Transmitting Health

SCIENTISTS AT THE PETER THE GREAT POLYTECHNIC UNIVERSITY ARE CREATING THE FUTURE OF BIOMEDICINE

Natalya MAKHOVA. Photos: the Polytechnic University Press Office, site scardio.ru

A handmade hi-tech bio-prosthesis.

'Into whatsoever houses I enter, I will enter to help the sick.' That line from the Hippocratic Oath is becoming exceptionally relevant today with the proliferation of translational medicine and the diminishing distance between promising developments and their practical use. This is largely on account of a new paradigm in medical science and innovative technologies which give researchers the possibility of looking into the hidden depths of the human organism. The characteristics of biomedicine are the interpenetration of life sciences (biomechanics, biophysics, biochemistry, bioinformatics, neurobiology, psychophysiology, genetics...), the modelling of pathologies in laboratory conditions with the aim of identifying the mechanisms of diseases and the search for new treatments for those diseases. Only universities can provide this interdisciplinary approach.

A graphic example of this — the Peter the Great Polytechnic University in St. Petersburg — is one of the leaders in this field in Russia, striving to develop according to Model 4.0, where a combination of material resources, competences and high technologies makes it possible not only to solve problems that are not within the compass of separate branches of industry but also to make an invaluable contribution in the public health domain. An innovative ecosystem is forming around the university, generating hi-tech biomedical designs.

In 2015, in conjunction with the Almazov National Medical Research Centre and several other educational institutions in St. Petersburg, the Polytechnic University set up the Translational Medicine science-education cluster. One of the cluster's main purposes is to carry out a full cycle of scientific research and experimental design work, including making preparations and industrial prototypes of appliances which can actually be used in doctors' daily practice. In 2016 the Polytechnic University and

the Shanghai Biotechnology Corporation signed a collaboration agreement and in October 2017, following a decision by the university's Academic Council, a new structural subdivision was founded — the Institute of Biomedical Systems and Technologies. This is by no means a spontaneous step or a nod to fashion — the Institute's programmes have already been running for two years as part of the 5–100 project. It will train specialists capable of meeting the most difficult challenges that face medicine and threaten public health in conditions of heightened stress, technogenic dangers, mutations of viruses and the deteriorating ecological situation on the planet. This important scientific-educational project is being implemented in conjunction with the Almazov Centre.

The modern world is rapidly changing perceptions of professions, making urgent demands of them. Doctors in the 21st century not only have to be up to date with advanced methods of diagnosis and treatment but also to actively introduce them into clinical practice and approach each patient individually, relying on the data of molecular-genetic and epigenetic examinations. This has prompted the Polytechnic University to solve a number of important problems at once in the field of hi-tech biomedicine. The university is contributing to the formation of multidisciplinary teams in which specialists in biomedicine and mathematics, mechanical engineers, chemists and even economists will work on an equal footing with clinicians. These specialists are also being trained at the university. Students of the Institute of Biomedical Systems and Technologies will learn truly innovative specialities: molecular design and bioinformatics, biomedical machinery and materials, nuclear and quantum medicine, cellular and regeneration medicine, neurobionics and medical robotics. Training of new-formation medical personnel on a master's programme will begin as early as autumn 2018. It is planned to take 10–15 students with basic medical education who will receive superscientific hi-tech education at the Polytechnic University and its partner institutions.

The Polytechnic University is also training medical specialists in its foundation department, which works effectively with the Russian Ministry of Health's Influenza Research Institute. The Institute's staff gives the students courses and hold laboratory sessions which facilitate their immersion in the profession.

Scientists at the Polytechnic University have already created several original medicinal preparations and technologies and have passed them on to medical institutions. For example, the staff of the Medical Ultrasound Apparatus laboratory under Alexander Berkovich have developed Russia's first diagnostic scanner for the identification and ultrasound treatment of cancerous tumours at an early stage without surgery. The scanner is in demand when tumours appear in the mammary and thyroid glands, the kidneys, liver and other organs. And ultrasound can be used simultaneously for diagnostic, therapeutic and thermometric purposes. The non-invasive treatment avoids surgical scars and post-operative complications. The university, in conjunction with the Novosibirsk

'With the help of our colleagues at the Polytechnic University we wish to introduce all the latest and best there is in science today into the doctor's surgery. I hope this lofty ideal — and we are looking beyond the horizon — will enable us to implement a pilot project for the training of specialists on the basis of new biomedical research'.

Evgeny SHLYAKHTO,
Academician of the Russian Academy of Sciences, Honoured Scientist of the Russian Federation, General Director of the Almazov Centre, President of the Russian Cardiology Society, Head Cardiologist of St. Petersburg and the Northwest Federal District

Left:
The Peter the Great Polytechnic University is working on the creation of new medicinal preparations and technologies.

At a session of the presidium of the Presidential Council on the Modernization of the Economy and Innovative Development of Russia held at St. Petersburg Polytechnic University Prime Minister Dmitry Medvedev was shown a bionic prosthetic arm made by students at the university in conjunction with specialists from the Turner Children's Orthopaedic Research Institute. Right — Rector of the Peter the Great Polytechnic University Academician Andrey Rudskoy. June 2016.

An apparatus for the removal of cancerous tumours with the aid of ultrasound has been developed at St. Petersburg Polytechnic University.

Instrument-Making Plant, is planning to start production of the scanner and put it on the market as early as 2019.

Ultrasound has also proved to be an effective treatment for varicose veins. The technology developed by St. Petersburg Polytechnic University has no analogues in the world. According to World Health Organization statistics, tens of millions of people currently suffer from varicose veins. The disease attacks the veins of the lower limbs and the venous valves which help the circulation of blood from the legs to the heart. The essence of the new method, which requires no great financial expenditure or major surgery, is that the ultrasound seeks the affected part of the blood circulation system. Depending on its depth in the patient's body a computer program selects the course of action and focuses a 10kW/cm^2 ray on the area to be treated, heating it to a temperature of 70–90 degrees Celsius. The procedure takes just a few minutes.

Another breakthrough in biomedicine achieved by the Polytechnic University's Nanobiotechnology Research Complex is the creation of a harmless peptide which prevents the adaptation of bacteria to antibiotics. This was a joint project with specialists from the St. Petersburg Nuclear Physics Institute (the National Research Center 'Kurchatov Institute'). It is known that bacteria constantly mutate and acquire the ability to nullify the effect of antibiotics. On a genetic level the peptide created by the scientists shuts down the systems of the accelerated evolution of bacteria. The method's effectiveness has already been proved and it has obtained a patent entitled Family of Peptides — Inhibitors of the Activity of RecA Protein Blocking Bacteria's SOS Response. This discovery should raise to a new level the effectiveness of preventive measures and the treatment of infectious and parasitic diseases, reducing their duration.

The Polytechnic University is also involved in the search for HIV vaccines and bio-agents for the treatment of Alzheimer's

disease. The fight with this global disease, which is becoming more widespread with the aging of the world's population, has proved to be particularly attractive to young scientists, who regard it as a real challenge. A youth molecular neurodegeneration laboratory was established at the Polytechnic University thanks to a mega-grant from the Ministry of Education and Science and is functioning with the support of a grant from the Russian Science Foundation. Those working there are mainly master's degree students and postgraduates from the Department of Medical Physics (headed by Olga Vlasova, Doctor of Physics and Mathematics). And the laboratory preparing our biomedical response to Alzheimer, like the master's programme, is headed by the Polytechnic University graduate Ilya Bezprozvanny, now a professor at Texas University in the USA.

Another biomedical project is the development of high-precision technology for people with physical disabilities. It is put into action not mechanically but with the aid of the neural networks in the brain. For example, the Turner Children's Orthopaedic Research Institute made a working model of a prosthetic arm for a patient. As part of the collaboration with the Vreden Institute of Traumatology and Orthopaedics a titanium prosthetic coxofemoral joint was produced on a 3D printer with the aid of additive technologies. At that time, in 2015, it was the first project in Russia to use additive technologies in the manufacture of hi-tech articles for medicine. With the aid of digital technologies the joint of an actual patient was scanned and polystyrene models were produced, on the basis of which the metal prosthesis was made. The prosthesis, which has extremely complex geometry, is made of a bio-inert material that is absolutely safe for the organism.

One could mention other groundbreaking projects which are already at the output stage, such as the creation and development of nanovessels and nanofibres, transplanted during the replacement of blood vessels and internal organs. In the very near future a patient at the St. Petersburg Clinical Scientific-Practical Centre of Specialized Types of Medical Assistance (Oncocentre) will have an operation to fit an artificial lower jaw. The prosthesis will be printed on a 3D printer at St. Petersburg Polytechnic University and modelled in accordance with the patient's anatomy.

It is no coincidence that the first biomedical centres appeared at leading world universities. The achievements of St. Petersburg Polytechnic University again show the importance of a favourable innovative environment for the formation of an interdisciplinary biomedical cluster. The designs developed here are a genuine contribution both to science and to the improvement of the nation's health. The results of the research are confidently emerging beyond the bounds of laboratories, leading to groundbreaking technologies capable of changing approaches to treatment and health care as a whole and providing full-value lives for many of our fellow-citizens – better health for the nation.

Professor Anatoly Popovich, Doctor of Technology and Director of the Institute of Metallurgy, Mechanical Engineering and Transport at St. Petersburg Polytechnic University (left), hands over a prosthesis developed at the university with the aid of additive technologies to Rashid Tikhilov, Director of the Vreden Institute of Traumatology and Orthopaedics.