

NATIONAL ACADEMY OF SCIENCES OF UKRAINE

BRIEF ANNUAL REPORT

2012

Main Results



B. E. Paton,
President of the Academy

In 2012, institutions of the National Academy of Sciences (NAS) of Ukraine carried out extensive fundamental and applied research and produced numerous promising developments in priority areas of science and technology.

New results were obtained in many cutting-edge fields of mathematics, information science, mechanics, physics, astronomy and radio astronomy, Earth sciences, materials science, studies of physical-and-technological problems of power engineering, in nuclear and radiation technologies, chemistry and biology. Institutions of socio-humanities research aimed their efforts at studying novel socio-economic, legal, spiritual, cultural and ideological transformations in Ukraine, the status and prospects of the Ukrainian society development. These results were used in drawing up numerous generalizing prognostic documents prepared for state authorities. Among them are the national report "National Strategy of Sustainable Human Development: Ensuring Equity", the Concept of Ukraine's Humanitarian Development till 2020.

Last year, Academy's scholars presented the results of their research work in nearly 800 academic books, 570 and 214 collected works included. Over 25 thousand research papers were published, 5,4 thousand of those – in leading specialized foreign journals. A large number of textbooks, reference and popular-science books were prepared for the education sphere – 470 books in total.

I would like to draw your attention to the extension of NAS scientific expert functions and commissions we have witnessed recently. No doubt, this has had a positive effect on the quality and quantity of evaluations and forecasts, proposals and recommendations prepared by its specialists for governmental structures. In 2012, NAS institutions provided 1880 expert evaluations of legal acts and program documents on the assignments of and in the interests of various bodies of state power, as well as information-and-analytical materials on various aspects of socio-political, socio-economic, S&T and cultural progress of the nation.

Of great importance for ensuring high scientific relevance of research are targeted NAS research programs. Today the Academy is implementing 19 integrative programs covering cutting-edge areas of fundamental and applied science, the interdisciplinary ones included. Over 20% of studies of NAS institutions are carried out under those programs, and the total share of targeted-program research in

the Academy is as high as 43%. We were able to achieve such a significant proportion due to insistent purposeful work towards introducing advanced principles in research management, which has been done in the Academy for a long time. A system of various programs and competitions has been formed and is operating. Beside state-supported targeted R&D programs initiated by the NAS of Ukraine and all-Academy integrated programs that have already been mentioned, it also includes fundamental research programs of Academy departments, the competition of R&D (innovation) projects, joint competitions with foreign scientific centers and foundations.

A lot of effort was given last year to establishing efficient co-operation with industrial ministries and agencies, large state and private companies in order to determine and jointly carry out high-priority tasks of technological renovation of Ukrainian enterprises.

Specialists of the Academy and the Ministry of Coal Energy of Ukraine prepared a collaborative project "Renovation of Ukraine's Energy Strategy out to 2030 in Electric Power Engineering".

A cooperation agreement between the National Academy of Sciences of Ukraine and the State Agency of Water Resources of Ukraine was concluded. Under this agreement, NAS specialists are to take part in the scientific back-up to improving the environmental status of surface water resources, developing land reclamation, centralized water supply of rural settlements, integrated flood-control measures etc.

A NAS Presidium guest session was held at the 'ANTONOV' State Company. It determined areas of further co-operation, namely, introducing novel technologies in aircraft construction, studying advanced aviation materials, their practical application in Ukrainian aircraft industry, improving aircraft aerodynamic performances etc.

The collaboration with the 'Pivdenne' State Design Office was furthered. A general contract on S&T co-operation in developing space vehicles was signed and research priorities were set. Among them are ballistics, aerodynamics, heat exchange, novel materials and technologies, general issues of prospective designing etc.

Direct and efficient ties with private manufacturers were extended as well. The program of technological projects formed by a joint working group of Academy scientists and specialists of Donbas Fuel-and-Power Company could be cited as an example of those. The implementation of some projects has already been started.

One should note that NAS of Ukraine has achieved significant R&D results, which are the basis for efficient collaboration with large enterprises. Last year 3900 business agreements were fulfilled; they focused on improving the engineering and technological parameters of manufacturing in various industries. The innovative activities of NAS scientists

resulted in 825 patent applications and 722 patents received for inventions and utility models. In the year under review, Academy institutions concluded 86 license agreements and contracts both in Ukraine and abroad. Significant results were achieved in implementing the R&D (innovative) projects selected through competition.

Yet, it should be admitted that the scope of R&D carried out under contracts with outside organizations and commercialization of novel developments do not correspond to our potential, so NAS sections, departments and institutions are to boost their efforts towards the practical use of research results.

An important line of Academy's innovative activities is implementation of state targeted R&D programs. In 2012 fulfilled were programs in grid-technologies, energy-efficient LED lighting devices, nanotechnologies and nanomaterials, microelectronic technologies, science-intensive sensor products. Under those programs, even though they were financed at 25% of the sums allocated by governmental decisions when approved, quite a number of important applied developments for various industries were produced. In particular, the state targeted R&D program of developing and manufacturing science-intensive sensor products for 2008–2012 resulted in 39 competitive technologies of growing novel materials for sensor devices; 80 systems for identifying and monitoring chemical and biological compounds to be used in pharmaceutical and food industries, in biotechnology, medicine and veterinary medicine; 57 state-of-the-art diagnostic and measuring units as well as means for metrological control of sensor devices.

NAS co-operation with education institutions was extended, which, no doubt, is a guarantee of upgrading education and science in Ukraine, solving major problems in its economy and state establishment. The following statistics are eloquent evidence of the close interaction of our scientists with education specialists. In 2012, over 200 agreements between Academy institutions and institutions of higher education on collaboration, students' work placement and internship were being fulfilled. Nearly 280 joint research projects were implemented. Over 100 monographs prepared in collaboration with university professors were published. About 250 joint research-and-training facilities (complexes, centers, laboratories, chair branches etc.) were widely using Academy's potential for training skilled specialists. Recently, 1800–1900 highly skilled NAS scholars have taught university students each year, every tenth of them being NAS academician or NAS corresponding member. Last year, over 1500 students prepared their graduation projects under the supervision of our leading researchers.

Among the top-priority tasks of the development and further integration of science and education is, first and foremost, the formation of common infrastructure (centers for shared use of unique equipment, electronic libraries and networks, supercomputer centers), raising the standards of training (especially in advanced areas of natural and engineering sciences as well as the joint association of research and education scholars to the world academic community.

NAS of Ukraine gave a lot of effort to extending the international S&T collaboration, which is an effective means of integrating Ukraine to the European and world economic and technological space. It is to be stressed that the Academy represents Ukraine in nearly 40 international scientific organizations. Of great importance is the fact that last year witnessed some shifts towards positive decision on Ukraine acquiring the status of an associate member of the European Centre for Nuclear Research (CERN), with which NAS institutions have been collaborating for many years. Our scientists have been involved in developing research programs and updating the equipment of the Large Hadron Collider, designing and conducting experiments on it and processing the data obtained.

During the term of Ukraine's presidency in the Central European Initiative the Academy was invited to become a member of the International Centre for Genetic Engineering and Biotechnology, which operates in Trieste (Italy) under the aegis of UN. The participation in the work of his centre will enable NAS scientists to receive grants and scholarships, take part in research and scientific forums organized by it, have access to the most recent international information on the advancement of respective cutting-edge science areas. To date we are finalizing the preparation of the document package to comply with all necessary national procedures of the membership legalization.

In 2012, active work was carried on to increase the participation of Ukrainian scientists in international research programs, European ones in particular. For example, according to the results of the ERA-WIDE competition of the EU Framework Program 7 (FP 7), 5 Ukrainian projects were supported. They aim at broader co-operation of Ukraine and the European Union in biomedicine, superhard materials, nanoscience and nanotechnologies, novel manufacturing technologies.

Last year, significant efforts went to promoting ties with scientific organizations of the CIS countries, supporting the operation of the Council of the International Association of the Academies of Sciences (IAAS), advancing the collaboration with the Council of Eurasian Association of Universities. In particular, the 'Kurchatov Institute' National Research Center hosted a session of the IAAS Council, and a Protocol on extending the Collaboration Agreement between the IAAS and the institute was signed. A joint session of the Council of Eurasian Association of universities and IAAS Council was also held; it was hosted by the Academy of Sciences of Turkmenistan in the framework of the 7th Forum of Science and Arts Workers of the CIS member states.

Our Academy also took an active part in the Days of Science and Education of the Russian Federation in Kyiv. During that event, the prospects of promoting Russian–Ukrainian S&T collaboration were discussed and a decision to organize the International Cluster 'Interdisciplinary Science-Intensive Technologies' was approved. That would enable us to join efforts towards accelerating the development of innovative technologies in power industry, nuclear medicine, nanoindustry etc. A com-

petition of collaborative projects with the Siberian Branch of the Russian Academy of Sciences was held.

Now I would dwell on the financial and logistic support to research activities. In 2012, the state-budget funding of the Academy increased by nearly 10% against the previous year and amounted to UAH 2.5bn. But institutions' needs for expenditures in protected budget items (salaries, payments for public utilities and energy), whose share in the total funding had amounted to 90%, rose significantly. In this situation, last year a significant number of NAS institutions had to work a shorter work week or give unpaid leaves to their employees.

Because of continuous underfunding, the Academy is faced with numerous problems. First of all, this is the obsolete fleet of scientific instruments and equipment in research institutions and laboratories. The centralized procurement of state-of-the-art equipment for NAS institutions is actually nonexistent. Currently, about 75% of scientific equipment that is used mainly in fundamental research and supposed to assist in achieving results of the international scope has been in use for over 15 years. In developed countries, the operation life of such equipment does not exceed 5–7 years.

To be sure, the Academy and its institutions take steps to search for other sources of finance. In particular, interested partners are being involved and the emphasis is placed on the research projects whose results are in the highest demand on the market and that have the shortest pay-off period. NAS institutions give a lot of effort to win foreign grants, and participate in international research projects that make provisions for extra funding and provide opportunities of employing up-to-date equipment.

Of utmost importance has always been and still remains the involvement of talented young people in science. I would like to point out that the system of addressed financial support to talented young researchers created at the Academy and in the state as a whole is operating quite efficiently. It includes prizes, scholarships and research grants. NAS Presidium regularly informs about such competitions and encourages young scientists to participate. We are pleased that in 2012 young researchers of the Academy won 15 annual prizes of the President of Ukraine, 10 prizes of the Verkhovna Rada, 7 personal scholarships of the Verkhovna Rada, 4 grants of the Cabinet of Ministers, more than 40 grants of the President of Ukraine.

Those efforts have brought some positive results. Today almost every fifth researcher in our Academy is a young scientist, and every sixth candidate of science is under 35. Such statistics, however, cannot satisfy us, all the more so that in the year before last the number of young researchers decreased against the previous year, which was for the first time in the last ten years. The recruitment of young people was no better in the reporting year either. Unfortunately, the total number of young researchers fell by nearly 2% as compared with 2011.

Our experience shows that today the decisive factors that could encourage a young person to join scientific profession, and a young scholar to remain

to work in Ukrainian science, are, first and foremost, proper conditions for implementing their ideas with up-to-date scientific equipment, realistic prospects of getting accommodation (either apartments of their own or employer-assisted housing). So, the State Budget is to provide special finding for this purpose.

Summing up the NAS activities of the previous year, one can state with certainty that, despite all problems and difficulties, its institutions and research teams achieved significant results in many science areas. As before, scholars will not spare efforts to further advance science in Ukraine, provide scientific support to technological, socio-economic and cultural renovation of the nation.

Issues of Co-Operation of Academy Science with Industrial Sector of Economy

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

The potential of Ukraine's industry for financing scientific research and establishing contracts with scientific institutes is very limited under current economic crisis. In this situation, in 2012 the National Academy of Sciences of Ukraine took a number of science-organization measures to set up and strengthen its contacts with industry.

The meeting of the NAS Presidium, which was held in June 2012, determined the major lines in further co-operation of the Academy with the 'ANTONOV' Company. Those aimed, in particular, at applying cutting-edge technologies in aircraft construction, R&D of novel metallic and composite materials for aviation, improving aerodynamic performances of airplanes and introducing state-of-the-art information technologies in avionics.

In October 2012, the agreement was signed on the collaboration of NAS institutions with 'Pivdenne' Design Office in developing space vehicles. Top-priority areas of this research include problems of ballistics, aerodynamics and heat exchange; structural strength and creation of novel materials and technologies; design and manufacturing of solid-fuel rocket engines and liquid-fuel launch vehicles; development of satellite systems as well as telemetric and control ones.

NAS of Ukraine attaches top priority to joint works of its institutions with partner enterprises. In particular, targeted Academy programs in space research and those concerning the operation life and safe exploitation of structures, buildings and equipment were complemented with sections providing for extra funding for R&D in space-vehicle production.

Within the framework of scientific back-up to nuclear power industry, researchers carry out work on regular monitoring of irradiation conditions and radiation load of reactor vessels, as well as extending the service life of nuclear power plants (NPP). The possibility of extending the safe operation of reactor vessels # 2, 3 and 6 of the Zaporizhska NPP has been validated. The economic effect due to extending the operation life of an NPP vessel for one year amounts to about \$1.5bn.

Another example of co-operation of science and industry is collaborative development of AI-28 turbo-jet aircraft engine by 14 NAS institutes jointly with the 'Ivchenko Progress' State Enterprise, 'Motor Sich' JSC and 'ANTONOV' Company.

Scientists of the Academy developed a technological process of rolled metal production from lightly-doped high-strength steel. The use of such rolled

metal for manufacturing new-generation railway freight cars will extend their service life from 23 to 32 years, increase the run up between overhauls to 500,000km, and reduce their mass and cost.

Specialists of the NAS of Ukraine designed a 1.25 MW water-heating gas boiler that has no international analogs and put it into operation in the Kharkiv municipal heating network. It has the efficiency of 98%, saves up to 40% of natural gas as compared with older facilities, and is 30% cheaper than imported boilers of the same power. In Ukraine the demand for replacement of outdated low-yield boilers amounts to nearly 9000. Commercialization of the first 700 new boilers will save about UAH 100m after three years of their exploitation.

Our scientists have perfected the technology of the vacuum-arc deposition of hardening coatings onto cutting tools and accessories for instrument-making and machine-building industries. Such hardened tools have been tested at the 'Kharkiv FED Machine-Building Plant' State Enterprise for cutting toothings in steel parts and showed a 5–7-fold increase in their durability and service life. The plant is going to invest about UAH 600 thousand for a large-scale commercialization of the technology.

There are also positive examples of NAS collaboration with private businesses. In particular, our Academy participates in the program to raise the technological level of coal mining and electricity generation at the Donbas Fuel-and-Energy Company (DFEC). The technology of bolting support of mine-workings, developed by our scientists and employed at DFEC mines in Pavlograd, Krasnodon and Krasnyi Liman, has already given the economic effect of UAH 100m.

The technology for hardening and reconditioning the walls of molds in continuous-casting machines by the deposition of pseudo-alloy coatings, proposed in the NAS of Ukraine and commercialized at the Mariupol Illich Iron & Steel Works, provided a manifold increase in the mold durability.

Unfortunately, so far the existing demand for R&D results in Ukraine is rather low. A substantial improvement in this situation can only be achieved through the introduction of measures stimulating innovative activities and creating favorable conditions for industry investments in science. Especially it concerns the state-owned enterprises and corporations with a share of state capital. It is necessary to support the programs of their innovative development with the aim of attracting investments. Scientists of the Academy are ready to take an active part in implementing such programs and have quite a number of promising proposals. A part of them was presented for consideration to the Government of Ukraine in August 2012.

Fundamental Problems of Developing Novel Substances and Materials of Chemical Production



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

The 63rd United Nations General Assembly declared 2011 the International Year of Chemistry. It was held under the slogan "Chemistry is our life, our future", emphasizing by this the crucial role of chemistry and chemical processes, substances and materials in solving numerous global problems of mankind.

Taking this into account, the NAS Presidium at its April 2011 meeting analyzed the state of chemical science, chemical training and chemical production in Ukraine. As a result of discussions, it decided to start the integrated targeted research program 'Fundamental Problems of Developing Novel Substances and Materials of Chemical Production' (hereinafter 'Program').

Today, the chemical industry of Ukraine relies on large-scale production enterprises; the majority of them were established back in the 1960-ies. Unfortunately, all of them are strongly energy-consuming, and what is much worse, most of them use natural gas, which Ukraine has to purchase abroad, not infrequently on unfavorable terms. As a result, the competitiveness of Ukrainian "large-scale chemical production" is falling dramatically from year to year and this trend can also persist in the future. The fact that those enterprises, using obsolete technologies, cause irreparable damage to the environment also is of importance.

The analysis of chemical production development in the world shows that the orientation solely on large-scale enterprises does not comply with the current state of scientific and technological progress. It also does not bring appreciable return, i.e. profit in economists' terminology, which can turn into loss at the time of crisis. In the recent decade, leading countries have focused, first and foremost, on the development of small-scale production of chemicals and materials, which, besides its high profitability and innovative attractiveness, is also capable of quick introduction of cutting-edge technologies. In fact, in the last two decades small-scale chemistry became the strategic industrial mainstream and its market amounts to hundreds of billions of euros.

Unfortunately, due to many years of short-sighted neglect of the necessity to develop this sector of chemical industry, there is a difficult situation in small-tonnage chemical production of Ukraine. The scarcity or complete lack of numerous chemicals and materials produced by small-scale chemistry, which could meet urgent needs of different branches of Ukrainian economy, in fact, paralyzed their development and forced the consumer to purchase these products or

materials for their production abroad, often on unfavorable terms.

The obvious solution for the existing very hard situation is to create domestic small-scale highly profitable chemical production that would be based on novel technologies and aimed at manufacturing a wide range of products during the structural reconstruction of Ukrainian economy. That could ensure a crucial progress in operation and development of various industries.

The creation of scientific background for the abovementioned production is the objective of the program 'Fundamental Problems of Developing Novel Substances and Materials of Chemical Production'.

The major goal of the Program is to work out fundamentals for developing radically new chemical substances and materials based on advanced environment-friendly energy- and resource-saving technologies for different industries and social sector, such as electronics, mechanical engineering, instrument production, power engineering, transportation, light and food industries, printing industry, household chemicals, agribusiness, medicine, biotechnology, etc.

The important objective of the Program is to coordinate and extend fundamental studies on the development of radically new substances and materials of chemical production, which are carried on at various NAS institutes, to work out environment-friendly energy- and resource-saving methods of their synthesis and ensure the concentration of efforts on the most promising innovative projects.

According to the Program's tasks, the Scientific Council of the Program has identified the following research areas: novel organic substances, materials and composites on their base for new-generation equipment; advanced inorganic materials for modern equipment; advanced polymer materials for various functional applications; modern chemicals and materials for medicine and agribusiness; the development of novel energy-, resource-saving and environment-friendly methods for small-scale production of chemicals and materials.

The development of fundamentals for creating such chemicals and respective materials could form the background for organizing the manufacturing of a wide range of competitive chemical products, chemicals, additives and goods. This would reduce the domestic manufacturer's dependence on imported science-intensive chemical products and would also increase the export potential of Ukraine.

In 2012, 35 institutions representing 8 NAS departments, submitted 106 funding requests to the first competition of Program projects. After expert examination, 36 projects proposed by 24 Institutes of 6 NAS departments were approved for funding; their implementation will be continued this year.

Socio-Humanitarian Factors of Society Development



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

In 2012, the NAS Section of Social Sciences and Humanities focused its research efforts on determining and studying priority lines of Ukrainian society modernization, reformation of the national economy and social system, the ways to minimize risks of crisis trends reactivation; on validating novel technologies of economic and social management, advancement of the humanitarian sphere, improving the spiritual health of the Ukrainian society and realizing its creative potential.

Carrying out the assignment of the government, scholars of the Section worked out a draft law of Ukraine 'On the Concept of Ukraine's Humanitarian Development till 2020'; this was broadly discussed in the society. It presented basic values and principles of Ukraine's humanitarian development, outlined the priorities of the state cultural policy as an element of the general strategy to modernize Ukraine.

The results of comprehensive research into various aspects of equitable and sustainable socio-economic development were presented in the paper «National Strategy of Sustainable Human Development: Ensuring Equity», which was prepared by scholars of the Economics Department. It validated fundamental principles of the humanization paradigm of implementing the strategy of sustainable human development. Its essence is raising the humanization imperatives to become the principal criteria of anthropocentricity and harmonious development of the society, economy, and ecosystems in both medium-term perspective and the horizon for high-grade reproduction of future generations.

Economic scientists substantiated the ways to minimize the impacts of global imbalances on the economy and social sphere of Ukraine, which would allow it to avoid the onrush of destructive processes and the emergence of ruinous deficits. On this basis, they carried out variant predictive and analytical computations for the period till 2015, which took into account the implementation of various approaches stemming from the principles of monetary and finance policy in the economy of Ukraine.

Scholars of the Department of History, Philosophy and Law substantiated the impact of ideological and manipulative factors on forming the political identity of Ukrainian population. They determined the causes and specific features of ethno-political conflicts in today's Ukraine, produced recommendations towards improving its legal framework to prevent ethnic conflicts, and prepared a draft concept of state ethno-national policy. Besides,

they specified factors that would contribute to the formation of civilizational identity of the Ukrainian society under globalization. Mechanisms for optimal interaction of political subjects in the Ukrainian political and legal context were worked out, relying on the generalization of world trends in parliamentarism development. Researchers also determined basic principles of harmonizing the Ukrainian legislation with the European and international law, worked out proposals towards adjusting the Ukrainian legislation to EU norms and standards. Another stage of the 'Ukrainian Society' monitoring poll produced sociological data showing the dynamics of changes in various spheres of Ukraine's social life from 1992 till 2012.

At the Department of Literature, Language and Art Studies, the practical result of fulfilling the tasks of scholarly support to the national and cultural revival of Ukraine, advancement of Ukrainian spiritual culture was the completion of publishing the fundamental study – the 5-volume «History of Decorative Art in Ukraine», publication of two volumes of the 6-volume «Shevchenko Encyclopedia» vols. 1 and 2), the 2nd and 3rd volumes of the academic «Dictionary of the Ukrainian Language» and the final, 5th volume of the «History of Ukrainian Culture» (books 2 and 3). Scholars of the Department took part in the work on the draft Concept and Program of the development and functioning of the Ukrainian language.

In 2013, Department's institutions start to implement new targeted NAS research programs 'Modernization of socio-cultural spheres in Europe and Ukraine' and 'Civil society, person, state: national experience and potential for interaction'.

In the immediate future, the efforts of socio-humanitarian scholars will be aimed at academic back-up to political, legal, socio-economic and cultural transformations that would create conditions for the maximum realization of the nation's economic and socio-humanitarian potential.

Strategic Lines of Promoting NAS International Collaboration



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

Promoting the integration of Ukrainian intellectual potential to the international research area is one of the major tasks of the NAS of Ukraine. The continuous development of international scientific and R&D collaboration, which we have witnessed recently, was carried out last year along the lines of strategic importance and was focused on maintaining and diversifying co-operation with our permanent partners, the proper representation of the Academy in international scientific organizations, its broader participation in international programs and projects.

In view of the course towards European integration, declared by Ukraine, one should point out, first and foremost, Academy's collaboration with research institutions of the EU and associated countries as the strategic direction. For example, an inter-academy agreement on scientific collaboration was concluded last July during a visit of the NAS delegation to the Republic of Austria, and a list of respective joint projects was approved. Organizing activities to found the Agency of the Polish Academy of Sciences in Kyiv were going on. With the assistance of the FRG Embassy in Ukraine, a round-table discussion 'Mobility of young scientists: possibilities of its support in Ukraine and in Germany' was held in Kyiv last October. To ensure broader participation of NAS specialists in EU programs, numerous information and training events were held by national focal points that operate at NAS institutions, as well as under START, NANOTWINNING and COMBIOM projects.

Last year the NAS of Ukraine became involved in implementing the EU Strategy for the Danube Region in Ukraine, with its respective representation in the Coordination Center set up by the Government. In line with the results of negotiations held during an annual forum on the Strategy implementation, the signing of the Letter of Intent between the EU Joint Research Center and the NAS of Ukraine is underway. According to it, the Academy is to be entrusted with the scientific back-up to the Strategy implementation on the territory of Ukraine.

An important practical aspect was provided for long-term collaborative research of Ukrainian, Belarusian and Polish scientists, which materialized in setting up the 'Polissia' international trans-border biosphere reserve under the aegis of UNESCO. Last autumn, official celebrations to mark the reserve foundation took place in Warsaw and were attended by official delegations of Belarus, Poland and Ukraine. An international conference was also held to discuss the prospects of preserving the protected territories

alongside with the lines of reserve development and setting up organizations that would ensure its efficient functioning. Undoubtedly, the latter will make an important contribution to the conservation of the unique wildlife of Polissia.

Besides, in 2012, ties with strategically important NAS partners in the Russian Federation were being extended. In particular, to promote co-operation with the Joint Institute for Nuclear Research (Dubna), a targeted NAS program 'Prospective Basic Research in High Energy and Nuclear Physics' was started. Our Academy took an active part in implementing the RAS Bogoliubov Program in theoretical physics; a competition of research projects of the NAS of Ukraine and the RAS Siberian Branch was held, with 20 joint Ukrainian-Russian projects being selected according to its results. The creation of the Russian-Ukrainian cluster "Nuclear Physics Technologies for Medicine" and the preparation of an inter-state program in nuclear physics are being discussed jointly with the 'Kurchatov Institute' National Scientific Center.

An important area in the promotion of international co-operation is the ever-growing Academy involvement in various committees and working groups that function under international scientific organizations. For example, due to the active interaction of the NAS of Ukraine with the Federation of All European Academies (ALLEA), our scientists and specialists have become members of permanent working groups on scientific training and intellectual property protection, have been taking part in joint activities and publications in those areas.

The Regional Session of the International Academy of Astronautics, which was held in Ukraine and attended by the heads of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine, resulted in signing the Memorandum of Understanding, Prospects and Priority Areas of Collaboration in Space.

Jointly with the Committee on Biosecurity and Biological Protection under the Council for National Security and Defense and the Department for Support of the Convention on the Prohibition of Biological and Toxin Weapons (CPBTW) of UN Office at Geneva, the NAS of Ukraine held the international conference 'Biosecurity and Bioprotection-2: implementing recommendations of CPBTW member states'. It made a significant contribution to the diffusion of knowledge on biosecurity and bioprotection as well as dual-use information.

The concluding Joint Summary Conference of the 10-year Closed Nuclear Centres Partnership (CNCP) Program, which was attended by representatives of Great Britain, Canada, Russia, Armenia, Belarus, Georgia, Kazakhstan, Ukraine and Uzbekistan, aimed at forming a system for supporting the commercialization of research results, management of commercial projects and coordination of partnership efforts in various countries.

Activities of NAS General Meeting and Presidium



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

In 2012 the NAS General Meeting and Presidium focused their activities on organizing, coordinating and maintaining fundamental and applied research in the major areas of science and technology, on dealing with issues of socio-economic, political and cultural progress of the nation, integrating Ukrainian scholars to international scientific collaboration and training highly skilled research personnel.

The annual session of the NAS General Meeting, held in April 2012 and attended by numerous guests, summarized Academy's work in 2011, highlighted the most significant research outcomes and examples of R&D results being introduced to practice, outlined top-priority tasks for the near future.

The summarizing report of Academician B.E. Paton, the NAS President, the address of the President of Ukraine, speeches of scientists and guests emphasized the positive role of NAS scholars in solving problems of the national scope, raising the efficiency of S&T development according to the innovative model, implementing priorities in the sphere of science, preserving and promoting leading science schools, involving talented young people to scientific research.

The NAS V.I. Vernadsky Gold Medals were ceremoniously presented to NAS Academician B.O. Oliynyk for his outstanding achievements in Ukrainian literature and literature studies, and to B.P. Ristovski, member of the Macedonian Academy of Sciences and Arts, for prominent works in the field of Slavic history, literature and art studies.

The General Meeting of the Academy elected 21 NAS academicians and 49 NAS corresponding members.

A session of the NAS general Meeting was held in November 2012. Its participants commemorated the 120th anniversary of Academician M.P. Kravchuk – a world-renowned scientist in the field of mathematics and talented pedagogue.

Last year, 22 NAS Presidium sessions were held, which discussed important issues of Academy's activities. They attached great importance to analyzing the status and prospects of the advancement of fundamental research. 17 scholarly presentations covering various research areas were considered.

In particular, noted were research results in spintronics, nanosized systems, tribology, using zirconium materials in nuclear power engineering, integrated research into the resistance of Antarctic microbial ecosystems to various extreme factors, monitoring of socio-economic processes and changes in Ukraine etc.

NAS Presidium meetings analyzed research and research-management activities of 11 Academy institutions. The attention of some institutions' heads was drawn to inefficient implementation of R&D results, insufficient involvement of non-budget funds, shortcomings in the training of highly skilled researchers.

A top-priority area of Academy's activities is co-operation with ministries, agencies, institutions, enterprises and organizations of Ukraine in developing certain economy branches. With a view to coordinating collaborative works, the NAS Presidium, jointly with the heads of 'ANTONOV' state company, the state company 'M.K. Yangel 'Pivdenne' Design Office', Donbas Fuel-end-Energy Company and 'Electronmash' State R&D Company, analyzed the current status and development prospects in aircraft industry, space vehicle production, coal mining and heat and electric power generation, accounting of resource consumption in housing and communal services.

The joint session of the NAS Presidium, the Board of the State Agency for Science, Innovation and Introducing Information Technologies, and the Council of the State Fundamental Research Foundation, that marked the 20th anniversary of the Foundation establishment, stressed its important role in the advancement of fundamental research.

A joint session of the NAS Presidium and the Board of the State Statistics Service discussed scientific methodology of the second All-Ukraine Census to be held in 2013.

A joint session of the NAS Presidium and the Board of the State Space Agency marked the 75th anniversary on NAS Academician S.M. Koniukhov – a prominent scientist and space vehicle designer. A memorandum on prospective co-operation with the International Academy of Astronautics was signed.

Having considered reports on the implementation of 6 NAS integrated research programs, the NAS Presidium stressed the importance of the results obtained and took the resolution on continuing the programs.

Positive appraisals were given to work presentations of 13 young scientists, and ear-marked finance was provided for their further research efforts.

The NAS Presidium made special emphasis on international scientific co-operation. Collaborative research was organized with the European Centre of Nuclear Research, the Joint Institute for Nuclear Research, the Science and Technology Center in Ukraine, the Russian Foundation for Basic Research etc.

Sessions of the NAS Presidium also considered the next election to the Academy, the efficiency of applied research, distribution of budget funds, academic publication work, awarding NAS prizes named after prominent scholars of Ukraine and many other issues.

Mathematics



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

In 2012, scientists of the NAS Department of Mathematics carried out important fundamental investigations in the field of mathematical sciences. Numerous significant scientific results were obtained.

Experts in differential equations and dynamical systems established the existence of the Lipschitz invariant manifold for nonlinear systems on the direct product of a torus and a Euclidean space under the conditions of indefinite coercivity and indefinite monotonicity. The proof of the Kolmogorov hypothesis concerning one-parameter groups of linear continuous operators in a Banach space was completed. Functional equations with several transformations of the argument were studied. Conditions for the existence of solutions of degenerate linear systems of impulsive differential equations were obtained. New discrete conditions for the Lyapunov stability were proved. New conditions were obtained for the preservation of an asymptotically stable invariant toroidal manifold of a linear extension of a dynamical system under small perturbations. The Ladyzhenskaya flattening property was proved for the trajectories of three-dimensional primitive equations with viscosity.

In mathematical physics and functional analysis, the investigation of the Cauchy problem for a two-sided Toda chain was completed. A classification of integrable and superintegrable two-dimensional models that describe quantum particles with nontrivial dipole moment and admit first-order integrals of motion was obtained. Exact solutions were found for three of the systems obtained, among them being a neutron interacting with periodic potential. For a family of orthoprojectors in Hilbert spaces, the dependence of structural theorems on parameters was investigated. An orthoscalar analog of the M. Kleiner theorem was obtained. The polynomials whose square is equal to one only on the set of isolated points of the real axis were described; on this basis a description of the spectra of the periodic Jacobi matrices was given. The existence of global weak solutions was proved for initial boundary-value problems for a system of coupled Navier–Stokes/Fokker–Planck/Poisson equations that model strongly disperse charged suspensions. It was proved that fluctuations of linear statistics of eigenvalues of matrix models with arbitrary beta and multiinterval spectra have a non-Gaussian form.

In the theory of functions, a new variant of the mean-value theorem was proved for holomorphic functions of many variables. Theorems on the existence of regular solutions of the Dirichlet problem for Beltrami equations of the second kind were proved.

Asymptotically exact estimates were obtained for the best one-sided approximations of a class of differentiable functions by algebraic polynomials.

In probability theory and mathematical statistics, a method of singular perturbation of the exponential operator of large deviations was used to analyze the asymptotic behavior of stochastic impulsive processes on increasing time intervals. A diffusion process in the Euclidean space that acts in a direction inclined with respect to the given plane (a semitransparent membrane) was constructed. The existence of the Rosen renormalized local time of self-intersection was proved for Gaussian processes that do not possess the Markov property. The limit properties of solutions of the Ito stochastic equations with different oscillation rates for space and time variables were established.

In geometry and topology, the structure of the Bott S^1 -functions was studied and their applications to the investigation of the semi-free circle action on manifolds were described. The Morse numbers were determined for a new class of cobordisms. Necessary conditions for the Grassmann image of a ruled surface were established, and the existence of nontrivial deformations with fixed Grassmann image was proved.

Algebraists described vector bundles and derived categories of coherent sheaves over a new class of noncommutative projective curves. The classification of matrix divisors over commutative domains was carried out with the use of the Φ -skeleton of a matrix.

In the field of mathematical problems of mechanics, a new mathematical model of the nonlinear dynamics of a levitated droplet was constructed. It was established that Lyapunov theorems on stability with respect to linear approximations do not work in problems of partial stability; for this reason, the notions of limited instability and unstable coordinates were introduced. A new method was proposed to solve thermoelasticity problems for a body with the inclusion of an absolutely rigid thermoactive (or thermoinsulated) thin disk. While studying the temperature distribution in thin thermosensitive disks and washers, scientists tested the method of linearizing parameters for the determination of temperature fields in thin-walled thermosensitive structural elements under convective heat exchange with the environment.

In mathematical modeling and computational and applied mathematics, developed and validated was a superexponentially convergent functional discrete method for solving the Sturm–Liouville problem with a differential operator whose principal part is the Legendre operator. Methods to analyze automaton-algebraic models over a finite ring were developed, and the complexity of the solution of the problem of modeling a family of automata was investigated. A new method was proposed to determine exact analytic solutions for the contact boundary-value problems of admixture diffusion in two-phase regular structures.

Information Science



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

In 2012, scientists of the NAS Information Science Department obtained a number of important fundamental and applied results.

New SKIT-4 supercomputer was developed and introduced to operation. The computer has the capacity as high as 11.82 TFLOPS and it ranks the 99th in the world's Green 500 list in terms of its energy efficiency. The new computer is twice as powerful as the previous SKIT-3 one, its power consumption being one fourth of that of SKIT-3. It is the most powerful computing resource of Ukraine certified according to the procedures of the European Grid Initiative, and in combination with the SKIT-3, it forms the basis of the Resource Centre of the Ukrainian National Grid.

A new algorithm was developed and tested for the purpose of global balanced search for solution of the maximum graph cut problem. This allowed scientists to improve records of 37 tasks, as well as develop a new model of recall system based on the call-by-call service, provided intervals between calls, servicing and waiting times are adequate. Optimum controllability of distributed systems, along with observations of call flow intensities, was studied. For the purpose of identifying parameters of such systems, gradient algorithms were constructed. Methods for asymptotic analysis of regression models based on estimating robust ideas and stochastic optimization were proposed. On the basis of quasi inversion, a new direction method was developed for a multi-loop controlled processing of the management of objects with degenerate and ill-conditioned transfer matrices.

Effective criteria to search for strong solutions of Navier-Stokes equation systems were proposed. The solving functions method for the problem of beam persecution task, based on multiple reflection properties, was validated. Approximation algorithms, optimal in accuracy and quick action, were constructed for functions of certain classes.

A pilot version of a new insertion simulation system was developed, with an algebraic programming system (APS) as its basis, which ensures flexibility in developing new insertion machines. The formulation of logical properties for the locally minimum separators was generalized. That allowed the rules for accelerated inductive deduction of dependency structures for causal networks to be extended.

Methods and algorithms of withdrawing data from information sources were developed. Rules of their processing and analyzing were proposed, which permitted a group of alternative scenarios of events to be

formulated. A logical-and-probabilistic method was developed to forecast hypothetical scenarios of natural and man-induced accidents as assumed events.

A new approach to recognition under a priori statistical model uncertainty was developed. The approach was developed to create advanced technologies in the field of visual thinking theory, particularly those for recognizing spatial objects based on the Bayesian strategic suboptimal constrictions. Computer software was developed for building spatial human body models to study the information transmitted by the sign language.

A methodology of constructing precision orientation systems for small space vehicles was developed for space industry. The tasks of optimizing launch vehicle performances were studied, with a view to the necessity of space technology commercialization, international co-operation, and conversion of military missiles. A mathematical model of the development of an unstable crystallization front on the Earth and in space was developed.

The mathematical model and the optical scheme of a laser beam projector (relying on the Barker code) was proposed, which allows the contrast of speckles to be reduced, with optical losses less than 10%. A mobile non-destructive system for reconstructing audio information from rare data storage items was worked out.

A new 9-channel modification of cardiomagnetic scanner was developed. It is aimed at introducing a new non-invasive method of magnetic cardiography to the clinical medicine. In co-operation with the state-owned 'Electromash' research-and-production enterprise, a parallel intellectual workstation with the peak performance of 5 TFLOPS was created.

A radio relay communication model for the range of 30–300 GHz was developed. A digital radio relay system of THz-band for transmitting and receiving digital information with the 1.5 Gbit/s rate was created for the first time in Ukraine. The necessity of including of the new six THz bands to the National Radio Frequency Resource Plan was justified. A pilot version of the portable workplace for inspecting documents with computerized information storage, biometric information in particular, was developed. Experimental tests of 'Floratest' infocomm technology designed for evaluating the chlorophyll content in some plant species were completed.

A number of Grid-, supercomputer, ICT (infocomm technologies), IAS (information-analytical systems) etc. projects were implemented.

Mechanics



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

In 2012, scientists of the NAS Mechanics Department obtained a number of new important theoretical and experimental results.

The resonant nature of the influence of the radiation force of an acoustic wave on a sphere in a fluid-filled cavity was determined, as well as the dependence of the force direction on the frequency. A model of coupled processes of deformation and short-term damage of a material with the decreasing element of deformation curve, based on deformation microdamage criterion, was constructed. An effective discrete-continual approach to studying the mechanical behavior of inhomogeneous shells was developed.

Procedures for calculating structural elements of power plants under thermoelastic-viscoelastic deformation were developed. Electroelasticity equations relying on Hamiltonian formalism and difference approximations were developed. Possibilities of the direct Lyapunov method were extended to investigate systems with uncertain parameter values. Rated models were constructed; on their basis, transient performances of cylindrical and spherical piezotransducers were investigated.

A technique to predict aerodynamic characteristics of compressor cascades was developed; it relies on experimental data generalization with the use of an artificial neural network. The technique has no analogs in Ukraine and allows blade rows of aircraft gas-turbine engine compressor to be designed in a shorter time.

Scientific and methodological fundamentals were developed to study the dynamics, stress loading, and mode of deformation of the elements of a new-generation high-speed passenger locomotive with a system of passive protection against emergency collisions. The design of its energy-absorbing device was patented in Ukraine. A radically new driver's cab design was developed. The EP20 electric locomotive with the planned speed of 200km/h, which relies on the engineering solutions proposed, was commissioned on 1 December 2012.

A nonlinear mathematical model was developed for the process of low-temperature jump-like deformation of metals; it enables scientists to adequately describe the effect of determining parameters on the unstable deformation of metallic materials at cryogenic (down to 4.2 K) temperatures and establish the thermomechanical conditions for the safe operation of major structural elements under deep freeze.

The complete range of physical and mechanical characteristics of strength and deformability for a new

type of carbon-carbon composite materials within the temperature range of 300 – 3000 K and heat rates of 1000 degrees/sec under different mechanical loads (tension, compression, bending, shear) was obtained for practical application at 'Pivdenne' government design office.

An ion-plasma thermal cyclic hardening technology for rolling mill drive elements was introduced at the Dnipropetrovsk forming-rolls plant, which allowed a 1.7 – 2 times increase in their service life.

Studies of the transformation of the coal substance found that its "rapid" disintegration involves two phenomena: the synthesis of methane molecules and their additional mechano-electric desorption. The amounts of methane generated by these processes, as determined by gas-chromatographic analysis, are several times larger than those predicted by conventional methods of forecasting the gas volume per ton of coal substance.

A model and methods were developed to study the dynamic rock load and changes in the stress field during anchor installation for assessing the impact of anchoring design parameters on the state stress of the marginal rocks. The model is the first to account for the time of installing the row of anchors and the beginning of their operation, which is of major importance for calculating temporal process parameters and improving anchorage.

The dependence of the fractal dimension of the oscillation spectrum of elastic membranes on tension variation in their middle plane was found. The formation of dispersive train at the reflection of solitary wave from a steep slope was discovered. The dependence of the frequency of train amplitude spectral maximum on incident wave characteristics was found.

Researchers created a pilot complex of facilities and tested a prototype module designed for connecting damaged pipelines having uncontrolled outflow with the main pipeline without stopping the outflow during the connection process. This helps eliminate accidents that occur during underwater extraction and transport of hydrocarbons. Theoretical investigations of wave energy utilization by wing-mover with two degrees of freedom were carried out. The optimal parameters of wing-mover were determined.

A new approach to studying the stability of vector differential equations with varying delays and norm-bounded nonlinear terms was proposed. Sufficient conditions for exponential stability, expressed directly through system parameters, were found.

In 2012 RekS (abbr. for *Rekuperatsiya Svintsa* – 'lead recuperation') plant for recycling lead-acid batteries was put into operation in Dnipropetrovsk. It was designed and built under the guidance of scientists of the NAS Institute of Transport Systems and Technologies and experts of WESTA International R&D Corporation. RekS plant is the first in Ukraine and CIS countries industrial complex for full and waste-free recycling of spent batteries.

Physics and Astronomy



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

In the reporting year, fundamental and applied research in physics and astronomy was carried out at the 18 Department's institutions, which were working in close contact with leading institutions of higher education, including the Taras Shevchenko Kyiv National University, the National Technical University 'Kyiv Polytechnic Institute', V.N. Karazin Kharkiv National University, Lviv Ivan Franko National University, Donetsk National University etc. That made it possible not only to generate new knowledge and use it in a number of developments, but also to improve the quality of young scientists' training. All research efforts were made in line with the main activities of the Department of Physics and Astronomy, and the experimental and theoretical results obtained made a significant contribution to the development of current insights into various physical processes occurring both on the Earth and in space.

The abovementioned can be confirmed by a number of examples the Department can be proud of.

In the field of fundamental interaction and microscopic structure of matter, the CSISRS/EXFOR Experimental Nuclear Reaction Database was supplemented with the measured values of the effective threshold and cross section of the population of isomeric states of the $^{122}\text{Te}(\gamma, n)^{121m}\text{Te}$ reaction at 9–20 MeV energy values.

In solid state physics, much consideration was given to applied research. In particular, technologies of thermomechanical treatment of titanium alloys were developed for manufacturing high-strength aircraft components at the 'ANTONOV' State Enterprise. A resource-saving technology was proposed for producing heavy-duty wires.

In the field of low-temperature physics, for the first time ever the quantum diffusion of neon in C_{60} fullerite was observed, that being important for a better understanding of this extraordinary phenomenon and for the possibility of developing inert gas filters and absorbers based on carbon materials. A new type of electromagnetic signal amplifier, using superconducting qubits, was proposed.

In optics and laser physics, the two-photon transition was achieved between the ground and isomeric states of thorium-299 nucleus, which is essential for the high-accuracy frequency standard. An optoelectronic sensor of metrological visibility range that is superior in its characteristics to foreign analogues was developed and manufactured. The method of synthesized phase objects for recognition of patterns and other images was worked out in collaboration with Korean colleagues.

In the field of surface physics, emission and plasma electronics, the switching of atomic bonds in molecules

by the electric field was achieved, this opening up new prospects for the controlled effect on the structure and physical properties of surfaces. Unique results were obtained in using a plane electrostatic lens as a transparent plasma electrode extractor for electron beams; that can be applied in technologies for modifying surface properties of materials and in high-power microwave electronics.

As far as nanophysics and nanotechnologies are concerned, the majority of Department's institutions took part in implementing two programs – that under the NAS of Ukraine and the Inter-Agency Ukrainian-Russian one. The research carried out under these programs is mainly of the purpose-oriented nature and is to end up in building production prototypes or in technology development. For example, the effect of magnetic-polaron current blockades at low temperatures and voltages, which are caused by quantum fluctuations of molecule position, can be used to manufacture nanotransistor elements.

In radio physics and electronics, a method was developed to analyze the magnetization of left-handed magnetic metamaterial by measuring its transparency in the millimetre wavelength range, this being important for the advancement of meta- and nanomaterials physics, as well as for building elements of fast-action devices of microwave electronics, solving some problems of flaw detection, etc.

In the field of soft matter physics, a field-effect transistor was built on the base of lyotropic liquid crystal films characterised by high carrier mobility.

In astrophysics, astronomy and radio astronomy, a number of galaxies were discovered that have an extremely low content of heavy elements. It is interesting to mention that 12 of the 17 known galaxies of this type were discovered by Ukrainian scientists.

It is encouraging to note that some results the Department of Physics and Astronomy, reported in the previous years, have been given high appraisals:

The winners of the 2012 State Prizes of Ukraine in Science and Technology were I. Klyui, V.P. Kostylev, A.V. Makarov, A.V. Sachenko and O.Yu. Avsentiev, researchers of the V.E. Lashkaryov Institute of Semiconductor Physics; V.G. Ivanchenko, V.K. Nosenko, Prof. V.N. Uvarov, NAS Corresponding Member, and Prof. V.N. Antonov, NAS Corresponding Member, researchers of the G.V. Kurdyumov Institute for Metal Physics, as well as S.G. Sharapov, an associate of the M.M. Bogolyubov Institute for Theoretical Physics. The Prize of the Russian Academy of Sciences and the National Academy of Sciences of Ukraine, awarded for the first time ever, went to Prof. Ya.S. Yatskiv, NAS Academician, for performing the cycle of works 'Russian-Ukrainian Space Geodesy and Geodynamics Network'.

The Order of Prince Yaroslav the Wise V Class was presented to Prof. V.F. Machulin, NAS Academician. Prof. M.S. Brodin, NAS Academician, was awarded the Order of Merit I Class. The Diploma of the Verkhovna Rada of Ukraine was received by Prof. B.I. Lev, NAS Corresponding Member.

Earth Sciences



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

In 2012, scientists of the NAS Department of Earth Sciences obtained a number of major fundamental and applied results. Some of those received awards and prizes.

A team of scientists, including NAS Corresponding Member S.K. Konovalov, doctors V.M. Byelokopytov and Ye.O. Hodin from the NAS Marine Hydrophysical Institute, was awarded the State Prize of Ukraine in Science and Technology for the work "Development and creation of the national collection of maritime navigation charts and the Oceanographic Atlas of the Black Sea and the Sea of Azov".

The workers of the Ukrainian State Research and Design Institute of Mining Geology, Geomechanics and Mine Surveying, operating under the NAS of Ukraine, M.H. Tirkel, O.O. Glukhov and V.A. Antsiferov received the NAS S.I. Subbotin Prize for their book «Study of Gas Content in Coal-Bearing Strata».

For their work «Settlement of Urban Population in Ukraine and its Migration», researchers of the NAS Institute of Geography A.A. Mozhovyi and S.O. Zapadnyuk were awarded the Verkhovna Rada prize for talented young scientists in basic and applied research and R&D.

In 2012, the efforts of Department's Bureau were focused on advancing research into increasing the amounts of mineral resources, the efficiency of their use, developing geo-ecological research, with a view to stabilizing and improving the environment in the country.

During the reporting year, Department's institutions maintained broad scientific ties with international organizations and research institutions of the CIS and other foreign countries that work in the field of Earth sciences. International scientific and S&T collaboration was carried out along several lines: participation in the implementation of international projects; participation in international conferences, seminars, working groups; participation in international research expeditions; internships in foreign institutions, etc.

The National Center for Seismic Data and NAS Seismic Network fulfilled assignments of the Interstate R&D Program on creating a system for seismological monitoring of CIS areas.

In December 2012, we signed an Agreement on collaboration between the Helmholtz Centre in Potsdam (GFZ German Research Centre for Geosciences) and the NAS Institute of Geophysics on

installing state-of-the-art digital equipment in 'Odesa' Geomagnetic Observatory to get this observatory included to the INTERMAGNET network.

The international exchange of seismic information with the Geological Survey of the U.S. State Department was going on. The American partners (Albuquerque Observatory, USA) were regularly provided with the records of seismic events and microseisms registered by the 'IRIS-Kyiv' seismic station, which is a part of the global seismic network.

NAS Ukrainian Research Hydrometeorological Institute co-operated closely with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), whose decision appointed the institute as the main organization in introducing the EUMETSAT technology for receiving and processing satellite meteorological information and its use in operational prognostic activities of the national hydrometeorological surveys of Armenia, Azerbaijan, Belarus, Georgia, and Moldova.

The International bathymetric map of the Southern Ocean was published; it was developed in 2002–2012 under the respective program of the International Scientific Committee on Antarctic Research (SCAR). To compile the map, data of 15 participant countries were used, including those collected by the NAS Institute of Geological Sciences in Antarctic marine expeditions.

Ukrainian Mineralogical Society, in co-operation with the Austrian, Polish, Romanian and Slovak Mineralogical Societies and the Hungarian Geological Society, held the 5th Joint 'Mineral Sciences in the Carpathians' Conference and the 3rd Central-European Mineralogical Conference (Miskolc, Hungary; 19–21 April, 2012).

The NAS Science and Engineering Center for Radiohydroecological Research held two international meetings in collaboration with experts from Germany, France, Sweden, Spain and the Netherlands on the problems of radioactive waste in Ukraine.

In 2013, Department's scientists will focus, first and foremost, on working out scientific fundamentals of and an integrated approach to the evaluation of mineral deposits development, which would ensure the maximum reliance on Ukraine's own resource base; improving geological and economic approaches in assessing the prospects of the mineral resource base and its development; developing technological research into promising types of mineral resources, including alternative and technogenic ones; research to improve the environment and increase safety in the mining industry.

Physical and Technical Problems of Materials Science



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

In 2012, scientists of the NAS Department of Physical and Technical Problems of Materials Science obtained a number of important scientific results, which are of great significance for various industries.

A pilot version of equipment was developed to form convection and radiation flows, using high-frequency power sources for non-contact welding of live soft tissues, treatment of infected and purulent wounds. The control system supports the mode of a non-contact thermo-surgical instrument in the range of 50–120°C and pulsed-periodic operating mode at a temperature of convection-radiation flow in the range of 100–65°C, which enables the ratio of convection and radiation components to be controlled within 30% limits, thus allowing welding the vessels of 3mm diameter during operations on parenchymatous organs, making cuts in the projection of these vessels using the “bloodless cut” technology, performing the sanitation of infected and chronic purulent wounds and carrying out high-frequency bipolar coagulation of soft tissues.

The effect of the materials of electrode coatings on precipitation of hard constituent of welding aerosol and the valence of manganese and chromium in aerosol composition were investigated. It was shown for the first time that manganese in the welding aerosol is present not only in 2- or 3-valence state, but also in Mn^{4+} state, which is characterized by a higher toxicity. Relying on the research done, electrodes with rutile coating (ANO-39 grade) were developed, which during welding reduce the aerosol release by one third as compared with MR-3 and ANO-36 electrodes, the most widely used in Ukraine and CIS countries. The new electrodes are not inferior to the best foreign analogs in terms of their hygiene and sanitary characteristics.

In studying the processes of mass transfer in Al_2O_3 – Y_2O_3 system, using microwave (MWH) and conventional (TH) heating, it was found that under MWH the successive formation of all phases on powdered samples, such as the YAM monoclinic phase, YAP perovskite and YAG garnet, occurs significantly faster and at temperatures lower by 150–200°C than that under TH conditions. The YAG ceramics synthesized by MWH can be promising for protecting products in oxidizing medium, as the coefficient of oxygen diffusion in it is by 10 orders of magnitude lower than that in zirconium oxide.

Investigations were carried out into the effect of electric current on adhesion and wetting of oxide materials by metallic melts at high temperatures, depen-

ding on the direction and value of the current passing through the interface. For the copper-based melt – ZrO_2 (hard electrolyte) system, a significant increase in adhesion was observed for the first time during passing the current in the melt–oxide direction, i.e. when hard phase was the cathode; with the opposite direction of current, the adhesion decreased. The electro-adhesion phenomena studied are of fundamental importance and can be applied in practice, in particular, for brazing of dissimilar materials.

Using the method of X-ray diffraction tomography, the localization of structural disadvantage zones in the chain of grown IIa type diamond crystals was determined. It was found that the region adjacent to the primer crystal zone is the source of dislocations which have clustering distribution in the crystal bulk and correlate with the zone-sector structure of crystal growth. This result would contribute to growing more perfect IIa crystals.

Department's scientists completed a series of investigations for the development of engineering methods to assess the residual life of structure elements with sharp stress raisers, i.e. cracks under cycling loading and the effect of operating environments. The methods are based on the concept of assessing the residual life of structure elements by the rate of fatigue crack growth. A wide class of structure elements with various crack-like stress raisers was studied and the dependence of the growth of these raisers during their cyclic loading was found; the criterion for determining the critical size of a crack-like raiser was formulated.

Technologies of sapphire growing in reduction gas media, which are competitive on the world market, were developed; the production of sapphire crystals of 170x250x35 mm³, 170x250x80 mm³, 260x300x40 mm³, 350x500x40 mm³ sizes was mastered. Using the equipment produced in Ukraine, a complete technological cycle for manufacturing sapphire optical windows and backings was developed. The characteristics of sapphire products achieved meet the best international standards.

L.I. Anatichuk, NAS Academician, was awarded the order of Prince Yaroslav the Wise V Class, V.L. Naydek, NAS Academician, was awarded the ‘Order of Merit’ I Class, Z.T. Nazarchuk, NAS Academician, and D.F. Chernega, NAS Corresponding Member, were awarded the ‘Order of Merit’ II Class, T.A. Prikhna, NAS Corresponding Member, was awarded the Order of Princess Olga III Class.

The high title ‘Honored Worker in Science and Technology of Ukraine’ was awarded to Yu.V. Milman, NAS Corresponding Member, and A.V. Gektin, Dr. of Physics and Mathematics.

Physical and Technical Problems of Power Engineering



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

In 2012, the efforts of scientists of the NAS Department of Physical and Technical Problems of Power Engineering (DPTPE) addressed major R&D problems of Power Engineering in Ukraine.

In 2012, scientists of the Department produced a number of significant results in fundamental and applied research.

Important studies on possible uses of nanotechnologies in the Power Engineering sector were carried out.

Systemic fundamental research into thermostable nano-liquids using thermographenite nano-dispersions, carbon nanotubes and aluminosilicates produced in Ukraine was carried out. It showed that nano-liquids have a significant potential in the power engineering sector, in the nuclear power industry.

A portable facility, a self-contained one as well as pilot facilities were developed for producing nanolaminate material – thermally expanded graphite or thermographenite – to be used as an effective super-absorbent of spilled oil and oil products.

Relying on symmetry analysis, scientists elaborated a theory of turbulent flow and heat-exchange in nano-liquids, which won international recognition.

An industrial nanobiotechnology of phospholipid vesicular nanostructures was developed on the basis of discrete-pulse input energy method. It allows a 10% increase in crop yields.

Among the fundamental results one can also mention the elaboration of mathematical models, calculation methods and numerical analysis of the effect of aerodynamic interaction between adjacent steps on the transient loads and fluctuations of axial compressor blades of aircraft engine. It allows an increase in the reliability and service life of the engine.

A 3-dimensional integrated mathematical model of rotating magnetic field of the stator three-phase cylindrical electromagnet mixer, used in the continuous casting machine, was developed.

An approximation operation method of digital signal processing in dynamic systems, based on S-transform, using the local and global versions of orthogonal Legendre polynomials, was extended. That enabled researchers to form programming model operators of fractional differentiation in the operating space.

Important applied studies were carried out in the area of natural gas saving and replacing. For example, a technology and integrated system for producing and using biogas of domestic waste dump waste

was developed to generate electricity. The first stage of a system with piston engines of 880 kW power was commercialized by 'LNC' LTD.

Experimental studies of air gasification of coal, peat and raw materials derived from biomass – agriculture and forestry waste, as well as shredded tires, in the direct, inverse and combined gasification processes were carried out. Recommendations on the choice of gasification technology, depending on the purpose of the process, were produced.

Among the applied results of research into environmental issues one can point out a technology for reducing sulfur dioxide emissions in wet ash collectors by recycling the ash captured and a novel engineering solution to stabilize the 'Ukryttia' ('Shelter') facility by filling the reactor cavity with syntactic compounds.

The implementation of the NAS multidisciplinary research program 'R&D Problems of Integrating the Power System of Ukraine to the European Energy System' ('Union') was completed. Most of its projects had been carried out by Department's institutions. Significant R&D results were obtained, which led to an important step towards providing R&D support to the integration of the United Energy Systems (UES) of Ukraine to the European Energy System, primarily, ensuring the necessary level of observation, monitoring and control of the UES of Ukraine and adjusting the regulatory and engineering framework of the UES of Ukraine to the European requirements.

In particular, taking into account the characteristics of the UES of Ukraine, Department's scientists formulated the requirements to and developed a model of the secondary voltage adjustment system and a method to assess the stability by the voltage in the operational control mode, produced and commercialized software in the control center of the 'Ukrenergo' NPC for the analysis of steady-state regimes, the static stability of regimes and the admissibility of loading controlled intersections. For the first time a radically new method to organize a system for automatic adjustment of frequency and power with the use of regulator consumers was proposed and implemented; a mathematical model of the system was developed and investigated. Scientists developed a mathematical model of the magnetic field of power lines and a new method for its reduction by a factor of 2–10 without the use of additional tools.

A number of R&D works carried out with the participation of Department's scientists received high state appraisal. O.E. Antonov and V.H. Melnyk with co-authors won the 2011 State Prize of Ukraine in Science and Technology. P.N. Kanilo received the 2012 State Prize of Ukraine in Science and Technology. B.S. Soroka was awarded the title of 'Honored Worker of Science and Technology of Ukraine'.

NAS Academician Yu.P. Korchevov, NAS Academician O.Yu. Maistrenko and O.I. Topal won the NAS V.I. Tolubinsky Prize. NAS Corresponding Member Yu.F. Snezhkin. Was awarded the O.V. Lykov Prize of the NAS of Belarus.

Nuclear Physics and Power Engineering



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

In 2012, scientists of the NAS Department of Nuclear Physics and Power Engineering obtained major scientific results.

A new procedure was developed to calculate the surface tension of heavy nuclei and the corresponding curvature corrections (Tolman length).

Isotopic-abundance ratios (Cs, Eu, Pu, Am and Cm) were measured in the fuel-carrying materials sampled in the interior of the Chernobyl nuclear power plant unit No 4 and in the soil around the NPP; the fuel burnup was determined. ^{243}Cm isotope activity was detected for the first time.

At the Large Hadron Collider (CERN, Switzerland), with the participation of Department's scientists, the probability of B^0_s meson decay to produce a muonic pair was first measured in a new energy range of proton-proton collisions (7 and 8 TeV), which confirmed the Standard Model prediction.

Theoretical studies were carried out into the first- and second-order quantum-electrodynamic processes, concerning the fine structure constant in the field of two intense pulsed laser waves.

A new mechanism was proposed for helicon plasma acceleration by ponderomotive forces in hybrid-mode electromagnetic fields localized in the peripheral plasma-column region.

For the first time ever, contrary to the pleiad rule, inversion was discovered in isotopic fractionation of hydrogen (^1H , D, T) and carbon (^{12}C , ^{13}C , ^{14}C) as being due to the magnetic isotope effect. Radioactive properties of the isotope nuclei do not violate the pleiad rule.

Model experiments were made to develop the concept of fast-neutron subcritical fusion hybrid reactor based on the combination of stellarator/mirror trap magnetic systems.

To investigate heat-transfer metals in new-generation reactors, a technique using the high-resolution Rutherford backscattering method was developed for *in situ* studies of component segregation in melts and their oxidation.

To investigate reactor materials, the world first unique complex, including convection loops with water in sub- and beyond-critical states as well as electron irradiation chambers, was built and tested. The highest fluence attained was 10^{20} el/cm².

A prediction for steel Kh18N10T swelling along baffle reflector cross-section of WWER-1000 reactor was made for ~ 30–60 years of operation time. This

prediction was based on the analysis of heavy-ion irradiation simulation experiments.

The test data analysis of reconstructed survival specimens provided substantiated time frames of safe reactor vessel service at nuclear unit No. 2 of the Zaporizhska NPP till the end of the 58th fuel life at the least (~ 2045).

Scientific methodology support of operations was provided for the removal of hazardous toxic hexachlorobenzene waste, amounting to 3430 tons, from the area of 1972m²; its disposal in the standby zone of the Dombrovsky open cast in the Kalush district of the Ivano-Frankivsk oblast had not met the environmental safety requirements.

Some new devices were created: an analyzer for the search and localization of hidden ionizing radiation sources; the monitor of the nuclear-material physical protection system to prevent unauthorized material handling and to increase the nuclear security of the state; an analyzer for monitoring tritium and carbon-14 discharges in the zones of NPP influence.

The compositions of uranium ores from producing fields of Ukraine were investigated and their identification characteristics determined, with a view to solving nuclear criminalology tasks.

Nuclear methods of monitoring the health status of children in environmentally neglected areas of Ukraine were introduced.

The State Prizes of Ukraine in Science and Technology were received by NAS Academician L.A. Bulavin and by researchers of the NAS Institute of Environmental Geochemistry: NAS Corresponding Members G.V. Lisichenko and Yu.L. Zabulonov, and Doctor of Science in Engineering S.N. Chumachenko as co- authors.

The NAS D.V. Volkov Prize was awarded to Doctors of Science in Physics&Mathematics Yu.L. Bolotin and O.Yu. Korchin, and NAS Corresponding Member P.I. Fomin for the series of works 'New approaches in particle physics, nuclear dynamics and astrophysics'.

The Fifth International Seminar-Workshop 'Development of Nuclear Power Engineering as a Factor of Continuous Interstate Co-operation' was held. Rapid growth was seen in the collaboration with international and national scientific and R&D centers and organizations, including CERN (Switzerland), IAEA, Euratom, Joint Institute for Nuclear Research, 'Kurchatov Institute' National Research Centre (RF), and 'Rosatom' state-owned corporation (RF).

Chemistry



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

Scientific research in chemistry is conducted at 11 Institutes and 2 Institute Divisions by about one thousand highly qualified scholars, 12 NAS academicians and 28 NAS corresponding members being among them.

In 2012 we achieved quite a number of important fundamental scientific results meeting international standards, namely:

The possibility of mechano-chemical production of graphene-like MoS_2 in the presence of chemically inert exfoliators was shown for the first time, which allows scientists to obtain stable dispersions of mono-layer MoS_2 particles in various organic solvents – promising materials for electronics and optoelectronics (NAS Academician V.D. Pokhodenko).

An active system based on pyridines and sulfur dioxide was developed; it efficiently dehalogenates freons at room temperature, yielding commercially important fluorinated olefins (NAS Academician V.G. Koshechko).

Glassy liquid crystal composites of alkanooates of alkali and alkaline earth metals with inclusions of CdS, CdSe (1 – 5 nm) showed that rapid self-defocusing and high nonlinear refractive index of nanocomposites determine the prospects of their application in new optoelectronic devices and laser technology (NAS Academician S.V. Volkov).

Conditions for synthesizing liophilic polymer organo-inorganic systems (OIS) with improved sorption properties were determined; those systems are promising for industrial applications (NAS Academician E.V. Lebedev).

New highly effective palladium-containing carbeno-complex catalysts for the reaction of reduction dehalogenation of halogenaromatic compounds by alkaline metal isopropoxides were developed, which could form the basis for commercial neutralization of chemical and pharmaceutical waste (NAS Academician A.F. Popov).

Fundamental physical and chemical properties of deuterium depleted (light) water at different temperatures were studied for the first time ever. The results achieved show the major role of deuterium – hydrogen isotope – in physico-chemical properties of water. It was proved that changes in density, surface tension, viscosity, boiling and freezing temperatures of water result from the presence of different deuterium concentrations in water, which leads to formation of clusters in various sizes and numbers respectively. It was shown that the maximum sizes of deuterium clus-

ters are characteristic of common water with ~150 ppm deuterium content. A new theoretical model of clusters formation was proposed. The physico-chemical characteristics of light water obtained allowed scientists to advance a breakthrough idea that accounts for all its anomalous properties (NAS Academician V.V. Goncharuk).

The method of analysis of radioligand for the first time showed the influence of the configuration of 3-atsetyloksy-1,2-dihydro-3H-1,4-benzodiazepin-2-ones on the type of their functional activity. While racemates are full agonist of benzodiazepine receptors, S-enantiomers showed partial agonist properties (NAS Academician S.A. Andronati).

For the first time ever, a method to evaluate the cytotoxicity of carbon nano-pipes (CNP) produced with in-house facilities was proposed; it relies on kinetic data of spin probe reduction by cell mitochondria of various tissues. Experimental evidence and quantitative data were obtained concerning selective toxic action of CNP and their oxidized form with respect to cell organelles – mitochondria of animal kidney, heart, lung and liver (NAS Academician M.T. Kartel).

Cyclic polyamines functionalized by difluoromethylphosphonate residuum were synthesized. Test results of the biological activity of the compounds obtained showed promise of their application in further purposeful search for phosphotyrosine mimetics based on macrocyclic amines and their derivatives (NAS Academician V.P. Kukhar).

Experimental evidence of the role of nano-sized ultra-pores in selective sorption of ammonium ions and the amount of heavy metal ions, radio-caesium included, were obtained (NAS Academician V.V. Strelko).

Optimum conditions for the synthesis of homogeneous lithium-conducting LIPON ($\text{Li}_3\text{PO}_4 - x\text{N}_y$) films by radio-frequency magnetron spraying were substantiated. The films are good protective covers for electrolyte in solid lithium accumulators and are characterized by room-temperature conductivity $\sim 3 \cdot 10^{10} \text{ Ohm}^{-1} \text{ cm}^{-1}$, activation energy $\Delta E \sim 0.27 \text{ eV}$, and a wide electrochemical window 0–5 V (NAS Academician A.G. Bilous).

The catalase activity of Cu(II) pirazolatnyh μ -(μ -pz) complexes is by three orders of magnitude lower than in the Co (II) complexes. Replacing μ -pz by phenantrolin increases the activity by two orders of magnitude. Maximum activity has been found for equimolar mix of mononuclear Cu(II) complex and binuclear Co (II). The entropy of activation reaction is positive with a predominant contribution of ΔS^\ddagger to ΔG^\ddagger . (NAS Academician G.L. Kamalov).

In the period under review, a General Meeting of the NAS Chemistry Department was held, 7 Bureau Meetings considered issues that focused institutions' research programs in the framework of the targeted research program of the Department 'Development of Modern Priority Areas in Chemistry'.

Biochemistry, Physiology and Molecular Biology



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

The activities of the institutions of the NAS Department of Biochemistry, Physiology and Molecular Biology in 2012 aimed at fundamental research in top-priority areas of biochemistry, animal and human physiology, molecular biology and biotechnology, genomics and proteomics, nanobiotechnologies, as well as works to create new medicines, diagnostics and agents for practical medicine, agriculture and veterinary. Department's researchers carried out large-scale research in functional biochemistry, genetics, oncology, studying the structure and function of proteins, molecular immunology, and cryobiology.

Using monoclonal antibodies in studies of thrombogenesis mechanisms, scientists of the NAS Palladin Institute of Biochemistry have demonstrated that α C-regions in monomeric and polymeric fibrin desA are connected with B (FpB) fibrinopeptides. After splitting-off by FpB thrombin the α C-regions within protofibrillae come off the molecule framework and strengthen the lateral association of protofibrillae.

Researchers of the NAS Bogomolets Institute of Physiology have shown the protective effect of the modification of fatty acid composition of cell membranes under conexin-43 injury in conditions of experimental diabetes mellitus, which allows them to recommend drugs with ω -3 fatty acids to be used for developing patterns of cardiovascular complications treatment in patients with diabetes.

Researchers of the NAS Zabolotny Institute of Microbiology and Virology have established the dependence of the synthesis of extracellular and surface lectines on the carbon source in the growth medium and on the genotype of *Bacillus subtilis* strains. They have found the effect of mutations in genes of *B. subtilis* *recP* and *recE4*, which belong to the reparation/recombination system, on the dynamics of lectine formation, the level of lectine activity of free and bound forms and the time of their presence in the culture liquid and on cell surface.

Investigations carried out at the NAS Institute of Molecular Biology and Genetics have shown changes in the degree of methylation of specific lysine residues related to tumor genesis, and a new phosphorylation site has been identified in the elongation factor of 1A translation.

New tactics for treating thermal burns of the 2–3A degree, which relies on AYBM-MH carbon sorbents, has been developed at the NAS R.E. Kavetsky Institute of Experimental Pathology, Oncology and Radio-

biology. A continuous 3-day contact between the sorption bandage and the wound surface facilitates the preservation of the main part of skin epithelial layer and reduces the term of injured tissue epithelization by a factor of two.

Researchers of the NAS Institute for Problems of Cryobiology and Cryomedicine have established new patterns in the development of autoimmune diseases and pathogenetically significant causes of their onset. It has been shown that a considerable role is played, in particular, by the inhibition of immunity T-regulatory link, a noticeable decrease in the apoptotic activity of immunocompetent cells, and a significant change in the body cytokine profile.

The efficiency of kanavanine, a toxic analogue of plant arginine, as an anti-tumor drug has been studied at the NAS Institute of Cell Biology. It has been shown that kanavanine use in an arginine-free medium or in combination with human recombinant arginase in a complete culture medium leads to a selective decrease in the viability of human epithelial tumor cells of various organ origins.

In the field of medicine, diagnostic methods to estimate the state of blood circulation and microcirculation system under cardiac insufficiency have been introduced in the clinical practice; methods for aorto-coronary shunting in patients with complicated lesions of coronary arteries have been developed; new factors of risk and development of diabetic retinopathies, drug renoprotection and renoprophylaxis in patients with chronic kidney disease have been detected; an integrated approach has been developed to estimate the potential risk at work places where nanotechnologies are used; a new theory has been formulated on the effect of environmental factors on the development and progress of arterial diseases in young people.

Department's institutes continued their collaboration with medico-biological institutions of other ministries and agencies of Ukraine as well as foreign ones.

For example, the first bilateral Ukrainian–Russian seminar was held on October 17–20 at the NAS Palladin Institute of Biochemistry. It addressed a most urgent problem of today's medicine, fundamental and applied biochemistry – *Proteins of Human Haemostasis System in Norm and Pathology*, and was jointly organized by the NAS of Ukraine and the Russian Foundation for Basic Research. The work of the inter-agency scientific seminar *Molecular Medicine* was regular. The NAS Department of Biochemistry, Physiology and Molecular Biology has become the Expert Evaluation Centre on Biosafety and Bioprotection in Ukraine and East-European countries. In April 2012, it hosted an international conference on implementing provisions of the Convention on the Prohibition of Biological and Toxin Weapons, alongside with two international seminars on biosafety and bioprotection.

General Biology



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

In 2012, the attention of biologists of the NAS Department of General Biology was mainly focused on further development of fundamental and applied research into physical, chemical, structural and functional principles of organization and functioning of plants and animals, on studies and conservation of biodiversity, as well as the development and wider application of advanced biotechnologies in genetics, plant breeding, plant introduction and acclimation, and in medicine.

For the first time, properties of new chiral mutagens were studied in M1–M3 generations of winter wheat, and at the cytological level; it was found that, in terms of their genetic activity, those are not inferior to the known supermutagens and, in some cases, are even superior to them in the frequency of visible mutations. The optimal and critical concentrations of those mutagens were determined.

It was discovered that the variation in germination rates of corn seeds was directly associated with epigenetic polymorphism, and this was seen in differences in the methylation profile of both the transcribed and satellite DNA.

It was shown that environmentally safe strains of *Agrobacterium tumefaciens* soil bacteria could be used for temporary transfer of specific genes to agricultural crops and further expression of these genes. As a result, crop plants can acquire important traits (drought resistance, insect resistance, etc.) without creating transgenic organisms.

It was found that under the effect of UV-B irradiation (6.8–68 kJ/m²) of plants the dose-dependent inhibition of growth of the main roots and swelling of cells occurred; excessive ectopic root hairs were formed, and the loss of positive root geotropism was observed. That was accompanied by a respective dose-dependent randomization and/or depolymerization of microtubules in various cell types. It was shown that moderate doses of UV-B irradiation increased the level of gene expression of different isoforms of α -tubulin, while high doses reduced that level.

The inhibitory effect of mycelial extracts of some medicinal mushrooms, including bird's nest mushroom (*Cyathus striatus*), on pancreatic cancer cells was observed, which could be used in developing new therapeutic strategies for the treatment of this disease.

It was found for the first time that the methane gas released from bottom gas jets of the Sevastopol marine area is of microbial origin and was formed from fresh non-oxidized organic matter of anthropogenic origin.

The attention of our researchers is always focused on studying the biodiversity of flora and fauna. Every year, scientists describe new species of unicellular and multicellular organisms, including plants, fungi, parasitic and free-living invertebrates etc. In the reporting year, 94 new taxa of fossil and living organisms were described as new to science. Researchers developed the EcoNet scheme for the forest-steppe zone of Ukraine, express methods to assess resources of medicinal plants, and the methodology for the State Registry of plant and fungus species listed in the Red Data Book of Ukraine.

Studies of Ukraine's flora and fauna were continued, with special emphasis on investigating those peculiarities of new alien invasive species that allow them to adapt to new environmental conditions. In particular, studies of invasive fish species revealed their high adaptive capacity and significant phenotypic variability of their physiological, biochemical and morphometric parameters depending on environmental conditions.

Geneticists and plant breeders created 18 varieties (cultivars) of agricultural, ornamental, medicinal, and technical crops. The novelty of this year's scientific research of institutions of the NAS Department of General Biology was confirmed by about 30 patents and certificates of authorship (inventor's certificates). The number of existing license agreements for the use of winter wheat varieties in agricultural production increases each year. In particular, in the reporting year this number rose by more than 13%, amounting to 2541 license agreements, which allowed 1.75 million hectares to be sown with plant varieties developed at the NAS Institute of Plant Physiology and Genetics.

Research done by scientists of the NAS Department of General Biology received high recognition from the Government; in particular, one research project was awarded with the State Prize of Ukraine in Science and Technology, two projects won the Award of the President of Ukraine for young scientists, and two projects – the Award of the Verkhovna Rada of Ukraine for young scientists. Many scientists were honoured with state awards and NAS certificates of recognition; some researchers received honorary titles.

A number of scientific, environmental and educational projects of scientists and research institutions of the Department were among winners in various competitions and received numerous prizes, awards and grants. In particular, the State Museum of Natural History of the NAS of Ukraine won the national contest 'Dynamic Museum', held by Rinat Akhmetov's Foundation for the Development of Ukraine. Over the next three years it will receive UAH 2.5–3m annually for its project 'Natural History Museum: from the theory of life evolution to the practice of a living museum'.

In the future, research biologists will place emphasis on the development of fundamental and applied research in top-priority areas of science and technology, as well as on the support of the National Commission on the Red Data Book of Ukraine, whose operation has been legally transferred to the NAS of Ukraine.

Economics



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

In 2012, the efforts of researchers of the NAS Economics Department were aimed, first and foremost, at investigating issues of the elimination of structural imbalance in the national economy, developing human potential, determining priority areas of society modernization, social and economic policy in the national and regional dimensions.

A number of significant results were obtained. Interactions of key macroeconomic balances (imbalances) on macroeconomic estimates were grounded, taking into account the conditions and risks of macroeconomic situation. Factors giving rise to the formation of large gaps in macroeconomic balances and their components, which could lead to a rapid spread of destructive processes and to the economy default, were determined and specified.

For the first time a conceptual framework of the humanization paradigm of implementing the strategy of sustainable human development was substantiated. Its essence is raising the humanization imperatives to become the major criteria of anthropocentrism and harmonious development of the society, economy and ecosystems both in the tactical perspective and in the horizon of high-grade reproduction of future generations.

The equitable socio-economic development was substantiated as such that ensures the equilibrium, and therefore sustainable, development of all its components: the growth that improves the GDP quality and economic structure, and is accompanied by both the improvement of living conditions of the people and the development of human abilities. Scientists determined that the equilibrium and fair proportion of economic development must comply with architectonics laws: equilibrium, averaging and hierarchical structure, and that the transition to sustainable and equitable development must begin with the basic institution of trust.

They singled out features of reproduction processes, the formation of GDP by income and expenditure, capital formation and distribution processes, which in the post-crisis period demonstrate instability and imbalance of macroeconomic structure, form bifurcation points, and maintain persistent degradation of individual sectors. Methodological approaches to developing models of structural breaks and growth cycles in Ukraine were validated.

Specific features of the post-crisis imbalances in the banking system of Ukraine were determined; they consist in a disproportion between deposit and credit policy of banks in terms of timing and amounts of

assets and liabilities. Proposals on the instruments to restrain the speculative financing regime, eliminate "credit pits" and raise stock liquidity were developed.

Ways were proposed to improve the efficiency of the legal regulation of economic activity on the basis of public ownership. Amendments to the Ukrainian legislation on privatization of state property and municipal enterprises to ensure socio-economic evaluation of privatization were worked out.

Scientists developed a set of regional mathematical economic models, designed to forecast revenues and expenditures of the budget system and off-budget funds of the regions with regard to the functioning of individual budget-economic activities, as well as software and analytical tools for scenario forecasting of key macroeconomic indicators of Ukraine till 2014.

They determined strategic lines and specific ways of the government influence on inequality through income and labor-market policy, housing policy, developing settlement infrastructure and improving the quality and availability of social services, social protection and social inclusion, the development of civil society and social dialogue, regional policy and local government.

For the first time, scholars synthesized the "objectives tree" of human development, based on ranking the priorities in terms of their manageability and the ability to develop program activities; that allowed them to determine medium-term priorities of fiscal policy for sustainable human development. The methodological framework for designing budgetary mechanisms of regulating human development was validated. 'The technique for measuring regional human development' was updated, which, together with the Program of the second census, was reviewed and approved by a joint meeting of the NAS Presidium and the Board of the State Statistics Service of Ukraine on 13 June 2012.

It was shown that under major internal and external threats, there is a need for using a remedial model of industrial policy with centralized and targeted regulation tools aimed at rapid resource flowing to counteract the emerging threats and creating preconditions for the transition to an advance model in the long term.

Relying on international experience, Department's scientists determined the major factors of forming balance of payment for different groups of countries, their relative role in structuring the balance of payments, as well as conditions of the effective application of regulatory tools to individual items of the balance of payment. They also formulated general principles of regulating the balance of payments under global instability and increasing threats of the global financial crisis.

In the near future, the efforts of economics scientists will be aimed at revealing the essence and forecasting the consequences of domestic institutional transformation of the socio-economic system of Ukraine in their relationships with the external environment and globalization processes.

History, Philosophy and Law



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

In 2012, research institutions of the Department achieved significant theoretical and practical results in integrated multidisciplinary studies of current globalization and transformation challenges. Scholars of the Department developed models of profound and comprehensive reforming of social institutions and government bodies, analyzed the ways of resolving regional, ethnic, religious contradictions and proposed ways to increase the efficiency of constitutional and legal regulation of social relations.

Impressive results were achieved in the implementation of numerous academic publishing projects. Scholars of the V.I. Vernadsky National Library of Ukraine prepared and published the 1st, 2nd, 9th and 10th volumes of the «Selected Scientific Works by Academician V.I. Vernadsky» (NAS Acad. O.S. Onyschenko, NAS Acad. V.A. Smolii, NAS Corr. Memb. H.V. Boryak, NAS Corr. Memb. V.M. Danylenko, NAS Corr. Memb. L.A. Dubrovina et al.), and the fundamental work «European Academies of Sciences. In Two Volumes», (NAS Acad. O.S. Onyschenko, H.V. Indychenko et al.).

Researchers of the NAS M.S. Hrushevsky Institute of Ukrainian Archeography and Source Studies published the 13th, 15th and 16th volumes of the edition «M.S. Hrushevsky. Works in 50 Volumes», (NAS Corr. Memb. P.S. Sokhan, O.O. Mavrin, I.B. Gyrych et al.).

Scholars of the NAS Institute of the History of Ukraine prepared a significant work «The National Question in Ukraine in the 20th and Early 21st Century: Historical Essays» (by NAS Acad. V.M. Lytvyn, NAS Acad. V.A. Smolii, C.V. Kulchytskyi, L.D. Yakubova et al.). Besides, history researchers published the 9th volume of the «Encyclopedia of the History of Ukraine» (NAS Acad. V.A. Smolii, NAS Corr. Memb. H.V. Boryak, C.V. Kulchytskyi et al.), «Kyiv: Illustrated History» (NAS Acad. V.A. Smolii, C.V. Kulchytskyi et al.), «Atlas of the History of Ukraine» (NAS Acad. V.A. Smolii, NAS Corr. Memb. H.V. Boryak, D.V. Isayev et al.).

The staff of the NAS Institute of Encyclopedic Research published the 12th volume of the «Encyclopedia of Modern Ukraine» (NAS Acad. I.M. Dziuba, M.H. Zheleznyak). Scholars of the NAS V.M. Koretsky Institute of State and Law prepared the 2nd revised edition of the «Comprehensive Encyclopedic Dictionary of Law» (its editor-in-chief is NAS Acad. Yu.S. Shemshuchenko).

Relying on the results of recent monitoring studies, the NAS Institute of Sociology prepared and published a fundamental monograph «Ukrainian Society

in 1992–2012. Reality and Dynamics. Sociological Monitoring» (by NAS Acad. V.M. Vorona, NAS Corr. Memb. M.O. Shulha et al.).

Scholars of the Department launched a new targeted research program «Political, Legal, Socio-Cultural and Civilization Fundamentals of Modernizing Ukrainian State and Society», aimed at developing a systemic view of effective legal, political, social and cultural mechanisms to accelerate the overall renewal and modernization of the Ukrainian society in the context of globalization and transformation challenges of the 21st century.

Within the NAS multidisciplinary research programs 'Forecasts and Models of Social and Cultural Transformation of the Ukrainian Society in the First Quarter of the 21st Century', 'Strategic Challenges for Integrating Ukraine to the World Community', 'Modernization of Ukrainian Society and Economy in the 21st Century' and 'Humanitarian Technologies as a Factor of Social Transformations in Ukraine', Department's institutions achieved significant theoretical and practical results in analyzing the current situation in the Ukrainian society and trends of its development. New approaches to addressing urgent political, social and cultural problems of the Ukrainian society were developed.

Institutions of the Department were involved in preparing such analytic conceptual documents for state authorities as the 'Concept of Reforming the Funding and Management of Scientific and R&D Activities', 'Concept of Targeted Social Program of Patriotic Education for 2013–2017'. Besides, scholars of the Department advanced proposals to the 'Criminal Procedure Code of Ukraine', 'Innovation Code of Ukraine', laws of Ukraine 'On Higher Education' and 'On Principles of State Language Policy'.

In accordance with the Presidential Decree (# 328/2012, 17 May, 2012) 'On the Constitutional Assembly', scholars of the Department participated in the work of respective committees of the Assembly to develop proposals for amendments to the Constitution of Ukraine, provided scholarly advice and information for the Assembly.

In 2013 the efforts of the Department's Bureau and institutions will be focused on integrative interdisciplinary studies of the 'Ukrainian person–Ukrainian society–Ukrainian state' triad as one of the main indicators of the development of the country and society in the past and today. Researchers of the Department will be engaged in ensuring scholarly back-up to the promotion of civil society, optimizing its relationship with the Government, developing the mechanisms of social support to the national socio-humanitarian policy and analyzing the impact of the global information environment on social and cultural spheres in Ukraine.

Philology Studies, Art Criticism, Ethnology

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

As before, in the year under review, scholars of the NAS Department of Literature, Language and Art Studies tackled fundamental and applied issues of the development of literature, language, art studies, traditional every-day culture, computer linguistics; they addressed major challenges of the scholarly back-up to the national and cultural revival of Ukraine, the unbiased analysis of various stages in the development of Ukrainian spiritual culture in the past and in the context of globalization processes of the early 21st century.

The practical outcome of the abovementioned tasks was the publication by Department's scholars of 87 monographs and collections of writings, 10 study textbooks and manuals for university students and school-children, 13 reference books and dictionaries, 39 academically treated and commented belles-lettres texts, nearly 1600 publications in academic proceedings and periodicals.

The high academic relevance of Department's research was proved by awarding the 2012 T.H. Shevchenko National Prize of Ukraine to art scholar T.V. Kara-Vasilieva for her book «History of Ukrainian Embroidery», the NAS O.O. Potebnia Prize to NAS Corresponding Member A.P. Zahnitko for his work «Theoretical Grammar of Modern Ukrainian Language. Morphology. Syntax», and awarding the NAS F.I. Schmit Prize to art scholar H.M. Ivashkiv for the work «Decor of Ukrainian Folk Pottery of the 16th – First Half of the 20th Century». Linguist N.M. Sydorchuk won the Prize of the President of Ukraine for Young Scholars for her work «Systems Engineering, Software and Hardware for Compiling and Supporting Digital Dictionaries». For their outstanding achievements in the advancement of Ukrainian science, NAS Academicians V.H. Donchyk and V.A. Shirokov were awarded with the Honour Diplomas of the Verkhovna Rada of Ukraine, and NAS Academician B.I. Oliinyk was honoured with the V.I. Vernadsky Gold Medal.

Literature scholars of the Department provided a comprehensive analysis of the status and trends in the development of Ukrainian and world literatures in the early 21st century. Besides, relying on the achievements of today's literature studies and novel methodological approaches, they reviewed the creative heritage of the leading figures in the history of Ukrainian belles-lettres – T. Shevchenko, I. Franko, Lesya Ukrainka, V. Vynnychenko – and its place in the international cultural context. A number of fundamental works were published: «As Those Are Not Mere Language and Sounds...» (by NAS Academician I.M. Dziuba), «Things Inevitable and Everlasting» (by NAS Academician

V.H. Donchyk), «Ukrainian Literature of Late Middle Ages» (by Yu.V. Peleshenko), «Poetic Art in the Discourse of Ukrainian and Writer's Literary Criticism» (by I.V. Luchuk), «Poetics of Oles Honchar's Novels» (by M.P. Kodak), profound scholarly collective writings «Shevchenko's World» (issue 4), «Comparative Literature Studies» (issue 4), «Heritage» (issue 4), 5 manuals and reading books in Ukrainian and world literatures, commented editions of literary works by T. Shevchenko, Lesya Ukrainka, N. Gogol, O. Oles and numerous foreign authors. Volumes 1 and 2 of the national-scale edition – the 6-volume «Shevchenko Encyclopedia» – were published, and volumes 1–5 of the «History of Ukrainian Literature» in 12 volumes were prepared for publication. The curriculum in Ukrainian literature for forms 5–9 of secondary schools was developed and introduced to schools operating under the Ministry of Education of Ukraine.

Linguistic scholars of the Department studied comparative historical and typological aspects of the formation and evolution of the Ukrainian language in comparison to similar processes and phenomena in other Slavic languages alongside with current trends of language development.

To implement the Decree of the President of Ukraine 'On the Development of the National Dictionary Base', Department's scholars worked out and put to operation the virtual terminological laboratory «Ukrainian–Russian–English Mechanics Dictionary» and the pilot version of the Ukrainian National Linguistic Corpus. 9 new-generation dictionaries were published, as well as such fundamental works as «Linguistic Consciousness: Structure, Typology, Formation» (by P.O. Selihei), «O.O. Potebnia. His Life and Creative Work» (by V.Yu. Franchuk), «Syntax of Ukrainian Modernist and Post-Modernist Artistic Discourse» (by N.V. Kondratenko), collected academic works «Ukrainian Language in the 21st Century» and «Speech Culture» (issues 76 and 77).

Art scholars, folklorists and ethnologists of the Department completed the publication of the fundamental study – «History of Decorative Art of Ukraine» in 5 volumes. All in all, the studies of diversified phenomena of traditional culture resulted in the publication of 58 collective and individual works: «Ukrainian Visual Art: Names, Biographies, Works (11th – 21st Centuries)», «History of Ukrainian Culture» (vol. 5, book 3), «Studies of Ukrainian Music: Present-Day Dimension», «Ukrainian Baroque Engraving» (by D.V. Stepovyk). Folklorist and ethnographic expeditions visited 14 oblasts of Ukraine as well as Briansk and Belgorod oblasts of the Russian Federation.

Main research-management activities of the Department in the year under review focused on developing new scholarly concepts and programs, national-scale and Academy activities to implement presidential decrees and government's assignments, on preparing and holding 39 international and all-Ukrainian academic conferences, on strengthening the international collaboration of Department's institutions with foreign research centers and extending their ties.

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



**Ya. S. Yatskiv,
Member of the Academy
Presidium**

The main purpose of scientific-and-publishing activities of the NAS of Ukraine is a wide dissemination of information about the research and development results of Ukrainian scholars through the publication of books and periodicals.

Preparation and issuing of NAS publications is done to fulfill both the state order and those of Academy research institutions.

The State order is fulfilled through two types of publishing projects, namely academic publications (periodicals included) and encyclopedias.

At present there are seven encyclopedic projects under way, including such socially important ones as «Encyclopedia of the History of Ukraine», «Encyclopedia of Modern Ukraine», «Shevchenko Encyclopedia», etc.

Preparation and issuing of academic publications is carried out by two Academy publishers: the State Enterprise (SE) 'Naukova Dumka' Publishing House (PH) and the 'Akademperiodyka' PH.

In the reporting year, the SE 'Naukova Dumka' PH issued 40 books (with the total number of over 12 000 copies), having over 900 publisher's sheets in total. 'Akademperiodyka' PH issued 18 books (their total number being about 5 500 copies), having all in all over 400 publisher's sheets. Thus, in 2012, the number of books published with the State budget funding amounted to nearly 8 percent of their total number issued by the Academy.

The contribution of Academy publishing houses to the total amount of NAS publication has gradually increased in recent years.

Still, such an increase does not meet the need for the preparation and issuing of high-quality academic publications.

Therefore, the NAS Scientific-and-Publishing Board (SPB), which is responsible for preparing and issuing books under the state order, initiated several measures to improve the existing situation. In particular, the special support program for publishing NAS scientific journals was updated; the issues of re-publishing Ukrainian scientific journals by foreign publishers and increasing the citation indexes of papers written in Ukrainian and Russian were analyzed etc. Special seminars and workshops were organized for those purposes.

Practical aspects of these matters were also discussed by the conference 'Academic periodicals: tradition and innovation', which was organized by the 'Akademperiodyka' PH.

Besides those activities, with a view to wider dissemination of academic publications and improving the work of NAS bookshops, the APB promoted the activities of the book publishing association – the NAS 'Academkniha' corporation and the 'Ukrinformnauka' subscription agency. It also took part in a variety of events in Ukraine and in CIS countries, organized by the International Association of the Academies of Sciences.

In general, academic publishing activities of the NAS of Ukraine in 2012 can be considered as successful. NAS institutions issued nearly 600 titles of scholarly monographs and more than 200 collections of research papers. They also increased the number of educational, reference and popular science publications. In 2012, foreign publishers issued 74 scientific monographs of NAS scientists. It is the largest number in the last 15 years.

In 2012, current works of Ukrainian scholars were published in 87 NAS journals, 20 of those are translated and published in English by foreign publishers, 10 journals are published in English by NAS scientific institutions. The total number of articles published in periodicals was over 25 thousand, nearly 90% of them being published in specialized home and foreign editions.

Yet, there are a number of urgent tasks for the coming years. Among them are:

- improving the publishing and printing facilities of the NAS 'Akademperiodyka' PH and providing a separate building for it;
- increasing the number of English-language publications of the NAS of Ukraine and their adequate reference and science-metric display in international information databases;
- increasing the financial support of book and encyclopedic publications issued under the state order;
- tightening the requirements to and improving the control over the scientific relevance of research institutions' publications by the respective NAS departments.

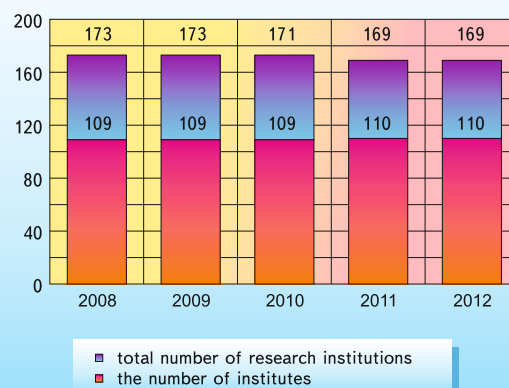
Regional Structure of the National Academy of Sciences of Ukraine



• Newly Formed:

Scientific council on problems of forest science and forestry

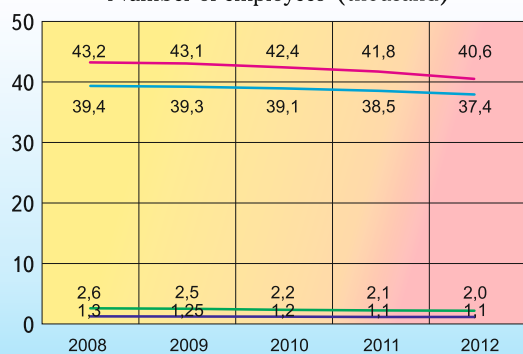
Total number of research institutions



NAS of Ukraine 2012

Total number of employees including:	40609
in research institutions	37426
in R&D organizations	2039
in service organizations	1144

Number of employees (thousand)

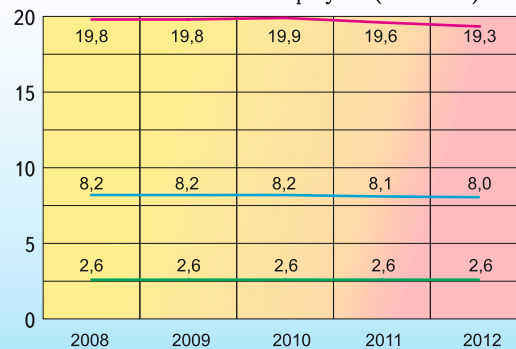


total
in research institutions
R&D facilities
in servicing

Statistics

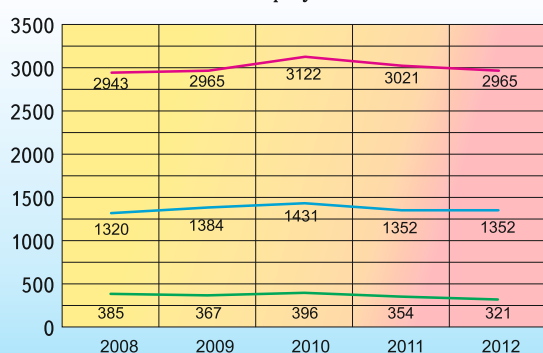
R&D employees including:	19337
Doctors of Sciences	2564
Candidates of Sciences (PhD)	7956

Number of R&D employees (thousand)



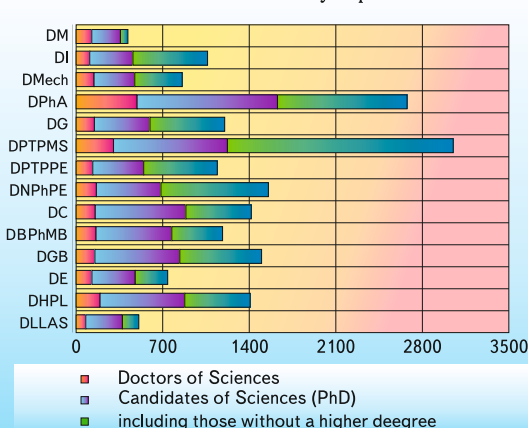
including those without a higher degree
Candidates of Sciences (PhD)
Doctors of Sciences

Number of employees under 35



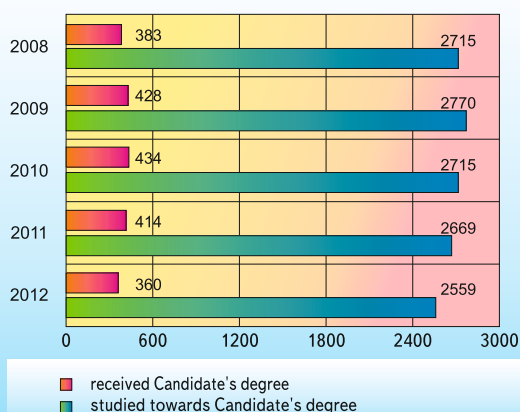
R&D employees*
Candidates of Sciences (PhD)*
Recruitment of university graduates
* without institutions under NAS Presidium

Distribution of scientists by departments

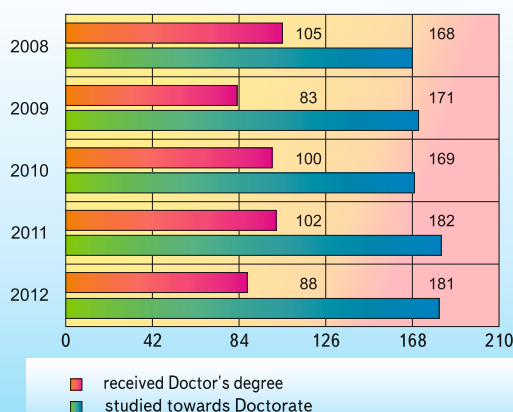


Doctors of Sciences
Candidates of Sciences (PhD)
including those without a higher degree

Training of research personnel



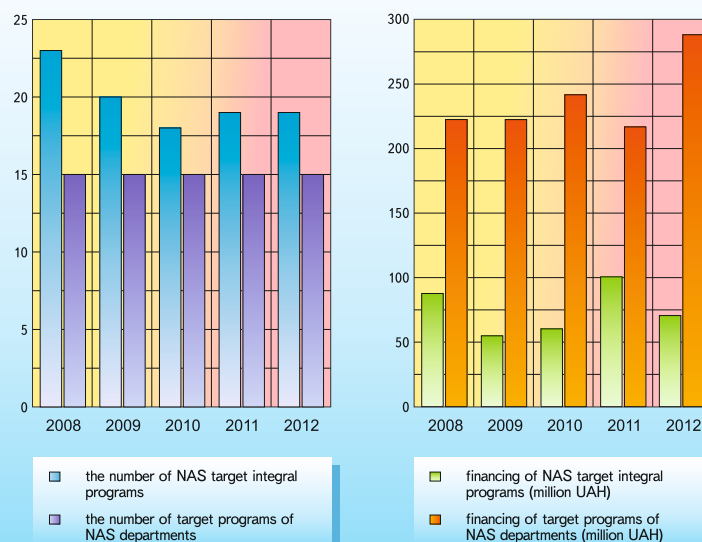
received Candidate's degree
studied towards Candidate's degree



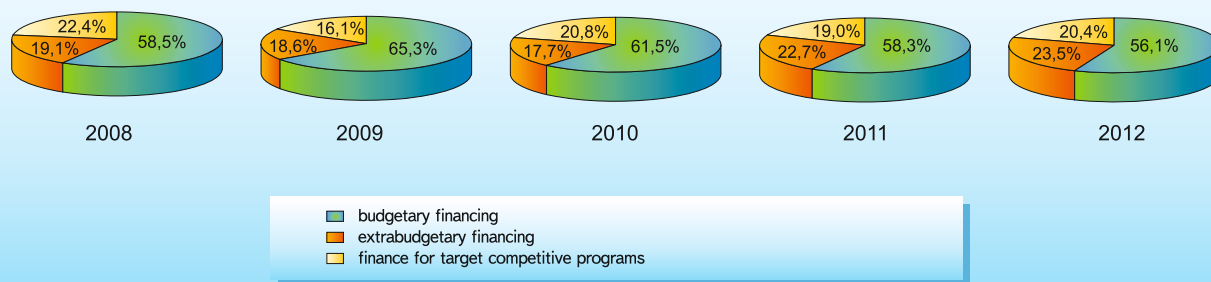
received Doctor's degree
studied towards Doctorate

Budget	thousand UAH
Total financing	3269281,4
General fund of the state budget	2513029,0
Basic funding from the State budget	1808838,5
Target programs finance	657963,6
Budget finance for personnel training	10866,3
Budget finance for health protection	35360,6
Extrabudgetary revenues	756252,4
Total expenditures	3241716,1
Expenditures on wages	2261128,4
Expenditures on equipment and instruments	179846,4
Expenditures on capital construction and reconstruction	43831,9
Expenditures on utilities	222739,3
Other expenditures	534170,1

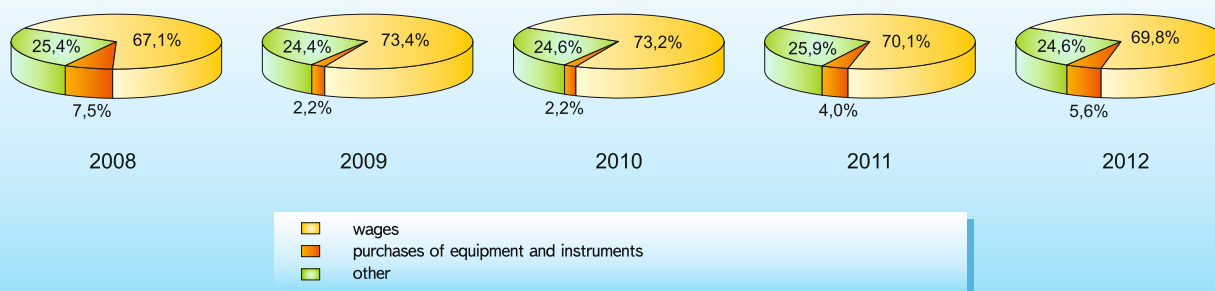
Target programs subjects



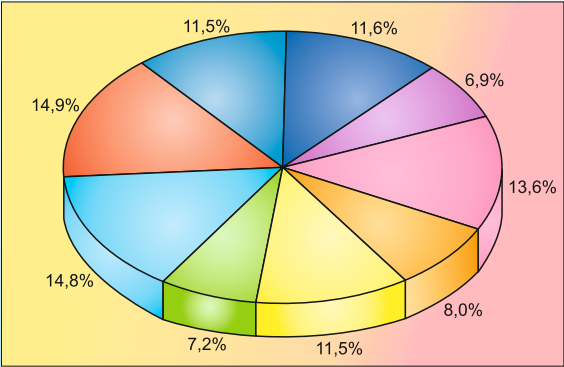
Distribution of finance by sources



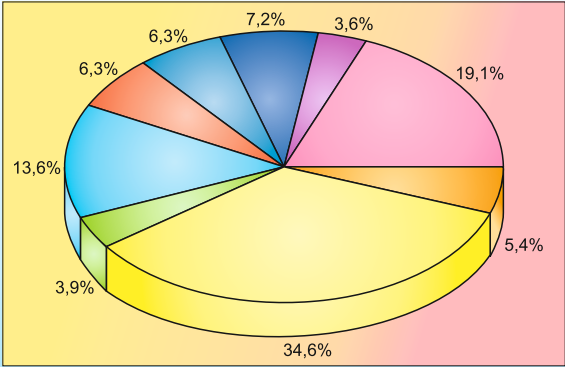
Distribution of expenditures by principal items



Distribution of basic budgetary
finance

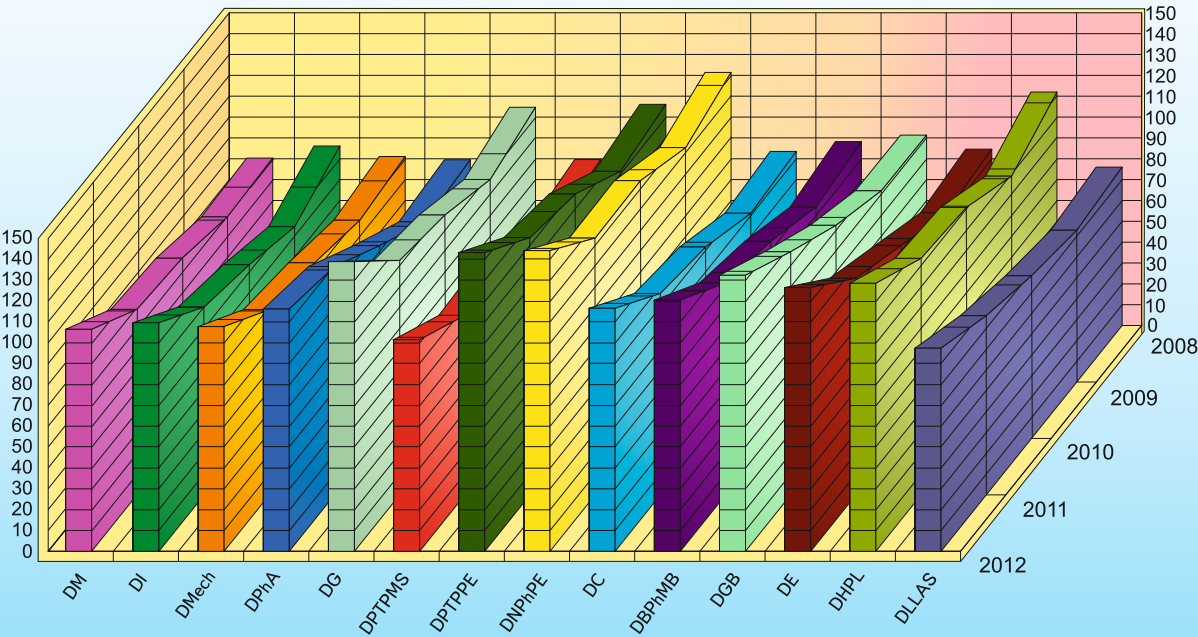


Distribution of extrabudgetary
finance



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

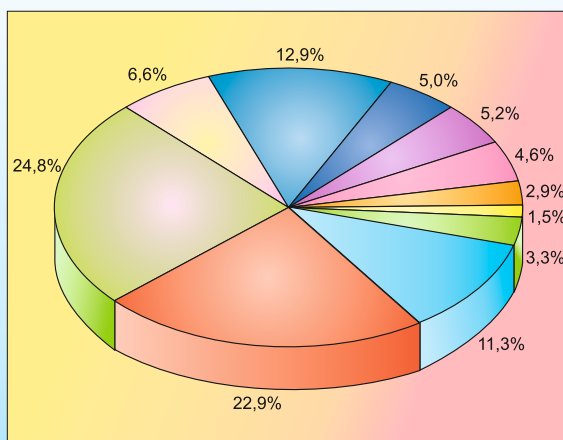
Distribution of budget finance per 1 researcher among Departments (thousand UAH)



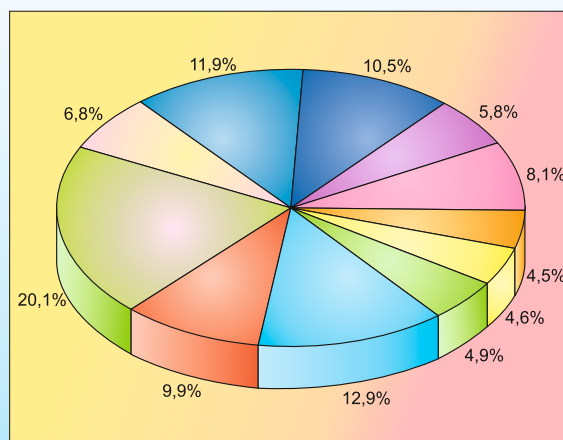
Publication of Academic Materials

In 2012 the publication of journal «Demography and Social Economy» was started

Monographs

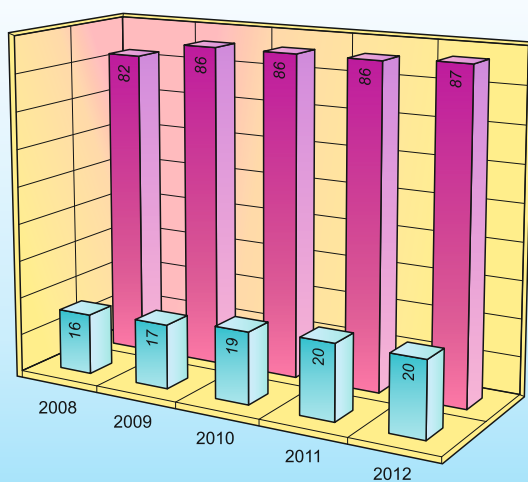


Papers



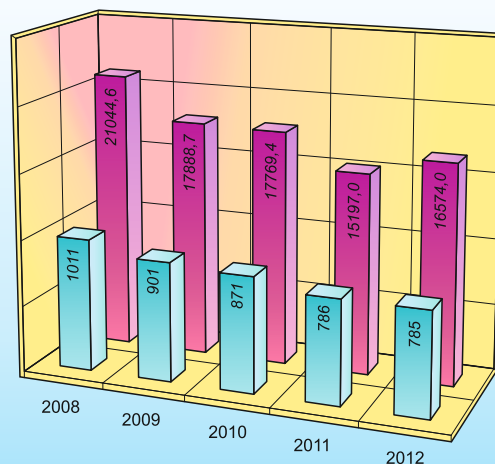
■ Mathematics, Mechanics, Informatics ■ Earth Sciences ■ Power Engineering ■ Chemistry ■ Economics ■ History, Philosophy and Law
 ■ Physics and Astronomy ■ Materials Sciences ■ Nuclear Physics and Power Engineering ■ Biological Sciences ■ Literature, Language and Art Studies

Academic Periodicals



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

Publication of Academic Books

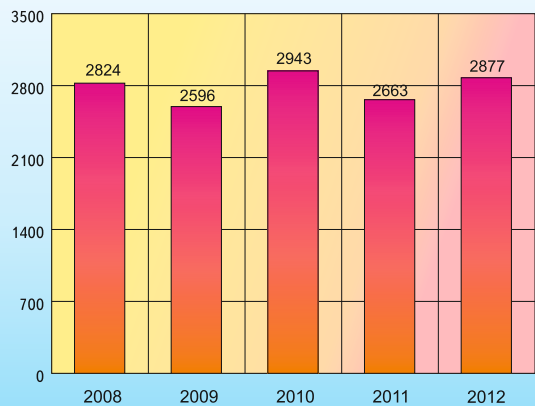


■ volume
 ■ the number of titles

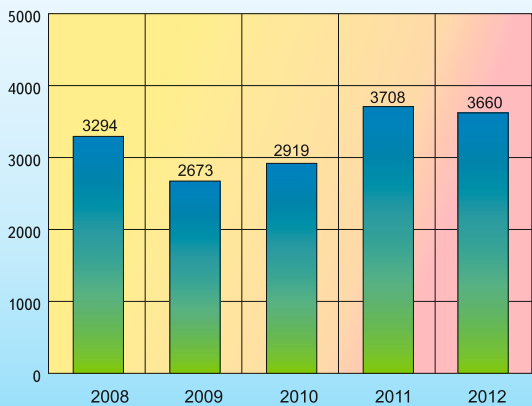
International Contacts of the National Academy of Sciences of Ukraine with Foreign Institutions



Foreign Scientists Received in Ukraine



Ukrainian Scientists Sent on Mission Abroad



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