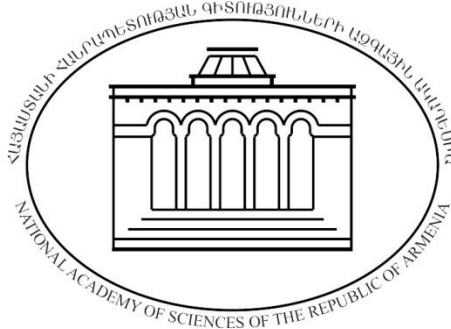


**NATIONAL ACADEMY OF SCIENCES  
OF THE REPUBLIC OF ARMENIA**

**R E P O R T  
ON MAJOR RESEARCH OUTCOMES  
FOR 2020**



**Yerevan - 2021**

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Research Organizations and Sub-Divisions*

## INTRODUCTION

In 2020, the Republic of Armenia faced two extremely difficult situations: the COVID-19 pandemic and the 44-day war unleashed by Azerbaijan. The economy of the country suffered huge losses, and, naturally, the normal functioning of NAS system was disrupted. However, to the credit of the scientific research organizations of NAS system, the tradition of obtaining a proper level of scientific results was preserved, various fundamental and applied scientific research was carried out.

46 programs to prevent the spread of the epidemic and its impact were presented to the RA Government, some of which were implemented. On a commission from the Government and with its financial support, the Institute of Molecular Biology of NAS prepared and provided to the RA Ministry of Health 100,000 diagnostic tests. Disinfectant "Bioxil", produced by the Institute of Chemical Physics of NAS, has been widely used in many areas of the Republic's economy, including in the Armenian army.

During the 44-day war, the Academy and its institutes have repeatedly made appeals to world-renowned scientific centers, individual scientists and NAS foreign members with a request to condemn the Turkish-Azerbaijani anti-Armenian aggression. Applications, appeals, and sincere letters of support have been received.

The scientists of NAS system were also directly involved in the work of various parts of the military-industrial system of the Republic.

In 2020, the Academy took an active part in the discussion of the draft law "On Higher Education and Science". The working version of the bill was discussed in all divisions and organizations of the Academy, the conclusion drawn up on the basis of comments and proposals was sent to the Ministry of ESCS. The opinion of the Academy on the draft law was repeatedly expressed by the members of the Academy, directors of research institutes in the press and on television, the decision to preserve the current status of the Academy was supported, the undoubted role and importance of the Academy for the development and progress of the country was emphasized.

In February 2020, by a unanimous decision of the Board of Directors of the scientific organizations of NAS, meetings of scientific teams were held in the scientific organizations of NAS, where, answering the question "Does this organization of NAS RA system agree to continue its activities in the system of the National Academy of Sciences", all organizations according to the results of closed secret voting by the majority of votes (98%) were in favor of the question raised.

In March 2020, the meeting of academicians and corresponding members of NAS approved the revised version of the 26th article of the bill "On Higher Education and Science" presented by the Board of Directors of the scientific organizations of NAS, which was sent to the Ministry of ESCS.

In 2020, NAS institutes organized 21 international and 27 republican conferences, mostly online.

In 2020, scientific institutions of NAS carried out research work on 5 target, 42 basic, 152 theme-funded and 105 contractual economic programs. Based on the results, 140 monographs and collections (including 11 abroad), 15 manuals (including 2 abroad), 1893 articles (including 839 abroad), 155 theses (including 92 abroad) were published.

*President of NAS RA, academician R.Martirosyan*



## **DIVISION OF MATHEMATICAL AND TECHNICAL SCIENCES**

*Academician-Secretary – academician L.Aghalovyan*

*Scientific Secretary – L.Martirosyan*

The Division of Mathematical and Technical Sciences includes the Institutes of Mathematics, Mechanics, for Informatics and Automation Problems, as well as the Department of Hydromechanics and Vibrotechnics.

The Division includes 12 academicians, 7 corresponding members, 24 foreign members, 5 honorary doctors.

During the reporting year 2 general meetings of the Division were held (due to pandemic meetings were held online).

At the annual general meeting held on May 19 L.Aghalovyan's report "On the main scientific and scientific-and-organizational results of the Division for the 2019 year" was approved. The scientific report of A.Petrosyan "Video conferences and distance learning platform of ASNET-AM network" (Institute for Informatics and Automation Problems) was presented at the meeting.

At the general meeting held on July 2 the candidacy for the vacancy of the director of the Institute of Mechanics was discussed. The candidacies of corr. member A.Avetisyan and DSc (phys.-math.) V.Avetisyan were submitted for discussion of the Presidium of NAS RA.

In 2020 11 meetings of the Bureau of the Division were held. The following issues were considered and approved: the working plan of the Division for 2020 year; the number of the postgraduate vacancies and their distribution among the Institutes for 2020-2021 academic year; the results of admission to the postgraduate school, research advisers and scientific topics of the postgraduate students; the decision project of the general meeting for the reporting year; applications on maintaining of scientific objects of national value for 2020 on state target programs, the reports of the Institutions of the Division for the year 2020, including the programs of basic funding; draft of the Law on Higher Education and Science of RA was considered; the structure and the number of the members of the new scientific council of the Institute of Mechanics was approved as well as the new chairman of the Scientific Council of the same Institute (Director of the Institute of Mechanics, DSc (phys.-math.) V.Avetisyan).

The main results of the scientific organizations of the Division, as well as some other scientific-and-organizational issues were discussed.

The following scientific journals are published on the Division specialities: "Proceedings of NAS RA.Mathematics" (6 numbers), "Proceedings of NAS RA. Mechanics" (4 numbers), "Proceedings of NAS RA and NPUA (series of technical sciences)" (4 numbers), "Mathematical Problems of Computer Science" (2 numbers), as well as the electronic "Armenian mathematical journal".

162 scientific articles (including 102 abroad) and 10 conference abstracts (including 7 abroad) were published in 2020 by the researchers of the Institutes of the Division, as well as 2 monographs (including 1 abroad), 1 tutorial (abroad) and 1 collection of scientific articles (abroad).

1 local scientific conference was organized.

5 projects on international grants have been implemented in the Institute for Informatics and Automation Problems.

1 Doctoral dissertation as well as 1 Candidate dissertation were defended during the reporting year.

In December of the reporting year annual report meetings of the Institutes were held (meetings were held online), the reports of the Institutes for 2020 year were discussed and approved. The meeting of the scientific team of the Institute of Mechanics decided to pay special attention to the issues on strengthening the country's defense capability. It was proposed to create a new department of Robototechnic's and Control Systems.

## **Institute of Mathematics**

### ***Major achievements***

Some problems of construction and uniqueness of the Gibbs random point fields on complete metric separable spaces with a locally finite measure have been studied. Under fairly general restrictions on the pair potential the limiting field  $P$  has been constructed and an explicit representation of the correlation functions of the field in the terms of Ursell kernel has been obtained. Under more restrictive conditions on the potential it has also been proved that if there is a Gibbs process in the sense of Dobrushin-Lanford-Ruelle, then it coincides with  $P$ . The results have been obtained using cluster expansions and the method of Kirkwood-Salzburg equations (Sup.: DSc(phys.- math.) S.Poghosyan).

## **Institute of Mechanics**

### ***Major achievements***

Applying the sophisticated mathematical method of generalized functions, a mesoscopic method for particle-reinforced composite materials has been developed allowing to carry out analysis of the stress-strain state of such composites explicitly depending on particles material characteristics and spatial distribution. The developed model can be used to consider structural optimization problems with respect to particle distribution and material properties. It is also applicable to processing of materials with new properties by means of additive manufacturing (Sup.: cand.( phys.-math.) A.Khurshudyan).

The effects of interaction of interfacial cracks, inclusions and stress concentrators of the stamp type with elastic homogeneous and piecewise homogeneous plane, semi-plane and space-deformable solids under the conditions of antiplane, plane and axisymmetric deformations have been researched. The simple analytical formulas for the main mechanical characteristics have been obtained, the regularities of their change have been revealed (Sup.: DSc(phys.-math.) V.Hakopyan).

### ***Outcomes of applied developments***

The problems of bulk shearing resistance of clay soil stratiform mass has been considered. It has been proved theoretically that when shearing stresses act perpendicular to stratiform the ultimate strength of the mass is reached at less values of shearing stresses than the total value of maximum-demand shearing resistance of separate stratiform mass (aiming at more precise form of estimation of the landslide slope stability) (Sup: DSc(geol.) S.Hayroyan).

## **Institute for Informatics and Automation Problems**

### ***Major achievements***

In the design and application of classification algorithms of a large number of classes by the use of class dichotomy collections, the code word-weighted decision-making rules have been applied. An approach of searching for local optimal fragmentation according to different quantitative indicators has been given. Experimental studies confirm the advantage of the proposed approach over the standard class splitting approaches (Sup.: corr. member L.Aslanyan).

Fundamental new theoretical approaches have been developed to study the classical and quantum three bodies' problems. This can serve as a basis for the development of new high-performance algorithms for modeling biomolecular chemical reactions, including taking into account external influences (Sup. : DSc(phys.-math.) A.Gevorgyan).

### ***Outcomes of applied developments***

A computational platform consisting of algorithms for alignment, phylogenetic tree construction, and temporal association detection algorithms has been developed, which is capable of

analyzing large populations of whole viral genomes. Adjustments for virus classification have been made, which could not be done with limited data processing. Experimental calculations have been performed both in well-known computer centers and on our own cluster resources. Python software, as well as industrial systems, e.g. Clustal Omega, MEGAX, SDTv1.2, and others have been developed and used (Sup.: corr. member L.Aslanyan).

A distributed multifunctional platform has been researched and developed as a video-conferencing service (MEET.ASNET.AM). An automated configuration solution has been prepared as a multi-EAP eduroam Institutional Radius Server (IRS) for several domains. Eduroam database management system has been developed. An updated version of the Automated Centralized Distribution System for LetsEncrypt SSL certificates has been created. All results are deployed in ASNET-AM network (Sup: cand. (tech.) A.Petrosyan).

The software for the server, which is the main component of the multiuser platform, has been developed and implemented. Involvement of the server in research of dynamic processes makes it possible to: calculate the information characteristics of the model; ensure simultaneous viewing of the results of users' joint work and current research; achieve structural changes to the model, as well as register and maintain the model states along with the transfer of the states to the relevant beneficiary organization for data processing (Sup.: cand.(tech.) S.Poghosyan).

The software package for spectral analysis of deck vibrations has been developed and tested, based on the results recorded by the drone (Sup.: DSc(tech.) D.Asatryan).

Based on the study of signals received from an atomic-force microscope (AFM, AM), a number of signal processing algorithms have been developed, which were involved in the calculation of unknown parameters. The parameters of the qualitative characteristics of chip platforms - Erosion and Dishing - have been calculated. A software system, which automates the calculation of the values of the Erosion and Dishing parameters, has been created (Sup.: DSc(tech.) S.Alaverdyan).

Efforts have continued to increase the security of web servers of ASNET-AM network. Penetration attempts of the internal structure of the websites of several organizations from ASNET-AM network have been found, and the information about them has been directed to the relevant administrators to make fixes. Development, maintenance and improvements of viewmon.asnet.am and viewmon2.asnet.am statistical systems have been continued, in particular, the number of input data collection streams of viewmon2.asnet.am system has been reached to 5 (Sup.: cand.(tech.) G.Petrosyan).

An internal domain system based on X.500 standards has been researched and developed. The modern Samba v.4 system is used as a basis, and on the basis of that a catalog domain system and file server has been built. The working principles and the implementation possibilities of modern VPN systems have been researched. A new protected VPN system has been developed and introduced (Sup.: cand.(tech.) R.Tadevosyan).

The eBGP and iBGP protocols have been studied to ensure the stable operation of the computer network. A fine adjustment of the OSPF(IPv4, IPv6) protocol has been carried out to optimize traffic flows with a complex (Sup.: cand (tech.) E.Prochorenko).

An algorithm for software solution for uploading data in RDF format, storing it in a distributed file system, and converting it to Property Graph has been developed. The application of well-known algorithms is studied on this data (Sup.: cand.(tech.) T.Shahinyan).

Based on the Openstack cloud environment, a complete two-zone cloud platform consisting of control nodes has been developed. Embedded IaaS solutions have been developed from related tools and packages, including data science and machine learning, weather forecasting and biology. The developed environment allows users to deploy and run various virtual machines, modify resources such as CPU or RAM if necessary. A cloud resource monitoring system has been developed, which allows collecting CPU, memory, input-output data, and presenting it through graphs. Each project has its own section and alerts that help to view the status of each project individually.

Physical process modeling machine learning model has been developed to convert the fluorescence spectrum of the R2 atomic vapor line D2 by changing the time of linear (triangular) scanning of the laser radiation frequency (Sup.: cand.(tech.) H.Astsatryan).

## **Department of Hydromechanics and Vibrotechnics**

### ***Major achievements***

Cavitation processes occurring in parts of the hydraulic turbine erode the impeller and the streamlined parts of its housing. To eliminate cavitation erosion in the working parts of the hydraulic unit, the system has been designed so that at all its points the fluid pressure is greater than the vaporization pressure. To prevent cavitation i.e. the reasons for its occurrence, it is necessary to eliminate pressure pulsations, and also to avoid the occurrence of shock pressure in the derivation at hydroelectric power plants, surge tanks are installed. The need for the construction of surge tanks is determined by the inertia of the water mass contained in the pressure head water supply structures of the HPP. For these purposes, the installation of surge tanks at small hydroelectric power plants is impractical due to their cumbersomeness, since it is often necessary to install tanks on the plains in the form of towers. The proposed method radically eliminates the occurrence of both hydrodynamic and acoustic cavitation phenomena in hydraulic turbines. This is achieved by the use of efficiently functioning stabilizers of wave and oscillatory processes, developed in the “NAS RA Department of Hydromechanics and Vibrotechnics” CJSC, which smooth out the pulsations of pressure and fluid flow (Sup: cand.(tech.) G.Avetisyan).

### ***Outcomes of applied developments***

The negative effects of wave and vibration processes that have arisen in pipeline systems of a hydrocracking unit for oil and its fractions have been investigated under the following parameters: pressure of the working environment:  $5 \div 30\text{MPa}$ ; temperature:  $+330 \div +450^{\circ}\text{C}$ ; volumetric feed rate:  $0.3 \div 1.0\text{ H}^{-1}$ .

Based on the research results, a two-phase multi-mode stabilizer of pressure and flow rate pulsations of the working medium has been developed to eliminate and reduce the pressure pulsations and vibration level on the pipelines of the hydrocracking unit RoA patent № 2550A, (Sup.: A.Simonyan).

## **DIVISION OF PHYSICS AND ASTROPHYSICS**

*Academician-Secretary – academician R.Kostanyan*

*Scientific Secretary – N.Davidyan*

The Division of Physics and Astrophysics includes the Byurakan Observatory after V.Ambartsumian, the Institute for Physical Research, the Institute of Applied Problems of Physics, the Institute of Radiophysics and Electronics, the International Center for Relativistic Astrophysics Network - Armenia and “Galaktika” CJSC.

The Division includes 7 academicians, 10 corresponding members and 27 foreign members.

During the reporting year 1 general meeting was held and 12 sessions of the Bureau were held to discuss and solve current issues.

At the annual general meeting held on May 16 the report on “2019 main results of the scientific and organizational activity of the Division” by Academician-Secretary acad. R.Kostanyan was discussed and approved. Due to pandemic the meeting was held on line.

During the sessions of the Bureau of the Division the following issues were discussed and approved: the applications of the subdivisions for Maintenance and Development Projects for the Base Financing Infrastructure of the Scientific and Technological Activity, postgraduate and travel applications; the expert opinions on letters received from Governmental various agencies have been replied to the applicants. The applications to purchase equipment submitted from the Institute for Physical Research and from the Institute of Radiophysics and Electronics were considered and satisfied. The staff and the structure of the Scientific Council of Byurakan Observatory was approved. The issues on increasing the efficiency of scientific work, extension of applied studies and evaluating the work of scientific organizations were discussed, the interdisciplinary programs of scientific organizations were developed as well. In addition, the reports of subdivisions about the implementation of the recommendations of the evaluation committees were discussed.

During the reporting year a number of national and international scientific events was held, international cooperation in the scientific organizations of the Division has expanded, new agreements have been signed, cooperation between scientific and educational institutions has been ongoing. The draft proposal of the Republic of Armenia on “Higher Education and Science” and the main standards, pros and cons related to the development of science were discussed. Basic applications for 2021, 2021-2026 programs and 2020-2030 strategy were discussed.

The proposals for the priority work of the Institutes on participation in the basic research programs of the CIS countries were discussed and approved. Under the new current situation, the organizations of the departments have submitted additional issues in the field of defense, high-tech and health-care to the relevant departments. The most basic and practical results of 2020 were discussed.

2 employees of the Institutions of the Division got their PhDs. 6 monographs ( including 3 abroad), 211 articles (including 116 abroad), 13 theses (including 12 abroad) were published by the Institutions of the Division, 1 license was obtained. In December of the reporting year, annual reporting meetings were held in the scientific organizations of the Division, the reports on scientific and organizational activity in 2020 were discussed and approved.

The Division publishes the following scientific journals: “Proceedings of NAS RA. Physics” (4 issues), “Astrophysics” (4 issues) and the electronic “Armenian Journal of Physics” (4 issues).

### **Byurakan Astrophysical Observatory after V.Ambartsumyan**

#### *Major achievements*

Based on the Hamburg-ROSAT (HRC) and Byurakan-Hamburg-ROSAT (BHRC) catalogs, which in turn, are sources identified in the ROSAT Bright Source (BSC) and ROSAT Faint Source (FSC) catalogs, a homogeneous AGNs sample has been created. A total of 4253 X-ray AGNs have been included. New subclasses of quasars, new subclasses for Narrow Line Seyferts, as well as for AGNs with composite spectra have been introduced (Sup.: cand.(phys.-math.) A.Mikaelian).

Using planar approximations, the inversion of the magnetic field of the galaxy has been simulated. It has been shown that it is possible to generate magnetic fields in which the direction of the circular magnetic field can be changed once or twice as it leaves the center of the galaxy. It has been shown that in galaxies in which the outflow of ionized gas is observed in the central regions, and in a rotating medium, the Berman effect works, creating a magnetic field in it (Sup.: cand.(phys.-math.) R.Andreasyan).

A program has been developed to determine some of the physical parameters describing the radiation of a single one-temperature gray body model. It has been used to calculate the dust temperature ( $T_d$ ), the density of the hydrogen column ( $N(H_2)$ ), and the mass of molecular clouds in a number of star-forming regions (Sup.: cand.(phys.-math.) H.Harutyunyan).

The reason for the phenomenon of a change in the spectral type of a star under conditions of constant surface temperature and bolometric luminosity has been found. It has been found out to what extent, depending on the ionization temperature, the scattering of radiation in the continuous spectrum affects the fluctuations of the hydrogen spectrum (Sup.:cand.(phys.-math.) E.Nikoghosyan).

The main reason for the decay of nuclear matter is viscosity due to the capture of an electron. It has been shown that in the ranges of density and temperature, where the decay time is comparable to the time of the merger of stars, the viscosity can significantly affect the dynamics of thermonuclear stars (Sup.: DSc(phys.-math.) A.Sedrakyan).

Unusual hydrodynamic phenomena have been discovered and described in the outflow of HH 83. The variable star V1318 Cyg S has been identified as an atypical object of the FUor type (Sup.: DSc(phys.-math.) T.Magakian).

An attempt has been made to determine the age of the Armenian stone monuments “VISHAP” by astronomical methods. It has turned out that the stone monuments that have come to us should be divided into groups with images of fish, bulls, rams and storks (Sup.: cand.(phys.-math.) G.Brutian).

### ***Outcomes of applied developments***

At the joint Armenian-Russian station 550000 measurements have been performed altogether and 600 orbits of artificial satellites have been restored during 250 observational nights (Sup.: cand.(phys.-math.) H.Harutyunian).

## **Institute for Physical Research**

### ***Major achievements***

A new type of atomic transitions has been revealed – a “fixed” transition, the frequency of which is practically unchanged in the magnetic field region of 180 – 700 G, while the transition probability is high. Such “fixed” transitions have been investigated for the  $D_2$  line of  $^{87}\text{Rb}$  ( $|1,+1\rangle \rightarrow |1',+1'\rangle$ ) and  $D_2$  line of Cs ( $|3,-3\rangle \rightarrow |5',-4'\rangle$ ) (Sup.: DSc(phys.-math.) D.Sarkisyan).

The temporal behavior of the atomic absorption signal under resonant excitation by a cw laser radiation has been investigated. The measurements have been carried out on the  $D_2$  line of  $^{85}\text{Rb}$  with a time resolution of  $\approx 1$  ns. An irregular oscillating behavior of the transmission signal, strongly pronounced at a high laser power and disappearing when the laser is detuned from resonance, has been found. The analysis using the Fast Fourier Transform has revealed the presence of power-dependent peaks at the Rabi frequency. The relationship between the observed effect and the phase-to-amplitude conversion caused by laser field phase fluctuations has been analyzed (Sup.: corr. member A.Papoyan).

The processes of electronic excitation transfer between impurity ions in double-activated crystals  $\text{YAG:Er}^{3+}$  (1at.%),  $\text{Ce}^{3+}$  (0.38at.%),  $\text{YAG:Er}^{3+}$  (5at.%),  $\text{Ce}^{3+}$  (0.25at.%),  $\text{AG:Er}^{3+}$  (13at.%),  $\text{Ce}^{3+}$  (0.5at.%) have been studied for the laser pumping at 445 nm and 405 nm with a pulse duration of 20 – 10000  $\mu\text{s}$ . The coefficients of non-radiation transition of excitation from  $\text{Ce}^{3+}$  to  $\text{Er}^{3+}$  in  $\text{YAG:Er}^{3+}$ ,  $\text{Ce}^{3+}$  crystals have been calculated, which are found to be five orders of magnitude higher than in the case of transfer from  $\text{Er}^{3+}$  to  $\text{Er}^{3+}$  in  $\text{YAG:Er}^{3+}$  (Sup.: acad. R.Kostanyan).

### ***Outcomes of applied developments***

A new method for non-destructive optical testing of holographic microstructures in the presence of a magnetic field has been proposed. The experiment has been realized for a refractive grating recorded by a Bessel laser beam in a Fe:LiNbO<sub>3</sub> crystal. The time evolution of the diffraction efficiency has been measured, and a slowdown in the erasure process in a magnetic field has been found. The role of polarons in the processes of recording and erasing holographic gratings has been revealed (Sup.: DSc(phys.-math.) R.Drampyan).

Conductive films of silver-doped (1.6%) zinc oxide (AZO) with electrodes made of Ag and fluorine-doped tin oxide (FTO) have been obtained by a technique of electron deposition. The current-voltage characteristic of the Ag/AZO/FTO structure has revealed ohmic behavior, while thermal annealing has resulted in transition to diode behavior with a Schottky barrier. The coefficient of ideality, height of the Schottky barrier and series resistance have been determined (Sup.: cand.(phys.-math.) R.Hovsepian).

YAlO<sub>3</sub>:Yb(1-10%) laser crystals have been grown by the Bridgman and Czochralski methods. It has been shown that the absorption due to color centers is noticeably lower in crystals grown by the Bridgman method. The radiative lifetimes of Yb<sup>3+</sup> ions have been measured. An average output power of 4 W, a pulse duration of 140 fs, and an optical efficiency of 16.3% have been obtained for a laser based on the developed crystals (Sup.: DSc(phys.-math.) A.Petrosyan).

In order to develop non-volatile memory systems (RRAM) and ionizing radiation sensors, metal-semiconductor-metal and metal-insulator-semiconductor structures based on ZnO films with impurities of Li, Ga, Ag, as well as lanthanum oxide with a hydrogenated surface (OH - La<sub>2</sub>O<sub>3</sub>) have been investigated. The results obtained are applicable in semiconductor electronics – for creation of RRAM memory systems based on polaron optical conductivity and negative differential resistance (Sup.: cand.(phys.-math.) Y.Kafadaryan).

Organic polymer films have been fabricated on the basis of nano- and micro-spheres composed of graphite nanocrystals. The absorbing properties of films for electromagnetic waves in the mid-IR region (2.5 - 20 μm) have been studied. Carbon nano- and micro-balls have also been enriched with Fe, Fe<sub>3</sub>O<sub>4</sub> and Fe<sub>3</sub>C nanoparticles, and their absorbing properties in the microwave range (8 - 10 GHz) have been investigated (Sup.: cand.(phys.-math.) A.Manukyan).

Four-sensor "stabilograph", a medical device based on SFCO sensors has been further elaborated in cooperation with PSI LLC and the Institute of Physiology of NAS RA. The issues of lithographic manufacturing of sensors, electronic systems and computer presentation of measurement results have been resolved. A demo sample of the device has been prepared. Work has continued on the development of a new magnetometer based on the SFCO sensor. A sensitivity of about 1000 pT has been achieved, and there are prerequisites for its increase (Sup.: DSc(phys.-math.) S.Gevorgyan).

### **Institute of Applied problems of Physics**

#### ***Major achievements***

The temporal characteristics of the redistribution of the intensity of diffracted synchrotron radiation in a quartz crystal in the presence of resonant ultrasonic vibrations have been investigated for the first time. It has been shown that excitation of acoustic waves of constant amplitude in a crystal requires some time ~ 1 ms, during which the process of changing the intensity has a complex characteristic, after which it stabilizes. That is, it takes only ms to reconfigure the parameters of such optical elements, while reconfiguring X-ray optical elements used in modern synchrotrons takes minutes and sometimes hours (Sup.: cand.(phys.-math.) V.Kocharyan).

A new type of artificial lung ventilation system has been developed, the main feature of which is the coordination of the natural frequency of the respiratory process with high-frequency oscillations of the inhaled and exhaled air. A laboratory sample of equipment has been designed and manufactured (Sup.: cand.(phys.-math) H.Khachatryan).

### ***Outcomes of applied developments***

Elements of optics of the charged particles with energy up to 100VeV on the basis of superconductors; new alternative sources of infrasound and ultrasound with controlled parameters; a new type of sources of electromagnetic waves with operated parameters have been developed and created (Sup.: corr. member A.Mkrtchyan).

A high-resolution X-ray microtomography method has been developed using a complex-shaped compensation filter for the study of biological and geological samples. An amplifier in the range from 0.1÷1 MHz, which provides 10÷700 V output voltages, has been developed and manufactured (Sup.: cand.(phys.-math.) V.Kocharyan).

A new type of artificial lung ventilation system has been developed, the main feature of which is the coordination of the natural frequency of the respiratory process with high-frequency oscillations of the inhaled and exhaled air. A laboratory sample of equipment has been designed and manufactured, which allows obtaining air pressure fluctuations of different profiles in the frequency range 0.1-15000 Hz. Computer software has been created that controls the operation of the equipment prototype (Sup.: cand.(phys.-math.) H.Khachatryan).

## **Institute of Radiophysics and Electronics**

### ***Major achievements***

Interaction of microwave magnetic field with biological tissues and ionic water solutions has been investigated. Special resonance electrodynamic structure, having strong localization of electric and magnetic microwave fields has been developed. The main result of these investigations is the presence of strong absorption of microwave magnetic field in biological tissues, having sufficient temperature dependence and independence on external DC magnetic field. This phenomena can be used in medical and biological applications in order to carry out non-invasive investigations (Sup.: corr. member A.Hakhoumian).

The possibility of rapid detection of high-speed (50-300 m/s) objects in proximity (1-20 m) has been investigated. Simple triangle ranging method based on the detection of scattered radiation has been proposed. Semiconductor laser or LED equipped with focusing lens can be used as a radiation source and will provide angular disclosure of radiation. As a sensitive element of the receiver, the photodiode has been used, equipped with slot diaphragm. The angular disclosure of radiation depends on the length and width of slot diaphragm (Sup.: cand. (phys.-math.) A.Makaryan).

Quasi-two-dimensional MoS<sub>2</sub> crystals consisting of one, two or more atomic monolayers have been obtained by pulsed-laser deposition, and their properties have been studied through Raman scattering, electron microscopy, X-ray diffraction, photoluminescence and optical absorption (Sup: corr. member S.Petrosyan).

Additional symmetries of specific refraction index profiles used in the well-known phenomena of perfect imaging and cloaking have been investigated. In the considered cases, the translation generator and the angular momentum are conserved. The ray trajectory parameters are expressed through the integrals of motion and the existence of a photon state with maximal angular momentum is observed, which can be used as an optical resonator (Sup: DSc(phys.-math.) Zh.Gevorkyan).

### ***Outcomes of applied developments***

Interaction of microwave magnetic field with biological tissues and ionic water solutions has been investigated. Special resonance electrodynamic structure, having strong localization of electric and magnetic microwave fields has been developed. The main result of these investigations is the presence of strong absorption of microwave magnetic field in biological tissues, having sufficient temperature dependence and independence on external DC magnetic field. This phenomena can be used in medical and biological applications in order to carry out non-invasive investigations (Sup.: corr. member A.Hakhoumian).

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The aqueous solution with iron nanoparticles has been investigated by a microwave stripline sensor based on the optimized double quadratic-shape design. Due to real-time near-field electromagnetic interaction between microwaves and sample  $S_{11}$  reflection coefficient of the sensor changes depending on iron nanoparticles concentration in the aqueous solution at resonant frequency. In this work we have examined the iron nanoparticles concentration in the 0–20  $\mu\text{g/l}$  concentration range at an operating frequency at about 1.7 GHz. The measured minimum detectable signal was 0.035 dB/( $\mu\text{g/l}$ ). The microwave response of sensor systems can be explained by the additional structural changes of water clusters due to the metal nanoparticles ablation. This implemented method has approachable development process and the accuracy of measurement is high, thus it can be applied as a physiochemical sensor for non-invasive monitoring of metal nanoparticles in complex liquids (Sup.: cand. (phys.-math.) R.Khachatryan)

Using the earlier developed medical diagnostic device the influence of electrical signals on the human skin has been investigated. Two separate computer programs have been developed, one of which is intended for the operator, the other for in-depth studies of the received signals. The theoretical analysis and the experimental research have been carried out. The comparative analysis of the obtained signal's spectra has been done (Sup.: acad. A.Ghulyan).

The measurement of electrical parameters of nanoscale thin films from the liquid nitrogen to the room temperature range have been made using the newly purchased and launched Hall effect measurement system (Sup.: cand.(phys.-math.) A.Musaelyan)

The development of a biochemical sensor model based on nanowire junctionless ion-sensitive field-effect transistors (ISFET) has been accomplished. The pH sensitivity of the ISFET sensor has been studied. It has been shown that the proposed analytical model allows to calculate accurately the dependence of the sensor sensitivity on the geometrical and physical parameters of the sensor (Sup.: cand.(phys.-math.). A.Yesayan)

Thin polycrystalline layers of the organic  $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x$  semiconductors have been synthesized and all their main optical parameters such as refractive index 3.15 and band gap 1.6 eV, have been obtained (Sup.: cand.(phys.-math.) K.Avjyan).

## **ICRAnet Armenia**

### ***Major achievements***

The spectral and temporal properties of 33 distant blazars ( $z > 2.5$ ) detected in the high-energy  $\gamma$ -ray band have been investigated by analysing the Fermi-LAT and Swift Ultraviolet and Optical Telescope/X-ray Telescope (UVOT/XRT) data. The  $\gamma$ -ray flux of those high-redshift blazars ranges from  $4.84 \times 10^{-10}$  to  $1.50 \times 10^{-7}$  photon  $\text{cm}^{-2}\text{s}^{-1}$  and the luminosity is within  $(0.10 - 5.54) \times 10^{48} \text{erg s}^{-1}$  which during the  $\gamma$ -ray flares increases up to  $(0.10 - 1) \times 10^{50} \text{erg s}^{-1}$ . The properties of distant blazar jets are derived by modelling the multiwavelength spectral energy distributions within a one-zone leptonic scenario assuming that the X-ray and  $\gamma$ -ray emissions are produced from inverse Compton scattering of synchrotron and dusty torus photons (Sup.: cand.(phys.-math.) N.Sahakyan).

## DIVISION OF NATURAL SCIENCES

*Academician-Secretary – corresponding member R.Aroutiounian*

*Scientific Secretary – cand.(biol.) S.Atshemyan*

The Division includes the Scientific and Production Centre (SPC) “Armbiotechnology”, the Scientific Centre of Zoology and Hydroecology, the Institute of Botany after A.Takhtajian, the Centre for Ecological-Noosphere Studies, the Institute of Biochemistry after H Buniatyan, the Institute of Hydroponics after G.Davtyan, the Institute of Molecular Biology, the Institute of Physiology after L.Orbeli.

The Division includes 7 academicians, 10 corresponding members, 27 foreign members as well as 12 honorary doctors.

1 general meeting, 6 Bureau meetings of the Division, 8 reporting meetings of the scientific Institutes were held during the reporting year. Due to pandemic all the Division meetings were held online.

At the annual meeting of the Division the report of the Academician-Secretary R.Aroutiounian on the scientific and scientific-organizational activities of the Division in 2019 was heard. The main fundamental and applied results of the Institutes, the possibility of involving foreign members of NAS RA in the development of international scientific relations, the problems that have arisen due to pandemic were discussed.

At 6 meetings of Bureau the following issues were discussed and approved: the 2020 working plan of the Division; the reports of the institutions of the Division on 2019 base funding, on the maintenance and development of the infrastructure, on the maintenance of the scientific objects of national importance and scientific and scientific-technical state projects of target programs; the applications for the positions of postgraduate studies and doctoral candidacy for 2020-2021; the applications of the Institutes for new appliances; the reports of the Institutes on the scientific-organizational activity in 2020.

The candidacy of L.Sahakyan for the vacancy of the director of the Centre for Ecological-Noosphere studies was discussed and approved.

During the reporting period the Division organized a round table dedicated to the problems of coronavirus in the RA, where reports were presented by virologists, as well as to the perspectives for the production of COVID-19 diagnostic tests in the Institute of Molecular Biology of NAS RA with the support of the RA Government. As a result of the efforts of the Administration and the staff of the Institute, for the first time in Armenia, more than 100,000 diagnostic tests were produced and delivered to the diagnostic laboratories of the National Center for Disease Control and Prevention of the MH RA. In order to develop and implement a scientific and technical basis for studying and combating COVID-19 and a set of measures to combat other epidemics, a Scientific Council for the Coordination of Scientific Research on COVID-19 was established at NAS RA (chairman: academician A.Saghiyan).

As a result of discussions at the meetings of the tender commission of NAS RA, the Institutes of the Division were provided with financing for the purchase of necessary equipment.

The Institutes have carried out a number of activities related to strengthening the defense capability, and have also collected humanitarian aid for the war-affected residents of Artsakh and Armenia.

13 local and international events were organized by the Institutes of the Division including seminars, conferences, scientific expeditions, a total of 741 participants, 492 of which were from abroad.

244 articles (150 – in foreign journals) and 72 abstracts (47 – in materials of foreign conferences), 4 monographs, 3 educational tutorials were published by the Institutes of the Division, 2 patents were obtained.

6 candidates' and 2 doctorates' dissertations were defended by the researchers of the Institutes at 5 specialized councils of the Division.

In general, based on the reports on the work done, it can be stated that the staff of the Institutes of the Division, despite the pandemic and the martial law, were able to mobilize their capabilities and forces to the maximum, preserve their scientific potential and implement outlined scientific plans.

### **Institute of Botany after A.Takhtajian**

#### ***Major achievements***

As a result of the assessment of the threat to the specially protected natural areas and ecological networks of Armenia from invasive plant species, those species that may be dangerous to the reserves and national parks of the RA, as well as to the territories of the ecological network "Emerald" created in Armenia have been selected. On the basis of the research carried out, proposals for the RA Ministry of Environment have been prepared, and the monograph "Aggressive Plants. The most important invasive and expanding plant species in Armenia" has been published (Sup.: DSc(biol.) G.Fayvush).

The results of dendrologists' long-term research, devoted to the applied aspects of creating ornamental plantings in Armenia and the cultivation of woody plants, have been generalized. Based on the results, a monograph has been published. It has been established that 534 species and garden forms of woody plants from 54 families and 144 genera are considered promising for growing in green plantations in various ecoregions of Armenia. This number of taxa includes 70 species and garden forms of conifers (6 families and 17 genera). Of the whole amount of the investigated plants about 18% (78 species, 23 genera) belong to *Rosaceae* family. The families *Cupressaceae* (24 species), *Pinaceae* (17), *Fabaceae* (28), *Caprifoliaceae* (24) and *Oleaceae* (20) are rich as well. Of the conifers, the genera *Biota*, *Thuja* and *Juniperus* are distinguished by a rich taxonomic diversity. This assortment of woody plants is presented according to the climatic conditions of large dendrological regions of the Republic, taking into account their vertical zoning, as well as the suitability of certain species for specific types of plantations. The importance of the ratio of introduced (foreign) and aboriginal (local) species of trees and shrubs in the arboreal composition of green spaces has been noted, the need for their optimal proportional ratio has been indicated. Practical recommendations have been developed for the reconstruction of green spaces and squares, replenishment with new highly decorative species and garden forms, as well as for the care and implementation of phytotechnical measures during the growing season (Sup.: corr. member Zh.Vardanyan).

### **Centre for Ecological-Noosphere Studies**

#### ***Major achievements***

In the frames of application of up-to-date nature-based solutions aimed at mitigating the environmental impact on children- one of the most vulnerable population groups- a study of the chemical composition of street dust on the territory of one of Yerevan's model kindergartens has revealed priority pollutants (Cr, Zn, Cu, Pb, As) and respective exceedance against MAC (1.4-2.8 times). A noncarcinogenic risk to children health caused by concentrations of these elements has been identified. For the first time the mechanical composition of street dust has been studied. It has been established that human health threatening particulate matter PM<sub>10</sub> constitute 94%, PM<sub>2.5</sub> - 19 %. These systematic investigations will underpin the assessment of the effectiveness and feasibility of the up-to-date "a green wall" nature-based solution implemented on the studied kindergarten site (Sup.: cand.(biol.) G.Tepanosyan).

#### ***Outcomes of applied developments***

The studies have indicated that the coronavirus COVID -19 pandemic has a negative influence on the diet of Yerevan residents. Despite the availability of food, 42,5% of consumers had to replace

the habitual products with cheaper ones. A food consumption database was upgraded to support regular studies for assessing health risks caused by chemical hazards in the Republic of Armenia (Sup.: DSc (food sci.) D.Pipoyan).

A service has been developed for determining naturally occurring radionuclides in goods both produced in the RA and imported (food stuffs, mineral water, building stones etc.) in compliance with common EAEU standards. Goods imported to Armenia fully meet the EAEU radiological standards (Sup.: cand. (biol.) O.Belyaeva).

With a view to creating a remote ecological landscape monitoring system in Armenia, in partnership with the Institute for Informatics and Automation Problems of NAS RA and the University of Geneva in Switzerland a multi-dimensional information system, or a data cube (<http://datacube.sci.am>) is being constructed for satellite data to compile, store and process. The data cube's repository includes Landsat and Sentinel satellite data and is upgraded on a regular basis. In this system, using a programming language Phyton, the algorithm of isolation and delineation of water bodies has been processed, which is planned to be used as a tool for deciphering water bodies from satellite data (Sup.: cand.(geogr.) Sh.Asmaryan).

## **Scientific Centre of Zoology and Hydroecology**

### ***Major achievements***

In order to develop methods of combating the phenomena of "blooming" of Lake Sevan, identification of hydrochemical and hydrophysical factors contributing to the "bloom" of lake waters, determination of the species composition and assessment of quantitative indicators of the autotrophic link have been carried out. The methodology of using Armenian zeolites has been developed in order to purify Lake Sevan from blue-green algae. The efficiency of zeolites for this purpose has been justified based on microbiological parameters. The genotoxicity and clastogenicity of water samples collected from three different sites of Lake Sevan basin (Lichk, Lchashen, Norashen) have been assessed by means of Trad-SHM and Trad-MCN assay using model test plant *Tradescantia* (clone 02). A significant increase in the level of point mutations, the number of micronuclei and changes in other indicators during the "blooming" period has been shown, the highest level was observed in the water samples of Lchashen observation point (Sup.: DSc(biol.) B.Gabrielyan).

Among terrestrial animals a total of 121 species of vertebrates, both common and rare including 5 species of amphibians, 28 species of reptiles, 76 species of birds, and 12 species of mammals have been documented. Significant changes have been observed in the number and the species composition of documented groups, particularly birds. Distribution maps have been developed for some of them (Sup.: cand.(biol.) M.Ghasabyan).

As a part of archaeozoological research, osteological material from the sediments of the Lake Sevan basin has been described and measured. Craniometric study of both domestic and wild forms of animals has been carried out. Over 4000 bone remains of domestic and wild animals from archaeological excavations in Shirak region have been examined, over 2000 bone fragments have been identified to the level of species, and morphometric data for over 400 bones of cattle and horses have been analyzed (Sup.: DSc(biol.) N.Manaseryan).

About 500 species of insects have been revealed. Species of beetles and plant-feeding gall midges new to the Armenian fauna have been described (Sup.: M.Kalashyan).

Based on the DNA sequencing results, phylogenetic trees for the members of the subgenus *Procerus* from the genus *Carabus* and for some groups of subfamily *Cetoniinae* of the Armenian Plateau have been constructed for the first time (Sup: cand. (biol.) G.Karagyan).

A total of 27 species of animal parasites, including 16 species of helminths, 5 protozoan species, 6 species of mites, 7 species of mollusks as intermediate hosts of helminths have been documented (Sup.: acad. S.Movsesyan).

For wild mammals of Armenia *Trichinella britovi* parasite species has been recorded for the first time. Genomic DNA has been isolated from blood samples of rodents and insectivores and by means of PCR series a fragment of the B1 gene specific for *Toxoplasma gondii* has been detected (Sup.: cand.(biol.) S.Aghayan).

Two species of plant pest mites from the family Tydeidae have been described as new to the fauna of Armenia (Sup.: DSc(biol.) K.Dilbaryan).

### ***Outcomes of applied developments***

The assessment of fish and crayfish reserves of Lake Sevan has been carried out. It has been shown that the total biomass of the crayfish in the lake was about 105 tonnes; the state of the crayfish population in the lake is deteriorating from year to year. Due to uncontrolled harvesting and diseases commercial stocks are depleted and the species is on the verge of extinction. In order to restore the productivity of crayfish it has been proposed to ban their harvest in the lake, to prohibit sale within the country and export outside it, as well as to fight poaching. A decrease in whitefish stocks was also observed: in 2020 the commercial stock of whitefish amounted to 586 tons instead of 667 tons in the previous year, and the total stock was 2345 tons instead of 2668 tons (Sup.: DSc(biol.) B.Gabrielyan).

The parasite species composition for animals (cattle, sheep, rabbits, birds, fish) and plants (fruit trees, vineyards, herbaceous plants) has been studied (Sup.: acad. S.Movsesyan).

Eleven species of parasitic plant nematodes have been found and identified. The most frequently occurring and dangerous species including viral vector species such as *X. index* and *X. vuittenesi* have been documented (Sup.: cand.(biol.) R.Mkrtchyan).

Biological measures of agricultural pest control have been researched. Research work on the preservation of the previously established cold-resistant line of the mite *Phytoseiulus persimilis* and development of the products with acaricidal and insect repellent properties has been underway. Testing of combinations of extracts isolated from *P. harmala*, *A. tenuifolia* and *E. orientalis* on aphids have shown different levels of insecticidal efficacy, the highest level has been observed in *A. tenuifolia* (Sup.: DSc(biol.) K.Dilbaryan).

Changes in some morphological and cytogenetic parameters of Marsh frog (*Pelophylax ridibundus*) and Green toad (*Bufo variabilis*) have been studied in different habitats. The results obtained can be used in diagnosing and monitoring the pollution of natural habitat of aquatic vertebrates (Sup.: cand.(biol.) I.Stepanyan).

## **Institute of Biochemistry after H.Buniatyan**

### ***Major achievements***

The study of biological activity of galarmin and analogues has been continued. It included a study of its interactions with toll-like receptors (Human TLR1 (6nih), Human TLR2 (6nig), Human TLR3 (1ziw), Mouse TLR4 (5ijc), Zebrafish TLR5 (3v44), Monkey TLR7 (6if5), Human TLR8 (4qc0), Mouse TLR9 (3wpf)). The strongest interaction has been observed with Mouse TLR4 receptor. The weakest interaction has been observed with Zebrafish TLR receptor. The observed strong interactions of the proline-rich peptide with the investigated TLRs indicate the possible high biological activity of these compounds in inflammatory processes involving these receptors (Sup.: DSc(biol.) S.Chailyan).

The regulation of enzymatic activities of adenosine deaminase (ADA), dipeptidyl peptidase IV, glutaminase and GABA-transaminase at autoimmune diseases has been studied and assessed. The high activity of ADA in the synovial fluids at rheumatoid arthritis is accompanied with high citrullination of small ADA (SADA). Citrullination hinders the interaction of SADA with DPPIV and formation of large ADA (LADA). Autoantibodies are produced against the accumulated citrullinated ADAs, which may lead to worsening of the disease (Sup.: cand.(biol.) A.Antonyan).

For revealing the isoenzymatic structural essentials, phosphoribosyl pyrophosphate synthase and xanthine oxidoreductase enzymes have been isolated and purified from human liver and brain (Sup.: cand.(biol.) K.Danielyan).

The copper-containing plasma protein ceruloplasmin, together with serum albumin and hemoglobin, serve as transporters of cationic porphyrins used in photodynamic therapy. The binding of this protein with cationic porphyrins and metalloporphyrins in neutral and acid domains, as well as with 0.1-0.9% concentration of sodium chloride in neutral medium in vitro

has been studied. In case of changes in the medium pH from neutral to acidic, significant conformational changes in ceruloplasmin occur, leading to the increase in the binding of cationic porphyrins / metalloporphyrins, whereas an increase in sodium chloride concentration of up to 0.9%, on the contrary, leads to a decrease in phosphorus (Sup.: cand.(biol.) A.Gyulkhandanyan).

### ***Outcomes of applied developments***

In case of streptozotocin-induced diabetes in rats, histopathological examination of pancreatic, renal and hepatic incisions have revealed improvement of tissue structures as a result of feeding with ethanol infusions of grape leaves, walnut kernel and rose petals. Decreased levels of malone dialdehyde, a biological marker of oxidative stress, have been observed. The most effective of the applied herbal infusions can be suggested for application in combination with medication for prevention and treatment of diabetes. Among the newly synthesized tertiary amino alcohols the GGN 322\*HCl, containing a heliotropine group, in vitro suppresses SADA inhibition from bovine lung in a competitive nature. The effectiveness of suppression allows recommending GGN 322\*HCl in clinical use as a means of alleviating diseases associated with increased adenosine deaminase activity (Sup.: cand.(biol.) A.Antonyan).

The role of natural immunoglobulins in removal of potentially pathogenic proteins has been studied. Low density lipoproteins (LDL) have been isolated from blood plasma and oxidized by various methods. The interaction of IgG with oxidized lipoproteins has been studied. It has been revealed that natural antibodies are able to bound with and neutralize oxidized lipoproteins. The data demonstrate the new role of the immune system in the development of cardiovascular (atherosclerotic) diseases.

The studies on quantitative determination of fungi with lectin sensitized silver nanoparticles have continued. In this case the lectins serve as the detectors of carbohydrate components of fungal cell wall (sensor's detecting component), whereas silver nanoparticles serve as a component providing the optical signal. Such approach allows quantitative determination of the amount of yeast with high sensitivity and specificity.

The activity of some enzymes is very sensitive towards small amounts of metals and it can be used for determination of these metals. The isolated soybean urease has been applied as such an enzyme. CdSe quantum dots have been applied as a fluorescent sensor. The potential of the enzyme for screening detection of some metals has been determined.

New nanocomposites of silver that are applied for quantitative and sensitive determination of organophosphat pesticides have been synthesized. In contrary to previous approaches based on application of the acetylcholinesterase, which have some limitation associated with activity of the enzyme and necessity to have a recombinant enzyme, the presented method has similar sensitivity and is devoid of disadvantages inherent with the enzymatic method (Sup.: cand.(biol.) V.Gasparyan).

## **Scientific and Production Centre “Armbiotechnology”**

### ***Major achievements***

For the purpose of expression cloning of aspartate and aromatic aminotransferase genes based on the complete sequence of the genome *Pectobacterium carotovorum* subsp. *carotovorum* PC1, two pairs of primers have been designed for IIS restriction sites of the *BsaI* restriction type. Using the Golden Gate Assembly method, the aspartate and aromatic aminotransferase genes of *P. carotovorum* 8690, *P. carotovorum* 8694, *P. carotovorum* 8726, *P. carotovorum* 8727, *P. carotovorum* 8756, *P. carotovorum* 8758 strains have been cloned into the pET28 (GG\_CD-LacZ) plasmid (Sup.: cand.(biol.) A.Hambardzumyan).

The presence of *argJ* genes encoding ornithine acetyltransferase of thermophilic bacteria *Geobacillus stearothermophilus* and *Thermotoga neapolitana* not subject to arginine inhibition has been shown on recombinant plasmids of *Escherichia coli* HK strain-producers. The results of testing the segregation or structural instability of these recombinant plasmids have shown that they exhibit 100% stability. For the recombinant *E. coli* HK strain-producers carrying the *argJ* genes, inoculation

and fermentation media have been developed, due to which the level of L-arginine biosynthesis increases by 22% (Sup.: cand.(biol.) A.Hovsepyan).

Strains of the *Pseudomonas* and *Xanthomonas* genera (MDC) showing multiple resistance to antibiotics cefixime, ceftriaxone, ciprofloxacin and azithromycin have been identified (Sup.: cand.(biol.) N.Hovhannisyan).

By the methods of chemical mutagenesis and selection, a resistant mutant of the *Brevibacterium flavum* 21 (p-FP-r) strain synthesizing tryptophan under conditions of deep cultivation has been obtained (Sup.: cand. (biol.) G.Avetisova).

With the use of the producer strain *Br. flavum* LGS-6, an effective technology for the production of the amino acid L-histidine has been developed, the yield of which in a 250 L bioreactor was 32 g/L (Sup.: cand.(biol.) V.Ghochikyan).

Effective methods for extraction (yield >85%) of biologically active compounds from rare and poorly studied plants (round-leaved wintergreen, peppermint, almond, prunes pits) and oyster mushroom, have been developed. The highest antioxidant activity has been found in aqueous-alcoholic extracts of the round-leaved wintergreen (Sup.: DSc(chem.) S.Dadayan).

The optimal conditions for the cross-coupling Glaser reaction of the  $\alpha$ -substituted propargylglycine nickel complex have been developed and the synthesis of negatively charged cobalt chiral complexes has been carried out (Sup.: cand.(biol.) A.Mkrtchyan).

The Sonogashira cross-coupling and azide-alkyne cycloaddition of the terminal alkyne group of the amino acid moiety of the nickel ( $\text{Ni}^{2+}$ ) propargyl alanine complex have been investigated. Undescribed in the literature 10 enantiomerically pure non-protein (*S*)- $\alpha$ -amino acids containing in a side radical aryl moieties of various substituents coupled by an acetylene and 1,2,3-triazole bridge have been synthesized. New potentially biologically active di- and tripeptides based on non-protein (*S*)- $\alpha$ -propargyl alanine amino acid have been obtained using the stepwise method for the synthesis of activated esters of peptides (Sup.: cand.(chem.) Z.Mardiyan).

An effective method for obtaining water-soluble melanin from waste of raw materials of plant and animal origin with a relatively high yield (20%) and purity (> 98%) has been developed, improved and patented (Sup.: cand.(chem.) A.Tsaturyan).

It has been shown that a number of strains of lactic acid bacteria and antimicrobial preparations based on them, with varying degrees of effectiveness, inhibit the growth of various *E. coli* serotypes isolated from samples of dairy products. The strains of *Lactobacillus helveticus* KG5' and *L. acidophilus* 1991 have been selected for their further use as biopreservatives (Sup.: cand.(biol.) K.Chitchyan).

The use of adapted bacterial cultures makes it possible to increase the extraction of copper from sulfide ore by about 5 times, up to 91-94% and 98% with a pulp density of 10% and 20%, respectively. The integration of bioleaching technology using biogenic iron into the processing of motherboards contributes to the efficient extraction of copper and other metals from secondary raw materials (Sup.: DSc(biol.) N.Vardanyan).

As a result of heterologous gene expression of the enzyme 5-ALA synthetase involved in the biosynthesis of 5-aminolevulinic acid (5-ALA), from the purple photosynthesizing bacterium *Rhodobacter azotoformans* and its E10 mutant in *E. coli*, new recombinant producing strains of 5-ALA have been created (Sup.: cand.(vet.) V.Goginyan).

A catalog of nodule bacteria (72 strains) isolated from a number of wild plants of the legume family contained in the Red Book of Armenia (genera *Astragalus*, *Onobrychis*, *Lotus*, *Lathyrus*, *Trigonélla*, *Trifólium*, *Pisum*, *Vicia*, *Galega*, *Melilotus*, *Vavilovia*, *Amorpha*, *Styphnolóbium*, *Caragána*) has been compiled. A new method for the restoration of saline soda soils using halotolerant strains of nodule bacteria has been proposed (Sup.: S.Haroutyunyan).

The work on ensuring long-term maintenance of deposited cultures of microorganisms, as well as the isolation, study and identification of new strains has been continued. The properties of some cultures of industrial significance have been investigated and their passport data have been summarized (Sup.: cand.(biol.) H.Zargaryan).

### ***Outcomes of applied developments***

Production and sale on the European market of a number of optically active non-proteinogenic amino acids of great medical, pharmaceutical and diagnostic importance, have continued (Sup.: acad. A.Saghyan).

Manufacturing of the fermented milk product “Narine” using the culture of lactic acid bacterium *L. acidophilus* MDC 9602 has continued. The production of fruit and drinkable “Narine” with the addition of natural syrups from apricot, peach, black mulberry and cherry, as well as the production of the lyophilized drug “Narine” have been continued. The production of fermented milk product “Narine” in enteric-soluble hard gelatin capsules has been set up. The products are sold in the leading pharmacy chains and supermarkets of Yerevan (Sup.: R.Hayrapetyan).

Production of complex biofertilizers “Ecobiofeed” and “Ecobiofeed +” for the needs of agriculture has continued. During the reporting period about 3 tons of biological preparations were produced, which are sold in various farms of the Republic (Sup.: cand.(biol.) G.Avetisova).

Production of drugs demanded on the Armenian drug market (hydrogen peroxide 3% and 30%, boric acid, magnesium sulfate, potassium permanganate, ammonium aqueous solution, castor oil, glycerin, 5% iodine solution) has continued. On a contractual basis, these products are sold in the wholesale network “Natali-Pharm”, “Vaga-Pharm”, “Farm-House”, “Uni-Pharm”, “Sanus”, “Armpharmacy”, “Alta” and others (Sup.: cand.(chem.) G.Hovsepian).

Production of natural vegetable oils of sea buckthorn, flax, milk thistle, almond, white and black sesame, apricot, peach, black cumin, pumpkin seeds and prune seeds has continued by the method of cold pressing. Serial production of new pomegranate seed oil has been set up. All these oils are of valuable nutritional, therapeutic prophylactic and cosmetological value (Sup.: DSc(chem.) S. Dadayan).

## **Institute of Molecular Biology**

### ***Major achievements***

The Institute has produced real-time PCR tests for COVID-19. In addition, the PCR method has been optimized, which allows detecting the virus in the sample without preliminary isolation of nucleic acids (Sup.: DSc(biol.) A.Arakelyan).

Within the framework of cooperation with the Institute of Botany of NAS of China, 3K resequencing of 95 Armenian grape varieties, as well as 78 samples of wild grapes, has been completed. According to preliminary data, 2 samples of wild grapes have shown genetic relationship to the indigenous grape varieties “Khndogni” and “Sev khaghogh”. This fact may indicate that “Khndogni” and “Sev khaghogh” belong to the indigenous and the longest evolving grape varieties, and the studied wild plants may be intermediate genotypes on the pathway of cultivation from wild types to cultivated ones. A molecular analysis of 12 viruses of 8 wine grape varieties by the RT-qPCR method has been completed as well (Sup.: cand.(biol.) K.Margaryan).

For the first time in Armenia, the causative agents of the most common foodborne bacterial infections displaying multidrug resistance (MDR) have been characterized using whole genome sequencing. The genetic background of virulence and antimicrobial resistance of MDR clinical isolates of *Shigella*, *Pseudomonas*, *Klebsiella*, and non-typhoidal *Salmonella* have been identified (Sup.: cand.(biol.) A.Sedrakyan).

### ***Outcomes of applied developments***

The Institute has produced real-time PCR tests for COVID-19 and provided 100,000 tests to the National Center for Disease Control and Prevention MH RA (Sup.: DSc(biol.) A.Arakelyan).

A new algorithm has been developed to improve the results of docking analysis. The effectiveness of this algorithm has been demonstrated in a series of experiments. The source code of the program is available at the following link: <https://github.com/sahakyanhk/iPBSA/blob/main/iPBSA.sh> (Sup.: DSc(biol.) K.Nazaryan).

The effect of monolaurin on ASFV in pig feed has been studied in collaboration with Natural Biologics (USA). Monolaurin has a stronger antiviral activity than medium-length fatty acids in a dose-depending manner. The results have shown that this substance can be used in the antiviral processing of feed products (Sup.: cand.(biol.) H.Zakaryan).

Bacteriophages showing lytic activity against non-typhoidal *Salmonella*, *Shigella*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* have been isolated. The isolated bacteriophages have been subjected to purification, enrichment, and adaptation, after which their litic activity, stability, host ranges, as well as efficiency against clinical isolates have been characterized. The library of promising phages has been created and 7 pilot antibacterial preparations have been developed based on the best candidate phages. The results obtained indicate that the created phage library can be used to design phage cocktails for efficient prophylaxy and treatment of the most common foodborn bacterial infections in Armenia (Sup.: cand.(biol.) A.Sedrakyan).

## **Institute of Hydroponics Problems after G.Davtyan**

### ***Major achievements***

As a result of three years' experiments, it can be assumed that the climate conditions of the Ararat Valley are not favorable for the self-propagation of paulownia. Three-year-old plants in the field conditions, without being looked after besides being watered twice a week, did not show intensive growth (maximum height - 45 cm, root collar thickness - 8 mm) or formation of new shoots from root sprouts. Meanwhile, in hydroponic conditions, where the plants are always provided with optimal air-water-nutritional conditions, growth of plants from root sprouts has been observed. Their height in one vegetation period reached up to 3.3 m with the root collar of up to 7 cm thickness, the plants also formed inflorescences, but did not manage to bloom.

Radiochemical studies have shown that regardless of the growth conditions (hydroponics – classical, water-stream, organic, and soil) the plant raw material of medicinal plants (stevia, sweet wormwood, lavender, rosemary, common chicory) and vegetables (endive, kale) is radioecologically safe in the Ararat Valley (a zone with a 30 km radius of technogenic influence of Armenian NPP, territory of the IHP). At that, in total  $\beta$ -radioactivity the medicinal plants make the following decreasing series - stevia > sweet wormwood > common chicory > rosemary > lavender and the vegetables make the following one - endive > kale. In hydroponics, the leaves of oriental thuja exceeded the leaves of moringa, plane tree, virginian juniper, pyramidal thuja, oak in total  $\beta$ -radioactivity 1.2, 1.2, 1.3, 1.4, 2.0 times, respectively.

As a result of optimization of mineral nutrition of Chinese cabbage it has been found that the plants prefer high concentration of macroelements (1.0 and 1.25 N), in which case the yield exceeds the other hydroponic variants and the soil control 1.3-2.9 times. In case of tested variants, high content (1.1-1.3 times) and output (1.1-3.8 times) of vitamin C have been observed in conditions of application of 1.0 N nutrient solution. Biosynthesis of extractive substances proceeded intensively at 1.0 and 0.75 N concentrations, while the soil plants were distinguished with the high content of flavonoids (1.3-2.0 times) (Sup.: corr. member S.Mairapetyan).

### ***Outcomes of applied developments***

The biotechnologies of soilless growth of Japanese cabbage Mizuna, Chinese cabbage Pak-choi and Arugula have been developed.

In HES the hydroponic bank of different essential oil-bearing, medicinal and food plants has been preserved and enriched (Sup.: corr. member S.Mairapetyan).

Vertical growing hydroponic module of horizontally spreading plants has been built and tested for the first time, where a new variety of melon has been successfully grown.

Rare in Armenia plant Rhubarb (Rheum), which is potentially new for the food industry, has been grown in hydroponic conditions for the first time.

The hydroponic hop cones, which are considered as raw material of beer have been grown, and transferred to local brewers to produce a pilot, small-scale beer (Sup.: cand.(biol.) A.Tadevosyan).

Scientifically based practical proposals for obtaining plant raw material of stevia and radish with more saturated by microelements have been developed (Sup.: cand. (biol.) M.Babakhanyan).

The collection of *in vitro* plants has been preserved and supplemented in the tissue culture laboratory (Sup.: cand.(biol.) E.Sargsyan).

About 700 different tree saplings have been sold for about 700 thousand AMD (Sup.: cand.(biol.) A.Hovsepyan).

Practical proposals have been developed, the use of which in agrocenosis and hydroponics will allow to obtain radio-ecologically safer plant raw material and will have environmental importance (Sup.: cand.(biol.) L.Ghalachyan).

## **Institute of Physiology after L.Orbeli**

### ***Major achievements***

Electrophysiological indicators of abnormal activity of cholinergic brain projections in fructose-induced type 2 diabetes (T2DM) have been revealed, as well as the therapeutic efficacy of Galantamine, a centrally acting acetylcholinesterase inhibitor. The results indicate the involvement of cholinergic neuronal circuits in the multifactorial pathogenesis of diabetic encephalopathy, as well as the beneficial effect of Galantamine on the indices of neuronal plasticity of cholinergic networks in T2DM (Sup.: DSc(biol.) V.Chavushyan-Papayan).

On the model of Parkinson's disease, neuroprotective effects of small doses of Central Asian cobra venom, Armenian viper venom and Galarmin have been revealed based on the analysis of morphohistochemical data. In comparison with Parkinson's disease, there are positive changes in the structural properties of the neurons of the substantia nigra and globus pallidus, the lesion of which is noted in this neurodegenerative disease. In the cellular structures of the rat brain, after exposure to propionic acid in different postnatal periods, various degrees of cellular damage are observed, which have a reversible effect. An enhanced glial reaction is noted among neurons, which calms down in the late postnatal period (Sup.: DSc(med.) T.Ghevondyan).

During the reporting period the scaffolds of various organs of animals, particularly rats and mice have been studied, as well as the study of the possibility of using human serum instead of the serum of calf embryo has continued. These studies are important for rehabilitation medicine. As a result of the study, scaffolds of rat and mouse liver have been obtained, and their immunogenicity has been determined by various methods (Sup.: cand.(biol.) Z.Karabekian).

### ***Outcomes of applied developments***

The young assistants of PSI Company and the Laboratory of Psychophysiology, the master of the Faculty of Radiophysics of YSU have developed an innovative project “A flat coil and low power tunnel diode activated oscillator system for studying the pulse waves of carotid artery” (Sup.: cand.(biol.) A.Khachunts).

## **DIVISION OF CHEMISTRY AND EARTH SCIENCE**

*Academician-Secretary – academician L.Tavadyan*

*Scientific Secretary – cand.(techn.) L.Gasparyan*

The Division includes the Scientific Technological Center of Organic and Pharmaceutical Chemistry, the Institute of Chemical Physics after A.Nalbandyan, the Institute of General and Inorganic Chemistry after A.Manvelyan, the Institute of Geological Sciences, the Institute of Geophysics and Engineering Seismology after A.Nazarov.

The Division includes 5 academicians, 5 corresponding members and 21 NAS RA foreign members.

1 general meeting, 7 meetings of Bureau were held during the reporting year.

At the annual general meeting of the Division held on May 22 the reports of the Academician-Secretary, acad. L.Tavadyan, directors of the research Institutes of the Division on their scientific and technical activity in 2019 were discussed. Due to pandemic the meeting was held on line.

At the meetings of Bureau the following issues were discussed and approved: the reports on the scientific and technical activity of the Institutes on the program "Preservation and development of infrastructure" of the Basic funding and state target program for 2020; working plan and distribution of part-time postgraduate study places with tuition fee reimbursement (free education) of the Division for 2021/2022. The issue on publication of academician A.Mantashyan's monography on "Chain reactions and accompanying processes" in the NAS RA Publishing house was heard and approved.

The applications for funding of scientific and technical activity of the Institutes on Basic funding "Preservation and development of infrastructure" and state target programs for 2021; the applications for purchase of the equipment in the scope of the programs on "Improvement of saturation and modernization of the Institutes of NAS RA " and "Maintenance, rearmament of scientific equipment, purchase of substances for scientific research, fulfillment of unforeseen urgent expenses of the Institutes of NAS RA" due to funds of NAS submitted by the Scientific Organizations of the Division were discussed and approved for 2020.

Materials related to prevention, spread and impact of COVID-19 coronavirus infection in Armenia were presented by the scientific organizations of the Division to the Presidium of NAS RA.

229 articles (including 109 abroad), 12 abstracts (including 9 abroad), 2 monographs (including 1 abroad), 1 manual were published by the Institutes of the Division, 1 patent RA was obtained.

Nine Candidates' and one Doctor's dissertations were defended in 2020.

The Division took part in annual meetings of the Institutes and discussion of their scientific results.

### **Scientific Technological Center of Organic and Pharmaceutical Chemistry**

#### ***Major achievements***

New N<sup>3</sup>-benzyl derivatives of N<sup>1</sup>-(4-methoxy-3-nitrobenzyl)-5-fluorouracil substituted in the phenyl ring have been synthesized by alkylation of the starting N<sup>1</sup>-(4-methoxy-3-nitrobenzyl)-5-fluorouracil with substituted benzyl chlorides in the K<sub>2</sub>CO<sub>3</sub> / DMF system. The previously undescribed N<sup>1</sup>- and N<sup>1</sup>, N<sup>3</sup>-bis-derivatives of uracil and 5-fluoro-, bromo- and iodouracils have also been synthesized as transport (prodrug) forms of biologically active analogues of nucleic bases by alkylation of the starting pyrimidines with 3-chloromethyl-4-methoxy-benzaldehyde in the above system.

In order to find new active and low-toxic anticancer drugs based on pyrimidines, conjugates of 5-fluorouracil with substituted pyrimidines and tri- and tetracyclic condensed pyrimidines, in which heterocyclic fragments are linked by a functionalized phenyl linker, have been obtained for the first time. New substituted bisoxadiazoles have been synthesized (Sup.: DSc(chem.) A.Harutyunyan).

### ***Outcomes of applied developments***

Dimethylvinylethynylcarbinol has been synthesized and a technology for the synthesis of piperidone has been developed on its basis. Methods for the preparation of vinylacetylene, dimethylvinylethynylcarbinol and piperidone have been proposed (Sup.:DSc(chem.) H.Attaryan).

### **Institute of Chemical Physics after A.Nalbandyan**

#### ***Major achievements***

Antioxidant properties of cobalamins (cyano-, hydroxo-, methyl-, adenosyl-): basic components of vitamin B12 have been studied and revealed quantitatively for the model reaction of methyl linoleate chain peroxidation by molecular oxygen in the micelle system using Biological Oxygen Monitor System (YSI 5300A, USA). It has been shown that cobalamins act as antioxidant regulators of lipid peroxidation. A mechanism of antiperoxyradical effect of cobalamins has been suggested (Sup.: acad. L.Tavadyan).

It has been revealed that combining strongly exothermic and violent reactions  $\text{MoO}_3 + 3\text{Mg}$  and  $\text{CuO} + \text{Mg}$  results in a slow interaction with weak self-heating (disynergic effect), caused by a change in the reaction mechanism: the process of Mg-thermal reduction of metals is preceded by formation of the  $\text{CuMoO}_4$  salt (Sup.: corr. member S.Kharatyan).

Fundamentally new theoretical approaches have been developed to study the classical and quantum three bodies' problems. It can serve as the basis for the development of new high-performance algorithms for modeling bimolecular chemical reactions, taking into account external influences as well (Sup.: DSc(phys.-math.) A.Gevorgyan).

### ***Outcomes of applied developments***

In the framework of the grant "Development of Draft River Basin Management Plan for Hrazdan River Basin in Armenia: Part 2" by the project "European Union Water Initiative Plus for the Eastern Partnership (EUWI+4 EaP) and International Office for Water", according to approaches and methodologies of EU framework directives on water a draft plan for Hrazdan river basin has been implemented (Sup.: cand. (chem.) S.Minasyan).

### **Institute of General and Inorganic Chemistry after M.Manvelyan**

#### ***Major achievements***

The compositions of glasses with high transmission and technologies for optical devices and night vision devices in the infrared region of the spectrum (400-6000 nm) have been developed. The glass forming regions, crystallization resistance, transmission in a wide spectral refractive index ( $n$ ), dispersion coefficient ( $v$ ) and thermal properties of glasses of the  $\text{PbGeO}_3$  ( $\text{BaGeO}_3$ ) -  $\text{Me}_2\text{O}_3$  (Me- Al, Ga, Bi, Sb) -  $\text{MeF}_2$  /  $\text{MeF}_3$  (Me- Pb, Cd, Al, Y) systems have been investigated in order to develop glasses with high IR transmittance (Sup.: DSc(tech.) N.Knyazyan)

The syntheses of silicate compounds based on the interaction of either chemically active silica hydrogel or layered silica previously recovered from serpentinites  $(\text{Mg}(\text{Fe}))_6[\text{Si}_4\text{O}_{10}](\text{OH})_8$  via the innovative technology, with the salts of strontium Sr and accompanied by the implantation of activator, namely europium ions  $\text{Eu}^{3+}$ , in their structure, have been performed. Their luminescent properties, depending on a number of factors: precipitation parameters, temperature and heating regime, the technique of activator implantation have been investigated and compared with the analogous data intrinsic to the similar compounds produced by the traditional methods (Sup.: DSc(chem..) N.Zulumyan).

### ***Outcomes of applied developments***

Transparent glasses with high transmittance in the infrared region of the spectrum (400-6000 nm) for optical devices and night vision devices have been synthesized (Sup.: DSc(tech.) N.Knyazyan).

Experimental samples of vanadium-diopside, iron-diopside, cobalt-diopside, as well as nickel-mulite, cobalt-mulite, iron-mulite of ceramic pigments have been obtained by the microwave method on a large laboratory setup. Based on these pigments, ceramic paints have been obtained, which were tested for the production of ceramic tiles. As shown by the results of laboratory tests, the obtained ceramic paints differ in a variety of colors and brightness. It has been found that the microwave method makes it possible to reduce the production time of these pigments by 2–3 times, as well as to reduce the temperature of formation of the diopside and mulite structure by 200–250 ° C (Sup.: cand.(tech.) V.Bagramyan).

### **Institute of Geological Sciences**

#### ***Major achievements***

Seismic tomography studies of Geomonitoring and Geoarchaeology Laboratory, Volcanology Laboratory and Institute of Earth Science of *Academia Sinica*, Taiwan have shown that the thickness of the continental crust in the area of Pleistocene Aragats and Pleistocene-Holocene Gegham volcanic massifs in the north-eastern part of the Armenian volcanic plateau is only 32-35 km, and the ratio of primary and secondary seismic waves velocities is characterized by an exceptionally high value ( $V_P / V_S = 1.90-2.15$ ). These characteristics sharply differ from the neighboring areas and indicate the local delamination beneath Aragats-Gegham volcanic cluster, the lithosphere removal and the presence of magmatic melts of mantle origin in the lower crust (Sup.: DSc(geol.) Kh.Meliksetian).

Correlation of planktonic foraminifera (PF), larger benthic foraminifera (LBF), and nannofossils from the Bartonian and Priabonian parts of Urtsadzor 350 m thick section corresponds to the planktonic foraminiferal zones P12/E10–11 to P15/E15, the nannofossil zones NP16 to NP19, the LBF zones SBZ17 to SBZ19, the SBF zones Heterolepaeocaena – Cibicidoideslandjaricum, Cibicidoidestruncanus, Planulinacostata (Sup.: cand.(geol.) L.Sahakyan).

For the assessment of Lake Sevan water ecosystem conditions, during different months of 2018-2019 the assessment of chlorophyll A content change in the water of Lake Sevan was carried out with the use of Sentinel-2 satellite data and C2RCC (Case 2 Regional Coast Colour) method. For the comparison, the satellite deciphered data from the UNESCO World Water Quality portal (<http://sdg6-hydrology-tep.eu/>) on the chlorophyll A content in the water of Lake Sevan in 2016 were used. According to the acquired satellite data, the chlorophyll A content in the water of the lake in 2018 and 2019 started to rise intensively from the end of May and reached its peak during July-August. The high content of chlorophyll A testifies to the gradual increase of the organic pollutants inflow into the lake (Sup.: cand.(tech.) A.Arakelyan).

A schematic geological map of the Devonian-lower carbon sediments dispersion of the Southern Caucasus has been completed. For the first time in the world, the orbelianus type has been reviewed which has a principal bio-stratigraphic significance for the Paleo-Tethys basin as an indicator form for the lower Famen. The paleo-geographical location during the Devonian-Lower Carboniferous period of the South-Armenian block was provided according to Aramazdospirifer orbelianus. 7 types of brachiopods were described and presented, out of which 6 belong to Rhynchonellida order, the other one – to Athyridida. The latter is a new type and was presented for the first time (Sup.: cand.(geol.) A.Grigoryan).

### ***Outcomes of applied developments***

Formulas have been proposed for strong earthquakes, to predict the magnitudes of displacements and accelerations under different ground conditions, taking into account the earthquake as a sudden mechanical rupture of the earth's crust (Sup.: acad. E.Khachiyan).

The map of the geothermal anomalies of the RA territory has been updated and completed with new data based on the calculated geochemical geothermometers of the thermo-mineral waters (Sup.: DSc(geol.) Kh.Meliksetian).

Within the frames of the contract signed between the IGS NAS RA and the Central Bank of Armenia, in 2020 the Laboratory of geoarcheology and geomonitoring participated in the project of managing productivity for Dilijan drainage tunnel, based on the IGS NAS RA report "Examination and assessment of the Dilijan drainage tunnel current condition", where the current condition of the entire length of the Dilijan drainage tunnel was presented. Conclusions and suggestions were provided for the company operating the tunnel. For the solution of the problems, a number of examinations and analyses have been carried out, as a result of which all the territories along the land tunnel, where it was necessary to carry out the cleaning of clogged pipes in the wells within the tunnel walls, were marked and categorized. Locations to dig new wells have been determined as well, which will allow the full and productive work of the tunnel drainage system (Sup.: cand. (geol.) M.Gevorgyan).

### **Institute of Geophysics and Engineering Seismology after A.Nazarov**

#### ***Major achievements***

Various patterns of oscillation amplitude curves in the lower and upper floors of multi-storey buildings have been discovered by means of in-situ tests (Sup.:cand.(geol.) J.Karapetyan).

An assessment of the quantitative characteristics of the stress field of the Earth's crust in Northern Armenia and adjacent regions has been carried out. A hierarchical model of the spatial-energy distribution of the spatial-deformation field of the earth's crust in Northern Armenia with vertical components of the relative deformation rates has been created. Analysis of the created model shows that in the adjacent blocks, separated by an incomparably small geographic size, the values of relative deformation are observed by one to two orders of magnitude, which indicates a strong fragmentation and high seismic activity of these blocks (Sup.: B.Sahakyan).

As a result of the analysis of the spectral composition of old buildings, it has been revealed that the prevailing peaks are more clearly expressed in the spectral composition of new buildings (Sup.: cand.(geol.) G.Hayrapetyan).

### ***Outcomes of applied developments***

A vertical pendulum seismic sensor has been designed, manufactured and tested (Sup.: A.Gasparyan, cand.(geol.) J.Karapetyan).

Research has been carried out on the development of a methodology and application of geophysical methods in mountainous areas associated with the safe operation of reservoirs and the establishment of the distribution of groundwater (the territories of lake Arpi, Karnut and Sarnakhbyur reservoirs) (Sup.: DSc(phys.-math.) R.Minasyan).

A prototype of electrical prospecting equipment has been developed and manufactured. It provides high measurement accuracy, is portable and easy to use (Sup.: M.Miranyan).

Analysis of the results of complex ecogeophysical studies and previously carried out engineering and geological works have made it possible to identify some basic regularities of the distribution of qarises in the underground spots of the city of Gyumri, as well as to estimate the geometric parameters of individual qarises (Sup.: R.Gasparyan).

## **DIVISION OF ARMENOLOGY AND SOCIAL SCIENCES**

*Academician - Secretary - academician Yu.Suvaryan*

*Scientific secretary - cand.(philosophy) H.Kocharyan*

The Division includes the Institute of History, the Institute of Economics after M.Kotanyan, the Institute of Philosophy, Sociology and Law, the Institute of Language after H.Acharyan, the Institute of Literature after M.Abeghyan, the Institute of Oriental Studies, the Institute of Archaeology and Ethnography, the Institute of Arts, Shirak Center for Armenian Studies, "Armenian Encyclopedia. Publishing House". All Armenian foundation for financing Armenian Studies acts in the frames of the Division.

The Division includes 7 academicians and 17 corresponding members.

In 2020 three general meetings of the Division were held. Due to pandemic all the Division meetings were held online.

At the annual general meeting on May 20 the report of acad. Y.Suvaryan on "The main results of the scientific and scientific-organizational activities of the Division in 2019" was discussed and approved.

At the general meeting on July 21 the scientific report of acad. R.Safrastyan "The Levant: Fundamental Issues of Regional Geopolitics" was heard and discussed.

The candidacy of DSc(phil.) V.Devrikyan for the vacant position of the director of the Institute of Literature after M.Abeghyan was heard, discussed and approved

At the general meeting on December 16 the scientific report of the corr. member A.Manasyan "The Legal and Political Aspects of the Artsakh Issue" was heard and discussed. The candidacy of cand.(hist.) R.Ghazaryan for the vacant position of the director of the Institute of Oriental Studies was heard, discussed and approved

In the reporting year the Division held 15 sessions of Bureau.

At the expanded meeting of the Bureau the scientific report of the corr. member P.Avetisyan "The Earliest Eurasian World-Systems, according to Newly Discovered Archaeological Data: Armenian Perspective" was heard and discussed.

The following issues were discussed and approved: the working plan of the Division for 2020, applications of the state target projects for the maintenance and development of the scientific and scientific-technical infrastructure of the scientific organizations of the Division in 2021, the reports on the implementation of the above-mentioned projects during 2020, the applications for the number of PhD positions in 2020, time schedule for the reporting meetings of the scientific organizations of the Division in 2020, the process of the work of the scientific organizations during the pandemic, etc.

The process of the realization of the 2012-2025 strategic plan for the development of Armenian Studies (approved by № 1 protocol of order of the RA Government, January 12, 2012), the issues related to the presentation of the ready papers for publication to the Scientific-Publishing Council of NAS, issues related to the international trips, etc were discussed as well.

The Division initiated and organized the "The Treaty of Sevres and Armenian Issue" conference dedicated to the 100<sup>th</sup> anniversary of the Treaty of Sevres, an online international conference dedicated to the 200<sup>th</sup> anniversary of Ghevond Alishan, an online scientific-practical conference "The genocidal behavior of Azerbaijan", organized by the joint initiative of the Ministry of Education, Science and Culture of the Artsakh Republic and the "Culture and Future" Foundation (Russia) and dedicated to the 100<sup>th</sup> anniversary of the Armenian Genocide in Shushi.

At the session of the Division Bureau on December 24 the reports on scientific and scientific organizational activities of the Bureau and the scientific organizations of the Division in 2020 were discussed and approved.

In 2020 three volumes of "Historical-Philological Journal", "Herald of Armenology" and "Journal of Social Sciences", two volumes of "Armenian Economic Journal", as well as two volumes of English electronic journal "Fundamental Armenology" were published.

The Institute of Language after H.Acharyan published two volumes of the "Language and Linguistics" journal, the Institute of Literature after M.Abeghyan published two volumes of the "Journal of Literature Studies".

123 books (7 abroad), 1 encyclopedia, 9 textbooks and manuals, 1012 articles (343 abroad) were authored and published by the staff of the Division scientific organizations.

## **Institute of History**

### ***Major achievements***

Within the framework of the theme "The Armenian Statehood from the Ancient Times to 1918" (Sup.: acad. A.Melkonyan), the issues related to the demographic characteristics and economic life of the Yerevan province have been covered on the basis of archival documents, statistical data, press materials and scientific literature.

Within the framework of the theme "Armenia and Armenians in the modern period. The Armenian question and the Armenian Genocide" (Sup.: DSc(hist.) K.Khachatryan), based on rich factual material, the problem of the Armenian territories occupied by Kemalist Turkey and Soviet Azerbaijan in 1920-1930 has been covered. This work makes it possible to understand the process of demarcation of the borders of the Republic of Armenia and the Republic of Artsakh. The work is equally important and actual from both a historiographical and politological point of view. The activity and position of Armenians who had settled in the territory of Mesopotamia (Iraq) since ancient times have been highlighted.

## **Institute of Archaeology and Ethnography**

### ***Major achievements***

Within the framework of the program "Problems of the Perspective Development of Armenian Archeology, Ethnography, Folklore Studies" (Sup.: corr. member P.Avetisyan):

a) the project "Neolithic culture of Ararat Valley during VII-VI millennia BC (according to the data of Aknashen settlement)" has been completed. Due to the laboratory analyzes and systematic works on the materials carried out during the study, exceptional data have been collected for the study of the history of formation of early agricultural societies in the ancient Near East. The results of the study demonstrate that at the initial stage of the establishment of civilization, a society with a complex social structure, developed economy and culture existed in the Ararat Valley. The monograph "Neolithic Settlement of Aknashen (Ararat Valley, Armenia): Results of 2005-2015 excavations" has been compiled and edited for Archaeopress, Oxford Publishing House. It consists of contributions summarizing the results of 15-years research of the joint Armenian-French expedition and contains significant novelties about the early agricultural societies of the Armenian Highland (Sup.: DSc(hist.) R.Badalyan).

b) During 2020 "Artsakh Archaeology Group" registered significant results in Tigranakert. The excavations have been carried out in five locations: The Eastern Wall of the Fortified District, the Second District of Antique Period, the Early Christian Square, Tsitssar Church, and the Rock-cut Canal. Excavations in the Second District of Antique period have brought to light structures belonging to the period of Tigran and the time after him, made of limestone, clay, mud brick, and in rare cases, of lime mortar. The ruins of a small early Christian church or chapel have been excavated on the top of Tsitssar. On the right bank of the Khachenaget, the exploration of one of the main water supply nodes of the city, the canal, has continued. The excavations took place in the rocky part of the canal, where during 2006 a section of ca. 300 meters was excavated. The first tunnel of the canal was opened during the excavations. This is an unprecedented result, as there are no such large and complex hydraulic structures on the other side of the Ararat Valley (Sup.: DSc(hist.) H.Petrosyan).

### ***Outcomes of applied developments***

Within the framework of the project "Stalin's repressions in Armenia", the documents on 1949 Armenian deportation have been analyzed. A collection of digitized copies of about 96 documents gathered from archives of the Russian Federation, Armenia, Artsakh and Georgia has been represented correspondingly ( Sup.: cand.(hist.) G.Kharatyan).

Within the project for tourism development in the archaeological sites excavated by the Institute, works on strengthening, improving and creating an archaeological park at the Agarak Archaeological Complex have been realized with the help of specialists invited from Italy (Sup.: corr. member P.Avetisyan).

Within the project "My Armenia" extensive research has been conducted in Vayots Dzor and Syunik regions, in collaboration with the Smithsonian Institution to implement cultural and rural tourism development programs (Sup.: cand.(ped.) S.Mkrtchyan, cand. (hist.) G.Shagoyan, R.Tsaturyan).

Within the the project "Study of the fortresses of the liberated territories of Artsakh" studies have been realized in the Kashatagh, Shahumyan and Hadrut regions of the Artsakh Republic. 40 known and newly discovered fortresses have been documented, topographic maps have been prepared. Exhibition of the materials was organized in the Parliaments of the Artsakh Republic and the Republic of Armenia. The materials are prepared for publication during the next year (Sup.: G.Sargsyan).

500 items of great historical and cultural value have been restored and prepared for museification: among them items of clay, bronze, iron, glass, bone and stone.

### **Institute of Oriental Studies**

#### ***Major achievements***

Within the framework of the program “Eastern Sources of the Ancient, Medieval and New Period about Armenia and the Armenians” (Sup.: cand.(hist.) R.Ghazaryan) the importance of studies on the origin, history and genealogy of the four main Armenian dynasties of the provinces of Artsakh and Utik, Proper Albania from the early period to the High Middle Ages has been stressed. Special attention has been paid to the written and epigraphic sources on the discussed issues, most of which have been published. Using numerous sources, this clarifies the issues of the history of Artsakh, Utik, as well as Aghvank, the history of the indigenous peoples living in the territory of the present-day Republic of Azerbaijan, which allows to give a more comprehensive answer to the distortions of our people’s history.

Within the framework of the program “Armenia and the Problems of Political, Social, Cultural and Ethnic History of Turkey, Iran, Caucasia and Arabic Countries of Mashriq” (Sup.: acad. R.Safrastyan) the tendencies of the development of geopolitical thought in Turkey, the peculiarities of the formation of foreign policy of the Justice and Development Party, the cycles of policy towards the Republic of Armenia in the first decade of its rule, the manifestations of the “Armenian” policy of the Justice and Development party, the process of Armenia-Turkey Zurich protocols and the results have been studied.

Within the framework of the program “International relations in Near East, Eastern Asia, South Caucasus and the Republic of Armenia” (Sup.: corr. member N.Hovhannisyan) the Silk Road concept put forward by China in the field of Eastern Asian studies has been studied, it provided an opportunity to substantiate the thesis of Armenia’s important role in this program. The research of the topic called “Implementing China’s New Silk Road Initiative in the Greater Middle East” is very important as well.

### ***Outcomes of applied developments***

During the reporting period the researchers of the Institute have regularly presented to the relevant bodies scientific and scientific-analytical materials contributing to the development and

implementation of a number of main directions of the RA foreign policy (particularly in the Middle East and the region), as well as concerning the RA national security. The employees of the Institute have been involved in the discourse around the RA foreign policy, presenting the results of their scientific studies during the expert interviews given to leading Armenian and foreign mass media.

The pledge of our cooperation with state bodies is the letter received from H.Petrosyan, Head of the RA Security Council office, expressing gratitude to acad. R.Safrastyan for participation in the development of the new National Security Strategy of the Republic of Armenia. Thank-you letters from the RA Security Council office were also received by employees of the Institute, candidates (hist.) G.Iskandaryan, A.Pashayan, and L.Hovsepyan who have also participated in the development of the new RA National Security Strategy.

Another episode of cooperation with state bodies is the meeting of the Chairman of the National Assembly Standing Committee on Science, Education, Culture, Diaspora, Youth and Sport, Chairman of Armenia-Iran Friendship Group M.Hayrapetyan with the staff of the Institute. The participants of the meeting spoke about Armenian-Iranian relations, as well as regional developments in general. The meeting was also attended by a member of the National Assembly, member of Armenia-Iran Friendship Group V.Hakobyan.

One of the important achievements of applied significance is the publication of school textbooks and higher education textbooks by the employees of the Institute, particularly the textbooks prepared and printed for Yezidi schools, as well as the educational-methodical manual called "Issues of the History of the Muslim East (7<sup>th</sup>-15<sup>th</sup> centuries)".

## **Institute of Language after R. Acharyan**

### ***Major achievements***

During the year 2020 considerable results have been achieved in the study of Armenian vocabulary. The research activities have covered both the Indo-European word layer, the different stages and manifestations of the development of the Armenian language, as well as all the observations of the vocabulary study.

Within the framework of the topic "Issues of Historical Development of the Armenian Language" (Sup.: cand.(phil.) G.Mkhitaryan) the words and archaisms not mentioned in Old Armenian, but assuming Indo-European origin in the Karabakh dialect have been revealed and interpreted. By observing the vocabulary of Agatangeghos's "Armenian History", the words and wordforms that deviate from the Grabarian rules and have a dialectal character have been separated, and their relation to the dialects of the time has been proved. The influence of Latin in the translated literature has been observed, the principles and patterns of formation of neologisms have been revealed.

Within the framework of the topic "Problems of the Study and Regulation of Modern Eastern and Western Armenian Languages" (Sup.: corr. member A.Sargsyan) the principles of Armenian translation of foreign terms have been revealed and explained, terminology issues and thematic groups of words have been considered. The research outcomes are summarized in the collection "Issues of the History of the Armenian Language", in articles and reports.

Within the framework of the topic "Study of Armenian Dialects" (Sup.: DSc(phil.) V.Katvalyan) the linguistic characteristics of the settlements of the RA Kotayk Region have been prepared, the dialectal affiliation of the speeches has been determined and interpreted. The peculiarities and ways of the formation of mixed type dialects have been determined according to the dialectal units of Kotayk Region. The outcomes of this research are presented in the book "Dialectal Overview of the Republic of Armenia. Book 2. Region of Kotayk", in scientific articles and reports.

### ***Outcomes of applied developments***

Within the framework of the grant project "Formal Description of Armenian Word Formation and Creation of the Corresponding Electronic Database" (Sup.: cand.(phil.) M.Sargsyan), from the word-formation viewpoint a formal description of the vocabulary of about 150.000 words to be

included in the database has been given. Guidelines for searching and using the database have been developed. In order to make it accessible to the general public, the database will operate on a separate website under the formlang.am web address.

Within the framework of the topic "Problems of the Study and Regulation of Modern Eastern and Western Armenian Languages" (Sup.: corr. member A.Sargsyan), the volume E of the "New Words" series was published including about 1500 neologisms with their explanations and relevant examples. Issues of Armenian transliteration of modern medical terms were discussed.

Within the framework of the topic "Issues of Historical Development of the Armenian Language" (Sup.: cand.(phil.) G.Mkhitaryan), the work "Book of Inquiries" by Grigor Tatatsi has been translated into Modern Armenian and published.

### **Institute of Literature after M.Abeghyan**

#### ***Major achievements***

Within the framework of the theme "History of Armenian Literature" (Sup.: DSc (phil.) V.Devrikyan) the principles of literary translation of the works of a number of Armenian, Russian and English writers of the early 20<sup>th</sup> century have been concluded and summarized, the works were consequently translated from Armenian into Russian and English, from Russian into English and Armenian, as well as from English into Armenian and Russian. The regularities that exist in the case of word choices in the translated language have been identified, as well as the issue on how the translator's creative temperament leaves its mark, conveying the stamp of his authorial personality to the translated works.

Together with the Mkhitarist Congregation, some principles of publishing the letters of St.Lazarus Armenologists-clergymen, which were applied during the publication of about 2240 letters of Gevond Alishan's three-volume letter collection have been developed (711 letters were included in the first volume that was published in 2020, the second and third volumes will be published in 2021). The history of Armenology in Europe in the second half of the 19<sup>th</sup> century was in fact mostly compiled thanks to the publication of Alishan's and other Mkhitarian clergymen's letters and due to the detailed notes of the letters, to the information about the addressees of the letters and to the explanations on the issues under discussion.

### **Institute of Philosophy, Sociology and Law**

#### ***Major achievements***

Within the framework of the theme "Historical-philosophical, socio-political and legal studies of the Armenian reality" (Sup.: cand.(law) L.Kazanchian) research has been conducted in four scientific areas: philosophy, sociology, law and political science.

Extensive interdisciplinary research devoted to in-depth analysis of current problems in the Republic of Armenia and the region has been conducted, including: identification of the Armenian civilizational identity, alienation of the individual, reform of the education system, complex migration processes, constitutional and legal reforms, as well as identification of public opinion in relation to the authorities.

In the context of linguistic philosophy, various structural and functional manifestations of "meaning" in language and in life have been systematically analyzed, as well as in the context of semiotics, the problems of "identity" have been interpreted, especially in the Russian informal discourse the transformation of the image of a "Caucasian" from Soviet to post-Soviet perception.

Fruitful interdisciplinary research has been carried out on the historical, philosophical, legal and political issues of the formation and development of parliamentarism. In particular, as a result of perennial scientific research and development, a large-scale treatise "Western European and post-war parliamentarism in a comparative perspective", has been presented to the scientific community, in which a comparative analysis of the experience of Western European and post-Soviet parliamentarism and the prospects of its development has been thoroughly considered.

A variety of socio-legal and political studies dedicated to identifying the historical, political, social causes and consequences of the Armenian-Azerbaijani war, both on local and foreign-language platforms, have been conducted.

### ***Outcomes of applied developments***

In cooperation with the law offices in the Republic of Armenia and the School of Advocates of the RA applied research on constitutional and legal reforms, the transition to a parliamentary form of government has been continued, and the results have been presented to government agencies and interested organizations. Moreover, the lawyers have provided free legal consultations to the victims of the Armenian-Azerbaijani war. Within the framework of local and international cooperation, a number of domestic structures have been provided with legal advice and opinions on controversial, conflicting legal issues (Sup.: cand.(law) L.Kazanchian).

## **Institute of Economics after M. Kotanyan**

### ***Major achievements***

Within the scope of the Research project “Problems of ensuring the continuous growth of the tax / GDP index and the ways of their solution in the Republic of Armenia” (Sup.: corr. member V.Harutyunyan) it has been noted that after joining the EAEU, the tax burden has increased by 2%. The increase in this indicator is due to the fact that after joining the EAEU, zero VAT rates were applied to operations for the supply of goods exported to the EAEU member states. The tax / GDP ratio has not changed significantly, in particular, in 2017 it was 18.7%, and in 2019 - 18.9%, t.e. the difference was only 0.2%, as a result, it has been concluded that this is the result of an ineffective policy, which does not lead to a reduction in the shadow economy.

Within the scope of the Research project «Export as the Basis of Economic Growth in the Republic of Armenia (Sectoral Strategy)» (Sup.: cand.(econ.) L.Sargsyan) the scientific trajectory of the impact of exports on economic growth has been revealed. Accordingly, export growth promotes economies of scale as well as foreign exchange inflows, which can lead to the more efficient resource allocation as well as the introduction of necessary raw materials and new technologies. As a result, we get productivity growth, higher added value and, as a result, economic growth. In addition, with the help of econometric methods, the duration of individual stages of this mechanism in the Republic of Armenia has been revealed. Thus, an increase in exports for up to 3 months leads to an appreciation of the exchange rate, which contributes to an increase in imports for up to 9 months. The growth in imports of raw materials and equipment, in turn, is the cause of economic growth for the next 3.5 years.

Within the scope of the Research project "Problems of Innovative Development in the Sphere of Agriculture of the Republic of Armenia" (Sup.: cand.(econ.) M.Manucharyan) the main directions for the introduction and commercialization of innovations have been identified through a comprehensive assessment of the innovative potential of the agricultural sector of the Republic of Armenia. It has been revealed that the main obstacles to the development of the agricultural sector of the Republic of Armenia are outdated fixed assets and technologies, due to which the expediency of innovative development of the sector is conditioned by the fact that in the current conditions almost all resources are limited, and resource savings occur. It should be noted that the sector continues to develop in a very extensive way. Currently, the investment activity of the sector is at a very low level, which is due to the low economic situation of the whole economy and individual regions.

### ***Outcomes of applied developments***

Within the scope of the Research project “Problem of ensuring the continuous growth of the tax / GDP index and the ways of their solution in the Republic of Armenia” (Sup.: corr. member V.Harutyunyan) it should be noted that each country is constantly faced with the problem of achieving the optimal level of the tax burden. A high level of tax burden at the initial stages is

considered a positive indicator for the state, as it provides large tax revenues. However, this issue cannot be treated unequivocally, since a high tax burden, on the other hand, leads to a decrease in business activity. And, as a consequence, it reduces the incentives for the population to work, which in turn leads to a decrease in tax revenues. Consequently, there are two important factors to consider when developing tax policy: first, taxes must be compatible with economic efficiency; secondly, the tax system must be equal, that is, compatible with the principle of fairness.

Within the scope of the Research project "Export as the Basis of Economic Growth in the Republic of Armenia (Sectoral Strategy)" (Sup.: cand.(econ.) L.Sargsyan) it has been proposed in the export structure of the Republic of Armenia to carry out a gradual transition from the export of resource-intensive and low-tech goods to the production and export of high-tech goods in order to make the impact of foreign trade on economic growth more positive. Ultimately, as a result of the detailed analysis undertaken to identify export opportunities, a number of sectoral opportunities have been identified, export mechanisms have been proposed and target markets for selected sectors have been identified.

Within the scope of the Research project "Prospects for the formation and development of high-tech economy in the Republic of Armenia" (Sup.: cand.(econ.) S.Dallaqyan) the following suggestions have been presented:

1. When developing a military expenditure policy the regional multiplier factor should be taken into account, and it has been substantiated that the military expenditures can not only be maintained throughout the economy, but also bring economic growth and further self-sufficiency by further correlation.

2. Introducing advanced approaches to solution of cyber security and information security problems in a number of sectors of the economy, as well as in the government activity, by developing a concept on cyber security in Armenia

Within the scope of the Research project entitled "Problems of Innovative Development in the Sphere of Agriculture of the Republic of Armenia" (Sup.: cand.(econ.) M.Manucharyan) it has been suggested to create preconditions for agricultural innovations to be available not only to rich farmers, but also to middle-income and low-income farms, which make up a larger share in Armenia. In this case, it is necessary to apply foreign experience, to provide a state guarantee of 50% of the cost of an innovative agricultural project, which will also reduce the level of risk in the sector. In order to strengthen cooperation, establishment of connections (investors, farmers), it is necessary to create web-platforms, as well as to organize exhibitions. In the context of innovative development, it becomes even more important to strengthen the connection between economics and science, and they must work in an atmosphere of joint partnership to ensure high efficiency.

## **Institute of Art**

### ***Major achievements***

Within the framework of the program "A comprehensive study of Armenian art" (Sup.: corr.member A.Aghasyan), investigations of the theater of Egyptian, Iranian and Canadian Armenians have been continued. The key results are put together in the voluminous monograph by cand.(art) A.Chtyan, entitled "The Armenian Theater in Egypt", representing the third regular volume of the series "Essays on the History of Art of Diaspora Armenians". The monograph gives a complete picture of the period under study, recounts the prerequisites and the historical background, conducive to the formation and progress of the Armenian theater of Diaspora.

## **Shirak Centre for Armenian Studies**

### ***Major achievements***

Within the scientific topic of «Archaeological and historical-ethnographic studies of Shirak-3» ( Sup.: cand.(hist.) A.Hayrapetyan) the following has been done:

- a. Rescue excavations of Jrapi grave fields, despite their small size, have provided new material for the study of the general location of settlements in the early Iron Age in the coastal areas

of Akhuryan, the settlement-grave field ratio, population density, high economic level, and for the study of their generality with other contemporary monuments of Armenia, burial ways, rituals, material and spiritual culture.

b. The study of zoological data obtained from the excavations of Lernakert has shown that in the III-I millennia BC one of the most developed branches of the region's economy was cattle breeding. The discovered material provides information on the food composition of the ancient communities of Lernakert, as well as on the development of various branches of the economy (leather industry, textile, dairy products) in the given period.

c. Examination of the history of the resistance struggle against Turkish troops in the villages of eastern Shirak in May 1918 has been conducted, the role of the struggle for survival in the history of the May heroic battles has been covered.

d. A map has been compiled presenting the results of the Turkish invasions. It has been compiled on the basis of a combination of oral histories, archival materials, scientific literature and other sources preserved in the rural areas of the Shirak region, and among the population of Gyumri about the Turkish invasions in 1918 and 1920. The map shows all the villages where self-defense battles were organized, the villages where the Turks had bases, military bases, where people were burned in haylofts and churches, where mass killings were organized.

#### **Armenian encyclopedia. Publishing house**

Publishing House of the Armenian Encyclopedia has published the one-volume "Encyclopedia: Hovhannes Tumanyan".

## **National Bureau of Expertise SNPO**

### ***Major achievements***

The organization has published the 3rd and 4th issues of the scientific periodical “Armenian Journal of Forensic Expertise and Criminalistics”, which include articles by leading foreign scientists and experts in the field of forensic science; the instrument and analytical park of the bureau was replenished with a modern ultrasonic multifunctional device “UDT-RF PRO”, which has a wide range of applications in carrying out, first of all, forensic commodity examinations; organizational and financial work has been completed to equip the instrument base of the organization with the latest analytical equipment - a mass spectrometer for high-performance liquid chromatography-mass spectroscopy (LC-MS-MS), which will provide the necessary reliability of expert studies of toxic compounds in biological media; the Leica TS10 total station and the unique Berla iVe software package, which has no analogues in the Eurasian Economic Union, have been purchased, which will allow starting scientific and practical research in a number of new areas.

### ***Outcomes of applied developments***

10357 forensic expertise have been conducted, it is planned to carry out about 230 additional forensic expertise.

In the framework of the Criminal Procedure Code of the Republic of Armenia, the Organization has carried out expertise in 27 expert types with around 129 expert subtypes and technological directions.

The Organization's expertise departments conducted 169 expertise based on court decisions in the framework of Civil Procedure, 53 expertise in the framework of Administrative Procedure, as well as 115 expertise in the frames of civil legal relations upon the contracts concluded with individuals and legal entities.

## STATE TARGET PROGRAMS

### **Creating a cloud computing environment for solving scientific and applied problems**

*Coordinator V.Sahakyan, cand.(phys.-math.), Deputy director of the Institute for Informatics and Automation Problems*

The program is aimed at addressing the problems of natural sciences (hydrometeorology, ecology, seismology, biology, and medical genetics) and the development of a cloud infrastructure using the possibilities of national research e-infrastructure.

Leading specialists took participation in the program from the Institute for Informatics and Automation Problems, the Institute of Geological Sciences (IGS), the Institute of Geophysics and Engineering Seismology after A.Nazarov (IGES), Institute of Physiology after L.Orbeli, the Institute of Molecular Biology, International Scientific and Educational Centre, the Ministry of Emergency Situations and the Ministry of Environment of RA.

During the reporting year research has been carried out for the development of cloud infrastructures and services to ensure the solution of scientific problems. Based on the Software as a Service (SaaS) cloud computing service model, work has been carried out to develop a control panel for the cloud computing environment. The new features of the main components and services (Nova, Keystone etc.) of the latest version of Openstack have been studied in detail. Cloud infrastructure has been improved, including a full cloud platform, based on the OpenStack, with two zones, each of which has its own controllers and computing resources. This platform is currently used by 12 scientific/educational and other organizations. Using the capabilities of the Prometheus/Grafana software platform, a monitoring service has been developed to monitor the operation of all virtual machines.

The Armenian Open Data Cube (ODC) platform has been developed to process data analysis, mapping methods and software. The ODC platform allows downloading existing satellite imagery of our region from the global data repository, specifying the boundary and projection conditions and to convert the resulting data to the format required for environmental research.

In the fields of meteorology and environmental science research has continued, including the implementation of climate change and vulnerability assessment models in Armenia, the implementation of solar radiation, spatial modeling of wind power distribution with the help of high-resolution weather forecasting using the Weather Research and Forecasting (WRF) digital weather forecast model, and the development of unified electronic platform for the environment.

In the field of seismology, seismologist cloud workspace and seismic cloud toolkit have been developed; the continuous receipt of records from digital seismic stations of observation network of IGS and storage of data in cloud repositories has continued, a developed specialized cloud work environment has been modernized and embedded software packages have been updated. A new seismic sensor, developed by IGES has been tested in real conditions, recording earthquakes to solve various monitoring and engineering challenges, as a result of which a portable seismic system has been developed, which is designed for continuous operation and meets modern requirements.

In the field of biology, the process of modeling of the previously obtained lipid bilayer / transmembrane integral complex biological system has continued, with the method of computer experiment. Certain software modules have been developed and modified.

In the field of medical genetics, an algorithm of multi-layered self-governing maps has been developed; the effect of somatic and hereditary mutations in BRCA1 and BRCA2 genes in breast and ovarian cancers on the expression of genes at the full genome level has been implemented. In the Armenian population, within the framework of the study on the distribution of genetic risks of resistance to chemotherapy of blood cancers, the transcriptome of blood cells of 3600 healthy people has been examined, using a number of algorithms of machine learning, biological data mining and functional annotation. The results allow to classify the subjects according to "blood transcriptome groups", to assess the relationship between the expression of genes in those molecular groups and the development of environmental factors and diseases, particularly blood cancers.

The results achieved during the implementation of the State Targeted Program have been published in 12 articles.

## **Development of geochemical maps to ensure sustainable agricultural development and food safety**

*Coordinator L.Sahakyan, cand. (geogr.), director of the Center for Ecological-Noosphere Studies*

In the frames of the project a region-wide soil survey has been conducted across the Ararat region. All in all, 84 soil samples have been taken to determine the concentrations of chemical elements Cr, V, Ti, As, Zn, Cu, Co, Fe, Mn, Ba, Pb, K, Ca and the values of  $\alpha$ ,  $\beta$  activity. A relevant database has been produced, the studied values have been mapped. Finally, it has been established that formation of fields of spatial distribution of concentrations of the studied values is due to the specificities of geological basis and location of pollution sources. The exceedances of MAC values accepted in the RA have been established for As (98% of samples) and Cr (70% of samples). Noncarcinogenic and carcinogenic risks to children's health have been identified in respect of As concentrations on two sampling sites alone.

## **Assessment of the mechanisms of eutrophication of Lake Sevan and development of methods to combat "algal blooms"**

*Coordinator B.Gabrielyan, DSc(biol.), director of the Scientific Center of Zoology and Hydroecology*

In order to develop methods for coping with the Lake Sevan “blooming” events, works have been carried out to reveal hydro-chemical and hydro-physical factors that enhance “blooming” as well as to identify and quantify the species structure of autotrophic chain.

The methodology of the use of Armenian zeolites has been developed in order to purify Lake Sevan from blue-green algae. The efficiency of zeolites for this purpose has been justified based on microbiological parameters.

After a microbiological examination of a 10-minute sample, it has been found that the content of microorganisms was reduced by 300 times. Recently, works have launched in order to increase the pace of influence of sorbent.

The genotoxicity and clastogenicity of water samples collected from three different sites of Lake Sevan basin (Lichk, Lchashen, Norashen) have been assessed by means of Trad-SHM and Trad-MCN assay using model test plant *Tradescantia* (clone 02). A significant increase has been reported in the level of point somatic mutation and micronuclei in tetrads of pollen microspores frequency in the *Tradescantia* inflorescences exposed to the water samples of lake's compared to the background. The maximum manifestation of these genetic effects from both investigated bioassays has been observed in Lchashen water samples.

These results indicate that Trad-SHM and Trad-MCN bioassays of the *Tradescantia* clone 02 can be applied for biotesting of water quality of hidroecosystems.

## **Geopark as an impetus for sustainable economic development and environmental protection in Gegharkuniq, Vayots Dzor and Syunik marzes**

*Coordinator A.Avagyan, cand.(geol.), Institute of Geological Sciences*

The international as well as local experience on the selection criteria of geosites has been analyzed. In general, scientific, educational-cognitive, aesthetic-touristic objects of inanimate nature that are rare, spectacular and have a high-value are selected as geological monuments.

Numerous examples of international and local literature have been studied for geosite classification, and a form of Geopark passport consisting of 11 requirements, as well as a table of partial and general evaluation has been developed for the first Geopark of the Republic of Armenia.

It is suggested to include areas mainly from Gegharkuniq and Vayots Dzor Marzes in the Geopark. There are three main reasons for this: the multiple reduction of funding, in case of war actions, the inclusion of as compact area as possible and the fact of being located on/near the border of the planned lands.

During the work, it became expedient to include also small areas from Ararat and Kotayk Marzes. This made it possible to add objects of nearby regional and international significance by adding a small area. Thus, the first Geopark of the Republic of Armenia will cover an area of about 4400 km<sup>2</sup>, which corresponds to 14.7% of the territory of the Republic of Armenia. It covers 102 community areas. The relief is mountainous, including the heights of 1019-3595 m. There are 6 climatic zones ranging from dry land (hot summer and cold winter) to alpine tundra.

The data collected during the first year have been included in the Geographic Information System as separate maps.

Geosite selection started with studying the available literature. Initially, the existing lists of natural and geological monuments were studied. The most important contribution to the choice of geosites has been made by the Armenian geologists as a result of many years of their work.

Analyzing the rich geological heritage, as well as the international experience of Geoparks, it has been suggested to establish not a Geopark of general geological monuments, but specialized geological hazards Geopark. The Armenian one will be distinguished by the fact that it will have examples of different spheres of geological hazards in a limited area (geodynamics, active tectonics, volcanology, seismology, stratigraphy, hydrogeology, etc.). This circumstance will make the first Geopark of Armenia an exceptional, and, even more, as a result of the selection, we will have regional geosites and several geosites of international significance.

About 40 geosites have been pre-selected so far. During 2020, all the planned local works have been fully carried out. They were carried out in Artanish Peninsula, along the eastern and western shoreline of Lake Sevan, along Gavaraget fault, on the sites of Smbatar, Vayotssar, Khonarhasar volcanoes and their lava flows, on the landslide site of St. Karapet Monastery, Horbategh, Zangakatun.

### **The main directions of the comparative study of the Armenians in their own and other national environment: challenges and prospects of the research**

*Coordinator R.Karapetyan, cand. (hist.), Institute of Archaeology and Ethnography*

During the year within the framework of the program two international seminar-discussions have been organized with the participation of foreign partners. The researchers of the department published about 10 scientific articles in different international journals. The network of experts from various diaspora communities has been established.

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