Baltic Science Network

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Research and Innovation excellence in Baltic Sea Region

Further details on the publication

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Institutional affiliation of the author	Research and Higher Education Monitoring and Analysis Centre (MOSTA)

Project in brief

Baltic Science Network (BSN) serves as a forum for higher education, science and research cooperation in the Baltic Sea Region (BSR).

BSN is a policy network gathering relevant transnational, national and regional policy actors from the BSR countries. The Network is a springboard for targeted multilateral activities in the frame of research and innovation excellence, mobility of scientists and expanded participation. These joint activities are modelled with an overall aim to ensure that the BSR remains a hub of cutting-edge scientific solutions with the capacity to exploit the region´s full innovation and scientific potential. The activities are modelled as examples of best practice which form basis of the policy recommendations drafted by the Network.

Disclaimer: This brochure is based on input from stakeholders and BSN partners and does not necessarily reflect the views of all participating Member States and organisations.

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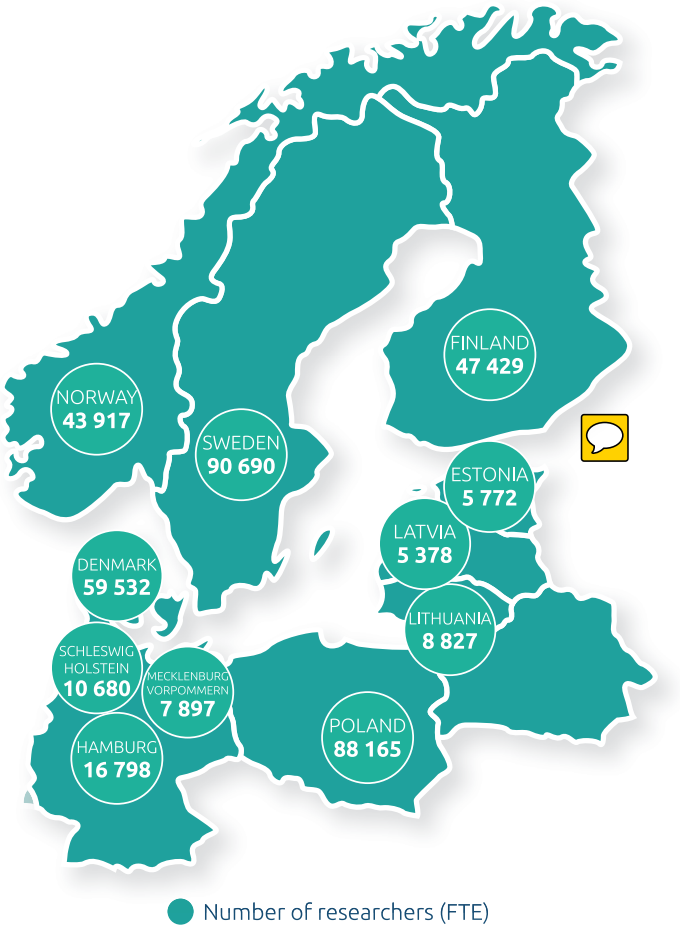
Research capacity in Baltic Sea Region as presented by number of researchers FTE

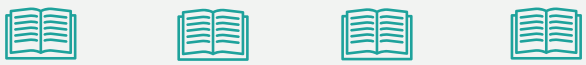


Introduction

This publication purpose is to highlight the most outstanding and excellent scientific achievements around the partner countries of Baltic Science Network.

In this booklet you'll find general information about each partner country and success stories of the scientific excellence.

Denmark



Change in Overweight from Childhood to Early Adulthood and Risk of Type 2 Diabetes

A high body mass index (BMI) and overweight during childhood increase the risk of developing type 2 diabetes later in life. Now researchers from the University of Copenhagen (SUND) and the Capital Region of Denmark have shown that this only applies to boys who continue being overweight during puberty or later. Their study - the largest of its kind in the world – was published in the New England Journal of Medicine in April 2018 and suggests that prevention and pre-pubertal treatment of overweight may be key weapons in the fight against type 2 diabetes.

Postdoc **Lise G. Bjerregaard** from the Centre for Clinical Research and Prevention, Bispebjerg and Frederiksberg Hospitals is behind the study, which was conducted together with **Thorkild IA Sørensen**, professor at the Novo Nordisk Foundation Center for Basic Metabolic Research, Section for Metabolic Genetics Department of Public Health and **Jennifer L. Baker** from the Centre for Clinical Research and Prevention and Associate Professor at the Novo Nordisk Foundation Center for Basic Metabolic Research, Section for Metabolic Genetics. The new Centre for Clinical Research and Prevention has a staff of 100, who conduct research within the fields of clinical epidemiology, population-based epidemiology and health promotion.

The study has been funded by the EU Framework Programme for Research and Innovation Horizon 2020 (n° 633595, DynaHEALTH) and the European Research Council (FP7/2007-2013, ERC n° 281419).

Easy cancer diagnoses of the future

Danish researchers have developed a unique method to discover up to 95 % types of cancer– and all that is required is a blood test.

The method has been developed by a team of researchers at The Centre for Medical Parasitology (CMP) at Copenhagen University and is described in an article on the academic journal, Nature Communications (August 2018). Having identified a protein in malaria parasites that binds to almost all types of cancer, and based on tests on early stage cancer patients in England, this research is highly promising in terms of both easier and early diagnosis as well as improving treatment in the future.

The Centre for Medical Parasitology (CMP) was founded in 1991. Research at CMP is focussed on malaria, and is mainly supported by external grants. All activities are organised in thematically defined teams, each led by a senior scientist. CMP is part of a well-established international scientific network, composed of scientist in Europe, Africa, America and Australia. More than 60 scientists and technicians are affiliated at CMP. A large proportion of these are engaged in graduate as well as postgraduate training.

The research was funded by the European Research Council (ERC), Danish Cancer Society, VAR2Pharmaceuticals, The Harboe Foundation, Aase og Ejnar Danielsens Fond, Kirsten og Freddy Johansens Fond, Svend Andersen Fonden, Anges og Poul Friis Foundation, the Danish Research Councils, and The Danish Innovation Foundation.

Estonia

1 315 635
Population

17 950€
GDP per capita

46 154
Students

5 772
Total FTE in R&D (2016)

1.28%
Expenditure on R&D per year (2016)

Higher Education institutions

11
Universities

26
Colleges

12
Research institutes

227
PhD degrees per year (5 years average)

Groundbreaking E-Society Technologies

The development of the underlying technologies of e-society has created the foundation for the current Estonian e-state and, thus, Estonia's reputation as the leading country in e-government technologies. The crucial role in these developments plays the work by Ahto Buldas, Professor of the Institute of Software Sciences at Tallinn University of Technology (TalTech). His contribution extends from the basic principles of the design and fault- and attack-tolerant implementation of e-society to the measurement techniques of attack-resistance and to reliable design of specific e-society supporting technologies, based on cryptography and block-chain technologies.

Ahto Buldas is a cryptographer on the one hand, and a system development specialist on the other. His research has always been applied-oriented and, in addition to more than 50 international research papers published in leading cryptography conferences, he is also the author of several dozen patents and patent applications. He has been a co-founder of international companies Cybernetica AS and Guardtime AS. Cybernetica has been the most important partner of Estonia in creating and developing e-state technologies. Guardtime products and services are used by the United States Department of Defence and technology giant Lockheed Martin, as well as the Estonian state and banks. The products and services of these companies are built and based on Ahto's research.

The work "Groundbreaking E-Society Technologies" includes the following research results of Buldas (only some of them listed):

- Time-stamping systems without

trusted intermediaries.

- Databases and Registries without Trusted Intermediaries.
- Provable Security of Services without Intermediaries.
- Proof Techniques for Attack Resistance and their Limits.
- Attack Resistant E-Services and their Infrastructure.

Ahto has actively participated in the application of his research. Under his direction or active participation, the following innovations at the forefront of technology have become through Cryptochip; Virtual Private Networks; Digital Signature Act; Validity Register for Digital Signature Certificates; X-Road Technical Architecture; International Standardization of Digital Signatures and Time Stamps; Scalable Infrastructure for Block-Chain Technologies; Server-Supported Digital Signature Service.

Most of the contemporary Estonian e-state builders have been Ahto's students. For the long-term excellent research and teaching of cryptography, Ahto was awarded the White Star IV Class Order in 2015.

In 2018 **Ahto Buldas** won the National Research Award "For Invention or Research and Development Based on Scientific Discovery that has Changed the Paradigms of a Field of Science or Led to an Innovative Product with Significant Socio-Economical Impact" for his research and development of the Base Technologies of e-Society.

The Estonian Genome Center, biobank and the personal medicine

Health care costs are increasing all over the world and one way to cope with the problem is to use new technologies for disease prediction, prevention and making it all personal and finally empower people so that they would participate more in their own health management. In Estonia, we decided about 20 years ago that the personal so-called 4P - prediction, prevention, personal and participatory - medicine is the right way forward. In order to make it personal we have to use the genetic information of everyone in order to estimate the genetic disease risks together with the classical risk factors like smoking, overweight etc. For that purposes, we established the Estonian biobank in year 2000 and as a first phase recruited 5% of the Estonian adult population (52 000) into it and characterized them genetically: everyone was genotyped with Global Screening Array with close to 800 000 single nucleotide variants on it. In 2019, additional 100 000 people were added to the biobank making it now 15% of the adult population and all have the genetic data. Next to the biobank the Estonian Genome Center (EGC) acquired the latest genome analysis (sequencing and genotyping) technology from Illumina and introduced the very active research program, publishing 60-80 papers per year. 40% of all papers published in Nature*and Science in this century with an Estonian address are from the EGC of the Institute of Genomics of University of Tartu. Three out of 7 very highly cites scientists in Estonia (Clarivate) are from the EGC. DNA sequencing was es-

tablished in the EGC as the diagnostic test covered by the Health Care Insurance Fund and was later transferred to the Tartu University hospital as an example of the classical technology spillover of the technology. As a result, the diagnostic yield increased from 7 to 25-30% in the children hospital and intensive care costs were down. Next, EGC developed new technology for the calculating the Genetic Risk Scores (GRS) (Läll et al 2016 GiM) and using the array data started to return the GRS where some of the traditional risk factors were taken in (like BMI, smoking, age, gender etc.). "Genetics First" as we call it proves very successful: e.g. familiar hypercholesterolemia (FH) is a very bad disease, leads often to the myocardial infarction and is underdiagnosed. Alver et al., (2018) in GiM demonstrated that, almost half of the people with loss of function mutations in the basic genes controlling the cholesterol level on the blood are not seen by the conventional medical system. As today, more than 1000 people have received the feedback from the biobank and are very happy to get really meaningful information (T2D, FH, breast cancer (BrCa), glaucoma, pharmacogenomics etc.). The Estonian government has started the first personal medicine project in the hospitals (BrCa and coronary artery disease (CAD)). By using the GRS, we can predict disease and use the early prevention measures to postpone or even prevent the disease. There is enough science to implement it already. But, of course, this is only beginning. This will have a huge social impact, controls the health care costs and allows to deliver more health care for the same cost.

The team of the senior scientists who have made all this happen are all trained in the leading genomics centers (The Broad Institute of Harvard and MIT, Cambridge, Oxford and Yale Universities, Uppsala University, The Baylor College of Medicine, UCLA, NCI NIH, MIT etc.), but all of them returned to the Tartu, because the opportunities the university has created to do excellent,

competitive research using the Estonian Biobank samples, data and technology. Last but not the least, the results of the research could be used in real life almost at the same time when discovered!

The team: **Krista Fischer, Elin Org, Reedik Mägi, Toomas Haller, Tarmo Annilo, Tõnu Esko, Lili Milani** and **Andres Metspalu.**

Team of Prof Niinemets tries to unravel the secrets of plant adaptation at Estonian University of Life Sciences

Professor **Ülo Niinemets** is the first Estonian scientist to receive the prestigious European Research Council advanced grant in 2013 for the project "Stress-Induced Plant Volatiles in Biosphere-Atmosphere System". He has published more than 300 research papers in international journals and collaborated with more than 800 scientists from 50 countries in these publications. He is included in ISI-Clarivate list of highly cited scientists (2017-2019 editions). In 2018 he received the Estonian National Science Prize in bio and geosciences category for the work „Mechanisms of acclimation and adaptation of photosynthesis: from canopy gradients to global rules". The work awarded was based on his recent contributions on three main lines of study: 1) Structural and physiological leaf photosynthesis adaptations in canopy gradients; 2) Limits of variation in plant structure and photosynthesis: from species-specific adaptations to global patterns; 3) The evolution of photosynthesis under stress, and the implications for designing more effective photosynthesis for future climates.

Prof. Niinemets is head of the Chair of Crop Science and Plant Biology at the Estonian University of Life Sciences. Starting from 2011, he has been leading two national centers of excellence. First, the Centre of Excellence in Environmen-

tal Adaptation (ENVIRON, 2011-2015) and the ongoing (2016-2022) Centre of Excellence in Ecology of Global Change: Natural and Managed Ecosystems (EcolChange). Both these Centers of Excellence have contributed to building a foundation for sustainable management of natural resources in Estonia and other Nordic countries under globally changing environmental conditions. In addition, they provide the scientific rationale to enhance ecologically sustainable economic growth via smart regional planning in forestry and agriculture: functionally diverse forests, cultivars for future climates, novel crops and sustainable nutrient cycles. Currently, the plant ecology and eco-physiology work of **Prof Niinemets** and his colleagues is focused on broad-scales analyses linking plants structural, chemical and physiological traits across the globe with the intention to find the universal „laws" of plant science. Such „laws" describe the general relationship between the plant key functional traits and climate. Information of these fundamental relationships is needed to understand the worldwide distribution patterns of plants as well as for targeted breeding of crops for present and future climatic conditions. The work of Prof Niinemets suggests that vegetation adaptation capacity should be included in future climate projections models because biosphere has much greater influence on climate than commonly thought.

Finland

5 513 130
Population

40 638€
GDP per capita

292 226
Students

47 429
Total FTE in R&D (2016)

2.8%
Expenditure on R&D per year (2016)

Higher Education institutions

14
Universities

25
Universities of applied sciences

12
State research institutes

1 822
PhD degrees per year (5 years average)

ERC Synergy Grant worth €10M will help develop new techniques for brain research, disease diagnostics, and patient care

The new methods are based on rapid, algorithm-controlled magnetic stimulation pulses that excite neurons and forge connections across brain regions. The research will explore new therapies for a wide range of neurological conditions—from depression to Parkinson's disease. The ConnectToBrain project was awarded a Synergy Grant of 10 million euros by the European Research Council (ERC).

The costs associated with neurological diseases amount to 1000 billion euros per year in Europe alone. The methods for brain stimulation therapy to be developed in the ConnectToBrain project are expected to save up to a billion euros annually in Europe with considerable cuts to both cost of care and duration of sick leaves.

The inner workings of the neurological system can be compared to a symphony orchestra. The various regions of the brain all "listen" to each other via internal neural pathways, not unlike musicians following the sound of all the instruments and the instructions of the conductor. Neurological conditions such as schizophrenia, stroke, or substance dependence impinge on the activity of the brain's neural connections and disrupt a person's ability to function—making the orchestra play out of tune and time.

The ConnectToBrain project seeks to radically improve the techniques for brain stimulation in current clinical use. Synergistically complementing the research group of Aalto University Professor **Risto Ilmoniemi**, other research groups include the team of Professor Emeritus **Gian Luca Romani** from "G. d'Annunzio"

University of Chieti–Pescara, Italy, and the group of Professor **Ulf Ziemann** from the University of Tübingen, Germany.

The international research teams complement each other's efforts: Aalto University's strengths lie in developing brain stimulation technologies, while the real time connectivity and the artificial intelligence algorithms developed at "G. d'Annunzio" University will analyse brain data and make diagnostic decisions, and the team at the University of Tübingen will transfer the technology and data analysis methods to actual patient care.

Risto Ilmoniemi is the first Finnish researcher to receive a Synergy Grant from the European Research Council (ERC).

Markku Kulmala studies physics and chemistry of atmospheric aerosols to increase our understanding of the mechanisms of climate change

Academy Professor **Markku Kulmala** is the world's leading expert in the physics and chemistry of atmospheric aerosols. He conducts research at the forefront of international efforts to significantly increase our understanding of the mechanisms of climate change, creating new opportunities to reduce the pace of climate change and mitigate its effects. He is widely regarded as one of the founders of a new field of research that explores the interactions between ecosystems and the atmosphere. His integrative approach in particular has significantly reshaped established research environments and structures.

Kulmala and his team investigate the impacts of human activity and natural processes on air quality and the climate. Air quality and climate interactions are varied and highly complex phenomena. Polluted air may change the local and even global climate, and the climate affects air quality in many ways. The research offers significant environmental, social and economic benefits.

Kulmala has also played a key role in developing international research infrastructures and establishing a major network of observation stations. The comprehensive measurements conducted at Finland's SMEAR stations (Stations for Measuring the Ecosystem–Atmosphere Relationships) have contributed to increasing the international significance of the research units under Kulmala's leadership. For example, Finland today hosts the headquarters and coordination the European Integrated Carbon Observation System (ICOS) as well as coordinates the European Research Infrastructure for the Observation of Aerosol, Clouds and Trace Gases (ACTRIS).

Eva-Mari Aro´s research on photosynthesis is top level in the world

Academy Professor **Eva-Mari Aro** has been Professor of Plant Physiology at the University of Turku since 1998. Aro's area of specialty is plant molecular biology. She has introduced a whole new area of strength of photosynthesis research

into the Finnish scientific landscape. At the same time, her laboratory has grown into one of the world's premier centres of photosynthesis research.

In recent years, Aro and her team have focused their efforts on studying how photosynthesis can be harnessed to produce compounds beneficial to humankind following the principles of sustainable development. Aro's research applies methods of synthetic biology to the efficient production of chemicals and energy using photosynthetic organisms, mainly cyanobacteria.

Rather than harnessing cyanobacteria for the production of biomass – the conventional route in bioenergy-related studies on algae – Aro works to develop "living factories", cells that can convert solar energy into fuels and useful chemicals. It is hoped that research in this area could provide a breakthrough that would contribute to fully replacing the fossil fuels.

Aro has received several international distinctions and awards and she holds numerous positions of trust both in Finland and abroad. In addition to being actively involved in many scientific and science policy networks at EU level, she serves on several selection committees for major international science prizes. At present, Aro is Vice-President at the Bureau of the European Academies' Science Advisory Council (EASAC). The Council provides independent scientific advice to European policy-makers under three programmes: Energy, Environment and Biosciences.

The Finnish Union of University Professors selected Aro as Professor of the Year in 2013.

Germany

Hamburg

1 830 584
Population

64 567€
GDP per capita

107 912
Students

16 798
Total FTE in R&D (2016)

2.22%
Expenditure on R&D per year (2016)

Higher Education institutions

19
Universities

19
Research institutions

25
Innovation agencies and hubs

950
PhD degrees per year (5 years average)

European XFEL

The European XFEL is a research facility of superlatives: It generates ultrashort X-ray flashes—27 000 times per second and with a brilliance that is a billion times higher than that of the best conventional X-ray radiation sources.

The world's largest X-ray laser will open up completely new research opportunities for scientists and industrial users.

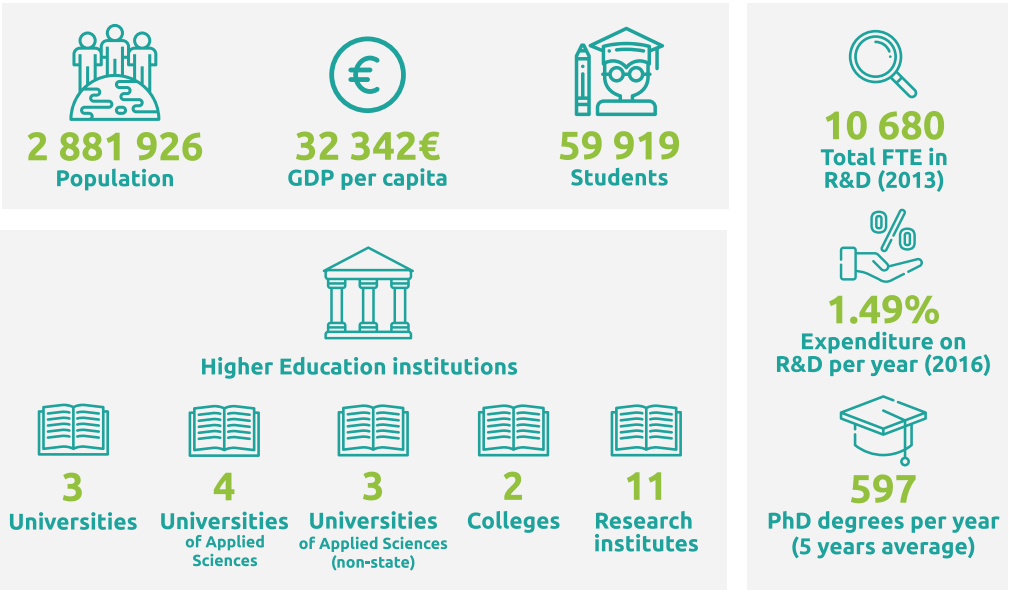
The 3.4 km long European XFEL generates extremely intense X-ray flashes to be used by researchers from all over the world. The flashes are produced in underground tunnels and will allow scientists to map atomic details of viruses, film chemical reactions, and study the processes in the interior of planets.

The European XFEL has been realized as a joint effort of many partners. The European XFEL GmbH cooperates closely with the research centre DESY and other organizations worldwide. Construction started in early 2009; user operation began in September 2017. The construction cost were 1,2 Billion €.

To a great extent, the European XFEL facility was realized by means of in-kind contributions by shareholders and partners.

With 12 participating countries (Denmark, France, Germany, Hungary, Italy, Poland, Russia, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom) the facility is a truly international enterprise located in Hamburg. The facility is attracting excellent scientists from all over the world and is thus an international nucleus for research excellence in the region.

Schleswig-Holstein



Precision Medicine in Chronic Inflammation

The Kiel University and her partner institutions in Schleswig-Holstein were once more successful in the national excellence programme (excellence strategy). This saves the funding for the cluster of excellence „Precision Medicine in Chronic Inflammation" (PMI) until 2025.

Barrier organs are the primary site of interaction between complex organisms and the environment. Tight control of interactions preserves integrity of the host organism, but also provides important regulatory signals to the immune system and to metabolic functions. While acute inflammation is a pivotal protective mechanism aiming to restore balance at barriers, chronic inflammatory reactions are often detrimental. Chronic inflammatory barrier diseases (CIBDs) represent an increasingly common group of immune disorders, with a lifetime prevalence of over 10% in Europe. These systemic disorders differ with respect to their main target organ(s), which include the gut, skin and lung. The development of targeted therapies that inhibit or stimulate single molecules in pathophysiology (e.g. anti cytokine antibodies) has probably been the most important therapeutic advance for these diseases. However, these therapies are often unable to completely control the disease. Therefore, in addition to remaining symptomatology, complications and cardiovascular, metabolic and malignant co-morbidities represent unmet medical needs.

In the current Cluster, researchers will not only deepen their understanding

of disease etiology and pathophysiology but validate and examine disease principles of importance in prospective human intervention experiments. The defining feature of PMI is a sustainable network of interdisciplinary researchers, driven by excellence principles and a strong scientific interaction between clinical research and basic science. A product for patients and physicians will be interventions and algorithms resulting in better disease control (and eventually restoration of healthy barrier functionality), which are aided by a precise individual selection of therapies and timings for interventions, including pre-emptive and preventive strategies.

ROOTS - connectivity of society, environment and culture in past worlds

From 2019 until 2025 a new cluster of excellence will be built up by Kiel University and her partner institutions in Schleswig-Holstein: „ROOTS - connectivity of society, environment and culture in past worlds“. The research project is part of the national excellence strategy.

A quest of universal interest is to gain a better understanding of how humans and societies developed in interaction with their environment. In a broad interdisciplinary conceptual framework, ROO TS will explore archaeological and historical “laboratories” in a diachronic perspective, covering a wide range of socio-environmental constellations, under the basic assumption that humans and environments deeply shaped each other, creating social, environmental and cultural connectivities.

These concern the mutual links between individuals, groups, and societies, as well as their physical and biological environments. The extent and velocity of connections are intimately linked to environmental conditions, access to food and other resources, conflicts and

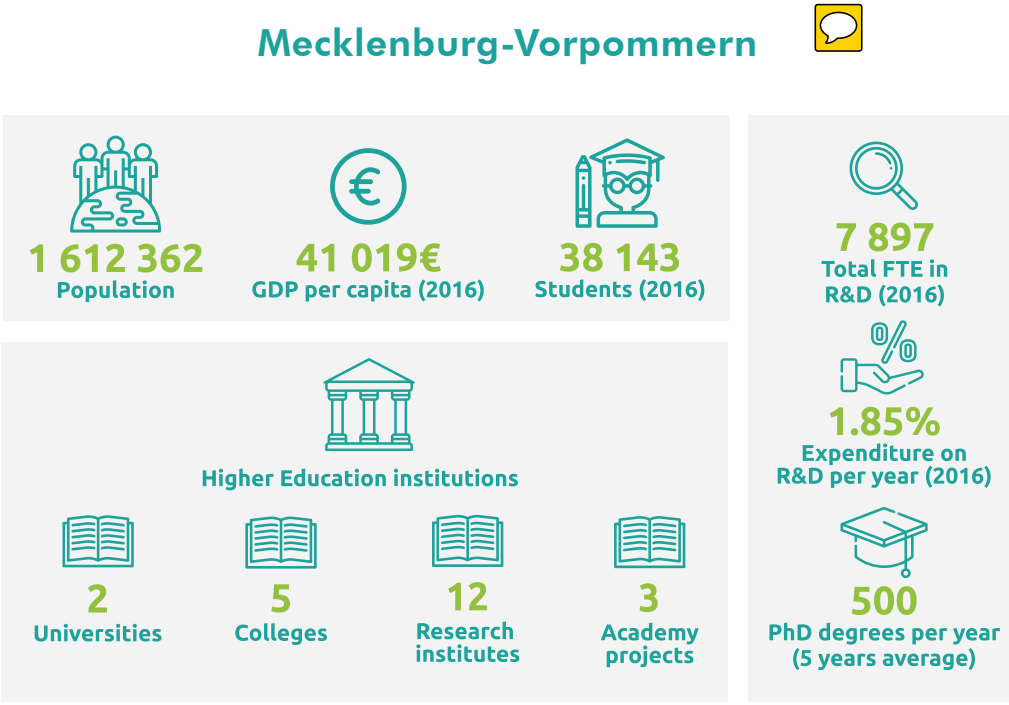
social tension, together with the production, access, and distribution of knowledge and innovation.

Society and the environment are and were subjected to events and characterised by structures and processes, which give rise to essential questions about our own role and fragility in both local to regional contexts, but also in the global system.

Socio-environmental phenomena will be explored as evolving at different spatio-temporal scales by integrating approaches from the humanities, and the life and natural sciences, thus stimulating cross-disciplinary dialogue. The extent, rate, and nature of past social, environmental and cultural interactions will be reconstructed and assessed, as well as their impetus for the development of past environments and societies. The outlined topic is of high relevance against the background of global challenges, in the areas of climate and energy, health and nutrition, spread of knowledge and innovation, urbanity, social inequality, conflict, mobility, and communication and security.

The cluster of excellence aims to explore the roots of social, environmental, and cultural phenomena and processes that substantially marked past human development.

Mecklenburg-Vorpommern



ERC Advanced Grant (NoNaCat)

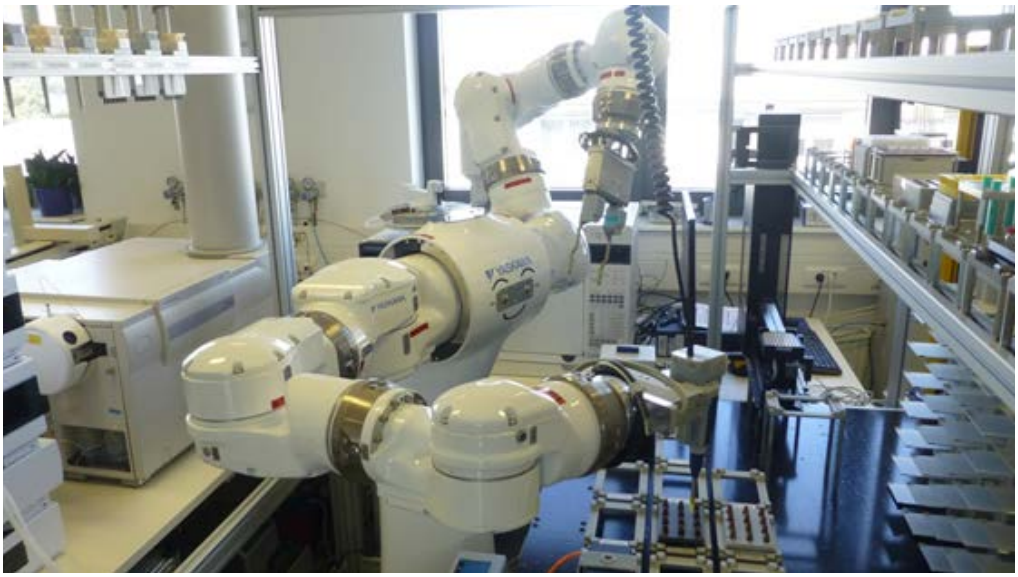
The major objective of the ERC Grant Project is the development of new active and selective catalysts based on earth abundant metals (e.g. Fe, Mn, Co,

Cu). These catalysts will be used for improved synthetic transformations which are of interest for organic chemistry in general and which are also of significant practical value for the chemical and life science industries. Traditional catalysts based on non-noble metals are not efficient for hydrogenation and dehydrogenation processes under mild conditions. However, by creating a suitable microenvironment with M-N interactions they are becoming active and selective. According to our concept the suitable surrounding will be created either by using nitrogen-containing pincer ligands or nitrogen-doped graphenes. Consequently, a variety of both molecular-defined homogeneous catalysts as well as nano-structured heterogeneous materials will be prepared, characterized and tested in various catalytic applications. More specifically, the following redox transformations will be investigated: Hydrogenation and transfer hydrogenation of carboxylic acids, esters, and nitriles; hydrogenation of amides and peptides; hydrogenation of carbon dioxide and selective oxidative coupling of alcohols to esters, amides, and nitriles. Furthermore, "waste-free" carbon-carbon bond forming reactions such as alkylations with alcohols and domino-synthesis of heterocycles from alcohols will be exploited. Finally, homogeneous and heterogeneous catalysts from earth abundant metals will be used in industrially relevant oxidative carbonylation reactions. With respect to methodology this proposal combines homogeneous with heterogeneous catalysis, which will result in new ideas for both fields.

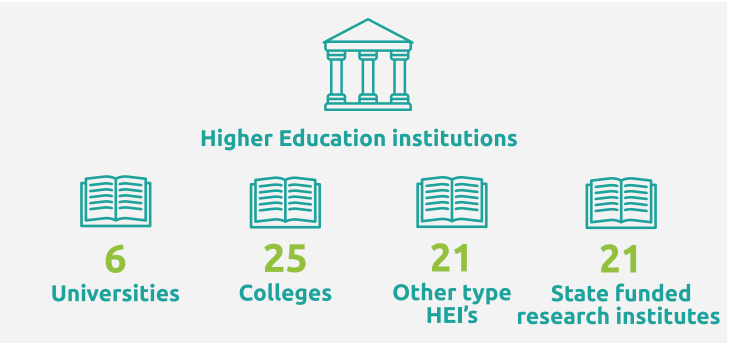
Multi-Degree-of-Freedom Robotics in Analytical Measurement

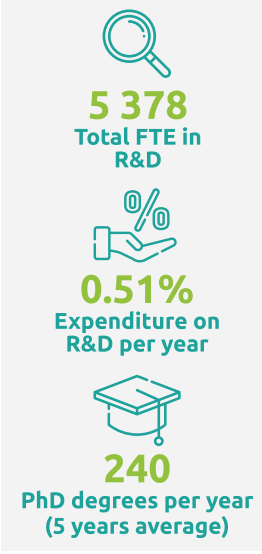
The Center for Life Science Automation (CELISCA) of the University Rostock develops high-end robotics solutions for enhancement of throughput und

quality for processes from life sciences. One of the challenging examples is the collaborative dual arm robot's work in sample preparation for analytical measurement. Those robots can be operated with flexible workflow control tools emulating human's work adapting to complex standard operation procedures from biology, synthesis control, medicine as well as environmental sciences.



Latvia





CAMART²

CAMART² is a EUR 31 million project upgrading the Center of Excellence in Advanced Material Research and Technology at the Institute of Solid State Physics at the University of Latvia (ISSP) to a new and significantly stronger Center of Excellence for materials and technology research. Within the center, research is conducted within the fields of Advanced Materials, Photonics, Nanotechnology and Micro- and Nanoelectronics. Through collaboration with the KTH Royal Institute of Technology in Stockholm and RISE Acreo, the project has already resulted in several successful publications in quality international journals such as "Physical Review Letters".

One of the aims of the project is to narrow the R&D gap between Latvia and more established European countries within the field of Materials Science. CAMART² does this by generating a critical mass of activity and attracting scientists from the surrounding region. Through the project, educational programs are being refined and an open access laboratory has been created. Further success is expected as the program progressed through the implementation stage which will commence in 2023.

Latvian Institute of Organic Synthesis (LIOS)

LIOS is an independent public research institute specializing in pharmaceutical research, organic chemistry, molecular biology and bioorganic chemistry. The institute is one of the leading H2020 competitive grant recipients and receives significant research funding from the private sector.

LIOS is one of only two organizations in the Baltic states that has received funding from the competitive Innovative Medicines Initiative (IMI) scheme (the other being the University of Tartu). Through the IMI program which is co-financed by the European pharmaceutical industry and the European Commission, LIOS received over EUR 6 million to conduct research on advancing the development of promising new antibiotic compounds targeting Gram-negative bacteria through the ND4BBB ENABLE project. This larger research collaboration has resulted in over 15 programs with several lead-to-candidate stage programs still currently being conducted.

LIOS continues to be a regional leader in organic chemistry, attracting talent and competitive research funding from various programs.

Lithuania

2 871 637
Population

14 900€
GDP per capita

118 474
Students

8 827
Total FTE in R&D

0.89%
Expenditure on R&D per year

Higher Education institutions

22
Universities

23
Colleges

22
Research institutes

400
PhD degrees per year (5 years average)

2018 KAVLI PRIZE IN NANOSCIENCE "for the invention of CRISPR-Cas9, a precise nanotool for editing DNA, causing a revolution in biology, agriculture, and medicine."

Professor **Virginijus Šikšnys** is the first Lithuanian scientist to be awarded prestigious Kavli Prize for his studies of the CRISPR-Cas antiviral defense systems in bacteria and developing novel molecular tools for genome editing.

To repair a defect in the genome of an organism that often triggers a disease, one would have to remove, alter, or insert a genetic code at atomically precise locations in the DNA sequence. This vision is now a reality with CRISPR-Cas9, a nanotool that opens a door towards curing hereditary diseases and boosting agriculture. CRISPR-Cas9 constitutes a revolutionary innovation compared to prior techniques, which were tedious, imprecise, and costly.

With their teams, **Emmanuelle Charpentier** and **Jennifer A. Doudna**, and independently **Virginijus Šikšnys** invented a way to develop CRISPR and Cas9 into a powerful nanotool. CRISPR-Cas9 confers to society enormous capabilities for positive innovations. Possible benefits are wide-ranging in scope and value. From a fundamental perspective, CRISPR-Cas9 is a breakthrough nanotool for research in the life sciences that will greatly enhance our understanding of genetic mechanisms. It enables the detailed study of many hitherto genetically intractable organisms. Potential applications of CRISPR-Cas9 are to optimize agriculture with regard to breeding crops and livestock having desired properties. Potential medical applications include the capability of correcting disease-causing mutations and using gene therapy to cure serious diseases

such as muscular dystrophy, sickle-cell anemia, and some forms of blindness and cancer.

CRISPR-Cas9 tool is simple to use. To address the DNA sequence that has to be altered asmall RNA molecule is synthesized that guides Cas9-gRNA complex to a specific sequence. Guided by the RNA, the complex binds to the DNA target and the Cas9 protein cuts DNA at exact location generating a double strand break. As the DNA segments reconnect, genes may be inserted or defunctionalized. In this way, disease-causing mutations can be corrected by changing the underlying genetic code. CRISPR-Cas9 works on many organisms, including plants, fungi, animals, and humans.

Ultrasound to safely measure brain pressure by Arminas Ragauskas – a nominee for European Inventor Award 2016 and a finalist of a category "Small and medium sized enterprises"

Lithuanian scientist **Arminas Ragauskas** has been nominated for European Inventor Award 2016 and was one of the finalists of a category "Small and medium sized enterprises" with the invention for measuring intracranial pressure and blood flow for fast and safe diagnosis of traumatic brain injury, strokes, glaucoma and brain tumours. Ragauskas' novel measuring devices are important tools for treating intracranial injuries, which are among the world's deadliest killers.

Quick response times are essential when diagnosing brain injury, especially when a brain trauma or tumour elevates cranial pressure to potentially lethal levels. Brought to market in 2015, two medical devices developed by **Arminas Ragauskas** and a team of fellow Lithuanian scientists give neurologists and other doctors precious extra time to de-

tect and assess increased cranial pressure. They no longer need to resort to costly and time-consuming invasive surgery, which itself is not without risk.

Ragauskas – along with colleagues **Gediminas Daubaris** and **Algis Dziugys** from the Health Telematics Science Institute at Kaunas University of Technology, Lithuania – achieved a breakthrough by applying the Doppler wavelength effect in order to arrive at an accurate reading of cranial pressure, using an ingeniously simple formula. The team's devices compute the pressure differential between the inside and the outside of the skull, based on a quick and simple reading obtained from a sensor placed on the patient's eye.

The invention itself has both – social and economic benefit. Traumatic brain injury (TBI) and central nervous system tumours rank among the leading causes of death worldwide. In Europe, roughly 2.5 million people suffer a TBI each year and some 75 000 die as a result. The invented devices help to detect increased cranial pressure quickly and reliably, which is key in responding to TBI and brain tumours. They are a major improvement over invasive surgery, for which patients have to be anaesthetised. The robust and accurate devices are garnering attention on the global brain-monitoring market, which includes diagnostic devices for TBI, strokes and tumours. The global market was worth EUR 6.6 billion (USD 7.5 billion) in 2015 (MarketsandMarkets) and is set to increase at a projected compound annual growth rate of 7% to reach EUR 10.5 billion (USD 11.5 billion) by 2020. Marketed by the inventor's start-up company Vittamed as non-invasive intracranial pressure meter Vittamed 205 and non-invasive cerebral auto-regulation monitor Vittamed 505, the devices received CE marking approval in 2014. The company is currently launching the products in Europe, Australia and the US, and recently secured Series A financing to the tune of EUR 8.79 million (USD 10 million) from Xeraya Capital Labuan Ltd.

Poland

38 433 600
Population

12 055€
GDP per capita

1 291 900
Students

Higher Education institutions

18
State universities

257
Non-state universities

260
Research institutes

88 165
Total FTE in R&D (2016)

0.97%
Expenditure on R&D per year (2016)

7 878
PhD degrees per year (5 years average)

Other success stories in Baltic Sea Region

The Estonian–Finnish Beamline (FinEstBeamS) built to the synchrotron radiation source MAX–IV in Lund, Sweden

The beamline is constructed through the cooperation of four universities (University of Tartu, University of Turku, University of Oulu and Tampere University of Technology). The beamline is producing ultrasoft x–rays enabling research on new materials and their electronic properties. First light was produced on 15th of December 2017. Joint construction of the beamline became possible due to long lasting and active cooperation between the consortium and Lund University. Funding for the basic equipment and instrumentation, materials, and staff during the construction phase was provided by an Estonian and Finnish consortium, supported by the EU through the European Regional Development Fund and the Academy of Finland.

Powering energy savings with ultracapacitors

Skeleton Technologies' patented curved graphene is changing the world of energy storage. Their superior technology enables them to deliver ground-breaking energy storage solutions with market leading power and energy density. Skeleton's products are used across industries from automotive to aerospace and everything in between. Skeleton Technologies, the European market leader in ultracapacitors and energy storage systems for transportation and grid applications, is named in the prestigious 2018 Global Cleantech 100 representing the most innovative and promising ideas impacting the future of a wide range of industries.

Novel concept of unmanned ground vehicles for the defense and civilian purposes

Milrem Robotics' primary focus is the manufacture of unmanned ground vehicles for the defense and commercial sector, development of robotic warfare solutions and performing concept of operations and doctrine level warfare analysis. The company has developed the first modular hybrid unmanned ground vehicle in the world that has applications as a force multiplier for dismounted troops, but also can be used for civilian purposes like search and rescue, agriculture and mining. Milrem Robotics also offers engineering services and prototyping.

Hearts and Coins

There is an electrical phenomenon - impedance - that allows us both to build better pace-makers and detect counterfeit coins. Impedance, a measure of that

how strongly a given material impedes travelling electricity through it - can be used to test the characteristics of many materials, both living and non-living. Mart Min, the professor at the TalTech University Min has devised smarter cardiac pacemakers that can detect patients' workload and automatically adjust their heartbeat and also a device to discover counterfeit Euro coins.

Using Myoton to evaluate superficial skeletal muscles

The myometric method and a device called Myoton provide a novel solution for obtaining unique evidence-based data on superficial skeletal muscles. Myoton has a wide area of use. It can be employed to assess the effect of interventions in science and medicine, prevent overload injuries in sport and work environments, evaluate rehabilitation efficiency, to evaluate and monitor the training process of athletes and even to monitor astronauts' muscle health before during and after space flights.

ESTCube-1 and ESTCube-2

The Estonian Student Satellite Foundation advances the Estonian space research and technology development by initiating flagship Estonian space missions and participating in satellite projects. The foundation continues and builds upon the heritage of the first Estonian satellite ESTCube-1. The foundation supports the creation of the next generation of space scientists, engineers and entrepreneurs by providing hands-on education to students. ESTCube-2 is a technology demonstration mission for deorbiting technology plasma brake, the interplanetary propulsion system electric solar wind sail (E-sail) and advanced satellite subsystem solutions.

Medicines from Milk

„The number of cows whose milk can be used to produce pharmaceuticals is still very small," says **Ülle Jaakma**, professor of reproductive biology at Estonian University of Life Sciences. „At the same time, this technology is eagerly awaited in the pharmaceutical world. The research group headed by Jaakma, working together with colleagues from the University of Tartu is trying to contribute to this revolution. A number of Estonian cows are now waiting to give birth to cloned calves that have one extra gene in their genome. These genes allow them to milk insulin, growth hormone orothertherapeu-tic substances once they grow up.

Mapping Human Mobility

To make smarter city planning decisions we need to examine the entire scope of everyday activities of individuals. The making of such analysis and maps has been made easy by the fact that we all carry our mobile phone with us. Researchers from the Mobility Lab, University of Tartu, have developed a novel methodology, based on mobile telephone use, which allows them to investigate the mobility of people: where do people live and where do they work, where do they travel on weekends, which area of the city do they prefer during certain time of day etc. Such data allows for better environmental and city planning decision.

Activity-dependent regulation of BDNF and Arc: master genes in synaptic plasticity

The aim of this project is to study the molecular mechanisms of neuronal activity-regulated expression of BDNF and Arc genes, including transcription, mRNA localization, and translation, in the nervous system. Decreases of BDNF and its receptor TrkB levels and activity are accompanied by and believed to lead to several pathologies, like obesity, impairment of learning and memory, neuropsychiatric disorders, including mood and anxiety disorders and schizophrenia, and neurodegenerative disorders, like Alzheimer, Parkinson and Huntington diseases.

Targeting glioma stem-like cells with tumor penetrating peptides

The project combines the expertise of the laboratory of Prof. **Rolf Bjerkvig** (University of Bergen) and the laboratory of Dr. **Tambet Teesalu** (University of Tartu), to develop tumor penetrating peptides that target GBM. The peptides that project team will develop will provide an angiogenesis-independent paradigm of tumor stem cell targeting that can be potentially applied to other types of solid tumors. As the drug does not have to be conjugated to the peptide, once a peptide has been clinically validated, it can be used to augment the efficacy of any imaging agent or anti-cancer drug - a major advance in glioma therapy could ensue.

Johanna Ivaska's research about SHANK protein

Johanna Ivaska and her research group were recently awarded with Medix Prize for research exploring cell invasion and cancer. The same article brought the group also the Elias Tillandz Prize of 2018.

In the research, a protein that prevents the spreading of cancer was found. The SHANK protein in question limits the activity of cancer cells and prevents them from invading tissues. Correspondingly, gene mutations in this protein weaken the effect of preventing invasion.

Jani Erola's INDIRECT project studies welfare state with focus on the idea of resource compensation

The ERC-funded INDIRECT project studies intergenerational inheritance of socioeconomic attainment, with a focus on the idea of resource compensation. Resource compensation can be seen to come into play when families lose resources and attempt to compensate for these losses. By extending the idea of resource compensation, the INDIRECT projects aims to advance the theory behind and empirical evidence for intergenerational socioeconomic inheritance.

Tuomo Suntola's innovative technology atomic layer deposition (ALD) won the 2018 Millennium Prize

Finnish physicist Tuomo Suntola's innovative technology, atomic layer deposition (ALD), has made our lives with high efficiency smartphones, computers and social media possible. ALD technology also offers medical and sustainable energy applications.

Jyri-Pekka Mikkola wants to change the world by making copies of fossil fuels out of sugar

Jyri-Pekka Mikkola Professor of Industrial Chemistry and Sustainable Chemical Technology at Åbo Akademi University and Umeå University, has made a major technological breakthrough that will make it possible to make copies of fossil fuels out of sugar. The next challenge is to have it replace an established industry. The first patent for producing exact copies of fossil fuels without requiring a single fossil component has already been approved. The dream of making it possible to power existing engines with carbon-neutral fuels has, in other words, already been realised.

Sirpa Jalkanen aims to stop the spread of cancer

Sirpa Jalkanen is a University of Turku professor whose research specialisation is in the fields of biomedical and clinical medicine. She is one of the world's leading researchers of the migration mechanisms of immune cells. Among her key accomplishments are the discovery and characterisation of trafficking molecules that regulate inflammatory diseases and the spread of cancer. Together with her research team, she has produced a number of groundbreaking results and innovative observations that have turned previously held conceptions about immunology and vascular biology on their heads.

Centre of Excellence in Law, Identity and the European Narratives studies the current European crises by studying the European narrative

The dilemma on the current European crises is that popular support for the ideals behind the EU, such as human rights, equality and shared prosperity, has dropped inside the union, while the massive wave of migrants making their way into the union are seeking precisely that: security, rule of law and economic opportunity. This CoE seeks to critically investigate the foundations of the European narrative about a shared heritage of law, values and ideals. It is funded by the Academy of Finland and is hosted by the University of Helsinki.

Centre of Excellence in Tumour Genetics Research aims to bring genomic medicine into practice

Tumors are a challenging disease group as every single case is unique due to the combination of the persons own genome, the tumor genomes formed

by the accumulation of mutations over time, and environmental factors. This CoE aims to improve the understanding of the functions of the genome and to bring genomic medicine into practice. This will be achieved by taking advantage of existing public data and creating and analyzing new key datasets from selected patient populations, identified using unique Finnish registries that allow population-scale data mining.

Kaisa Matomäki is one of the worlds top young researchers in analytic number theory

Kaisa Matomäki together with **Maksym Radziwill** was awarded with the 2019 Breakthroug New Horizons In Mathematics Prize. The prize was awarded for fundamental breakthroughs in the understanding of local correlations of values of multiplicative functions. Breakthrough prizes are awarded to young researchers who have made remarkable breakthroughs in their career.

Cluster of Research Excellence

The University of Hamburg succeed triumphantly in the 2018 call for excellent research clusters within the German Excellence Strategy, co-financed by the federal government and the German Länder.

All four applications for research clusters from Hamburg were approved and will receive approx. 165 Mio. € over 7 years in funds.

The following clusters will be funded:

- „Climate, Climatic Change, and Society (CliCCS)“ addressing questions regarding climate change
- „Advanced Imaging of Matter:

Structure, Dynamics and Control on the Atomic Scale (AIM)“ researching in the field of photon- and nano-science
- „Quantum Universe“ for the field of quantum physics
- and
- „Understanding Written Artefacts: Material, Interaction and Transmission in Manuscript Cultures“, focusing on combining humanities and material sciences.

More than 1000 scientists will be working in these transdisciplinary research clusters from various faculties of the universities and other research institutions such as DESY and Max-Planck-Institutes. The clusters will solidify Hamburg’s position as nucleus for excellent research.

Marine Science/ GEOMAR

Schleswig-Holstein is an important place for marine science in Germany and world-wide. There are three research institutes with a broad range of marine research topics located in Schleswig-Holstein. The biggest is GEOMAR, Helmholtz Centre for Ocean Research Kiel. It is one of the world’s leading institutes in the field of marine sciences. The institute investigates the chemical, physical, biological and geological processes of the seafloor, oceans and ocean margins and their interactions with the atmosphere. With this broad spectrum GEOMAR is unique in Germany. Additionally, the centre has successfully bridged the gap between basic and applied science in a number of research areas. The GEOMAR is a foundation under public law jointly funded by the federal (90 %) and state (10 %) government. GEOMAR has a staff of 1,000 (status on 31 March 2017) and a yearly budget of around 75 Mio. Euro

SIA TILDE

Through a series of FP7 and Horizon 2020 research grants SIA Tilde has succeeded in significantly improving machine translation technologies, creating solutions for integrating the Latvian language into the digital single market. New technologies make it possible to create innovative multilingual products and services. Particular attention has been paid to develop terminology in the Latvian language for use in the digital economy.

SNIFFPHONE

The analysis of exhaled air for screening purposes is a “hot topic” in the area of medical diagnostics. Scientists from the University of Latvia have researched nanotechnology diagnostics based on volatile biomarkers including for diseases involving organs which are not directly participating in the external respiratory process. The new approach involves analyzing exhaled air using mobile technologies, making the screening tool more easily accessible and simpler to use for medical professionals.

Sources