

# **NATIONAL ACADEMY OF SCIENCES OF UKRAINE**

**BRIEF ANNUAL REPORT**

**2011**



## Main Results



**B. E. Paton,**  
**President of the Academy**

2011 was a special year for Ukraine. The nation celebrated the 20<sup>th</sup> anniversary of its independence. And one can state with confidence that scholars of the National Academy of Sciences (NAS) of Ukraine have made a significant contribution to the establishment of Ukrainian independence.

The results of Academy's activities in the year under review also prove this.

The development of the theory of functions and quasi-conformal mappings match the best international achievements. Of great importance is the fact that scientists did not confine their efforts to generating purely theoretical knowledge but developed new variational methods for solving applied problems related to tomography, studies of thermal and magnetic fields in composite materials etc.

Relying on powerful super-computer systems and information technologies, experts in cybernetics, mathematics, geophysics, and economics carried out a wide range of interdisciplinary research for developing mathematical methods, algorithms and application program packages to solve problems with high dimensionality.

Last year saw significant efforts in the modernization and use of the world's largest UTR-2 and URAN radio telescopes, and the construction of Giant Ukrainian Radio Telescope (GURT). The achievements of NAS radio astronomers in decameter radio astronomy have shown its international level and won worldwide recognition.

One should also note the involvement of Academy specialists in equipping the Ukrainian 'Sich' satellite for remote sensing of the Earth with state-of-the-art scientific instruments, in preparing and implementing joint Russian-Ukrainian experiments on board the Russian segment of the International Space Station. In total, over 30 research institutions of the Academy carried out task-oriented space research last year. To improve their coordination a targeted interdisciplinary NAS program of space research for 2012–2016 was started.

Investigations in the field of novel materials were developed further. Among them were studies of graphene properties, which, undoubtedly, are on the forefront of modern physics and technology. Our theorist physicists were the first to predict astonishing electron characteristics of this promising nanoelectronics material. Academy's scientists also created a novel class of tribotechnical composite materials, conducted profound investigations into nanodisperse

luminescent materials, new metal hydride alloys and other hydrogen active materials.

Major fundamental results were obtained in the biology of stem cells and the development on their basis of highly efficient tissue- and cell-based preparations that are promising for the reconstruction of damaged organs and tissues. Our biologists made a significant contribution to science: they gathered a collection of recombinant human antibodies and producer hybridomas of monoclonal antibodies. It is a major bank of cell lines producing antibodies to a number of functionally important human proteins and antigens of infectious agents, being a very useful resource for studies and diagnoses of disorders in the system of hemostasis.

A wide range of theoretical and applied results obtained by scholars in socio-economic field was instrumental in preparing numerous fundamental publications, analytical and prognostic reports, concepts and draft laws. Among them was the third National Report 'National Sovereignty of Ukraine under Globalization', the 'Concept of Ukraine's Humanitarian Development up to 2020'. Those documents meet challenges of the national and global dimensions, which the Ukrainian society was faced with and which it will have to overcome in the future. The publications of the 11<sup>th</sup> volume of the «Encyclopedia of Modern Ukraine» and the 8<sup>th</sup> volume of the «Encyclopedia of the History of Ukraine» were important results of 2011.

As before, one of the top priorities in Academy's activities was the scientific back-up to solving the problems of utmost importance for the whole nation and to innovative economic growth. In this connection, of great importance was the meeting of V.F. Yanukovich, the President of Ukraine, with the President of the National Academy of Sciences. It stressed the key role of science in further modernization of the country, strengthening of its competitiveness, which, according to the President of Ukraine, requires up-to-date mechanisms of science involvement in the process.

In the reporting year, Academy's scientists dealt with such a pressing problem as energy saving and energy efficiency. A joint session of the NAS Presidium and the Board of the State Agency for Energy Efficiency and Energy Saving addressed that issue. The session identified the areas of research towards improving the efficiency of energy consumption, employing alternative and renewable energy sources, developing an economic mechanism to stimulate energy saving and its use.

A significant contribution to solving energy-efficiency problems was a successful implementation of the Academy-initiated state program to develop and introduce energy-efficient LED light sources and illuminating systems. Under this program, industrial manufacturing has already been started, and the products have found practical application in Kyiv, Kharkiv and Donetsk.

The Academy also organized close and efficient collaboration with the Ministry of Regional Develop-

ment, Construction, Housing and Communal Services, with other interested ministries, agencies and companies, aimed at improving energy efficiency in housing and public utilities. Academy's scientists, for example, participated in the implementation of a large-scale project for processing biogas from dumps of solid domestic waste; the first step of that work involved 12 such dumps in 10 Ukrainian oblasts.

The work on scientific back-up to nuclear energy industry of Ukraine was continued. In view of the tragic events of 25 years ago at the Chornobyl NPP and those of the last year in Japan at the Fukushima-1 NPP, special emphasis was placed on improving the safety of both the operating and prospective nuclear facilities. Those issues, alongside with results of research in nuclear energy engineering, and plans to develop nuclear energy industries of Ukraine and Russia, were discussed at the fourth annual Ukraine-Russian R&D conference 'Advancement of Nuclear Energy as a Factor of Sustainable Inter-State Collaboration', which was attended by specialists of more than 30 research and producer institutions of the two countries.

Of great importance for Ukrainian nuclear physics and nuclear power engineering are the agreements on nuclear safety reached by the Presidents of the USA and Ukraine last year. According to them, the American side assumed an obligation to provide financial and engineering support to Ukraine as the remuneration for eliminating highly enriched uranium. The assistance will be provided for constructing and commissioning a novel nuclear facility in 2014 – a neutron source based on subcritical assembly that will be controlled by an electron accelerator. It will be hosted by the National Science Center 'Kharkiv Institute of Physics and Technology'. The installation has already been designed collaboratively by researchers of the Argonne National Laboratory and our Academy; today the design is under expert examination for operation safety, with a view to obtaining the necessary license.

Of the utmost importance for Ukraine is the development and use of cutting-edge biotechnologies. Achievements of molecular genetics and gene engineering create new possibilities for significantly improving the efficiency of plant selection and seed growing, producing new valuable plant and animal genotypes, developing new vaccines and diagnostics. Academy's specialists in genetic selection provided farming industry with 5 new highly efficient winter wheat varieties. Over 1 million hectares were allotted for growing these and other new varieties of grain crops.

There are also a number of new biotechnology developments of our scientists produced by collaborative efforts with the National Academy of Agricultural Sciences (NAAS). Last year a joint meeting of NAS and NAAS Presidiums was held, where we discussed possible ways of further advancement of biotechnologies and their role in ensuring the food security of the country. It is crystal clear that the rational use of Ukraine's natural potential relying on advanced biotechnologies could help Ukraine take a leading place in the world agricultural production.

Significant outcomes of Academy research have also found their application in such a socially impor-

tant area as public health. Today NAS scientists can propose nearly 200 developments to practical medicine; some of those have already been used in clinical practice. For example, last year, specialists organized the production of the FAZAGRAPH instrument, which permits a quick estimate of the functional status of human cardiovascular system, and the portable 'Trenar' electronic device for restoring locomotor functions disturbed by severe diseases. Manufacturers have started the introduction of the 'Diabet' device, intended for detecting carbohydrate metabolism imbalance in humans and aid to diabetes patients. New effective carbon implants to restore skeletal system in humans with bone defects, osteoporosis, and to treat compound fractures are characterized with the highest biocompatibility among the available analogs; they have received a certificate and the respective medical permission. Over 100 operations have been performed in Ukraine with the use of such transplants.

The number and the range of surgeries using high-frequency electric welding of soft tissues continue to grow. Since this technology is very promising, the E. O. Paton Electric Welding Institute, M. M. Amosov National Institute of Cardiovascular Surgery and Kyiv Polytechnical Institute set up the Inter-Agency Center of Cardiovascular Engineering.

Jointly with specialists of 'Rosatom' and the 'TVEL' Fuel Company, Academy's scientists started to implement a project on developing technologies and producing the equipment for nuclear medicine; that would permit efficient diagnostics and treatment of cancer and cardiovascular diseases at early stages.

One should also mention that in the reporting year regional science centers, operating under NAS and MES of Ukraine, initiated the implementation of numerous regional R&D programs aimed at a wider use of research achievements in dealing with environmental problems, optimizing energy and resource consumption, improving the reliability of operation and extending the residual life of buildings and structures. At the end of the year, after a rather long interruption, the collaboration between the NAS of Ukraine and the Kyiv City State Administration was resumed. A collaboration agreement was signed, which is aimed at introducing advanced, more efficient and economical technologies in energy-supply systems, scientific support to improving the environment in the Ukrainian capital, increasing the efficiency of public transport operation and city roads, upgrading medical services for Kyiv inhabitants. Scholars' attention will also be focused on protecting the historic environment, on intellectual, cultural and spiritual progress of Kyivans.

Furthering the cooperation with educational institutions was among the priorities of NAS activities. Now this multidimensional interaction involves extensive work of many scientists with schoolchildren, a significant support to and close collaboration with the Junior Academy of Sciences, targeted training of students at science-and-education centers established jointly with leading universities, training of highly skilled research personnel, joint research in a wide range of areas and shared use of unique scientific equipment, preparing monographs, study textbooks and manuals.

I'd like to emphasize that the NAS of Ukraine has

been giving a lot of attention to youth, involving and anchoring them in the science sphere. The Academy and the state provide targeted support to gifted young scientists, awarding prizes, scholarships, research grants to them, publishing their research works. And I should stress that all those efforts, taken over a long period of time, have produced a positive effect on the number of young researchers in the Academy. Yet, for a cardinal turn in the situation for the better, the state must take further large-scale measures. In this connection, the Council of the Presidents of the Academies of Sciences of Ukraine addressed the state authorities with an appeal to immediately start dealing with such urgent problems of young researchers as providing housing, state-of-the-art scientific equipment and appropriate salaries for them.

In 2011, the international ties of the Academy were strengthened. Traditionally, the main place was taken by promoting collaboration with the CIS academies of sciences, primarily, with the Russian Academy of Sciences (RAS). The signing of the Agreement on S&T Collaboration with the RAS at a joint session of academies' Presidiums last summer in Moscow and the Agreement on Scientific Collaboration with the RAS Siberian Branch were important public events.

The NAS of Ukraine participated in the activities of the International Association of the Academies of Sciences (IAAS), first and foremost, in preparing and holding a joint session of IAAS Council and the Council of the Eurasian Association of Universities in the framework of the VI Forum of Artists and Intellectuals of the CIS member countries. It was held in Kyiv in October 2011 and determined principal collaboration tasks. Among them were, in particular, coordinating and holding joint research, promoting the development of the CIS International Innovation Center for Nanotechnologies, organizing the International Scientific Center for Astronomical and Bio-Medical Research in the Elbrus area, numerous summer schools, sessions and training courses for young scientists, post-graduate and university students, hosted by leading CIS research institutions and universities.

A priority line of international scientific collaboration was joint work with the European Center of Nuclear Research (CERN) and the Joint Institute for Nuclear Research (JINR). In the framework of various programs of these centers, NAS scientists were involved in investigating elementary particle physics and determining their interaction model. In 2011, intellectual ties with the International Institute for Applied Systems Analysis (IIASA) achieved a new level.

Major efforts went into forming an adequate information and advisory service to assist in involving Ukrainian scientists to European programs and projects. Long work of the Academy in this area resulted in signing a joint order of the National Academy of Sciences and the State Agency on Science, Innovation and Informatization on establishing national contact centers of the European Commission FP7.

Now in brief on providing research with necessary resources. In the reporting year the NAS financing from the general fund of the state budget amounted to UAH 2.3bn. That was nearly 6,3% more against the previous year, which permitted a salary rise in the Academy by 7% and full payment for public utilities and energy. Given that, we only managed to keep the

total core financing of research institutions at the previous level. Yet, allocations for all-Academy targeted research programs and competitive R&D projects were, unfortunately, reduced significantly. The financing of employer-assisted housing, the construction of research facilities and renovation of unique research equipment by the state budget was discontinued. A positive result of the previous year in this respect was a 42% rise in revenues to the special fund of the budget, which amounted to nearly UAH 625m.

The trend of inadequate NAS financing from the state budget persists in 2012. The law 'On the 2012 State Budget of Ukraine' provides UAH 2.439bn for financing the Academy from the general fund of the state budget, which only is 6% more than the respective expenditures of the previous year. But, in view of a scheduled step-by-step rise in the first wage grade and the minimum wage in 2012, there will be a need of increasing the wages fund by 25 % as compared to 2011. There are also plans to raise prices for utility services this year. Besides, the approved NAS financing for 2012 from the state budget does not provide for its capital expenditure needs.

In view of all this, the top priority for NAS departments and all its institutions, alongside with economical and rational spending, must be more active efforts for increasing the revenues to the special fund of the budget. The work on optimizing networks of departments' institutions and coordinating their research with the advancement of key science areas and the needs of the nation must be continued. It should be mentioned that 10 institutions were liquidated or reorganized last year, but this work is to be continued.

Undoubtedly, the principal task of the Academy and its institutions under present conditions is to carry out R&D work at a high scientific level, preserve leading science schools, be more actively involved in preparation and implementation of large-scale innovative projects. I am sure that the National Academy of Sciences of Ukraine has sufficient scientific, R&D, and creative potential to overcome current financial problems and make a major contribution to socio-economic, technological and cultural progress of the nation.

**Implementation of Innovative Developments by the Institutions of the NAS Section of Physical, Engineering, and Mathematical Sciences in Domestic Industry**

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

Besides generating new fundamental knowledge, an equally important task for the scientists of the NAS of Ukraine is application-oriented scientific research. Institutions of the NAS Section of Physical, Engineering, and Mathematical Sciences have produced numerous scientific and technical developments whose implementation can give a noticeable boost to the branches of Ukrainian economy. Section's scientists make considerable efforts to search for partners with whom the available scientific results could be brought to the level of high technologies and products. There are a number of examples to illustrate this successful cooperation.

Jointly with power engineering and construction specialists, scientists of the Institute of Mathematics used their achievements to calculate the thermomechanical behavior and protective ability of the reactor shell of power unit No. 1 at the Pivdenno-Ukrainska NPP under extreme combined action of natural and technological factors.

Researchers of the Institute of Information Recording Problems, who gained considerable experience in developing methods and facilities to diagnose eye defects, in collaboration with medical institutions produced a technology and technological equipment, and organized manufacturing of combined spheroprismatic lenses, as well as eyeglasses with them, for squint treatment.

Experts of the International Research and Training Center for Information Technologies and Systems developed a software/hardware complex for generating intricately shaped signals to provide information support for the commercial production of the 'Fazagraf' device. That is to be widely applied for diagnosing the functional state of human heart. The complex was implemented at the G. I. Petrovskiy Kyiv Plant of Automatic Devices.

At the request of the O. F. Zasyadko Mine, the Institute for Problems of Mathematical Machines and Systems in collaboration with other institutions of the NAS of Ukraine, the Ministry of Coal Industry of Ukraine, and the Ministry of Education, Youth and Sports of Ukraine developed technical proposals and tasks for establishing a safety control center in mining.

Scientists of the G. S. Pysarenko Institute for Problems of Strength, jointly with the 'Motor Sich' joint-stock company, via physical simulation of aero-elastic processes formulated criteria for forecasting the behavior of blade rows and modernized the test bed for determining loads on compressor blades in aircraft gas-turbine engines. The economic benefit due to

the implementation of this development amounts to UAH 700,000 for every aircraft engine produced.

Researchers of the G. V. Kurdyumov Institute for Metal Physics, together with the NAS Physics-and-Technology Research and Educational Center, developed and produced an industrial prototype of portable equipment for ultrasonic impact treatment of metals and alloys, in particular, for strengthening and increasing the durability of welded joints. The application of this equipment at the Kryukiv Carriage Works (Kremenchuk) ensured a reduction in strains in lateral carriage walls and an increase in fatigue strength of welded elements in carriage underframes.

At the V. E. Lashkarev Institute of Semiconductor Physics, an industrial prototype of automatic equipment intended for collecting and separating saturated vapour emitted by heat-consuming facilities was developed, produced, and applied in industry. Fuel saving due to its use at enterprises that rely on saturated vapor as the heat-carrier can reach 40–50%.

At the Ukrainian State R&D Institute of Mining Geology, Rock Mechanics and Mine Surveying, a methodology was developed to estimate gas content in coal-bearing beds of the Donbas region on the basis of formation analysis. The procedure was implemented at the V. M. Bazhanov Mine of the 'Makiivuhillia' State Enterprise. Owing to the application of this method, elimination of the necessity to drill just one borehole can produce an economic benefit of over UAH 1.7m.

Scientists of the Physical-and-Technological Institute of Metals and Alloys, relying on their research into crystallization and structure formation in low-carbon peritectic steels, proposed an optimized regime for the secondary cooling zone in continuous slab casting. The innovation allowed the final faultiness of slabs to be reduced by 37% at the Alchevsk Metallurgical Works. Due to the reduction in metal losses when producing 17,000 tons of this steel, the economic benefit amounted to more than UAH 8m.

Using a polycrystalline diamond film with high radiation resistance, experts of the National Science Center 'Kharkiv Institute of Physics and Technology' developed, fabricated, and tested the first domestic detector of ionizing radiation for in-pile dosimetry in systems of radiation control at NPPs of Ukraine.

The examples given above prove once again that, even in a difficult economic situation, the demand for R&D results still exists. The task for our scientists must be the focus in their activities on those branches of national economy that are of top priority for the country and whose development and modernization would call for major investments.

In 2011, the institutions of the Section developed and submitted to the Administration of the President of Ukraine a number of large-scale proposals towards the development and wide implementation of novel technologies and facilities in medicine, power engineering and energy saving, advanced materials, computer science, prospecting and exploration of mineral resources, nuclear power engineering.



## Activities of Inter-Agency Scientific Council of the National Academy of Sciences and the National Academy of Agricultural Sciences of Ukraine for Agricultural Sector Development



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

Development of its agribusiness is one of the top priorities of Ukraine's economy. This is primarily due to the fact that the agricultural sector incorporates a considerable share of national wealth – fertile Ukrainian soils, and ensures to a large extent food security and export potential of the state.

The National Academy of Sciences (NAS) of Ukraine, which integrates research institutions working in various scientific fields, since the time of its establishment has placed a special emphasis on solving agricultural problems, both on its own and in close collaboration with institutions of the National Academy of Agricultural Sciences of Ukraine (NAAS).

In recent decades the agricultural sector in developed countries has undergone considerable qualitative changes due to the wide application of high technologies. That gave rise to essentially new requirements to fundamental and applied research, as well as consolidated and coordinated efforts of scientists in this field.

The activities of the Inter-Agency Scientific Council of NAS and NAAS for the Agricultural Sector (hereinafter, Council) are aimed at these tasks and targets. The Council was set up through the initiative of the President of the National Academy of Sciences of Ukraine, NAS Academician B.E. Paton, by the joint resolution of the NAS Presidium and the NAAS Presidium of 28 April 1999 # 151/9, and has been successfully operating for more than 12 years.

The Council membership includes prominent scholars of the two academies and leading experts of ministries and agencies of Ukraine, which helps extend and strengthen intellectual ties between institutions of the academies, scientists and other specialists. The Council promotes the coordination of research in agriculture and improvement of the efficiency of targeted research into its specific problems. It also determines priority areas of fundamental and applied research in the interests of various branches of agriculture, draws up recommendations for their further development etc.

Principal work of the Council is done in standing and interim committees (working groups), which analyze the status of and major trends in specific sectors of agricultural science and production, and prepare proposals for consideration by the Council. The issues discussed at Council meetings are of utmost relevance and importance for the nation. Some of those include:

- land use and preservation of soil fertility in Ukraine;

- strategy for agriculture transformation and ensuring food security of Ukraine;
- ways of using lands contaminated by radionuclides in the national economy;
- prospects of biofuel production in Ukraine;
- efficient farming land management in the present-day conditions;
- problems of weed-infested crops and ways of reducing weed damage to agriculture;
- the use of remote sensing technologies for the agricultural sector of Ukraine.

As a result of discussions at its meetings, relevant decisions are made by the Council and analytical policy reports are prepared with proposals to take urgent measures; these reports are then forwarded to the Presidential Administration, the Cabinet of Ministers, the Verkhovna Rada, and respective ministries of Ukraine.

The relevance and importance of the abovementioned issues for the agricultural sector of Ukraine is indisputable; however, Council's activities are faced with some objective problems.

In particular, unfortunately, there is a low demand for and priority given to proposals and recommendations prepared by the Council and submitted to central policy-making bodies. As a result, those proposals are not always implemented in their practical decisions.

Another important issue is the need for better coordination of agricultural research conducted in our academies. The situation could be improved through closer cooperation between respective scientific departments of the academies and the establishment of joint R&D programs with parity financing.

The joint session of the NAS and NAAS Presidiums, held on 12 October 2011, addressed important issues of furthering collaboration between the academies. In particular, the meeting approved the successful work of the Council. Yet, it noted that the development of certain research areas, the degree of implementation of scientific results, and the level of cooperation and coordination of research between institutions of the two academies do not fully meet the present-day requirements. A better shared use of their S&T potential and the employment of updated organizational and economic mechanisms for the implementation of promising developments in the agricultural sector are the most urgent tasks.

In the near future, agricultural policy of Ukraine should be adapted to global trends in that field. It is time to change the policy for advancing the agricultural sector of Ukraine, taking into account globalization trends, interests of domestic producers, and the need for preserving the national features of rural lifestyles and socio-economic structure of agriculture.

The solution of the abovementioned strategic tasks and development of respective government programs will contribute to the sustainable development of agriculture and the whole economy of Ukraine.

## **Socio-Humanitarian Factors of Scientific Back-Up to Modernization of the Ukrainian Society**



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

In the life of the nation, 2011 was marked with systemic reforms aimed at overcoming the challenges of the 21<sup>st</sup> century and modernizing the Ukrainian society. According to the tasks outlined by the state and the Government, the NAS Section of Socio-Humanities focused its efforts on developing the conceptual vision of a radically new course towards the implementation of urgent modernizing transformations, finding science-based solutions to problems of economic development and overcoming challenges caused by the world recession, validating the priorities of economic and social policy and the necessary changes in Ukraine's political system and, respectively, ensuring the cultural progress of the country.

Today's globalization has added the utmost relevance to the issues of ensuring the national sovereignty of Ukraine. The National Report of the NAS of Ukraine 'National Sovereignty of Ukraine under Globalization' has been the response of socio-humanitarian sciences to this challenge. The Report is a strategic and yet practice-oriented document proposing ways of strengthening national sovereignty and mechanisms of introducing additional factors to ensure domestic and international sovereignty of Ukraine.

Under the assignment of the highest state administration bodies, the Section has completed the draft Concept of the Humanitarian Progress of Ukraine up to 2020, which determines the principal trends in the development of the humanitarian sphere, proposes mechanisms for improving the humanitarian policy of the state and further society modernization.

Section's scholars took part in preparing the National Report «Ukraine: on the Way to Social Involvement» on human development in 2011 – an independent edition of the UN Development Program (UNDP) in Ukraine.

Significant results were achieved in the scientific back-up to socio-economic transformations. Research carried out by the Department of Economics enabled its scientists to validate new approaches to post-crisis structural reforms as a factor of transforming a unipolar world into a multipolar one, to analyze the ideology of the globalized world's monocentrism, which allowed them to predict trends in the development of global mega-civilization and modifications of civilization regions in the 21<sup>st</sup> century. Specific features of the principal risks in the development of labour market and unemployment were isolated and revealed. A procedure was developed for quantitative evaluation of the effect of foreign corporate borrowings on budget revenues, alongside with recommendations

towards improving the efficiency of legislation on the state support to business. The 'Intelligent Automated Information-and-Analytical System for Budgetary Process Back-Up', based on super-computer, was produced; it permits scientists to validate budgetary decisions and forecast the consequences of budgetary and fiscal policy for the socio-economic development of the nation.

The studies carried out by scholars of the Department of History, Philosophy and Law enabled them to develop theoretical models of interacting cultures and civilizations in today's world, determine geopolitical, historical, and socio-cultural features of the Ukrainian society in terms of Ukraine's integration to the world community. Another stage of the all-European monitoring 'European Social Survey' was conducted. Legal scholars prepared the Concept of Forming and Organizing the Constitutional Assembly Activities, approved by the Presidential Decree of 25 January 2012 # 31 and proposals towards: improving constitutional legislation of Ukraine concerning elections and referendums, defense and national security, lines of administrative and judiciary reforms; scientific back-up to the implementation of the National Anti-Corruption Strategy for 2011–2015, which would improve the efficiency of the system for preventing and fighting the corruption.

A large-scale 6-volume research project «Ukraine: History of a Great Nation» was completed. Published was the «Political Encyclopedia» – the first encyclopedic edition in Ukraine which analyzes the key categories of political science, provides profound and comprehensive definitions for the most popular notions of the political and scholarly discourse.

The Department of Literature, Language and Art Studies analyzed the formation and evolution of the Ukrainian language, the effects of inner and extralinguistic factors on its development; specific features in the development of culture of Ukrainians and ethnic minorities in Ukraine early in the 21<sup>st</sup> century, the dynamics of formation and reproduction of typical social identities. The publication of fundamental 5-volume «History of Ukrainian Art» was completed. Prepared were the 1<sup>st</sup> and 2<sup>nd</sup> volumes of the projects of the national scope – «Shevchenko Encyclopedia» in 6 volumes and «History of Ukrainian Literature» in 12 volumes. The laser disk 'Integrated Lexicographic System «Dictionaries of Ukraine» was issued.

In the near future, efforts of socio-humanitarian scholars will be aimed at profound research into the major issues of the state and society development, producing scientific models, proposals and recommendations as to the ways of dealing with priority tasks in the advancement of economy, the social sphere, ensuring the cultural progress of Ukraine.



## Advancement of International Collaboration



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

At the present stage of science development, conducting high-grade research, mobilizing resources of foreign partners for this purpose requires increasingly closer scientific collaboration. The National Academy of Sciences of Ukraine gives a lot of attention to this line of its activities.

To preserve, support and advance common S&T area, the NAS leadership, relying on the International Association of the Academies of Sciences, took consistent steps to promote collaboration with the academies of sciences of the CIS countries.

In particular, the potential of collaboration with Russian partners grew significantly. A joint session of RAS and NAS Presidiums, held in Moscow in June 2011, discussed, among other issues, bilateral scientific collaboration. An updated Agreement on S&T Collaboration between RAS and NAS was signed, and the RAS and NAS prize for outstanding research results was established.

Last year, the implementation of the joint NAS and RAS research program 'The Black Sea as a Simulation Model of the Ocean' was started. Another example of successful Ukrainian-Russian collaboration is the joint project 'Potential'; its task is to control and forecast space weather, using the 'Sich-2' satellite. 'Pivdenne' Design Office, in collaboration with R&D teams of the Academy, ensured the preparation and implementation of this project concerning the development and tune-up of the equipment for diagnosing ionosphere plasma parameters.

Summing up the visit of a high-profile delegation of the Novosibirsk oblast to Kyiv, the National Academy of Sciences of Ukraine signed an agreement on scientific collaboration between the National Academy of Sciences of Ukraine and the Siberian Branch of the Russian Academy of Sciences, which provides for joint research on a competitive basis.

At the meeting of the NAS President B. E. Paton with the President of the Republic of Turkmenistan G. Berdymukhamedov during the official visit of the President of Ukraine V. F. Yanukovich to Turkmenistan, an arrangement on developing ties in science was reached. The Presidents of both academies signed an Agreement on Scientific Collaboration. Besides, the Presidents of the NAS of Ukraine and the National Academy of Sciences of the Republic of Armenia signed the updated Collaboration Agreement in Kyiv on 22 October 2011.

Of significant importance is the fact that the National Academy of Sciences of Ukraine took part in the

national display of Ukraine at the International Exhibition to mark the 20th CIS anniversary. The aim of the exhibition was to promote inter-state collaboration in the priority areas of CIS activities. The participation in this event contributed to improving the international image of the Academy and to furthering its collaboration with CIS scientists. The developments demonstrated by the NAS Departments of Physical-and-Technical Problems of Materials Science, Information Science, Physics and Astronomy attracted special interest of exhibition visitors.

Of significant importance was the meeting of the NAS President B. E. Paton with the scientific adviser to the State Council of the Republic of Cuba Fidel Castro Diaz-Balart that took place in May 2011. During the meetings the parties gave a lot of attention to scientific and R&D collaboration between Ukraine and Cuba. The meeting resulted in signing a protocol further to the Agreement on Scientific Collaboration between the NAS of Ukraine and the Academy of Sciences of the Republic of Cuba signed earlier.

The interaction of the NAS of Ukraine with institutions of the PRC was also extended. To develop it and increase its efficiency, the NAS E. O. Paton Electric Welding Institute has become a co-founder of the Chinese-Ukrainian E. O. Paton Welding Institute, whose establishment and activities have reached the level of inter-government relations of Ukraine and the PRC. In December 2011, the NAS delegation headed by the NAS Vice-President A. G. Naumovets visited Guangzhou and took part in numerous events and the first session of the joint commission on S&T collaboration between the People's Government of Guangzhou and the NAS of Ukraine. An agreement on bilateral collaboration was signed during the session.

Beside long-term bilateral interaction with academies and science centers of other countries, great emphasis was placed on active collaboration with leading international scientific organizations and programs.

New conditions of collaboration with the International Institute for Applied Systems Analysis, approved by an IIASA Council decision in 2011, provide for future implementation of a large-scale joint project in the interests of Ukraine under the Strategic IIASA Research Plan for 2011–2015.

Increasingly deeper has become NAS involvement in research under numerous programs of the European Center of Nuclear Research (CERN, Geneva) and Joint Institute for Nuclear Research (JINR, Dubna). Experiments in the framework of long-term programs ALICE, LHCb, CMS etc, using gauges developed by scientists of Academy institutions and grid infrastructure of a high-power computing system, ensure a high level of research in cutting-edge areas of high energy physics.

## Activities of NAS General Meeting and Presidium



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

In the reporting year the principal activities of the NAS General Meeting and Presidium were aimed at further advancement and coordination of research in top-priority areas of science and technology, broader participation of Academy scientists in resolving highly relevant issues of state functioning, integration of Ukrainian scientists to the education process and international scientific community.

The annual session of the NAS General Meeting, held on 21 April 2011 and attended by V. M. Lytvyn, the Head of the Verkhovna Rada of Ukraine and NAS Academician, R. V. Bohatyriova, the Secretary of the Council for National Security and Defense of Ukraine, presidents of the specialized academies of sciences, representatives of ministries and agencies of Ukraine, the Kyiv City State Administration, academic community, mass media, and foreign guests, summarized Academy's work in the reporting year, identified the ways of ensuring the efficiency of its further activities. The summarizing report of Academician B. E. Paton, the NAS President, and its discussion, in particular, showed that in this important and challenging period in the life of the nation – overcoming the impacts of the world financial and economic crisis – the major task for the NAS of Ukraine is to produce reliable scientific back-up to dynamic socio-economic, technological, political and cultural transformations for country's modernization, improvements in the quality of life of its citizens.

NAS President B. E. Paton presented the highest Academy award – the V. I. Vernadsky Gold Medal – to NAS Academician M. P. Lysytsia for his outstanding achievements in optics and spectroscopy and to Professor Manuel Cardona – the Honorary Director of the Max Plank Institute for Solid State Research for prominent achievements in solid state physics and optics. Diplomas were also presented to winners of NAS prizes named after famous scholars.

In 2011, three sessions of the NAS General Meeting were held to mark the jubilees of outstanding scientists. On 18 February 2011 the session of the NAS General Meeting commemorated M. V. Keldysh, a prominent scientist in the field of mathematics, mechanics, space science and technology, talented science manager, Academician of the USSR Academy of Sciences, marking the 100<sup>th</sup> anniversary of his birth. On 20 April 2011, a jubilee session of the NAS General meeting was held to mark the 130<sup>th</sup> anniversary of Academician O. O. Bogomoletz – a famous scientist in pathophysiology, a state and public figure, science manager, the President of the Academy of Sciences of the Ukrainian SSR in 1930–1946. It was attended by

numerous representatives of scientific community. On 19 October 2011, both scientists and industrial manufacturers took part in a jubilee session of the NAS General Meeting commemorating the 100<sup>th</sup> anniversary of M. K. Yangel, a prominent mechanics scientist, designer of space vehicles, and the founder of the scientific and designer school of missile production.

Last year NAS Presidium meetings gave priority consideration to the advancement of fundamental research in natural, engineering sciences and socio-humanities. It heard over 20 scientific presentations: those on highly relevant issues of physics, nanotechnologies, materials science, Earth sciences, medicine, and the development of Slavic studies. In the period under review, special emphasis was placed on the implementation of state S&T targeted programs and targeted research programs of NAS Departments, summing up their implementation, coordinating fundamental research done by agencies and organizations of Ukraine. To fulfill a President's assignment, a joint meeting of the Presidiums of NAS, NAPS, NAMS and the Union of University Presidents of Ukraine discussed and approved the draft Concept of Humanitarian Progress of Ukraine up to 2020. A joint session of NAS and NAAS Presidiums identified important areas of biotechnology research for establishing competitive agribusiness and ensuring food security of the state. Presidium meetings also considered promising approaches and novel solutions to the advancement of chemical industry in Ukraine, its heat-and-power public utilities, safe operation of coal mines, and domestic production of medicines. In particular, a joint meeting of the NAS Presidium and the Board of the State Agency on Energy Efficiency and Energy Saving defined ways of improving the efficiency of energy consumption, ensuring the energy security of the country. An agreement on S&T collaboration in implementing cutting-edge energy technologies was signed. Of great importance was the joint session of RAS and NAS Presidiums, where the Agreement on S&T Collaboration was signed. The session also heard a number of presentations made by leading NAS and RAS scientists, considered the progress of joint research projects, and approved the Regulation on the Prize for outstanding scientific results of joint research.

In the reporting year, the NAS Presidium aimed significant efforts towards supporting and advancing research of young scientists. Its meetings discussed the results of R&D works carried out by young scholars with Academy grants, ear-marked financing for the studies of young scientists, awarded NAS prizes for best research works to young scholars and students, granted academy and state scholarships.

In the year under review, the NAS Presidium held 23 meetings and 10 meetings of the Presidium Bureau, approved 369 resolutions, specifically, those on international and publishing activities, assessment of research institutions, allocating ear-marked finance for supporting Academy's infrastructure, organizing the all-Ukrainian Science Festival, marking memorable dates, the 25<sup>th</sup> anniversary of the Chornobyl accident, in particular.

## Mathematics



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

In 2011, scientists of the NAS Department of Mathematics carried out important fundamental research in the field of mathematical sciences. Numerous significant scientific results were obtained.

Experts in the field of differential equations and dynamical systems proposed a new Floquet-type formula for periodic systems and investigated the coexistence of homoclinic and periodic trajectories of dynamical systems. The correct solvability of a system of equations that describes the interaction of a viscous liquid in a bounded reservoir was proved. The absolutely continuous spectrum of the realization of the three-dimensional Schrödinger operator with infinitely many point interactions was investigated. It was shown that the asymptotic behavior of the solution of the Cauchy problem for a modified Korteweg–de Vries equation is described by a modulated hyperelliptic function. Conditions were established for the correct solvability of the problem for linear anisotropic partial differential equations.

In the field of mathematical physics and functional analysis, the Cauchy problem for two-sided Toda chains was studied. The systems of integrable coupled Schrödinger equations were classified. The structure of families of orthoprojectors connected with each other by relations of the Temperley–Lieb type was investigated. A model of a cell gas was constructed, which is a quasicontinuous approximation of continuous systems of classical statistical mechanics. New estimates were obtained that characterize the accuracy of the reconstruction of the potential of the Sturm–Liouville boundary-value problem on a semiaxis in the case where scattering data are known only on a finite interval of spectral parameter values. The structure of the Maxwell operator spectrum in periodic composite media was studied, and examples of media corresponding to operators with given gaps in the spectrum were constructed.

In the field of the theory of functions, the polynomial Smale problem was solved, and new mean-value theorems were proved for functions of real and complex variables. The theory of variations, limit behavior, and asymptotic homogeneity of solutions of the Beltrami equations was developed. Asymptotically exact estimates were obtained for the best nonsymmetric approximations of nonsymmetric classes of functions by algebraic polynomials in the mean, and exact-order estimates were found for the widths of the Nikol'skii–Besov classes of periodic functions of many variables in  $L_q$  space.

In probability theory and mathematical statistics, a

method was developed for the asymptotic analysis of large deviations for random evolutions with locally independent increments in the scheme of asymptotically small diffusion. For compact perturbations of the Wiener process, the form of regularization of local times of self-intersection was determined. The central limit theorem was proved for linear statistics of the eigenvalues of orthogonally and symplectically invariant ensembles of random matrices of a large order. The supports of Gaussian distributions on locally compact Abelian groups were described. The principle of large deviations was validated for inverse stochastic equations.

In the field of geometry and topology, the computation of Morse numbers for smooth manifolds of the dimension larger than 5 was completed. An estimate was obtained for the width of a spherical layer in which a compact convex hypersurface is located. Sufficient conditions for a surface to belong to a four-dimensional space were proved. The criterion for the convexity of an acyclic compact set in the Euclidean space was investigated. All invariant hyper-Kählerian structures on cotangent bundles of symmetric Hermitian spaces were found.

Algebraists generalized Kahn's results concerning the relationship between the Cohen–Macaulay modules on surface singularities and vector bundles. A relationship between factorizations of groups and nondegenerate involutive set-theoretic solutions of the Yang–Baxter quantum equation was described.

In the field of mathematical problems of mechanics, a modal system that describes forced oscillations of a liquid in circular cylindrical tanks was constructed. A new method was proposed for solving axisymmetric problems of static thermoelasticity for a body with thermally active or thermally insulated thin inclusions. The method of linearizing parameters to determine temperature fields in thin-walled thermosensitive structural elements was tested. Spectral controllability of an elastic Kirchhoff plate with two-dimensional control was investigated. The thermomechanical behaviour of non-ferromagnetic electroconductive bodies under the action of pulsed electromagnetic fields was studied.

In mathematical modeling and computational and applied mathematics, a theory of exact and truncated compact difference schemes for solving boundary-value problems for nonlinear ordinary differential equations was constructed, and the theory of exponentially convergent methods was developed to solve the Cauchy problem for abstract differential equations.

For his significant contribution to the theory of difference equations and discrete dynamical systems, O. M. Sharkovsky was awarded the Bernd Aulbach Prize of the International Society of Difference Equations.

Scientists of the Department supervised the preparation of 8 doctor-of-science and 33 candidate-of-science theses. They published 23 monographic works, 10 study books and manuals.

Department's institutions were organizers and co-organizers of 14 science forums, attended by leading scientists of the USA, Europe and CIS countries.

## Information Science



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

In 2011, scientists of the NAS Department of Information Science obtained a number of important fundamental and applied results.

Relying on the information technology developed, they discovered changes in weakly expressed magnetic properties of the coal substance, which enabled them to understand the nature of sudden gas releases. The effect of administering harmful substances to laboratory animals on iron metabolism derangement was determined. That resulted in the overload of the animals' livers.

The concept, methodology, architecture, software and hardware for Internet communication, web portal and data centers of the Verkhovna Rada of Ukraine were designed.

In control theory, solutions were obtained for problems of determining invariant sets of a wide class of nonlinear discrete systems under uncontrolled additive disturbances. Using the systems approach, scientists developed methods for numerical analysis of multicomponent distributed systems, including those under pulsed and lumped influences, alongside with methods for accelerated modeling of the failure probability for new queueing systems. Efficient iterative methods were constructed to calculate weighted false inverse matrices and normal sham of incorrect problems of linear algebra. New methods for solving incorrect problems of binary classification were proposed. To calculate integrals of 12 fast-oscillating functions, formulas of the optimum accuracy and close to integrand functions were built. In game processing management, new team interception strategies were developed for capturing several fugitives under different constraints of conflict and uncertainty. Using sub-gradient imposition, a new method of dual layout was proposed for solving the problem of recognition.

Relying on symmetry properties in base records, scientists built effective Bayesian procedures for recognizing gene fragments in the genomes of higher organisms.

Mathematical models were developed to forecast space weather and describe binary alloy solidification under gravity convection. New models of dynamic distribution in energy networks were proposed, as well as methods and algorithms for efficient analysis and structuring the results of optimization-simulation experiments. A transformation approach for constructing intelligent multi-agent systems was constructed, which was based on meta-models of illegible withdrawal rules. Scientists proposed an emergency

risk assessment method reliant on varied geo-spatial information, and a system approach of accompanying the prediction process with computer tools, alongside with instruments for diagnostics of complex engineering systems.

In programming theory and technology, an updated version of insertion machine was developed for modelling multilevel structures of agents and environments; an ontology-oriented methodology for the functional composition of semantic web services, as well as agent architecture, methods and tools for intelligent search in Semantic Web environment were worked out.

An emotion- and articulation-based model for analyzing facial mimics was constructed. Software and hardware complexes of communication and telecommunication centers and terminals were developed and implemented in videoconference halls of the Armed Forces of Ukraine. A web-oriented interface for the access to Russian and Ukrainian SDC information portals was produced and integrated.

Fundamentals of the structure of ontology-controlled systems for processing language and subject-oriented knowledge were worked out. To assess emergency risks, a geo-information service with mapping function was developed; it was employed in the UN-SPIDER program supporting center. Specialists proposed methods of producing micro-prism structures with preset properties and minimum light flux losses for ophthalmology, as well as methods to minimize their chromatism due to the use of extra amplitude-phase diffraction lattices.

An IT complex for mass screening and treatment of severe common diseases was proposed. A number of results were obtained that improved the efficiency of data processing in grid environments and computer networks. A new class of electronic science-and-education space models was constructed. Novel algorithms for data protection were developed.

Principles of the advancement of long-term national standards in science-intensive IT were determined.

A concept of constructing sensor networks and mobile information technologies for agribusiness was worked out, as well as principles of designing next-generation intellectual video cameras.



## Mechanics



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

In 2011, 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 honoured with awards.

The concepts and approaches to developing the fundamentals of nanomechanics of composite materials, including the validation of transitions from discrete (atomic) structure to diverse continuum structures of materials were formulated. The study of static and dynamic deformation of complex shell systems made of advanced materials was carried out, accounting for inhomogeneous structure and type of material anisotropy.

Constitutive equations and methods were developed to solve problems of thermoviscoplasticity for deformation along linear and small-curvature paths, taking into account the third invariant stress deviator. A theory of dynamical equations stability on the time scale was developed and applied to neurodynamic problems and automatic regulation theory. A technique was developed to analyze transient nonlinear processes in cylindrical shells filled with flowing liquid under localized radial loading.

A number of driver's seat suspensions for varied transportation facilities were designed and manufactured. Experimental studies of these suspensions were carried out and results were obtained which showed that the proposed new designs of pneumatic suspensions are superior in their dynamic properties to the best pneumatic suspensions produced by the world-renowned companies (*Sears Seats*, USA and *Grammer*, Germany) with passive as well as semi-active and active vibration protection systems.

Devices for diagnostics and monitoring of ionosphere plasma parameters were developed, manufactured and tested. The 'Potential' scientific instrumentation system was installed on board the 'Sich-2' spacecraft. Based on the technique developed for processing output signals of instruments during their flight tests, a set of kinetic parameters of neutral and charged particles of the Earth polar ionosphere plasma was determined.

The general theory of mixed finite element methods was refined to solve quasi-static boundary-value problems describing non-isothermal processes of elastic-plastic deformation in bodies of irregular structural shape, with account being taken of the loa-

ding history. Relying on this, scientists improved methods to calculate the stress-strain state kinetics and resistance to brittle fracture of NPP reactor pressure vessels with cracks in the simulation of the operating and emergency modes of loading; those could be used for validating the safety margins and extending the lifetime of Ukrainian NPPs.

Structural-synergy models of deformation and fracture of elastic-hereditary systems and respective three destruction criteria were developed, namely, the energy criterion of dissipative type, the entropy one and the criterion in terms of structure damage. Algorithms were worked out to calculate the durability of the system, allowing for the instability of its structural parameters in time. Relying on the results of fundamental study, scientific principles were developed for creating a broad range of radically new vibro-seismo-isolators that improve the safety of high-risk facilities.

The mechanism of abnormal gas seeps in mined coal beds was established through integrated atomic and molecular studies based on physical modeling. The mechanism involves methane generation due to mechano-chemical synthesis reaction which occurs in the destruction of the coal substance aliphatic part under favorable thermodynamic conditions in the presence of appropriate reaction catalyst.

The dependences of phase velocities and features of wave attenuation in elastic-fluid mediums on the properties of fluid, medium structure and elastic parameters were established. The relationships describing the generation of surface waves, nonlinear ones in particular, by vessels moving in complex navigation channels, and their interaction with bank slopes were determined.

Mathematical models of filtration of multicomponent liquids and gases in natural and artificial porous mediums with phase transitions were developed, and fundamental patterns of hydrodynamic and hydrochemical field formation were analyzed. Methods were proposed to control hydrodynamic and hydrochemical parameters, using advanced technologies and novel types of engineering structures for water purification, protection of territories from flooding and groundwater pollution.

A method to study the exponential stability of systems of nonlinear differential equations with variable structure and permanent and time delays was developed. A nonlocal method for qualitative analysis of families of free and parametric oscillations of nonlinear Hamiltonian systems was proposed and criteria for their stability were found.

NAS scientists and specialists of the WESTA International Scientific-and-Industrial Corporation developed and commercialized technologies for refining black lead from the scrap of spent accumulator batteries (ACB), alloys for shunts of lead-acid ACB, and the main stages of technologies for reprocessing spent ACB scrap.



## Physics and Astronomy



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

For scientists of the NAS Department of Physics and Astronomy, last year was a year of fundamental and applied research that produced major results and enriched physical science. According to the main areas of Department's work, studies were carried out both at 18 NAS institutions and at higher education establishments. Research efforts were aimed not only at the generation of fundamental knowledge, but also at the development of novel technologies, innovation activities, and application of the new information in training programs.

In the field of fundamental interactions and microscopic structure of matter, one should note calculations of elementary particles spectra and their correlations in nuclear collisions, which is important for interpreting the experiments conducted at the Large Hadron Collider. Parameters describing W- and Z-bosons, or the most fundamental particles of matter, were determined.

In solid-state physics, noteworthy are investigations into spatial reorientation of magnetic vectors under the effect of laser pulses on magnetic crystals; this enables specialists to control the state of matter by optical methods. Besides, a unique possibility was found to provide targeted control of the strength and ductility of titanium alloys in manufacturing products with improved performances. The formation of vortex superlattices in magnetic films was predicted, thus opening up new horizons in constructing memory cells with a high recording density. The existence of extra slits in the spectra of magnetic-superconductor heterostructures was proved, this being essential for producing new superconductors. And, finally, a coal classification permitting a specification of the existing range of its grades was proposed on the basis of optical methods.

In low-temperature physics, a gigantic isotopic effect was detected in thermal expansion of carbon nanotubes with helium, which results from quantum diffusion processes. Special computer programs that could be used to compute thermal parameters for spacecraft under in-flight deep cooling were developed for the 'Pivdenne' Design Bureau.

Specialists in optics and laser physics worked out a theory of the so-called dark resonances, allowing new structures of time and frequency standards to be proposed. A bio-dosimeter covered by a Ukrainian patent was developed and manufactured. Principles of forming microporous Au and Ag films with improved optical properties were established. A pioneer procedure for analyzing liquid crystals was developed

on the basis of singular optics principles. Specialists also succeeded in manufacturing a thermoelectric module for elements cooling, to measure the content of heavy carbons in natural gases.

In surface physics and emission electronics, monolayer molecular structures on metal faces were produced. This opened ways to the selective control of surface properties, which could find application in molecular nanoelectronics.

These achievements were complemented with those in nanophysics and nanotechnologies, namely: magnetization of granulated films in inclined fields was studied; the module with 90W capacity in the range of 33 GHz was manufactured on the basis of Si diodes; and the phenomenon of organic conductor supersensitivity to ambient gases was discovered, which laid the foundation for the development of high-precision sensors intended for disease diagnostics.

In radio physics and electronics, the phenomenon of non-linear response of lamellar superconductors to the electromagnetic field was discovered, this being of great relevance for the development of superconducting state electrodynamics.

In soft matter physics, photo-orientation of nematic on chalcogenide glass surface was observed, proving that the latter is a promising material for liquid-crystal devices. The theory for flow in porous media was elaborated, allowing a better understanding of the nature of membrane selectivity.

Unique spectral examinations of numerous stars were carried out in astrophysics, astronomy and radio astronomy. Information on the fine structure of the spectra of numerous intergalactic sources was obtained. An ultralow-noise antenna amplifier was developed for the Ukrainian Giant Radio Telescope, providing a significant improvement in its sensitivity.

Some results obtained by the Department were duly appreciated. Two groups of researchers, namely, astronomers and semiconductor scientists were awarded the State Prizes of Ukraine in Science and Technology.

The highest NAS award – V. I. Vernadsky Gold Medal – was presented to Prof. M. P. Lisitsia, NAS Academician. Prof. V. T. Cherepin, NAS Corresponding Member, became a winner of the State Prize of Russia in Education. The Ilya Prigogin Gold Medal was awarded to L. S. Brizhik. The Prize of the Academies of Sciences of Belarus, Moldova and Ukraine went to Prof. O. E. Beliyev and Prof. Ya. Ya. Kudrik, NAS Corresponding Members. Prof. M. S. Soskin, NAS Corresponding Member, was awarded the F. I. Fyodorov Prize of the NAS of Belarus. State awards were presented to a number of Department's scientists.

The problems that complicate research still persist: the ageing of scientific staff, absence of the necessary amount of advanced equipment, limited subscription to scientific publications (electronic ones included), the major problem being the housing for young scientists. Yet, even in this situation, Department's efforts are aimed at pilot research that is of utmost importance for the future of Ukraine.

## Earth Sciences



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

In 2011, researchers of the NAS Department of Earth Sciences obtained a number of important fundamental and applied results. Some of those were honoured with prizes and awards. Examples of such important research works are as follows.

A new promising type of oil and gas fields was identified, which is associated with groups of sand bodies. Criteria were developed to forecast them in various-age terrigenous formations in Ukraine; they could serve as the basis for discovering both small and large fields.

A new class of Ukrainian mineral water was studied – a polymetallic water whose balneotherapeutic effect is determined by the microelements it contains. Conditions of formation and occurrence of this water were studied, alongside with its major- and trace-element composition as well as peculiarities of its biological effect. Selenitic mineral water was found in Ukraine for the first time; it is characterized with high selenium concentration exceeding the balneoactive norm. A correlation analysis was made between cancer incidence and elements of the chemical composition of drinking water in some regions of Ukraine. The results of research work were implemented in health care institutions and geological organizations.

Department's scientists compiled the Stratigraphic Code of Ukraine, which integrates rules and scientific criteria determining the geochronological base of state geological mapping, prospecting, exploration, use of minerals and diverse geological works in Ukraine.

The relationship of structural, textural and technological properties of rock salt was found; that could be the basis of its involvement into economic activities, underground construction in particular.

Production technologies were developed and synthetic analogues of natural and biogenic magnetite obtained. Samples of synthetic nanomagnetite were investigated with methods of transmission electron microscopy, X-ray diffraction and magnetometry. It was demonstrated that magnetic properties of synthesized nanomagnetite samples were practically indistinguishable from those of natural magnetite samples.

For the first time a methodology was developed for integrated geological and geophysical forecasts of methane collectors in coal deposits on the basis of petrophysics, borehole and ground geophysics. The methodology allows the siting of boreholes with maximum production rate of methane.

Specialists developed, manufactured and tested on locations new meters of surface streams – surface drift GPS buoys – designed for evaluating parameters of submarine groundwater discharge.

Climate variability of hydrophysical fields of the Black Sea was calculated on the basis of modified general circulation model of the Black Sea.

2011 State Prizes in Science and Technology were awarded to research works carried out at the Institute of Geological Sciences.

Ye.P. Gurov, researcher of the Institute of Geological Sciences, was honoured with the NAS P.Tutkovsky prize for a series of studies addressing the Earth interaction with cosmic matter.

S.P. Karmazynenko, researcher of the NAS Institute of Geography, received the annual prize of the President of Ukraine for young scientists for her cycle of works 'Micromorphological Studies of Fossil and Recent Soils in Ukraine'.

Research results obtained at the NAS Marine Hydrophysical Institute in collaboration with Russian scientists became the basis for implementing a joint research program of NAS and RAS 'The Black Sea as a Simulation Model of the Ocean'. The NAS Marine Hydrophysical Institute, NAS O. Kovalevskiy Institute of Biology of the Southern Seas, NAS Institute of Geological Sciences, RAS Institute of Computational Mathematics, P. Shyrshov Institute of Oceanology will be involved in it. The implementation of the joint program will strengthen integration in marine science and technology between researchers of the National Academy of Sciences of Ukraine and the Russian Academy of Sciences, and facilitate prompt response to the consequences of intense commercial development of marine areas, natural disasters, etc.

In 2011, Ukrainian Hydrometeorological Research Institute, operating under the Ministry for Emergencies and the NAS of Ukraine, was responsible for the development and submission to the Secretariate of the UN Framework Convention on Climate Change of the next National Cadastre of anthropogenic emission sources and greenhouse gases absorption by sinks in Ukraine. The document presents detailed information on the amount of emissions of six direct-action greenhouse gases, secondary greenhouse gases, as well as data on sulphur dioxide emissions.

An agreement was concluded on scientific cooperation with the 'Geochange' International Committee on Issues of Global Changes of the Geological Environment. To implement this agreement, the NAS S. Subbotin Institute of Geophysics was provided with the state-of-the-art ATROPATENA station for seismic-gravitation wave control.

In 2012, research efforts of Department's institutions will be directed towards furthering research to develop mineral resources, improve the efficiency of their use, and advance geoeological studies, with a view to stabilizing and improving the natural environment in Ukraine.

## Physical and Technical Problems of Materials Science



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

In 2011, scientists of the NAS Department of Physical and Technical Problems of Materials Science achieved a number of research results that are of a great importance for various branches of economy.

Studies of the effect of welding process parameters and tool's design features on the quality of joining of soft live tissues were carried out and their optimum values were determined as applied to EKV3-300 'Patonmed', a new-generation apparatus. A new basic commercial electro-surgical instrument was designed and tested in practice; it has updated ergonomic, functional and service characteristics. The equipment was certified for clinical application. A modified device was designed and clinically tested for application in ophthalmology; new surgical procedures were developed in collaboration with medical specialists.

Computational studies of the effect of complexly-stressed state of metals and hydrogen localization of ductility showed that with an increase in the stress level in metal the hydrogen effect is increased. Calculations of stress-strain state of a specimen with a stress raiser at static three-point bending were made with account for defects. The presence of hydrogen in metal results in the formation of microdefects at a lower value of local plastic deformation. The calculations showed that at the macrolevel this leads to the formation of cracks at a lower value of specimen bending, which is observed experimentally.

For the first time, scientists recorded a new hydride phase  $\text{Ti}_3\text{SnH}_{1+x}$  of BCC structure with the lattice parameter  $a=5.35\text{\AA}$ . It had higher hydrogen content as compared to the relatively well-known  $\text{Ti}_3\text{SnH}$  hydride of FCC structure that is maximally filled with hydrogen. The new and known hydride phases exist under similar temperature and pressure conditions, and with an increase in hydrogen capacity of FCC the  $\text{Ti}_3\text{SnH}$  hydride is substituted completely with the BCC of  $\text{Ti}_3\text{SnH}_{1+x}$  hydride. The novel results obtained will be used in the development of hydrogen accumulators with increased hydrogen capacity and cyclic resistance.

Using X-ray photoelectron spectroscopy, it was found that the primary precipitated amorphous tetrahedral carbon ta-C films contain a fraction in their composition that has over 80% of  $\text{sp}^3$  coordinated carbon atoms forming a tetrahedral coordinated phase in the film structure. Implantation treatment of initial ta-C film coatings by carbon ions leads to an increase in  $\text{sp}^2$  coordinated carbon atoms in the film structure that form nanocrystalline graphene structure elements in tetrahedral amorphous carbon phase

with an increase in the implantation dose.

Basic characteristics of hydrogenation and fracture of promising pipeline steels were established. The existence of some critical hydrogen concentration  $C_H^*$  in metal was shown; this leads to a significant loss in material resistance to its local fracture. The values of this characteristic for pipeline steels and the relation between the  $C_H^*$  parameter and the ultimate strength of the material were determined. The  $C_H^*$  characteristic is recommended as an important engineering parameter for evaluating the serviceability of pipelines for the transportation of hydrogen and its mixtures.

Heat conditions for growing crystals of sapphire of the optical quality and structural perfection, using horizontal directed crystallization (HDC) method, were determined and tested at 80 mm plate thickness, being a record for HDC. At the common  $350 \times 170 \times 80$  mm crystal size this development exceeds more than twice the economic efficiency of the conventional HDC method, ensures its compatibility as compared with the Kyropoulos method, and provides an opportunity for Ukraine to enter the world market of 6–10-inch sapphire backings for micro- and optical electronics.

A theory was developed to calculate and optimize the distribution of sources and heat flows in short-circuited, anisotropic and penetrated thermal elements based on  $\text{Bi}_2\text{Te}_3$ ,  $\text{PbTe}$ ,  $\text{PbTeGe}$ ,  $\text{SiGe}$ , and  $\text{FeSi}_2$  semiconductor materials under maximum thermodynamic efficiency of energy conversion. The designed models of thermoelectric batteries for cooling gas and liquid flows allow the development of thermoelectric cooling systems of maximum thermodynamic efficiency, whose cooling coefficient exceeds the best foreign analogs by 20–30%.

B.E. Paton, NAS Academician, was awarded the Order of Freedom. S. I. Kuchuk-Yatsenko, NAS Academician, and I. K. Pokhodnya, NAS Academician, were awarded the Order of Prince Yaroslav the Wise IV Class; V. V. Panasyuk, NAS Academician, was awarded the Order of Prince Yaroslav the Wise V Class; N. V. Novikov, NAS Academician, was awarded the 'Order of Merit' I Class; V. I. Makhnenko, NAS Academician, and A. A. Minaev, NAS Corresponding Member, were awarded the 'Order of Merit' II Class; G. P. Bogatyreva, Dr. of Technical Sciences, was awarded the Order of Princess Olga III Class.

A. A. Minaev, NAS Corresponding Member, was a winner of the State Prize of Ukraine in Education.

## Physical and Technical Problems of Power Engineering



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

In 2011, research efforts of the NAS Department of Physical and Technical Problems of Power Engineering (DPTPE) were directed towards the most important issues of power engineering in Ukraine. Their high relevance stems from a dramatic increase in energy prices on the world markets in recent years.

The work on implementing the multidisciplinary NAS research program 'R&D Problems of Integrating the Ukrainian Power System to the European Power System' ('Association') was going on. Scientists of the Department also took part in NAS integrated research programs 'Issues of Operation Life and Safety of Structures, Buildings and Machines' ('Operation Life'), 'Biofuel' and 'Fundamental Problems of Hydrogen Energy'.

In 2011, scientists of the Department obtained a number of significant fundamental and applied results.

For the first time ever, nanofluids based on nanolaminated termografenite, nanoalumosilicates and carbon nanotubes were produced; they permit a 2–3 times increase of critical heat fluxes in power engineering. Their use could reduce the size of heat exchange equipment and improve its performance in energy generation, transportation, machine building, electronics, metallurgy and medicine.

A hybrid method was proposed to search for the global minimum of multi-purpose extreme functional, which uses both conventional deterministic approaches and genetic algorithms. This allowed scientists to obtain a more efficient solution of ill-defined inverse problems of field theory.

Novel technologies of test-bench measurements and provision of specified magnetic characteristics based on theoretical and experimental studies of spacecraft magnetism were developed; those were used in the Ukrainian 'Sich-2' satellite. That ensured a high-quality magnetic orientation of the satellite, which was confirmed by its trial operation in orbit.

For the first time in Ukraine, a technology of circulating fluidized bed (CFB) was developed. The commercial operation of CFB-boiler unit # 4 was started last year at Starobeshivska power plant. Optimal combustion and waste-drying regimes were perfected at the CFB-boiler unit, which allowed specialists to ensure stable commercial operation of the facility in compliance with European standards for emissions of sulfur oxides, nitrogen and dust. It permitted the utilization of coal preparation waste from waste heaps and tailing ponds, as well as off-balance solid fuels

amounting to at least 300 thousand tons of equivalent fuel annually in compliance with European standards on harmful emissions. The unit is the best in Ukraine in terms of economic and environmental performance.

In 2011, scientists of the Department, jointly with those of other NAS departments, gave much attention to gas saving and replacement, which is of great importance for Ukraine. In particular, technologies and equipment for using biological raw materials as an alternative fuel to replace natural gas in boilers and industrial furnaces were developed. The prototype of the first in Ukraine 3.0 MW industrial gas generator for the gasification of waste wood and agricultural waste was designed. A pilot plant for modernizing heat supply of metro stations was designed and commissioned; it allowed a 6-fold decrease in heating costs for one station, the replacement of about 0.7m cubic meters of natural gas and a significant reduction of harmful emissions and greenhouse gases. On Vatutinska refractory products plant, a novel heating system for powerful rotary kiln using finely dispersed agriculture and forestry waste was developed and implemented. The introduction of this equipment in rotary kilns at steel works and construction materials factories would provide replacement of nearly 1.0bn cubic meters of natural gas with alternative fuels.

As a part of NAS integrated research program 'Association', new models of evaluating electric power systems and associations were developed. They allowed specialists to work out scenarios of changing basic modes under synchronous operation of IPS of Ukraine with EU of Russia as well as in the mode of transition to the synchronous operation with ENTSO-E electric power associations. Using the updated and extended 'Pyramida-V' software complex, this program also investigated the prospects of developing the entire Ukrainian gas-transportation system out to 2030. CR-factorization method was employed for modeling the electricity market of Ukraine to solve the problems of finding market equilibrium under imperfect competition. The method significantly reduces resource-intensity of procedures to search for the initial basis of maximum profit. It is also important to compile a database of hydrological parameters of small rivers and small hydro power plants in Ukraine, which would enable specialists to determine hydroelectric potential and work out regional programs of developing small hydropower facilities.

Relying on experimental studies of degradation processes in fuel-containing materials (FCM) of the 'Shelter' facility, Department's scientists concluded that radiation defect formation in paw-like FCMs leads to their structural transformation to a different state. Research results showed the necessity to remove the paw-like FCMs from the 'Shelter' facility in 2020–2025.

A number of Department's scholars were honoured with high state awards. For example, NAS Academician O.O. Klyuchnikov received the title of the Hero of Ukraine and the Order of the State.



## **Nuclear Physics and Power Engineering**



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

In 2011, scientists of the Department obtained new significant research results.

Among them, exact solutions for the equations describing dislocation-free glide in amorphous solids were obtained for the first time. So, the theoretical strength of metallic glass was determined, and the modes of inhomogeneous plastic deformation in the solids of this family were described.

Within the framework of International CERN NA63 Collaboration, the effect of suppression of ultrahigh-energy electron bremsstrahlung in a thin layer of substance, predicted by Ternovsky, Shulga, Fomin, (Ukraine), was confirmed experimentally.

It was found that the growth of the neutron layer thickness in beta-unstable nuclei is due to both the skin-effect stemming from the geometrical increase in the nuclear size and the halo effect due to diffusivity of proton/neutron surface layers.

Alpha-decay of the natural platinum isotope  $\text{Pt}^{190}$  to the excited level of the daughter nucleus with the half-life of  $2.6 \times 10^{14}$  years was first observed.

A relativistic theory of resonances associated with the virtual particle transition to the mass shell was constructed for the processes of electron-positron pair photoproduction in the nuclear field and electron scattering by photon in the pulsed laser field. The theory expands fundamental ideas concerning the interaction of strong laser fields with matter.

Physical mechanisms were found that may lead to anomalous energy distributions of epithermal ions during plasma heating in tokamaks by neutral beam injection.

Theoretical principles for the method of dynamic analysis of nonstationary radiation fields (of background intensity) were elaborated. Software/hardware means were developed for the practical implementation of the method. Those were proposed to be employed in systems for detecting radioactive materials and ionizing radiation sources that move at different speeds.

A conceptual design was developed for a neutron source based on the subcritical assembly controlled by electron accelerator. At the National Science Center 'Kharkiv Institute of Physics & Technology', the construction of this state-of-the-art nuclear research facility was started; it is scheduled to be put into operation in 2014.

A quasimonochromatic X-ray source with a doublet of electrostatic quadrupole lenses was created on the basis of electrostatic ion accelerator.

A test bench based on a multicharged ion linear accelerator was developed to investigate mechanical properties of structural materials, in particular, elastic-plastic properties of materials exposed to ion beam under axial and cyclic loads.

The first home-produced ionizing-radiation detector was developed on the basis of a polycrystalline radiation-resistant diamond film, to be used in radio technology and nuclear engineering, as well as radiation control systems of nuclear power plants of Ukraine.

A radically new device for analyzing discrete-continuous aerosols was proposed for radiation control systems, NPP aerosol emission monitoring, and for facilities of nuclear power cycle.

Relying on their studies of irradiation embrittlement of reconstructed check test pieces of the PWR-type reactor vessel metal, Department's scientists validated the time frames of safe reactor-vessel service at nuclear units No 1, 2, 6 of Zaporizhska NPP, and No 3 of South-Ukrainian NPP.

Radiation technology processes of manufacturing and certification of consumer articles were developed, using a new composite material – radiation-modified polymer concrete.

Pilot models of special-purpose equipment and control systems were produced for the technical support of uranium deposits prospecting.

The title of Honored Worker of Science and Technology of Ukraine was awarded to S. P. Roshchupkin, Doctor of Physics and Mathematics, Head of the Strong-Field Quantum Electrodynamics Laboratory at the NAS Institute of Applied Physics.

The NAS O. I. Leipunsky Prize was awarded to NAS Academician L. A. Bulavin, NAS Corresponding Member V. I. Slisenko, and Doctor of Physics and Mathematics V. V. Klepko for a series of works on neutron spectroscopy of condensed media.

The Fourth Ukraine-Russia Workshop 'Development of Nuclear Power Engineering as a Factor of Continuous Interstate Cooperation' was held. Collaboration with international and national scientific, R&D centers and organizations, including CERN (Switzerland), IAEA, Euratom, 'Kurchatov Institute' National Research Center (Russia), 'Rosatom' state-owned corporation (Russia), the UK Closed Nuclear Centres Programme, is advancing rapidly.



## Chemistry



**V. V. Goncharuk,**  
**Academician-Secretary of**  
**the Department**

Research in chemistry is conducted at 11 institutes and 2 divisions of institutes by about one thousand of highly skilled scientists. There are 11 NAS Academicians and 26 NAS Corresponding Members among them.

In 2011 we obtained a number of important fundamental scientific results complying with international standards. They are as follows.

An efficient mechano-chemical method was developed to produce graphene oxide with a wide oxidation range in the absence of aggressive mediums characteristic of the available chemical procedures for synthesizing this key substance in graphene production (NAS Academician V. D. Pokhodenko).

An effective hybrid nano-sized catalytic system with  $\text{Al}_2\text{O}_3$  ( $8 \div 10\text{nm}$ )/C/Pd ( $0.5 \div 1.5\text{nm}$ ) structure was created, with arylisocyanates as precursors for the solid carbonic cover on the  $\text{Al}_2\text{O}_3$  surface. Using these systems in fine organic synthesis, scientists were able to achieve  $82 \div 96\%$  product yield and conduct reactions in water medium at room temperature, without organic solvents and inert atmosphere (NAS Academician S. V. Volkov).

Patterns of changes were discovered in the chemical structure of organo-inorganic polymer matrix, namely, in its inorganic component; those changes influence crystallization conditions of its organic component and improve electro-physical properties of the nano-composite system (NAS Academician E. V. Lebedev).

A series of cationic bis-cyclometallized iridium complexes of phenantroline were synthesized; they are promising for electro-fluorescence organic or polymeric light-emitting devices due to the high stability and quantum yields of luminescence, as well as short excited-state lifetimes (NAS Academician A. F. Popov).

The effect of water isotopologs on osmotic phenomena and membrane transport of water was found for the first time ever. Independent research methods showed that isotopic osmosis – transfer of water with the natural presence of deuterium into heavy water is caused by a high degree of freedom of water with the natural presence of deuterium. The same properties enabled scientists to achieve the highest membrane permeability in membrane separation of water with various deuterium contents (NAS Academician V. V. Goncharuk).

The dependence of thermodynamic parameters of complex formation of 1,4-benzodiazepine derivatives

with benzodiazepine receptors of the central nervous system of experimental animals on the ligand structure was investigated for the first time. For the majority of compounds studied, complex formation resulted from both nonspecific and specific interactions. Only one case of ligand binding with the receptor (that of 3-acetyloxibenzodiazepinone) was mainly due to non-specific interactions (NAS Academician S. A. Andronati).

A new synthetic approach to obtaining fluorinated benzo[d][1,3]dioxol-containing derivatives of N-phosphonomethylglycine was proposed; some of these derivatives showed the properties of proteinthiophosphatase inhibitors. With structure optimization, they could give rise to new medicines for type II diabetes (NAS Academician V. P. Kukhar).

Prospects for medical application of new inorganic ionites based on highly porous amorphous titanium and zirconium silicates in purification and regeneration of dialysis liquid in artificial kidney systems, portable ones included, were demonstrated for the first time (NAS Academician V. V. Strelko).

Magnetic liquids which can be heated to the target temperature by electric field were developed on the basis of weakly agglomerated nano-particles of  $(\text{La,Sr})\text{MnO}_3$  solid solutions and agarose water solution. It was shown that stabilization temperatures of magnetic liquids correlate with the temperature of phase transition from ferromagnetic to non-magnetic state (NAS Academician A. G. Belous).

Depending on the structure and composition of the chelating ligand, the nature of acido-ligand effect on the catalytic activity of salt complexes  $\text{CoX}_2$  ( $\text{X}=\text{Cl}, \text{Br}, \text{I}, \text{NCS}$ ) with N,N,N',N'-tetra-substituted thiocarbamoylsulfenamides containing 'off-chelate' residue of dimethylamine (I), piperidine (II) and piperazine (III) was revealed. It was found that in the case of bi-nuclear complexes III, the activation of hydrogen peroxide on a bimetallic center is more probable (NAS Academician G. L. Kamalov).

The possibility of obtaining various fluorine-containing carbonic acids by electro-chemically activated introduction of carbon dioxide into geminal freons was proved for the first time; this would allow joint conversion of environmentally harmful freons and  $\text{CO}_2$ , yielding commercially important products (NAS Academician V. G. Koshechko).

On the initiative of the International Union of Theoretical and Applied Chemistry (IUTAC) and UNESCO, UNO announced 2011 as the International Year of Chemistry. In the framework of that event, the Department, jointly with the Kharkiv Polytechnical Institute, held a guest scientific session with special presentations, lectures of leading chemists for students and general public. Scientists of the Department took an active part in the International Forum 'Complex Provision of Laboratories' ('LABComplex-2011').

The Institutions of the Department participated in the implementation of 7 NAS programs, 6 joint projects with RFBR, and 3 R&D projects.

## Biochemistry, Physiology and Molecular Biology



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

Activities of Department's institutions in the year under review were directed to solving fundamental problems in the key areas of molecular biology, biochemistry, physiology, microbiology, genetics, oncology, cryobiology, and cryomedicine; to developing new medicines and facilities for the diagnostics of the most common human diseases. A lot of attention was given to creating novel biotechnologies. A number of major scientific results were obtained.

In the Palladin Institute of Biochemistry, a collection of recombinant and monoclonal antibodies was set up. It consists of hybridoma cell lines secreting murine monoclonal antibodies as well as a large library of  $10^9$  specificities of human recombinant single-chain variable antibodies (scFv Abs).

Researchers of the Bogomoletz Institute of Physiology determined the role and functional properties of ionic receptors/channels located in plasma membrane and in the membranes of intracellular organelles under normal and pathological conditions (such as: epilepsy, chronic pain, diabetes, ischemia etc.). In particular, the role of IP3 receptors of the internal nuclear membrane was investigated in terms of their participation in  $Ca^{2+}$  signaling in the nucleus of pyramidal neurons of hippocampal CA1 area and cerebella Purkinje neurons.

In the NAS D.K. Zabolotny Institute of Microbiology and Virology, the effect of mutations in *B. subtilis* *recP* and *recE4* genes, belonging to recombination system, on the dynamics of lectin production and activity of its free and bound forms was shown. Mutation in *recE4* gene significantly increased the lectin activity on the galactose-containing medium, while mutation in *recP* gene led to the loss of bacteria's ability to produce both forms of lectins.

In the Institute of Molecular Biology and Genetics, the functioning of key translational components, aminoacyl-tRNA synthetases, was proved to occur in specialized cellular compartments due to their strong interaction with ribosomes and cytoskeleton, which is one of the important factors ensuring high efficiency and fidelity of protein biosynthesis in humans.

The R. E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology showed that normal and malignant transformed B-lymphocytes differ by FoxO expression, in particular, by the expression of FoxO1 and FoxO3a factors that regulate transcription of proapoptotic genes. It was also discovered that the level of FoxO1 activation/phosphorylation in normal and malignant transformed B cells is

regulated via CD150.

Scientists of the NAS Institute of Problems of Cryobiology and Cryomedicine discovered a reduced expression level of genes regulating hemopoietic and immune suppressive activities of bone marrow stem cells in recipients with autoimmune diseases. Correction of the expression rate of these genes was proved to be under the effect of cryopreserved products of fetoplacental complex accompanied by hemopoiesis activation and stimulation of T-regulatory cells, which reduced the manifestation of pathologies of autoimmune genesis.

In the Institute of Cell Biology, the orthologs of *Saccharomyces cerevisiae* genes *MON1*, *CCZ1* and *YPT7* were identified in the *Pichia pastoris* methylotrophic yeasts. These genes code for proteins acting in a complex responsible for degradation of oleate-induced peroxisomes, vacuolar hydrolase traffic from cytosol into vacuoles (cytoplasm-to-vacuole targeting, or Cvt pathway) and non-specific macroautophagy in *S. cerevisiae*. Orthologs of *MON1*, *CCZ1* and *YPT7* were found to be important for autophagic pathways in *P. pastoris*. Strains with deletion of any of the above-mentioned genes revealed a complete defect in pexophagy, Cvt pathway and non-specific macroautophagy.

In the field of medicine, NAS scientists determined the role of distal blockades in His-Purkinje system, which leads to the asynchrony in the functioning of heart ventricles and to progressive heart failure. The mechanism of developing asynchrony in the work of heart ventricles was established. A method was introduced to restore the synchronism in the functioning of heart ventricles during congestive heart failure. This allowed specialists to improve indices of left ventricle systolic function, decrease symptoms of heart failure and achieve a substantial improvement in patients' functional status and prognosis. Aneurysm formation and diagnostic peculiarities were studied in left ventricular thrombosis. Anatomical validation of the method to correct them was elaborated. A range of new molecular mechanisms of regulating suprarenal gland cortex function were studied.

Fruitful collaboration of Department's institutes with other bio-medical institutions of various ministries continued, in particular, that with institutes of the National Academy of Medical Sciences and Ministry of Health. Meetings of the scientific seminar 'Molecular Medicine' were regular; they discussed the most recent advances and challenges in bio-medical sciences.

A competition of projects for grants under the new NAS targeted research program 'Functional Genomics, Proteomics and Metabolomics in Systems Biology' was held. The implementation of other important NAS research programs was in progress.

The State Key Laboratory of Molecular and Cellular Biology was founded on the basis of NAS Bogomoletz Institute of Physiology and the Institute of Molecular Biology and Genetics. It carried out important research projects.

## General Biology



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

In 2011, efforts of scientists working in the field of biology were focused primarily on research into molecular and cellular fundamentals of the organization and functioning of biological systems, studies of biodiversity and assessment of its current status in order to develop new conservation strategies and activities, and on further advancement of physiology, genetics, and biotechnology.

By combining the abilities of experimental mutagenesis with chromosome engineering, mutant varieties with rye-wheat translocation were created. These cultivars have high productivity, environmental plasticity, group resistance to pathogens causing major diseases, they do not require intensive chemical protection, and are most suitable for organic agriculture. The original allele (*a1*) of grain quality superexpression was identified in the locus of high-glutenin *Glu B1*; using this allele, several lines of winter wheat with extra-quality grain were developed.

A magnetic isotope effect was detected during DNA repair process in living cells for the first time; this effect consists in magnesium atoms with nonzero nuclear spin accelerating the process in question.

Stable and stress-modified ionome components were identified for developing highly efficient systems of wheat nutrition and biofortification. It was shown that the regulatory role of phytolectins under formation and functioning of plant-bacterial systems was due to the multivector spectrum of their biological activity towards plants and soil microorganisms; that proved good prospects for using agglutinins in agrobiotechnology.

A hypothesis was proposed on the role of rapid changes in light-harvesting complexes of photosystems I and II that would facilitate our understanding of mechanisms of signal transduction systems in plants. Active stress responses of plants are involved in the processes of herbicide-induced pathogenesis. These data open up wide opportunities in searching for new preparations with different mechanisms of plant toxicity.

For the first time ever, biotech corn plants with targeted suppressor gene of praline dehydrogenase were produced and their seed generation obtained. It was shown that plants can produce full-size antitumour monoclonal antibodies. The first cDNA library of finger millet (*Eleusine*) was collected. Transgenic carrot plants were obtained; these plants express genes of secretory proteins of *Mycobacterium tuberculosis* and human alpha-2b interferon that could be used for

prevention and treatment of viral and bacterial diseases.

Further research into biodiversity was going on: over 90 new taxa of unicellular organisms, plants, fungi, invertebrates, fishes and snakes were described as new for science. A concept of the adaptive strategy of alien plant species as a system of properties of individuals, populations, species and communities that had evolved during adaptation to new environmental conditions under global climate changes and urban ecosystem transformations was formed. A new approach to assessing species endemism of vascular plants in Ukraine and formation of invasive species ranges was proposed. A forecast was made for a possible reduction in habitats of the most vulnerable animals in Ukraine; pathways of the dispersal of invasive alien species, including many pests and weeds, were discovered.

The analysis of aquatic community structures in catchment areas of the Dnieper, the Danube, the Tisa, the Pripyat, and the Western Bug rivers allowed scientists to determine the ecological status of transboundary river systems, make their typification and identification, and propose activities towards biodiversity conservation.

A new research area was validated – the extreme marine biology of hydrogen sulfide layers of the Black Sea. Novel technologies were developed to obtain biologically active substances from marine raw materials for dietary nutrition and drug preparations for treatment and health care.

Structural and functional features of natural, demographic, and socio-economic units of geo-social systems of the Beskydy Mountains were determined as well as prospects of their transition to sustainable development.

Data on collections of rare and endangered plant species that are introduced, protected, propagated and studied in botanical gardens and arboreta of Ukraine were generalized.

27 varieties of agricultural, ornamental, medicinal and industrial crops were created. New innovative winter wheat cultivars and corn hybrids were produced; they were recognized as new achievements in plant breeding. 2231 license agreements for using winter wheat cultivars in farming were issued and provided with scientific support. The new wheat varieties are grown in the area of 1.7m hectares, which is a significant contribution to food security in Ukraine.

The innovative nature of the research done at Department's institutions in the reporting year was confirmed by 92 patents and invention certificates. Studies of their scholars were duly appreciated: 26 scientists received national, international and academy awards and prizes, honours and honorary degrees, diplomas and certificates.

Scientists working in the field of biology will aim their further efforts at generating new fundamental scientific knowledge, searching for promising areas of biological research, and at introducing applied research in the national economy.

## Economics



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

In 2011, research efforts of the NAS Economics Department were aimed, first and foremost, at projecting and strategic planning of the national economy development, elimination of its structural imbalance, development of human potential, as well as scientific validation for dealing with issues of economic integration in the context of global recession challenges; at identifying priority areas of society modernization, social and economic policy in the national and regional dimensions.

A number of significant results were obtained. New theoretical and methodological approaches to post-crisis structural reforms as a factor of transforming the unipolar world to a multipolar one were substantiated; the monocentrism ideology of the globalized world at the turn of the XX-XXI century was analyzed, which enabled scientists to forecast trends of global mega-civilization and modification of civilization regions in the XXI century.

The substance of the institution of trust as a system of norms, rules and regulations that determine the extent of confidence in the compliance of behavior of the object of trust with perceptions of its subjects about the mode of this behavior without actualizing the appropriate basis for such confidence was revealed. It was proved that confidence in the economic sphere is based on equivalence relations, which form the basis of cost and are embodied in market economy. The periodization of main historical stages in the development of institution of trust in the space-time coordinates was done.

The specifics of the interaction of macro-instability factors in terms of sectors were presented in detail, namely: the impact of output decline due to crisis, prices growth, dramatic changes in the external and internal demand and other destabilizing factors on structural changes in industry and the real sector of the economy of Ukraine in 2008–2010; the specific features of the major risks in the development of labour market and unemployment were singled out and characterized; methods and models were proposed to determine the price stability index in a changing economic environment.

The relationship and interdependence of human development components, particularly those between a wider choice and personal responsibility, between increased opportunities and higher requirements, broader rights and obligations, was determined; that allowed scholars to substantiate the need for individualized social policies and an increase of the role of citizens in development processes.

For the first time a methodological approach was developed to quantify the impact of external debt on corporate revenues; it is based on formalizing the taxation of transactions to involve, service, use and repay such debts.

Strategic lines of forming a management system to develop public-private partnership in Ukraine at the macro-, meso- and micro-level were proposed, as well as recommendations towards improving legislation on the state support of business, primarily, economic subsystems of strategic importance – those of energy and banking.

Scientists of the Department, jointly with institutions operating under NAS Department of Information Science, developed the interdisciplinary project 'Intelligent Automated Information-and-Analytical System for Budgetary Process Back-Up Based on National Super Computer'. The system created would allow them to validate budget decisions and to implement state-of-the-art computer valuation models of the impact and scenario-based forecasting of fiscal policy effects on the socio-economic development of Ukraine's regions and the state as a whole.

A full-scale reconstruction of the series of demographic dynamics of Ukraine in its present boundaries in the mid-XIX – early XXI centuries was done and complete tables of fertility and mortality in this period were built. The demographic projection for Ukraine out to 2060 was updated according to 7 options.

A conceptual model was developed to measure socio-economic inequality; features of the transformation determinants of this inequality in contemporary Ukrainian society were established.

Mechanisms for reducing the negative impact of foreign-trade factors and those of international capital movements on the economy of Ukraine were found by investigating external factors of macroeconomic instability in the model of Ukraine's economy growth; policy measures were validated to neutralize potentially destabilizing effect of foreign-trade factors and factors of unregulated capital movements on the free trade area with the EU, including factors that could result from the free trade agreement.

In the near future, the efforts of economists will be aimed at evaluating risks and potential threats to the development of Ukrainian society and economy in the period of expectation of the second wave of global economic crisis; at forming novel principles of civilizational and national development based on the ideology of sustainable development and equitable distribution of natural resources; at devising scientifically validated models, algorithms and management techniques that could ensure formulation and implementation of modernization policy as a way of recognizing the spatial variability and mechanisms of the interaction and development of the economy, society and state.



## History, Philosophy and Law



**O. S. Onyshchenko,**  
**Academician-Secretary of**  
**the Department**

In 2011, research institutions of the Department achieved substantial theoretical and practical results in scholarly back-up to the processes of Ukrainian society modernization, reformation of Ukraine's political system, re-integration of the national historical and cultural legacy to academic and cultural life of the country, ensuring the national sovereignty of Ukraine under globalization.

Good results were obtained in the implementation of numerous research and publishing projects. Prominent scholars of the Department were engaged in preparing the annual national NAS report 'National Sovereignty of Ukraine under Globalization' (NAS Acad. O. S. Onyshchenko, Yu. A. Levenets, Yu. S. Shemshuchenko et al.).

In the framework of the project 'Ukraine: History of a Great Nation', NAS Institute of the History of Ukraine published the final 6<sup>th</sup> volume of the work «Ukraine: Chronology of Development. Contemporary History. 1917–2010» (by NAS Acad. V. A. Smolii et al.). The 8<sup>th</sup> volume of the «Encyclopaedia of the History of Ukraine» (NAS Acad. V. A. Smolii, H. V. Boryak et al.) was published. New projects (a multivolume «History of Ukraine» and two-volume «History of Kyiv») were started.

Researchers of the NAS M. S. Hrushevsky Institute of Ukrainian Archeography and Source Studies published the 12<sup>th</sup> volume of the multivolume edition of M. S. Hrushevsky's works (NAS Corr. Memb. P. S. Sokhan). The staff of NAS Institute of Encyclopedic Research published the 11<sup>th</sup> volume of «Encyclopaedia of Modern Ukraine» (NAS Acad. I. M. Dziuba, M. H. Zheleznyak), the 1<sup>st</sup> volume of «Shevchenko Scientific Society Encyclopedia» (O. A. Kupchynskiy). Scholars of the V. I. Vernadsky National Library of Ukraine prepared fundamental work «Peresopnytsia Gospel. 1556–1561. Studies. Transliterated Text. Word Index» (NAS Acad. O. S. Onyshchenko, NAS Corr. Memb. L. A. Dubrovina et al.).

Researchers of the NAS I. F. Kuras Institute of Political and Ethnic Studies published «Political Encyclopedia», which is the first Ukrainian encyclopedic edition that provides a thorough analysis of the state of today's political studies (NAS Acad. Yu. A. Levenets et al.). The NAS Institute of Sociology published the fundamental monograph «Ukrainian Society. Twenty Years of Independence. Sociological Monitoring» in 2 volumes (by NAS Acad. V. M. Vorona, M. O. Shulha).

The Department's targeted research program 'Cultural and Civilizational Dialogue of the 21<sup>st</sup> Cen-

tury: Issues of Ukraine Integration to the World Community' was completed. Within it, historical, social and cultural factors of Ukraine integration to European and world community were analyzed.

Results of the abovementioned studies were sent to state authorities to be used in preparing administrative decisions on reforming the political and legal systems, developing civil society, improving the principles of the foreign policy of the state.

Under the NAS targeted multidisciplinary research programs 'Forecasts and Models of Social and Cultural Transformation of the Ukrainian Society in the First Quarter of the 21<sup>st</sup> Century', 'Strategic Challenges for Ukraine Integration to the World Community', 'Modernization of Ukrainian Society and Economy in the 21<sup>st</sup> Century' and 'Humanitarian Technologies as a Factor of Social Transformations in Ukraine', institutions of the Department worked out models of social, economic and political development of Ukraine alongside with proposals on the ways of implementing social, ethnic, educational and information policy of the state.

Institutions of the Department were involved in preparing such analytic conceptual documents for state authorities as 'Concept of Humanitarian Development in Ukraine up to 2020', 'Concept of State Ethno-National Policy', 'Concept of National Program for Cultural Heritage Preservation for 2012–2022', 'Concept of State Program for Popularizing History Knowledge for 2012–2017', 'Program of Ukraine's and Russia's Humanitarian Collaboration for 2011–2012'. Besides, scholars of the Department advanced proposals to the 'National Anti-Corruption Strategy for 2011–2015'.

In accordance with a Presidential Decree (of 21 February 2011, # 224) 'On Supporting the Initiative of Establishing the Constitutional Assembly', scholars of NAS V. M. Koretsky Institute of State and Law ensured scholarly back-up to the Constitutional Assembly preparation (NAS Acad. Yu. S. Shemshuchenko et al.).

In 2012, the efforts of the Bureau and institutions of the Department will be focused on interdisciplinary research into modern globalization and transformation challenges; developing models of effective reformation of state and social institutions; determining the ways of settling regional, ethnic and religious conflicts.



**Philology Studies, Art Criticism, Ethnology**

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

In the year under review, scholars of the NAS Department of Literature, Language and Art Studies continued to aim their efforts at fundamental and applied issues of the development of literature, language, art studies, traditional every-day culture, and computer linguistics; they addressed major challenges of the scholarly backup to the national and cultural revival of Ukraine, provided the unbiased analysis of various stages in the development of Ukrainian spiritual culture in the past and in the context of globalization processes of the early 21<sup>st</sup> century.

The practical outcome of the abovementioned tasks was the publication of 84 monographs and collections of writings, 24 study textbooks and manuals for university students and schoolchildren, 14 reference books and dictionaries, 48 academically treated and commented belles-lettres texts, nearly 1700 publications in research proceedings and periodicals.

The high academic level of Department's research is proved by awarding NAS F. M. Kolessa Prize to literature scholar R. F. Kyrchiv for the work «20<sup>th</sup> Century in Ukrainian Folklore» in 2011; linguist U. V. Shtandenko won the Prize of Verkhovna Rada of Ukraine for Young Scientists for his writing «Nominal Suffixal Derivation of Verbs in the Old Ukrainian Language of XIV–XVIII Centuries». Linguist T. B. Lukinova was honoured with Princess Olga Order II Class to mark her outstanding service to the advancement of Ukrainian scholarship. NAS Academician H. P. Pivtorak was awarded the title 'Honoured Worker of Science and Technology of Ukraine'.

Literature scholars of the Department made a comprehensive analysis of the status and trends in the development of Ukrainian and foreign literatures at the beginning of the 21<sup>st</sup> century and, relying on the achievements of today's literature studies and novel methodological approaches, the creative work of leading figures in the history of Ukrainian belles-lettres: T. Shevchenko, I. Franko, Lesia Ukrainka, V. Vynnychenko and its place in the world cultural space. A number of fundamental works were published: «Ukrainian Literature: Writers and Writings» (by NAS Academician M. H. Zhulynskiy); «The Fate of Ukrainian Literature Is the Fate of Ukraine» (by NAS Academician V. H. Donchyk); «There Are Poets for Epochs» (by NAS Academician I. M. Dziuba); «Dramatics of Mykola Kulish» (by M. P. Kodak); «Author and Character in Contemporary Ukrainian Prose» (by O. B. Polishchuk); collected comprehensive scholarly works «Ivan Franko. Texts. Facts. Interpretations», «Proze Criticism: Articles and Essays». Also issued were 17

manuals and reading books of Ukrainian and foreign literatures, commented editions of writings by T. Shevchenko, N. Gogol, O. Oles and numerous foreign authors.

Department's linguistic scholars, using comparative historical and typological methods, studied the establishment and evolution of the Ukrainian language as compared to similar processes and phenomena in other Slavic languages, the current state and dynamics of Ukrainian language functioning under linguo-transformations of the early 21<sup>st</sup> century, formation and codification of the language standard of contemporary literary Ukrainian. To implement the Decree of the President of Ukraine 'On the Development of the National Dictionary Base', Department's linguistics scholars completed the preparation and issued 10 thousand copies of two laser disks «Integrated Lexicographic System 'Dictionaries of Ukraine' Version 4.1», with the register of 258 thousand entries. They compiled and put into operation on-line versions of the first volume of the 20-volume «Dictionary of the Ukrainian Language», electronic «Ukrainian–Russian–English Welding Dictionary». They also developed and put to practice the virtual lexicographic laboratory «Thesaurus of the Russian Language» and the technical-system support for the pilot version of the virtual all-Ukrainian biography laboratory. 7 new-generation dictionaries were published, alongside with such fundamental writings as «Ukrainian Lexicography in All-Slavic Context: Theory, Practice, Typology», «Computer Lexicography» (by NAS Corresponding Member V. A. Shirokov, «Dynamics of Ukrainian Periodicals Lexicon of Early 21<sup>st</sup> Century» (by M. I. Navalna), «Mixed Dialect: between Ukrainian and Russian» (by L. T. Masenko) etc.

Relying on the outcomes of research into varied phenomena of traditional culture, scholars in arts, folklore and ethnology carried out an integrated study of the peculiarities in the development of culture of Ukrainians and ethnic minorities in Ukraine at the beginning of the 21<sup>st</sup> century, the current state of ethnic and national self-identification, dynamics of labour migration to EU countries and the Russian Federation, as well as formation of typical social identities in this milieu. Information notes, proposals and recommendations based on those studies were sent to the Verkhovna Rada of Ukraine and other state administration bodies. 45 collected and individual works: «History of Ukrainian Art» in 5 volumes, «History of Ukrainian Culture» (vol. 5, books 1 and 2), «History of Decorative Art in Ukraine» (vol. 4), «Ethnic and Ethno-Cultural History of Ukraine» (vol. 2), «Ukrainian Music Encyclopedia» (vol. 2), «Ukrainians of Bashkiria. Studies and Documents» (vol. 1), «Ethnography and Folklore Studies of 'Rus Triad'» (by R. F. Kyrchiv), «Processes of Ukrainian Labour Migration in Russia: Social and Gender Aspects» (in English), a collection of works «Contemporary Foreign Ethnology», which presents writings by more than 200 ethnologists from Europe, Asia, America, and ethnological studies by F. Kolessa, F. Vovk, F. Vashchuk et al.

## **Statistics**

## Regional Structure of the National Academy of Sciences of Ukraine



### • Reorganized:

Lviv Branch of T. H. Shevchenko Institute of Literature - into Ivan Franko Institute

Institute of European Research - into the Institute of World History

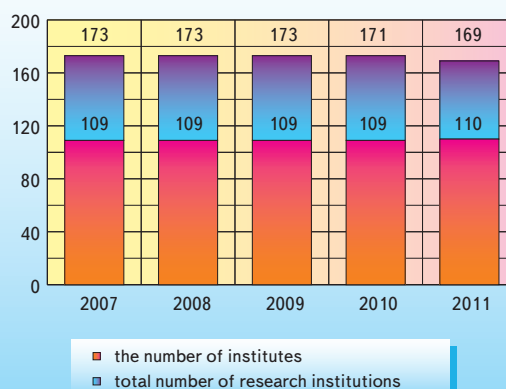
### • Transferred:

National Museum of Folk Architecture and Life of Ukraine - The Ministry of Culture of Ukraine

### • Liquidated:

'Naturológ' State R&D Center

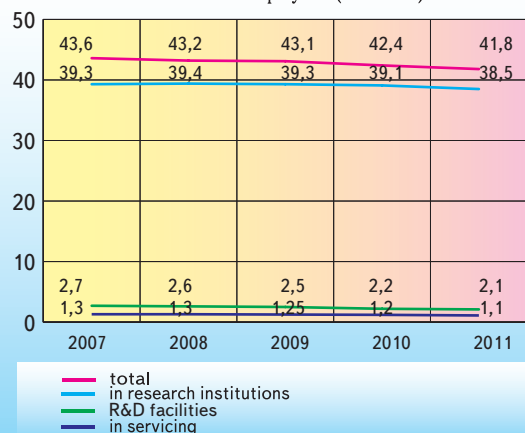
Total number of research institutions



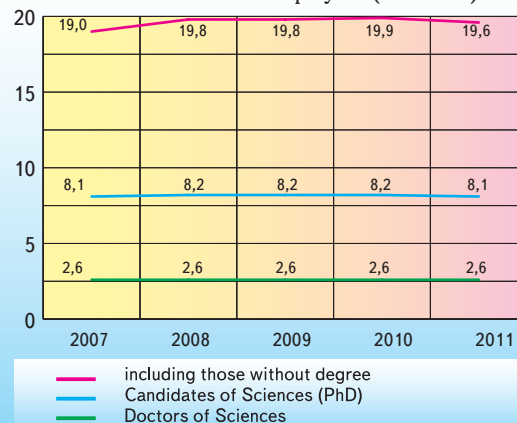
Total number of employees	<b>41754</b>
including:	
in research institutions	<b>38475</b>
in R&D organizations	<b>2132</b>
in service organizations	<b>1147</b>

R&D employees	<b>19552</b>
including:	
Doctors of Sciences	<b>2583</b>
Candidates of Sciences (PhD)	<b>8063</b>

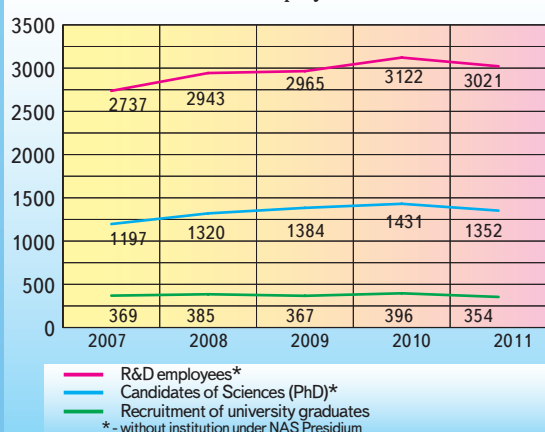
Number of employees (thousand)



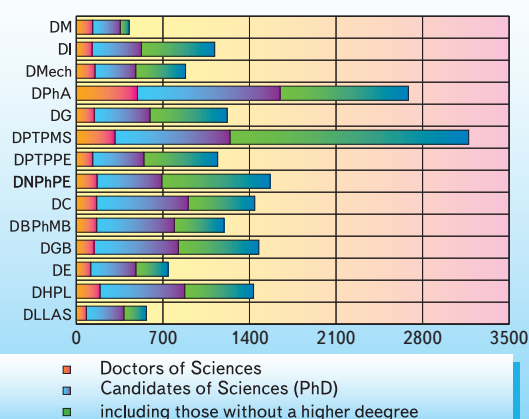
Number of R&D employees (thousand)



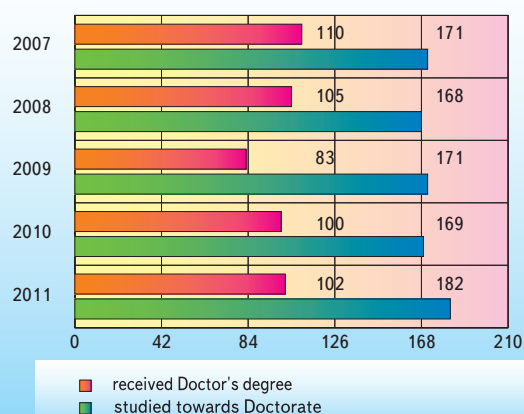
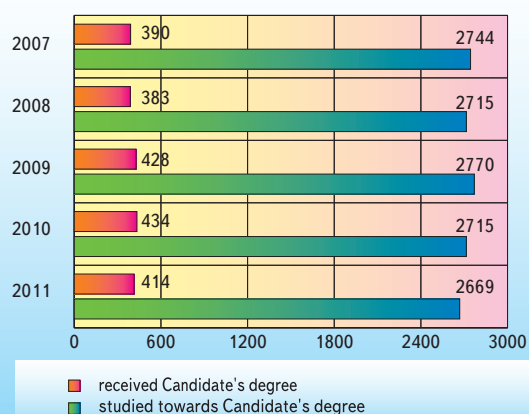
Number of employees under 35



Distribution of scientists by departments

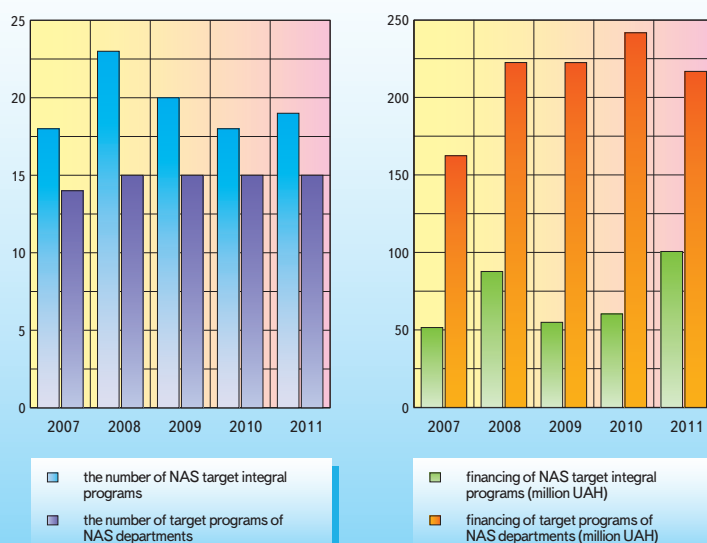


Training of research personnel

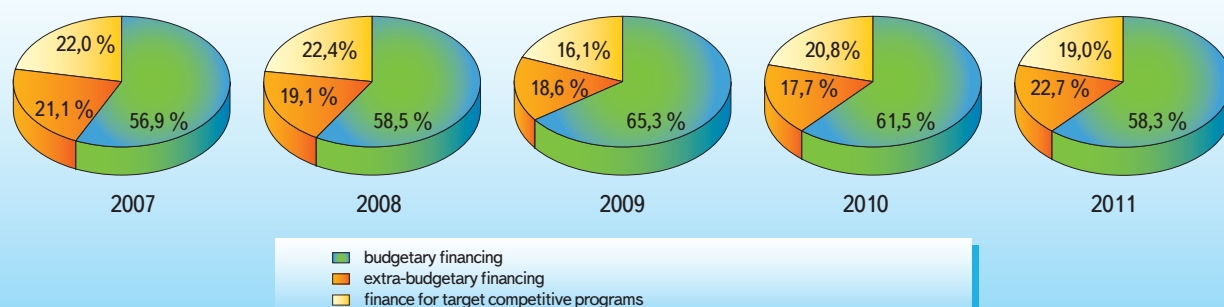


Budget	thousand UAH
Total financing	2805802,5
General fund of the state budget	2180930,0
Basic funding from the State budget	1606075,7
Target programs finance	524906,2
Budget finance for personnel training	9990,6
Budget finance for health protection	31198,9
Other	8758,6
Extra-budgetary revenues	624872,5
Total expenditures	2777708,4
Expenditures on wages	1948064,4
Expenditures on equipment and instruments	110698,7
Expenditures on capital construction and reconstruction	36691,4
Expenditures on utilities	189442,1
Other expenditures	492811,8

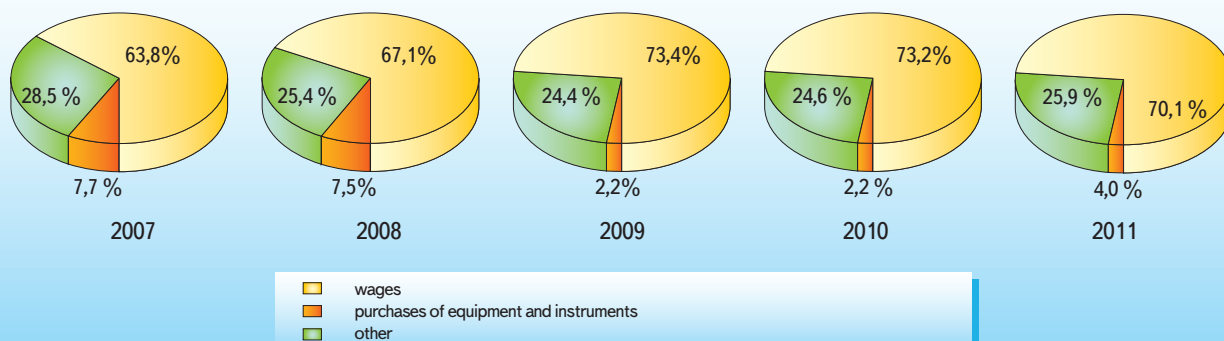
Target programs subjects



Distribution of finance by sources

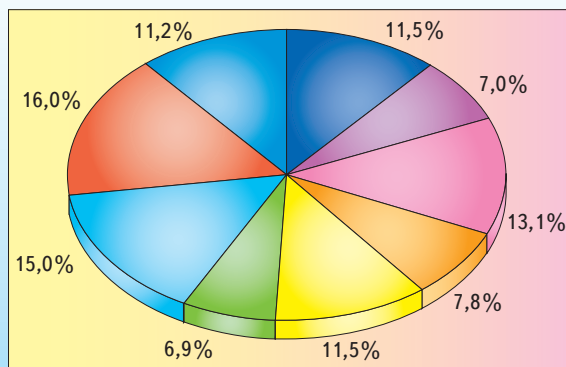


Distribution of expenditures by principal items

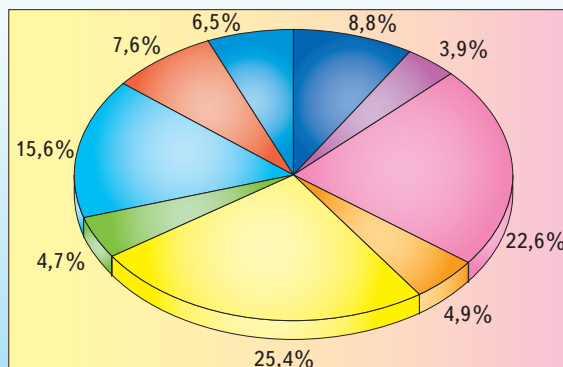




Distribution of basic budgetary finance

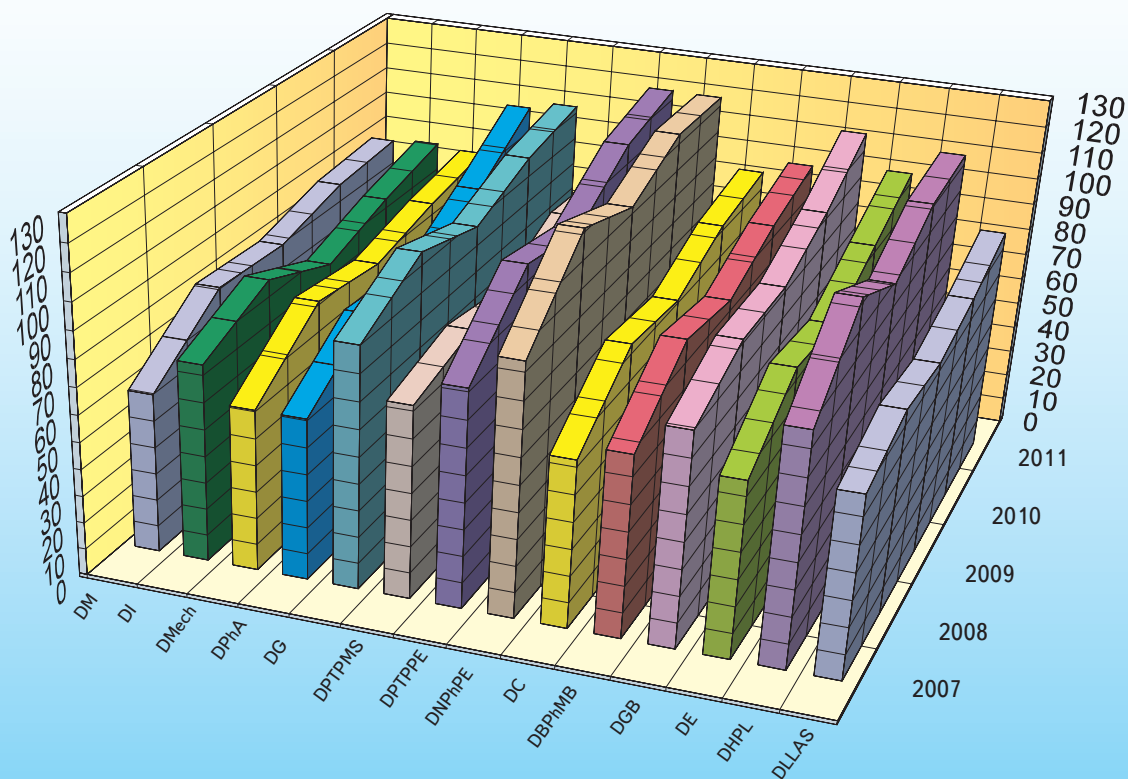


Distribution of extra-budgetary finance



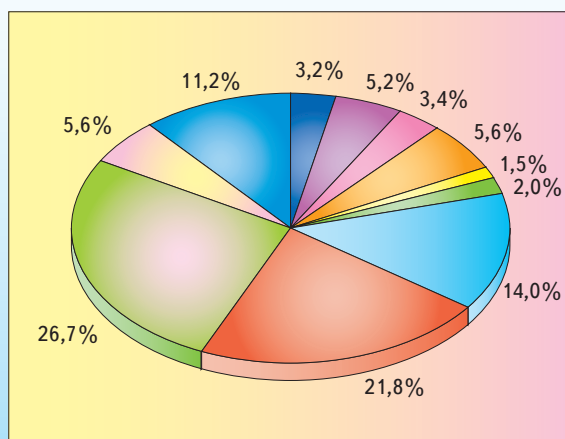
■ Mathematics, Mechanics, Informatics   
 ■ Earth Sciences   
 ■ Power Engineering   
 ■ Chemistry   
 ■ Social Sciences and Humanities  
■ Physics and Astronomy   
 ■ Materials Sciences   
 ■ Nuclear Physics and Power Engineering   
 ■ Biological Sciences

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

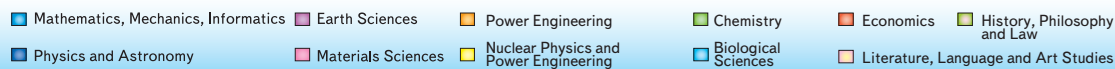
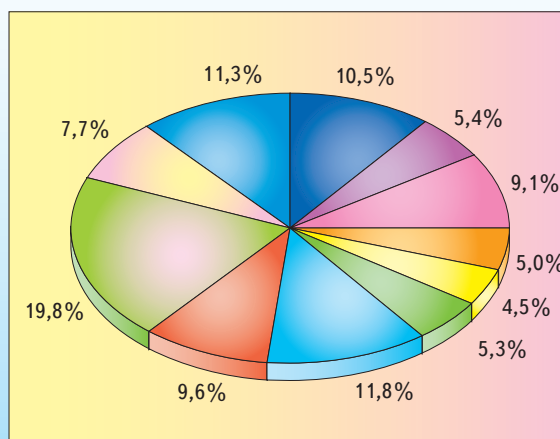


## Publication of Academic Materials

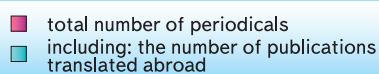
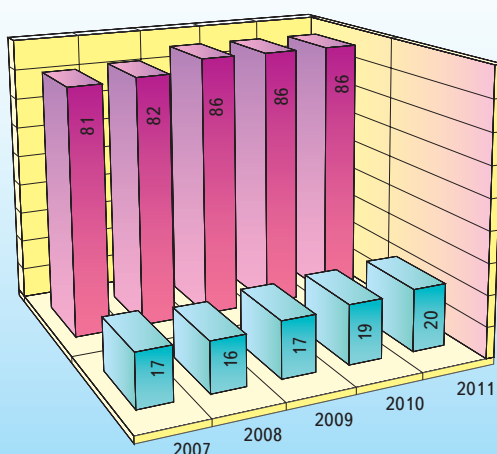
### Monographs



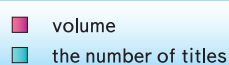
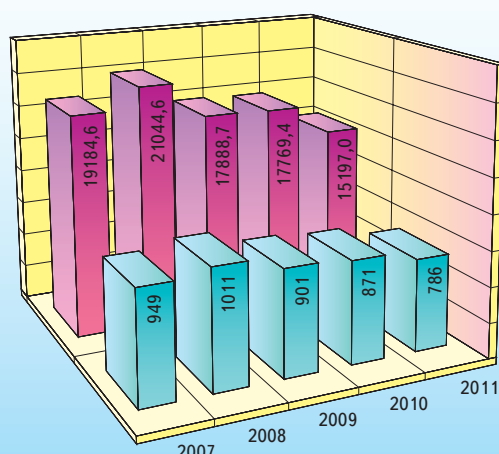
### Papers



### Academic Periodicals



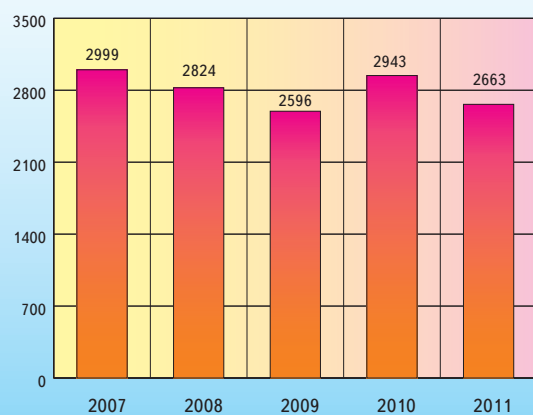
### Publication of Academic Books



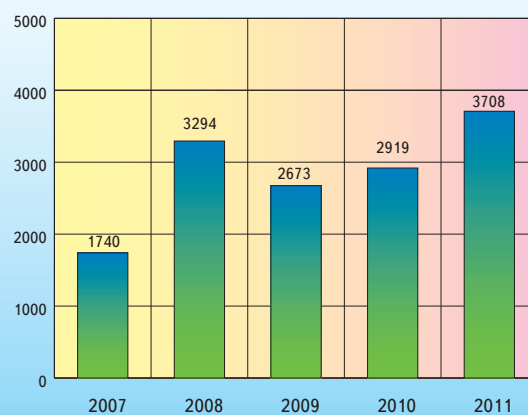
## International Contacts of the National Academy of Sciences of Ukraine with Foreign Institutions



Foreign Scientists Received in Ukraine



Ukrainian Scientists Sent on Mission Abroad



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