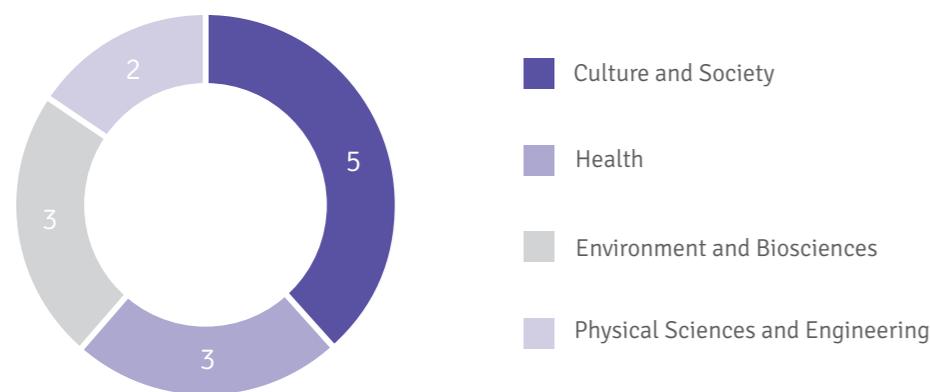


Norwegian-Estonian Research Cooperation Programme 2012–2017

The overall objective of the Norwegian-Estonian Research Cooperation Programme is to enhance research-based knowledge development in Estonia through research cooperation between Norway and Estonia. 13 donor partnership projects were funded as a result of the single call launched in 2013. The projects represent all areas of research: culture and society, environment and biosciences, physical sciences, engineering and health. The first projects started in September 2013 and the latest in September 2014. Nine projects ended in 2016 and four in April 2017.

The activities organised to develop bilateral relations and to ensure the wider impact and better results of the Programme were designed to strengthen further research cooperation and participation in the EU Research and Innovation programme Horizon 2020 and to put more effort into capacity building (e.g., introducing Norway Grants and research cooperation programmes to wider audience, enabling project promoters to take part in the Annual Conferences of the European Association of Research Managers and Administrators, inviting Norwegian experts to give presentations in capacity building conferences and seminars).

Projects by thematic area



Key facts

PROGRAMME OPERATOR	Estonian Ministry of Education and Research
IMPLEMENTING AGENCY	Estonian Research Council
DONOR PROGRAMME PARTNER	Research Council of Norway
PROGRAMME BUDGET	3.3 million euros 90%—Norwegian Financial Mechanism 10%—Estonian Ministry of Education and Research
RESULTS OF THE 2013 CALL	170 eligible proposals (requesting a total of 48.2 million euros) 13 financed projects (duration 2013–2017)
PROJECT PROMOTERS	University of Tartu Tallinn University of Technology Estonian University of Life Sciences Tallinn University
PROJECT PARTNERS IN NORWAY	University of Bergen University of Oslo University of Stavanger University of Tromsø Norwegian University of Life Sciences Norwegian Institute of Bioeconomy Research
NUMBER OF COOPERATING RESEARCHERS	44 in Estonia (women's representation 38%) 36 in Norway (women's representation 21%)
NUMBER OF HIGH LEVEL PUBLICATIONS ¹	60

¹ Scholarly articles indexed by Web of Science, Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index and/or indexed by Scopus (excluding chapters in books)

/Title of the project/

Activity-dependent regulation of BDNF and Arc: Master genes in synaptic plasticity (EMP128)

/Project leader/

Tõnis Timmusk, Tallinn University of Technology

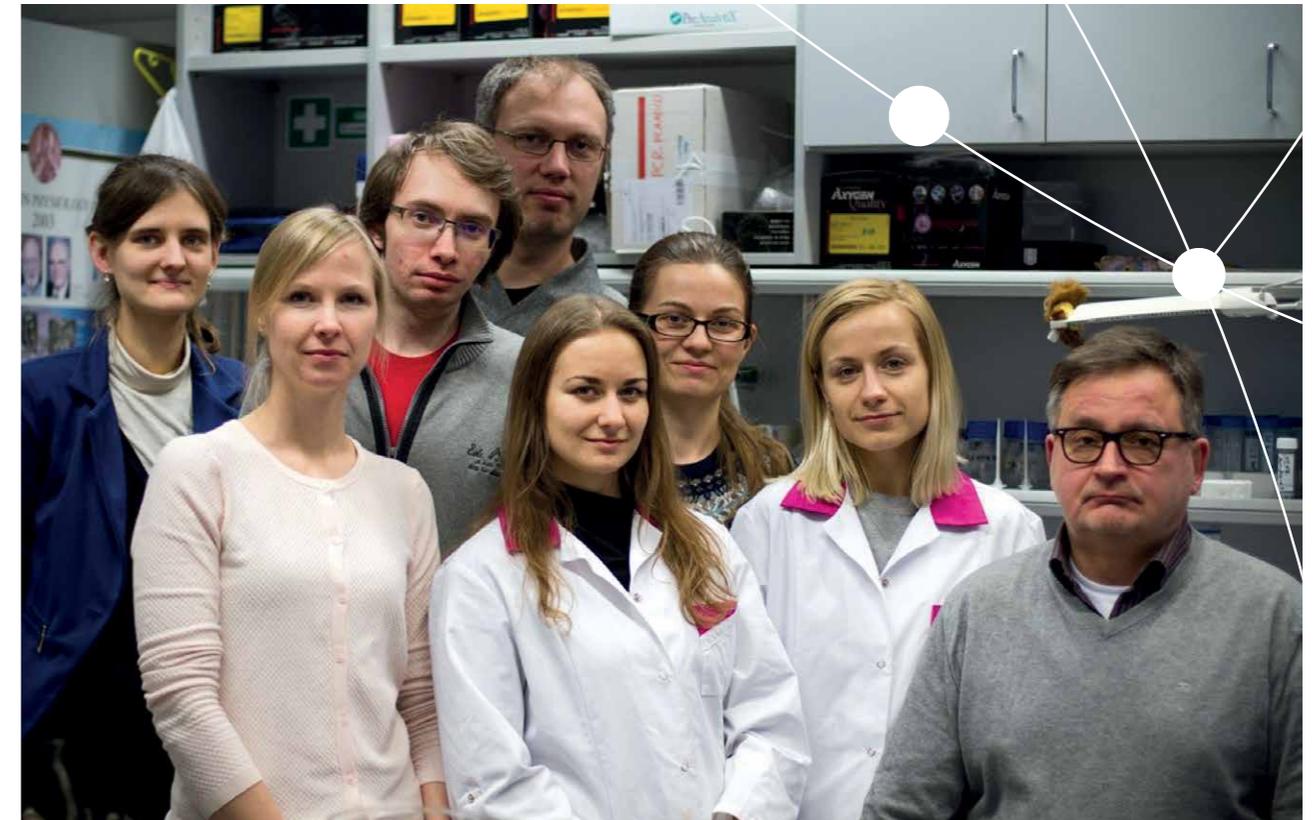
Neurons and glial cells are specialised cells with a complex morphology that represent the functional units of the nervous system. They are generated in remarkable numbers, particularly in higher vertebrates. In the adult human brain, for example, there may be more than 85 billion neurons and even more glial cells. An axon (from Greek, axis), also known as a nerve fibre, is a long, slender projection of a nerve cell, or neuron, that typically conducts electrical impulses away from the neuron's cell body. The junctions across which a nerve impulse passes from an axon terminal to a neuron, muscle cell, or gland cell are called synapses. During the developmental period of synaptogenesis, neurons become dependent on their target tissue; if the target is removed, neurons degenerate and die. This long-term dependence between neurons and their target tissue is called neurotrophic interaction. The molecular bases of trophic interaction are neurotrophic factors that are secreted in limited amounts from target cells. Neurotrophins, including brain-derived neurotrophic factor (BDNF), are a

family of neurotrophic factors that bind to their Trk family cell surface receptors and lead to receptor activation and intracellular signal transduction. Neurotrophins promote the survival, differentiation and maintenance of specific neuronal populations, and have other important functions, including the regulation of activity-dependent synaptic plasticity, stimulation of neurite outgrowth, protection and repair of neurons during tissue injury.

The modifiability of neuronal connectivity by formation of new synapses, and alteration of the strength and stability of existing synapses, is regarded as the main cellular basis for memory and long-term behavioural adaptations. The genes encoding neurotrophin BDNF and activity-regulated cytoskeleton-associated protein ARC are considered to be the master genes of synaptic plasticity. In addition, BDNF is of particular interest owing to its deregulation in nervous system disorders. Decreases in 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's, Parkinson's and Huntington's disease. Therefore, knowledge about the regulatory mechanisms of the BDNF gene is important both for understanding nervous system function and finding new drug targets. We have studied the molecular mechanisms of the neuronal activity-regulated expression of

BDNF and Arc genes, including transcription, mRNA localisation and translation in the nervous system. The experimental approach took advantage of the complementary know-how and expertise of the groups of Professor Tõnis Timmusk, Tallinn University of Technology, in BDNF gene structure, expression and transcriptional regulation, and Professor Clive

Bramham, University of Bergen, in BDNF and Arc function in vivo, electrophysiology, imaging and translational regulation. Our results have revealed the novel mechanisms in the (1) regulation of BDNF gene transcription by its receptor TrkB signalling; (2) regulation of BDNF and Arc translatability by membrane depolarisation and TrkB signalling.



Tõnis Timmusk's project team

/Title of the project/

Targeting glioma stem-like cells with tumour penetrating peptides (EMP181)

/Project leader/

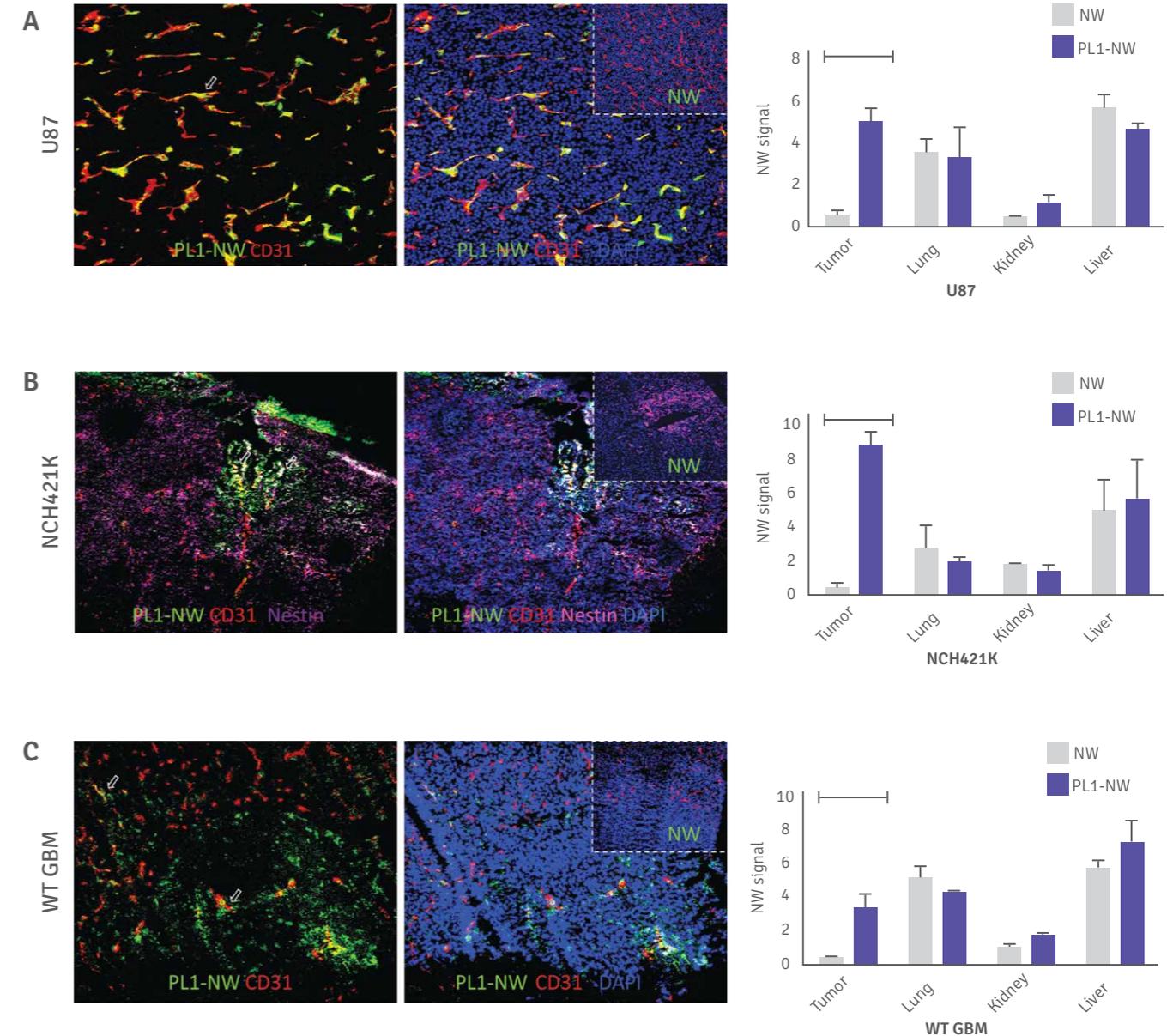
Tambet Teesalu, University of Tartu

Glioblastoma (GBM) is the most common primary brain tumour in adults. Despite aggressive treatment, the majority of patients die within a year of diagnosis. A major problem preventing curative resection is the extensive infiltration of stem-like glioma cells in the brain. The goal of this project was to find the homing “courier” peptides for the precision-guided delivery of drugs and imaging agents to glioma cells. Our project combined Professor Rolf Bjerkvig’s (University of Bergen) laboratory’s expertise on the state-of-the-art, clinically relevant human GBM models with the expertise of the laboratory of Dr. Tambet Teesalu (University of Tartu) on homing peptide screening platforms and targeted drug delivery technologies.

First, we transferred the glioma models from the University of Bergen to the University of Tartu and characterized the tumours with immunofluorescence staining, using cell type and status-specific antibodies and histochemistry. Second, these advanced and clinically relevant glioma models from Bergen were used in Tartu to identify the

peptides that home to glioma lesions and target infiltrative glioma stem-like cells. On the one hand, we tested the homing of tumour homing peptides from our past screens for their ability to recognize glioma lesions and found that two peptides, TT1 and PL1, were effectively homing to a panel of glioma models, including stem cell-like models NCH421k and P3. On the other hand, we performed *de novo* screens using peptide bacteriophage libraries to identify new glioma homing peptides. These new *in vivo* screens resulted in the identification of four candidate peptides with robust selectivity towards stem cell like glioma cells. In addition to peptides that target tumour cells, the screens resulted in the identification of a novel protumoral macrophage-targeting peptide, UNO. Third, we tested the ability of the peptides with regard to tumour selectivity and the activity of nanoparticle contrast agents (iron oxide nanoworms, silver nanoparticles, polymersomes) and nanodrugs (Abraxane® and iron oxide nanoworms functionalised with a toxic peptide). These studies demonstrated that functionalisation with glioma homing peptides renders nanoparticles selective towards glioma lesions. This increase in tumour selectivity translated to improved tumour imaging and potentiated therapeutic response.

The peptides that we developed are able to penetrate gliomas (and potentially other tumours) for precision-guided payload delivery. The preclinical data suggests that this strategy allows improved



antitumor therapeutic response and warrants follow-up collaborative studies on optimising the platform for clinical development.

As per scientific output, five reports acknowledging the grant have already been published. Due to the long term nature of the studies, several joint studies are currently in submission or in the final stages of preparation. The grant also contributed significantly to three PhD projects that are expected to be completed later in 2017. Beyond immediate scientific/training outcomes, the project contributed to the bidirectional sharing of know-how between the partners and the establishment of long-lasting collaborative research activities and joint training programs between the laboratories in Bergen and Tartu.

Homing of FAM-PL1-NW particles to GBM. Iron oxide NWs coated with FAM-labelled PL1 peptide or FAM through a 5KPEG linker were IV injected (7.5 mg iron per kg body weight) into GBM mice. Five hours after the injection, the mice were perfused

through the heart with PBS/DMEM; the organs were collected. The organ sections were stained and examined with confocal microscopy. (A) U87 GBM subcutaneous model, (B) NCH421K orthotopic model, and (C) WT GBM orthotopic model were injected with FAM-NW and FAM-PL1-NW peptide. Blue represents nuclei stained with DAPI; green represents FAM-NW or FAM-PL1-NW; red represents blood vessels stained with anti-CD31 antibody and magenta represents human nestin expressed by NCH421K cells. The control FAM-NW images shown in the square box and scale bar corresponds to 100 μ m. The last column represents FAM-PL1-NW biodistribution analysis via image analysis with ImageJ to quantify FAM (green) positive areas. Quantification of FAM signal in representative tissue sections from tumours and control organs (mean pixel intensity). Error bars, mean \pm SEM (N=3-6); Statistical analysis: P-value determined using unpaired t-test; *P< 0.05;***P < 0.001,**** p < 0.0001.

Author: Prakash Lingasamy, MSc

/Title of the project/

Language and auditory brain: Studies on central sound representation in auditory cortex (BerTa-LAB) (EMP180)

/Project leader/

Risto Kalervo Näätänen, University of Tartu

The ability to understand spoken language is so essential that we hardly recognize the extraordinariness of this cognitive process. The sounds that reach our ear are transformed into a conscious representation of meaningful speech in mere milliseconds. We effortlessly extract the semantic and syntactic information, but also the location, mood, age, gender, social status etc. of the speaker. We only consciously notice speech processing when it does not function the way it should. Trying to understand

speech in a foreign language, struggling to keep up with a conversation at a loud party, or even hearing “voices” talking to you that are not really there—these are examples of various situations where our auditory system is challenged beyond its comfort zone. In this project, we explored the fundamental mechanisms that enable our brains to process auditory sounds. With collaboration between the laboratory of experimental psychology, University of Tartu (Risto Näätänen, Nele Pöldver and Kairi Kreegipuu), and the Bergen fMRI group, University of Bergen (Kenneth Hugdahl, Kristiina Kompus and René Westerhausen), we shared knowledge of study protocols and expertise in experimental and brain imaging techniques, and conducted experimental research in parallel in both institutions.

We showed that processing language information is strongly affected by the mother tongue of the perceiver, most probably due to experiential differences during early language development



Illustration of difference in usage of initial plosive stop-consonants in Estonian and Norwegian. Left, a Norwegian sign containing the word dansestudio (‘dancing studio’) with voiced initial plosive. Right, an Estonian sign showing the word tantsustudio (‘dancing studio’) starting with unvoiced plosive.

and the formation of memory traces. In a language with tonal properties, the processing of pitch is supported by brain networks involved in speech processing, whereas in a non-tonal language, pitch is processed differently. In a language with a clear distinction between voiced and unvoiced consonants, perceivers are more sensitive to the voicing properties in speech. These results are important for diagnostic tools and study protocols where language-related material is used. To clarify which stimuli to use in clinical and laboratory settings, we compared natural and computer-based synthesized stimuli, and showed the preferred percept of natural stimuli.

We investigated the plasticity of the auditory system and its structural and metabolic determinants using

the mismatch negativity (MMN) paradigm, which reflects the brain's automatic response to changes in stimulation. Drug challenge studies indicate that NMDA receptor-mediated synaptic plasticity is particularly involved in the MMN, therefore we studied the role of the excitatory neurotransmitter, glutamate, and showed for the first time that the inter-individual variation in the glutamatergic neurotransmission affects the MMN in healthy individuals in the absence of pharmacological manipulation. We also showed an increase in the MMN amplitude after rapid, short-term LTP-like auditory training. The mechanisms of cortical plasticity following training are important to study due to their importance for learning and memory, as well as possibilities for intervention in the case of disturbances in sensory processing.

/Title of the project/

Sami–Estonian language technology cooperation: Similar languages, same technologies (EMP160)

/Project leader/

Heiki-Jaan Kaalep, University of Tartu

The project brought together language technology research in Norway and Estonia to explore a common challenge: how to make robust models for complex morphologies like those present in the Sami and Estonian language. The two cooperating research groups already used the same approaches, and the Tromsø group had experiences in building a model that can be integrated into different practical applications. In this project we shared a common infrastructure and open source tools, and put the morphological models into use for machine

translation (MT) and advanced interactive computer-assisted language learning (iCALL) systems.

MT

The Finnish-Estonian and Estonian-Finnish translation pipelines are operational (<http://gtweb.uit.no/tolkimine/>), although the direction from Estonian to Finnish is an early experimental one. The resources (Estonian-Finnish lexicon, transfer rules) and documentation are available at http://wiki.apertium.org/wiki/Finnish_and_Estonian and <https://svn.code.sf.net/p/apertium/svn/incubator/apertium-fin-est/>.

The North Sami–Finnish and Finnish–North Sami directions are operational (<http://gtweb.uit.no/mt-testing/>). Both systems are in an early phase. The resources (Sami-Finnish lexicon, transfer rules) and documentation are available at <https://svn.code.sf.net/p/apertium/svn/nursery/apertium-sme-fin/>.

iCALL

iCALL system Oahpa by the University of Tromsø is meant as a supporting tool for learning vocabulary and grammar. It offers a platform where the user may practice the generation (and not blind repetition) of morphologically complex forms, complete with explanations and guidelines. Oahpa consists of six games: a word quiz (Leksa), a numeral quiz (Numra), morphology drill game Morfa-S (isolated word forms) and Morfa-C (word forms in a sentential context), a question-answer drill (Vasta) and a dialogue game

(Sahka). The latter two require syntactic analysis on top of the morphological analysis.

Estonian Oahpa (<http://testing.oahpa.no/eesti/>). Leksa, Morfa-S (nouns and verbs), Morfa-C (nouns), Vasta-S are currently operational. These are based on the lexicon from the textbook E nagu Eesti (ca 1,000 words with translations into English, Russian, Finnish, Swedish and German).

The vocabulary training program Leksa is usable for people with different language backgrounds as there are seven languages to translate to/from: English, Finnish, Russian, German, Swedish, Norwegian and North Sami. The entire user interface of Estonian Oahpa is localised to Estonian, English, Russian, Finnish and Swedish. We have added Swedish because there are Estonian learners in Sweden—the Estonian school in Stockholm teaches it and university level courses of the Estonian language are provided at Uppsala University.

Võru Oahpa (<http://oahpa.no/voro/>) is more developed than Estonian Oahpa. Numra (all the games), Leksa, Morfa-S (nouns, adjectives and verbs) and Morfa-C (nouns and verbs) are currently operational. The Leksa lexicon contains ca 1,200 words with translations into Estonian, Finnish, English, North Sami and Norwegian. The program is put to use as a part of the Võru language course at Tartu University. As a novel feature, we added audio (pronunciations) to Leksa and Morfa-C.

/Title of the project/

Novel analysis and design tools for low-density parity-check codes (EMP133)

/Project leader/

Vitaly Skachek, University of Tartu

Towards optimal data communications

Low-density parity-check (LDPC) codes have become a standard in contemporary digital wired and wireless communications, and in data storage. They are widely used in a broad variety of mobile communications systems, satellite communications, computer hard drives and flash memories. The key reasons for the success of LDPC codes are their high resistance to noise and efficient decoding algorithms.

Typically, practical decoders for LDPC codes employ iterative message-passing algorithms, which are applied to so-called Tanner graphs, or bipartite graphs determined by the parity-check matrices of the codes. These decoders are very fast and efficient in correcting errors. The optimization of LDPC codes and their decoding algorithms is very important in improving their performance. Yet, unfortunately, our understanding of the causes of failures in LDPC codes is still rather limited. Today, the optimization of practical LDPC codes is done experimentally,



Eirik Rosnes and Nalin Jayakody discussing research in Bergen, October 2015
(Photograph by Øyvind Ytrehus)

partly due to the limited set of tools available for the code designer.

In this project, we studied techniques for the construction of more efficient and reliable LDPC codes, new decoding methods and analytical tools

for LDPC codes, as well as a variety of general questions related to the design and use of graph-based error-correcting codes. For example, we developed a novel method for decoding LDPC codes on a channel with Gaussian noise. With the proposed method, a standard belief-propagation decoder is applied, after which a certain number of positions in a data vector is erased by using a combination of a reliability criterion and a set of masks. This provides a system of linear equations, where the list of candidate solutions can be produced. The approach allowed us to improve the efficiency of the decoding.

Another idea explored in this project is to add a number of extra linear equations without changing the code. These additional equations allow for detecting more inconsistencies in the data than before without a significant increase in complexity. By expanding on this idea, we obtained theoretical estimates of the number of equations that are to be added.

We investigated the parameters of an important family of codes called array-based spatially-coupled LDPC codes. By using computer-based analysis, the parameters of different codes in this family were compared, and some good and bad codes were identified. Various codes from this family were tested experimentally in a simple wireless network simulation.

A number of research visits between Tartu and Bergen were organised. During these visits, the members of the research teams shared their experience and ideas, and performed joint work.

The project served as a basis for training graduate students and post-docs. In the course of the project, three Master's theses were defended in Tartu (Yauhen Yakimenka, Ivo Kubjas and Akashkumar Rajaram). A number of articles related to the project were published in scientific journals. The results were also presented at a number of international conferences.

/Title of the project/

DNS and 3D Reynolds stress turbulence modelling in particulate channel flows with inter-particle collisions and applications (EMP230)

/Project leader/

**Aleksander Kartushinsky,
Tallinn University of Technology**

General objectives of the project were as follows:

1. 3D numerical simulation of the turbulent particulate flows in channels with two approaches:
 - a) Eulerian joint 3D RSTM and PDF formalism for dispersed phase
 - b) joint DNS and Lagrangian tracking method.
2. Validation of the results and elaboration of the robust mathematical model for the turbulent particulate channel flows, taking into account inter-particle collisions.

The 3D numerical closure model was elaborated for the combined equations intended for the dispersed phase of the turbulent particulate channel flows. It is based on the RSTM approach for the simulation of the carrier gas phase, and PDF formalism for the dispersed phase.

A distinctive feature of the elaborated model is the possibility of solving the transport equations for each component of the Reynolds stresses of the dispersed phase.

The model has several important advantages over the Lagrangian approach for the simulation of turbulent particulate flows:

- 1) direct simulation of the particles' concentration
- 2) direct simulation of the particles' influence on a carrier flow
- 3) absence of basic limits for the parameters of a particulate flow, namely, the flow

Reynolds number and value of the particles' concentration.

The elaborated model has been validated by its application for 3D RANS numerical simulation of various types of turbulent channel particulate flows: 1) conventional horizontal flow; 2) grid-generated horizontal flow, 3) uniform shear horizontal channel flow and 4) vertical upward and downward flows.

The turbulent dispersion of solid particles has been calculated for each flow type by means of the elaborated 3D model. As an example of the application of the model, Figs. 1 and 2 show the distributions of particle mass concentration calculated for each flow type. It is evident that in case of uniform shear horizontal channel flow the effect of the orientation of the velocity shear appears



Research Group Leader Aleksander Kartushinsky, principal investigator of the project

through the decrease of the particles' dispersion in case I of directional coincidence between shear and gravity (Fig. 1) as compared with case II of their mutual perpendicularity. (Fig. 2).

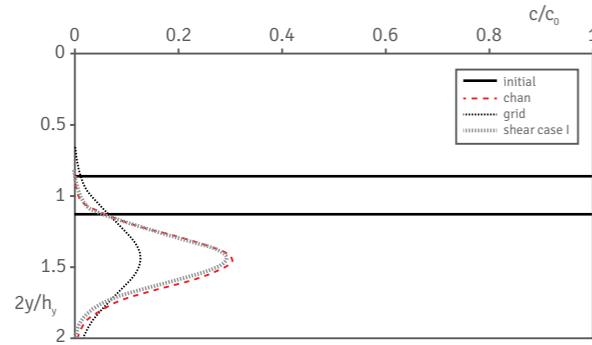


Fig. 1. Transverse distributions of particles' mass concentration for the horizontal channel turbulent flow

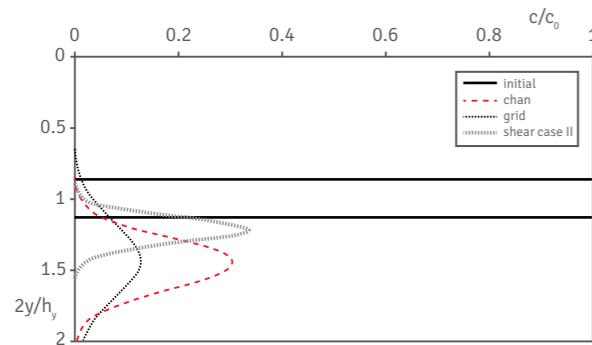


Fig. 2. Transverse distributions of particles' mass concentration for the horizontal channel turbulent flow

The Norwegian project team worked on the investigation of particle-particle interactions in the case where particles are cohesive, wet or dry. In addition, attention was paid to extending the results for practical applications, namely hydrate flow in oil pipelines, particle-fluid flow in flowmeters, and dust explosions.

The main results achieved by the Norwegian project team:

1. A new model for collision efficiency with liquid bridging. The model was found theoretically and validated against numerical and real experiments.
2. A new kind of hard-sphere model for dry particle-particle collisions.
3. A new model based on the Population Balance Modelling principle for the analysis of hydrate flows in the petroleum industry.
4. Observations of particle flow in a so-called Hartmann tube used for investigating dust explosions. The research revealed flow structures necessary for scientists and engineers working on these issues.
5. Investigation of multiphase flow in a Venturi-type flow meter. This research led to the observation of non-uniform flow structures.

/Title of the project/

Animals in changing environments: Cultural mediation and semiotic analysis (EMP151)

/Project leader/

Timo Maran, University of Tartu

The main goal of the project was to find out how humans perceive animals in changing environments, how the human cultural mediation of animals contributes to environmental change, and how environmental change in turn influences human-animal relations. The project focused on potential problematic cases of changing human-animal relations and their cultural representations in the Estonian and Norwegian context. To achieve the objectives, the project relied predominantly on semiotic methodologies and aimed to develop a general zoosemiotic model for studying animal representation in changing environments.

The research groups in Tartu (T. Maran, R. Magnus, K. Tüür, N. Mäekivi, S. Rattasepp) and Stavanger (M. Tønnessen, P. Thibault, K. Armstrong Oma) took part in the project. The partnership especially contributed into the research methods used in the project and helped to establish a general research model for analysing cultural mediation and the



Estonian group: from the right Riin Magnus, Silver Rattasepp, Timo Maran, Nelly Mäekivi, Kadri Tyrr

semiotics of animals in changing environments. This model made dynamic use of J. von Uexküll's Umwelt theory, and combined it with the analysis of different representational modes and the specific structure of communicational, environmental and social networks. The project developed a multi-layered methodology for analysing human-animal relations, where animal semiosis, environmental conditions, human social and cultural characteristics as well as cultural textual processes were included. The project further enhanced the current understanding of sign systems' hybridisation, the communication of humans and animal species and the semiotic dynamics of human-animal aggregations.

Four case studies were performed within the project: 1) Animal agency in nature writing as a

medium of communication; 2) Representations of large mammals, especially wolves, with a focus on environmental change in different ecological and demographic conditions; 3) Agencies and conflicts of interest in zoological gardens as an environment for mediated communication; 4) Adaptation of guide dogs to change in urban environments. The proposed case studies provided significant new knowledge about the different topics studied. For instance, the case study on guide dogs revealed that disabled human-dog teams are integrated agencies that face three basic types of challenges (perceptual, social, and communicative) in urban environments. This case study also resulted in a doctoral dissertation defended by R. Magnus.

The main outcome of the project, both regarding the theoretical core and applied studies, was the open access collective monograph: Maran, T.; Tønnessen, M.; Armstrong Oma, K.; Kiiroja, L.; Magnus, R.; Mäekivi, N.; Rattasepp, S.; Thibault, P.; Tüür, Kadri 2016. *Animal Umwelten in a Changing World. Zoosemiotic Perspectives* (Tartu Semiotics Library 18). Tartu: University of Tartu Press. Altogether, the project resulted in 43 research publications, six of these were co-authored by Estonian and Norwegian scholars. The project results also included two edited collections, one thematic special issue of a research journal and one monograph thematically connected to the project.



Morten Tønnessen
taking notes

/Title of the project/

Role of enzymes' processivity in degradation of recalcitrant polysaccharides (EMP171)

/Project leader/

Priit Väljamäe, University of Tartu

The project was carried out in collaboration with Professor Morten Sørli from the Norwegian University of Life Sciences.

The main component of the plant cell wall—cellulose—and the major component of crustaceans' exoskeleton—chitin—are the two most abundant polysaccharides in nature. They are huge reservoirs of renewable organic carbon. Biorefining these materials for producing biofuels and commodity products helps to develop environment-friendly sustainable industry. The use of cellulose and chitin as raw material for industry is challenged by their recalcitrance towards both chemical and enzymatic degradation, which is caused by their crystalline structure. In nature, cellulose and chitin are degraded by microorganisms that produce a variety of different enzymes—celluloses and chitinases—for that purpose. These enzymes are also used in the industrial processing of cellulose and chitin. Unfortunately, the enzymatic degradation of polysaccharides is relatively slow. This decreases the cost efficiency of biomass-based products



Priit Väljamäe in the laboratory with chitin and cellulose substrates

and makes it difficult to compete with oil-based products. The main components of enzyme cocktails used in the enzymatic hydrolysis of cellulose and chitin are processive enzymes (enzymes that release a number of soluble sugar units before leaving the insoluble polymeric substrate). Therefore, the aim of the project was to elucidate the role of enzymes' processivity in the hydrolysis of recalcitrant polysaccharides and get one step closer to the better use of different waste products containing cellulose and chitin.

The project relied on combining the large and unique catalogue of enzymes available at the Norwegian University of Life Sciences with the equally unique substrate-labelling methodologies available at the University of Tartu. Substrate-labelling technologies originally developed for cellulase research were successfully adapted for chitinase research during the project. Measurements of processivity and

underlying rate constants of chitinase ChiA from bacterium *Serratia marcescens* and its genetically engineered variants with altered processivity revealed that high processivity was required for the efficient degradation of the crystalline portion of chitin. Processivity became a penalty on the less recalcitrant forms of chitin, reducing the rate of enzyme recruitment. Since strong product binding was necessary for processivity, another cost of processivity can be seen in the strong product

inhibition of the enzyme. Therefore, the benefits of processive enzymes in the degradation of recalcitrant polysaccharides depend on the method for biomass pre-treatment that alters the substrate crystallinity, and the presence of synergistic enzyme components that alleviate product inhibition. Besides the scientific output, the project provided a solid base for the long-lasting cooperation between project partners.

/Title of the project/

Biodiversity in the dark: High-throughput sequence analyses of arctic fungal communities (BioFun) (EMP265)

/Project leader/

Leho Tedersoo, University of Tartu

Fungi are key players in terrestrial ecosystems as decomposers, pathogens and mutualists. In arctic habitats, ecto- and ericoid mycorrhizal and root endophytic symbiosis dominate due to adaptation to highly organic, nutrient-poor soils. However, little is known about the fungal diversity in arctic habitats. Since most fungi do not produce

conspicuous fruit-bodies, DNA-based methods are required to uncover the fungal diversity. The recently developed high-throughput sequencing (HTS) techniques provide great potential for exploring the fungal diversity, but these methods have their shortcomings and inherent biases. The principal objectives were to 1) compare the relative performance of HTS tools; 2) develop strategies for standardisation and improved quantitative view; 3) develop a global fungal identifier by integrating high-quality sequence databases, clustering, alignment and phylogenetic tools.

Within this project, we generated a massive reference data set from boreal and arctic fungi (>2,000 fungal sequences) that has been deposited in the UNITE database (<http://unite.ut.ee>), with a link to GenBank and communicable as interactive



Relict arctic plants can be found in Estonian wooded meadows (Photograph by L. Tedersoo)

digital object identifier-based taxonomic entities. In terms of bioinformatics and databasing, we elaborated a PlutoF workbench-associated tool for storing quality-filtered high-throughput sequencing data and metadata for easy access and rapid download. To further refine the analytical tools, we also compared the performance of HTS methods on both mock communities as well as root and soil samples, suggesting that the choice of primers and DNA barcodes is of great importance

and at the moment, PCR-free protocols are not viable alternatives to amplicon-based studies. In parallel with identification, we developed a novel method for the genome sequencing of fungi from old voucher specimens using minute quantities of initial material.

Soil fungal communities were mainly determined by plant cover and diversity, because these are the intimate biological association partners for

mycorrhizal symbionts and pathogens, whereas the role of climate and soil properties was of minor importance. Given this information, it is important to secure pathways of natural migration for plants or perform assisted migration in critical steps. Considering the low spatial autocorrelation and dispersal limitation, fungi and bacteria are easily distributed together with migrating plants with much greater capacity for landscape-scale (mid-distance) dispersal, which requires no specific action. We also showed that soil-inhabiting saprotrophic and ectomycorrhizal fungi exhibit strong seasonal patterns that are further complicated by annual variation, depending on soil moisture. In atypical growth habitats and microsites (so-called edge habitats), the diversity of ectomycorrhizal fungi was lower compared to more typical microsites. Despite this, the distinct communities of atypical habitats contribute to the overall richness. This also alerts us to the fact that with global change, the proportion of such edge habitats with depauperate fungal diversity may become more common. By definition, these edge habitats are more vulnerable to environmental stress and local extinction. Taken together, all scientific and mutual scientific exchange objectives of the project were successfully performed. Eight research papers were directly and about 10 other articles were indirectly linked to the project.

The involvement of the Norwegian partner was highly fruitful because it enabled us to integrate different skills and knowledge, resulting in a more rapid and successful publishing of primary research. We would like to particularly note that we switched to using the University of Oslo's sequencing service that is of high quality and has a rapid turnover time owing to their highly qualified personnel. Due to this project, we continue a close collaboration with our Norwegian partner both in terms of the intellectual and practical sides of research.

The project has received high-level feedback in the Estonian press, including in television (ETV: *Osoon*) and popular newspapers (the daily *Postimees*) that have greatly facilitated the dissemination of information about the project and fundamental knowledge about the basic results to the public. In research, several other research teams have used our public and open data in further analyses, addressing more specific questions and running global meta-analyses. For our collaboration, it has added an additional dimension of benefit through the shared supervision of PhD students and further applied collaboration projects for European funds (BiodivERsA, regional funding schemes).

/Title of the project/

DNA-based early detection and diagnostics of alien invasive forest pathogens and tracing of their introduction pathways into northern Europe (EMP162)

/Project leader/

Rein Drenkhan, Estonian University of Life Sciences

Climate change and increased global trade facilitate the spread of species beyond their natural range. Some of the introduced species alter the balance of ecosystems by outcompeting local species and becoming invasive. The annual economic costs due to invasive alien species within Europe alone have been estimated at 12 billion euros. The threat posed by alien invasive species also concerns Baltic and Nordic forests, which are increasingly challenged by new tree pathogens.

Once an introduced pathogen has settled in a new area, it is very difficult to eliminate it. Therefore, one project objective was to design and implement DNA-based diagnostic methods that allow their early detection. We employed these protocols with regard to imported tree plants and wood, and 5% of these samples carried a pathogen that is not native to Northern Europe. For the first time in the world,

the red band needle blight pathogen *Dothistroma septosporum* was found on Serbian spruce. This demonstrates the risks of plant trade, i.e., pathogens may also arrive with plants that we have previously not known to host a specific pathogen.

The second project objective was to employ genetic analyses to identify the source populations of two alien pathogens invasive in Europe. We found no support to the hypothesis that the targeted pathogens in Northern Europe (the agent of ash dieback, *Hymenoscyphus fraxineus*; *D. septosporum*) could originate directly from the Far East (Asia), a region of extensive plant import to Europe. In contrast, *D. septosporum* surprisingly showed gene flow in the opposite direction, i.e., from Northern



Red band needle blight pathogen (*Dothistroma septosporum*) on Scots pine needles (Photograph by R. Drenkhan)

Europe to the Far East. The clear distinction between the European and Asian populations of *H. fraxineus* is in contrast to the working hypothesis of the scientific community.

The project also supported the collaborative work of 66 researchers from 33 countries: we detailed records of red band needle blight from 65 countries all over the world and collated them to the international *Dothistroma* needle blight geo-database (<http://arccgis.mendelu.cz/monitoring/>).

Additional results include the discovery of new locations for the quarantine pine needle pathogen, *Lecanosticta acicola*, records of new host species for the ash dieback pathogen *H. fraxineus* and the pine pathogen *Diplodia sapinea*.

The project demonstrates the risks involved in international plant trade, and emphasises the need for increased political and public awareness to counter this threat.

Project dissemination: so far eight scientific papers, two of which were joint publications with our Norwegian partner, have been published. Additional joint manuscripts are in preparation. A total of 26 presentations to national and international audiences have been made. Further information: <http://mi.emu.ee/struktuur/metsakasvatuse-osakond/mimk-projektid/project-emp-162/project-overview/>



Halvor Solheim and Rein Drenkhan documenting the presence of the ash dieback agent *Hymenoscyphus fraxineus* on the leaf petioles of local ash species during our expedition to the Russian Far East (Photograph by T. Maaten)

/Title of the project/

Political and socio-psychological determinants of inclusive integration context and their interdependencies (EMP138)

/Project leader/

Raivo Vetik, Tallinn University

One of the challenges of the state-of-the-art research on acculturation strategies and integration policies in Western democracies is in translating desired socio-psychological outcomes into effective policy measures. Considering the political aspects of the inclusive integration context is, in this perspective, of crucial importance. This research project studied both the political and socio-psychological determinants of inclusiveness in the migrant adaptation context as well as their interdependencies.

While our empirical focus has been on the adaptation of Russian migrants in Estonia and Norway as well as integration policies in these countries, we also took a broader comparative perspective owing to the link between the project and an international network. The first results of the project have been published as chapters on Estonia and Norway in the volume *Mutual Intercultural Relations in Plural Societies* (Cambridge University Press 2017),

edited by John Berry, which includes chapters on 15 countries.

The key results of the project are concerned both with theoretical and methodological innovation as well as analysis based on the project data. The academic added value of the project lies in the fact that we have proposed and implemented an innovative theoretical model by combining the political and socio-psychological aspects of acculturation into a unified theoretical framework based on the work of John Berry and Pierre Bourdieu. Empirically, we can report findings on three levels. First, we have found on the level of the two nations that their different histories and levels of interethnic polarization have a major impact on positioning strategies and adaptation outcomes both in inter-ethnic and intra-ethnic relations. Second, our empirical analysis reveals that the more polarized the intercultural context, the stronger the tendency to construct the 'other' in terms of divisive intercultural boundaries. We have found that this tendency can be best explained with the notion of 'asymmetry of acculturation field' introduced in our project. Third, we have shown that the main factors behind the tendency to construct divisive intercultural boundaries have to do with the lower socio-economic and cultural status of the so called 'ethnocentric' segments within both the minority and majority groups.

We expect that our theoretical model and empirical findings will generate new synergy in the wider academia. The presentation of our results at a number of conferences so far has revealed that the asymmetrical acculturation model proposed in this project has the potential of good reception in literature, and it can contribute into integration policies. For example, the theoretical innovation proposed in the DIMA project and realised in our new scales has been utilized in the project Monitoring of Integration in Estonian Society commissioned by the Estonian Ministry of Culture at the end of 2017.

Partnership has been essential in achieving the project's objectives during all the phases carried out so far. The theoretical innovation of the project was initially proposed by the Estonian partner, while the Norwegian partner contributed by adding a developmental psychology perspective to the relational model proposed in the project. The dissemination of the results among stakeholders in the two countries has been carried out in close cooperation between the partners. We hope that the knowledge transfer regarding research on good practices in the governance of multicultural societies will contribute into informed decision-making both in our two nations and beyond.

/Title of the project/

Topical issues of consumer credit in Estonia and Norway (EMP205)

/Project leader/

Karin Sein, University of Tartu

The objective of the project was to analyse problems connected to consumer credit not only in Estonia and Norway but also in the whole Nordic-Baltic area. The premise of the project was that the credit market in the Nordic-Baltic region is highly integrated

and characterized by orientation to modern credit products such as consumer loans obtainable via mobile phones or the Internet. Such innovative credit products, including so-called fast loans, have made it extremely easy to obtain credit. At the same time, these loans are also often connected with extremely high interest rates and other costs. This has created a high level of consumer over-indebtedness and at the beginning of the project there was an active discussion about the possible solutions in all Nordic-Baltic countries. Therefore, the primary goal of the research project was to find out what legal measures should be used to tackle

these problems, while finding an acceptable balance between consumer protection, right to innovative entrepreneurship and fair access to credit.

Comparative research showed that countries have used different methods for tackling those problems and that some methods, such as APRC/interest rate restrictions and licencing, seem to be more effective than others. For example, the unconscionability doctrine introduced into Estonian law has proved to be ineffective in practice, largely for procedural law reasons. It also turned out that the standards for responsible lending as well as the sanctions for breaching this principle differ greatly from country to country. The research further showed that substantive law provisions alone are not enough for effective consumer protection in the area of consumer credit. The fact that consumers tend to be rather passive in asserting their rights means that in practice procedural law factors are at least equally important. This is especially evident in the ex officio obligation of the unfairness control of standard terms, consumer arbitration and order for payment procedure. The regulation of consumer insolvency and debt settlement as well as social attitudes and the fear of stigmatisation also play a crucial role in dealing with consumer over-indebtedness.

The Norwegian participants in the project were Professor Kåre Lilleholt and the administrative staff of the Faculty of Law, University of Oslo. The 2013 and 2015 conferences and the 2016 seminar



Karin Sein, the principal investigator of the project (Photograph by Piia Kalamees)

brought together researchers from Estonia, Norway and other European countries in addition to representatives of important stakeholder groups. The project has definitely contributed to a deeper and more consolidated relationship between the law faculties in Tartu and Oslo. Owing to co-authorship, seminars, research stays in Oslo, guest lectures in Tartu and Tallinn the co-operation has run very smoothly.

The project was not limited to purely academic activities: disseminating the findings among the

stakeholders and thereby influencing legal policy was considered important from the very beginning. Estonian project participants have had meetings with consumer credit stakeholders in Estonia and acted as independent advisors for Estonian government officials by drafting new legislative amendments aimed at tackling usurious consumer credit. Therefore, one might conclude that the project has had a positive impact on disseminating information on responsible lending in the Nordic-Baltic area and contributed to better consumer protection in the field of consumer credit.

/Title of the project/

Understanding policy change: Financial and fiscal bureaucracy in the Baltic Sea Region (EMP264)

/Project leader/

Rainer Kattel, Tallinn University of Technology

One of the most crucial challenges faced by social scientists is understanding and explaining changes in policies: why certain policy ideas and practices become dominant and persist over others. While there is a large body of research devoted to

these issues, this project aims to emphasise the role of micro-level routines within public sector bureaucracy and organisations—an area largely left untouched by existing research. Economists, political scientists and legal scholars tend to view bureaucracy as an external variable and typically also as a static institution: bureaucrats implement what policy makers have decided, and they either do it well or not. This is so because most scholars and analysts suffer from what could be called “a policy bias”: substantive policy or institutional changes are often seen as more important than the ways in which these changes come to be implemented and the persons who implement them. Consequently, much of research and debate concentrates on political, policy and institutional issues, leaving

the organisational and bureaucratic level almost unexplored. Meanwhile, the internal organisation of tasks, hiring and promotion practices, internal performance standards, contracting out/in procedures, coordination practices with other organisations and how these routines contribute to either policy changes or the persistence of ‘old ways’ is what interests us most.

Financial and fiscal bureaucracies (ministries of finance, financial supervisory authorities, central banks) have grown, at least over the last two or three decades, into the focal points of economic governance in many countries. These institutions are in charge of government spending and revenue gathering, they regulate and supervise the financial sector, deal with foreign direct investors, to name but a few key functions. The project focuses on the cases of five countries in the Baltic-Nordic region: Estonia, Latvia, Lithuania, Sweden, and Norway.

In EU member states, both financial and fiscal governance are affected by the increasing harmonisation of respective regulations (and supervision). Such influences, however, often collide with the institutional patterns that have evolved in EEA countries over decades, thereby challenging policy makers to provide an effective response to the process of ‘Europeanisation’. This is especially apparent in areas of financial regulation and supervision, while similar developments were also intensified in the fiscal domain following a series

of fiscal crises across the EU. Among country-cases studied in the project, various responses to the processes of ‘Europeanisation’ have been identified: from the adoption of financial regulations ahead of the development of financial instruments that would be subject to the very same EU regulation, to perceiving the need to loosen certain regulatory requirements as compared to existing local standards; from the ‘professionalization’ of policy advice following increasing interaction with the EU bodies to outright criticism of imposed rules. In addition, specific attention was paid to the historical legacies of bureaucratic practices in the five countries viewed.

Interviews in the respective countries were carried out jointly with the Norwegian partners, three two-day meetings took place (2014 in Tallinn, 2015 in Oslo, 2016 in Tallinn) to discuss intermediate results and preliminary findings, a number of jointly written articles were submitted for presentation at the 12th Baltic Conference (Riga, June 2017), and are intended to be published in the special issue of the *Journal of Baltic Studies* (2017).

Projects funded under the Norwegian-Estonian Research Cooperation Programme

No	Project title	Start	End	Project Promoter	PI (Estonia)	"Norwegian partner"	PI (Norway)	Budget in €
EMP128	Activity-dependent regulation of BDNF and Arc: master genes in synaptic plasticity	1.01.2014	31.12.2016	Tallinn University of Technology	Timmusk, Tõnis	University of Bergen	Clive Bramham	315 789
EMP133	Novel Analysis and Design Tools for Low-Density Parity-Check Codes	3.09.2013	30.04.2017	University of Tartu	Skachek, Vitaly	University of Bergen	Oyvind Ytrehus	299 440
EMP138	Political and socio-psychological determinants of inclusive integration context and their inter-dependencies	3.09.2013	30.04.2017	University of Tallinn	Raivo Vetik	University of Bergen	David Lackland Sam	250 000
EMP151	Animals in changing environments: Cultural mediation and semiotic analysis	3.09.2013	31.12.2016	University of Tartu	Maran, Timo	University of Stavanger	Morten Tønnessen	202 686
EMP160	Sami - Estonian language technology cooperation: similar languages, same technologies	3.09.2013	30.04.2017	University of Tartu	Kaalep, Heiki-Jaan	University of Tromsø	Trond Trosterud	229 400
EMP162	DNA-based early detection and diagnostics of alien invasive forest pathogens and tracing of their introduction pathways into northern Europe	1.02.2014	30.11.2016	Estonia University of Life Sciences	Drenkhan, Rein	Norwegian Institute of Bioeconomy Research	Ari Hietala	259 300

No	Project title	Start	End	Project Promoter	PI (Estonia)	"Norwegian partner"	PI (Norway)	Budget in €
EMP171	Role of enzymes processivity in degradation of recalcitrant polysaccharides	1.11.2013	28.06.2016	University of Tartu	Väljamäe, Priit	Norwegian University of Life Sciences	Morten Sørli	195 360
EMP180	Language and auditory brain: studies on central sound representation in auditory cortex	1.01.2014	29.02.2016	University of Tartu	Näätänen, Risto Kalervo	University of Bergen	Kenneth Hugdahl	128 282
EMP181	Targeting glioma stem-like cells with tumor penetrating peptides	1.09.2014	31.12.2016	University of Tartu	Teesalu, Tambet	University of Bergen	Rolf Bjerkvig	300 000
EMP205	Topical issues of consumer credit in Estonia and Norway	3.09.2013	30.06.2016	University of Tartu	Sein, Karin	University of Oslo	Kåre Lilleholt	149 326
EMP230	DNS and 3D Reynolds Stress Turbulence Modeling in Particulate Channel Flows with Inter-Particle Collisions and Applications	1.01.2014	31.12.2016	Tallinn University of Technology	Kartušinski, Aleksander	University of Bergen	Pawel Kosinski	203 661
EMP264	Understanding policy change: Financial and fiscal bureaucracy in the Baltic Sea Region	1.01.2014	30.04.2017	Tallinn University of Technology	Kattel, Rainer	University of Oslo, Hedmark University College	Lars Mjøset	265 000
EMP265	Biodiversity in the dark: High-throughput sequence analyses of arctic fungal communities (BioFun)	3.09.2013	31.08.2016	University of Tartu	Tedersoo, Leho	University of Oslo	Håvard Kausserud	315 790

