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Mobilitas
COMPASS
Grantees

2014

Estonian Research Council

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2014

Grantees

Tallinn
2015



Estonian Research Council

(Eesti Teadusagentuur)

Soola 8, 51013 Tartu, Estonia

Representation in Tallinn:

Lauteri 5, 10114 Tallinn, Estonia

Phone +372 731 7359

etag@etag.ee

http://www.etag.ee

Mobilitas Programme Manager: Tiina Loit

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Dear reader

The researcher mobility programme *Mobilitas*, co-funded from the European Social Fund, is running from 2008 until the end of 2015. The programme aims to activate the international exchange of researchers and knowledge and is targeted at postdoctoral and top-level researchers. Based on the profiles recognised by the European Framework for Research Careers, this means Recognised Researcher (R2) through Established Researcher (R3) to Leading Researcher (R4).

The Estonian Research Council has awarded 127 postdoctoral grants, the majority of which are for incoming grants, but there are also 28 outgoing grants and 12 grants for mobility within Estonia. The postdocs who have received grants work in 7 different R&D institutions – 73 in the University of Tartu, 27 in the Tallinn University of Technology, 10 in Tallinn University, 8 in the National Institute of Chemical Physics and Biophysics, 7 in the Estonian University of Life Sciences, and one in both the Estonian Literary Museum and Protobios.

18 top researchers have received funding for creating their own research group. 6 of the research groups are working in the area of material technology, 5 investigating topics related to biotechnolo-

gy, and the others are concerned with environmental technology (3 groups), energy (3 groups) and information and communication technology (1 group).

The grants are divided between 4 R&D institutions: the University of Tartu and the Tallinn University of Technology (both have 6 grants), the National Institute of Chemical Physics and Biophysics (4 grants), and Tallinn University (2 grants).

In 2014, we published the booklet – “*Mobilitas Compass 2013*” containing a collection of popular narrative texts on research conducted by the *Mobilitas* postdocs and top researchers in order to present the outcome of the programme to the public. The booklet was co-authored by 52 grantees.

By the end of 2014, 68% of all the grantees had finished their project work. This booklet introduces 37 grantees – 3 top researchers and 34 postdocs – who completed their research projects during 2014. I would like to thank all of them for their kind cooperation.

Tiina Loit
Mobilitas Programme Manager



Partner Institutions

University of Tartu

Tallinn University of Technology

Tallinn University

National Institute of Chemical Physics and Biophysics

Estonian University of Life Sciences

Estonian Literary Museum

Protobios LLC

Intermediate Body

Ministry of Education and Research

Implementing Agency

SA Archimedes



harry.alles@ut.ee

Harry Alles

Top Researcher in the field of material technology

- ♦ **Title: Manufacturing, processing and characterization of graphene-based nanostructures**
- ♦ **Grant: MTT1, 1 Mar 2009 – 28 Feb 2014**
- ♦ **Partner institution: University of Tartu**

“*The top researcher Mobilitas grant allowed me to set up graphene studies in the University of Tartu that is now a partner of a large-scale European Graphene Flagship project.*”

Towards Graphene-based Gas Sensors

Graphene, a single atomic layer of carbon, has been a star in materials science in the last ten years due to its extraordinary properties like very good electrical and thermal conductivities. At the same time, it is the thinnest known material and the strongest one ever measured.

In the Institute of Physics at the University of Tartu (IPUT), our goal was to prepare graphene sheets of the size and quality suitable for device applications, in particular, for the development of gas sensors based on graphene. Thus, one of the highlights of this project was that we were able to show that, under ambient conditions, the graphene

sensors, initially insensitive to oxygen gas, can be activated with relatively weak ultraviolet light. These results were published in the top class journal *Applied Physics Letters*. Since 1 Oct 2014, our research group studies the application of this principle in the case of other gases under the large-scale European Graphene Flagship project.

In fact, the initial results, obtained within this project, already allowed the material scientists in Tartu to join the international network of research groups working on graphene. In addition to the Mobilitas project, two European graphene research projects were running in IPUT during 2010–2013.



akbk@kth.se

Anna Karin Borg Karlson

Top Researcher in the field of environmental technology

- ▶ **Title: Chemical Ecology**
- ▶ **Grant: MTT2, 1 Nov 2009 – 31 Dec 2014**
- ▶ **Partner institution: University of Tartu**

“A successive integration of the students in chemistry and biology by offering courses in chemical ecology and natural product chemistry followed by funded research projects in chemical ecology would be the basis for building up competence in the research of sustainable and organic cropping and forestry.”

Chemical Ecology

The aim of the project “Chemical Ecology” was to initiate education and support the ongoing research in Estonia.

Chemical ecology is an interdisciplinary research field dealing with the isolation, identification, synthesis and evaluation of the biological effects of naturally occurring chemicals in various organisms. Knowledge in this area can help replace toxic biocides with nontoxic degradable compounds to facilitate the development of sustainable pest control in agriculture and forestry.

During the five years, we developed a PhD course in Chemical Ecology with Estonian teachers and guest lecturers from Lithuania, Norway and Sweden. The goal was to initiate a network with PhD students with research topics in chemistry or biol-

ogy. The course was taught twice and attracted 20 master and PhD students both from the chemistry and biology faculties at the University of Tartu and from the Estonian University of Life Sciences.

The research in chemical ecology is focussed on state of the art methods in the identification and synthesis of biologically active compounds such as insect pheromones, complex flower scents and microbial compounds. Knowledge of the active chemical signals can be used in the development of sustainable control methods in agriculture and forestry in Estonia and elsewhere. The project has generated 9 publications in international scientific journals and 13 manuscripts so far.



sugita@tlu.ee

Shinya Sugita

Top Researcher in the field of environmental technology

- ♦ **Title: Dynamic Landscape Analysis in Southern Estonia (DYLAN-Estonia): Spatial Dynamics of Vegetation and Land Cover through Time**
- ♦ **Grant: MTT3, 1 Sept 2009 – 1 Sept 2014**
- ♦ **Partner institution: Tallinn University**

“I continue working as a senior scientist at the Institute of Ecology, Tallinn University. I am currently leading a six-year IUT project that evaluates the impacts of the Holocene storminess changes on the coastal landforms and vegetation.”

Landscape-scale Change in Holocene Vegetation

The Holocene records of vegetation and climate provide baseline information for plausible scenarios of the future changes in land cover. The Haanja Heights area in SE Estonia is unique in NW Europe because of the availability of many small depressions 10–20 m in diameter, from which the past changes of vegetation in the landscape-scale (10–20 ha) can be reconstructed using fossil pollen preserved in sediments 1–2 m deep. The sediment records from 15 study sites in the area reveal that the spatial structure of vegetation shifted significantly when late-successional trees such as spruce and lime became dominant in the region about 9000 years ago. The regional climate between 7000–2000 years ago was probably drier than today, causing sediment hiatuses at most of the sites. Although

human activities affected the vegetation composition over the last 2000 years, the spatial scale of the vegetation mosaic has not been dramatically altered. The site-to-site variation of the vegetation composition has been large through time. Spatial patterns of soils and topography may have played a role, affecting the vegetation structure; however, the correlations between the species composition and those factors have not always been significant, suggesting that other factors such as species interactions and local climate variations have been important. In view of human-induced global warming, palaeo-records such as ours are informative for the future planning of natural resource management and conservation locally and globally.



ulrike@rohn.as

Ulrike Rohn

- ♦ **Title:** Economic and cultural implications of Social Network Sites – A case study of Estonia and Germany
- ♦ **Supervisor:** Halliki Harro-Loit
- ♦ **Grant:** MJD18, 1 Oct 2009 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu

“*In now work as a researcher in Finland, and I find that the results of my postdoctoral research are essential to my ongoing and future research career.*”

Social Network Sites – Between Culture and Business

In my research project, I studied social network sites (SNSs), such as Facebook, from two perspectives: the user and the company perspective.

Studying users, I was interested in if, how, and to what extent the increasing global success of SNSs leads to an increasing cross-cultural connectivity. For this, I conducted focus group interviews as well as an online survey (n=1,464) with Estonian, Russian-Estonian, and German users of SNSs. The results showed that, on SNSs, users are less directly connected with users from other countries and cultures through their personal lists of contacts than they are indirectly connected through the increasing use of the same SNS: Facebook. Furthermore, the study found that Russian-Estonians tend to have fewer contacts with

people with the same mother tongue than Germans and Estonians do. At the same time, however, they are more connected with users outside their country of residence. The survey also showed that there is only a small amount of connectivity between Estonian and Russian-Estonian SNS users.

Studying companies, I conducted in-depth interviews with media companies in Estonia and Germany to find out how they use SNSs for the distribution and promotion of their content. The interviews conducted between 2010 and 2014 yielded insight into how the use of social media platforms has led to organizational changes and increasing professionalization over the years.



eve.avel@hotmail.ee

Eve Avel

- ♦ **Title:** Testate amoebae and water-table level fluctuation in NE Estonian bogs
- ♦ **Supervisor:** Margus Pensa
- ♦ **Grant:** MJD31, 4 Aug 2009 – 3 Oct 2014
- ♦ **Partner institution:** Tallinn University

“*In the future, I would like to proceed with palaeoecological research, using different microorganisms and pollen assemblage data.*”

Testate Amoebae and Water in NE Estonian Bogs

Testate amoebae are a group of protists living in aquatic to moist habitats and are known as good indicators of soil and peat moisture levels and water chemistry. Because of their well preserving external shells (tests) in sediments, they are used in palaeoecological studies.

During the project, modern testate amoebae assemblages were studied from five NE Estonian bogs to relate their distribution to local environmental variabilities. The data was collected into a transfer function for water table depth which enabled to reconstruct water level change in Selisoo bog during the last 5000 years. Using macrofossils, pollen and testate amoebae assemblages in the study, it was possible to reveal the natural development of the bog (including two major fires in Selisoo bog – 4200 years BP and 130 years BP) and human impact (since 550 years BP) on it during the last five millennia.



Nebela carinata is one of the largest species of testate amoebae and prefers wet living conditions.



michal.cagalinec@ut.ee

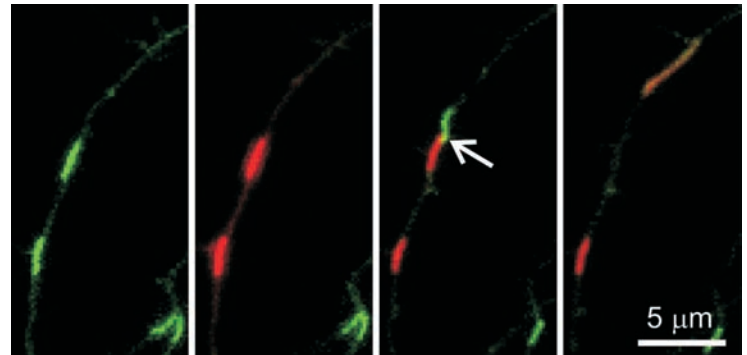
Michal Cagalinec

- ♦ **Title:** Mitochondrial Dynamics in Models of Neurodegenerative Diseases
- ♦ **Supervisor:** Allen Kaasik
- ♦ **Grant:** MJD35, 1 Sept 2009 – 31 May 2014
- ♦ **Partner institution:** University of Tartu

“Currently applying for new funding, I hope I will be able to continue with my research focused on mitochondrial dynamics and ultrastructure in neurons and myocytes.”

Mitochondrial Dynamics and Neurodegeneration

Perturbations in mitochondrial functioning is a common characteristic of neurodegenerative diseases. Mitochondrial dynamics, involving the movement, fusion and fission of mitochondria has been observed to be impaired for a long time before the energetic deficit appears. Therefore perturbations in mitochondrial dynamics are considered an early marker of the disease. Neurons as highly polarized cells are critically dependent on proper energy and, thus, mitochondrial distribution. However, the details of how mitochondria are distributed, transported and maintained when located far from the cell body are not well understood. We have shown by the use of mitochondria-targeted photoconvertible proteins that mitochondrial fusion and movement in neuronal axons happen in highly sophisticated



Fusion detection in axons. Mitochondria expressing photoconvertible protein KikumeGR1 were converted to red. Fusion between red and green mitochondria is indicated by an arrow.

patterns. These were negatively influenced in experimental conditions, mimicking neurodegenerative diseases of interest.



liisi.keedus@helsinki.fi

Liisi Keedus

- ♦ **Title:** *The Making of the Scientific Imagination: Debates on American Political Science, 1945–1965*
- ♦ **Supervisor:** Vello Andres Pettai
- ♦ **Grant:** MJD48, 1 Apr 2010 – 31 Oct 2014
- ♦ **Partner institution:** University of Tartu

“As of January 2015, I am a Marie Curie research fellow at the Erik Castrén Institute of International Law and Human Rights at the University of Helsinki. My main research fields are the history of twentieth century political thought and intellectual history in Europe in the inter-war period.”

The Making of the Scientific Imagination

The project carved out a historical perspective on the debates on the relation between scientific objectivity and social values by reassessing the development of political science in the United States after World War II. This was a period of dramatic transformation for American political science, which later became the model for the studies of politics around the world.

In the mainstream of the discipline, political scientists sought to transform their field into a “rigorous”, “analytic”, and “theoretical” science. At the same time, this attempt was constantly challenged by the integration of European émigré scientists – not only in the field of political science but also in “sister-disciplines” such as philosophy, sociology and law. The antagonisms between these currents gave

birth to a myriad of new ideas, concepts, debates and problems.

What were the historical, epistemological and discursive dimensions of the intersections between science, values and politics in the aftermath of World War II? How did the newly “scientific” science assert itself as science, and what conceptual tools did it use – and how did it instrumentalise or clash with the newly imported “European” debates – to construct and legitimate its fields? How were the horizons of scientific imagination and language shaped and re-shaped in political science? How can this historical knowledge contribute to a critical perspective on our contemporary scientific-axiological choices?



maria.malksoo@ut.ee

Maria Mälksoo

- ♦ **Title:** *The Power Politics of Memory in Eastern Europe: Securitising the Legacy of Communism in the Baltic states, Poland, Ukraine, and Russia*
- ♦ **Supervisor:** Andres Ilmar Kasekamp
- ♦ **Grant:** MJD60, 1 Mar 2010 – 21 Apr 2014
- ♦ **Partner institution:** University of Tartu

“*My next project zooms in further on the impact of the failure of transitional justice in post-communist Russia on its foreign policy discourse and practice.*”

The Politics of Mnemonical Security in Europe

The Polish plane crash on the way to commemorate the victims of Katyn in the spring of 2010 and the violent events in Ukraine four years later, laden with historical (mis)perceptions, provided the contextual starting and end points of my research project. My general aim was to explore the conflicts over historical remembrance of communism between Poland, Ukraine, the Baltic states and Russia. With the toolkit of Critical Security Studies, I examined the calls to politically and legally condemn the communist regimes at a pan-European level.

By seeking recognition for the inclusion of their experiences and assessment of communism into the established European mnemonical narrative and a normative verdict on twentieth-century totalitarianisms, the East European actors concurrently seek

recognition for their agency as Europeans. In turn, Russia's State Duma's recent passing of the memory law, targeted specifically against the 'dissemination of false information on the activities of the Soviet Union during WWII' and the 'rehabilitation of Nazism' is another example of politically orchestrated attempts to secure a particular 'national memory' by means of law.

My inquiry into the sources and meanings of the nascent pan-European remembrance of totalitarian communist regimes points to the various East European struggles for mnemopolitical emancipation, competitive claims on the security of memory within the wider Europe, and the gradually changing mnemonic identity of the EU.



lili.milani@ut.ee

Lili Milani

- ♦ **Title:** In-depth genetic and epigenetic analysis of the cytochrome P450 system by next-generation sequencing
- ♦ **Supervisor:** Andres Metspalu
- ♦ **Grant:** MJD71, 1 Mar 2011 – 28 Feb 2014
- ♦ **Partner institution:** University of Tartu

“*The next step is to incorporate these pharmacogenetic markers into a database of genetic variants relevant for the implementation of personalized medicine in Estonia.*”

Drug Prescription Based on Genetics

Interindividual variability in drug metabolism and response is extensive. The drug levels in plasma can vary more than 1000-fold between two individuals having the same weight and given the same drug dosage. This is a result of variation in receptors and the activity of enzymes in charge of drug metabolism. The variation is caused by combinations of genetic, physiological, and environmental factors, which are usually not accounted for when prescribing drugs.

The aim of this research project was to identify genetic signatures that control interindividual variation in drug metabolism. We used modern DNA sequencing technology to identify genetic and epigenetic variation in major genes involved in drug metabolism in a unique collection of liver samples. In collaboration with scientists from Karolinska

Institutet, Sweden, we developed a novel method to study the genetic and epigenetic regulation of genes. Next, we used a genome-wide approach to explore the regulation of gene expression in the human liver. Combining genetic and epigenetic information, up to 80% of the variation in gene expression could be determined for hundreds of genes relevant to liver function. Many of the genes have also been associated with different metabolic diseases or traits.

In conclusion, these findings are very important for the better understanding of interindividual variation in drug metabolism and response, and their implementation in daily clinical practice will eventually lead to better drug response and less adverse effects in patients.

Gemma Atkinson



atkinson@ut.ee

- ♦ **Title:** Origin and functional evolution of ribosome-associated environmental response enzymes
- ♦ **Supervisor:** Tanel Tenson
- ♦ **Grant:** MJD99, 6 Sept 2010 – 11 Apr 2014
- ♦ **Partner institution:** University of Tartu

“My research continues on the evolution of the factors of protein biosynthesis machinery. Meanwhile, predictions from the results of my Mobilitas-funded project are being tested experimentally in collaborating laboratories.”

The Diversity and Molecular Evolution of Ribosome-Interacting Proteins

The ribosome is the molecular machine used by the cells of all life on earth to produce the proteins necessary for survival and growth. Various protein factors interact with the ribosome to control its functional cycle and to sense the state of the ribosome. These proteins are often essential and ancient, having evolved before the last common ancestor of all extant life.

The project began with a comprehensive survey of the diversity and functional evolution of proteins in the RelA/SpoT Homologue (RSH) family of proteins. These factors sense starvation and other stresses by interacting with the ribosome and other molecules. We performed high-throughput

sensitive sequence searching of over 1000 genomes from across the tree of life, in combination with phylogenetic analyses to consolidate the previous identification of diverse RSHs in different organisms and provide a much-needed unifying terminology for the field. We classified the RSHs into 30 subgroups and carried out comparative sequence analysis among the subgroups to predict novel aspects of function and intermolecular interactions.

We then expanded the research to other ribosome-interacting factors, identifying among other things a protein critical for the normal functioning of yeast mitochondria, previously thought to be absent in this organism.



anu.ploom@ut.ee

Anu Ploom

- ♦ **Title:** Structure-reactivity relationships in reactions at atoms of the third period elements
- ♦ **Supervisor:** Margus Lopp
- ♦ **Grant:** MJD105, 1 Sept 2010 – 30 Nov 2014
- ♦ **Partner institution:** Tallinn University of Technology

“After completing this project, I will continue my research with organosilicon and organophosphorus compounds.”

Reactivity of Silicon and Phosphorus Compounds

Quantitative structure-reactivity analysis has widely been practiced in organic chemistry for deducing reaction mechanisms, calculating physicochemical parameters of molecules, and has substantial importance in drug design and in materials science. Most often, these methods have been focused on reactions at carbon atom. Differently from this, I have worked with organosilicon compounds. During my PhD studies, I have elaborated a new algorithm, which describes structure-reactivity relationships in organosilicon chemistry.

This project aimed to test the applicability of the algorithm on the other elements of the third period, starting from organophosphorus compounds. This selection is partially based on the fact that organophosphorus compounds play an essential role in biological processes and, therefore, have

a central role in the design of new biologically important materials. The new algorithm has been successfully applied to describe the reactivity of organophosphorus compounds.

In parallel to this theoretical work, I have practically investigated the reactivity of the Grignard reaction with organosilicon compounds, which is the most important method of silicon-carbon bond making in both laboratory practice and chemical industry. Despite the increasing use of the reaction in silicone industry, there have been no attempts to ascertain the structure-reactivity relationships in the Grignard reaction with silanes before our work. The analysis of the reactivity data gave novel and essential information about the mechanism of this reaction.



vinay.choubey@ut.ee

Vinay Choubey

- ♦ **Title:** Multiple Roles Of Alpha-Synuclein In Origin of Mitochondrial Dysfunction And Neuronal Death
- ♦ **Supervisor:** Allen Kaasik
- ♦ **Grant:** MJD120, 1 June 2011 – 31 May 2014
- ♦ **Partner institution:** University of Tartu

“I am continuing Parkinson disease related research at the University of Tartu on Grant PUT513. Big thanks to Estonian Research Council (Mobilitas and PUT513) and the University of Tartu.”

The Role of Mitochondrial Dysfunction in Parkinson Disease

Parkinson's disease (PD) is a major neurodegenerative disease which afflicts 1–5% of the global aged population. PD causes mobility and psychiatric disturbances due to the degeneration of dopaminergic neurons located in the brain region substantia nigra. The leading proposed cause of PD is mitochondrial dysfunction. Interestingly, several genes linked to the familial form of PD are found to be involved in mitochondrial maintenance. The objective of my research was and is to find out the cause of mitochondria dysfunction which could lead to PD.

During this project, we found that overexpression of PD-linked mutant α -synuclein (A53T) in neurons induces autophagic (self-destruction) mitochondrial degradation and net loss. That caused bioenergetic deficit and resulted in neuronal death. The

inhibition of mitochondrial autophagy by silencing autophagy proteins Beclin1, Atg12, and Parkin restored mitochondrial density and provided protection. Subsequently, we investigated the role of Beclin-1 in mitochondrial removal (mitophagy). We found that Beclin1 interacts with PD-linked protein Parkin and regulates Parkin translocation to mitochondria, the initial step of mitophagy.

Further, we observed that the depletion of Beclin-1 prevents Parkin translocation-induced mitofusin loss which allowed mitochondrial fusion. Thus, Beclin-1 suppression might not only interfere with the clearance of dysfunctional mitochondria but also allows the fusion of mitochondria irrespective of their functional status. This could contribute to the mitochondrial dysfunction known to be present in PD.



toomas.silla@mbg.au.dk

Toomas Silla

- ♦ **Title:** New Mutations in Old Genes: Discovering Cancer-Related Variations in Non-Coding Ultra-Conserved Genes
- ♦ **Supervisor:** Mathijs Voorhoeve
- ♦ **Grant:** MJD147, 1 May 2011 – 30 Apr 2014
- ♦ **Partner institution:** University of Tartu
- ♦ **Receiving institution:** Duke-NUS Graduate Medical School, Singapore

“*This project is still ongoing. In collaboration between Estonian Genome Centre, Tartu University Hospital and National Cancer Centre Singapore, we have sequenced UCEs in familial breast cancer samples in order to link mutations in UCEs to breast cancer development.*”

New Mutations in Old Genes

Ultra-conserved genes or elements (UCGs/UCEs) in the human genome are extreme examples of conservation. These regions are longer than 200 base pairs and are 100% identical between human, mouse and rat reference genomes. Despite scientists' efforts, the biological function of these regions has remained elusive. It has been proposed that UCEs can act as long distance enhancers and/or they can be transcribed to non-coding RNAs.

We were interested to see to which extent UCEs contain natural variations and whether these variations could potentially impact UCE function. We characterized natural variations in 2884 UCEs in two distinct populations, Singaporean Chinese (n=280) and Italian (n=501), by using a pooled sample, targeted capture, sequencing approach. This

next generation sequencing methodology allows us to analyze relatively large sets of samples in an economical way. We identified, with high confidence, in these regions the abundance of rare variations of which 75% is not present in the databases. By combining our data with 1000 Genome Project data, we showed in three independent datasets that prevalent UCE variants are more often found in relatively less-conserved nucleotides within UCEs, compared to rare variants. Moreover, prevalent variants are less likely to overlap transcription factor binding site. All together, these results suggest that UCEs are not under selective pressure as a stretch of DNA but are under differential evolutionary pressure on the single nucleotide level.



mithudri03@gmail.com

Mithu Guha

- ◆ **Title:** What Regulates the Autoimmune Regulator?
- ◆ **Supervisor:** Pärt Peterson
- ◆ **Grant:** MJD164, 1 June 2011 – 31 May 2014
- ◆ **Partner institution:** University of Tartu

“After finishing my *Mobilitas* grant, I continued in Pärt Peterson’s group as a researcher working on the role of the autoimmune regulator (*Aire*) gene on central tolerance.”

What Regulates the Autoimmune Regulator?

My research project was focussed on the characterization of the role of AIRE for the prevention of autoimmune diseases. AIRE is a key transcriptional regulator in the thymus and contributes to the negative selection of autoreactive T-cells. Mutations in AIRE result in the aberrant expression of thymic autoantigens and cause autoimmune polyendocrinopathy-candidiasis-ectodermaldystrophy (APECED).

One reported AIRE-interacting partner is TOP2A, and this interaction has been found to promote TOP2A initiated double-stranded breaks. We aimed to study the possible involvement of double-stranded DNA breaks in the AIRE transcriptional activation of target genes in AIRE-expressing HEK293 cells treated with etoposide or merbarone, the well-known inhibitors of TOP2A.

We observed an upregulation of AIRE target

genes after treatment with etoposide that stabilizes TOP2A to cleaved DNA and prevents the religation of DNA breaks.

In contrast, treatment with merbarone, which blocks topoisomerase-mediated DNA cleavage, did not affect AIRE target gene expression. These specific differences indicate a possible role for the double-stranded breaks in AIRE-dependent transcription. We used FAIRE-seq to map open chromatin regions in AIRE-expressing HEK293 cells. We found that significantly more CpG island promoters become accessible in the presence of AIRE.

We conclude that AIRE/etoposide enhances the upregulation of AIRE target genes through the involvement of DNA double-stranded breaks and renders CpG island promoters more accessible.

Eduard Aleksanyan



eduard.aleksanyan@ut.ee

- ♦ **Title:** Development of novel scintillators based on thin nanocrystalline films
- ♦ **Supervisor:** Marco Kirm
- ♦ **Grant:** MJD166, 23 Sept 2011 – 22 Sept 2014
- ♦ **Partner institution:** University of Tartu

“Currently, I work at the A. Alikhanian National Science Lab located in Yerevan, Armenia. In cooperation with colleagues from UT, we continue the investigation of new types of materials with their potential application in light emitting and short wavelength radiation converting devices.”

Innovative Scintillating Materials

Over the past several years, rapid progress in various imaging technologies facilitated an increasing demand for new luminescence materials with improved performance. This motivates researchers to find and develop such compounds for a wide range of applications covering fields from medicine and high-energy physics to homeland security.

In comparison with scintillators in use, the new advanced luminescent materials must have a faster and more proportional response with increased light yield. In order to maintain a high spatial resolution, the scintillator layer has to be really thin. Therefore, my research focused on the investigation of HfO_2 and ZrO_2 thin films. Both these materials possess suitable absorption properties, but their scintillating properties need further investigation.

We also synthesized nanopowders and prepared ceramics in cooperation with Polish scientists. The results show that, by selecting different preparation methods and process parameters, it is possible to modify the properties of novel materials.

My research greatly benefitted from using advanced time-resolved VUV spectroscopy setups under synchrotron radiation excitation at the DORIS (in Hamburg, Germany) and MAX-III storage rings (Lund, Sweden), built by our research group during 2013–2014. Finally, my stay in Tartu deepened cooperation between Armenian and Estonian scientists. This is a good ground for a new postdoctoral fellow or PhD student to be engaged in research at excellent laboratories provided in new Physicum of the University of Tartu.



alikpop@mail.ru

Alexandr Popov

- ♦ **Title:** Rare-earth ions doped nanoparticles for fluorescent medical diagnostics
- ♦ **Supervisor:** Ilmo Sildos
- ♦ **Grant:** MJD167, 1 Aug 2011 – 31 July 2014
- ♦ **Partner institution:** University of Tartu

“*A continued research into the nanoparticles suitable for bioimaging will be carried out in Russia by collaborating with colleagues in the Institute of Physics, University of Tartu.*”

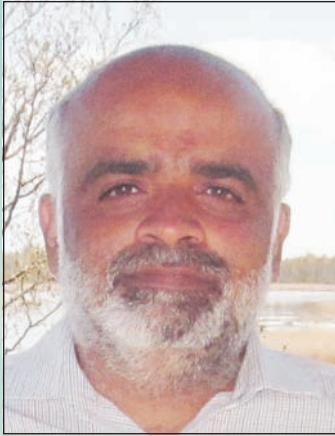
Inorganic Nanoparticles as Labels for Biological Systems

The application of luminescent inorganic nanoparticles (NPs) in medicine and biology will allow us to use the same drug simultaneously for the diagnosis and therapy of a disease. Special NPs prepared can selectively penetrate diseased cells and, detecting the luminescence signal, a doctor can see the location of diseased cells or tissue. For this, the NPs are doped with rare-earth ions which have the luminescent transitions in the near infrared range of the spectrum (“the transparency window” of biological tissues).

The low intensity of the infrared luminescence is one of the main problems in the applications of NPs. Luminescence quenching occurs due to the presence of water molecules in the NPs which arise due to the chemical composition features and synthesis chemical parameters.

Our main achievement is the development of a technique based on the analysis of the time decay curves of NPs luminescence. This technique allows us to determine the state and localization of water molecules in the NPs. Water molecules may be situated as an internal or surface defect of the crystal structure or attach to the inner surface of the ultra small emptiness of the NPs. We used chemical methods to achieve the reduction of water molecules concentration and, thereby, increase the luminescence intensity of the NPs.

This work was carried out in close collaboration with scientists from chemical engineering, theoretical physicists, and biophysicists. The results would make a crucial contribution to the knowledge required for the synthesis of high quantum yield dielectric NPs free of water.



nasir.sohail@ut.ee

Nasir Sohail

- ♦ **Title:** Study of the flatness (homological) properties of S-posets in connection with the amalgamation of partially ordered monoids
- ♦ **Supervisor:** Valdis Laan
- ♦ **Grant:** MJD198, 21 Nov 2011 – 28 Nov 2014
- ♦ **Partner institution:** University of Tartu

“*My future endeavor is to work in a university towards establishing my own research agenda. Next to the amalgamation of ordered monoids, I can now see that one can ask similar questions about quantels, in particular, and ordered algebras in general.*”

Amalgamation of Partially Ordered Monoids

The amalgamation properties of partially ordered monoids, briefly pomonoids, were first considered by S. M. Fakhruddin in the mid 1980s. In the recent past, S. Bulam-Fleming and N. Sohail rekindled this study. In this project, we further investigated these properties and explored their connections with dominions and epimorphisms. To characterize the dominions of pomonoids, we first proved an ordered analogue of the celebrated Isbell zigzag theorem.

Subsequently, we showed that dominions and (hence) epimorphisms and the special amalgamation of monoids are not affected by the introduction of order. Together with Dr. L. Tart, I also generalized these findings to partially ordered semi-groups. This work narrowed down the conjecture

that absolutely flat (inverse) pomonoids are amalgamation bases to asking whether they are weak amalgamation bases. Together with Dr. V. Laan and Dr. L. Tart, I also studied different notions related to pomonoid amalgams in the general setting of ordered algebras, which provided me a further insight into the amalgamation of pomonoids.

The amalgamation of ordered monoids is a relatively new research area in pure mathematics that has many open problems which might be of interest to future researchers. In particular, we are interested in (ordered) inverse monoids, which may be thought of as representing partial symmetries. The results obtained in this project also motivate me to study similar problems for (general) ordered algebras and relational structures.



omelkovs@gmail.com

Sergey Omelkov

- ▶ **Title:** Electronic excitations and their dynamics in functional fluoride and oxide based materials
- ▶ **Supervisor:** Marco Kirm
- ▶ **Grant:** MJD219, 1 Jan 2012 – 31 Dec 2014
- ▶ **Partner institution:** University of Tartu

“*I will stay in Tartu and continue studying prompt processes in the scintillating materials. My duties will also include the development of optical materials for fusion reactors.*”

Electronic Excitations in Complex Optical Materials

The scintillators are optical materials which convert ionizing radiation into visible or UV light. However, the energy of radiation has to pass a very long way inside a crystal to become light. The initial particle transfers energy to the electrons of the material. “Electronic excitations” are different states of these electrons, carrying energy in different ways. To understand the performance of an optical material, it is often necessary to investigate what happens or could happen to these excitations before they have a chance to release their energy as light. There is a good understanding of it in simple (binary) compounds, but complex materials like the ones studied in the project are much

trickier. Often, the structural properties of such materials enable several entities of the same type of excitation. The project contributed to the understanding on how differently they can act.

The most interesting aspect of the research came out when the pulse cathodoluminescence setup was reconstructed for the needs of the project. Its short pulses allow us to study the first stages of energy conversion in the materials. It has been known that some light is emitted already at these stages, but the setup lets us study this in detail and possibly use this prompt light in the future to increase the time resolution of the scintillators.



fer_rodcas@hotmail.com

Fernando Rodriguez-Castañeda

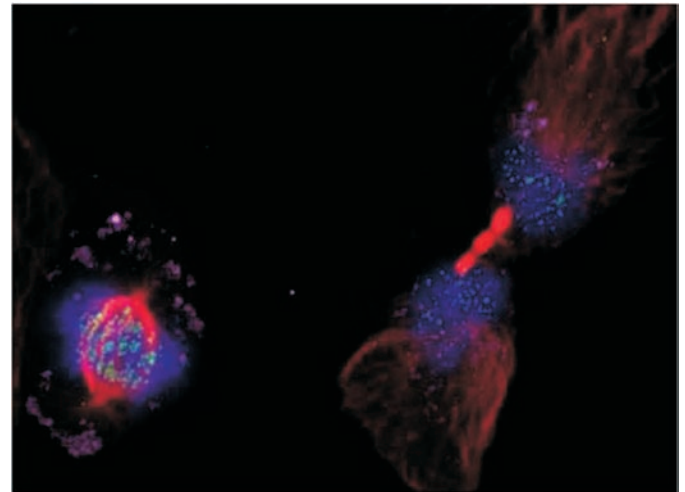
- ♦ **Title:** Identification of the mammalian chromatin host factor involved in the segregation of the human papillomavirus genome
- ♦ **Supervisors:** Mart Ustav
- ♦ **Grant:** MJD228, 10 Feb 2012 – 21 Nov 2014
- ♦ **Partner institution:** University of Tartu

“ I will further develop my career in Guatemala. In Tartu, I initiated a collaboration with a national hospital in order to study high-risk HPVs circulating in the country. ”

Cutaneous Papillomavirus in Skin Cancer

There are hundreds of different human papillomavirus (HPV) genotypes. The most studied belong to the alpha-genus. They infect the ano-genital tissues, and their role in the causation of anogenital cancer (*i.e.*, cervical cancer) is well established. In contrast, beta-genus HPV, also known as cutaneous since they are commensal papillomavirus of the human skin, have been found in the skin lesions of individuals with a rare genetic disorder, epidermodysplasia verruciformis.

These individuals have a higher risk of developing non-melanoma skin cancer than the general population, and both cutaneous HPV and UV radiation are considered risk factors for progression to cancer. In addition, transplant recipients undergoing immunosuppression therapy also have an increased risk of non-melanoma skin cancer associated with cutaneous HPV. We use an osteosarcoma cell line U2OS to study certain aspects of the life cycle of the human papillomaviruses.



Immunofluorescence of U2OS cells transfected with an expression vector of the viral protein E2. Chromatin in blue; beta-tubulin in red; centromeres in green; and E2 in magenta (3D reconstruction of the confocal microscopy images).



alieshbill@yahoo.com

Sheila Gamut Oyao

- ♦ **Title: Promoting multi-faceted approach to teaching and assessment for interdisciplinary science education incorporating cross-curricular topics**
- ♦ **Supervisor: Miia Rannikmäe**
- ♦ **Grant: MJD235, 1 Jan 2012 – 31 Dec 2014**
- ♦ **Partner institution: University of Tartu**

“*I will continue to do research and write a book that reflect the probable direction of science education in the new millennium, focusing on closing the gap between the school curriculum and the current societal and environmental issues within the modern society.*”

Towards a Competence-based Learning Framework

Many education curricula in Europe and elsewhere in the world are now embracing the development of competence which is seen as encapsulating a complex amalgamation of knowledge, skills or practices, attitudes, and values that have much relevance to a variety of purposes and contexts, ranging from the personal to social and to global spheres.

Seeing this potential for a competence approach, my research work proposes a competence-based learning framework that has global applicability, which is applied to the study of ‘big ideas’; viz the study of natural hazards and disaster risk reduction. Although this domain is least taken to be a key science learning area, it provides a good exemplar, illustrating the future science curricula which

moves towards the promotion of global competence. This developed framework focuses on new visions of competences, placing emphasis on nurturing connectedness and behavioural actions toward resilience and sustainability so as to adequately prepare learners to face and handle real-life challenges in the 21st century.

A part of this research work is the exploration of how Estonian students in basic education viewed natural hazards, considering that Estonia is least vulnerable to many of these natural events. Then, a cross-cultural comparison is made with the Filipino counterparts to gain comprehensive perspectives that will develop a knowledge base to support global competence.



katrin.kepp@ut.ee

Katrin Kepp

- ♦ **Title:** Analysis of genetic variation in p65 binding sites in a rheumatoid arthritis cohort of European descent
- ♦ **Supervisor:** Sonia Davila
- ♦ **Grant:** MJD236, 1 Nov 2011 – 31 Oct 2014
- ♦ **Partner institution:** University of Tartu
- ♦ **Receiving institution:** Genome Institute of Singapore (GIS)

“*In collaboration with GIS and UT, I am going to continue my research in the field of complex genetics. Furthermore, the functional role of the genetic variants detected will be described in RA pathogenesis.*”

p65 Binding Sites in RA Development

Rheumatoid Arthritis (RA) is known as a complex disease, with a high proportion of the disease risk to be accounted for by the genetic makeup of the individual as well as environmental and hormonal contributions. Over the recent years, genotyping-based genome-wide association studies aiming to identify the genetic basis of complex diseases have dominated the genetic field. However, it is now widely recognized that much of this genetic contribution still remains unexplained. Therefore, new approaches are needed to reveal the so-called “missing genetic heritability”. A recent development in sequencing technologies is one of the best ways of filling this gap in human genetics. Many complex disease studies have shown the important role of genetic variations on gene expression via transcription factors (TF) bindings and, thus, they may contribute to the development of human disease.

In this project, I combined NGS (Next Genera-

tion Sequencing) technologies to identify sequence variation within the previously described TF binding sites (>15,000) of one of the subunits of p65, associated with susceptibility to RA in two populations (Estonia and Sweden). Chronic up regulation of TF p65 has been shown in the synovial fluid of RA patients, thus, indicating an important role in disease development.

As a result of this project, a set of genes with genetic polymorphisms within p65 binding regions with the indication of the potential differential activation by p65 was detected. In the future, these regions may potentially provide interesting therapeutic targets to tackle this devastating disease. In addition, the whole assay build up in this project is valuable in the case of other (autoimmune or infectious) diseases where inflammation and p65 have been shown to play an important role.



Vimala Huchaiah

- ♦ **Title:** Development of research and diagnostics tools for ZnT8, a new autoantigenic target in type-1 diabetes
- ♦ **Supervisor:** Raivo Uibo
- ♦ **Grant:** MJD239, 1 Jan 2012 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu

“At present, I am working as a researcher at the University of Tartu.”

vimala.biology@gmail.com

The Presence of Autoantibodies Is an Important Predictive Marker for T1DM

The main objective of the project was to develop a diagnostic test system for screening autoantibodies against ZnT8 in patients' sera to predict type-1 diabetes mellitus (T1DM).

T1DM is an organ-specific autoimmune disorder involving autoimmune destruction of the insulin producing β -cells of pancreas, which leads to metabolic abnormalities. To date, this is an irreversible process and, consequently, the patients depend on exogenous insulin administration to survive. The appearance of autoantibodies usually precedes the onset of diabetes by months/years. These are islet cell autoantibodies, antibodies against insulin (IAA), glutamic acid decarboxylase (GADA), protein tyrosine phosphatase (IA2A/ICA512) and Zinc transporter-8 autoantibodies (ZnT8A).

Autoantibody against the protein zinc transporter-8 (ZnT8) is the most recently reported (2007) marker which has joined the list of autoantibodies measurement to confirm the T1DM manifestation clinically. Three to four autoantibody types increase the risk of progressing to T1DM by 60–100%, as the risk of progression to clinical disease correlates with the number of autoantibodies rather than individual titers.

Radioimmunoassay has been developed for antibodies directed against GADA, IA2A and IAA. ELISA staining for autoantibodies on sections of human pancreas and immunofluorescence assays are also routinely used. To minimize the use of radioisotopes, a luminescent marker (*Gaussia luciferase*) was used in this newly developed diagnostic assay to detect ZnT8A.



gbuono.geo@gmail.com

Giuseppe Buono

- ♦ **Title:** Paleoeological and Isotopic investigation of the Ordovician-Silurian of Estonia: a key to understand the dynamic of ecosystems
- ♦ **Supervisor:** Tõnu Meidla
- ♦ **Grant:** MJD241, 1 Jan 2012 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu

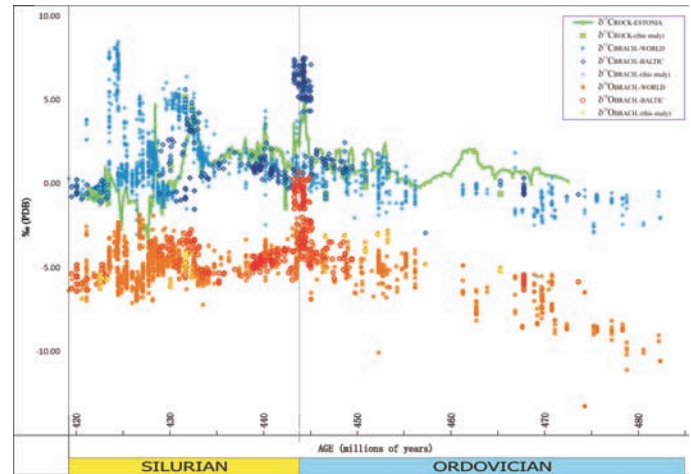
“Once I have finalized all the outputs coming from this project, I will hopefully continue my career, eventually still in Estonia.”

Geochemistry of Estonian Paleozoic Fossils

The main aim of the study was the investigation of stable isotope (carbon and oxygen) fluctuation in the biogenic fossilized material of the Ordovician and Silurian periods (approx. from 485 to 419 million years ago) in Estonia, and its meaning in a global context.

For this purpose, we collected hundreds of marine invertebrate fossils, mainly brachiopods, from 20 localities in Estonia (mainland and islands). Specimens preservation has been carefully investigated through a detailed series of analyses focused on assessing fossil ultrastructure, mineralogical phases and elemental composition. Stable isotopic composition was analyzed only in very well preserved carbonate shells.

Among the relevant results of the study are: (a) an isotopic signal is better preserved in the fossil shells rather than in rocks; and (b) the determination of paleolatitudinal and paleobathimetric iso-



Worldwide Ordovician and Silurian carbon and oxygen isotopic record brachiopods derived.

topic (and related thermal and salinity) gradients and their shifting through time happens according to tectonic plates shifting.



imre.mager@gmail.com

Imre Mäger

- ♦ **Title:** Targeted exosomes for the delivery of splice-switching oligonucleotides (SSOs) to muscle and brain
- ♦ **Supervisor:** Matthew Wood
- ♦ **Grant:** MJD242, 1 Dec 2011 – 30 Nov 2014
- ♦ **Partner institution:** University of Tartu
- ♦ **Receiving institution:** University of Oxford

“After completing this project, I intend to continue studying extracellular vesicles for exploiting their biological functions for therapeutic applications.”

Mimicking Nature: Extracellular Vesicles for Drug Delivery

Cell-to-cell communication is required for normal functioning of all multicellular organisms. Information exchange can occur via direct contacts, secretion of soluble molecules, and by the release of cell membrane derived vesicles. These extracellular vesicles modulate the functions of their target cells by activating signalling pathways and by delivering their cargo molecules (proteins, RNA, etc.) to the intracellular environment. My project was aimed at exploiting these natural properties of the extracellular vesicles for the delivery of desired therapeutic oligonucleotides, designed to modulate the gene expression of preselected targets.

The project required solving several problems. Firstly, methods for isolating extracellular vesicles needed thorough optimisation to produce vesicle

samples from complex cell secretome in an ultrapure, reliable and scalable fashion. This was solved by adopting a unique size exclusion chromatography based workflow for vesicle isolation which enabled the precise characterisation of vesicle contents.

Secondly, efficient strategies had to be designed and evaluated for loading the isolated vesicles with the desired oligonucleotide cargos. This was achieved by modifying oligonucleotides in a specific way to increase their association with extracellular vesicles in a releasable manner so that vesicle-associated molecules would retain their biological activity upon entry to recipient cells. Success in both work packages allowed the testing of extracellular vesicles for the delivery of splice-switching oligonucleotides in a spinal muscular atrophy *in vivo* disease model.



arvo.tullus@ut.ee

Arvo Tullus

- ♦ **Title:** Growth dynamics of deciduous trees under changing climatic conditions: physiological causes and implications for forest management
- ♦ **Supervisor:** Anu Sõber
- ♦ **Grant:** MJD257, 1 Dec 2011 – 30 Nov 2014
- ♦ **Partner institution:** University of Tartu

“ I will continue with studies of forest ecosystem responses to environmental change as senior researcher in the same work group where I fulfilled my postdoc grant at UT. ”

Rising Air Humidity Affects Northern Forests

Global warming will bring more precipitation in Northern latitudes, and warmer air can hold more water vapour, meaning that air humidity will increase. The current project was conducted in the Free Air Humidity Manipulation (FAHM) facility, which is the world's first open-air experiment where the responses of trees and forest ecosystems to elevated air humidity are studied. As test species, silver birch and hybrid aspen are used.

As expected, under elevated humidity conditions, transpirational water flow through the trees decreased which, on the one hand, helped to maintain soil moisture but, on the other hand, hindered the acquisition of nutrients that are mobile in soil and move to the roots with transpiration-driven water flow. Especially, the uptake of nitrogen to the tree leaves was restricted which, in its turn, decreased

the photosynthetic capacity of the leaves. Consequently, during the first 2–3 experimental years, the growth rate of both tree species was significantly slower under elevated humidity. During the following seasons, the growth rate of birches recovered and became faster in the final study year, while the growth of aspen remained suppressed. As one of the acclimation mechanisms, birches growing under elevated humidity delayed their autumn leaf fall for 2–3 weeks, which enabled them to maintain photosynthetically active foliage longer.

The results suggest that, besides increasing temperature and CO₂ concentration, rising air humidity will also become an important climate change related factor that is going to affect the growth and functioning of trees in Northern forests.



heikkilapa@gmail.com

Pauli Heikkilä

- ♦ **Title:** Foreign policy of exile Estonians, 1944–1972
- ♦ **Supervisor:** Olaf Mertelsmann
- ♦ **Grant:** MJD259, 1 Jan 2012 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu

“For three years I have told a joke that Estonia is actually the last place to study Estonian emigration. Albeit it might not be true, the study now continues abroad.”

International Cooperation During the Cold War

In the aftermath of World War II, approximately 70,000 Estonians fled from the Soviet troops to the West where they restarted their lives in Swedish, American, Canadian, etc. societies. They also initiated political campaigns to restore Estonian independence.

Although a delightfully active research community has emerged around the Estonian diaspora, there are still few studies of their political aspirations and organizations. Even my project is not directly interested in Estonian endeavors but uses them as a departure point to study international cooperation among refugees from Central and Eastern Europe.

Assembly of Captive European Nations (1954–1972) was the most important form of their mutual efforts and, although Estonians constitute only one

of the nine member organizations, revealing their participation will illustrate the history of this extensive, yet nowadays nearly forgotten, organization.

Archives are the basis of any historical research, and the study of Cold War diaspora requires visits to Western Europe and the USA. Thanks to a Fulbright scholarship during my project, I was able to study the most relevant collections in the Immigration History Research Center in Minneapolis and Hoover Institute at the Stanford University.

Fortunately, there is also emerging collaboration among researchers from Central and Eastern Europe. The theme carried me away, and I have more to show from the Baltic federation during World War II and the protests towards the Olympic sailing in Tallinn in 1980, which are outside the initial time frame.

Juha Matti Linnanto



juha.m.linnanto@gmail.com

- ♦ **Title:** Time Evolution of Electronic Excitation in Photosynthetic Complexes
- ♦ **Supervisor:** Arvi Freiberg
- ♦ **Grant:** MJD262, 15 May 2012 – 14 May 2014
- ♦ **Partner institution:** University of Tartu

“After Mobilitas, I am working at UT as a senior researcher. I continue my work to understand the mechanisms and functions of the photosynthetic apparatus.”

Light Harvesting and Energy Transfer in Photosynthetic Complexes

The Sun is the main energy source of life on Earth, with nearly every organism depending on photosynthesis or its products for energy. In photosynthetic organisms, light harvesting (LH) antenna complexes trap the Sun's light and transfer light energy to the photosynthetic reaction centre (RC) complexes where electron and proton transport processes take place. And finally, series of electron and proton transfer and biochemical reactions convert the energy of the Sun's photons into chemical energy in the form of sugars, lipids, and other compounds that sustain cell life.

The LH antenna and RC complexes have such molecule architectures that captured solar energy flows efficiently via different molecule complexes towards the RC as water flows in a river. However, the structure of a molecular complex itself does not

directly tell the direction of the energy flow as landscape tells the direction of water flow in the river. Therefore, different spectroscopic and computation methods are needed to study the light harvesting and energy transfer (ET) properties of photosynthetic complexes.

The research project focused on the spectroscopic and ET properties of LH and RC complexes. The study gave new information on the vibronic transitions of molecules and their complex structures. In the project, we modelled the photosynthetic unit for filamentous anoxygenic phototrophs (FAP). The model reproduces experimentally observed transition rates and suggests effective excitation energy transfer via different LH antennae to the RC complex of FAP.



elmo.tempel@to.ee

Elmo Tempel

- ♦ **Title:** Dark matter search using astrophysical sources
- ♦ **Supervisor:** Martti Raidal
- ♦ **Grant:** MJD272, 1 Nov 2011 – 31 Oct 2014
- ♦ **Partner institution:** National Institute of Chemical Physics and Biophysics

“After my postdoc, I got a position as senior researcher at Tartu Observatory. I am establishing my own research group in the field of observational cosmology.”

Dark Matter and Galaxy Filaments

One of the greatest advances in cosmology has been the discovery of how matter and light are organized on scales larger than those of galaxies – the main building blocks of our Universe. Galaxies are not uniformly distributed in space.

Instead, they are arranged into various structures: groups, clusters, chains, filaments, sheets, and superclusters. Galactic filaments are the most stringent structures found in nature, containing nearly half of the total mass (visible and dark) of the Universe.

Today, the cold dark matter cosmological model is established with a few percent precision. We live in a universe that is energetically dominated by dark matter (27%) and dark energy (68%). However, the model does not clarify the nature of these mysteri-

ous but dominant dark components. Important hints can be found by analyzing the details of matter distribution.

The aim of the postdoc project was to search for indirect dark matter signals from nearby astronomical sources – our own galaxy, galaxy groups and large-scale cosmic filaments. An interesting result was the discovery of a line-like excess of gamma rays from the Galactic centre and from the nearby galaxy clusters. Whether this signal is of dark matter origin or not is still debatable.

Additionally, we mapped the galactic filaments in the nearby universe with unprecedented details. We showed that the galactic filaments have a significant role in the formation and evolution of galaxies.



dsantalova@gmail.com

Diana Santalova

- ♦ **Title:** Multivariate regression models in application for transport flows analysis and forecasting
- ♦ **Supervisor:** Tõnu Kollo
- ♦ **Grant:** MJD280, 1 Jan 2012 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu

“*I continue collaboration with the supervisor of my project and search for new funding opportunities.*”

Forecasting Transport Flows

The main objective of the project is the forecasting of passenger transport flows, applying multivariate regression models. Special attention has been paid to the modified gravity model. This is a non-linear regression model for passenger correspondences estimation between pairs of spatial points. The matrix of estimated correspondences is called the correspondence matrix. Correspondence matrix is required for any transport model as input information. The model contains the “traditional” gravity part and the regression part. The gravity part consists of the products of populations at the points and distance between them. The regression part contains various predictors describing the correspondence between points more completely. The model contains numerous unknown parameters which makes the estimation of the model quite complicated. Unknown parameters and correspondences are estimated using aggregated data, i.e., the total numbers of passenger departures at every point in

a considered time interval. The model was estimated under the assumption that error term is a normally distributed random variable, and statistical properties of the estimates have been verified as well. Another assumption of the model is that estimated correspondences are symmetric which contradicts the real life. This can cause loss of estimation accuracy, which can be observed as increasing the mean square error. Our approach for diminishing the mean square error is based on a hypothesis that the non-symmetry of the correspondences can violate the assumption about the normality of error distribution. The model was generalized to a model with skew-normal error distribution, and a method of its estimation was proposed, verified and tested.

This and other models proposed within the research, and their estimation methods, are universal and can be successfully applied in any area of different patterns of factors.



toniso@ut.ee

Tõnis Org

- ♦ **Title:** Mechanisms of Scl/Tal1 dependent gene activation and repression during mesoderm diversification
- ♦ **Supervisor:** Hanna Mikkola
- ♦ **Grant:** MJD284, 1 Nov 2011 – 31 Oct 2014
- ♦ **Partner institution:** University of Tartu
- ♦ **Receiving institution:** University of California, Los Angeles

“*I will continue to explore how transcription factors work in the context of chromatin and epigenetic information to ensure a properly functioning hematopoietic system.*”

Cell-based Therapies for Blood Disorders

My research aims to understand the mechanisms that direct mesoderm diversification, which holds a great potential to advance the development of cell-based therapies for cardiovascular and blood disorders. The bHLH transcription factor Scl is known as the master regulator of the hematopoietic fate. We discovered that, in addition to its critical function in promoting hematopoietic development, Scl is also required to repress cardiomyogenesis. However, the mechanisms for this repression have remained unknown.

Using ChIP-sequencing and microarray analysis of embryonic stem cell derived mesodermal cells, that can give rise to both hematopoietic and cardiac lineages, we show that Scl both directly activates a broad gene regulatory network required for blood development and represses transcriptional

regulators required for cardiogenesis. The repression of cardiac and mesodermal programs occurs during a short developmental window through Scl binding to distant enhancers that are primed for activation, while binding to hematopoietic regulators extends throughout hematopoietic development.

The analysis of cardiac transcription factors Hand1 and Gata4 binding sites in mesoderm showed that many of them overlap with Scl binding sites. This suggests that Scl hampers cardiogenesis by blocking the enhancers that cardiac master regulators would use for gene activation. These results denote Scl as a true master regulator of hematopoietic *vs.* cardiac fate choice and suggest a mechanism by which lineage-specific bHLH factors direct the divergence of competing fates.



antonio.racioppi@kbfi.ee

Antonio Racioppi

- ♦ **Title:** Stückelberg Z' and scalar dark matter
- ♦ **Supervisor:** Martti Raidal
- ♦ **Grant:** MJD298, 1 Oct 2012 – 30 Sept 2014
- ♦ **Partner institution:** National Institute of Chemical Physics and Biophysics

“*I am finishing my second postdoc at KBFI where I am planning then to establish my own research group.*”

The Dark Unknown

It is a summer time night. We are in the countryside, far from the city lights. The weather is beautiful and warm. No clouds. We look up at the sky, and we see many stars shining. All the rest is darkness (except for the moon and some planets which are visible because they reflect sunlight). However, such darkness is not empty. It is full of several objects like planets, natural satellites, asteroids and so on... Still, our present knowledge can explain just a small fraction of it.

The Standard Model (the proved present description of the microscopic world) can only describe 5% of the mass of the universe: the stars, planets, galaxies, etc. mentioned before. The remaining 95% of the mass of the universe is not explained by the Standard Model and consists of

dark energy (68%) and dark matter (27%). The origin of the appellation “dark” is quite simple. Such a matter does not emit light, therefore, it is dark, and it cannot be directly seen. So far, the evidence of its existence is only indirect and gravitational: ordinary matter is attracted to it. Dark matter is searched for in detectors where a dark matter particle colliding with an atomic nucleus could be seen. Unfortunately, we have not seen it yet, therefore, we do not know its properties.

My project consists of developing viable and testable models of dark matter. In particular, I study models in which dark matter is a scalar particle coupled to the Higgs boson and involved in the stabilization of the electroweak vacuum.



evely.leetma@ut.ee

Evely Leetma

- ♦ **Title:** Smoothing problems
- ♦ **Supervisor:** Tom Lyche
- ♦ **Grant:** MJD340, 1 Aug 2012 – 31 July 2014
- ♦ **Partner institution:** University of Tartu
- ♦ **Receiving institution:** Centre of Mathematics for Applications, Oslo

“ I plan to continue my research in the chosen field, particularly working on different approximation methods, including subdivision and parametric interpolation. ”

Computer-aided Geometric Design

Computer-aided geometric design (CAGD) is a wide research area, dealing with the computational aspects of geometric objects — how to produce a computer-compatible description of some shape. The main tools in CAGD are splines and different recursion formulas, defining smooth subdivision curves and surfaces. Often, there is some amount of discrete data, and the problem is how to approximate the underlying continuous process. These problems are called data fitting problems. Data fitting problems could be divided into two groups — exact and inexact data fitting (interpolation and smoothing, respectively).

In the case of interpolation, the desired curve or surface goes through the given datapoints. The main topic of our research is the choice of parameter values corresponding to these datapoints. We analyze the family of parameterizations that de-

pends on the chord lengths of data polygon and consider maximum local deviation and global deviation as the measures of the badness of the approximation. This gives us an approach to find a reasonably good approximation with small computational cost which mimics the given data polygon maximally.

In the case of smoothing problems, the data is given approximately, i.e., the resulting curve/surface should pass ‘close enough’ to the given datapoints. The most natural problem, where ‘close enough’ means that on each datapoint the maximum deviation is given, is called the smoothing problem with obstacles. We study how to reduce the smoothing problem with obstacles to the solution of smoothing problem with weights.



fredrik.stocker@ucrs.uu.se

Lars Fredrik Stöcker

- ♦ **Title:** A gradual transition: Perestroika, opposition, secession and transformation in Estonia in the light of the border-crossing elite networks from the mid-1980s to the early 1990s
- ♦ **Supervisor:** Karsten Brüggemann
- ♦ **Grant:** MJD347, 1 Oct 2012 – 30 Sept 2014
- ♦ **Partner institution:** Tallinn University

“A follow-up project, hosted by Uppsala University and the University of Vienna, will deal with the trajectory of early market reforms in the Lithuanian and Ukrainian SSR.

”

Early Market Reforms in Estonian SSR

Research on the economic transformation in the USSR has mainly been focusing on the post-Soviet period and the successor republics of the Soviet Empire. The early market reforms launched by the Soviet leadership from 1987 onwards, by contrast, which generated a new class of ‘Soviet capitalists’ and contributed to a considerable economic decentralization in the USSR, have so far been neglected by the scholarly community.

The project focused on the implementation of economic reforms in the Estonian SSR, which soon became a Soviet forerunner of marketization. Reformers among the political elite, but also first private entrepreneurs, profited especially from the cooperation with Estonian émigrés in Sweden and

North America, which developed after the liberalization of the border regime. Émigrés soon came to play a leading role as business partners for Soviet Estonian joint ventures, economic advisers and mediators between Estonia and Western companies and organizations. Their commitment laid the ground for Estonia’s first business schools and companies that still exist today and culminated in the formation of an expert group that offered economic advice to several Estonian governments. This transnational network considerably accelerated the integration of Estonia into Western markets even before political independence was achieved and sheds an interesting new light on the reasons for Estonia’s post-1991 economic success.



jaanis.juhanson@ut.ee

Jaanis Juhanson

- ♦ **Title:** Spatial patterns of denitrifying microorganisms for improved mitigation strategies for nitrous oxide emissions from arable land
- ♦ **Supervisor:** Sara Hallin
- ♦ **Grant:** MJD376, 1 Jan 2013 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu
- ♦ **Receiving institution:** Swedish University of Agricultural Sciences

“For the next couple of years, I will continue working at the Swedish University of Agricultural Sciences where I conducted my research study financed by Mobilitas during years 2013–2014.”

Spatial Patterns of Denitrifiers

Nitrous oxide (N_2O) is a major greenhouse gas contributing to 6% of the anthropogenic greenhouse effect, and N_2O emissions from terrestrial environments represent up to 70% of global N_2O sources. The biological emission of N_2O from soil is mainly controlled by denitrification, an anaerobic respiratory process that reduces soluble NO_3^- and NO_2^- to the nitrogen gases NO , N_2O and N_2 via four enzymatic complexes. A key step in regulating N_2O emissions is the reduction of N_2O to N_2 , which is catalyzed by the nitrous oxide reductase encoded by the *nosZ* gene.

To date, two different type of *nosZ* genes are known. The current project studies the composition and field-scale spatial patterns of microbial

communities possessing either *nosZ* clade *I* or clade *II* genes in relation to edaphic factors and potential N_2O reduction activity. Results showed that the diversity, abundance and community composition of the microorganisms capable of N_2O reduction were influenced by different soil factors, indicating niche differentiation between the different types of *nosZ* communities in agricultural soil.

Further investigations of the predicted spatial patterns of denitrifier community regulating N_2O emissions will give insight into the mechanisms shaping these communities, which could provide us with knowledge-based land management strategies for mitigating N_2O emissions.



alexandr.svetlicinii@eui.eu

Alexandr Svetlicinii

- ♦ **Title:** Transplantation of the EU competition rules and standards in a small market economy: the case of Estonia from regional, EU and international perspective
- ♦ **Supervisor:** Tanel Kerikmäe
- ♦ **Grant:** MJD437, 1 Oct 2012 – 30 Sept 2014
- ♦ **Partner institution:** Tallinn University of Technology

“After completing my postdoc project in Estonia, I plan to continue comparative legal research on competition law and market regulation in Asia.”

Competition Rules for Small Markets

The enforcement of competition rules is one of the most important EU policies contributing to the functioning of the EU Internal Market, strengthening the competitiveness of the EU economies and individual Member States and according wider choice and lower prices to the consumers. Competition law is also one of the areas where EU institutions, rules, and standards significantly affected the development of the national competition rules of Member States.

Despite the obvious differences in market realities of various Member States, the rules and standards for the competition law of the EU have been continuously copied from the EU level onto the national level of individual Member States. My postdoc project explored the problems of apply-

ing of the EU-modelled competition rules (used for the protection of competition on the Internal Market comprised of 28 countries) in a small market economy such as Estonia.

The study revealed that, although Estonian competition rules mirror the EU model, their enforcement practice differs significantly due to the specifics of the domestic markets and a complex procedural framework in which the competition rules are applied (including administrative, misdemeanour, criminal and civil procedures).

These findings have contributed to the discussion on the efficiency and uniformity of the EU competition rules and their enforcement by EU Member States.



olegjanson@gmail.com

Oleg Janson

- ◆ **Title:** Microscopic modeling of magnetic materials using DFT+U and hybrid functionals
- ◆ **Supervisor:** Alexander Tsirlin
- ◆ **Grant:** MJD447, 1 Jan 2013 – 31 Dec 2014
- ◆ **Partner institution:** National Institute of Chemical Physics and Biophysics

“My next project is at the University of Technology in Vienna (Austria) where I work on the application of DFT and DMFT-based methods to strongly correlated materials.”

The Microscopic Modeling of Magnetic Materials

The recent burst of activity on quantum magnets delivered an impressive number of exotic ground states and magnetic behaviors. Manifestations of these phenomena can be directly probed by modern experimental techniques.

However, the underlying physics can be very complicated, turning the interpretation of the experimental data into a challenging task. *Ab initio* calculations based on density functional theory provide a rare opportunity to dive into the microscopic roots of magnetism – exchange interactions between the atoms. These interactions cannot be directly measured, yet, they govern the experimentally observed behavior. Hence, a microscopic magnetic model is a crucial piece of information in understanding the experiment.

In this project, microscopic magnetic modeling was carried out for several magnetic insulators based on *3d* elements. A highlight of this research is the study of Cu_2OSeO_3 , the compound known as the only to-date known insulator showing the emergence of skyrmions – topological magnetic defects with a whirlpool-like structure. Using a multi-scale approach, we were able to trace the formation of skyrmions to the microscopic exchange interactions that operate on completely different length scales. This is a first example of such an *ab initio* analysis for a bulk skyrmionic material.

The ongoing improvement of computational techniques allows us to envisage future applications of microscopic modeling to further ambitious tasks.



uwe.sperling@mail.ee

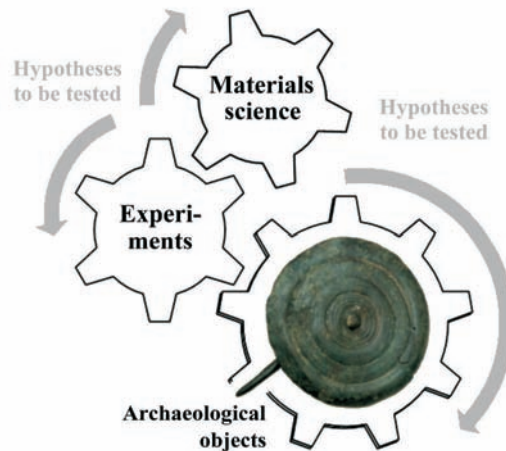
Uwe Sperling

- ♦ **Title:** Research in the metalwork of Bronze Age Estonia – archaeometric and experimental methods applied
- ♦ **Supervisor:** Valter Lang
- ♦ **Grant:** MJD458, 1 Jan 2013 – 31 Dec 2014
- ♦ **Partner institution:** University of Tartu

“After *Mobilitas*, I will continue my studies in joint projects on the same multidisciplinary venue with archaeologists and research laboratories in Sweden, Germany and Estonia.”

Archaeometry of Bronze Age Metalwork

My studies focussed on bronze production in prehistoric Estonia, which is about 800 BC (Late Bronze Age) when the region had active connections with distant European regions for the exchange and import of copper and tin (e.g., the Alps and Britain). The project addressed challenging questions on the archaeological remains from bronze casting workshops (e.g., Asva): How has technical knowledge moved? Have (few) specialists only been involved in contact and travel? What about the social role and function of precious metals? I tested various hypotheses with experiments, replicating processes (fabrication of clay moulds; melt, cast of bronzes), and with methods of materials science (archaeometry). The interesting results do not only point to a complex and multi-tiered organisation of this exclusive branch of craft but also to entire households involved in these technological practices.



The concept of the interdisciplinary nature of the study, and the technological ('embodied') know-how to be decrypted from archaeological finds such as the disc-pipin of Kaali meteorite-crater.

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