estonia

Higher Education and Research in Estonia

European Union
European Regional
Development Fund

Investing
in your future

Coverphoto: Rasmus Jurkatam

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Introduction

Estonia has a broad, innovative and diverse higher education and research landscape. This booklet serves as a primer for anyone interested in learning about the higher education (HE) and research possibilities in Estonia, providing an overview of the HE and research systems, institutions and course programs conducted in English on bachelor's, master's and doctoral levels. The booklet is also your guide to funding, with simple and short info on how to finance your studies and research in Estonia. In order to highlight the success of Estonian researchers and the impact research has had in giving life to new innovations, the booklet presents short stories from different fields. The Frascati classification of science and technology is used to structure the booklet — dividing the content into 6 sections.

Your journey to discover higher education and research in Estonia starts here. Enjoy the trip!

An overview of Estonia

Estonia sits at the north of Europe, and is the northernmost of the three Baltic states. The Baltic sea meets its western and northern coastlines and over to the east by Lake Peipus and the Narva River. The east and southeast of the country borders Russia, and Latvia to the south. Estonia's capital city is Tallinn, just 85 km south of Finland's capital Helsinki, across the Gulf of Finland. Sweden is Estonia's closest western neighbour across the Baltic Sea.

Estonia often gets referred to as a small country, but in fact, with an area of 45,000 sq. km, Estonia is bigger than Belgium, the Netherlands, Denmark and Switzerland! Though it's still five times smaller than Great Britain. Almost half of the country is covered by forest and woodland.

Here are some interesting facts about Estonia:

About 22%

of Estonia is wildlife preserves

- The longest day in the summer lasts for over 19 hours, whilst the shortest winter day lasts only six hours.
- Various bogs and wooded swamplands cover over one fifth of the country — beaten worldwide only by our northern neighbour, Finland.
- About 22% of Estonia is wildlife preserves
- Estonian wooded meadows are amongst the world's richest communities — with one square metre being home to more than 70 plant species. This figure can exceed the small-scale diversity found in the tropics at times.
- Hiiumaa island is the Nordic Bora-Bora. With a surface area of a thousand square kilometres and barely 10,000 inhabitants, each visitor can easily find paradise and a tourist-free beach of their own such as Luidja or Tahkuna.
- The Kaali meteorite crater is from the world's last giant meteorite that fell into a high density area. The power of the blast was comparable to that of a nuclear bomb, leaving a scar on the landscape that inspired many a folk tale.

Estonia has the highest number of meteorite craters per square kilometre in the world

- Estonians have a recorded 133,000 folk songs, one of the biggest collections in the world.
- Estonia is egalitarian, with about 50% of engineers and scientists being women (European Union average being 29%).

The Baltic Sea Region is one of the fastest growing economic regions in Europe, and Estonia is located at its heart. Home to more than 90 million people, the region is also Europe's fastest growing, most diverse and rewarding markets in Europe, spanning the well-developed economies of Scandinavia and Northern Germany, the rapidly expanding economies of the Baltic States and Poland, and the vast potential markets of Northwest Russia.

Estonia's liberal and innovative economy is built on a solid foundation of IT, or information technology. It's one of the most popular areas of business and also 'the thing' to study. Nowadays, IT has infiltrated services and the industrial sector, greatly changing the way things are done. The main trend leans towards simplification, innovation and customer-friendliness.

In Estonia it's easy to open a company, you can register a new one in under 3 hours.

Also, companies don't have to pay income tax for reinvested profits, this really encourages entrepreneurship; promoting innovation and the quest for new solutions through business ventures. Income tax is only payable on profits paid out to shareholders.

Estonian is the official language of Estonia. Spoken by about 1.1 million people in the country itself and thousands of others abroad, this Finno-Ugric language is closely related to Finnish and distantly related to Hungarian. Over the years Estonian has been influenced by German, Russian, Swedish and Latvian, though is not related to any of them.

The higher education and research system

In Estonia a child starts their education with the general education level. General education is divided into pre-school, basic and upper-secondary education (Chart 1). Pre-school education is delivered to children between the ages of 18 months to seven years in dedicated educational institutions.

Basic education serves as the mandatory minimum of the general education requirement,

which can be acquired either partially in primary schools (grades 1 to 6), basic schools (grades 1 to 9) or in upper-secondary schools that also teach the basic school curricula. After graduating from the basic school, there are a number of possibilities for the continuation of education. There's the possibility to acquire general secondary education at an upper-secondary school, vocational secondary education at a vocational education institution or simply an occupation. Attaining general secondary education entitles students to continue their studies at a higher education institution or to obtain vocational education.[1]

[1] Pre-school, basic and secondary education. Ministry of Education and Research, Republic of Estonia. hm.ee/en/activities/pre-school-basic-and-secondary-education (10.03.2020).

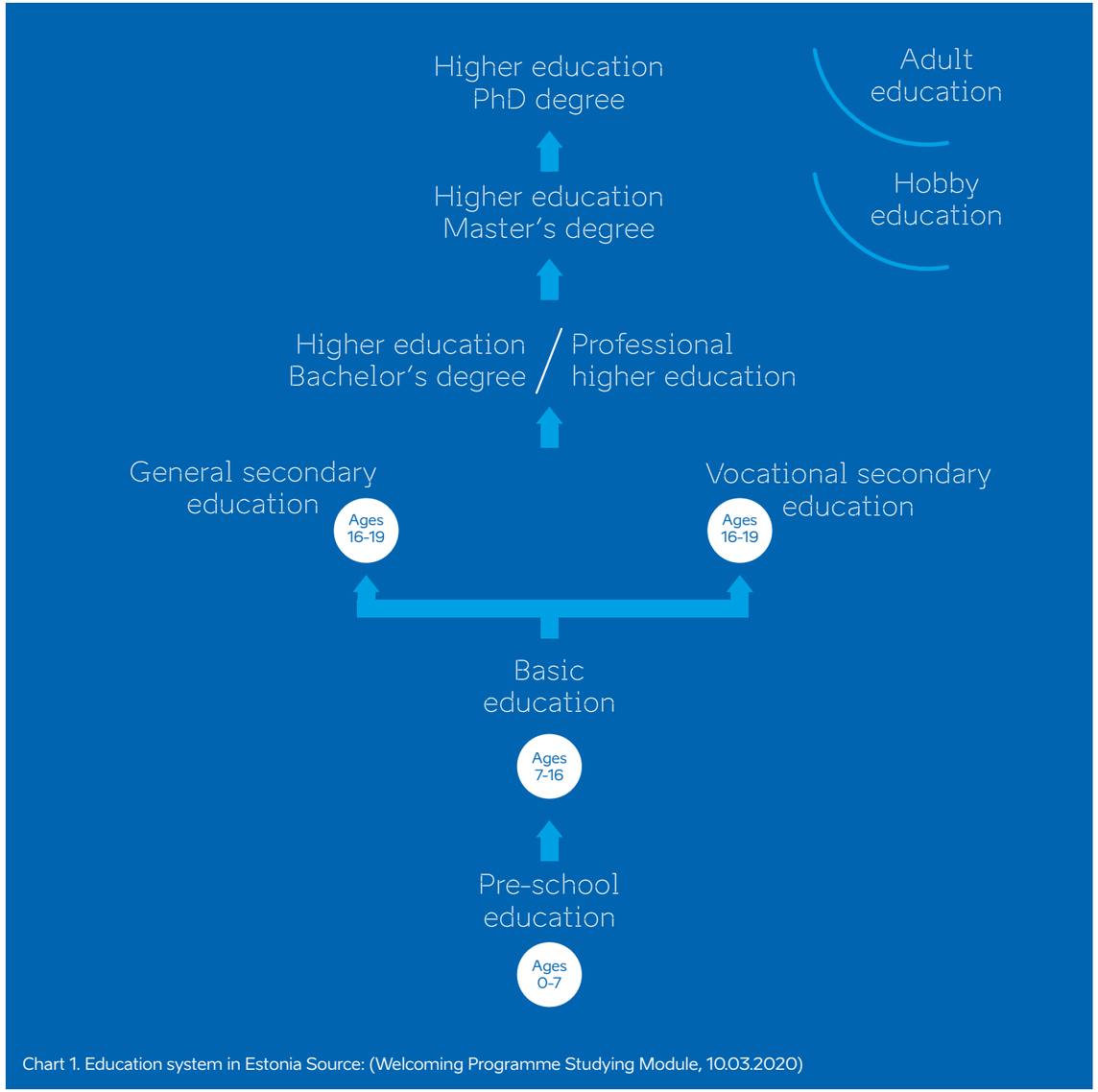


Chart 1. Education system in Estonia Source: (Welcoming Programme Studying Module, 10.03.2020)

When choosing to continue in a higher education institution, you can pick either a bachelor's programme (3 years), an integrated programme (5–6 years) or a professional higher education programme (Chart 2). Both bachelor's (BA) and professional higher education programmes will allow you to apply to a Master's (MA) level programme (1–2 years). The final level of higher education is doctoral level (PhD programme).[2]

Since the academic year of 2012/2013 higher education has been free of charge in Estonia, for those studying full-time in Estonian.[3]

The PhD route takes four years and ends with a thesis and a doctoral degree. After that you can choose a job in industry or in science and/or carry on your academic career as a postdoctoral student.

[2] Description of the Estonian higher education system (2013). Ministry of Education and Research, Republic of Estonia. hm.ee/sites/default/files/higher_education_system_2013.pdf (10.03.2020).

[3] Higher education. Ministry of Education and Research, Republic of Estonia. hm.ee/en/activities/higher-education (10.03.2020).

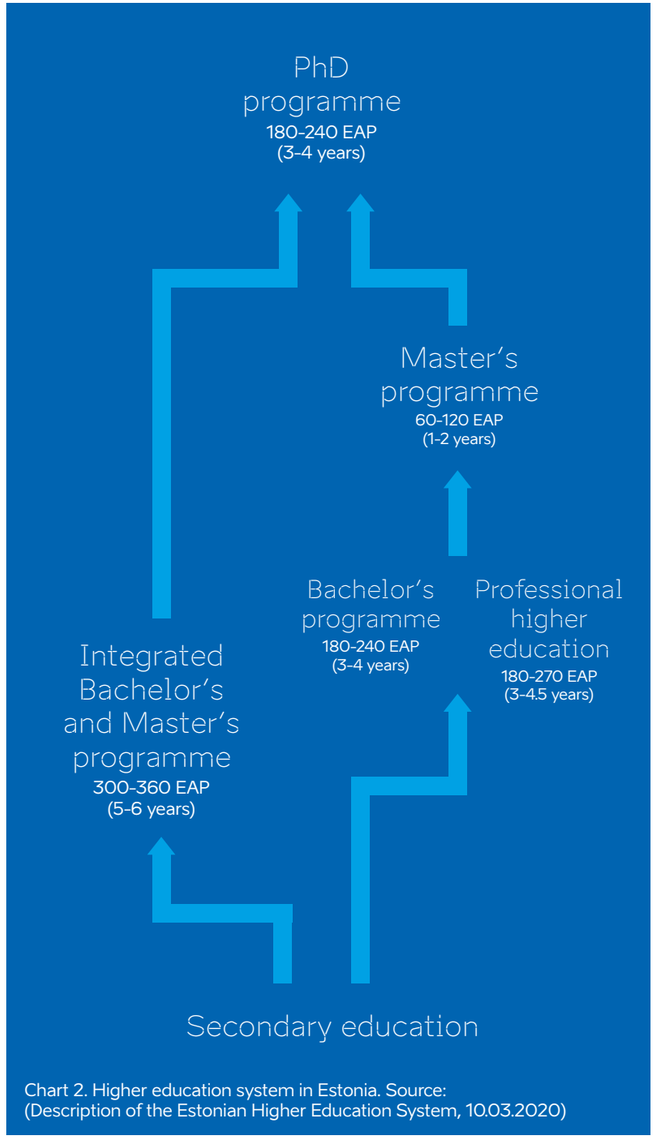


Chart 2. Higher education system in Estonia. Source: (Description of the Estonian Higher Education System, 10.03.2020)

Study in Estonia Event "Goodbye Academic Year 2017"
Photo: Höije Nuuter

The research system in Estonia

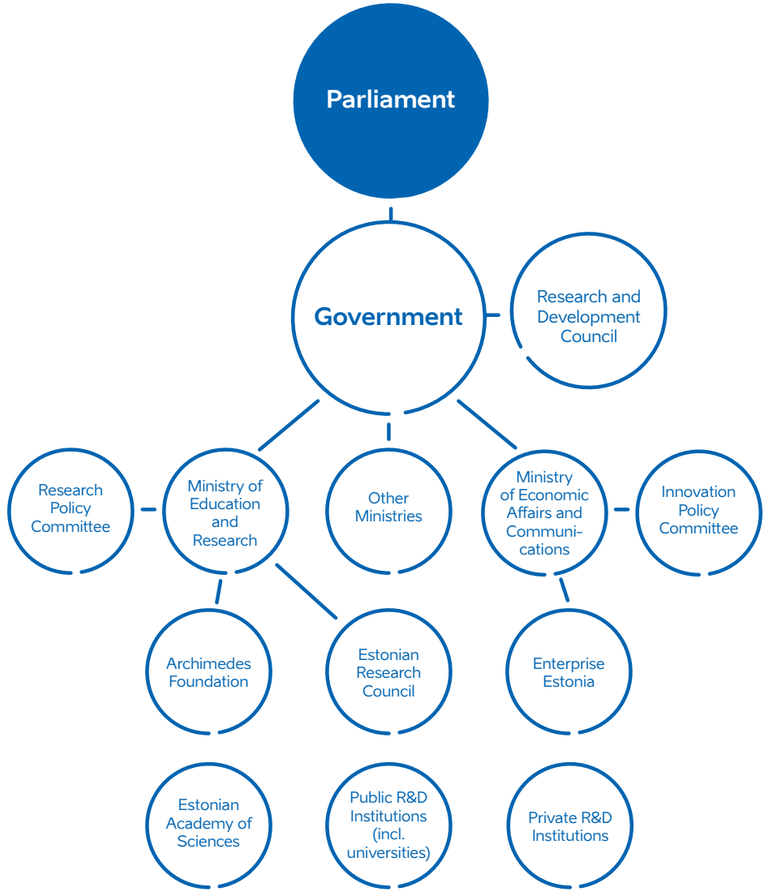


Chart 3. The research and development organisation structure in Estonia. Source: Estonian Research Council.

The legal basis for the organisation and functioning of the Estonian research system is the Organisation of Research and Development Act. The parliament of Estonia approves the overall research strategy based on this act. The government draws up the actual research policy, prepares sectoral development plans and coordinates cooperation between the ministries. The Research and Development Council provides technical advice to the government as needed.[4]

Ministries prepare and implement sectoral policies. The Research Policy Committee is an advisory body to the Ministry of Education and Research. The advisory body to the Ministry of Economic Affairs and Communications is the Innovation Policy Committee. State foundations, the Estonian Research Council and the Archimedes Foundation, are the principal institutions that organise research within the area of responsibility of the Ministry of Education and Research. Enterprise Estonia, which operates under the supervision of the Ministry of Economic Affairs and Communications, is the principal institution that funds innovation.

Research and development work is carried out by public sector research institutions (primarily universities) and private sector research institutions. The Estonian Academy of Sciences is an independent association of top-level scientists and scholars, with commitment and responsibility to advance scientific research and represent science nationally and internationally.[5]

[4] Estonian Research 2016 etag.ee/wp-content/uploads/2015/12/TA_teaduskogumik_ENG_veeb.pdf (23.05.2019).
[5] Estonian Research 2019 etag.ee/wp-content/uploads/2019/04/Estonian_Research_2019_veeb.pdf 24.05.2019).

Estonian higher education institutions

Here's the full list of higher education institutions in Estonia. These institutions are all in the jurisdiction of the Ministry of Education and Research. There are newer institutions as well as those with a long-standing history. The University of Tartu, for example, is one of the oldest in Northern Europe (1632). All the universities and many other institutions offer programmes in English; there really is something for everyone with an interest in higher education. We'll also give you a short description of the institution and what it's best known for.

Estonian University of Life Sciences.
Photo: Lauri Veerde

Universities under public law

Estonian Academy of Arts

artun.ee/en

The definitive centre of visual culture competence in Estonia, this university provides higher education in architecture, art, design and theoretical studies in these fields. The Academy welcomes motivated people who are visually and socially sensitive, as well as those who want to develop their thinking skills, seek new opportunities, and fulfil their potential as creative people.

Estonian Academy of Music and Theatre

eamt.ee/en/

The Estonian Academy of Music and Theatre is a public university offering postsecondary education in all major fields of the musical and dramatic arts at the undergraduate, graduate and postgraduate levels. Research into a multitude of subjects takes place under the musicology, education, pedagogy, and dramatic art departments.

Estonian University of Life Sciences

emu.ee/en

Located in Estonia's student capital Tartu, this is one of the top 100 universities in the world in the field of agriculture and forestry.

Tallinn University of Technology

taltech.ee/en

The only university of technology in Estonia and the flagship of Estonian engineering and technological education. Here, synergy between various fields (technological, natural, exact, social and health sciences) is created and new ideas are born.

Tallinn University

tlu.ee/en

This modern university is continuously developing, its main strengths lie in the fields of humanities and social sciences, as well as a strong and ever growing competence in the field of natural and exact sciences. The university also accommodates one of the most state-of-the-art film and media schools in Europe.

University of Tartu

ut.ee/en

The biggest university in Estonia, the most highly ranked university in the Baltic states and one of the oldest universities in Northern Europe.

University of Tartu

Privately owned universities

Estonian Business School

ebs.ee/en

The oldest and biggest private university in the region and among the top 300 business schools in the world. It offers students a great opportunity to learn from experienced entrepreneurs and renowned researchers in the field of business.

State professional higher education institutions

Estonian Aviation Academy

lennuakadeemia.ee/en

A state-owned professional higher education institution educating and training specialists for Estonian aviation enterprises and organisations.

Estonian Academy of Security Sciences

sisekaitse.ee/en

A state institution, providing professional education for civil servants belonging to an area of government under the Estonian Interior Ministry. The objective of the academy is to create secure conditions for stable development across the state of Estonia. They do it through internal security related academic education, research and development activities, and the training of honest, competent public servants. This in turn contributes to the security of the entire European Union.

Estonian National Defence College

ksk.edu.ee/en

This is an institution of vocational training. Developing from secondary education for applied higher education and military research related to national defence, their aim is to train and educate senior non-commissioned officers, as well as junior and senior officers for the Estonian Defence Forces, the National Defence League and other military institutions.

Tallinn Health Care College

ttk.ee/en

The college provides professional higher education in Health and Welfare through applied research and development. Promoting the professions taught in the college is important, as well as influencing health behaviours in the population, contributing to the shaping of a healthy living environment and the organisation of in-service training.

TTK University of Applied Sciences

tktk.ee/en

The largest university of applied sciences in Estonia, TTK is a state higher education institution for professionals, offering competitive higher education in the fields of engineering, production, technology, architecture and construction.

Pallas University of Applied Sciences

pallasart.ee/en/

Tartu Art College is a university of applied arts dedicated to developing Estonian art, helping conserve cultural heritage, promoting the use of contemporary information technology, and supporting entrepreneurship and the creative industries.

Tartu Health Care College

nooruse.ee/en

Professional higher education is gained through their study programmes on midwifery, nursing. There are programmes for nursing specialists, bioanalytical laboratory scientists; and on environmental health, radiography and physiotherapy. Vocational education is acquired through study programmes for care workers, child minders and emergency medical technicians.

Private professional higher education institutions

Baltic Methodist Theological Seminary

emkts.ee

The seminary specialises in practical theology and biblical study. Their mission is to promote spiritual formation and provide applied higher theological education and in-service training that adheres to the needs of Church and society in accordance with international requirements.

Estonian Entrepreneurship University of Applied Sciences

euas.eu

They have four main fields at the level of professional higher education: (startup) entrepreneurship, management, information technology and design for creative entrepreneurship. This university plays a significant role in educating small entrepreneurs, specialists and managers.

Institute of Theology of the Estonian Evangelical Lutheran Church

ui.eelk.ee

The Institute of Theology is an educational centre for the entire Lutheran church in Estonia, providing not only degree programs in theology but also continuing training, both for pastors and other professionals, and also volunteers in the church ministry.

Estonian Free Church Theological Seminary

kus.kogudused.ee/en

Tartu Theological Seminary has evolved into an academically respected educational institution that collaborates closely and cooperatively with the local churches. The Seminary provides applied higher education, vocational training, counceling and mentorship.

Tallinn University of Technology

Estonian research institutions

Most research and development in Estonia is carried out within the universities. The largest public research university is the University of Tartu, followed by Tallinn University of Technology, Tallinn University, the Estonian University of Life Sciences, the Estonian Academy of Music and Theatre and the Estonian Academy of Arts. There are, however, several independent research institutes that also perform research at a high level. Today, nearly all basic research is conducted in the public sector; the private sector focuses mainly on product development and innovation.

Positively evaluated Estonian R&D institutions are as follows:

Center of Food and Fermentation Technologies

tftak.eu/en

The Center of Food and Fermentation Technologies main scope and content of the research is the development of a systems biology platform for the study of microorganisms. This platform is applied to solve food technology and nutritional science tasks which are primarily concerned with food quality, the stability of sensory and nutritional properties, and the relationships between food and health.

BioCC

biocc.eu

The focus of the competence centre is to enhance the industry's competitiveness and profitability through innovative solutions, encompassing the whole chain (feed industry, cattle breeding and nutrition, dairy technology, human nutrition and medicine) of the production of healthy added-value milk and dairy products. The shareholders of the company are the University of Tartu, the Estonian University of Life Sciences, Starter Ltd., Dairy Co-operative E-Milk and Animal Breeders Association of Estonia.

Cybernetica

cyber.ee/en

Cybernetica is a R&D intensive ICT company that researches, develops and manufactures software solutions, light signalling and telematics products, maritime surveillance and radio communications systems. They also investigate and apply theoretical and practical security solutions.

Estonian Academy of Arts

artun.ee/en

The Estonian Academy of Arts is Estonia's most important centre of expertise in art, design, architecture, art history, cultural heritage and art education. This is the leading university in Estonia awarding doctoral degrees in the arts, and is the main promoter and advocator of artistic and practice-based research.

Competence Centre for Health Technologies

ccht.ee/home

The Competence Centre for Health Technologies is a biotechnology company focused on research and product development in the fields of personal medicine, drug development and both human and veterinary reproductive medicine. Their collaboration partners include leading Estonian scientists and biotechnology companies, as well as scientific medical and R&D institutions from Europe, Asia and America.

Estonian Academy of Music and Theatre

eamt.ee/en

The Estonian Academy of Music and Theatre (established in 1919) is the only institution in Estonia where academic research in musicology, music theory and ethnomusicology is integrated with university level teaching from undergraduate to doctoral levels.

Estonian Business School (EBS)

ebs.ee/en

Estonian Business School is the oldest privately owned business university in the Baltics. With more than 1500 students, their goal is to provide enterprising people with academic knowledge, skills and values for successful implementation. Researchers and doctoral students at this university participate in international research groups, international scientific conferences, and publish joint articles with researchers and doctoral students in other countries.

Estonian Literary Museum

kirmus.ee/en

The Estonian Literary Museum is the leading centre for Estonian Studies in Estonia. Its aims include the preservation of the Estonian language and culture, advancement of Estonian Studies and the participation in international research and development activities.

Estonian National Museum

erm.ee/en

The Estonian National Museum preserves the essence of continuity and tradition. The museum is the generator and developer of cultural dialogue which links the past to the future. The museum's role as a centre of ethnological research is to record, study and interpret culture as a way of life, taking into account its periodical, spatial and social diversity.

Estonian Crop Research Institute

etki.ee

Research and development activities of the Estonian Crop Research Institute support increase of efficiency and competitiveness of agricultural production, mitigate negative impact of agricultural production on the environment and help in the maintenance of agrobiodiversity.

Estonian University of Life Sciences

emu.ee/en

The Estonian University of Life Sciences is the country's centre for research and development in agriculture, forestry, animal science, veterinary science, rural life and economy, food science, biodiversity, nature protection, renewable natural resources and environmentally friendly technologies.

Institute of the Estonian Language

en.eki.ee

The Institute of the Estonian Language is a research and development institution whose mission is to contribute to the survival and good health of the Estonian language, by the cultivation and advancement of standard Estonian, by compiling and editing dictionaries essential for the national culture and by the maintenance of relevant data collections, as well as by fundamental and applied research supporting the above activities. It also provides language-technological support.

National Institute for Health Development

tai.ee/en

The National Institute for Health Development is a government established research and development body collecting, connecting and providing reliable national information from a multitude of sources, related to the health of the Estonian population.

Protobios LLC

protobios.com

Protobios is an Estonian biotechnology company founded in October 2003, and is positioning itself as a developer of new diagnostic tests as well as a service provider in the field of immunome analysis.

Tallinn University

tlu.ee/en

Research in Tallinn University (TLU) is conducted in five focus fields, through six institutes and one regional college. In order to support interdisciplinary and international cooperation, TLU has launched five centres of excellence. Being established as a research university only in 2005, Tallinn University has taken its place among the 5% of the best universities in the world in a very short time. TLU has also a strong social conscience and an open-minded, flexible and collegial environment for academic and personal growth.

National Institute of Chemical Physics and Biophysics

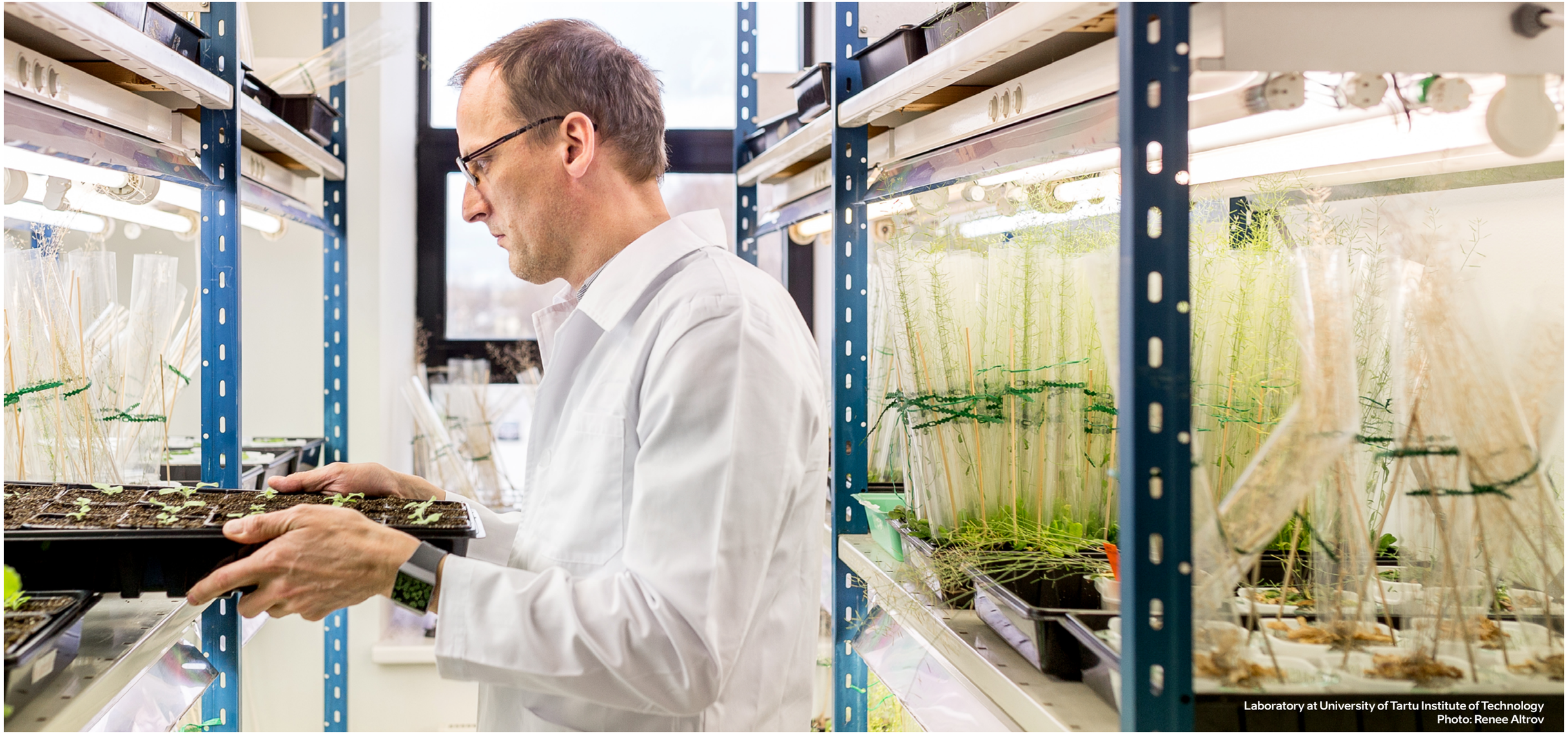
kbfi.ee

The National Institute of Chemical Physics and Biophysics is an interdisciplinary research institute which carries out basic and applied research in materials science, genetic engineering and biotechnology, environmental technology, and in the field of particle physics and informatics.

Software Technology and Applications Competence Center

stacc.ee/en

The Software Technology and Applications Competence Centre (STACC) is an R&D organisation where companies can access expertise in (big) data analytics and co-develop visionary technology products in this field.



Laboratory at University of Tartu Institute of Technology
Photo: Renee Altrov

Tallinn University of Technology

taltech.ee/en

Tallinn University of Technology (TalTech), the only technological university in Estonia, is the flagship of Estonian engineering and technology education. In TalTech a synergy between different fields (technological, natural, exact, economic and health sciences) is created and new ideas are born. TalTech is set to become one of the leading technological universities in the Baltic Sea region.

Under and Tuglas Literature Centre

utkk.ee/en

The Under and Tuglas Literature Centre of the Estonian Academy of Sciences is an institution of research and development attached to the Estonian Academy of Sciences. Its mission is to study Estonian literature and the local written culture in general, both from historical and theoretical perspectives, within the context of a historically multilingual Baltic space, as well as world literature.

University of Tartu

ut.ee/en

The University of Tartu (UT) is Estonia's leading centre of research and training. As Estonia's national university, UT stresses the importance of international cooperation and partnerships with reputable research universities all over the world. The University of Tartu belongs to the top 1% of the world's most-cited universities and research institutions in the fields of Clinical Medicine, Chemistry, Environment/Ecology, Plant and Animal Science, Geosciences, Social Sciences, Molecular Biology and Genetics.

Funding

Funding studies for international students

Estonian higher education institutions (HEI) charge fees that are comparable with those in other European countries, as well as offering various degree programmes taught in English, some of them with tuition fee waivers. International students in Estonia can make use of one of many generous scholarship schemes designed to help with different expenses and boost student mobility.

Bachelor and Master studies funding

Tuition fees for English taught degree programmes at different universities can vary a fair bit, depending on the level of studies and the speciality in question. Generally, tuition fees range from 1500€ to 6000€ per year (except the Medicine programme which is 11 000€ per year) for Bachelor's and Master's programmes. Some higher education institutions may have different tuition fees for students from the European Union and those from outside the European Union. Additionally, some universities offer select Bachelor's and Master's programmes with no tuition fee at all (tuition fee waivers, tuition free programmes), especially in the engineering and ICT field. There is a wide range of scholarships available for both Bachelor and Master studies students.

Doctoral studies funding

Doctoral studies are tuition free at public universities with the possibility of fee waiver available at the private institutions. Every faculty and Doctor of Philosophy (PhD) programme has a set number of study places financed by the state. In 2019, the monthly scholarship for all doctoral students who are accepted is 660€, this is granted to all state financed doctoral students. This monthly scholarship also covers the doctoral student's national health insurance. Many additional scholarships are also available for international PhD students! Applicants should apply for the scholarships through their university.

Living costs and working

Monthly living costs come in at around 300-500€ in addition to housing costs. Monthly rent for a dormitory is between 70-100€, rent for a one-bedroom apartment is around 250-400€. During your studies, you are allowed to work without an additional permit. You can also stay in the country for 9 months after you graduate to look for a job.

Exchange studies funding

Exchange students coming to Estonia are exempt from tuition fees from Estonian universities and are entitled to a small grant if it's stipulated in their agreement.

Scholarships

The Estonian Government and different organisations have created various scholarship schemes (Estonian National Scholarship programme, Dora Pluss, Kristjan Jaak Scholarships, Compatriots programme, Skype and Study IT in Estonia Master's Scholarships, Estophilus, etc.). These are available for full time international students and researchers, exchange students, short course participants and visiting scholars and lecturers. They're used mainly for funding studies, developing mobility (short and long-time, exchange studies) and supporting different research areas and fields.

More information about scholarships:
studyinestonia.ee/scholarships and haridus.archimedes.ee/en


Photo: Rasmus Jurkatam

Funding research

Research in Estonia is mainly financed by government and businesses, which both account for approximately 40% of research funding. The rest comes from foreign funds (mainly EU framework programmes). National funding is organised mainly by the Estonian Research Council but also by sectoral ministries. National funding instruments are

- Baseline funding
- Research infrastructures
- Centres of excellence
- Doctoral schools
- Research grants
- Proof-of-concept grants
- Mobility grants
- Applied research funding

Baseline funding

Baseline funding means financing of R&D institutions for the purpose of attaining their strategic development objectives, including co-financing national and foreign projects and opening up new research routes, and investing in infrastructure. Baseline funding is provided from the state budget via the Ministry of Education and Research to R&D institutions who have been evaluated positively. Baseline funding maintains financial stability and gives R&D institutions a better chance to focus on their core activities.

Research infrastructures

The Ministry of Education and Research provides support for R&D institutions to cover their infrastructure costs. EU Regional Development Fund is used to make investments to Research Infrastructures. A Research Infrastructure is comprised of facilities, equipment, collections, archives and structured information. The national research infrastructure roadmap a long-term planning tool, is used as input for investment decisions. The infrastructures that are included in the roadmap can be physical objects, service providers or memberships in international research infrastructures.

Centres of excellence

A centre of excellence consists of one or more high-level research teams with international reach that have a clear set of common research objectives. The research teams may be from one or several R&D institutions. The aim is to support high-level research and enhance the international impact of Estonian research. Centres of excellence receive support from the EU Regional Development Fund for a financing period of seven years. The funded activities include research and development, acquisition of equipment, mobility of researchers, national and international cooperation and popularisation of research findings.

Doctoral schools

Doctoral schools are launched in partnership between at least three R&D institutions. In the 2014–2020 period, Estonian universities launched 13 doctoral schools. They are project-based and funded from the EU Regional Development Fund. Their general purpose is to enhance the efficiency and quality of doctoral studies and to ensure accordance with the needs of the labour market. Doctoral schools support various events and research projects, and the mobility of PhD students as well as mobility across sectors.

Applied research

To further increase the economic and social impact of science in Estonia, targeted funding measures have been created in support of applied research:

- NUTIKAS - supports companies in commissioning the necessary applied research or product development projects from universities or research institutions in smart specialisation growth areas.
- RITA — aims to increase the state's role in the strategic managing of research. Ministries select the topics for applied research based on their sectoral needs and the research is conducted by Estonian R&D institutions.

Research grants

Research grants are intended for high-level R&D projects undertaken by individual researchers or research groups working in Estonian R&D institutions. There are three categories of grants that correspond to different levels of research careers:

- A postdoctoral research grant supports researchers who obtained their doctoral degree from an Estonian R&D institution who are launching their career at a foreign R&D institution.
- A start-up research grant supports researchers who are launching their independent career at an Estonian R&D institution in setting up their own research group and educating doctoral students.
- A team grant supports researchers who are continuing their career at an Estonian R&D institution in leading a strong research group and educating doctoral students.

Proof-of-concept grant

A proof-of-concept (PoC) grant (up to one year) is a competency-based research funding instrument for experimental development in order to test and/or create conditions for the commercialisation of research outcomes. The PoC grant is aimed at enhancing technology transfer, applying research outcomes in enterprises and in society, and strengthening the societal and economic impact of research.

Mobilitas Pluss Programme

The objective of the Mobilitas Pluss Programme is to internationalise research, increase mobility and support early career researchers. The programme has various mobility support schemes:

- Postdoctoral grants
- Returning researcher grants
- Support for study visits and training abroad
- Measures to support participation in Horizon 2020

For further funding opportunities see:
etag.ee/en/funding/research-funding/

Study and research areas

The following is an overview of the different research fields, with highlights of the best current achievements in each field by our researchers. It gives an outline of the research infrastructure units in the relevant field and the programmes in this field taught by higher education institutions. Just take some time to have a look at the highlights, Estonian researchers are currently making some wonderful things happen. If you feel inspired, then you're welcome to pick a programme and start studying in that field too!

The science fields are grouped according to the

Field of Science and Technology

(FOS) classification in the Frascati Manual (FM) (OECD, 2016)[8]:

This international classification has implications for many different areas of interest, including R&D surveys, R&D projects, policy issues and higher education. It can also be used by the business enterprise sector, making it the most suitable for use in this guidebook.

1. NATURAL SCIENCES
2. ENGINEERING AND TECHNOLOGY
3. MEDICAL SCIENCES
4. AGRICULTURAL SCIENCES
5. SOCIAL SCIENCES
6. HUMANITIES AND THE ARTS

[8] Frascati Manual 2015. Guidelines for Collecting and Reporting Data on Research and Experimental Development. read.oecd-ilibrary.org/science-and-technology/frascati-manual-2015_9789264239012-en#page1 (20.02.2018).

Natural Sciences

Natural science deals with the physical world, e.g. physics, chemistry, geology and biology. Research conducted under this field helps us find answers to environmental challenges as well as looking far above the Earth with the study of space as well. So, the scope for discovery here is quite wide.

Estonian researchers stand out with their innovative ways on how to use big-data to find everyday solutions for scientific problems.

Estonian natural sciences put great emphasis on studying the reasons for climate change. The current changes in climate are often seen as the impact of industrial development, but Ülo Niinemets, professor of plant physiology at the Estonian University of Life Sciences, argues that plants in the biosphere also emit gasses, with hundreds of thousands of various chemical byproducts. He and his colleagues use big data analysis to assist in their studies.

Take business management for example, big data analysis can be effectively applied here as well. The professor of software engineering at the University of Tartu, Marlon Dumas, has studied business process management (BPM) for more than a decade. The analysis of data helps to reduce the costs and error rates of business when applied correctly.

However, the cherry on top of big data analysis in practice, is Sharemind. Programmable, secure computations with practical applications. In other words, it is a data-analysing service based on complex mathematical calculations, which has a wide scope of impact and can give us a wider view on our government, society and broader environment.

Parabolic Antenna at Tartu Observatory. Photo: Renee Altrov

Highlights of Estonian Natural Sciences

Big-data analysis and safety: unraveling the encrypted foundation of digital society

Data has become an essential part of our everyday life in the digital age, as heaps of it is produced by our day-to-day activities. Despite all the information that we give out voluntarily, we expect it to be stored safely in governmental or commercial databases, which figuratively speaking, make up the 'encrypted foundation' of the digital society.

However, data sharing has its risks, especially to the wellbeing of data owners. Legislation and distrust derived from the need for privacy are only some of the barriers that prevent data sharing. The question is, how can we work with data whilst preventing any breaches to people's privacy?

This is how the researchers at Cybernetica came up with a data analysis solution, allowing governments, public and private companies to make decisions based on numbers and facts, instead of mere intuition and experience, and by utilising existing data in a secure manner.

Sharemind was developed in Cybernetica, a cybersecurity company where the core technologies of the Estonian e-government, like X-Road and internet voting solution have been created.

The team who developed the Sharemind secure data analysis concept was led by Dan Bogdanov, who obtained his PhD degree in 2013 for his thesis 'Sharemind: Programmable secure computations with practical applications', based on experimental governmental data-sampling.

Governmental authorities use databases to keep track of relevant data, such as student records in the Ministry of Education and Research, or tax records in the Estonian Tax and Customs Board. If these databases could be analysed by data scientists, relevant correlations might be found, which would help create better policies. In this example, comparing student records with tax records help analyse the correlation between working during studying and dropout rates. Current data protection laws prevent the

Sharemind has proven its indispensability in several applications and international projects, not to mention data-driven decision-making for governments.

comparing of such data, as it might compromise privacy. Sharemind however, allows the performing of analysis while the data stays encrypted — thus, technically invisible — preventing any misuse of private data.

Dr. Bogdanov has stated that the main idea behind Sharemind is to build trust between different organisations, by providing a 'data diving' co-encryption solution. Simply put, in our example the data from both the Tax and Customs Board and Ministry of Education was uploaded to the Sharemind application server, which acts as the main data-classification server. Then, different bulks of data were shared in an encrypted form between three different servers twice. After this process of cross-sharing the different pieces of data, Sharemind's analytics and reporting system gave researchers an output which showed that there is indeed a relationship between higher education and higher income, but no relationship between working during studies and dropping out.

More importantly, Sharemind showed that it's possible to carry out statistical analysis far more accurately than before, whilst retaining privacy. This experimental data-sharing project has built a path towards new applications, that until now organisations have only ever dreamed of. Sharemind has proven its worth in several applications and pilot projects, ranging from cooperation with the US military labs to human genome research, not to mention data-driven decision-making for governments. This Estonian data analysis solution has the potential to impact the world on a truly epic scale, revolutionising the way we share and process data in the digital society.

The goal of Sharemind research has been to enable new privacy-preserving data-driven services that organizations have so far only dreamed of. Sharemind has reached a maturity where it is used by governments and companies to support disease diagnostics, build financial reports, or make better policies. Research is still ongoing to improve the usability, performance and security aspects of the underlying secure computing technology.

Sharemind has many successful implementations worldwide, ranging from financial and medical sectors to mobile phone location data and government databases. For example, Sharemind has been used for:

- confidential financial benchmarking by the Estonian Association of Information Technology and Telecommunications,
- linking and analysis of governmental databases on tax and education to support policymaking,
- analysing mobile phone location data for tourism statistics by the Indonesian Ministry of Tourism.

Photo: Rasmus Jurkatam

Business process management: the art and science of overseeing how work is performed

Business leaders around the world are always trying to make their services or production quicker, leaner and more cost-efficient. Aiming for increased efficiency helps businesses gain an edge over their competitors and sparks innovation. But how can you see which areas are in need of improvement?

Marlon Dumas, Professor of Information Systems at the University of Tartu is among the top 1% of the world's most cited researchers in the field of computer sciences. He has researched Business Process Management, or BPM, for more than a decade.

For him, Business Process Management is the art and science of overseeing how work is performed in an organisation, in view of ensuring consistent outcomes and identifying and taking advantage of improvement opportunities.

A typical example of a business process is the order-to-cash process. It starts when a company receives a purchase order from a customer and ends when the products or services are delivered and the customer has paid. An order-to-cash process in a large company can have dozens of steps, each of which involves several actions and decisions. Having to deal with dozens if not hundreds of suppliers and customers, each one with their own idiosyncrasies, makes matters even more complex. BPM means deconstructing processes to see how each person or component in the chain works.

In other words, BPM acts as a bridge between business operations and IT systems, and allows us to understand how IT systems add value to the organisation by streamlining its work practices.

Professor Dumas and his colleagues from the University of Tartu in collaboration with researchers from the University of Melbourne have created a data-driven process improvement tool called Apromore. It analyses vast amounts of data from corporate systems to help analysts discover and prevent potential problems in business processes.

But once you have discovered the source of the problem, how do you decide on the best course of action to improve it? The current approach relies on processing large amounts of data, often only on the basis of the intuition and experience of the analyst. However, there are millions of parallel possibilities and solutions for improving any process.

Currently, Marlon Dumas is using an ERC Advanced Grant to develop an open-source tool called Pix that will use Artificial Intelligence (AI) to generate process improvement ideas automatically. Pix will consider all possible improvement opportunities and identify the combinations of changes that optimize the desired performance measures (e.g. cost and time). However, the final choice on how to act is left to the company's analyst.

Laboratory at University of Tartu Institute of Technology
Photo: Renee Altrov

Global climate change: the underestimated impact of biosphere

Global climate changes are often viewed from the human impact perspective, or to put it another way, we often see industrial development and mass production as the main cause of droughts, floods and other extreme weather conditions.

Plant physiology professor Ülo Niinemets from the Estonian University of Life Sciences argues that a biosphere made up by plants also has an impact on global climate change, this is due to trace gas releases that participate in oxidative reactions in the atmosphere, also, through aerosol and cloud formation.

Professor Niinemets therefore believes, that adding the biospheric trace gas emissions to regional and global climate models will significantly improve the predictions of global climate change.

What are these volatile compounds and how are biospheric trace gas emissions measured? During growth, plants produce around 100,000 chemical products, out of which 1700 are known to be volatile. These volatile organic compounds (VOCs) can be found in different parts of the plants, like the flowers, roots, leaves and fruits.

Niinemets and his team at the Estonian University of Life Sciences have focused on detecting trace gases emitted by vegetation, constitutively and in conditions of stress. They have found that whilst a few plant species are well known as constitutive emitters, all species can be triggered to produce VOCs under situations of stress often encountered in nature.

Some researchers argue that mapping different stress factors and their impact on emissions of VOCs is still vague, but Niinemets and his team have found encouraging evidence that the strength of the emission signal can be quantitatively related to the severity of different stress factors. Among other biological stress factors, such quantitative responses have been observed for European oaks infected by the powdery mildew fungus, and related to outbreaks of leaf beetles in alder trees.

Such quantitative responses could prove Prof. Niinemets' theory that plant emissions worldwide have been vastly underestimated.

Research Infrastructure Units of Natural Sciences

Estonian Center of Analytical Chemistry
Estonian Environmental Observatory
Natural History Archives and Information Network (NATARC)
Estonian node of European Life-sciences Infrastructure for Biological Information (ELIXIR Estonia)
Estonian Research and Education Optical Backbone Network
Estonian Scientific Computing Infrastructure (ETAIS)
European Molecular Biology Laboratory (EMBL)
Estonian-Finnish beamline at MAX-IV Synchrotron Radiation Source (FinEstBeAMS)
European Spallation Source ERIC
European Organization for Nuclear Research (CERN)

Estonian Membership in ESFRI object

European Life-sciences Infrastructure for Biological information (ELIXIR)

Higher Education Programmes in Natural Sciences

The following higher education institutions offer programmes in English in the field of natural sciences:

Institution	Level	Name of the Programme
Estonian University of Life Sciences emu.ee/en	PhD	Environmental Sciences and Applied Biology
Tallinn University tlu.ee/en	PhD	Analytical Biochemistry Ecology Physics
Tallinn University of Technology taltech.ee/programmes	PhD	Physical Science
University of Tartu ut.ee/en	MA	Excellence in Analytical Chemistry (Erasmus Mundus)
	PhD	Chemistry Geography Geology Materials Science Mathematical Statistics Mathematics Molecular and Cell Biology Molecular Engineering Physics Zoology and Hydrobiology

2 Engineering and Technology

In Estonia the area of engineering and technology sees significant scientific attention reserved for the material sciences, textile technology, electronics, robotics and a host of other fields.

There's a remarkable amount of scientific support behind the nanofiber fabric. Estonian scientists have developed a unique method of electrospinning, which will make it possible to produce large quantities of nanofiber in the future. Nanofiber fabric is thinner than a hair's breadth, which may consist of hundreds of fibers. It's used in medicine and electronics, but may also revolutionise the clothing industry in the coming decades.

At the same time a significant amount of research is being done in another area of engineering: developing a robot that copies the shape and motions of a fish. The objective behind that development is to understand how fish interact with their environment and how water flow could be used to save energy.

Photo: TalTech

Highlights of Estonian Engineering and Technology Sciences

Yarn electro-spinning – unique method of producing nanofibrous yarns

If regular yarn consists of a few dozen spun fibers, then engineers have developed yarn thinner than a human hair, which may consist of hundreds of component fibers. It's called nanofibrous yarn.

This 21st century material may revolutionise the clothing industry in the coming decades by providing smart material that could both store or conduct electricity.

Tallinn University of Technology (TalTech) has worked out a unique method of electrospinning as a result, which will make it possible to produce large quantities of the yarn in the future. Electrospinning means turning polymer solution into fibers in a high-voltage electrical field, and even though principle of electrospinning has been seen before, the one created at TalTech is unique.

In a glass cabinet under laboratory conditions at TalTech's Laboratory of Polymers and Textile Technology, preparation for the production of nanofibrous yarns is currently underway. Once the spinning machine is working it'll be reminiscent of a how a spider might spin a web, although nanofiber can actually be several times thinner than a spider's web. The principle of twisting together in a vortex of air, and where the speed of the air flow is very high, is what makes this machine effective. Andres Krumme, professor at TalTech's Department of Materials and Environmental Technology, said that the electrospinning machine developed at the university can take in large quantities of polymer solution at great speed, and therefore create large quantities of yarn in comparison with similar technologies developed so far.

The machine is suitable for the protective and sterile environment of the medical industry because, for example, it's compact and easy to use in a hospital laboratory. Such fibers could be spun into growth substrates for cells, as cells like to grow on nano-scale fibers, which could see various skins or veins grown in artificial conditions, and also medical sewing threads, which could contain substances aiding the healing of wounds.

Multilayered nanofibrous structures can also be utilised as the harness of capacitor components in smart textiles.

The electrospinning machine, which was built in TalTech alongside several cooperation partners and the Archimedes Foundation, is awaiting a patent.

U-CAT & Filose: breakthroughs in underwater biorobotics

Engineers throughout history have looked to the animal world for inspiration. This search for new ideas has developed into the research field known as biorobotics. Researchers working in this field are creating biomimetic robots, whose functions and abilities have been derived from plants and animals.

Engineers working at Tallinn University of Technology (TalTech) Department of Computer Systems: Centre for Biorobotics, have created two notable underwater robots. The first of those research and development projects was FILOSE, which resulted in the creation of the first flow sensing underwater robot. This fish shaped robot, whose form and movements are similar to those of a rainbow trout, is flow-aided and uses flow-relative navigation. The FILOSE fish robot prototype gave a new understanding of how fish interact with the flow around them, and how water flow could be used to save energy. Knowledge gained about how fish move upstream was used in the building of several upstream fish passes near water dams in Estonia.

The second project TalTech researchers have completed is an underwater robot called U-CAT, this has made a significant breakthrough in maritime archeology. The robot's principle of movement and ergonomic design is similar to that of sea turtles. The shape of a turtle gives the robot the ability to change direction quickly, and the fact it's so small and doesn't need a connection cable means it can navigate into very small spaces.

The designer of the U-CAT concept, Taavi Salumäe, explained that if conventional underwater robots use propellers for locomotion, the fin-type propulsors of U-CAT have the advantage of being able to drive the robot in all directions without disturbing the water and beating up silt from the bottom, which may decrease visibility inside the shipwreck.

The robot carries an onboard camera capturing video footage that can be used to reconstruct the underwater site at a later date. U-CAT is already helping maritime archaeologists, who say that this cordless turtle-shaped robot could help them examine thousands of Second World War shipwrecks in the Baltic Sea that have previously been too difficult to access.

Photo: Courtesy of Centre for Biorobotics, Tallinn University of Technology

Research Infrastructure Units of Engineering and Technology

Marine Technology and Hydrodynamics Research Infrastructure (SCC)
Center of Nanomaterials Technologies and Research (NAMUR+)
Smart Industry Centre (SmartIC)
European Space Agency (ESA)

Higher Education Programmes in Engineering and Technology

The following higher education institutions offer programmes in English in the field of engineering and technology:

Institution	Level	Name of the Programme
Estonian Academy of Arts artun.ee/en	PhD	Architecture and Urban Planning
Estonian Entrepreneurship University of Applied Sciences euas.eu	BA	Game Design and Development Software Development and Entrepreneurship
Estonian University of Life Sciences emu.ee/en	MA	Landscape Architecture
	PhD	Engineering Sciences
Tallinn University tlu.ee/cometostudy	MA	Digital Learning Games Open Society Technologies
Tallinn University of Technology taltech.ee/programmes	BA	Cyber Security Engineering Integrated Engineering
	MA	Applied Physics Communicative Electronics Computer and Systems Engineering Cyber Security (joint program with the University of Tartu) Design and Technology Futures (joint program with the Estonian Academy of Arts) E-Governance Technologies and Services Environmental Engineering and Management Health Care Technology Industrial Engineering and Management Materials and Processes for Sustainable Energetics (joint program with the University of Tartu) Mechatronics Technology of Wood, Plastics and Textiles
	PhD	Building and Civil Engineering and Architecture Chemical and Materials Technology Chemistry and Biotechnology Civil and Environmental Engineering Electrical Power Engineering and Mechatronics Information and Communication Technology Mechanical Engineering

Institution	Level	Name of the Programme
University of Tartu ut.ee/en	BA	Science and Technology
	MA	Applied Measurement Science Actuarial and Financial Engineering Bioengineering Computer Science Geoinformatics for Urbanised Society Materials Science and Technology Robotics and Computer Engineering Software Engineering
	PhD	Computer Science Engineering and Technology Environmental Technology Gene Technology

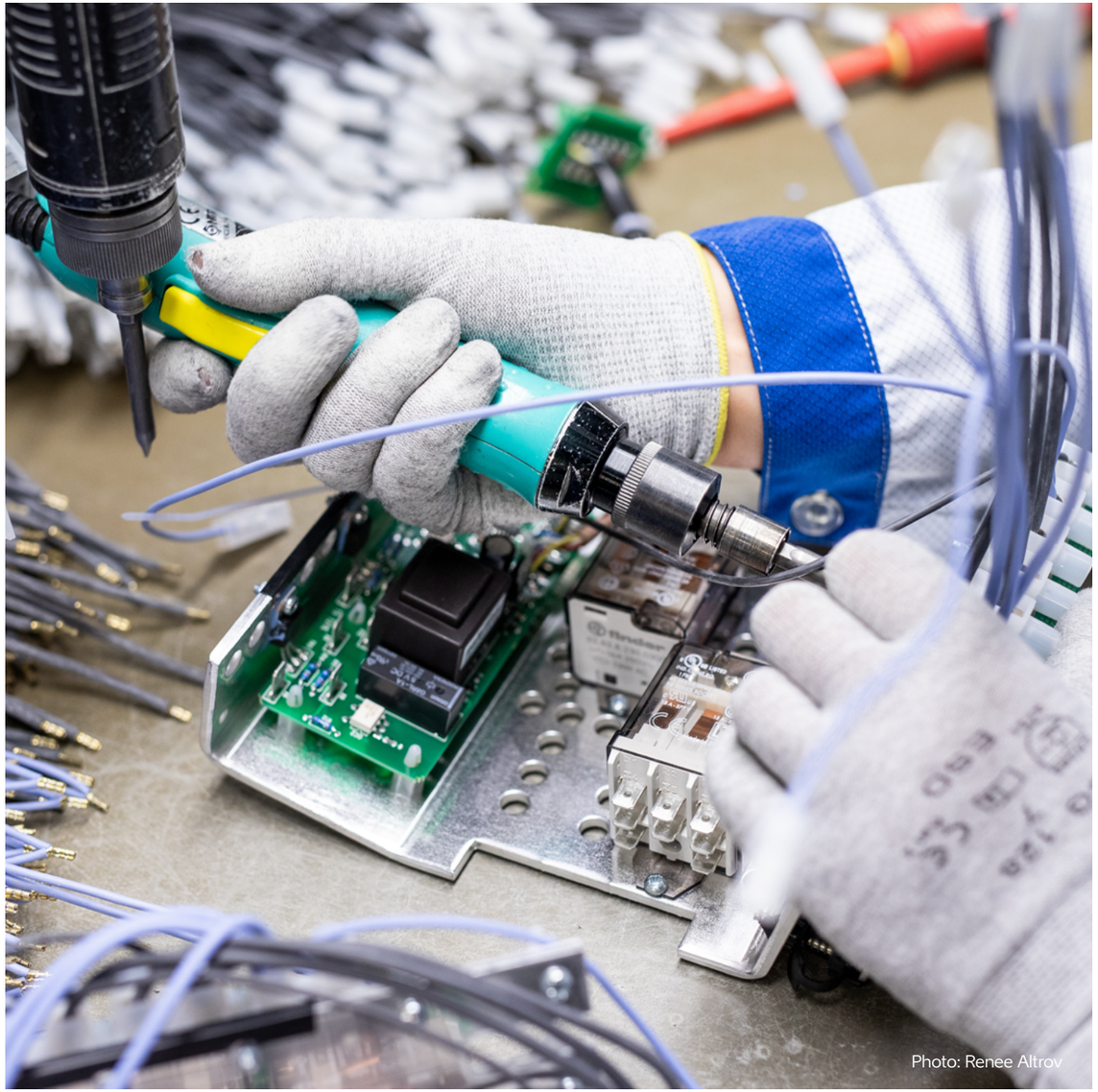


Photo: Renee Altrov

3 Medical Sciences

Clinical medicine and basic medicine are well developed in Estonia. Areas explored in the most fundamental parts of medical research include molecular biology, genetics, immunology, neuroscience, etc. The Estonian Biobank holds protected data on 20 percent of the country's adult population (200,000 participants) and is a massive boon to medical research. Estonia stands out for its ongoing ambition of developing and implementing the personal health care system. Furthermore, in the framework of genetics research, significant steps have been taken in finding new solutions for screening genetic disorders and studying the genetical structure across Europe.

Photo: Ben Grey/Creative Commons

Highlights of Medical Sciences

NIPT – harmless prenatal testing of chromosome disorders

Prenatal screening enables the assessment of foetal congenital disease in the early stages of pregnancy. Currently, testing demands a hypodermic invasive biopsy that is both hazardous and inconvenient for the baby and the mother alike. Approximately ninety percent of tests turn out to be negative, which means that the inconvenience was also unnecessary.

Non-invasive prenatal genetic testing (NIPT) is the latest and most precise screening method for detecting chromosomal disease. It is based on the modern sequencing technology of foetal cell-free DNA that is extracted from a 10 ml sample of the mother's venous blood.

The use of the NIPT method in prenatal screening can reduce the number of women undergoing risky and stressful invasive procedures. These include pregnant women whose foetus does not actually have a chromosome disorder, but who are sent to amniocentesis or chorionic villus sampling due to false positive results in the screening.

Congenital diseases are mainly chromosome disorders, of which the most prevalent are changes in the number of chromosomes, like Down (chromosome 21 trisomy), Edwards (chromosome 18 trisomy), and Patau syndrome (chromosome 13 trisomy). A NIPT that detects all the previous diseases can be conducted from the 10th week of pregnancy onwards.

Head of Precision Medicine Laboratory Kaarel Krjutškov explained that researchers from the Competence Centre on Health Technologies in collaboration with the University of Tartu have developed and successfully entered the Estonian market with their existing NIPT test. As of 2020 the Estonian Health Insurance Fund covers the cost of NIPT testing for women who are at higher risk of having a baby with a chromosomal abnormality.

Researchers at the Precision Medicine Laboratory are focused on using the latest scientific advances to solve modern challenges in reproductive medicine. A next generation of the NIPT test that will provide risk assessments for additional diseases will be launched in the coming years. In addition, the researchers have developed the personalized medicine test beREADY to find the optimal time for embryo transfer for each woman undergoing Assisted Reproductive Technology (ART) treatment. This test will help increase the success rate of ART treatment, especially for women with recurrent implantation failure.

Novel applications of SNP array data: finding out the genetic structure of Europe

In 2001, the Human Genome Project international consortium published a first draft and initial analysis of the human genome sequence. This draft sequence, of which data was immediately and freely released to the world, covered more than 90 percent of the human genome. The release became a stepping stone for further refinement of biological information, and for seeking the medically relevant implications of such DNA data.

Over a decade later senior researcher at the University of Tartu Estonian Genome Center, Tõnu Esko, has made efforts to fill the gaps in what's known about the genetic structure of northeastern European populations, doing so using the whole-genome single nucleotide polymorphisms allele or SNP allele frequency data, cataloged by the international SNP Consortium.

Alongside the advances in statistical methods and the determining of the haplotype structure of the human genome, the SNP data collecting method made the analysis of large quantities of genome data possible without any biological priors, and enabled the discovery of new pathways and biological mechanisms. This not only provided insights into human traits, but also into the origin of different diseases.

Genome researcher Tõnu Esko highlighted that the ultimate goals of human genetics are to understand the genetic architecture of complex traits and transfer the genetic findings into the medical field, in order to improve disease diagnosis and treatment.

Esko analysed genotype data of more than 270,000 SNPs of samples from 19 European populations during his research, which made the creation of a genetic structure map of the northeastern European population possible.

The results revealed that Finns are surprisingly distant from Swedes and other northeastern Europeans in their positioning, whilst Estonians tended to cluster next to their geographical neighbours, the Latvians, Lithuanians and northwestern Russians. This demonstrated that the Estonian Biobank samples could be analysed together with other cohorts of European ancestry in large-scale gene discovery studies.

Tõnu Esko emphasises that in order to effectively conduct genetic research, population-wide data collection is needed, with both collections of human biological samples as well as associated comprehensive clinical and lifestyle information.

This is why the Estonian Genome Center, which includes a wide range of health information, biological samples, and high-resolution genomic data for more than 150,000 samples from the Estonian population (by the end of 2019), is a valuable resource for further research of human genetic data.

Research Infrastructure Units of Medical Sciences

Estonian Center for Genomics
National Center for Translational and Clinical Research

Estonian membership in the ESFRI object

Biobanking and Biomolecular Resources Research Infrastructure BBMRI ERIC

Higher Education Programmes in Medical Sciences

The following higher education institutions offer programmes in English in the field of medical sciences:

Institution	Level	Name of the Programme
Tallinn Health Care College ttk.ee/en	BA	Assistant Pharmacist
Tartu Health Care College nooruse.ee/en	MA	Radiography
University of Tartu ut.ee/en	BA	Medicine
	PhD	Exercise and Sport Sciences Medicine Neurosciences Pharmacy

Estonian Genome Center at the University of Tartu
Photo: Renee Altrov

4 Agricultural Sciences

Estonian agriculture is a heartwarming story of connected people. From producer to processor, advisor to scientist, collaboration is key. Being connected ensures agricultural land remains healthy, practices environmentally sound and regional traditions respected; and we'll have locally produced and grown food on our tables. High quality and pure food is one of the natural resources of Estonia, therefore research into food safety and the sustainable production of quality food plays a key role. Plant ecology in general is one of the research fields where the diversity and productivity of Estonian life sciences becomes evident.

Photo: Kadri Kaarma

Highlights of Agricultural Sciences

Where is carbon bound and could harvesting stumps be an alternative energy source?

The need for bioenergy is increasing and stumps seem to be a prospective source of bioenergy.

In Estonia large scale stump harvesting is not yet a common practice, but the question is becoming a hot topic in a number of Nordic countries. According to the Paris Agreement 2015, the government of Estonia should ensure a significant reduction in the use of fossil oil shale and an increase in the share of bioenergy in the short term. Therefore, there is a need for a scientific study to answer the question of whether stump harvesting is profitable in terms of the environment and economy.

Veiko Uri - a Professor at the Estonian University of Life Sciences - and his colleagues, have studied the issue. Their recent study focused on the effect of stump harvesting on net nitrogen mineralisation, and on nutrient leaching. The research group concluded that harvesting of spruce stumps does not induce serious environmental hazards in relation of nutrient cycling.

There's 1.5 times more carbon accumulated in the soil of Europe than there is in forest biomass. The question is, how much of the carbon is accumulated in the soil and how much is in the biomass? And in light of this, is it still reasonable to harvest forest and stumps?

The results of different studies indicate that on fertile soil much of the carbon is mainly accumulated in the biomass. The biomass in the soil contains 10 per cent of the stand's carbon.

Should we harvest stumps? The answer is yes, it could be a prospective source for bioenergy. Stumps harvested from one acre could be used for heating up to six households a year, but since harvesting is expensive, the profitability of the usage of stumps needs further analysis.

Research Infrastructure Units of Agricultural Sciences

Plant Biology Infrastructure

Higher Education Programmes in Agricultural Sciences

The following higher education institutions offer programmes in English in the field of agricultural sciences:

Institution	Level	Name of the Programme
Estonian University of Life Sciences emu.ee/en	BA	Veterinary Medicine
	PhD	Agricultural Sciences Botany and Ecology Forestry Veterinary Medicine and Food Science

Laboratory at University of Tartu Institute of Technology
Photo: Renee Altrov

5 Social Sciences

Achieving success in Estonia is a game of juggling international research and public expectations for scientists. Having to convince the public that your work will also be visibly applied to everyday life. As a result, an interesting and exciting trend has emerged. Research within social sciences in Estonia has various applications in media studies, psychology, innovative learning and teaching solutions, as well as demographic studies, etc. However, most of all Estonia is famous for its e-solutions, e-voting and most recently e-residency amongst others.

As a result, Estonian social scientists are interested in the impact of e-voting on political behaviour. They have rather surprising findings to share from their studies based on the experiences of e-voting in Estonia.

Another concern of modern societies is the growing amount of bureaucracy. The issue of whether bureaucratic institutions can be innovative has also become a poignant field of study for Estonian researchers.


Photo: e-estonia.com

Highlights of Social Sciences

The impact of ICTs on political behavior – impact of internet voting

In 2005, Estonia became the first country in the world to introduce unlimited internet voting, and the number of e-voters has steadily increased ever since. As a relatively new phenomenon it is interesting to see the impact that information and communication technologies have on political behaviour.

Kristjan Vassil, former senior research fellow and current vice-rector for research at the University of Tartu has been focusing on the impact of ICT on political participation and electoral behaviour, specifically on internet voting and voting advice applications (VAA). Internet voting can be seen as a remedy for low voter turnout. On the other hand, various internet applications have been popular only within a limited group of technology enthusiasts. However, research has shown that both internet voting and VAAs have a nuanced impact on turnout, voting choice, and overall preferences.

E-voting has become widespread in Estonia, but an increasing number of e-voters does not necessarily mean that a diverse set of voters use internet voting.

Internet voting initially spread amongst a distinct subpopulation of younger tech-savvy voters only. This pattern started to noticeably change after the third e-enabled election. Nowadays paper and e-voters are almost indistinguishable from each other, indicating that this voting mode has spread out among a diverse set of voters.

Does internet voting boost turnout? As of 2019, Estonia has had eleven elections where people could cast legally binding votes over the internet. The figures were at first around two percent, but e-voting has steadily increased since. In 2014, every third vote was cast online and in 2019, close to 50% of votes were cast online. Internet voting has however not boosted turnout in Estonia. A large share of voters have simply switched from paper to online, but typical non-voters have not found their way to e-voting as of yet. Internet voting has thus made voting faster and more convenient for those who tend to participate actively anyway.

Kristjan Vassil has drawn two important conclusions. Firstly, technology has the potential to bridge social divides and ease political participation, not only for those who do not face any substantial obstacles, but also for the less privileged who command fewer resources. Secondly, the potential enabling effects of e-voting did not surface immediately after the adoption, but required a period of at least three elections.

Governance and innovation – can bureaucracies be innovative?

Much of the technology in your electronic reading device was funded either directly by the public sector or is a spillover from this funding. It may have been commercialised and packaged into new desirable and useful products, but the fundamental technologies that make our modern devices 'smart' were publicly funded.

But what makes states entrepreneurial? What is it that makes government machinery dynamic and bold enough to shape the future of innovation? Research led by Professor Rainer Kattel, Institute for Innovation and Public Purpose, University College London, and Ragnar Nurkse Department of Innovation and Governance at Tallinn University of Technology shows that successful governments—entrepreneurial states — manage to do a delicate balancing act. They are able to create space for agility (taking risks and experimenting, responding to new challenges) and providing stability (minimising long-term risks and uncertainty).

Capacity for innovation in bureaucracy is about having the space (skills, networks, organisations) for both agility and stability. Professor Kattel's research shows that governments create capacity for innovation through new organisations or new organisational forms, often led by charismatic outsiders or networks of such people. In other words, research shows us that innovative bureaucracies have to behave like start-ups and anti-start-ups at the same time: such organizations are often the ultimate agents of disruption (think of Estonia's e-residency project to export public services and create new markets) and/or of stability (think of EU's CERN and its decade-long build up and funding).

Research Infrastructure Units of Social Sciences

Infotechnological Mobility Observatory (IMO)
Estonia in the European Social Survey ESS
Estonian Generations and Gender Survey 2020 (GGS2020-EE)

Estonian Membership in ESFRI object

European Social Survey ESS ERIC

Higher Education Programmes in Social Sciences

The following higher education institutions offer programmes in English in the field of social sciences:

Institution	Level	Name of the Programme
Estonian Academy of Arts artun.ee/en	MA	Urban Studies
Estonian Academy of Music and Theatre ema.edu.ee/en/	MA	Cultural Management (joint programme with Estonian Business School and Estonian Academy of Arts)
Estonian Business School ebs.ee/en	BA	International Business Administration
	MA	International Business Administration MBA in Management (1-year program) MBA in Management (2-year program)
	PhD	Management
Estonian Entrepreneurship University of Applied Sciences euas.eu	BA	Creativity and Business Innovation Startup Entrepreneurship
	MA	International Business Administration
Estonian University of Life Sciences emu.ee/en	MA	Agri-Food Business Management
Tallinn University of Technology taltech.ee/programmes	BA	International Business Administration Law
	MA	Entrepreneurial Management International Business Administration Law Technology Governance and Digital Transformation
	PhD	Economics and Business Administration Public Administration

Institution	Level	Name of the Programme
Tallinn University tlu.ee/cometostudy	BA	Law Liberal Arts in Social Sciences Politics and Governance
	MA	Communication Management Educational Innovation and Leadership Human-Computer Interaction Human Rights in the Digital Society International Relations Social Entrepreneurship Well-Being and Health Behaviour
	PhD	Demography Educational Sciences Government and Politics Health Behaviour and Wellbeing Information Society Technologies Psychology Social Work Sociology
University of Tartu ut.ee/en	BA	Business Administration
	MA	Contemporary Asian and Middle Eastern Studies Democracy and Governance Educational Technology European Union-Russia Studies Information Technology Law Innovation and Technology Management International Law and Human Rights International Relations and Regional Studies Quantitative Economics Wellness and Spa Service Design and Management
	PhD	Economics and Business Administration Educational Science Law Media and Communication Political Science Psychology Sociology

Photo: Renee Altrov

6 Humanities and the Arts

Estonia is a relatively small country. It's also one of the world's smallest countries to have its own educational and scientific infrastructure, steeped in its own cultural traditions and in its own language. Humanities scholars have a dual role to play in Estonia, to both produce top-notch international research whilst bearing the torch for the Estonian language, culture, education, and scientific inquiry. Here are a few pointers to help you get a feel for what they do.

Photo: Rasmus Jurkatam

Highlights of Estonian Humanities

Do we need evolution for living? Or making meaning and communication instead?

"For living, itself? We can usually do it without any evolution. Evolution is very slow, while meaning-making is rapid." These were the words of Kalevi Kull, a theoretical biologist and a professor of biosemiotics in Estonia, at the University of Tartu.

Semiosis is interpretation and decision-making between a range of options and it is the basis of our phenomenal world. Kalevi Kull and his colleagues from Copenhagen-Tartu School of Biosemiotics, state that the body structure of an organism is largely a product of former semiosis. The organism's body together with the structure of the ecosystem, also serves as scaffolding for the sign processes that carry on the ontogenetic cycle, and the organism's behaviour. Thus providing the experience-based channels for decision-making in intermediary situations where a choice is required.

Evolution has occurred when some changes become irreversible after their stabilisation, and it usually means a modification of existing constraints, or scaffolding. Kalevi Kull argues that by living, not only can we not avoid evolution, but we actually influence it.

Demonstration of the role of communication and meaning-making for the organisation of living systems is the central focus of a biosemiotic specialist's work. This utilises an application of semiotic models in biology, and not only in biology to be precise. Contemporary biosemiotics has strongly influenced the whole of the semiotics field, as the humanitarian sphere recognises the importance of pre-linguistic sign processes as inevitable in human life.

This research at the Department of Semiotics by Kalevi Kull and his colleagues, including his pupils Timo Maran and Riin Magnus, draws on the great figures of local science such as Jakob von Uexküll and Juri Lotman, whose ideas have received a new synthesis through the work of the biosemiotic specialists.

Why not use Facebook and Wikipedia for informal learning in the workplace?

Informal learning in the workplace is a multi-episodic activity that's often connected to current demands and workplace tasks. This very fact makes it easy to apply knowledge but hinders the taking up of individual learning experiences through systematic organisational learning practices. Supporting learning experiences that can't be planned with technology has proven to be a major challenge, and it's far from being solved.

The Learning Layers project is devoted to tackling these issues with informal learning processes.

Several applications have been developed in this project, as well as an infrastructure that enables their technical integration. The infrastructure relies on a semantically enriched Artifact Actor Network (AAN), that combines the approaches of the social network (e.g. Facebook) and the artifact network (e.g. Wikipedia). In turn it describes the relationship between actors and artifacts in different learning contexts. The data related to the AAN can potentially be very useful in supporting learning activities further, or to simply monitor the learning processes. How to take advantage of this AAN to monitor and feedback on these learning processes is still a challenge, but could be approached by using the learning analytics techniques.

Tobias Ley, ERA Chair Professor for Learning Analytics and Educational Innovation at Tallinn University, studies how to support learning analytics in the workplace by exploiting an AAN that has been implemented by the Social Semantic Server. A recent experiment carried out with students, shows the technical viability of this approach with the Social Semantic Server. It's also encouraging how the Social Semantic Server can create a semantically enriched Artifact Actor Network.

These networks helped the teacher analyse the learning process of the students, and understand their behaviour. This way exemplified how the Social Semantic Server can integrate the data from different applications and coherently combine it to support learning analytics in the workplace. Currently, Tobias Ley is conducting further research in order to understand which of these contextual relationships are meaningful for the domain, and how can they be exploited to explain learning processes in the workplace.

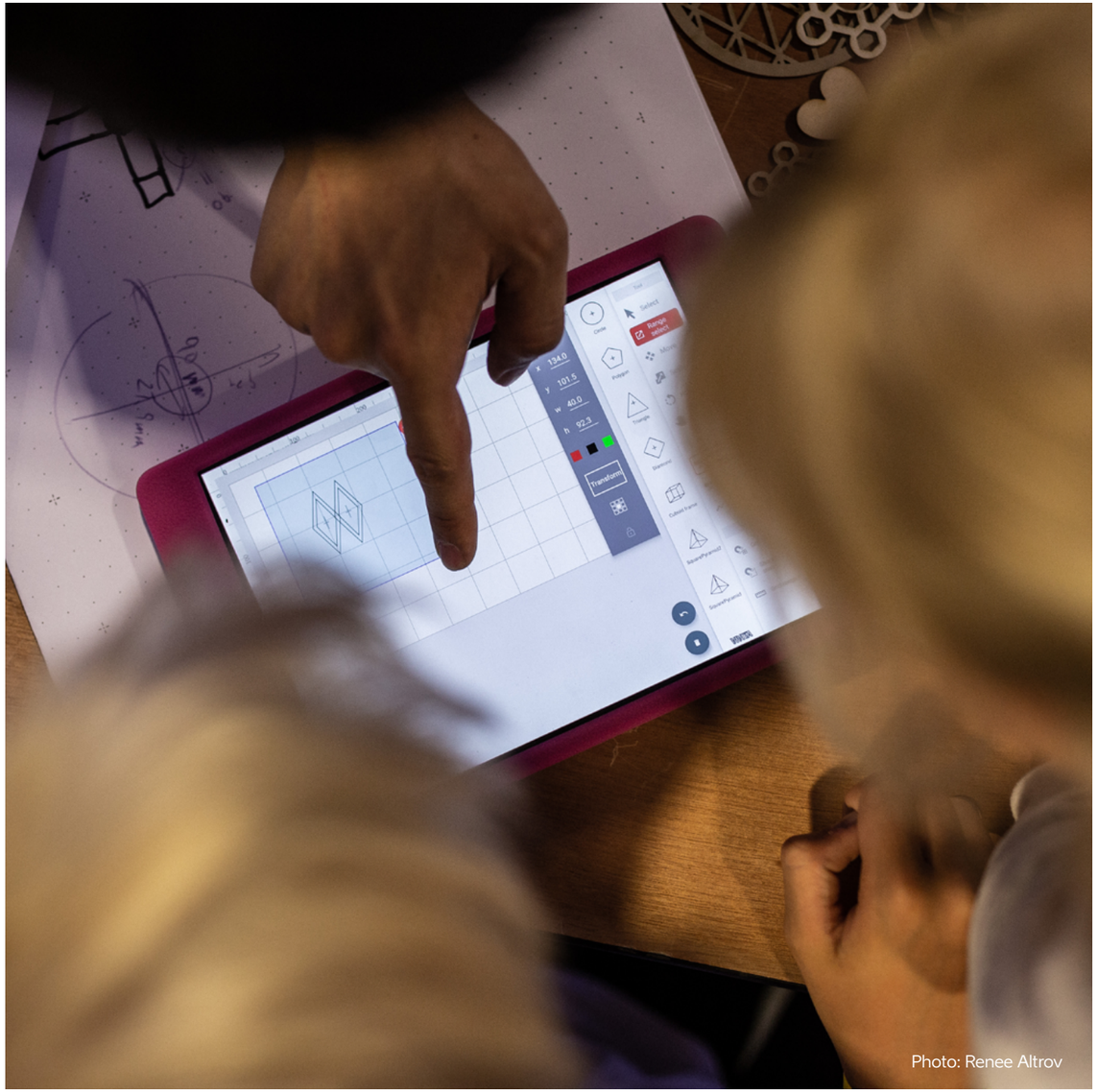


Photo: Renee Altrov

Research Infrastructure Units of Humanities

Estonian e-Repository and Conservation of Collections
Center of Estonian Language Resources

Estonian membership in ESFRI object

Common Language Resources and Technology Infrastructure CLARIN ERIC

Higher Education Programmes in Humanities

The following higher education institutions offer programmes in English in the field of humanities and the arts:

Institution	Level	Name of the Programme
Estonian Academy of Arts artun.ee/en	MA	Animation Contemporary Art Design and Crafts Interaction Design
	PhD	Art and Design
Estonian Academy of Music and Theatre ema.edu.ee/en	BA	Music
	MA	Contemporary Performance and Composition Contemporary Physical Performance Making Music
	PhD	Music and Dramatic Art Musicology
Tallinn University tlu.ee/cometostudy	BA	Audiovisual Media Crossmedia Liberal Arts in Humanities
	MA	Anthropology Documentary film Estonian Studies Literature, Visual Culture and Film Studies (joint program with the Estonian Academy of Arts) Screen Media and Innovation
	PhD	Audiovisual Arts and Media Studies History Linguistics Studies of Cultures
University of Tartu ut.ee/en	MA	European Languages and Cultures Folkloristics and Applied Heritage Studies Philosophy Semiotics Sound and Visual Technology
	PhD	Estonian and Finno-Ugric Linguistics Germanic and Romance Languages and Literatures History Literature and Cultural Research Philosophy Russian and Slavonic Philology Semiotics and Culture Studies Theology and Religious Studies

Science and Startups

Estonia is always striving to be an attractive and revered place for startups. According to the Wall Street Journal, Estonia produces more startups than any other European country in relation to its population; this really is the place to make your great idea into a successful business. Science based startups are a perfect way to build valuable connections between business, academia and research. These connections accelerate the progress of knowledge, create innovation and give a welcome boost to the Estonian economy.

Why Estonia?

The boom in the number of startup entrepreneurs in Estonia is influenced by a number of factors, including taxes and how companies are registered in the country. Estonia has one of the most liberal tax regimes in the world, whereby companies only have to pay corporate income tax on their dividends, and the proudly tech-savvy Estonian government does its best to develop the startup scene. There is no corporate income tax on retained and reinvested profits in Estonia. However, if the company decides to distribute dividends, then the corporate tax of 14% or 20% becomes payable. The Estonian tax system is highly attractive particularly to startup firms such as fintech, IT development and many others.

Last but not least, the Republic of Estonia is the first country in the world to offer e-Residency.

This is a transnational digital identity available to anyone across the globe interested in setting up a location-independent business online. It's possible to establish an Estonian company online within a day, administer the company from anywhere in the world and open a bank account without ever physically visiting Estonia.

Support and programmes for startups

The Estonian government offers active support for would-be startup owners, having many state-backed organisations and foundations providing advice, information and financial help for entrepreneurs and startups. There's plenty of advice on effective ways of funding their new business, how to apply for and get a startup grant from Enterprise Estonia, European Union structural assistance or securing a start-up loan secured by KredEx.

Education institutions are also in close cooperation with the local startup community. Tallinn University of Technology (TalTech) "Mektory STARTERtech preincubation programme" is just one example of the free development programmes for students with great business ideas. The Tehnopol Science Park, located near TalTech, is a business hub that houses over 150 technology companies. The Garage48 community startup team run a coworking space in the creative city of Telliskivi Loomelinnak, called Lift99, as well as Garage 48 Hub in Tartu. There's also Spring Hub based in the Tondi area of the city, an independent startup workspace and 'family' providing training and support; Technopolis Ülemiste, which is home to several contemporary startups, is another important hub based in Ülemiste City.

The Tartu Science Park is the innovation engine of South Estonia. IdeaLab at the University of Tartu also provides STARTER pre-incubation programmes for all the local students, making their dreams of entrepreneurship come alive. As a result, international students and researchers in Estonia are often exposed, and closely in contact with, the Estonian startup culture and its unlimited possibilities.

From graphene-based ultracapacitors to laundry detergent, here we present some of the highlights of the startup scene to you. Teams that have implemented scientific approaches, are a response to research results or innovations, and that are climbing vigorously up the ladder of success.

Photo: Skeleton Technologies

Skeleton Technologies

Skeleton Technologies is the global leader in graphene-based ultracapacitors and energy storage systems for transportation and grid applications, based in Estonia. This enterprise delivers high power, high energy, reliable and long-life storage solutions for the industry. Using the patented nanoporous carbide-derived carbon or 'curved graphene' allows them to exceed the limitations of their competitors up to four times in relation to power density and two times to energy density. The enterprise was founded in 2009 by Taavi Madiberk and Oliver Ahlberg. Taavi Madiberk brought his knowledge and experience from the IT, locomotive and non-profit sectors. Oliver Ahlberg has previously worked in IT and the creative services. Their solutions can be used on the ground, in the air and in space.

The enterprise offers intelligent module solutions for the transportation, space, automotive, marine, heavy duty and energy industries.

Skeleton Technologies' full systems include everything from the modules to the inverter, so the only thing the customer needs to do is enjoy the long lifetime and reliability of ultracapacitor-based energy storage systems. Their customers include the European Space Agency and several Tier 1 automotive outfits. Ultracapacitors solve crucial energy storage and power delivery problems in relation to power quality, renewable energy and transportation, also within the industrial sector by recapturing energy which would be otherwise lost. In addition to energy and power density, their ultracapacitors have low internal resistance and high chemical purity, which gives a significant reliability advantage over activated carbons. They received the best startup award at Ecosummit in 2015 and US magazine Forbes chose one of the founders as a top young leader in the science and healthcare sectors. They have also been recognised as one of the global pioneers in the clean technology sector and named in the prestigious 2018 Global Cleantech 100, produced by CTG (Cleantech Group), The Global Cleantech 100 represents the most innovative and promising ideas impacting the future of a wide range of industries, according to the players in the market. They have truly achieved global breakthroughs in ultracapacitor performance.

Planet OS

Intertrust provides trusted computing products and services to leading global corporations — from mobile and CE manufacturers and service providers to enterprise software platform companies. These products include the world's leading digital rights management, software tamper resistance and secure data platforms in the energy, IoT, auto, media, consumer marketing tech and healthcare sectors.

Founded in 1990, Intertrust is based in Silicon Valley, with regional offices in Boston, New York, London, Paris, Tallinn, Riga, Mumbai, Beijing, Seoul and Tokyo. The Company has a legacy of invention, and its fundamental contributions in the areas of computer security and digital trust are globally recognized. Intertrust holds hundreds of patents that are key to Internet security, trust, and privacy management components of operating systems, trusted mobile code and networked operating environments, web services, and cloud computing.

In August 2017, Intertrust acquired US-Estonian technology company Planet OS that provides big data infrastructure helping renewable energy companies transform the way data is used in their organizations. Planet OS was founded in 2012 by two Estonian entrepreneurs, Rainer Sternfeld and Kalle Kägi. The company's core products, Powerboard and Datahub, are used to operate some of the biggest wind farms in the world. Datahub aggregates and stores massive amounts of data from a multitude of sources, while Powerboard enables the visualization of streaming data.

Planet OS Datahub provides access to 63 high-quality datasets from the world's leading scientific organizations and weather data publishers, it's users are from industries exposed to external weather risk, e.g. agriculture, renewable energy and insurance. Datahub and a simple, easy-to-use API is accessible to everyone at data.planetos.com.

Now a part of Intertrust, the company is expanding their engineering office in Tallinn, and seeking for talented developers who are eager to build data-driven applications that solve ambitious real world problems.

Photo: Planet-OS_Intertrust

Photo: Defendec

Defendec

Defendec is an innovative company specialising in the development of world-class remote premises surveillance technology. With its main base in Estonia, the company also operates in Washington D.C.

They provide surveillance in four sectors: border guard, defense systems, infrastructure and oil and gas.

Previously known as Smartdust Solutions, the company began at 2006; in 2010 the name was changed to Defendec. Founded by Jaanus Tamm and Tauri Tuubel, the company started to focus on defense and surveillance technology around the time of the name change. Jaanus Tamm has years of experience in IT and has established three separate IT companies. Tauri Tuubel has extensive experience in product development, IT and has led an engineering team in a global company.

Defendec's main product is Smartdec. This is an autonomous situational awareness platform for surveillance in remote areas. The system's small, wireless and easily camouflaged detectors, equipped with high definition cameras and long-life batteries, recognise human and vehicular infiltrations. Smartdec is one of the longest lasting and most reliable perimeter intrusion detection systems on the market. It monitors a specified area, detects intruders, analyses data and provides visual confirmation in a matter of seconds.

ReconEyez, an intrusion detection system built to secure assets within the oil and gas industry, was designed specifically to protect vulnerable areas where CCTV is either too expensive to install or that are inaccessible. ReconEyez can be used to provide early warnings as well as to mitigate the risks of intrusion, theft, vandalism, terrorism and technological or natural disasters.

The company's new type of wireless sensor networking technology is patented. They cooperate with European Border Guards and Frontex. The company also supports academic research.

Defendec was named the defense industry company of the year in 2015, with their surveillance technology being now used in more than 30 countries around the world. The company is also one of the subcontractors implementing the Smartdec project in Middle-Eastern countries, Eastern Europe, The Nordics and South-East Asia.

ReLaDe

ReLaDe is a startup company based in Estonia which is revolutionising the concept of laundry detergent. Regular chemical detergents are toxic and harm reproductive health when spread into the water ecosystem, so ReLaDe founders argue that instead of using these toxic compounds, biological enzymes can be used without any loss of performance and with lower energy consumption. The five-man University of Tartu spin-off company created this green technology, which greatly reduces the environmental footprint created during the production of chemical detergents, as well as reducing the amount of chemical contamination in drinking water per household.

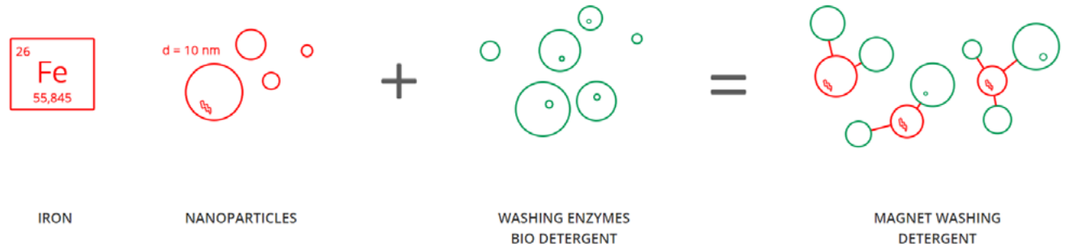
As a result, magnetic detergent molecules can be removed very easily from wastewater via magnetic force, and reused in subsequent wash cycles for months. The company's main target group are washing machine producers.

ReLaDe have invented a biological laundry detergent that contains magnetic nanoparticles which bind the detergent's enzyme molecules and magnetises them.

The founders, who received third place in the European Climate Launchpad competition and Horizon 2020 Phase I funding, are still looking for partners and clients who could invest in, or use their technology, especially in high-end washing machines.

ReLaDe claims that their laundry detergent can be reused at least hundred times, which means that if produced on an industrial scale and adopted into widespread use, it could have significantly positive health and environmental implications.

Reusing Laundry Detergent.



Contributors

This booklet has been produced as a work of collaboration by Study in Estonia and Research in Estonia brands that promote higher education and research in Estonia.

STUDY IN ESTONIA is a cooperation platform of institutions of higher education in Estonia to increase visibility of Estonia as an attractive study destination and promote the possibilities for studying for international students. The activities are coordinated by Archimedes Foundation in the framework of Dora Pluss activity and financed by the European Regional Development Fund. More info here: studyinestonia.ee

RESEARCH IN ESTONIA is an initiative that introduces Estonian research on an international scale by carrying out marketing activities with the vision that by 2022 the international awareness of Estonian research and researchers will have increased. The initiative is carried out by Estonian Research Council in the framework of Mobilitas Plus. With it's activities Research in Estonia supports the image of Estonia as an attractive science based country, ensures that the information about Estonian research is up-to-date and accessible and aims to highlight the cooperation between researchers, companies in smart specialization fields.
More info here: researchinestonia.eu

ARCHIMEDES
Eesti hariduse ja teaduse heaks
For education & research in Estonia
www.archimedes.ee

Eesti Teadusagentuur
Estonian Research Council

Abbreviations

AAN	Artifact Actor Network
API	Application Programming Interface
BA	Bachelor of Arts
BMTS	Baltic Methodist Theological Seminary
BPM	business process management
B. Sc.	Bachelor of Science
CCCR	Competence Center for Cancer Research
CCTV	Closed-circuit television
CERN	European Organisation for Nuclear Research
COST	European Cooperation in Science and Technology
EAA	Estonian Academy of Arts
EASS	Estonian Academy of Security Sciences
EBS	Estonian Business School
ENM	Estonian National Museum
ERIC	European Research Infrastructure Consortium
ESA	European Space Agency
ESFRI	The European Strategy Forum on Research Infrastructures
ESS	European Spallation Source
ETAIS	Estonian Scientific Computing Infrastructure
ETIS	Estonian Research Information System
EU	European Union
EUAS	Estonian Entrepreneurship University of Applied Sciences
FM	Frascati Manual
FOS	Field of science and technology
HE	higher education
HEI	higher education institutions
IMO	Infotechnological Mobility Observatory
IT	Information technology
ICT	information and communications technology
JPI	Joint Programming Initiatives
JTI	Joint Technology Initiatives
MA	Master of Arts
NAMUR	Nanomaterials — research and applications
NATARC	Natural History Archives and Information Network
NIPT	prenatal testing of chromosome disorders
PhD	Doctor of Philosophy
PHE	Professional higher education
R&D	research and development
SNP	single nucleotide polymorphisms allele
STACC	Software Technology and Applications Competence Centre
TalTech	Tallinn University of Technology
TLU	Tallinn University
US	United States
UT	University of Tartu
VAA	voting advice applications
VOCs	Volatile Organic Compounds

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