Special issue on Proceedings of V International Conference „Physics for the Life Sciences“ (St. Petersburg, October 15–19, 2023)

The present issue of Technical Physics is focused on research presented at V International Conference „Physics for the Life Sciences“ and the School of Young Scientists organized by the Ioffe Institute with the assistance of the All-Russia non-profit organization „Federation of Anaesthesiologists and Reanimatologists.“ These events were held on October 15–19, 2023, in St. Petersburg and broadcast online. The regularity of the Conference reflects the interest of physical, chemical, medical, biological, and agricultural scientists in interdisciplinary research in life sciences.

The School of Young Scientists, which accompanied the Conference, had more than 50 attendees. They were presented with ten lectures on such topical issues as biophotonics of molecular oxygen, specific features of vibrational spectroscopy and EPR of biological objects, analysis and forecasting of electrical conductivity of fibrous composite materials, specifics of micro- and nanostructured luminophores for biomedical applications, biophysics of cell membranes, features of phase separation of biopolymers in the organization of intracellular space, prospects for the development of bioelectronics, and issues of plant breeding in the context of global climate change. The School received high praise from the Conference participants.

Two applied research sub-forums were held at the Conference: „Physical Methods in Agricultural and Genetic Selection Technologies“ (moderated by V.A. Dragavtsev and M.V. Arkhipov) and „Medical Monitoring and Visualization Technologies“ (moderated by K.M. Lebedinskii). The total number of Conference attendees exceeded 170. Among these were researchers from leading scientific centers of Moscow, St. Petersburg, Novosibirsk, Yekaterinburg, Krasnoyarsk, Kazan, Tomsk, Kaliningrad, the Netherlands, etc. (including 26 Doctors of Sciences, 39 Candidates of Sciences, and 55 participants under 35 years of age). The Conference program included seven invited presentations on current issues in biology, genetics, medicine, agrophysical sciences, and interdisciplinary research; 78 oral presentations; and 44 poster presentations. A discussion on the COVID-19 pandemic was held. Reports authored by members of the scientific community of the organizing institution (Ioffe Institute) were presented at six of the eight sub-forums of the Conference.

The organizers were praised for the high level and topicality of the Conference and received feedback on possible future improvements. According to the decision of the Program Committee, the next (sixth) Conference will be held in 2025 in St. Petersburg.

Brief summaries highlighting the research presented at the sub-forums are given below. These summaries were compiled from materials provided by the coordinators of sub-forums: T.E. Sukhanova, E.S. Kornilova, K.M. Lebedinskii, O.S. Vasyutinskii, and A.V. Nashchekin.

The „Nanomaterials and Nanodiagnostics in Biology and Medicine“ sub-forum was focused on the issues of fabrication of nanomaterials and nanostructures based on plasmon-resonance silver and gold nanoparticles, superparamagnetic iron oxide nanoparticles, and diamond nanoparticles for diagnostics and therapy of diseases; visualization of intracellular processes and subcellular visualization of bone tissue and its regeneration processes; development of drug delivery systems with controlled substance release via remote opening of nanocomposite polyelectrolyte capsules under the influence of various physical effects; and production of genetically modified cells with the use of transfection (mechanoporation) techniques and an array of filamentary nanocrystals. The results of development of mathematical models of drug distribution kinetics in biological objects with the use of randomly inhomogeneous media were presented. These models should help accelerate preclinical trials; optimize protocols for chemotherapeutic and radiological treatment of oncopathologies; produce efficient adsorbents for water purification based on cyclic biopolymers: cellulose, lignin, tree bark, and hogweed stems; and develop new methods for immobilizing bacteria (specifically, Lactobacillus brevis) for the purpose of production of probiotic drugs for medicine and veterinary science.

In 2023, the „Nanosensorics in Biology and Medicine“ sub-forum was integrated into the Conference program, since the focus of study of molecular mechanisms of tissue and cell functioning has shifted in recent years from the microlevel to the nanolevel. It became necessary to construct nanoscale sensors capable of operating in the extra- or intracellular space and to develop relevant detection methods. Such sensors are being designed throughout the world based mostly on luminescent compounds and optical detection methods. Reports on the production and characterization of nanoscale metallized complexes responding to oxygen levels and pH and on the luminescence of bimetallic complexes of f elements with N-heterocyclic ligands were presented. Several studies were focused on the issues of determination of intra-endosomal pH with the use of internalized targeted quantum dots and assessment of the level of reactive oxygen intermediates in the cytoplasm of cells with the application of genetically encoded HyPer proteins (hydrogen peroxide sensors). The results of evaluation of the oxygen status of tumor cells *in vitro* and *in vivo* by the PLIM method with the aid of oxygen sensors were presented. A number of papers concerned with the use of graphene-based sensors (specifically, in the diagnostics of Alzheimer's disease), AFM and SEM detection of viral infections and visualization of influenza viruses on the surface of graphene, and optimization of

the sensor response in graphene transistors for detection of biological substances in solutions were also delivered.

Sub-forum „Medical Monitoring and Visualization Technologies." The authors of „Wavelet Analysis of Turbulence of Frequency-Modulated Cardiac Rhythm Signal" attempted to address an important problem in clinical practice: analysis of the cardiac rhythm under turbulence, which is caused by certain arrhythmias, with the use of continuous wavelet transform. The possibilities of increasing the accuracy of measurements with the modulation method of liquid flowmetry and relaxometry were outlined in the paper titled „Specifics of Nuclear Magnetic Resonance Examination of Condensed Media Based on Relaxation Times T1 and T2."

The „Physical Methods in Agricultural and Genetic Selection Technologies" sub-forum featured reports on the fundamentals of management of genetic selection processes in plant cultivation and on the production and agricultural application of silica nanocomposites. The results of application of physical methods (microfocus radiography, *L*-dielcometry, electrochemistry, infrared spectroscopy, etc.) in rapid diagnostics of the state of plants and electrogenic processes in root-inhabited environments were presented. Scientific and methodological aspects of voltage generation in plant bioelectrochemical systems in controlled agroecosystems, which is one of the current trends in agricultural physics, were discussed using the example of humic acids (root system growth stimulators that are used widely in agriculture). The prospects for scaling the obtained results on the properties of bioelectrochemical systems based on electrogenic processes in the root-inhabited environment of lettuce were analyzed with account for various phases of ontogenesis. The scientific legacy of Lidiya Nikolaevna Gall', who passed away during the Conference, was discussed. She was a brilliant scientist, organizer, and mentor who never ceased to inspire her colleagues with enthusiasm.

Sub-forum „Physical Aspects of Photobiology." An original polarization-modulation method for examination of photoprocesses in biological molecules under excitation by femtosecond laser pulses was applied in the study of anisotropic relaxation of NADH in water-alcohol solutions in the picosecond range to analyze the energy transfer in the NADH coenzyme, which is essential to metabolic processes in cells and tissues. The effect of picosecond anisotropic relaxation in excited states of NADH, which may be used to monitor the efficiency of oxidation-reduction reactions in the cells of living organisms, was discovered. A large research group presented the results of a study into the mechanisms inducing death of cells with iron oxide nanoparticles under laser exposure. The temperature distribution in iron oxide nanoparticle ensembles in biological samples was measured by time-resolved fluorescence thermometry. It was demonstrated that „hot spots" with temperatures above 100°C emerge inside a cell when the energy trapped by nanoparticles is released. Their distribution governs the thermal response of a sample (in particular, is conducive to permeabilization of lysosome membranes and mitochondrial stress). The application potential of iron oxide nanoparticles in photodynamic therapy and controlled drug release was assessed.

Biotechnology advances associated with the expanded capacity for microstructuring of biomaterials; the production of scaffolds (carriers) with the required geometry, mechanical strength, resorption parameters, and biocompatibility; and the development of additive biotechnologies assert the relevance of introducing a new sub-forum into the Conference program: „Functional Materials for Cell Engineering and Implantology." It was focused on fabrication of new materials, scaffolds, and tissue-like structures based on biomaterials and cells and studies of such structures. Specifically, several issues in preclinical studies of biomaterials for medical applications were discussed thoroughly. A comprehensive approach to assessing the biocompatibility of medical materials *in vitro* with the use of informative research techniques (fluorescence microscopy, immunophenotyping, enzyme immunoassay, etc.), which allows one to reduce the cost of new medical products and accelerate their entry into the clinical trial phase, was presented. The production of hyaline cartilage, which consists of a small number of highly differentiated cells and a large amount of extracellular matrix and covers the inner surface of large joints of the body, with the use of additive biotechnology and cell engineering techniques was reported in a different paper. Long-term viability of a cell culture inside cell-engineered structures was demonstrated. Another approach to the design of tissue-engineered products relies on the use of human umbilical cord biomaterial as the starting material, which is subjected to special physical and chemical processing (decellularization, lyophilization, etc.) in order to isolate a product that holds promise for biointegration into the body. This material was implanted subcutaneously into mice, and was found to induce no inflammatory reaction and to be colonized gradually by cells.

Most of the above results are reported in papers included into the present special issue of Technical Physics.

Editor-in-chief of Technical Physics, A.G. Zabrodskii, academician of the Russian Academy of Sciences