REGIONAL REPORT

EESTI TEADUSFOND

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Research in Estonia:
race for quality and competitiveness

The history of science in Estonia spans centuries; however, never has its scale been so comprehensive and its targets so high.

The history of scientific research in Estonia goes back to 1632 when the University of Tartu was founded. Since then, Estonia has been a natural partner for international research institutions, with many well-known scientists studying and working here.

After Estonia regained its independence in 1991, the research and development system had to undergo several changes. The system did not simply need a transformation, but had to be completely rebuilt. The Estonian Science Foundation (Eesti Teadusfond or ETF) was founded as an organization for research financing; the legal and funding systems, and the network of research institutions, were also gradually changed. The gathering of the former Soviet-style independent research institutes into the universities was one of the most successful changes. This allows students to get access to high-quality research, and so the resources can be used more efficiently.

Over the past two decades, Estonia has made considerable progress in improving its research and development system and financing, as well as supporting excellence in science. The increase of research and development spending during the period from 2000 to 2006 was the fastest in the European Union (EU). However, Estonia is still behind the average EU indicators. We are aiming to reach a total spending level of 1.9% of the gross domestic product (GDP) this year. Currently, research and development is mainly government-funded, but the private sector has increased its share from 23% in 1998 to 42% in 2007.

The Estonian research and development system has to be ready to address flexibly the new global and societal issues of the twenty-first century. The main objectives of the research and development activities and the key technologies are presented in the Estonian Research and Development and Innovation Strategy 2007–2013 "Knowledge-based Estonia". The strategy's three main objectives are to promote competitive quality and increased productiveness, innovative business activity creating added value in the global economy and an innovation-friendly society aimed at long-term development.

The public-sector expenditures on research and development are determined using competitive mechanisms. Targeted financing, research grants and grants within research programmes are awarded on the basis of mostly international peer review. Baseline financing and infrastructure support are also allocated based on quality criteria. This is certainly one of the reasons behind the recent rise in scientific output as measured by publishing indicators as well as by the general visibility of Estonian research. Financing from the EU Framework Programmes has also considerably advanced the extent of international collaboration and the quality of research outcomes.

The ETF is an important part of the research and development system. Its priorities are to support the most qualified and successful researchers and research groups, to support researchers in their early careers, and to facilitate the international cooperation and mobility of researchers. The "My First Grant" programme is targeted at young researchers starting their independent research careers, and the researcher mobility programme Mobilitas (financed from the European Social Fund) and the Estonian research mobility scheme ERMOS (financed from the Seventh Framework Programme) support postdoctoral studies in Estonia and abroad. In the standard grant programme, the involvement of master's degree or PhD students is an important criterion in the evaluation process of proposals.

Eiko Lainjärv

Toivo Maimets, professor of cell biology, Institute of Molecular Cell Biology, University of Tartu, and chairman of the ETF.

The ETF also represents the Estonian research community at an international level. It is a member of the European Science Foundation and the European Heads of Research Councils (EUROHORCs), and participates within its frameworks in multilateral initiatives. The bilateral cooperation programmes of the ETF reach beyond the borders of the EU.

GENERAL DATA ON RESEARCH AND DEVELOPMENT FINANCING IN ESTONIA

Population in January 2010:	**1,340,127**
Gross domestic product in 2009:	**€13,730 million**
Research and development financing in 2008 (percentage of gross domestic product):	**1.29**
Gross domestic expenditure on research and development (GERD) in 2006:	**€151 million**
Total number of researchers (full-time equivalent) in 2006:	**3,513**
Researchers (full-time equivalent) per thousand labour force in 2006:	**5.1**
Planned support from European Union Structural Funds to research and development in 2007–2013:	**€550 million**

Sources: Statistics Estonia, Eurostat, DG Research and Estonian Ministry of Education and Research

From nanoworld to space technologies

The Institute of Physics of the University of Tartu (IPUT), founded in 1946, is the biggest research and development centre in the fields of physics, materials science and nanotechnology in Estonia. About 140 highly qualified scientists and 65 PhD students are involved in materials science, experimental physics, theoretical physics, biophysics and environmental physics research. In 2000–2004, the institute was the European Centre of Excellence "ESTOMATERIALS", and during 2002–2007 it was a national centre of excellence. IPUT also has a leading role in teaching physics, materials science and computer engineering. Thanks to improving funding conditions, the number of short- and long-term international PhD students has steadily increased during past years. Investments into the research infrastructure and a creative atmosphere have attracted more than 20 foreign researchers as well as native Estonians, returning after PhD and postdoctoral studies, to join the staff of IPUT.

According to the Institute for Scientific Information (ISI) database, Professor Jaan Aarik and Dr Kaupo Kukli are among the top 1% of the most-cited scientists in materials science. Scientists at IPUT actively develop thin film-processing technologies like atomic-layer, pulsed laser and sol-gel deposition, which together with advanced microscopy techniques such as scanning electron microscopy (SEM)–focused ion-beam (FIB) microscopy, atomic-force microscopy (AFM) and scanning tunnelling microscopy (STM), and modern methods of optical and electron spectroscopy, form an excellent basis for international cooperation. For instance, in a recently launched European Collaborative Research (EUROCORES) project "Entangled spin pairs in graphene" that focuses on the generation and manipulation of spin-coherent electron states, the task of IPUT is to develop tunnel barriers for spin-dependent electron injection into graphene.

Researchers at IPUT are frequent visitors to European research facilities like the Ångstrom Laboratory in Uppsala and the synchrotron radiation centre MAX-lab in Lund. Visits to the LASERLAB facilities in Saclay and Vilnius, and to the world's first vacuum ultraviolet (VUV) free-electron laser in Hamburg (FLASH), have helped to clarify the effects governing the performance of scintillators.

On the "Estonian Research Infrastructures Roadmap", IPUT has a leading role in research and applications of nanomaterials, in construction of the Estonian beam-line at the MAX-IV synchrotron source and in the European Spallation Source in Sweden. IPUT actively participates in the creation of the Estonian Environmental Observatory and the Estonian Structural Biology Infrastructure. Applied studies for companies interested in nanomaterials are carried out together with the Estonian Nanotechnology Competence Centre.

In collaboration with the European Space Agency, young scientists at IPUT are developing the Estonian student satellite EstCube-1 that will be launched in 2012.

Margus Ansu/PM/Scanpix Baltics

Mobilitas top researcher grant awardee Dr Harry Alles studies graphene and its applications at IPUT.

The importance of being national and international

The National Institute of Chemical Physics and Biophysics (NICPB) carries out fundamental and applied research in diverse fields of materials science, gene technology and biotechnology, environmental technology and computer science.

The NICPB was founded in 1980. Besides the founder, Professor Endel Lippmaa, a number of world-renowned scientists have also worked, or are working, at the institute: professors Mart Saarma, Georg Liidja, Valdur Saks, Erkki Truve and Richard Villems, DSc Tõnis Pehk, and Drs Martti Raidal, Ago Samoson and Dan Hüvonen, to name a few.

The institute's research programmes combine different areas of science and include particle physics, nuclear magnetic resonance (NMR) spectrometry, new spin materials and states, ionic conductivity and catalysis, macromolecular interactions, environmental chemistry, *in vitro* toxicology and the 3Rs (that is, replacement, refinement and reduction), and bioenergetical nonlinear photonics.

Eiko Lainjärv

Mobilitas postdoctoral fellow Andi Hektor (right) carries out his research at CERN while Mukesh Chandra from India is at the NICPB.

The institute housed the National Centre of Excellence of Analytical Spectrometry (CEAS) in 2002–2006, formed on the basis of six research groups of the Laboratory of Physics of the NICPB and a biology-related research group. The research fields covered by the CEAS ranged from high-energy and quantum physics to proteomics and functional genomics.

This year, the institute was elected to house two of the 20 projects of the "Estonian Research Infrastructures Roadmap": the Estonian Magnet Laboratory (EML) and the Estonian participation in the European Organization for Nuclear Research (CERN).

The core of the EML is the existing know-how and infrastructure in the NICPB. Five magnets ranging from 200MHz to 800MHz in ^{1}H frequency, the last of which is equipped with a sensitive cryoprobe for liquids and biological samples, are available for NMR studies. Solid-state NMR spectroscopy has unique variable-temperature sample spinners from liquid helium temperatures to those well above room temperature, developed in the NICPB. Terahertz (THz) spectrometry has a sensitive and unique bolometric detection system in combination with a 12-T magnet. The physical properties measurement system (PPMS) is equipped with a 14-T magnet, and for optical measurements there is a femtosecond laser system and a Fourier spectrometer that covers a range from THz to ultraviolet frequencies.

In the CERN framework, the NICPB contributes to the development of Large Hadron Collider (LHC) detectors and to the LHC computing grid (WLCG). Our researchers participate in the analysis of LHC experimental data, and the NICPB houses a Tier-2 level computing centre for the Compact Muon Solenoid (CMS) detector.

Studies into complexity in nature and technology

The Institute of Cybernetics (IoC), founded in 1960 as a multidisciplinary research institute of the Estonian Academy of Sciences, is nowadays an autonomous research unit at the Tallinn University of Technology. Having limited human resources, research institutions in small countries need to fight constantly to sustain a critical mass of researchers. Multidisciplinary institutes like the IoC are one way to provide working infrastructure to motivated researchers in different fields of study, resulting in a broader spectrum of expertise and higher potential to participate in international projects.

The IoC has three departments (Mechanics and Applied Mathematics, Control Systems, and Software) and four laboratories (Photoelasticity, Wave Engineering, Systems Biology, and Phonetics and Speech Technology). The activities of two scientific centres are also coordinated from the IoC: the Centre for Nonlinear Studies (CENS) and the Estonian Centre of Excellence in Computer Science (EXCS). The spectrum of research fields in the IoC has always been broad, but the common denominators are applied mathematics and complexity. The keywords describing our activities include the following: complex and nonlinear phenomena in wave dynamics and coastal engineering, solitons and solitary waves, acousto-diagnostics, turbulence, fractality, econophysics, acoustics of the piano, integral photoelasticity and photoelastic tomography, cell energetics, semantics of programming languages and type theory, visual and ontology oriented programming, knowledge representation and program synthesis, cybersecurity, analysis and synthesis of nonlinear control systems, inverse and ill-posed problems, speech synthesis, speech analysis and speech recognition.

The high level of our research can be characterized, for example, by the fact that the IoC hosted two out of the 10 national centres of excellence in research: the CENS and the Centre of Dependable Computing. The IoC has always been the driving force for nationwide collaborative initiatives in computer science and mechanics. It takes part in numerous international projects, including activities of the Marie Curie Actions programme and projects funded by the European Structural Funds, the Framework Programme and the Wellcome Trust.

Eiko Lainjärv

Wellcome Trust senior research fellow Marko Vendelin and Mobilitas postdoctoral fellow Hena Ramay study heart muscle cells at the IoC.

Because of our high-level results in different research fields and the inspiring atmosphere, the IoC has become an internationally recognized research centre that attracts more and more talented young researchers worldwide.

Eiko Lainjärv

European Molecular Biology Organization (EMBO) Installation Grant awardee and Wellcome Trust senior research fellow Arnold Kristjuhan's research at IMCB is on the mechanism of changes in the structure of chromatin.

A national leader with serious international ambitions

The Institute of Molecular and Cell Biology (IMCB) of the University of Tartu was founded 20 years ago. The idea was to join all the relevant activities of the university and the independent laboratories of the Estonian Academy of Sciences. During these two decades, the IMCB has established itself as a leading Estonian centre for research and teaching in rapidly developing fields such as fundamental and applied studies in molecular biology, cancer research, human genetics and studies of complex genetic diseases.

Currently, we employ 130 persons, most of whom are academic staff members. The institute offers degrees in molecular and cell biology, and gene and environmental technology. The IMCB has nearly 80 PhD and 70 master's degree students. During the years 1990 to 2009, 98 PhD and 314 master's degrees were awarded. In the context of a small country, these numbers are big. The IMCB staff members annually publish around 90 scientific papers in recognized international peer-reviewed journals.

The main strength of the institute is the functional integration of teaching, internationally recognized high-level research, technological development and innovation. It is important to underline the fact that the IMCB has always taught at all three academic levels: bachelor's, master's and PhD. This creates a constant flow of new, talented young people, who want and are able to become good scientists. For two periods (2005–2008 and 2009–2015), the institute has been host to the Estonian Graduate School in Biomedicine and Biotechnology, which also includes international partners.

Many small- and medium-sized biotechnology enterprises originate from the IMCB. The researchers, faculty members and graduates of the IMCB actively take part in designing, governing and managing strategic issues of research and society, both nationally and internationally.

During the years 2001 to 2007, the IMCB led the consortium that formed the Estonian National Centre of Excellence for Gene and Environmental Technologies. Currently, the institute participates in the work of two Estonian centres of excellence.

Every year, our scientists open new, strategically important directions of research, and are successful in ensuring their development under conditions of tight international competition where they have found a good balance between competition and collaboration.

Prit Pechter

Dr Hannes Kollist (left) and Mobilitas top researcher grant awardee Mikael Brosche study plant stress responses at TUIT.

Combining basic research with innovation, interdisciplinarity and globalization

Only 7% of clothing is sold online, compared with 50% of computers and 61% of books. Although internet applications have changed the world, some areas of business have not yet adopted the changes.

Together with industrial partners, Professor Alvo Aabloo from the University of Tartu, Institute of Technology (TUIT) is providing one solution: a virtual fitting room application for online clothing retailers that allows the users to find the size that fits them. Fits.me was the overall winner of the Plugg.eu Startups Rally 2010, one of the most important European conferences for web technologies. The Intelligent Materials and Systems Laboratory led by Aabloo brings together knowledge from diverse fields of expertise: materials science, robotics, chemistry, computer science and electronics. The laboratory is mainly focusing on the development and exploitation of ion-conducting polymers that change their shape and size when electrically stimulated.

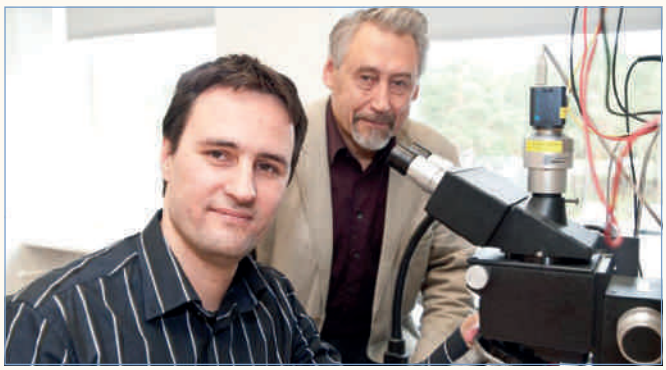
The research groups of professors Mart Ustav and Andres Merits in the TUIT have provided insights into the molecular biology of DNA and RNA genomic viruses. Both groups are also part of the Centre of Excellence in Chemical Biology. Ustav's group has established that a rare type, complex, recombinant HIV-1 strain dominates the epidemic in Estonia. FIT Biotech is using the basic knowledge of HIV to develop a vaccine. Merits' group has achieved advances in studying the biogenesis of alphavirus replication complexes and the mechanisms of virus–host interactions, and is currently working on finding inhibitors for those processes.

The TUIT was founded 10 years ago, with the aim of increasing the competitiveness of Estonian companies. In 2004–2006, four research and development centres (Biomedical Technology, Material and Chemical Technology, Environmental Technology, and Information Technology) were established and equipped. At present, the institute has 135 staff members, including 40 PhD students. The institute is relying on strong leading researchers managing project portfolios from basic research to product development. The protection and commercialization of research results is considered as a primary option — the researchers at the institute are the authors of 16 out of the 38 most promising inventions in the university's intellectual property portfolio. The research institute's strategy to focus simultaneously on basic research and innovation, with an innovation support structure working closely with researchers, and its commitment to repatriate native researchers as well as to create an international research community, have proven to be successful and sustainable.

"Were the internet to have a postal address, it would most likely be here in Estonia"

"We have reason to be proud of our highly developed telecommunications network. Estonia is a place you can take your laptop into the deepest forest and still hook up to the internet. It is no accident that Skype was born here." These words of the President of Estonia, Toomas Hendrik Ilves, characterize well the transition of Estonia into one of Europe's most information and communication technologies (ICT)-savvy nations. The transition has been powered by the innovative use of ICT, the extensive implementation of public ICT services such as e-elections, e-taxes, e-healthcare and e-schools, and the widespread adoption of ICT by the general public and several successful Estonian ICT companies.

The Faculty of Information Technology in the Tallinn University of Technology (TUT) is one of the main ICT research bodies in Estonia. The faculty, together with its more than 150 staff members, plays a decisive role in the Estonian economy, providing education in the fields of software, systems, computer, electronics, telecommunication and information-management engineering. Different research groups collaborate with a wide range of Estonian and international enterprises and public authorities. The research activities of the faculty are coordinated by the Centre for Integrated Electronic Systems and Biomedical Engineering (CEBE) — one of the seven Estonian centres of research excellence.



Eiko Lainjärv

Mobilitas postdoctoral fellow Athanasios Giannitsis and his supervisor Professor Mart Min develop bioimpedance measurements in microfluidic devices at TUIT.

The mission of CEBE is to carry out fundamental and strategic interdisciplinary research and development in the fields of electronic components, systems, and computer and biomedical engineering, with applications in medicine, semiconductor and information technologies. Our ultimate goal is to achieve synergy by uniting the emerging knowledge of nanotechnologies, biomedical sensors, signal-processing methods, design and test paradigms based on system-on-a-chip (SoC)/network-on-a-chip (NoC) technology and advanced design for dependability methods, to come up with flexible solutions for real-time, mobile and reliable embedded systems.

In recent years, the faculty has shown considerable ambition and entrepreneurial flair for developing its research capacities by being a partner in the national development centre programme (ELIKO). ELIKO's mission is to improve the competitiveness of the ICT industry through the deep integration of research and production institutions. ELIKO will help in reducing the risks of development and validating the emerging ICT solutions for tomorrow.

Since 2005, the faculty has invested more than €4 million in research infrastructure. Our researchers are coordinating or participating in more than 10 EU-funded projects and the faculty has spun off almost 10 high-technology companies. ■