Baltic Science Network

Research and Innovation Excellence in the Baltic Sea Region

Interreg Baltic Sea Region

EU STRATEGY FOR THE BALTIC SEA REGION FLAGSHIP

EUROPEAN UNION
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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 members and does not necessarily reflect the views of all participating Member States and organisations.

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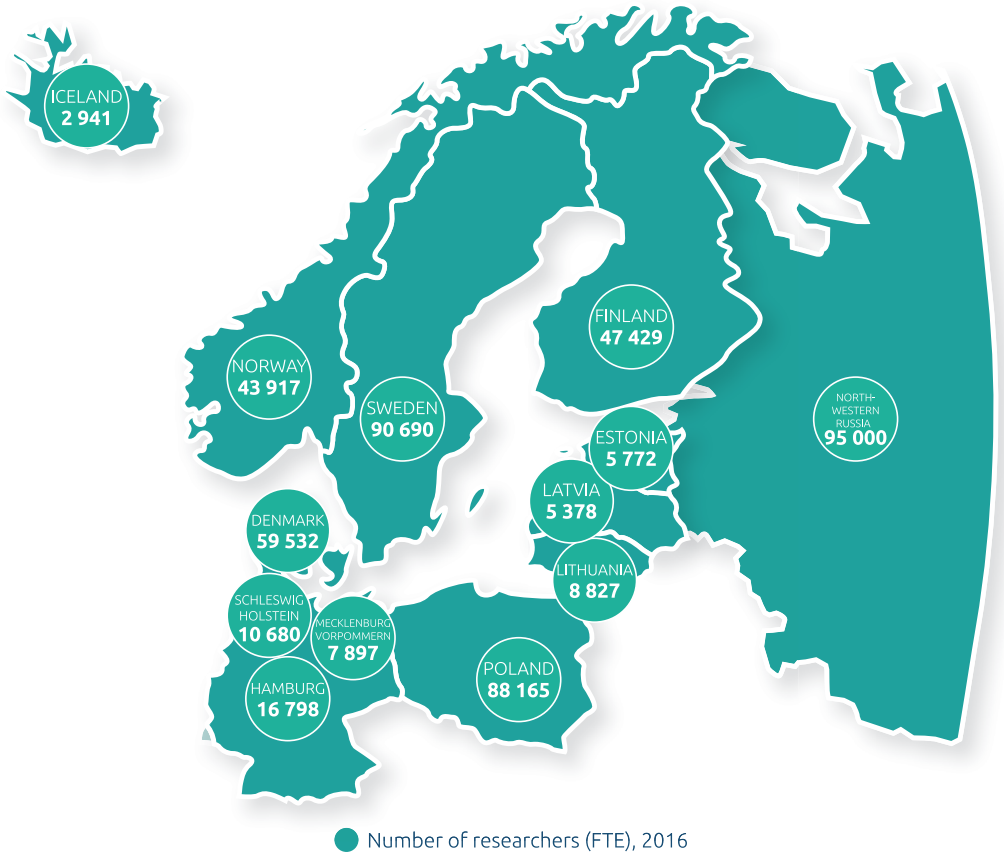
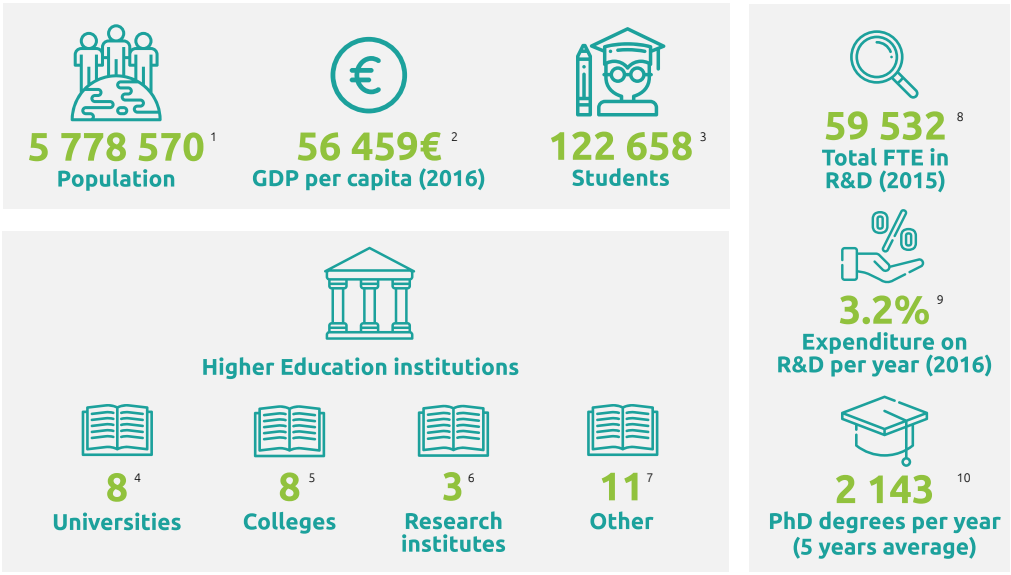
Research capacity in Baltic Sea Region as presented by number of researchers FTE



Introduction

The purpose of this publication is to highlight examples of excellent, scientific achievements from around the Baltic Sea region. 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).[11]

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.[12]

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

7
Universities

13
Colleges

13
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.[13]

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 cited scientists in Estonia (Clarivate) are from the EGC. DNA sequencing was established 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 University of 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.**[14]

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 Environmental 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.[15]

Finland

5 513 130 [16]
Population

40 638€ [17]
GDP per capita

292 226 [18]
Students

Higher Education institutions

14
Universities

25
Universities of applied sciences

12 [19]
State research institutes

47 429 [20]
Total FTE in R&D (2016)

2.8% [21]
Expenditure on R&D per year (2016)

1 822 [22]
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).[23]

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).[24]

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.[25]

Germany

Science and research is federally organised in Germany. Therefore, only the Baltic rim states of Germany (Hamburg, Schleswig-Holstein and Mecklenburg-Vorpommern) are represented in this publication.

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.

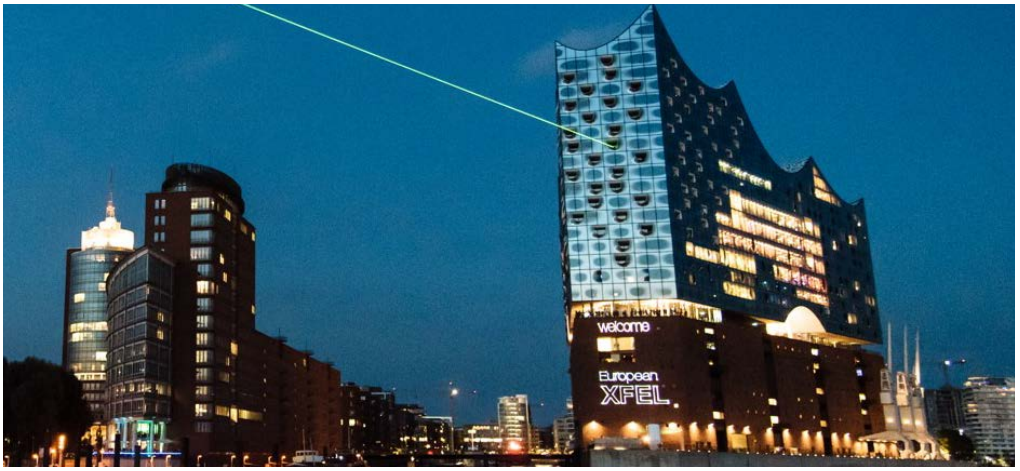
The 3.4 km long European XFEL generates extremely intense X-ray flashes to be used by researchers from all over the world. The flashes are produced in underground tunnels and will allow scientists to map atomic details of viruses, film chemical reactions, and study the processes in the interior of planets.

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 and Schleswig-Holstein. The facility is attracting excellent scientists from all over the world and is thus an international nucleus for research excellence in the region.



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.

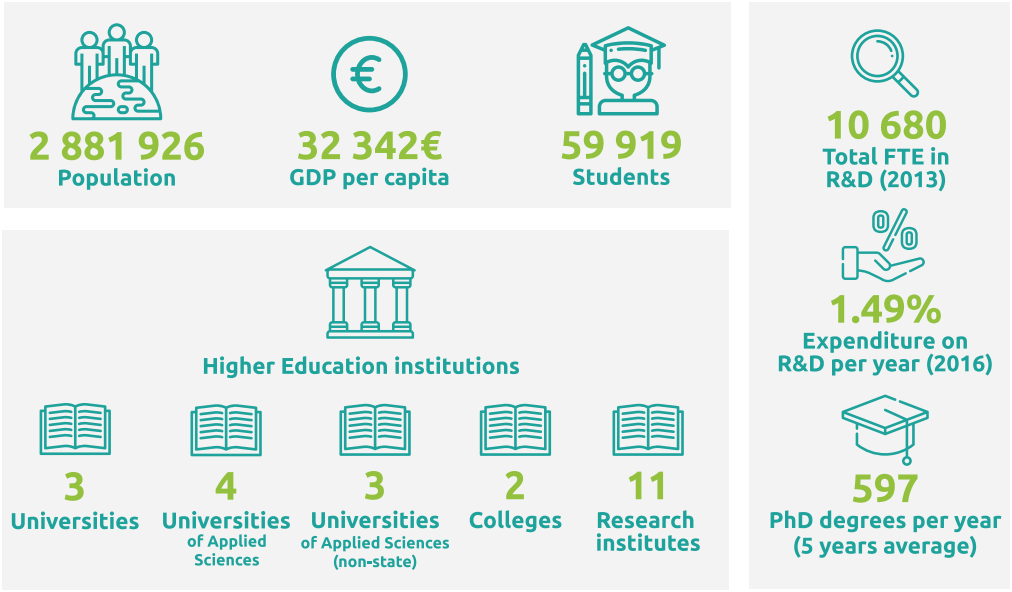
The following clusters will be funded:

- „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.
- „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.

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.

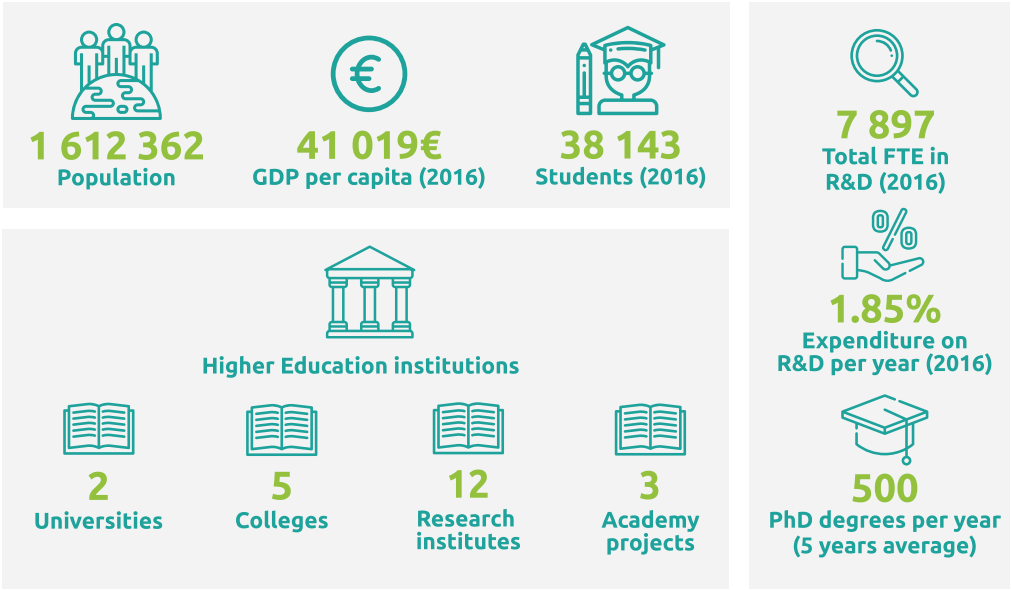
The cluster of excellence aims to explore the roots of social, environmental, and cultural phenomena and processes that substantially marked past human development.

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

Mecklenburg-Vorpommern



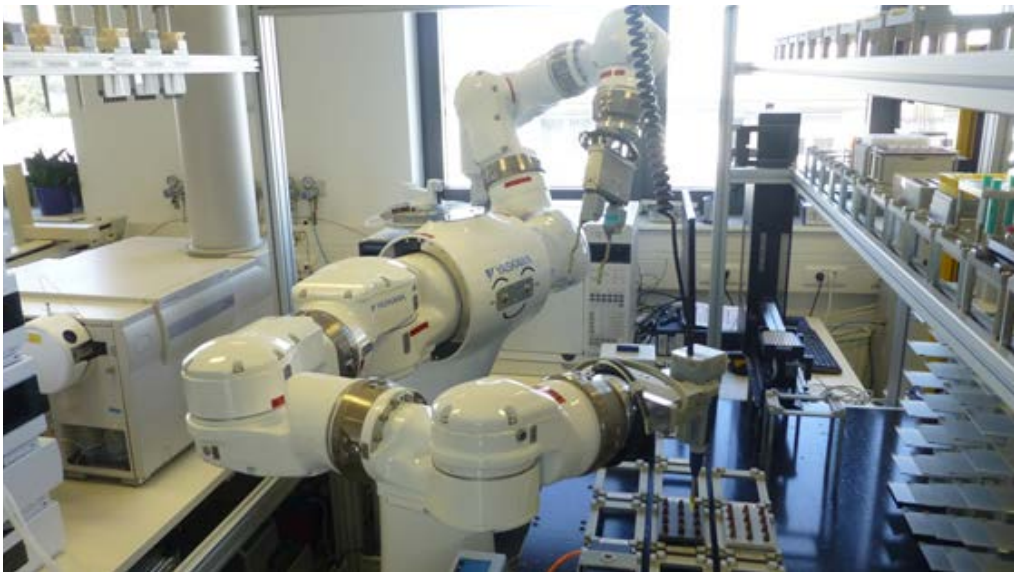
ERC Advanced Grant (NoNaCat)

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 and 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.



Iceland

348 580
Population

63 180€
GDP per capita

18 838
Students

Higher Education institutions

7
Universities

2 941
Total FTE in R&D (2015)

2.08%
Expenditure on R&D per year (2016)

66
PhD degrees per year (5 years average)

Planet Youth, evidence based prevention

During the 1990s and the first years of the 21st century, substance use among 15- and 16-year-old adolescents increased in many European countries and in the USA. Iceland and the other Nordic countries were no exception to this development, and if anything the problem seemed to be even more severe. Alcohol and substance use is a major cost factor for societies around the world and in Europe alcohol is the third most common cause of premature death

In this context, a group of Icelandic social scientists at the Icelandic Centre for Social Research and Analysis (ICSRA), a non-profit research institute now affiliated with Reykjavik University, along with policy makers and practitioners in the field, began collaborating in an effort to better understand the societal factors influencing substance use among adolescents and potential approaches to prevention. ICSRA developed an evidence-based approach to adolescent substance use prevention that involved a broad range of relevant stake holders who worked together on this community-based, socially embedded effort. The method is composed of four steps which extends from research to action on a local level and has been used in the majority of municipalities in Iceland since 1998.

The result has been noticeable and the substance use of Icelandic adolescent has decreased from being the highest in Europe in 1998 to be the lowest in Europe in the year 2016. The research output of the Centre continues to be at the forefront of international research efforts and is providing expert and logistical support for youth research and intervention projects in several countries in Europe, North- and South America and Africa. ICSRA has partnered

with a total of 58 communities in 23 countries and over 100,000 adolescents have participated in their surveys to date.

The founder of ICSRA, **Dr. Inga Dora Sigfusdottir** is currently leading a group of scientists in the US and Europe, who are carrying out an extensive interdisciplinary life course study of children and adolescents aimed at improving our understanding of the biological, environmental and social factors that influence health and behavior of adolescents and eventually adults. That research is currently being funded by a 2 million Euro grant from the European Research Council.

The CarbFix Project

Reducing industrial CO2 emissions is considered one of the main challenges of this century. The recently published IPCC report on global warming of 1,5°C demonstrates the huge benefits of limiting temperature increase to this value. For humankind to reach this challenging but necessary goal, unprecedented changes in society are needed to drastically reduce CO2 emissions.

The CarbFix method captures otherwise emitted CO2, dissolves it in water and injects it into basaltic geological formations. There, the CO2 is turned into rock in less than two years and thereby permanently removed from the atmosphere. The CarbFix team has developed the method from scratch over the past twelve years; moving from laboratory-scale and numerical simulations, through pilot-scale field injections, to stage-wise build-up of industrial-scale capture and injection. Innovative equipment and methods for capturing, injecting, and monitoring have been designed and built. These efforts were partly made possible through funding from the European Union. The annual CO2 emissions of Hellisheidi geothermal power plant, the home of CarbFix, have been reduced by 34% since industrial scale carbon capture and storage (CCS) operations

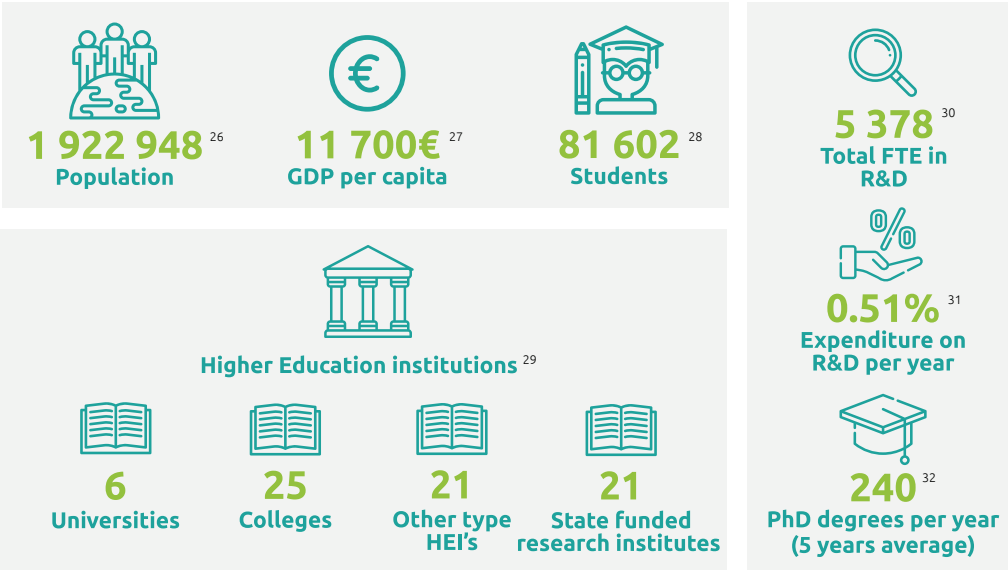
began in 2014 until 2017. Furthermore, collaboration with the Swiss company Climeworks has allowed for a pilot-scale demonstration of a conjugate process of direct capture of CO2 from ambient air at Hellisheidi followed by injection of captured CO2 through the CarbFix method. Plans call for upscaling these activities at Hellisheidi.

The CarbFix method provides a safe and efficient alternative to conventional CCS-methods in which CO2 is stored in less reactive rock formations as a supercritical phase. It only takes two years to petrify the injected CO2 in CarbFix, whereas mineralization happens on the scale of hundreds to thousands of years in conventional CCS. Risks of leaks are also eradicated in CarbFix as the injected phase is denser than the surrounding groundwater and therefore sinks as opposed to rising to the surface through buoyancy forces. Water used for dissolving CO2 can be circulated through the subsurface and re-used after petrification of the CO2. Research related to transforming the method so that seawater can be used for mineral storage in the ocean floor is also underway. Cost of the overall CCS chain at Hellisheidi amounts to less than $25/ton.

Basalts are one of the most common rock types on Earth, covering about 5% of the continents and a large portion of the ocean floor. Global storage capacity in basalts is an order of magnitude larger than the CO2 emitted if all fossil fuel on Earth was to be burnt. The CarbFix method thus provides one of the available solutions for limiting CO2 emissions in vicinity of basaltic terrains.

The CarbFix project has been a joint project between industry and academia from its inception. The project is lead by Reykjavik Energy, the largest geothermal energy company in Iceland. Other founding partners are the University of Iceland, CNRS in Toulouse and Columbia University in New York. Reykjavík Energy along with a group of 17 partners across Europe recently received a EUR 16 Million grant from Horizon 2020. The funding contributes to the „Geothermal Emission COntrol“ (GECO) project, which aims to advance the provision of cleaner and cost-effective geothermal energy across Europe and the World with reduced emissions of carbon and sulphur.The GECO project is largely based on the CarbFix method.

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.

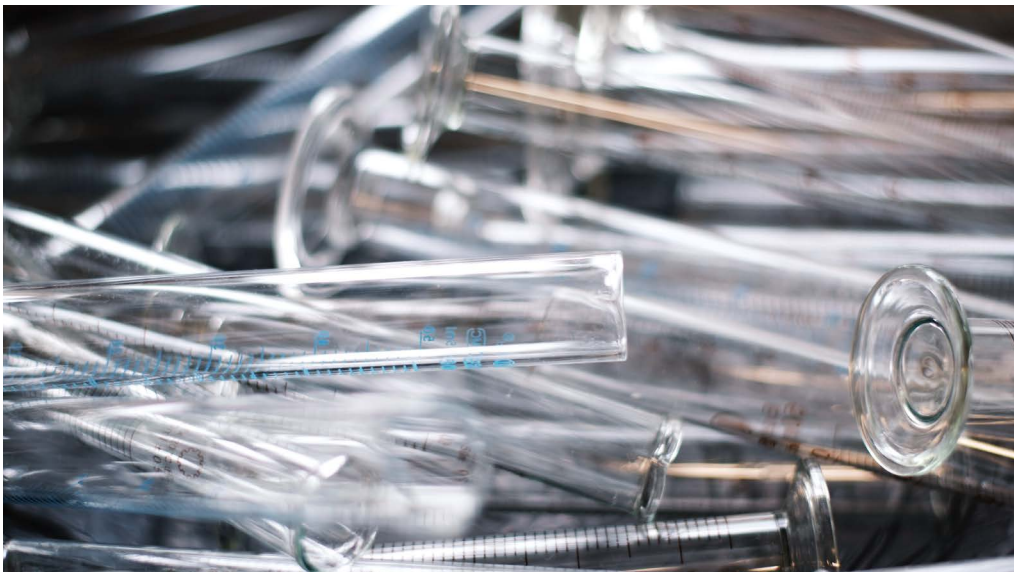
Latvian Institute of Organic Synthesis (LIOS)

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

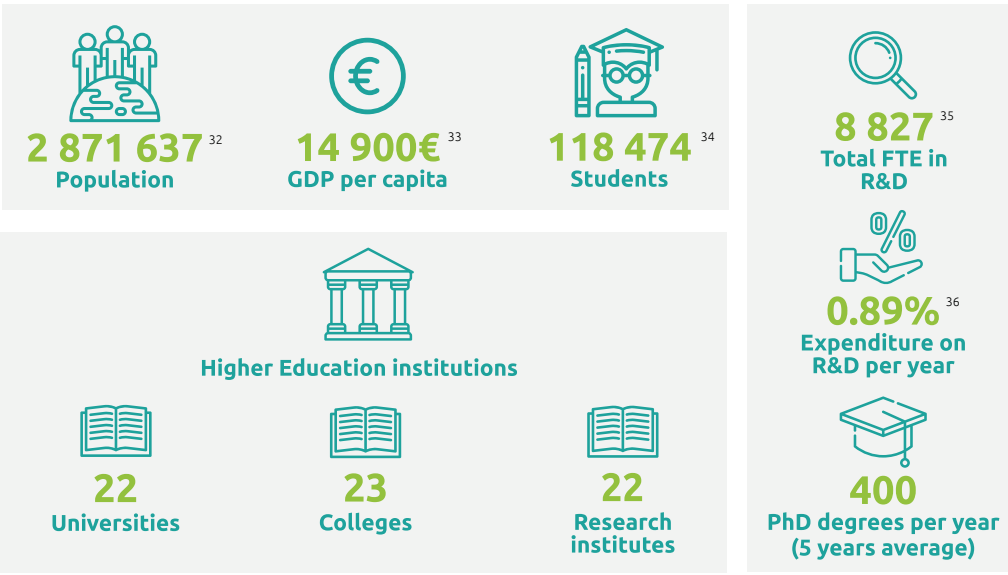
receives significant research funding from the private sector.

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



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.[37]

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 detect 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.[38]

Norway

5 295 600
Population

65 570€
GDP per capita

293 123
Students

43 917
Total FTE in R&D (2016)

2.03%
Expenditure on R&D per year (2016)

1 493
PhD degrees per year (5 years average)

Higher Education institutions

10
Universities (state)

6
Specialized university institustions (state)

3
Specialized university institustions (non state)

5
University colleges (state)

14
University colleges (non state)

10
research institutes with core funding from one or more Norwegian ministries (state)

38
research institutes with core funding from one or more Norwegian ministries (non state)

The 2014 Nobel Prize in Physiology or Medicine 2014

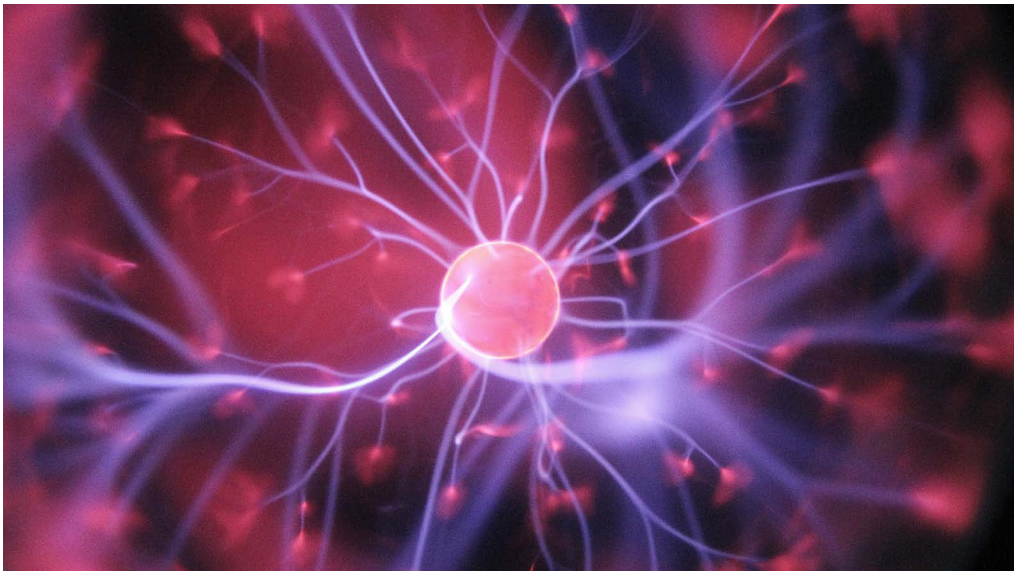
The 2014 Nobel Prize in Physiology or Medicine 2014 was awarded with one half to **Dr. John O´Keefe** and the other half to **Dr. May-Britt Moser** and **Dr. Edvard L. Moser** for their discoveries of cells that constitute a positioning system in the brain. The brain's „Inner GPS" enables virtually all creatures to navigate their surroundings.

How do we know where we are? How can we find the way from one place to another? And how can we store this information in such a way that we can immediately find the way the next time we trace the same path? These Laureates have discovered a positioning system, an "inner GPS" in the brain that makes it possible to orient ourselves in space, demonstrating a cellular basis for higher cognitive function.

In 1971, **John O'Keefe** discovered the first component of this positioning system. He found that a type of nerve cell in an area of the brain called the hippocampus that was always activated when a rat was at a certain place in a room. Other nerve cells were activated when the rat was at other places. O'Keefe concluded that these "place cells" formed a map of the room.

More than three decades later, in 2005, **May-Britt** and **Edvard Moser** discovered another key component of the brain's positioning system. They identified another type of nerve cell, which they called "grid cells", that generate a coordinate system and allow for precise positioning and pathfinding. Their subsequent research showed how place and grid cells make it possible to determine position and to navigate.

The discoveries of **John O'Keefe**,



May-Britt Moser and **Edvard Moser** have solved a problem that has occupied philosophers and scientists for centuries – how does the brain create a map of the space surrounding us and how can we navigate our way through a complex environment

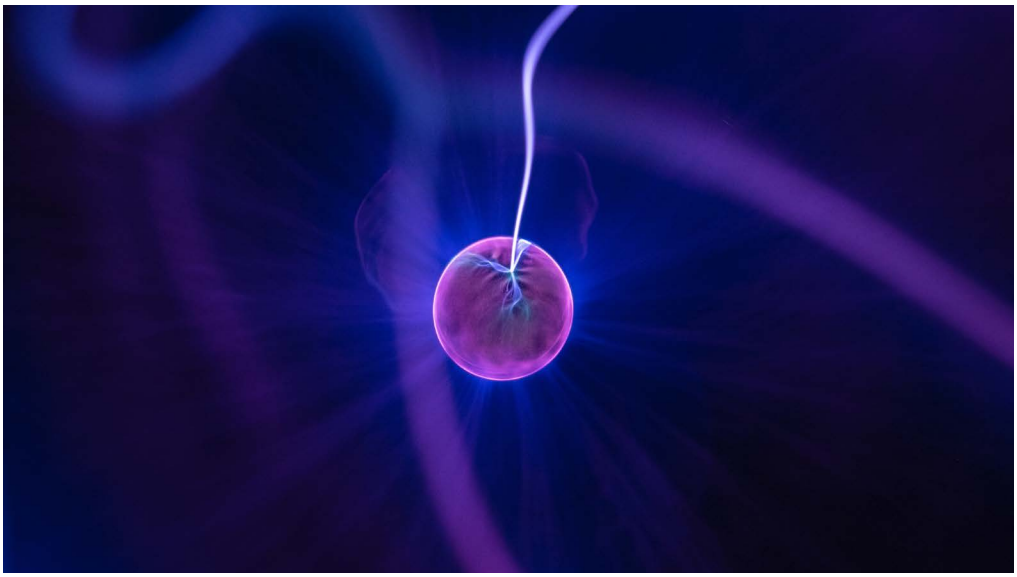
The laureates' findings may eventually lead to a better understanding of the spatial losses that occur in Alzheimer's and other neurological diseases. The hippocampus and entorhinal cortex are often damaged in early stages of Alzheimer's, with affected individuals losing their way and failing to recognize the environment. Knowledge about the brain's positioning system may, therefore, help us understand the mechanism underpinning the devastating spatial memory loss that affects people with this disease.

John O'Keefe was born in 1939 in New York City, USA, and holds both American and British citizenships. He received his doctoral degree in physiological psychology from McGill University, Canada in 1967. O'Keefe is currently Director of the Sainsbury Wellcome Centre in Neural Circuits and Behaviour at University College London.

May-Britt Moser was born in Fosnavåg, Norway in 1963 and is a Norwegian citizen. She studied psychology at the University of Oslo together with her future husband and co-Laureate **Edvard Moser.** She received her Ph.D. in neurophysiology in 1995. She was a postdoctoral fellow at the University of Edinburgh and subsequently a visiting scientist at University College London before moving to the Norwegian University of Science and Technology in Trondheim (NTNU) in 1996. May-Britt Moser was appointed Professor of Neuroscience in 2000 and is currently Director of the Centre for Neural Computation in Trondheim (at the Kavli Institute).

Edvard I. Moser was born in born 1962 in Ålesund, Norway and has Norwegian citizenship. He obtained

his Ph.D. in neurophysiology from the University of Oslo in 1995. He was a postdoctoral fellow together with his wife and co-Laureate May-Britt Moser, first at the University of Edinburgh and later a visiting scientist in John O'Keefe's laboratory in London. In 1996 they moved to the Norwegian University of Science and Technology in Trondheim (NTNU), where **Edvard Moser** became Professor in 1998. He is currently Director of the Kavli Institute for Systems Neuroscience in Trondheim.



The Kavli Institute for Systems Neuroscience

The Kavli Institute for Systems Neuroscience is a Kavli Foundation Institute since 2007, a Centre of Excellence since 2002, and a department under the Faculty of Medicine and Health Sciences NTNU. The research centre was established in 1996.[39]

Poland

38 433 600 [40]
Population

12 055€ [41]
GDP per capita

1 291 900 [42]
Students

88 165 [46]
Total FTE in R&D (2016)

0.97% [47]
Expenditure on R&D per year (2016)

Higher Education institutions

18 [43]
State universities

257 [44]
Non-state universities

260 [45]
Research institutes

7 878 [48]
PhD degrees per year (5 years average)

World-class R&D activities within the International Research Agendas

The Reseach Agendas Programme gives top scientists the opportunity to create a innovative centres of excellence in Poland, which will conduct world-class research activities focused on a specific scientific challenge. The inititive is awarded by the Foundation for Polish Science thanks to funding from the European Regional Development Fund under the Smart Growth Operational Programme.

Three of the awarded projects with a total funding of approx. EUR 25 mln are implemented in the north of Poland indicating a high exellence profile of the region in biological and biomedical sciences, and in quantum physics. The University of Gdańsk is hosting two such centres: International Centre for Cancer Vaccine Science, and International Centre for Theory of Quantum Technologies, and the Medical University of Gdańsk the third one: 3P-Medicine (Preventive, Personalized, Precision).

Cancer is a leading cause of death worldwide. Research programmes focused on cancer-immune interactions are a highly promising approach to improve human health and advance cancer treatment. The International Centre for Cancer Vaccine Science (ICCVS) at the Unversity of Gdańsk, led by **Prof. Ted Hupp** and **Prof. Robin Fahraeus** conducts inter-disciplinary and highly collaborative research in a range of diverse scientific themes related to cancer vaccine science, including neoantigen science, cancer-immune synapse, cancer immunology, mass spectrometry, and translational cancer models. Close strategic partnership with the University of Edinburgh provides not only a unique opportunity for scientific

collaboration but also for best practise transfer in R&D management.

Cancer may appear in humans due to inherited genetic predispositions, but it also often develops due to genetic aberrations acquired over the human life cycle, for example as the result of the action of various factors, such as smoking, poor diet, or certain viral infections. **Prof. Jan Dumański** and **Prof. Arkadiusz Piotrowski** have established at the Medical University of Gdańsk a research centre specializing in research on acquired genetic anomalies as risk factors for cancer and other illnesses: 3P-Medicine (Preventive, Personalized, Precision). The project is implemented in strategic partnership with Uppsala University (Sweden).

World-class scientists **Prof. Marek Żukowski** and **Prof. Paweł Horodecki** have received funding to establish the International Centre for Theory of Quantum Technologies (ICTQT) at the University of Gdańsk. Strategic partner is the Austrian Academy of Sciences, the Institute for Quantum Optics and Quantum Information). ICTQT conducts research into the fundaments of quantum physics, quantum communication and information and quantum technologies. The activity focuses particularly on the development of new technologies, with stress on cybersecurity and new computational techniques i.e. research which will lay the foundations for future key branches of information technology such as the security and development of quantum internet, quantum computers and quantum networks and also the development of quantum simulation. Quantum codes are completely secure and breaking them would be equivalent to breaking the laws of Nature.

Excellence and cooperation in marine and maritime studies

The University of Gdańsk (UG) pays close attention to research into marine and maritime studies. By fulfiling its motto 'In mari via tua' (the sea is your way), the University of Gdańsk strives towards the development of the Pomeranian region, whose greatest asset is indeed the sea.

UG is the initiator and leader of the National Centre for Baltic Research, which brings together local authorities and Pomerania's academic institutions to realise the goals of Polish maritime policy.

UG recently joined consortium aiming to receive a status of European University together with leading marine / maritime universities at coasts of all european basins.

The main fields of marine excellence are: marine environmental protection, maritime law (national and international), law and infrastructure of Pomeranian cities, maritime criminology, maritime transport and economics, maritime literature, folklore of north-eastern Poland, Balto-Slavic mythology and history of Gdańsk and Pomerania.

Russia

Northwestern Russia

13 899 310
Population

8 900€
GDP per capita (2016)

681 234
Students

95 000
Total FTE in R&D

1.1%
Expenditure on R&D per year

Higher Education institutions

347
Colleges

90
Higher education

67
Research institutions

1 800
PhD degrees per year (5 years average)

Graphene on silicon carbide as a basis for gas- and biosensor applications

Dr. Aleksander Lebedev from the Silicon Carbide Research Group of the Ioffe Institute developed promising technology of graphene growth on silicon carbide (SiC). His study was announced as key scientific result of 2017 by Russian Academy of Sciences. Graphene is a promising material with unique properties, such as high surface-to-volume ratio, low electrical noise, and exceptional transport properties associated with its two-dimensional structure. One of the most promising techniques for graphene synthesis, which can be integrated into industrial production, is the thermal decomposition of the surface of semi-insulating SiC substrates. The main advantages of this method are the high structural perfection of the resulting graphene films and the possibility of growing a graphene film on a semi-insulating substrate.

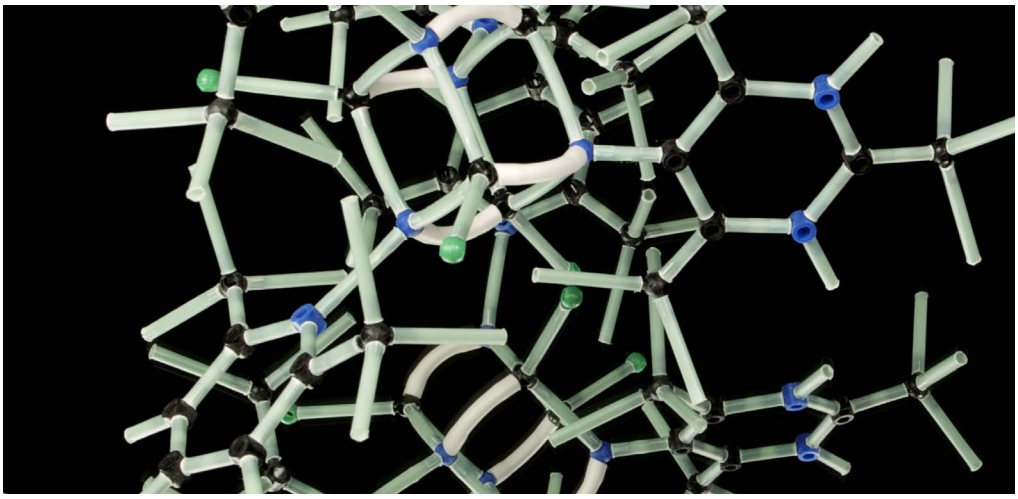
Graphene films were grown by thermal decomposition of single-crystal semi-insulating 6H-SiC and 4H-SiC substrates under Ar at 1800–1850 °C over 10 min. The growth was carried out on the Si-face [SiC (0001)] of a substrate. Before synthesis, organic and inorganic solvents were used to clean the substrate surface. The structural, chemical, and electronic characteristics of graphene were monitored by Raman spectroscopy, atomic force microscopy (AFM), X-ray photoelectron and angle-resolved photoemission spectroscopy (XPS and ARPES).

In his study of the characteristics of graphene films grown by thermal decomposition on the SiC surface and in the performance test of graphene as a gas sensor and a biosensor Dr. Lebedev found that this technology allows the synthesis of high-quality monolayer graphene films with a small fraction of bilayer graphene inclusions. Tests of gas sensors and biosensors based on SiC-supported graphene films showed an extremely high sensitivity to detectable substances. These results demonstrate that the graphene growth technology on SiC is promising for development of next-generation sensors i.e. for environmental analysis or early diagnostics of cancer.[49]

DNA detection by THz pumping

DNA semiconductor detection and sequencing is considered to be the most promising approach for future discoveries in genome and proteome research which is dramatically dependent on the challenges faced by semiconductor nanotechnologies. DNA pH-sensing with ion-sensitive field effect transistor (ISFET) is well-known to be a successfully applied electronic platform for genetic research. However this method lacks fundamentally in chemical specificity. Nanotechnology Research and Education Centre of the St. Petersburg Academic University of Russian Academy of Sciences developed the first ever silicon nanosandwich pump device, which provides both the excitation of DNA fragments' self-resonant modes and the feedback for current-voltage measurements at room temperature. This device allows direct detection of single-stranded label-free oligonucleotides by measuring their THz frequency response in aqueous solution. These results provide a new insight into the nanobioelectronics for the future real-time technologies of direct gene observations.

This experimental method was announced as key research result of 2016 by Russian Academy of Sciences.[50]



Sweden

10 207 086
Population

44 200€
GDP per capita

360 200
Students

35 979
Total FTE in R&D

3.25%
Expenditure on R&D per year

Higher Education institutions

15
Universities

18
Colleges

10
Research institutions

2
Private universities

2 838
PhD degrees per year (5 years average)

European Spallation Source (ESS)

The European Spallation Source (ESS) is a new research infrastructure under construction in the city of Lund, in southern Sweden. The facility's unique capabilities will both greatly exceed and complement those of today's leading neutron sources, enabling new opportunities for researchers across the spectrum of scientific discovery, including materials and life sciences, energy, environmental technology, cultural heritage and fundamental physics.

The European Spallation Source is a pan-European project with 15 European nations as members and Sweden and Denmark as host nations. The ESS facility is being built in Lund, while the ESS Data Management and Software Centre (DMSC) is located in Copenhagen, Denmark. Around two to three thousand guest researchers are expected to carry out experiments at ESS each year. Most of the users will be based at European universities and institutes, others within industry.

The European Spallation Source is one of the largest science and technology infrastructure projects being built today. The facility's design and construction includes the most powerful linear proton accelerator ever built, a four-tonne, helium-cooled tungsten target wheel, two dozen state-of-the-art neutron instruments, a suite of laboratories and a supercomputing data management and software development centre.

The first experiments are expected to be carried out in 2023 and the facility is expected to be in full use in 2025.[51]

MAX IV

MAX IV Laboratory is a Swedish national laboratory providing scientists advanced X-rays for research. With more than 30 years of experience operating the MAX I-III facilities, the laboratory is now commissioning MAX IV, which was inaugurated on 21 June 2016.

X-rays were discovered some 120 years ago and today we use X-rays in all kinds of aspects of everyday life – from medical applications to industrial testing, and for developing innovative materials. With MAX IV, Sweden has set out to build the brightest X-ray source in the world. The work performed in Sweden over the last 30 or 40 years in regards to X-rays has made Sweden world leading in the field of accelerator physics.

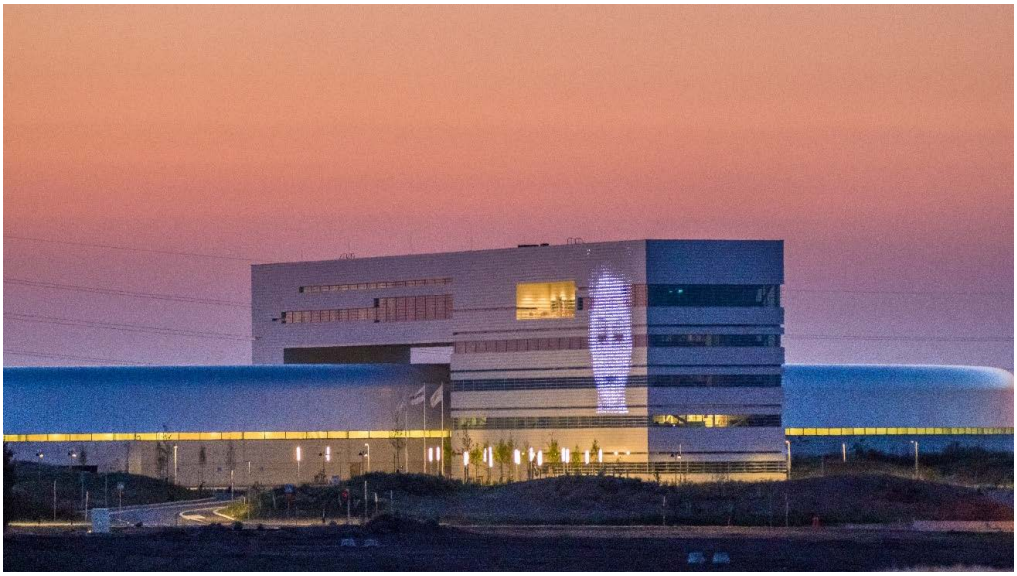
With the MAX IV facility, Sweden has the highest quality of X-rays available to scientists from academia and industry. The X-rays will be used at instruments tailored to various fields of studies and several other countries such as Denmark, Finland and Estonia are involved in constructing some of these instruments.

The use of X-rays will help us understand, explain and improve the world around us. They will enable us to study different materials we use today and improve them beyond the performance that we currently know. In addition to this, MAX IV will also allow scientists to develop new materials and products that we today cannot fully imagine, such as medications with better and more precise functions and fewer side-effects, nanoparticles for diverse areas of application, including paints, catalysis or computing, or lighter and stronger packaging materials.

An important strength of synchrotron X-rays is that the technique developed by physicists has made its way into mainstream natural science and engineering. Today, a facility such as

MAX IV is home to research projects in biology, physics, chemistry and environmental science, as well as geology, engineering, pharmacology and cultural heritage.

MAX IV is also keen to engage with industry to provide R&D departments tools to study raw materials and to process and develop new products with the help of X-ray technology.



Sources

Denmark:

[1] DK-Statistik, 2017, 4th quarter
https://www.statistikbanken.dk/statbank5a/SelectVarVal/saveselections.asp
[2] DK-statistik 2017, BNP-tal fra Årligt Nationalregnskab 2017 omregnet ved OECD kurs for 2017 (6.603)
http://www.statistikbanken.dk/statbank5a/selectvarval/saveselections.asp
[3] Finansloven 2017, UFM's Ministerhæfte, § 19.22
[4] Finansloven 2017, UFM's Ministerhæfte, § 19.22 .
[5] University-Colleges, Studyindenmark.
http://studyindenmark.dk/study-options/danish-higher-education-institutions
[6] Government Research Institutes pr. 2018.
[7] Artistic Higher Education Institutions, Schools of Maritime Education & Training (Studyindenmark).
http://studyindenmark.dk/study-options/danish-higher-education-institutions
[8] OECD.stat, 2015.
[9] DK-Statistik, 2016.
[10] DK-Statistik, 2013-2017
https://www.statistikbanken.dk/statbank5a/SelectVarVal/saveselections.asp
[11]https://healthsciences.ku.dk/news/2018/04/weight-loss-before-puberty-reduces-the-risk-of-type-2-diabetes/
https://www.nejm.org/doi/full/10.1056/NEJMoa1713231?af=R&rss=currentIssue
[12] https://www.dr.dk/nyheder/viden/kroppen/ny-blodproeve-kan-afsloere-om-du-har-kraeft
https://www.nature.com/articles/s41467-018-05793-2

Estonia:

[13] https://home.cyber.ee/~ahtbu/buldas-cv-eng.pdf
[14] https://www.geenivaramu.ee/en
[15] https://niinemetslab.wordpress.com/

Finland:

[16] https://www.stat.fi/tup/suoluk/index_en.html
[17] https://www.stat.fi/tup/suoluk/suoluk_kansantalous_en.html
[18]https://vipunen.fi/fi-fi/_layouts/15/xlviewer.aspx?id=/fi-fi/Raportit/Korkeakoulutuksen%20opiskelijat_A2.xlsb
[19] https://minedu.fi/en/heis-and-science-agencies
[20] https://doi.org/10.1787/data-00182-en
[21] http://www.stat.fi/til/tkke/2016/tkke_2016_2017-10-26_tie_001_en.html
[22] Degree data from:
https://vipunen.fi/fi-fi/_layouts/15/xlviewer.aspx?id=/fi-fi/Raportit/Korkeakoulutuksen%20tutkinnot_A2.xlsb
[23]https://www.aalto.fi/news/erc-synergy-grant-worth-eu10m-will-help-develop-new-techniques-for-brain-research-disease
http://aka.fi/en/about-us/media/press-releases/2018/first-research-project-led-by-finnish-university-receives-erc-synergy-grant/
[24]http://www.aka.fi/en/about-us/scientists-behind-the-research/academicians-of-science/finnish-academicians-of-science/academician-markku-kulmala/
[25]http://www.aka.fi/en/about-us/scientists-behind-the-research/academicians-of-science/finnish-academicians-of-science/academician-eva-mari-aro/

Latvia:

[26] Eurostat
https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00001&plugin=1
[27] Eurostat. Real GDP per capita
https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=sdg_08_10&plugin=1
[28] IZM http://www.izm.gov.lv/images/izglitiba_augst/Parskats-par-Latvijas-augstako-izglitibu-2017gada.pdf
[29] IZM
[30] CSB
http://data1.csb.gov.lv/pxweb/lv/zin/zin__zin/?tablelist=true&rxid=a39c3f49-e95e-43e7-b4f0-dce111b48ba1
[31] CSB
http://data1.csb.gov.lv/pxweb/lv/zin/zin__zin/?tablelist=true&rxid=a39c3f49-e95e-43e7-b4f0-dce111b48ba1
[32] IZM

Lithuania:
[33] Eurostat http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en
[34] Eurostat http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_pc&lang=en
[35] ŠVIS, http://svis.emokykla.lt/
[36] eurostat, http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
[37] Statistics Lithuania https://osp.stat.gov.lt/statistiniu-rodikliu-analize?indicator=S3R315#/
[38] www.kavliprize.org
[39] http://www.epo.org/learning-events/european-inventor/finalists/2016/ragauskas.html

Norway:
[39] https://www.ntnu.edu/web/kavli/home

Poland:
[40] Ludność. Stan i struktura oraz ruch naturalny w przekroju terytorialnym w 2017 r. Stan w dniu 31 XII, https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc/ludnosc-stan-i-struktura-oraz-ruch-naturalny-w-przekroju-terytorialnym-w-2017-r-stan-w-dniu-31-xii,6,23.html.
[41]International Monetary Fund https://www.imf.org/external/pubs/ft/weo/2018/01/weodata/weorept.aspx?sy=2017&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=48&pr1.y=12&c=964&s=NGDP_RPCH%2CNGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC&grp=0&a=.
[42]Szkolnictwo wyższe w roku akademickim 2017/2018 (dane wstępne) https://stat.gov.pl/obszary-tematyczne/edukacja/edukacja/szkolnictwo-wyzsze-w-roku-akademickim-20172018-dane-wstepne,8,5.html.
[43] Instytucje szkolnictwa wyższego
https://polon.nauka.gov.pl/opi/aa/rejestry/szkolnictwo?execution=e2s1.
[44] Ewidencja uczelni niepublicznych https://polon.nauka.gov.pl/opi/aa/rejestry/run?execution=e1s1
[45] Jednostki naukowe https://polon.nauka.gov.pl/opi/aa/rejestry/nauka?execution=e3s1.
[46] Nauka i technika w 2016r.
http://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/nauka-i-technika/nauka-i-technika-w-2016-roku,1,13.html
[47] Gross domestic spending on R&D https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm.
[48] Szkoły wyższe i finanse 2012-2016
https://stat.gov.pl/obszary-tematyczne/edukacja/edukacja/szkoly-wyzsze-i-ich-finanse-w-2016-r-,2,13.html
https://stat.gov.pl/obszary-tematyczne/edukacja/edukacja/szkoly-wyzsze-i-ich-finanse-w-2015-r-,2,12.html
https://stat.gov.pl/obszary-tematyczne/edukacja/edukacja/szkoly-wyzsze-i-ich-finanse-w-2013-r-,2,10.html
https://stat.gov.pl/obszary-tematyczne/edukacja/edukacja/szkoly-wyzsze-i-ich-finanse-w-2012-r-,2,9.html

Russia:
[49] http://www.ioffe.ru/HTML/achievements/Rest_0131/Rest_0131.pdf
[50] http://journals.ioffe.ru/articles/viewPDF/41972

Sweden:
[51] www.esss.se

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