National Academy of Sciences of Ukraine
Institute of Molecular Biology and Genetics (IMBG)

IMBG RESEARCH AND INNOVATION STRATEGY IN BIOMOLECULAR ELECTRONICS

for 2024-2030

developed in the frames of
BIONANOSENS project of Horizon 2020 EU program

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CONTENT

1 INTRODUCTION

This document was developed to outline the upcoming stages, long-term perspectives, and numerical indicators of the progress of the Institute of Molecular Biology and Genetics of NAS of Ukraine (IMBG) in research, innovation management, and international cooperation in the Biotechnology area from 2024 to 2030.

IMBG plans its activities to enhance its contribution to Ukraine's economic and social development priorities, increase world-class research output, ensure the effective use of budget funds and property, and improve the quality of scientific personnel. The specific objectives are to:

- Ensure a high level of scientific research focused on solving contemporary science and technology problems.
- Increase innovative activities and expand scientific support for addressing current state and social development issues.
- Expand international scientific cooperation, primarily within European Community programs.
- Improve the structure and management system.
- Develop personnel potential and modern research infrastructure.
- Enhance the efficiency of budget fund usage, conduct a complete inventory of the property complex, and ensure its effective use.
- Improve communication with society and popularize scientific activity.

The strategy of IMBG is primarily aimed at strengthening the Institute's leadership in life sciences and biotechnology within Ukraine's scientific community, enhancing its significance for foreign partners as a leading Ukrainian scientific center, and increasing scientists' responsibility in addressing the socio-economic challenges of Ukraine and the broader Eastern European region.

The relevance of the scientific problems addressed by the Institute's scientists is underscored by the significant unmet needs in Ukraine's biotechnology sector, particularly concerning human health, well-being, and environmental safety.

This Strategy results from the implementation of a large twinning European Horizon Europe project at IMBG and was adopted by the internationally recognised experts of the project`s General Assembly. The Strategy presents a roadmap showing how the project's achievements will be sustained and utilized for further Biotechnology development in Ukraine.

The document serves as a roadmap for the Institute's sustainable development in analytical biotechnology over the next seven years. It is intended for IMBG's European partners, EU officials, Ukrainian authorities, and all stakeholders in the Biotechnology sector.

It is available in the websites of the Institute and of the EU funded IMBG project.

1.1 Realization of the Strong Research and Innovation Potential of Ukraine as Associated Country to Horizon Europe

World Globalization and Sustainability

Agenda 2030 set up by the United Nations General Assembly and Sustainable Development Goals (SDGs) focus on three trends that determine global processes: global changes in production and labor markets, the acceleration of technological development, and climate change. Overcoming these challenges requires modern management tools, knowledge in investment and innovations, and the responsibility of public authorities, scientists, and citizens.

Ukraine is the second largest country in Europe and the 22nd largest in the world. It joined the global process aimed at sustainable development and presented the National Report on Sustainable Development Goals in Ukraine up to 2030 at the UN Summit in 2017.

Ukraine faced significant economic challenges during the transformation processes before the war started in 2022. Structural, energy, and financial crises, exacerbated by the COVID-19 pandemic from 2019-2021, led to unsustainable economic development and a loss of resources, capital, and time. Now, after two years of war, the country requires military and financial support from partners to survive and succeed in its struggle against the aggressor.

Role of Science and Innovations in Ukraine's Renovation and Economic Stability

The development of the Science, Technology & Innovation sector holds promise for the entire economy, contributing to the country's prosperity and well-being. “Ukraine 2030 - The Doctrine of Sustainable Development” outlined in 2018 the revised "Program of Development of Innovations" and "Reform of the State Policy on Science and Research".

The UN estimated Ukraine’s population to be about 44.2 million in 2017, with approximately 100,000 Ukrainians dedicating their lives to science and innovation in the institutions of the National Academies of Sciences and national universities. Despite permanent financial constraints, important disciplines such as biotechnology have been successfully developed in the National Academy of Sciences of Ukraine over the past 25 years. This success was partly due to EU institutional support and international cooperation with leading EU research centers and individual researchers, which have helped keep Ukrainian science sustainable.

Ukraine’s significant scientific potential and desire to join the European Research Area were vividly demonstrated during the Euromaidan protests (Revolution of Dignity) in 2013–2014, where scientists were among the most active advocates for EU integration. As a result, in 2015, Ukraine became an Associated Country to the Horizon 2020 EU Framework Programs for Research and Innovation. Then, on June 9, 2022 the Agreement with the European Commission on Ukraine's Associated status to the Horizon Europe EU Framework Program for Research and Innovation (2021-2027), previously adopted by the Supreme Council of Ukraine, came to force. The Association Agreement with Horizon Europe has provided Ukrainian scientists with even more opportunities to participate in the **European Research Area, an open space for knowledge, research, and innovation** in Europe.

However, the country still lacked a robust Technology & Innovation sector infrastructure, resulting in a gap between science on one side and the economy and society on the other.

To bridge this gap, Ukraine should strengthen its successful long-term research collaborations with European scientists and participate in relevant European research, development, and innovation programs, particularly in biotechnology. This focus will ultimately improve the quality of life in Ukraine. This strategic priority should be at the heart of the development strategy for biotechnology

science in Ukraine and the future development of IMBG as one of the leading research centers for biotechnology studies in the country.

In 2017, IMBG researchers and managers took active part in the national expertise procedure aimed at developing the consolidated position concerning Smart Specialization Strategy (3S) in Ukraine in cooperation with EU Joint Research Center (JRC). It was performed due to the Orders of the First Vice-Premier Minister S. Kubiv dated 10.06.2016 №18942/2/1-16 and11.10.2016 №18942/7/1-16. Acording to the provisions of these documents, IMBG expert group headed by the former IMBG Director Prof. Anna El`ska had developed 15 main directions of Smart Specialization in Ukrainian "Biotechnology" priority area. One of the most promising among them was the part "Biosensors for biomedicine, human health and sustainable environment", which opened new ways for collaboration with business and innovation development.

However, rude Russian aggression into Ukraine in 2022 made the previous plans unrealistic. Currently, EU and leading partner countries in the world help Ukraine and the post-war socio-economic development could be discussed in realistic way.

Ukraine obviously needs support from partner countries for post-war renovation, and many of them have already launched initiatives to aid Ukrainian cities and regions.

Post-War Reconstruction of Ukraine

After the war, Ukraine will require deep institutional and structural reforms and large-scale technological transformations, aiming to double its GDP and increase labor force employment to 70%. The implementation of these tasks will depend on various factors:

1. Creation and development of high-technology and competitive industries (from basic science to production and maintenance).
2. Increase in domestic demand due to household income growth and intensified investment processes.
3. Transition from raw materials and primary processing products to high value-added products and services, supporting the export of such products.
4. Implementation of infrastructure projects (highways, transport interchanges, metro, high-speed passenger railways, vehicles for rail and water transportation: cars, barges, etc.).
5. Rapid increase in productivity of the agro-industrial complex.

Currently, in addition to threats to Ukraine's state sovereignty and territorial integrity, there are real and potential threats to human security due to the increasing scientific and technological lag from developed countries.

Besides, facing large-scale socio-economics and ecological disasters caused by war, ensuring post-war biological and chemical safety for humans is crucial, involving the timely detection, prevention, and neutralization of real and potential threats in health protection, ecology, and the natural environment.

The development and production of new biosensor systems based on modern materials and technologies can radically improve diagnostic systems for testing biologically active, environmentally hazardous, and highly toxic chemicals. These advancements will enhance parameter control and data processing and analysis in health care and environmental institutions.

Production of such devices is a great challenge in Ukraine because of the declined since 1990s microelectronic industry. However, as a result of the desperate struggle of against the aggressor with partners' support, Ukraine has an ambition to become a military hub of defense technologies after war ending. In this connexion, **a new program to revitalize microelectronic production is currently being developed by the Ukrainian Institute of the Future**. This program aims to address several issues:

- Realizing Ukraine's strong research and innovation potential.
- Developing the business of microelectronic production.
- Providing microelectronic devices to all customers, including those in the military, agricultural, and health (diagnostics) sectors.

Pro this program says the argument that in Ukraine, there are real conditions conducive to the development of biotechnology, such as:

- Availability of highly qualified scientific and support staff with experience working abroad.
- Possibility to create advanced scientific, technical, and technological structures by utilizing existing scientific and industrial entities of various forms of ownership and subordination, including institutions of the National Academy of Sciences (NASU), National Academy of Medical Sciences (NAMSU), and others.
- Despite the war's consequences, the military industry is being developed, including microelectronic production. As part of Ukraine's renovation, the microelectronics business will become an integral part of the industry, enabling the production of Ukrainian nanodevices, including biosensors.

However, the contra arguments include the gap existence between the research and development system on one side and the market on the other, which is currently deepening due to:

- The significant need for a complete update of the experimental base of scientific institutions and the development and acquisition of unique and valuable production equipment.
- An underdeveloped technology and innovation infrastructure and a lack of experience in the commercialization of technologies and applications.
- Insufficient funding for high-tech, complex projects.

Additional specific challenges include high costs of development and implementation in the fields of biotechnology and biotechnologies, long periods required to bring products to market, and high investment risks with no obvious benefits. Complex, interdisciplinary research and implementation into the biotechnology industry require large groups or even consortia of technology authors and developers.

IMBG as a one of the leading Ukrainian research institutions in biotechnology, Center of excellence in biomolecular electronics, will participate actively in all initiatives targeted at the renovation of Ukraine, especially in the area of its competence connected to analytical biotechnology innovation development, management and implementation into practical use for biomedicine, healthy lifestyle and environment.

1.2 IMBG as leading Ukrainian Research Center in analytical biotechnology area

The Institute of Molecular Biology and Genetics (IMBG) of the National Academy of Sciences of Ukraine (NASU) was established in 1973 and it stands as a premier Ukrainian institution in life science research, boasting a high level of potential and delivering top-tier results, particularly in the field of biotechnology.

IMBG is represented by 14 Scientific Departments and 7 R&I Laboratories. The Institute has one of the highest levels research potentials in Ukraine, including many prominent scientists working here. Presently its staff is comprised of 300 employees (including 217 researchers), 23 Doctors of Sciences (Dr.Sc) and 100 Doctors of Philosophy (PhD), 3 Full Members of NASU and 5 Corresponding Members of NASU. About 25 PhD students work at the Institute each year.

IMBG funding goes from the state Ukrainian funding of the National Academy of Sciences of Ukraine, as well as its own costs: IMBG earns about 50% costs for its activities from the different national and international competitions in Research and Innovation projects.

Currently, the key research areas of IMBG are following the main trends in molecular biology, genetical and molecular biotechnology sciences.

IMBG core competencies:

- Development of new molecular, cell biotechnologies;
- Elucidation of fundamental and practical aspects of structural and functional genomics;
- Research on proteomics and protein engineering;
- Application of bioinformatics, computational modelling and new drugs design
- Innovations in analytical biotechnology.

Analytical biotechnology is one of the most important parts of IMBG innovation activities. It uses a collection of tools, techniques and computational models to discover molecular rules of life, probe cellular process, and facilitate the design and engineering of biology. Basic understanding of life process originates from our capability to characterize biomolecules and dissect cellular process. These practices lay the foundation for many modern healthcare, manufacturing, military, energy and environmental applications.

IMBG is one of the leading research centers in Ukraine on biomolecular electronics as a part of analytical biotechnologies, and the contemporary goal is development of biosensors as the market-driven innovations.

According to the data of the "Bibliometrics of Ukrainian Science" project operating on the Google Scholar platform, in 2024 IMBG is the 4th in the ranking of institutions and universities of Ukraine in terms of the number of "Life Sciences" scientists whose Hirsch index is IH $\geq$ 40. 27 scientists of the Institute are among the “Best 100” scientists of Ukraine according to h-index in the field of "Life Sciences".

In 2024, in the overall rating of 500 educational and scientific institutions of the National H-index Ranking https://ua.h-index.com/educational-institutions, IMBG takes 12th place out of 50 best

institutions — «**Leaders of the country's scientific potential**» (or 9th place if one does not take into account such "institutes" as academies of sciences, ministries and other organizations subordinate to dozens of scientific institutions and universities).

According to the results of the contest of innovative activity of institutions of the NAS of Ukraine for achieving the best indicators in inventive work for the year 2023 the second place awarded to IMBG, and the Innovator of the year 2023 in NAS of Ukraine was a IMBG researcher Dr. O. Bilolivan.

In 2018-2022, IMBG Director Anna El`ska was a Head of Scientific council of the Special program of NAS of Ukraine **«"Smart" sensor devices - a new generation based on the modern materials and technologies»**. IMBG had won and fulfilled 13 projects of these program out of total 28, together with 17 other institutes of NAS of Ukraine, including biology, chemical and physical ones.

During the implementation of the program, a number of applied problems, important for medicine, environmental protection and food industry, were solved:

- Wireless networks of "smart" multisensors and biosensor devices for express diagnostics of the condition of grape and fruit crops and control of the wine production process have been developed and prepared for serial production.
- An experimental sample of a conductometric enzyme analyzer with the necessary software and metrological support for determining the concentration of arginine in food and hygiene products was developed, manufactured and tested in real conditions.
- An experimental sample of the cardiomagnetic scanner for the diagnosis of heart diseases "Cardiomagscan" was developed and manufactured, which is undergoing trial operation at the Main Military Clinical Hospital.
- An experimental sample of a portable total toxicity signaling device based on an array of enzyme pH-sensitive field-effect transistors was developed and manufactured for the rapid determination of the total toxicity of aqueous solutions of various origins, a number of metrological measures and experimental testing at environmental facilities were carried out
- Experimental operation of a portable digital electrocardiograph was carried out at the Department of Anesthesiology and Intensive Care of the National University of Health and in a number of military medical institutions. The device was put into production at the "Metekol" plant (Nizhyn).
- An experimental sample of a portable device based on enzyme potentiometric biosensors with the necessary software and metrological support was developed and manufactured for the analysis of mycotoxins (toxic metabolites of mycelial fungi), which was tested in samples of agricultural crops.
- An experimental sample of a photoplethysmograph with a pneumatic device for compressing blood vessels "Hemodin" was produced for the diagnosis of the microcircular link of blood circulation, which was tested in a number of military medical institutions.
- An experimental sample of a portable multisensor device for determining the main metabolites of the human body with the necessary software and metrological support was developed and manufactured, which was tested on blood samples of healthy people and patients with kidney failure.
- A prototype of a chemosensory system suitable for the analysis of L- and D-stereoisomeric forms of physiologically important amino acids, peptides, low-molecular-weight proteins in biological environments for rapid diagnosis of early stages of genetic, oncological and neurodegenerative diseases, such as Alzheimer's disease, was developed and created.

It can be stated with certainty that significant scientific and practical results have been achieved during the implementation of the planned tasks of the Program. They have been published in more than 340

journal publications (among them 73 articles were published by IMBG scientists), including such highly rated journals as Sensors and Actuators B (impact factor 8.42), Biosensors and Bioelectronics (impact factor 11.44), Electroanalysis (impact factor 3.22), Analytica Chimica Acta (impact factor 6.91), Talanta (impact factor 6.06) and others, presented in more than 300 scientific forums of various levels (among them IMBG was presented at 97 meetings), submitted applications and received for about 90 Ukrainian patents (among them 12 were created by IMBG innovators).

Among these IMBG results, 6 patents for innovations are visible in the international databases and have a strict perspective for immediate commercialization according to the Marketing analysis of IMBG biomolecular electronics innovation capacities, which was made by professional economists in the frames of the IMBG BIONANOSENS project funded for 2011-2014 by the Horizon 2020 EU program.

Also, in the frames of the Marketing analysis performed, 20 IMBG biosensor protopypes were analyzed. It was shown that among them:

- 9 developments could be used in medicine and in pharmaceutical area
- 6 biosensors are ready for application in environmental monitoring
- 7 developments have prominent potential for using in the quality control of agricultural products and crops, as well as for food technologies control
- 5 developments could be used for wastewater control
- and 2 biosensor developments are oriented to the dual-use goods production

From the other hand, different biosensors are at different stages of development:

- 9 as laboratory prototypes, ready to be used
- 4 are under development (among them 1 is a new modification of the laboratory prototype, aimed at the different application area)
- 8 – were developed as laboratory prototypes some years ago, but now need time and costs to be renovated.

Most of the developments presented as prototypes have the following advantages:

- Portability
- Speed of analyzing
- High sensitivity
- Can determine several components simultaneously

The last advantage belongs to 5 devices among all developed prototypes:
1) Potentiometric multisensor system for determination of urea, creatinine and glucose
2) Amperometric sensor array for simultaneous determination of glycerol, glucose, lactate and ethanol.
3) Potentiometric biosensor based on butylcholinesterase for inhibitory determination of chaconine and solanine
4) Amperometric biosensor based on glutamate oxidase for highly sensitive determination of glutamate concentration.
5) Conductometric multibiosensor to determine a number of saccharides

As a conclusion of the Marketing analysis, the following key priority factors that should be considered in the further successful commercialization of IMBG innovations:

- Signing of the Member Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their Member States, on the other hand, and its implementation.

- Introduction of smart specialization as a basis for regional development.
- Orientation of state policies on the development of industrial parks and innovation ecosystems
- Focus on development of the National microelectronic industry during the renovation of Ukraine.
- Development of various technologies that provoke the emergence of new industries (biotechnology, genetic engineering, lithium-metal batteries, hyper-positioning, etc.)
- Development of state institutions that support innovative development (State Financial Innovation Institute, Ukrainian Startup Fund).
- Ukraine's participation in EU grant programs such as Horizon Europe, LIFE, EU Single Market Program (SMP), Creative Europe, EUREKA, COST, Erasmus+, in the European Entrepreneurship Network EEN, in the European cluster platform.
- Emphasis on sustainable development goals in the world and in Ukraine, their consideration in state, regional and local strategies and programs
- Successful Implementation of the European Green Deal
- Stabilization of the economic situation in the country and EU support in Recovery and reconstruction of Ukraine https://eu-solidarity-ukraine.ec.europa.eu/eu-assistance-ukraine/recovery-and-reconstruction-ukraine_en
- Implementation of the HACCP food safety management system https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/hazard-analysis-critical-control-point-haccp
- Satisfactory condition of the medical system of Ukraine
- Deterioration of public health and quality of life.
- Trends in a healthy lifestyle and achieving longevity in society.
- General high level of education of the population, development of science
- Development of information technologies and IT business in Ukraine, e-commerce.
- Development of artificial intelligence technologies
- Development of virtual, augmented and mixed reality technologies
- New Procedure for state water monitoring.
- High soil contamination with excessive amounts of pollutants.

1.3 IMBG BIONANOSENS project – way to the excellence in research and innovation

In achieving its goals, IMBG prioritizes international cooperation, twinning initiatives, wide networking with European colleagues and developing new scientific contacts. This strategic direction highlights the cornerstone of IMBG's development trajectory for the foreseeable future.

The Institute is actively involved in international large-scale research consortia. Our main countries for cooperation are France, Germany, USA, Great Britain, Poland, Italy, Greece, and Japan. In total, IMBG has had permanent cooperation with universities, research and medical institutions in 34 different countries until now. Among IMBG international donors there are currently CNRS (Centre national de la recherche scientifique, France), NATO (North Atlantic Treaty Organisation), STCU (Science and Technology Centre in Ukraine), earlier – NIH (national Institute of Health, USA), Wellcome Trust Fund (United Kingdom), etc.

Regarding the European Framework Program for Research and Innovation, the Institute started its first project under FP5 and continues to collaborate in projects until the most recent Horizon Europe.

In 2019, in the frames of the Horizon 2020 EU Framework program for Research and Innovation, IMBG identified several key areas of concern. The Institute seeks assistance and foster robust synergistic relationships with EU partners to effectively navigate these challenges thereby propelling IMBG scientific advancement and successful innovation management:

- Establishment of institutional grant management procedures in accordance with EU standards
- Establishment of an innovation unit at IMBG to support the Institute’s staff in project management tasks
- Providing better access to international networks for the Institute in view of future proposal building
- Trainings on project proposal writing and project management
- Promotion and training of young researchers,
- Facilitating the dissemination and exploitation of research results produced by IMBG.

The Horizon 2020 project proposal was prepared for participation in a call H2020-WIDESPREAD-2018-2020. Initiated by IMBG, the BIONANOSENS project “Deeping collaboration on novel biomolecular electronics based on “smart” nanomaterials” was dedicated to fostering collaboration on novel biomolecular electronics based on "smart" nanomaterials. To achieve its objectives, the Institute formed a consortium comprising five partners, including IMBG and leading European research and management centers in Austria, France, and Germany: Université Claude Bernard Lyon 1 (UCBL), Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Center of Social Innovations in Vienna (ZSI), Lyon Ingénierie Projets (LIP). IMBG assumed the role of coordinator for the consortium to ensure successful project implementation.

IMBG served as both an initiator and a beneficiary of the BIONANOSENS project, and also as its target institution. The project`s tasks were meticulously designed to enhance the Institute's capabilities in innovation management and international cooperation while further advancing its excellence in biotechnology research. The project aimed also to establish an operational network of EU and Ukrainian scientists, fostering diverse approaches to research, innovation, and innovation management in analytical biotechnology.

The BIONANOSENS project started amidst the backdrop of the worldwide COVID-19 pandemic. The interim 15 months report on the project was under consideration by the EU at the very moment of the beginning of the rude Russian aggression in Ukraine. The project was paused for 2 months, then its duration was prolonged for 6 months more. However, despite all the circumstances the BIONANOSENS project activities were fulfilled successfully with only slight changes in scope and timing, and have their valuable impact on the Institute`s research innovation potential as well as on the IMBG`s place in the national scientific community and in the ERA. 3 scientific meetings, 3 management trainings, the Call for start-ups in biotechnology area and the Summer school for early stage researchers were conducted in the project frames. IMBG Annual Competition "The Best Article of the Year" was held for the scientific papers published in 2021 (18 winners, including 4 young scientists), in 2022 (32 winners, including 5 young scientists working in Ukraine), and in 2023 (41 winners, among them 8 young scientists).

The entire BIONANOSENS project activities were carried out against the state-of-the-art standards in managing EU funded R&I projects – including Responsible Research and Innovation, Gender balance, Open access (Data management, Intellectual Property management), exploitation and commercialization orientation, and ethics. The project's principal achievements include:

1. Establishment of the IMBG International Advisory Board – General Assembly providing annual international expertise of the Institute activities and achievements, sharing experience in doing world level research and innovation management, recognizing Ukrainian institute as an international Centre for Excellence in analytical biotechnology.
2. IMBG R&I Strategy in biomolecular electronics was developed for the next 7 years. It was based on the current SWOT analysis of IMBG identifying strengths, weaknesses, threats, and potential areas for improvement, with guidance from esteemed European partners helping to improve research and management practice in the nowadays Ukrainian realities.
3. Promotion of healthy competition among IMBG Departments in excellence of research and innovations, sharing the best research practice.
4. Twinning with leading European research and management centers, bolstering IMBG's role in Ukraine's analytical biotechnology development.
5. Enhanced visibility of IMBG in the European Research Area, resulting in increased invitations to participate in European research program calls.
6. Establishment of the Innovation Management Unit (IMU) to enhance innovation management infrastructure and address the evolving needs of IMBG scientists.
7. Creation of a PR-management group to raise awareness of biotechnology research and innovations' societal impact in Ukraine.
8. Effective coordination and management of European-level projects in Ukraine, showcasing IMBG's capability to contribute actively to EU scientific and technical programs, establish international consortia, win grants, and execute projects aligned with societal needs.

Besides, the BIONANOSENS project achieves many additional advantages for IMBG further development, which will be very valuable for the further IMBG sustainable development.

- The Joint Research Programs with European partners, which were developed as a result of the strengthening collaboration within the BIONANOSENS project, describe in details scientific tasks of the collaboration, including preparing new joint project proposals. Partnership with known international organizations will be important for resolving issues such as access to expertise, equipment and materials that may not be available in Ukraine

- Participation in the new EC Framework Program Horizon Europe is one of the best ways for the IMBG researchers to be integrated into European Research Area. Like all scientists of Ukraine (as an Associated State to Horizon Europe) they must work hard to raise awareness on their high level of science and increase their visibility among European colleagues.
- Usage of the opportunities given Ukrainian scientists by special initiatives of Horizon Europe under Marie Skłodowska-Curie Actions and European Research Council — ERA4Ukraine: European Research Area for Ukraine and ERC4Ukraine: European Research Council for Ukraine. Bringing excellent research and innovation experience is extremely important for further development of science in Ukraine and for solving current problems in Ukrainian participation in Horizon Europe.
- Supporting the IMBG research departments, which by now participated only in CA and CSA projects, in their attempts to become successfully engaged in future collaborative RTD&I projects with the EU partners. The funding structure of Horizon Europe provides a favourable framework condition to facilitate this process.
- Building the Institute capacities in the international cooperation will be supported by the IMBG Innovation Management Group (IMU) through its fundraising activities, sharing information about new grant possibilities, spreading knowledge on success stories good practices in project management and coordination, contacts with the Horizon Europe Office in Ukraine and Ukrainian National Contact Points of Horizon Europe (NCP).
- Synchronized activities with Ukrainian NCP Network will be very helpful in this activity. Especially fruitful cooperation should be with NCP Health, NCP on People mobility (Marie Skłodowska-Curie actions), and NCP on Legal and Financial issues.
- Representation of Ukraine in the ERC Program Committee by the BIONANOSENS Program Manager, Science Manager and Senior Scientists Yanina Mishchuk, PhD will serve as an additional motivator of participation in the "Excellent Science" pillar calls.

Addressing the current challenges in Ukraine-EU cooperation, the IMBG recognizes the need for political intervention to overcome these obstacles. The Institute strongly seeks to actively cooperate with politicians to implement positive changes and strengthen Ukraine's position in accessing and participating in EU projects:

- Correlation of the standards in banking regulation, book-keeping and audit;
- Special grant status for the funding, obtained by Ukrainian research institutions for implementation of the EU projects (no taxes; spending grant resources in the strict accordance with the project activities without restrictions)
- Harmonization of the legal framework with the EU countries in the field of drug registration, pre-clinical and clinical testing, and revision of the resulted documents.
- Harmonization of the legal framework with the EU countries in the field of Intellectual rights protection, IPR.
- State support for the active (potential) participants of the European projects (grants for grants writing, return grants for Ukrainian scientists working abroad etc).

In 2024, the next IMBG Twinning project 101160053 SURE-AMR "Strengthening Ukraine`s research excellence in the field of antimicrobial resistance under a one health approach" got the EU funding for 36 months in the frames of the call HORIZON-WIDERA-2023-ACCESS-02. It will help IMBG to sustain the achievements gained by the BIONANOSENS project implementation in 2021-2024 and ensure further successful innovation infrastructure development.

2 IMBG INPUT IN FURTHER DEVELOPMENT OF BIOMOLECULAR ELECTRONICS IN UKRAINE

Synergy processes in scientific cooperation between BIONANOSENS partners in development of innovative biomolecular electronic devices were resulted in five Joint research programs aimed at continuation of the collaborative research directions and implementation of their results. In these joint programs, the main results, as well as priorities and perspectives of EU-IMBG excellent biotechnology research and smart devices development in cooperation with EU partners were elucidated.

Having such experience and EU partner`s support, in 2023 IMBG developed the strategical **Concept for the research and innovation program of the National Academy of Sciences of Ukraine "Modern Biosensor Systems for Human Safety and Security" for 2023-2030.**

It was due the leading role of IMBG in the biotechnology area in Ukraine, which can be demonstrated by years of IMBG governance of NASU special programs on biomolecular electronics, for example Special program «“Smart” sensor devices - a new generation based on the modern materials and technologies» in 2018-2022, where former IMBG Director Prof. Anna El`ska was a Head of Scientific council, and BIONANOSENS coordinator Prof. Sergey Dzyadevych acted as Scientific secretary of the program.

A new conception of analytical biotechnology development in Ukraine created by IMBG as a leading institution was inspired by and partly included best practices and experience exchange with advanced EU research centers – BIONANOSENS partners. Prof. Sergey Dzyadevych, one of the key authors of the new Program for 2023-2030, was planned to be the Head of the Program's Scientific council.

In this program, it was stated that the following issues are significant for further development of modern nano-biotechnologies in Ukraine:

- Increasing the efficiency of fundamental developments.
- Facilitating the practical implementation of new ideas and technologies.

On November 30, 2022, at the regular meeting of the Presidium of the National Academy of Sciences of Ukraine, chaired by the President of the National Academy of Sciences of Ukraine, Academician Anatoliy Zagorodnyi, Deputy Director of the Institute of Molecular Biology and Genetics of the National Academy of Sciences of Ukraine, corresponding member (now – full member) of the National Academy of Sciences of Ukraine Prof. Sergiy Dzyadevych gave a speech titled "Biosensors - a Modern Direction of Analytical Biotechnology", which actually was a presentation of the new Program to the grantor – NAS of Ukraine.

It was stressed that Ukraine needs a program for the development of analytical biotechnologies, along with the renovation of the microelectronic industry. The leading place in the structure of Ukraine's economy should belong to industries that, due to the available personnel and material resources, can create competitive high-tech products with high added value on the world market. The only real way to achieve this is to promote the creation and production of intellectually rich products, particularly modern biosensor systems for human safety. This also includes the full integration of Ukraine's scientific and technical sphere into the European and global research space. An example of such integration is the funding by the European Commission under the Horizon 2020 program of the Institute of Molecular

Biology and Genetics of the National Academy of Sciences of Ukraine, aimed at deepening cooperation in the field of the latest biomolecular electronics based on "smart" nanomaterials.

Thus, the development and production of biosensor systems align with today's global scientific and technical trends. This involves creating new materials based on high technologies, including nano- and biotechnologies, applying fundamentally new approaches to the creation of sensor systems based on a broad range of biological and physical effects, and the widespread use of intelligent computer networks to ensure biological, environmental, and food safety.

IMBG scientists, together with scientists from other academic institutes - the V.E. Lashkarev Institute of Semiconductor Physics, the Institute of Electrodynamics, the V.M. Glushkov Institute of Cybernetics, the Institute of Cell Biology, the Institute of Organic Chemistry, and several SMEs working on analytical biotechnologies - have already created a number of experimental samples of biosensor devices, which were tested during the analysis of real biological, pharmacological, food, and other samples.

State-of-the-Art Program on Biomolecular electronics:

In the current European and global context, ensuring the biological and chemical safety of people is becoming an urgent issue. Biosensor systems based on modern materials and technologies can fundamentally change the organization of diagnostic systems for testing biologically active, chemical, and toxic substances, as well as improve parameter control, data processing, and analysis in health care and environmental systems.

Biosensor systems are analytical intelligent devices that combine biological, chemical, or biomimetic sensitive elements with separate signal conversion systems. The key to creating such systems is the synergy of various scientific areas in the technologies of creating selective sensitive elements and physical transducers.

The most important characteristics of such biosensor systems are their high sensitivity and selectivity, ease of use, speed of analysis, and the wide range of substances that can be detected. This makes their implementation in express analysis in medicine, ecology, and the chemical and pharmaceutical industries crucial for solving current problems related to health care, biological, ecological, and food safety.

Goal and Tasks of the Program:

The main goal of the Program is to develop modern biosensor systems ready for practical implementation for express analysis in medicine, ecology, and the chemical and pharmaceutical industries, addressing current problems related to health care and ensuring biological, ecological, and food safety.

The main tasks of the Program

- Development of new promising bioselective materials based on nano- and biotechnologies, including nanozymes, synthetic calixarene models of enzymes, aptamers, etc.
- Development and preparation for serial production of new-generation biosensor devices, including multisensor systems.
- Wide use of intelligent computer networks in the implementation of sensor systems in practice.
- Development of new methods for data array processing and analysis.

- Transition to maximum simplification and miniaturization of devices, construction of portable systems for public use.
- Combination of sensor systems with smartphones, GPS systems, and the Internet.
- Trial operation of experimental samples of devices with potential customers.
- Conducting metrological studies.
- Patenting the results of the work, presenting them at domestic and international conferences, and publishing them in leading scientific publications.
- Creating popular scientific articles, textbooks, and manuals, and organizing conferences and meetings to provide information on the results of the Program.
- Applying the R&D results into educational practice through new educational programs with modern trends in biomolecular electronics.
- Creating startup companies to put the results into practice.

Expected Results of the Program

The comprehensive target program of scientific research of the National Academy of Sciences of Ukraine "Modern Biosensor Systems for Human Safety" aims to develop and implement new biosensor devices for rapid analysis in medicine, ecology, and the chemical and pharmaceutical industries. These devices can provide faster, more reliable, more sensitive, and cheaper analysis of various substances compared to existing analytical methods. This will enable:

- Improved quality and availability of medical diagnostics.
- Prevention of environmental pollution.
- Prevention of low-quality food products from entering the trade network.
- Prevention of the population from consuming drinking water contaminated with harmful chemical compounds and pathogens of infectious diseases.
- Improved control of technological processes in the pharmaceutical, biotechnological, and chemical industries.

As part of the implementation of the Program's tasks, the developed biosensor systems must have patent protection, practical approval, and metrological support, in accordance with the state strategy for the development of the innovative sphere of Ukraine.

A necessary condition for the implementation of the Program is also the commercialization of the developed devices - finding manufacturers and customers. It is assumed that during the implementation of the Program, several standardized experimental samples of devices will be created, ready for production at Ukrainian enterprises and their introduction into business practice. Cooperation with Ukrainian SMEs working in the field of biomolecular electronics and with innovation funds of Ukraine will be established within the framework of the implementation of Ukraine's innovation policy.

Another important issue for Ukraine is the creation of prerequisites for integration into the European educational space by synchronizing educational policies and practices. In this direction, it is planned to create and adapt educational and scientific programs on biosensor technologies, which will be implemented for the training of bachelors, masters, doctors of philosophy, and doctors of science at Kyiv Academic University, institutions of the National Academy of Sciences of Ukraine, the Institute of High Technologies of Taras Shevchenko Kyiv National University, etc.

The estimated preliminary amount of financing for the Program is UAH 7-10 million per year. Unfortunately, the funding of the Programe was suspended due to the rude Russian aggression against Ukraine. Now the Program is waiting for the recovering costs planned for the restoration and modernization of the scientific and innovation infrastructure in the National Recovery Plan of Ukraine.

2.1 Cooperation with the stakeholders of Ukrainian biotechnological community

In Ukraine, the one of the IMBG goals as a Center of Excellence in Biomolecular Electronicis is to reach and to gather Ukrainian Biotechnology stakeholders from science, business and customer organizations in order to make Biotechnology innovation, research and education comprehensive and having the real benefit for society.

As a leading Excellence Center, the Institute cooperates actively with the different Ukrainian institutions that are mentioned in the implementation plan of the **Conception of the research and innovation program of NAS of Ukraine "Modern biosensors systems for the human safety and security" for 2023-2030,** developed by IMBG.

List of organizations that are planned to participate in the implementation of the Program

Institute of Molecular Biology and Genetics of the NAS of Ukraine
Institute of Semiconductor Physics named after V.E. Lashkaryova of the NAS of Ukraine
Institute of Cybernetics named after V.M. Hlushkova NAS of Ukraine
O. V. Palladin Institute of Biochemistry of the NAS of Ukraine
Institute of Organic Chemistry of the NAS of Ukraine
Institute of General and Inorganic Chemistry named after V.I. Vernadsky NAS of Ukraine
Institute of Physical Chemistry named after L.V. Pysarzhevsky NAS of Ukraine
Institute of Cell Biology of the NAS of Ukraine
Institute of Electrodynamics of the NAS of Ukraine
Institute of Microbiology and Virology named after D.K. Zabolotny NAS of Ukraine
Institute of Biocolloid Chemistry named after F.D. Ovcharenka of the NAS of Ukraine
Institute of Chemistry of High Molecular Weight NAS of Ukraine
Institute of colloid chemistry and water chemistry named after A.V. Dumanskyi of the NAS of Ukraine
Institute of Bioorganic Chemistry and Petrochemistry of the NAS of Ukraine
Institute of Physics of the NAS of Ukraine

List of potential device manufacturers within the Program

State Scientific and Engineering Center of Microelectronics of the Institute of Cybernetics named after V.M. Hlushkova NAS of Ukraine (Kyiv)
State enterprise "Energoimpulse Scientific and Production Center of the Institute of Electrodynamics of the National Academy of Sciences of Ukraine" (Kyiv)
NVP "METEKOL" (Nizhyn)
NPF VD MAIS (Kyiv)
"Engineering Laboratory" NVF (Lviv)
SKTB Institute of Semiconductor Physics named after V.E. Lashkaryova of the NAS of Ukraine
"Sparing-Wist Center" NGO (Lviv)

Developing innovations in multidisciplinary field – biomolecular electronics, IMBG has strong cooperation with several leading Ukrainian **scientific and business organizations in different areas**:

- Wireless networks of "smart" multisensors and biosensor devices for express diagnostics of the state of grape and fruit crops and control of the wine production process was developed and prepared for

serial production together with the Institute of Cybernetics named after V.M. Hlushkova of the National Academy of Sciences of Ukraine and private company VD MAIS.

- Experimental sample of a portable total toxicity signaling device based on an array of enzyme pH-sensitive field-effect transistors was developed and manufactured for the operational determination of the total toxicity of aqueous solutions of various origins together with the Institute of Semiconductor Physics named after V.E. Lashkaryova of the National Academy of Sciences of Ukraine. A number of metrological measures and experimental testing at environmental objects were carried out.
- Experimental sample of a portable conductometric enzyme analyzer for arginine determination with the necessary software and metrological support was developed and manufactured together with the Institute of Electrodynamics and the SME Research and Production Center "Energoimpuls". It was tested on real samples of commercial and directly squeezed juices and hygiene products.
- YURiA-PHARM, a Ukrainian pharmaceutical group of companies implements several developments of IMBG patented in Ukraine, basing on the Licensing agreement. The company also participates in IMBG grants and events, and supports IMBG in biotechnology and biomedical innovations.
- Besides, the State Center for Metrology and Standartization of Ukraine (Ukrmetrteststandart) implemented IMBG methodici for biosensor technologies. For a number of experimental samples of sensor devices, together with SE "Ukrmetrteststandart", metrological support was carried out, technical documentation, drafts of technical conditions for biosensor production and operational layouts were developed, methods of attestation of the devices according to a number of their most important characteristics were worked out, work protocols of laboratory layouts of sensor systems were worked out.

In the course of innovation development and widening IMBG Innovation Management Unit activities, the Institute plans to reach even wider range of stakeholders for achievement the goal of **commercialization of the Institute`s innovations**:

Priority target groups:

- food producers, including producers in the production/ processing chain;
- food sellers: large trading companies, retail chain owners, wholesalers/distributors, exporting /importing companies;
- industry associations (introduction of industry quality standards);
- consumers of food / non-food products, associations of consumers, consumer protection organizations;
- authorities for certification and control of safety and quality of products (food / non-food), including government Services and Agencies;
- standardization authorities;
- medical institutions (clinics, laboratories, veterinary clinics, telemedicine networks), patronage and social services;
- manufacturers of medical equipment, manufacturers of pharmaceutical products;
- farmers, companies and enterprises of agricultural sector;
- companies providing environmental services, environmental control authorities;
- insurance companies;
- financial and investment companies included in the list of companies with mandatory reporting on sustainable finance;
- local authorities (in particular, local communities);

- producers in various industries with products that should comply with certain indicators;
- customs authorities / services;
- public safety authorities and government emergency authorities (control and monitoring of hazardous substances);
- army and critical infrastructure enterprises;
- innovative SMEs;
- large innovative companies (wide application of biosensors - from control of employee's health to the introduction of innovations in enterprises and production of innovative products);
- international organizations (eg UN organizations);
- international programs / projects (participants and stakeholders);
- research institutions / universities (cross-sectoral cooperation, dissemination).

For further coordination of the Biotechnology R&I in Ukraine, the Database of the Stakeholders in Biotechnology is been developed by IMBG Innovation Management Unit, which will be used in the day-to-day work and updated permanently with special monitoring of new innovative legal entities (spin-off or SME).

IMBG leading role in biotechnology research in Ukraine is based, among other factors, on the following:

- cooperation and twinning with the advanced partnering EU institutions – leading world-class centers in Biotechnology and innovation management

- using the advantages of the mentorship of the International Advisory Board – General Assembly, created both in the frames of the FP7 COMBIOM#294932 project (2011-2015) and BIONANOSENS#951887 (2020-2024)

- successful participation in the National competitions – winning funding of the Ministry of Education and Science of Ukraine, of the Ukrainian State Fund for Fundamental Research (till 2018) and the National Research Foundation of Ukraine (NRFU), created in 2018

- active participation and getting funding from EU framework programs (IMBG participated actively since FP5, in total the Institute has had 9 EU funded projects).

For all Ukrainian stakeholders, further strengthening IMBG competitiveness in corresponding research area will be a case of successful story of effective involvement in ERA, increasing visibility in Ukraine and in ERA, improving responses to the socio-economic needs of Ukraine.

2.2 Building IMBG capacities in innovation management and commercialization of the research results

Formation of Innovation Management Unit (IMU) in IMBG with the help of EU partners in the frames of the IMBG H2020 project BIONANOSENS #951887 was a step forward in boosting IMBG innovation management effectiveness. Advanced EU partners have contributed their experiences, good practices which were adapted/tailor-made to suit into the IMU structure and in composing the list of its goals.

The following main goal was set during choosing the IMU format and staff: achieving appropriate IMBG infrastructure capable of developing and sustaining high quality innovation development, application of research results and collaboration especially at the international level.

The tasks of the unit were set as the following:
- Grants acquisition
- Establishment of networks
- Grant management (project and financial management)
- Knowledge/technology transfer (Research and innovation outputs to business (startups/spin-offs, other SMEs, Industry)
- IPR and ethical issues (including (in line with responsible and innovation (RI) principles)

For further coordination of the Biotechnology R&I in Ukraine, the Database of the Stakeholders in Biotechnology is been developed by IMBG Innovation Management Unit, which will be used in the day-to-day work and updated permanently with special monitoring of new innovative legal entities (spin-off or SME).

Collection of information about partner`s experience - best practice, innovative research applications, case studies and successful stories from of EU partners and beyond served as examples for IMBG and were implemented during the BIONANOSENS project life time.

Following the partner's advices, the IMU Action Plan was composed To further straighten the performance and further development of the portfolio of the services provided by the Unit, and its main objective was to identify strategies and actions that strengthen IMBG further development.

Action Plan of the IMBG Innovation Management Unit

- Identification of the other R&I funding sources (Horizon Europe, other national and international funding programs, etc) and creation of the IMBG data base on available funding sources (e.g.: selected calls).
- Creation of IMBG data base of the most active in international collaboration IMBG researchers.
- Creation of the data base of IMBG international cooperation partners.
- Creation of the database of successful project proposals.
- Supporting the Project Proposal Application forms filling by IMBG researchers – consultations and trainings for the IMBG staff.
- Organisation of the training Workshop on Horizon Proposal writing (2 days) for young researchers from IMBG with mentoring of advanced researchers from partner institutions abroad (mostly online).

- Analysis successful grant proposal applications.
- Analysis of the shortcomings and weaknesses in the rejected grant proposals
- Organization of Information days on Horizon Europe topics and rules at IMBG in cooperation with other national biomedical institutions with support of Health NCP of Ukraine and newly established (November 2023) Horizon Europe Office in Ukraine.
- Organization of regular trainings/workshops for researchers at IMBG on proposal writing for Horizon Europe as well as other national and R&I related funding programs with mentoring of advanced researchers from partner institutions abroad (mostly online).
- Establishing and supporting knowledge/technology transfer infrastructure (e.g. IMBG research and innovation results for business - e.g. start-ups/spin-offs, other SMEs, industry from Ukraine and EU member states).

Long-term IMU actions (2026 - 2030):

- Evaluation of the IMU R&I support measures and adjustment to the current needs of the IMBG and funding landscape.
- Strengthening continuous professional development of IMBG researchers and project managers (trainings, workshops, online tools, etc.)
- Ongoing Analysis of the needs and funding possibilities.
- Providing institutional support and state-of -the art infrastructure for Research & innovation together with IMBG Management.

The benefits of BIONANOSENS, especially the establishment and strengthening of IMBG's innovation management unit, even after the project activities are fully implemented, as well as the implementation of the IMU Action Plan with the support of overseas partners, will ensure the sustainability of IMU's impact on IMBG's research and innovation activities in the future, which will make R&D making IMBG more efficient, applicable and useful.

The IMBG Laboratory of technology transfer, innovative activity and intellectual property, including the Innovation Management Unit is also acting as an “office for commercialization of innovations”, and is aware that the goals of application of the innovations developed must be implemented in cooperation with business and using marketing analysis approaches:
(1) identification of market segments, their approximate size and growth rate;
(2) analysis of the main producers and sellers - competitors for products relevant to IMBG;
(3) general analysis of consumers’ behavior;
(4) analysis of production capabilities of manufacturing sensor devices, components and materials for them.
(5) analysis of business models used by manufacturers of similar devices and materials;
(6) a series of joint brainstorming to identify possible value propositions based on IMBG technologies was conducted;
(7) recommendations for the formation of value propositions and algorithms for the commercialization of innovations were proposed.

Priority areas of commercialization of developments (Applications):

- control of food safety and quality;
- control of safety and quality of industrial (non-food) products, the composition of which is critical in terms of influence on the human body;
- control and monitoring in ecology (water quality, pollutions etc.);
- medicine/ Healthcare (preventive monitoring of health indicators - personal / private, personal medicine, telemedicine, laboratories, public procurement for clinics and hospitals, veterinary medicine, medicine in / local communities, monitoring of post-COVID, complications of neurological diseases, diabetes, vascular disease, kidney, etc., control of crisis health conditions for private consumers and for workers in critical infrastructure, security, defense, army, government emergency bodies, police, officials, workers in some areas for which health is critical, such as construction, transport etc);
- control for compliance with standards in various fields (by areas of IMBG innovations);
- control at customs (detection of counterfeits - monitoring of declared and available indicators, detection of products with threats for human health/ hazardous substances);
- fulfillment of Ukraine's commitments under the EU-Ukraine Association Agreement (list of areas), under various DCFTAs;

Potential/ possible ways of commercialization and business models:

- creation of a division on commercialization (analytical and consulting function) in the IMBG;
- creation of the Center for collective use;
- creation of the State Key Laboratory;
- cooperation with another institution (for example, KAU) on commercialization;
- establishment of a Research Infrastructure based on IMBG (with the further development of digital infrastructure/ e- infrastructure);
- establishment of a separate legal entity (Center, laboratory) in the partnership with IMBG to provide services for measurement, monitoring, certification;
- establishment of spin-offs for commercialization of defined developments;
- development of startups based on the new ideas for the commercialization of individual developments (participation in hackathons, accelerators, startup support programs);
- public-private partnership with the participation of IMBG, business partners, local authorities, and customers;
- participation in clusters (for example, in the areas of smart specialization of the Kyiv region);
- transfer of rights to IP (licenses, license agreements);
- establishment of a trademark / brand;
- digitalization of services (platform for fulfilling orders / providing services);
- fulfillment of individual orders according to contracts;
- commercialization of a joint product of intersectoral cooperation projects (possible cases: release of patches connected to a mobile application with the function of constant monitoring and simultaneous introduction of drugs/medicines and regulation/control of their quantity according to certain indicators; joint project with Ukrainian army structures or enterprises/ institutions of critical infrastructure on control of crisis health conditions);
- participation in international donor programs;
- participation in a large international project;
- public procurement (products, control and monitoring services);

- EU commercial / pre-commercial procurement (participation in EU tenders and procurement under the Horizon Europe program, as well as on the procurement platform of Invest Horizon);
- cooperation with large dealers / distributors of certain types of products.

There is the strong need also to use effectively also all the instruments provided by EC to innovators of Horizon Europe projects. For example, one of the biosensor devices, “Bio-sensor for heavy metal detection” developed in IMBG, has been analysed and recognized as ready for commercialization by the experts of the **European Commission's Innovation Radar platform**. The biosensor prototype was created in 2021 in the frames of another IMBG Horizon Europe project, Waste2Fresh # 958491 “Smart innovative system for recycling wastewater and creating closed loops in textile manufacturing industrial processes”.

This “Bio-sensor for heavy metal detection” has been analysed by the European Commission's Innovation Radar as “Business Ready” with High Market Creation Potential of the innovation, the information was accessible to the public via the Innovation Radar platform between 45 days, joining the 9000+ EU-funded innovations showcased on the platform.
The innovation was recognized as perspective and three further opportunities were highlighted for IMBG, that is a huge step ahead in development in IMBG innovation infrastructure and could be add to the IMU activities:

- Innovator organisations featured on the Innovation Radar platform can ‘claim their page’ and upload additional information about the organisation and innovations.
- Innovator organisations with the ambition of bringing their EU-funded innovation to the market can apply for "go to market" training and support from Dealflow.eu, the support action of Innovation Radar financed by Horizon Europe.
- Innovator organisations can apply for Horizon Results Booster services provided to Horizon Europe projects at no cost. The services on offer are: “Portfolio Dissemination and Exploitation Strategy”, “Business Plan Development” and “Go to Market” support.

Inclusion of IMBG to this initiative could open up new opportunities for IMBG to partner with business or academic organisations and trigger interest from potential customers or investors in the Institute`s innovations. Above all it demonstrates to a global audience the innovative work IMBG is active in delivering

2.3 Talent management perspectives in IMBG

Involving young scientists, early stage researchers and students is significant for development of high level innovative analytical biotechnology in IMBG and for networking of biotechnology area stakeholders in Ukraine through the participation in the educational process, providing unique lectures and scientific seminars, and original educational programs.

For this purpose, IMBG makes strong relationships with biotechnology, molecular biology, biochemical and biophysical departments of the Universities. 34 leading IMBG scientists are also Professors in the best Ukrainian Universities: Taras Shevchenko Kyiv National University, National University of "Kyiv-Mohyla Academy", National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" and others. Implementation of the results of fundamental investigations into the modern educational process is one of the priorities of the IMBG Center of Excellence in biotechnology area.

Moreover, IMBG is functioning also as a part of the Ukrainian educational system. IMBG has PhD Department with unique 4-year PhD programs in molecular biology, molecular genetics and biotechnology. There are almost 50 PhD students studying in this Department.

In 2021 IMBG created also joined Department of Molecular Biology and Biotechnology with Kyiv Academic University. The Department works on Magister programs including Biotechnology and is based at the Institute`s premises and on the Institute`s staff.

Tight cooperation with EU partner representatives (UCBL, HZDR, with colleagues from the Dresden Concept and Professors from the TU Dresden) was conducted in forms of exchanging experience and giving the best practice examples of development of smart devices in France and in Germany. It resulted in improvement by IMBG team of IMBG PhD courses and creation of special bright and attractive Masters and Bachelor degrees educational programs on biotechnology and particularly on biomolecular electronic with the accent on smart devices for Ukrainian universities.

BIONANOSENS project coordinator Prof. Sergiy Dzyadevych and IMBG Department of Biomolecular electronics have developed 21 educational courses on different aspects of analytical biotechnology in order to attract the most interested youth to work in IMBG laboratories, to prepare qualified and experienced young scientists for boosting IMBG R&I and a whole biotechnology area in Ukraine.

All these courses were incorporated into the licensed educational programs of IMBG and partnering universities:

Courses for PhD programs:

Institute of Molecular Biology and Genetics of NAS of Ukraine

- "Biosensors based on natural biomacromolecules and biomimetics" – DrSci T.A Sergeyeva
- "Modern biology for the development of the latest biotechnologies" – Prof. S.V. Dzyadevych

Institute of High Technologies of the Taras Shevchenko Kyiv National University

- "Molecular biotechnology" - Prof. S.V. Dzyadevych
- "Newest bioanalytical technologies" - Prof. S.V. Dzyadevych
- "Aspects of preparation of scientific publications and projects for international grants" - Prof. S.V. Dzyadevych

Courses for Master's degree programs:

National University "Kyiv-Mohyla Academy"
- "Biosensor technologies" - DrSci T.A Sergeyeva

National Technical University "Igor Sikorskiy Kyiv Polytechnic Institute"
- "Biomolecular electronics" - DrSci O.O. Soldatkin
- "Practical biosensorics" - DrSci O.O. Soldatkin,

Kyiv Academic University
- "Fundamentals of biomolecular electronics" - Prof. S.V. Dzyadevych., DrSci T.A Sergeyeva
  "Methods of immobilization of biomolecules" – Dr V.M. Peshkova, PhD

Institute of High Technologies of the Taras Shevchenko Kyiv National University
- "Physico-chemical foundations of biomolecular electronics" - Prof. S.V. Dzyadevych
- "Modern aspects of the creation and practical application of biosensors" - Prof. O.P. Soldatkin

Courses for Bachelor's degree programs:

Institute of High Technologies of the Taras Shevchenko Kyiv National University
- "Biotechnology" (biology) - Prof. O.P. Soldatkin
- "Biotechnology" (chemistry) - Prof. O.P. Soldatkin
- "Biosensors" (biology) - Prof. O.P. Soldatkin
- "Nano-bioanalytical systems" (biology) - Prof. S.V. Dzyadevych
- "Biomolecular electronics" (applied physics) - Prof. S.V. Dzyadevych
- "Biotechnology and bioengineering" (applied physics) - Prof. S.V. Dzyadevych
- "Fundamentals of biosensorics" (electronics) - Prof. S.V. Dzyadevych
- "Fundamentals of bioelectronics" (electronics) - Prof. S.V. Dzyadevych

Institute of Philology of the Taras Shevchenko Kyiv National University
- “Scientific image of the world” - - Prof. S.V. Dzyadevych

Besides, IMBG will further encourage and attract students, ESR and young scientists to join IMBG innovative team and conduct biotechnology science by providing wide range of impressive and cognitive actions with leading role of IMBG Innovation Management Unit and IMBG Council of Young Scientists.

Among them there are foreseen special events for researchers` and public audiences:

- Annual calls for best papers published by young scientists as the main authors or by themselves only.
- Calls for Start-ups of young innovators.
- Inviting of the well-recognized Ukrainian and European scientists to make interesting presentations,
- Continuation of the Science club by Council of Young Scientists with presentations of state-of-the-art world publications on biotechnology achievements.
- Active participation in the annual Ukrainian Science Days – providing lectures, excursions in IMBG.
- Organization of round tables with mass-media on elucidation of innovations in biomolecular electronics to the wide public.
- Annual IMBG Open days to enable visits to its scientific departments and laboratories to help youth to understand the importance of innovations in science and role of bioelectronics in improving their quality of life.

3. DISSEMINATION AND EXPLOITATION PLAN AND POPULARIZATION OF IMBG RESEARCH RESULTS IN 2024-2030

In addition to the numerous events, which are planned for the nearest seven years in order to attract new qualified young scientific, as well as early stage researchers, students and even pupils to be interested in development of modern nano- and biotechnologies, IMBG plans to further disseminate information about its research directions and innovation results for scientific community and wide public in Ukraine,

Sharing interesting information about IMBG researchers' achievements with our colleagues abroad, in EU research and innovation management institutions also is planned.

Besides, popularization of IMBG research to wide public will be considered as crucial issue for enhancing IMBG social impact and visibility of the IMBG Center of Excellence in biomolecular electronics in Ukraine. The aim is to cooperate closely with media and public to become more visible to the society and to promote and popularize research in analytical biotechnologies and bioelectronics. This will help to reduce the gap between science and society and to raise the social awareness of nano-and biotechnology research and innovations.

Using the the Dissemination and Exploitation Toolbox developed in the frames of the BIONANOSENS project in tight cooperation with EU partners, IMBG Innovation management unit will carry out their dissemination and exploitation activities in EU-funded projects - building more and better capacities in conceptualising, designing, submitting, and eventually securing EU R&I funding for IMBG in the future.

Also, the Dissemination and Exploitation plan was developed by the BIONANOSENS partners for further enhancing IMBG capacities in socio-economic impact and recognizing of achievements of IMBG researchers and innovators by scientific community as well as wider public society.

It was pointed out in this plan, that when it comes to writing a comprehensive exploitation strategy, it must also touch upon a strategy for dissemination. Without sketching a strategic dissemination framework that is the prerequisite allowing exploitation to happen as an innovation implementation process, the latter simply won't be possible.

By forging a comprehensive dissemination and exploitation plan with clear instructions targeted at project partners and feasible objectives to be reached, this plan details the how-to of the exploitation of the project results. It suggests transferring project results into different contexts and situations, to recognize good practices and to encourage relevant key players in engaging with the project and in making use of its outputs and results. It further suggests embedding project results into the practices of organisations and mainstreaming them into the national (Ukrainian), European or global context.

The IMBG Dissemination and Exploitation plan focusses on four main steps in the dissemination and exploitation process, including the design, implementation, impact management and controlling of dissemination and exploitation actions.

It is a document that will be continuously managed by IMBG and its EU partners and its content can be re-visited at any time in case it becomes necessary. For instance, the project's environment of key target groups and stakeholders may change over time. If this change is of a substantial nature, IMBG will re-assess its dissemination and exploitation strategy to meet these new demands.

4. SUSTAINABILITY OF THE BIONANOSENS PROJECT RESULTS AND KEY PERFORMANCE INDICATORS OF THE SUCCESSFUL IMPLEMENTATION OF THE STRATEGY TILL 2030

The IMBG Strategy for excellence in biomolecular electronics, detailing further R&I development in the Analytical Biotechnology area, was formulated within the BIONANOSENS twinning action (2020-2024). Its aim is to uphold the project's outcomes, ensuring the continued leadership of IMBG as the Ukrainian Center of Excellence in Biomolecular Electronics, enhancing IMBG's innovation management efforts, and fostering international collaboration.

The implementation of this Strategy will serve as a roadmap for IMBG's innovation management and research in the analytical biotechnology field over the next seven years.

Given the strategic significance of this document, the sustainability of BIONANOSENS achievements hinges on the following core directions of IMBG's Innovation Management Unit activities for stable development in 2024-2030:

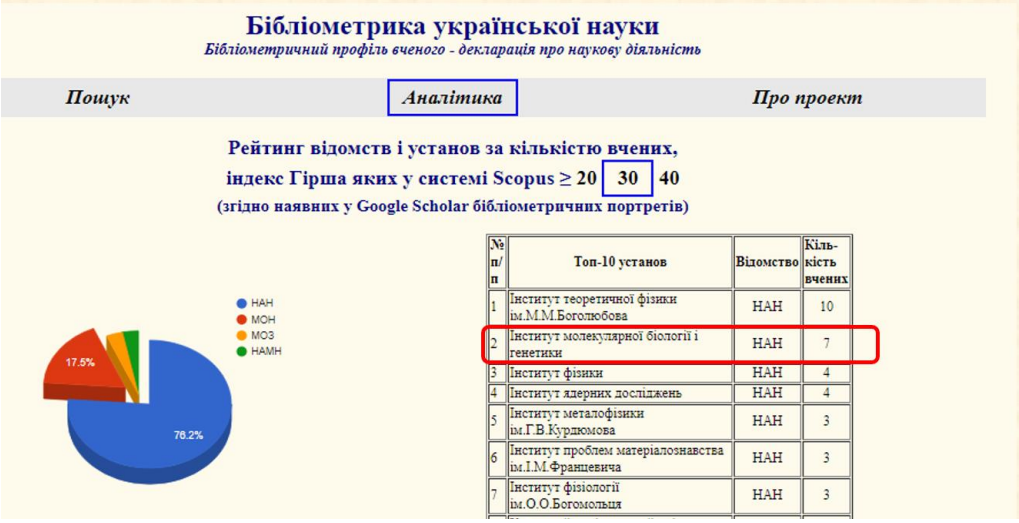
1. Continuation of permanent supervision by the IMBG International Advisory Board (General Assembly) providing international expertise of the Institute`s activities and achievements, sharing experience in doing world level research and innovation management.
2. Providing regular 5-year SWOT analysis of IMBG capacities and research and innovation development identifying strengths, weaknesses, threats, and potential areas for improvement.
3. Organization of the regular 5-year monitoring Marketing analysis of IMBG innovations capabilities.
4. Further realization of the Joint Research Programs of collaborating teams in the partner institutions.
5. Promotion of healthy competition among IMBG Departments in excellence of research and innovations, sharing the best research practice.
6. Twinning with the leading European research and management centers, boostering IMBG's role in Ukraine's analytical biotechnology development as the Ukrainian Center of Excellence in Biomolecular Electronics.
7. Enhancing visibility of IMBG in the European Research Area, applying for the international grants to keep the Institute an active and valuable part of European Research area, using the strengthened international collaboration with EU partners and developing the IMBG infrastructure for international cooperation management.
8. Applying for the large programs of national funding to keep the Institute as leading research center on Biotechnology in Ukraine
9. Intensification of activities of the PR-management group created to raise awareness of biotechnology research and innovations' societal impact in Ukraine.
10. Sharing experience in effective coordination and management of European-level projects in Ukraine, showcasing IMBG's capability to contribute actively to EU scientific and technical programs, establish international consortia, win grants, and execute projects aligned with societal needs.

In the IMBG Strategy (2015-2020), which was created for sustaining of the results of the preceding EU-funded IMBG project COMBIOM#294932 (2011-2015), 7 Key Performance Indicators (KPIs) were slated for accomplishment within five years post-project completion. All these objectives were met till 2020, underscoring the successful execution of the IMBG Strategy action planned:

Key performance indicator description № 1 – 2015: IMBG should enter the five top organizations in the NASU rating of scientific success http://jsi.net.ua/scopus/ratings_nanu/index.html

Monitoring of the resulting indicator value:

- Unfortunately, the scientific performance rating of the NAS of Ukraine ceased its activity and 2015 was the last year of its rating. http://www.jsi.net.ua/scopus/ratings_nanu/index.html
- Instead, in 2020, the Institute ranked second in Ukraine according to the rating of the V.I. Vernadskyi National Library of Ukraine by the number of scientists whose h-index is ≥ 30 (7 employees of the IMBG) http://nbuviap.gov.ua/bpnu/index.php?page_sites=top_sc_15&ind=30:



Бібліометрика української науки

Бібліометричний профіль вченого - декларація про наукову діяльність

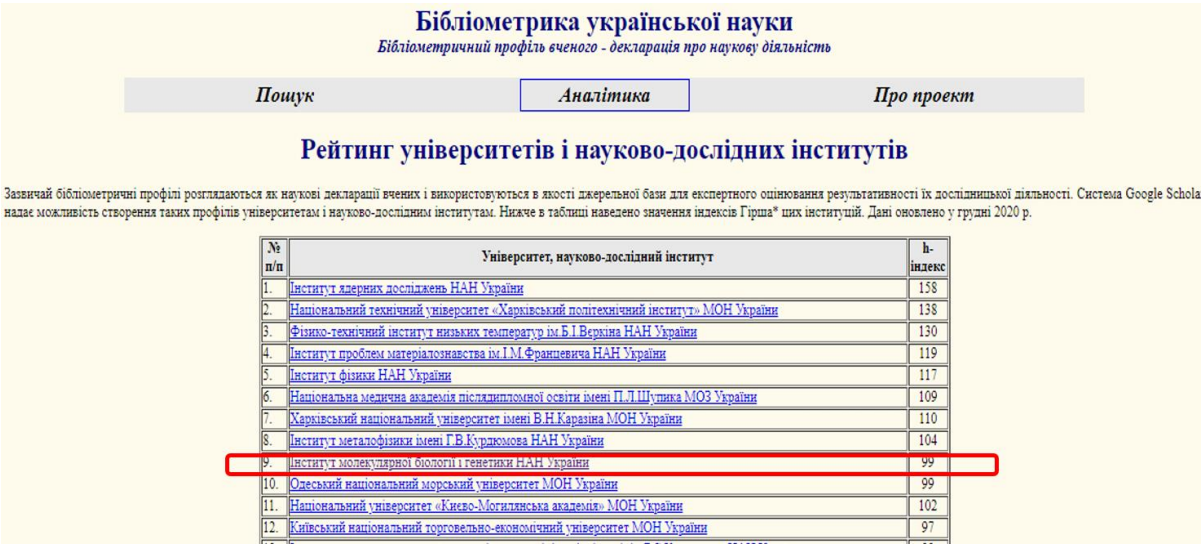
Пошук | *Аналітика* | *Про проект*

Рейтинг відомств і установ за кількістю вчених, індекс Гірша яких у системі Scopus ≥ 20 | 30 | 40

(згідно наявних у Google Scholar бібліометричних портретів)

№ п/п	Топ-10 установ	Відомство	Кіль-кість вчених
1	Інститут теоретичної фізики ім.М.М.Боголюбова	НАН	10
2	Інститут молекулярної біології і генетики	НАН	7
3	Інститут фізики	НАН	4
4	Інститут ядерних досліджень	НАН	4
5	Інститут металофізики ім.Г.В.Курдюмова	НАН	3
6	Інститут проблем матеріалознавства ім.І.М.Францевича	НАН	3
7	Інститут фізіології ім.О.О.Богомольця	НАН	3

- In 2020, IMBG was in 9th place in the ranking of 190 universities and institutions of Ukraine according to h-index http://nbuviap.gov.ua/bpnu/index.php?page_sites=ustanovy:



Бібліометрика української науки

Бібліометричний профіль вченого - декларація про наукову діяльність

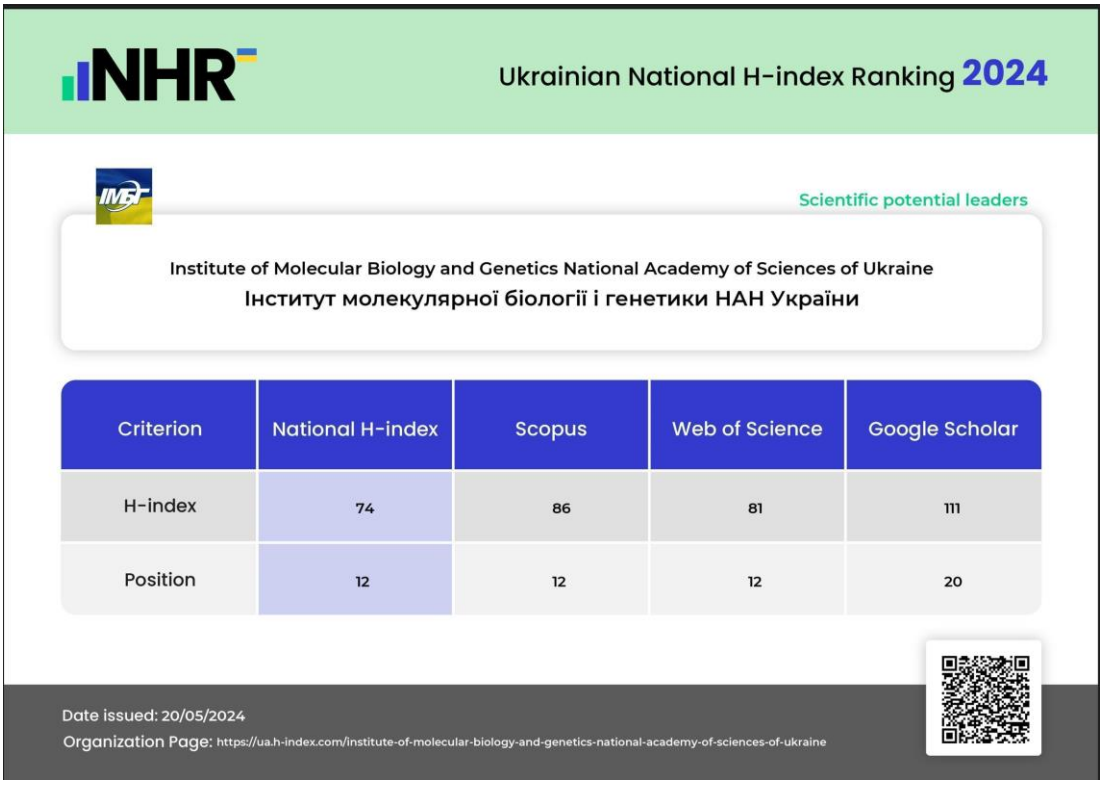
Пошук | *Аналітика* | *Про проект*

Рейтинг університетів і науково-дослідних інститутів

Зазвичай бібліометричні профілі розглядаються як наукові декларації вчених і використовуються в якості джерельної бази для експертного оцінювання результативності їх дослідницької діяльності. Система Google Schola надає можливість створення таких профілів університетам і науково-дослідним інститутам. Нижче в таблиці наведено значення індексів Гірша* цих інституцій. Дані оновлено у грудні 2020 р.

№ п/п	Університет, науково-дослідний інститут	h-індекс
1.	Інститут ядерних досліджень НАН України	158
2.	Національний технічний університет «Харківський політехнічний інститут» МОН України	138
3.	Фізико-технічний інститут низьких температур ім.Б.І.Веркіна НАН України	130
4.	Інститут проблем матеріалознавства ім.І.М.Францевича НАН України	119
5.	Інститут фізики НАН України	117
6.	Національна медична академія післядипломної освіти імені П.Л.Шупика МОЗ України	109
7.	Харківський національний університет імені В.Н.Каразіна МОН України	110
8.	Інститут металофізики імені Г.В.Курдюмова НАН України	104
9.	Інститут молекулярної біології і генетики НАН України	99
10.	Одеський національний морський університет МОН України	99
11.	Національний університет «Києво-Могилянська академія» МОН України	102
12.	Київський національний торговельно-економічний університет МОН України	97

- In 2024, the IMBG took 12th place in National H-index Ranking among 500 Scientific potential leaders — the best Ukrainian scientific and educational institutes, including the main universities and ministries, as well as the National Academy of Sciences of Ukraine as a single institution https://ua.h-index.com/en.



Key performance indicator description № 2 – 2015: Number of the articles in non-Ukrainian scientific journals with IF ≥1 each year not less than 25 (10 above IF = 3).

Monitoring of the resulting indicator value: In 2020, IMBG researchers published 53 papers in peer reviewed international scientific journals, among them 43 articles with IF ≥1, and 30 papers with IF ≥ 3. In 2023, IMBG scientists published 100 papers in peer reviewed international scientific journals, with $1 \leq IF \leq 25{,}7$.

Key performance indicator description № 3 – 2015: International grants applications yearly – 10 (including Horizon Europe project applications as well as Wellcome Trust, NATO, CNRS, STCU grants etc)

Monitoring of the resulting indicator value: In 2020, IMBG researchers applied to 14 grants (bilateral, Erasmus+, Bridge2ERA, HPC Europa-3 infrastructure program. 20 funded international projects (grants) were conducted in IMBG in 2020, and 34 – in 2023.

Key performance indicator description № 4 – 2015: New partnership: each year to join not less than 5 organizations for collaboration at the level of the Agreement signed; joint workshops or joint grant written.

Monitoring of the resulting indicator value: in 2020, IMBG researchers jointed 7 new consortia, 5 new Scientific Cooperation Agreements were signed, most of the negotiations took place virtually.

Key performance indicator description № 5 – 2015: 5 patent applications in Ukraine and / or abroad till 2020.

Monitoring of the resulting indicator value: the State Intellectual Property Service of Ukraine received 60 Ukrainian patents for the innovative developments of the Institute's employees in 2015-2020, including 16 patents for inventions. In addition, a US patent for the invention was obtained in 2017 by IMBG: US patent No. 970175 «MEMBRANE TRANSPORTER NAPI2B (SLC34A2) EPITOPE FOR ANTIBODY THERAPY, ANTIBODIES DIRECTED THERETO, AND TARGET FOR CANCER THERAPY»

Key performance indicator description № 6 – 2015: At least 5 international conferences organized by the Institute till 2020.

Monitoring of the resulting indicator value: During 2015-2020, 49 scientific forums were organized in IMBG and by IMBG, among them Kyiv Non-Coding Meeting 2018, five (annual) IMBG Conferences for Young Scientists (CYS) with international participation, and several innovation management meetings with mentoring of partners from abroad, such as Forum "Science. Business. Innovations"(2018) "Innovation Market" (2019).

Key performance indicator description № 7 – 2015: 80% of the IMBG young scientists stay in IMBG and 50% coming back from abroad.

Monitoring of the resulting indicator value: till 2020, 90% of IMBG PhD students were working in the Institute, and valuable measures were developed to attract young researchers to return from abroad. Unfortunately, in 2024 several millions of Ukrainians were escaping abroad and will remain there until the end of the war, so we cannot now expect an increase in the number of those who have returned. However, we can still admit new young people to postgraduate studies and do everything possible to ensure that they remain working at the Institute in the future.

Moving forward, IMBG's primary objective is to sustain the achievements gained through the BIONANOSENS project. The IMBG R&I Strategy in biomolecular electronics outlines future perspectives, emphasizing the realization of project benefits, continued improvement of international cooperation, and ongoing capacity building to ensure IMBG remains an active participant in the European Research Area.

The IMBG Strategy for Excellence for 2024-2030 implies the next 7 key points, which could serve as indicators showing efficiency of its implementation till 2030, and which are twice higher than those were indicated for the previous period:

N	Key performance indicator description	Prognosed KPI value

1.	The IMBG place in Ukrainian National H-index Ranking among scientific and educational Institutes	5
2.	Number of the IMBG articles in non-Ukrainian scientific journals with IF≥1 each year Among them - with IF above 3	50 20
3.	International grant applications yearly (including Horizon Europe project applications as well as Wellcome Trust, NATO, CNRS, STCU grants etc).	20
4.	New partnership: each year to join organizations for collaboration at the level of the Agreement signed; joint workshops or joint grant written	7
5.	Patent applications in Ukraine and / or abroad till 2030	10
6.	Conferences with international participation organized by the Institute till 2030.	5
7.	Young scientists in IMBG	20%

We anticipate that the upcoming Twinning project of the Institute with 4 European research centers, 101160053 SURE-AMR, which was selected for the EU funding within the HORIZON-WIDERA-2023-ACCESS-02 call, will further bolster the sustainability of BIONANOSENS results and provide monitoring of IMBG capacity growth. It will also facilitate the monitoring of Strategy implementation over the next 36 months of its lifetime.