

ACHIEVEMENTS IN SCIENCE 2017 • LATVIA

THEORETICAL SCIENCE

The original theory of topological modelling ensures the design of safe and high-quality software architecture from the very beginning to the end and provides it during the maintenance

Janis Osis and Uldis Donins. "Topological UML Modelling. An improved approach for domain modelling and Software development". Elsevier, Cambridge, Massachusetts, USA, 2017, 253 pp.

Jānis Osis, Honorary Member of the Latvian Academy of Sciences (LAS), *Dr.sc.ing.* Uldis Doniņš

Institute of Applied Computer Systems, Riga Technical University

Theoretical foundations for software development and new software development approach to replace existing inefficient and low-quality approaches are created. The original theory of topological modelling ensures the design of safe and high-quality software architecture from the very beginning to the end and provides it during the maintenance.

Determination of the molecular mechanism of spider silk formation and assessment of the degree of biomimicry of artificial spider silk spinning

LAS Corresponding member Kristaps Jaudzems, *Mg.chem.* Mārtiņš Otiņš

Latvian Institute of Organic Synthesis (LIOS) in collaboration with Karolinska Institute in Sweden (Karolinska Institutet) and Institute of Analytical Sciences in France (Institut des Sciences Analytiques)

Spider silk is a high-performance material with perspective applications in a number of areas ranging from biomedicine to construction. The spiders spin their web from silk fibres that are made of proteins. Thus far, the process of the spider silk fibre formation was incompletely understood, making it difficult to develop effective technologies for the production of artificial spider silk. Researchers at LIOS have studied the process of native spider silk spinning and established the mechanism of molecular transformations that ensure controlled conversion of soluble silk proteins into solid fibres. The acquired knowledge was used to assess the degree of biomimicry of the state-of-the-art approaches for artificial spider silk spinning, allowing to propose improved technologies for the production artificial spider silk.

A new compound E1R has been developed to improve memory processes and treat epilepsy

Dr.med. Līga Zvejniece, *Dr.pharm.* Edijs Vāvers, *Dr.pharm.* Baiba Švalbe, *Dr.chem.* Maksims Vorona, LAS academician Maija Dambrova, LAS academician Grigorijs Veinbergs, LAS academician Ivars Kalviņš (Latvian Institute of Organic Synthesis, LIOS), *Dr.biol.* Ilga Misāne, *Dr.med.* Ilmārs Stonāns (JSC Grindeks)

E1R or methylphenylpiracetam is a promising new low-molecular compound for the treatment of memory disorders and epilepsy. E1R was synthesised in the Latvian Institute of Organic Synthesis, comprising excellent organic chemistry skills and expertise in the synthesis

of optically active compounds. The E1R is the first known positive allosteric modulator of Sigma 1 receptor that improves memory processes and prevents seizures. Based on the results obtained by scientists about the potential use of E1R in clinical practice six international patents are registered and five articles published in prestigious international journals.

Involvement of persistent viral infections in the development of nervous system diseases

Dr.habil.biol. Svetlana Čapenko, *Dr.med.* Santa Rasa, *Dr.med.* Sandra Skuja, *Dr.habil.med.* Valērija Groma, LAS academician Modra Murovska
A.Kirchenstein Institute of Microbiology and Virology, Institute of Anatomy and Anthropology, Laboratory of Anthropology, Riga Stradiņš University

Around 95% of humans are exposed to herpesvirus-6 and -7 (HHV-6, HHV-7) during early childhood. After the primary infection beta-herpesviruses can establish life-long latency without visible clinical changes, however the role of these viruses in the development of human diseases as well as the factors reactivating viral infection from latency are not completely clarified. We investigated involvement of HHV-6 and HHV-7 infection in the development of unexplained nervous system disorders, like encephalopathy, fibromyalgia and myalgic encephalomyelitis/ chronic fatigue syndrome (ME/CFS) using various methods of molecular virology, immunology and morphology. In patients with fibromyalgia significantly often concurrent HHV-6 and HHV-7 infection, its activation, higher viral loads and levels of pro-inflammatory cytokines has been found. In case of encephalopathy, the presence of beta-herpesvirus infection markers, including expression of virus-specific antigens in the brain tissue, has been significantly more often detected. Studying structural changes in the human olfactory tract (one of the pathways for infection in the brain) is shown that HHV-6 mostly alters the oligodendrocytes and myelin they create. By studying ME/CFS, it has been shown for the first time that HHV-7, like HHV-6, can integrate into the genome of the cell, resulting in the infection being inherited from generation to generation.

A qualitatively new approach to musical instruments used in Latvia in different historical periods has been proposed, summarizing historical, organological, folkloristic, linguistic and other data

Valdis Muktupāvels. „Tautas mūzikas instrumenti Latvijā” (“Folk musical instruments in Latvia”). Rīga: Latvijas Universitātes Akadēmiskais apgāds, 2017, 320 pp.

A qualitatively new approach to musical instruments used in Latvia in different historical periods has been proposed, summarizing historical, organological, folkloristic, linguistic and other data. Based on theoretical concepts and experience of European organology, a systematics of musical instruments has been developed, thus enabling Latvian organological data to be circulated internationally. The published study contains a rich and thematically broad spectrum of information on musical instruments, complemented with 157 historical pictures and photos of museum artefacts, with instrument distribution maps, musical scores and different indices.



A unique research on Latvian poetry during the period of Reformation, late Renaissance and the era of Baroque

Māra Grudule. „Latviešu dzejas sākotne 16. un 17. gadsimtā kultūrvēsturiskos kontekstos” (The origins of Latvian poetry in the 16th and 17th century against the backdrop of cultural and historical contexts), Latvijas Universitātes Literatūras, folkloras un mākslas institūts, 2017, 416 pp.

The monograph “The origins of Latvian poetry in the 16th and 17th century against the backdrop of cultural and historical contexts” published by the Institute of Folklore, Literature and Arts of the University of Latvia is a unique research on Latvian poetry during the period of Reformation, late Renaissance and the era of Baroque; on spiritual songs and occasional poetry, mostly translations from German. The comparison of the German originals and the translations are critical to the value of the book and allow to conclude that 1) Latvian literature from its very beginnings fits into the European tradition; 2) the translator almost always considers the addressee by introducing in the translations elements characteristic of Latvian spiritual world and culture, e.g. flora and fauna; 3) the poetical tradition of this epoch can be traced in Latvian poetry of the 18th and 19th centuries and even today.

The research reveals how Rainis, an avid social democrat, became to elucidate the essence of Latvian national aspirations and construct a vision of the future independent Latvian state in a united Europe and the world

Gundega Grīnuma. „Viņpus Alpiem. Rainis un Aspazija Kastaņolā: Jaunatklāti tuvplāni”, Mansards, 2017, 968 pp.

This work illuminates the least studied period in the life of Latvian poets Rainis and Aspazija during their political exile in Switzerland from 1906 to 1920. The monograph draws on an array of newly

discovered archival materials – documents, journal extracts, drafts of unfinished plays, notes on intended future projects and various philosophical, artistic and political questions, as well as letters and memories of the writers’ contemporaries – to reveal how Rainis, an avid social democrat, became to elucidate the essence of Latvian national aspirations and construct a vision of the future independent Latvian state in a united Europe and the world.

APPLIED SCIENCE

Novel materials for infrared light convertors and white light sources

LAS Full Member Uldis Rogulis, *Dr.habil.phys.* Māris Sprīngis, *Dr.phys.* Anatolijs Šarakovskis, *Dr.phys.* Jurgis Grūbe, *Dr.phys.* Andris Fedotovs, *Dr.phys.* Edgars Elsts, *Mg.sc.ing.* Guna Krieķe, *Mg.phys.* Andris Antuzevičs, *Mg.phys.* Meldra Ķemere

Institute of Solid State Physics, University of Latvia

Novel transparent glass ceramics with fluoride nanocrystals doped with rare-earth ions have been sintered. The important optical properties for applications have been optimized, by controlling the size of the nanocrystals and concentration of the rare-earth ions, namely, the luminescence efficiency and the colour of the emitted light. The obtained oxyfluoride glasses and glass ceramics efficiently transform the infrared radiation (IR) into the visible light. The efficiency of the materials and compatibility with optical waveguides allow to use them for the development of optical sensors and IR visualisation. By variation of the



chemical composition, the materials which emit eye-pleasant white light, are long-term durable and applicable in the light sources were obtained.

Engineering of software tools for energy price reduction, power system modelling, control and planning

LAS Corresponding Member Antans Sauhats, *Mg.sc.ing.* Zane Broka, *Mg.sc.ing.* Kārlis Baltputnis, *Dr.sc.ing.* Romāns Petričenko, *Dr.sc.ing.* Gatis Junghāns, *Dr.sc.ing.* Oļegs Linkevičs, *Dr.sc.ing.* Laila Zemīte, LAS Honorary Member Namejs Zeltiņš, *Dr.sc.ing.* Renāta

Varfolomejeva, *Dr.sc.ing.* Ļubova Petričenko, *Dr.sc.ing.* Jevgeņijs Kozadajevs
Institute of Power Engineering, Riga Technical University

The research is aimed to enhance the effectiveness and reliability of power supply, foster the energy independence of Latvia and its integration into the European power system. Within the research, detailed mathematical models of the Latvian power system and its components have been elaborated. Results of the research studies have been published in a number of international scientific journals and conferences proceedings as well as applied in practice in the operation of the Latvian power system, thus bringing benefit to system operators, power producers and consumers in both Latvia and its neighbouring countries. The developed software tools have also been employed in implementation of several local and international research projects.

Wide range of thermal insulation materials from renewable and recycled raw materials

Dr.habil.chem. Uldis Stirna, LAS Corresponding Member Uģis Cābulis, *Dr.sc.ing.* Vladimirs Jakušins, *Mg.sc.ing.* Miķelis Kirplūks, *Mg.sc.* Anda Fridrihsone

Latvian State Institute of Wood Chemistry

In order to reduce dependence on imported oil and taking into account the EU's provisions on the reduction of greenhouse gas emissions, an effective thermal insulation material - polyurethane foam formulation using rapeseed oil produced in Latvia - has been developed. In addition, Latvian State Institute of Wood Chemistry has been working with other natural oils and recycled raw materials, such as PET waste. The developed thermal insulation materials are competitive with the incumbent materials on the market. New polyol synthesis methods have been developed, knowledge base has been accumulated to develop thermal insulation materials according to the requirements of the specific end user. The developed foam is approved not only as a thermal insulation, but also as shock-absorbing parts for cars.

Innovative protein and fiber-rich products from legumes grown in Latvia

LAS Corresponding Member Sandra Muižniece-Brasava, *Dr.sc.ing.* Asnate Ķirse, *Dr.sc.ing.* Liene Strauta, *Dr.sc.ing.* Ruta Galoburda, LAS Corresponding Member Daina Kārklīņa, *Bc.sc.ing.* Evija Puiškina

Latvia University of Agriculture, Faculty of Food Technology

Novel solutions for the production of protein and fiber-rich products – pulse spreads, extruded legume snacks and bars – from grey peas, broad beans and field beans grown in Latvia have been developed (supported by the EU 7th Framework Program project



“Eurolegume”). The research focuses on the use of advanced technologies to ensure the nutritional value and safety of products (high pressure processing, extrusion cooking, biodegradable and active packaging). The results of the research have been published in 20 scientific publications, two PhD thesis have been defended, the results have been presented at 25 international scientific conferences and exhibitions, and the products are ready for commercialization (Technology Readiness Level – TRL 7).

The study on occurrence of pharmaceutical compounds residues in the environment of Latvia and the possibilities of reducing of their concentration

Dr.chem. Vadims Bartkevics, *Dr.biol.* Olga Mutere, *Dr.chem.* Ingars Reinholds, *Dr.chem.* Iveta Pugajeva, *Dr.chem.* Dzintars Začs, PhD students – Ingus Pērkons and Jānis Ruško

Institute of Food Safety, Animal Health and Environment “BIOR”, University of Latvia

Pharmaceutical products have raised significant concerns in recent years for their persistent input and potential threat to the ecological environment and human health. Because of its continuous introduction in the environment, pharmaceuticals are considered as “pseudo persistent compounds”. Human and veterinary drugs are continually being released to the environment mainly as a result of manufacturing processes, improper disposal or metabolic excretion. Scientists of the Institute of Food Safety, Animal Health and Environment “BIOR” and University of Latvia have performed the study on occurrence of pharmaceutical compounds residues in the environment of Latvia and the possibilities of reducing of their concentration in sewage water samples. Application of innovative analytical techniques has demonstrated a wide range of pharmaceutical compounds residues in Latvian environmental samples, whereas an efficiency of existing wastewater clean-up techniques is rather low for a number of compounds. As a result, several promising pharmaceutical residue reduction technologies based on activated sludge treatment and biostimulation have been proposed.



DIPLOMA OF THE PRESIDENT OF THE LATVIAN ACADEMY OF SCIENCES
Theoretical Science

The monograph explores how artworks and other objects of cultural value owned by Riga people were expropriated, destroyed, lost or wasted during the early phase of the second Soviet occupation, as well as traces the collection history of state museums in these years

Jānis Kalnačs. “Rīgas dzīvokļu “likumīgā” izlaupīšana. 1944–1949” (The ‘legitimate’ plundering of Riga’s apartments), Rīga: Neputns, 2017, 464 pp.

The monograph explores how artworks and other objects of cultural value owned by Riga people were expropriated, destroyed, lost or wasted during the early phase of the second Soviet occupation, as well as traces the collection history of state museums in these years. The author has studied and interpreted documents from the Latvian State Archive and the State Archive of the Russian Federation, visual and textual materials from the Latvian National Museum of Art, Latvian National History Museum, Museum of Writing and Music, Riga History and Navigation Museum, Eduards Smiļģis Theatre Museum, Pauls Stradiņš Museum for History of Medicine, University of Latvia Academic Library, Occupation Museum of Latvia, Bildarchiv Foto Marburg and provincial museums, a wide range of published sources from various periods, articles and images in periodicals, memoirs and other personal testimonies.

A study in literary history focusing on the age of Enlightenment in Latvian culture over the second half of the 18th century and early 19th century

Pauls Daija. Literary History and Popular Enlightenment in Latvian Culture. Newcastle upon Tyne: Cambridge Scholars Publishing, 2017, 160 pp.
Institute of Literature, Folklore and Art, University of Latvia

This book is a study in literary history focusing on the age of Enlightenment in Latvian culture over the second half of the 18th century and early 19th century. The book provides a new and detailed insight into the contribution of Baltic German pastors in the development of Latvian literary culture during the era of Gotthard Friedrich Stender and Garlieb Merkel. By tracing the changes in Latvian literature, gradual process of secularization and introduction of new themes, the monograph uncovers the import of the ideas of the Popular Enlightenment into the Baltic Provinces from the German-speaking countries and offers an insight into the most significant literary works of the Enlightenment era.



Applied Science

Development of new basing on permanent magnets induction pumps for liquid metals

Dr.phys. Imants Bucenieks
Institute of Physics, University of Latvia

Problems of liquid metals transportation are rather actual for development of new energy plants (such as fusion reactors, neutron Spallation sources, 4th generation fast neutrons reactors) in which different liquid metals (lead, mercury, lead and bismuth/lithium eutectics, sodium) are used as working medium as well as heat transfer agents. At liquid metals transportation big problems arise at using mechanical pumps the operation of which is associated with submerged in liquid metal mechanical parts and necessity of ensuring leak-tightness. From this point of view it is clear the advantage of electromagnetic induction pumps in which active magnetic system has no contact with liquid metal. In its turn, the new developed electromagnetic induction pumps basing on permanent magnets have essential advantages in comparison with traditional 3-phase inductors pumps as in them there are no windings at all (which are necessary for feeding of magnetic poles in inductors) as they are replaced by permanent magnets. As a result new permanent magnets pumps have simpler construction, smaller overall dimensions and higher efficiency.

First trips of a self-driving car in Latvian history

LAS Corresponding Member Modris Greitāns, *Mg.sc.comp.* Ingars Ribners, *Mg.sc.ing.* Alesandrs Ļevinskis, *Mg.sc.comp.* Nauris Dorbe, *Mg.sc.comp.* Krišjānis Nesenbergs
Institute of Electronics and Computer Sciences

A versatile unmanned car control solution and algorithms for vehicle autonomy and co-operative driving have been designed and tested, as well as implemented on several cars in Latvia. Using one of these cars Latvian team was able to secure a place among 11 teams from around the world participating in the Grand Cooperative Driving Challenge 2016 in the Netherlands. First autonomous car rides in Latvia were held in 2017 at the former Rumbula airfield and Biķernieki Sports Center. The work on self-driving car solutions is continued by the Institute in cooperation with LMT, CSDD and “Pilot Automotive Labs”, a start-up from Singapore, in order to make autonomous cars in Latvia an everyday occurrence. Because of this achievement the Institute has also started multiple projects in EU



research programme Horizon 2020, in cooperation with such car manufacturing giants as Daimler, BMW, Scania etc.

Innovative silicone polymer based two-component systems for perspective sealant and adhesive applications

Dr.sc.ing. Jānis Zicāns, Nikolajs Kurma, Uldis Reknors, *Dr.sc.ing.* Remo Merijs Meri, Juris Umbrāško, Ritvars Bērziņš, Juris Bitenieks
Institute of Polymer Materials, Faculty of Material Science and Applied Chemistry, Riga Technical University, in collaboration with JSC TENACHEM/Soudal Group (Latvia/Belgium) un Werner Hollbeck GmbH (Germany)

New chemical compounds have been synthesized to increase environmental soundness and technological efficiency of silicone/silyl-terminated polymer and epoxy two-component adhesives and sealants for building and automotive markets in the form of self-levelling sealants, as well as high strength and deformation adhesives and sealants. Formulations of the compositions have been developed to increase curing kinetics, as well as most relevant indicators of technological (storage stability, viscosity, curing kinetics, gel point, early strength) and exploitation (tensile strength, hardness, stability in water, resistance to UV irradiation) properties have been determined. Evaluation of environmental soundness of the components of the elaborated systems has been performed and dibutyltin and tributyltin based catalysts, known negatively affect reproductive system, have been substituted with environmentally more friendly alternatives.

How do nanoparticles affect genes responsible for plant hardiness

Dr.biol. Inese Kokina, *Dr.phys.* Vjačeslavs Gerbreders, *Dr.phys.* Andrejs Ogurcovs, *Mg.biol.* Ilona Mickeviča, *Mg.biol.* Marija Jermalonoka, *Mg.biol.* Inese Jahundovica, *Bc.biol.* Linda Bankovska
Institute of Life Sciences and Technology, Daugavpils University

Cultivated plants play an important role in human life, however plants, as well as all animals and human beings, are exposed to various diseases. Due to harm caused by diseases, serious problems occur in the quality and quantity of harvest, therefore there always exists a need for such plants that would be hardy or resistant to diseases. Flaxseed - an important plant among the cultivated species in Latvia and in the world - has been chosen as a model object for this research. The plant is widely used in food industry, medicine, textile industry, agriculture, etc., hiding the best features in the valuable flax-seed and the high-qualified fibre. Specialists of different fields - both geneticists and physicists - had been involved in the broad and complex research. The idea is based on the possibility to cause



genetic fluidity in two genes responsible for plants resistance by applying an interesting and innovative method. Small gold and silver particles or nanoparticles, which cannot be seen with a naked eye, and which are thousand times smaller than human hair's thickness, have been used as the cause of fluidity. All the research manipulations have been implemented in artificial or in vitro systems, using group of cells called tissue cultures in scientific environment. As a result, a heightened fluidity in the genes responsible for hardiness have been detected. Research results are of high significance in practice because the acquired data and the offered method will help to get new genotypes of flax in future, which may be used in plant selection for disease resistance.

