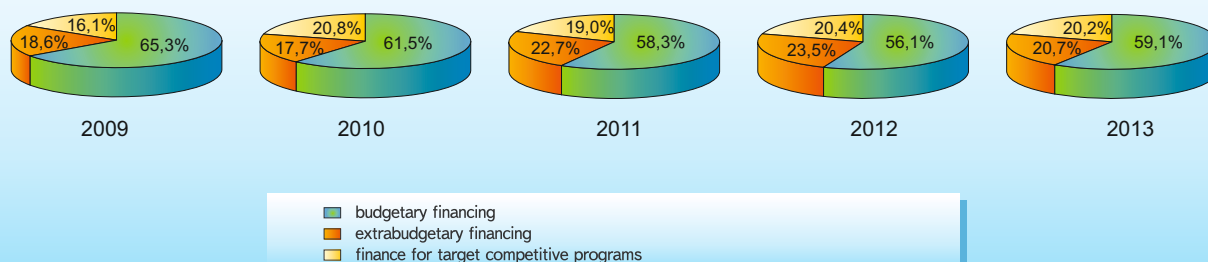
received Doctor's degree
studied towards Doctorate

Budget	thousand UAH
Total financing	3322531,1
General fund of the state budget	2661757,8
Basic funding from the State budget	1932741,7
Target programs finance	679228,8
Budget finance for personnel training	12282,3
Budget finance for health protection	36505,0
Extrabudgetary revenues	660773,3
Total expenditures	3311753,9
Expenditures on wages	2411810,3
Expenditures on equipment and instruments	196797,4
Expenditures on capital construction and reconstruction	5965,3
Expenditures on utilities	204741,8
Other expenditures	492439,1

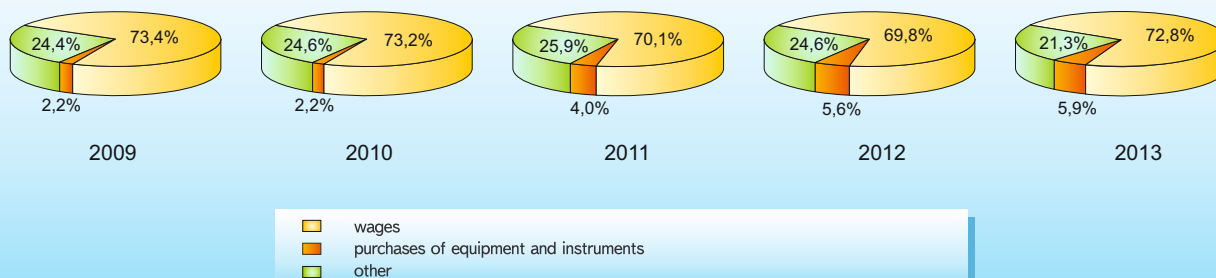
Target programs subjects



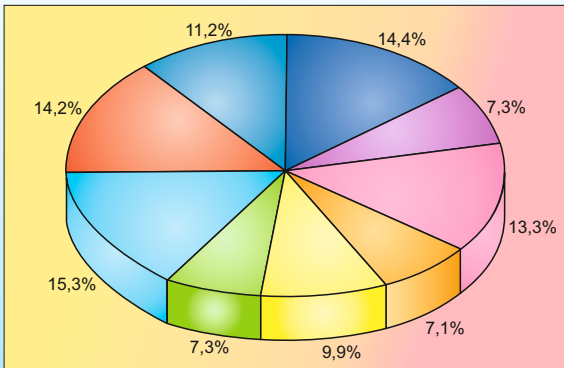
Distribution of finance by sources



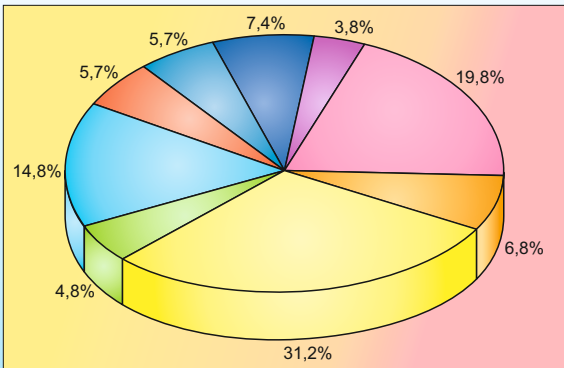
Distribution of expenditures by principal items



Distribution of basic budgetary finance

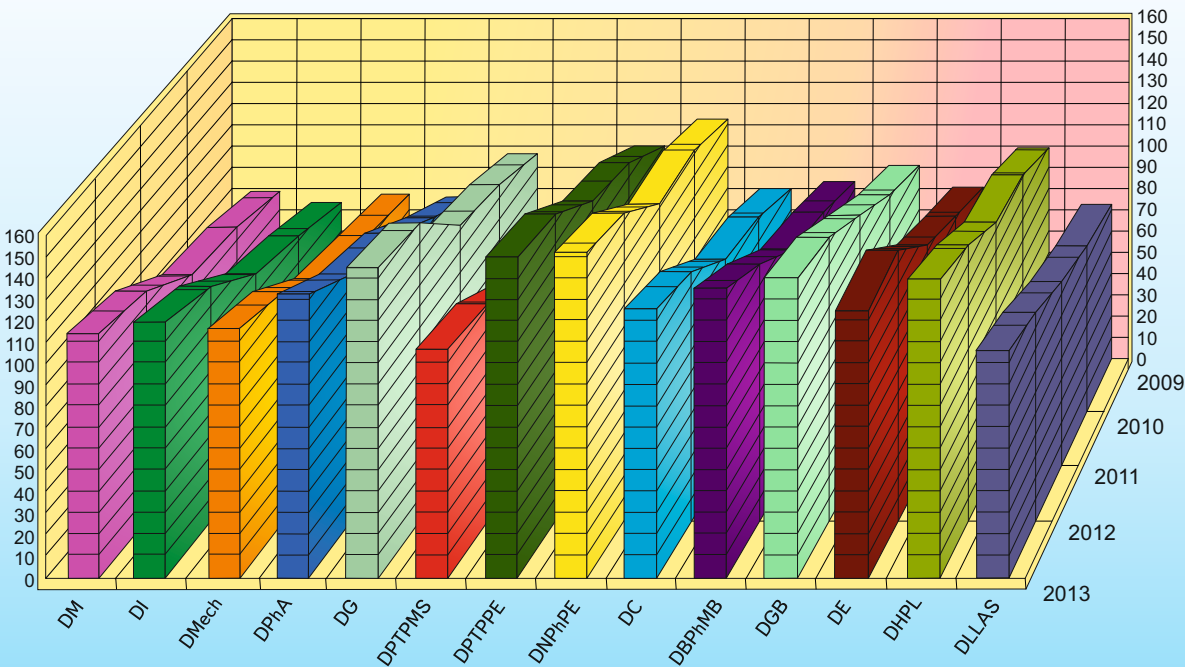


Distribution of extrabudgetary finance



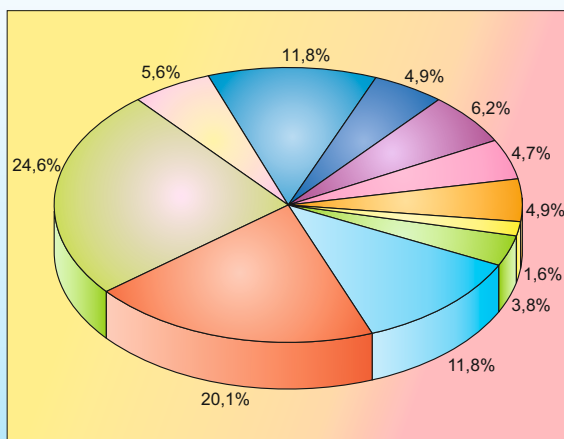
- | | | | | |
|-------------------------------------|--------------------|---------------------------------------|---------------------|--------------------------------|
| Mathematics, Mechanics, Informatics | Earth Sciences | Power Engineering | Chemistry | Social Sciences and Humanities |
| Physics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

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

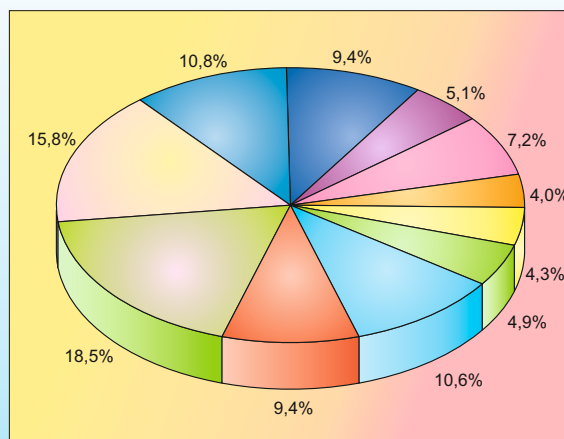


Publication of Academic Materials

Monographs

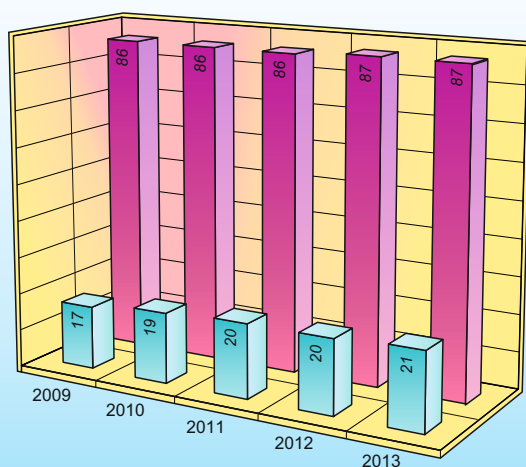


Papers



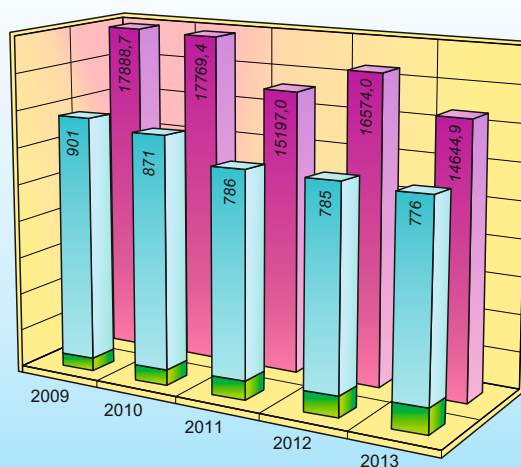
■ Mathematics, Mechanics, Informatics ■ Earth Sciences ■ Power Engineering ■ Chemistry ■ Economics ■ History, Philosophy and Law
■ Physics and Astronomy ■ Materials Sciences ■ Nuclear Physics and Power Engineering ■ Biological Sciences ■ Literature, Language and Art Studies

Academic Periodicals



■ total number of periodicals
■ including: the number of publications translated abroad

Publication of Academic Books

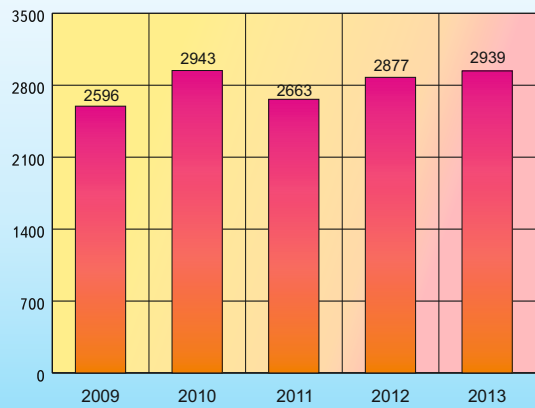


■ volume
■ the number of titles (■ incl. abroad)

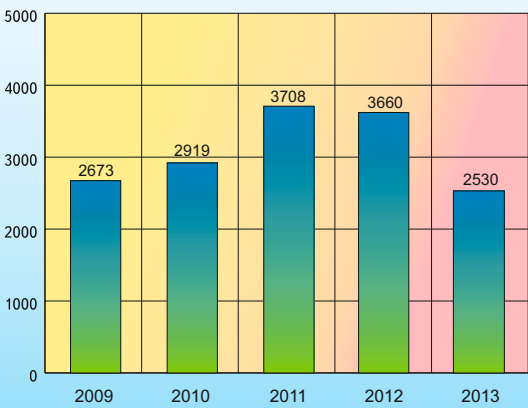
International Contacts of the National Academy of Sciences of Ukraine with Foreign Institutions



Foreign Scientists Received in Ukraine



Ukrainian Scientists Sent on Mission Abroad



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