



Latvian Academy of Sciences ACHIEVEMENTS IN SCIENCE 2022

FUNDAMENTAL SCIENCE

1. New approaches to the development of personalized anticancer drugs.

LAS full member Ivars Kalviņš, *Dr.chem.* Viktors Andrianovs, *Dr.chem.* Ilona Domračeva, *Dr.chem.* Iveta Kaņepe, *Mg.sc.ing.* Diana Zeļencova–Gopejenko, *Mg.sc.* Irēna Leite. Latvian Institute of Organic Synthesis.

The common study of Latvian and Polish scientists deepens the understanding of the mechanism by which malignant tumors form metastases in the human body and evade the attack of the immune system. The obtained results can be used in the development of anticancer drugs for personalized therapy. It has been shown that cancer cells produce a lot of special enzymes called PDIA1 and PDIA3, which increase the ability of migrating cancer cells to stick to capillary blood vessel walls, as well as to form metastases and cause thrombosis of surrounding blood vessels. As a result, human immune cells are unable to access and destroy metastasizing cancer cells. As part of the research, specific molecules that block the activity of these enzymes have been designed, synthesized, studied and patented. Experiments have shown that these low-toxic substances reduce the growth of cancer, as well as the formation of blood clots, and are suitable for the development of personalized anti-cancer drugs based on them.

2. A New Study in the History of Latvian Literature and Culture.

Pauls Daija, Benedikts Kalnačs (eds.). A New History of Latvian Literature. The Long Nineteenth Century. Berlin: Peter Lang AG, 2022. pp. 280.

A study on the history of nineteenth-century Latvian literature performed by the Institute of Literature, Folklore and Art of the University of Latvia was published in February 2022 by the prestigious academic publishing house Peter Lang in Berlin, Germany.

This innovative collective monograph sets the task of reconsidering nineteenth-century Latvian literary history. The authors focus on the interpretation of Latvian culture in an interdisciplinary and comparative perspective and link cultural processes to the development of modern Latvian society. The three parts and ten chapters of the book discuss the role of press in the creation of the public sphere, the importance of the nineteenth-century literary societies, the so-called reading revolution, the connections between growing visual literacy and the reception of literary texts, the links between folklore and the nineteenth-century Latvian literature, and the importance of translations in shaping Latvian literature as world literature, among other topics. The book is edited by literary scholars Pauls Daija, LAS corresponding member, and Benedikts Kalnačs, LAS full member; the team of scholars also include art historian Kristiāna Ābele, LAS full member, literary scholar Inguna Daukste-Silasproģe, LAS corresponding member, historian Mārtiņš Mintauris, folklore researcher Ginta Pērle-Sīle, and cultural historian Aiga Šemeta.



3. A unique study of national and international significance in the modern history of Latvia: Latvians – officers in the army of the Russian Empire in the 2nd half of the 19th century – 1914.

Ēriks Jēkabsons. Latviešu virsnieki Krievijas impērijas armijā. 19. gadsimta otrā puse – 1914. gads. (Latvians – Officers in the Army of the Russian Empire. The Second Half of the 19th Century to 1914) Rīga: LU Akadēmiskais apgāds, 2022. pp. 544.

LAS full member *Dr.hist.* Ēriks Jēkabson's monograph is a unique study in the recent history of Latvia with national and international significance. It evaluates the so far undeservedly forgotten part of the Latvian intelligentsia – officers of Latvian origin in the army of the Russian Empire from the 2nd half of the nineteenth-century until 1914.

The goal of the book is to establish what was the Latvians' contribution to the Russian Army from the second part of the 19th century to 1914 from the viewpoint of the officers of Latvian extraction, by analysing statistical data, the causes and circumstances of creation of such data, the motivation and activities of the people involved, the conditions of work, as well as the role of the national factor in this largely forgotten yet important group of the soldiers that formed the Latvian nation and its elite.

For the first time in Latvian historiography, the study provides a broad insight into the military service and the profession of an officer in the army of the Russian Empire, the involvement of Latvian soldiers in the military conflicts of the considered period and the formation of national identity. The biographies of the officers included in the work personify the historical events revealed in the research. The facts presented in the monograph and the analysis of the data obtained in the careful studies of Russian and Latvian archives help the modern society to understand the complex processes in which the Latvian nation was formed and its will-power matured. Ēriks Jēkabson's monograph, the sources used in it, and the rich factual material provide an impetus for further researches in social, military, political, and other areas of history and ancillary disciplines. The work is also relevant for a wider part of Latvian society – local researchers, family history researchers and other interested parties.

4. Research about the first Latvian philosopher Jēkabs Osis and the philosophy of personalism.

Andris Hiršs. Persona un personālisms: pārdzīvojot ideālisma sabrukumu. Latviešu pirmā filosofa Jēkaba Oša dzīve un darbi. (“Person and Personalism: Enduring the Collapse of Idealism. The First Latvian Philosopher Jēkabs Osis”) Rīga: LU Akadēmiskais apgāds, 2022. pp. 572.

Jēkabs Osis (1860-1920) is known in the Latvian history of philosophy as the first academically educated Latvian philosopher. His works and academic accomplishments influenced the development of Baltic intellectual thought during the first half of the twentieth century. The aim of the book “Person and Personalism: Enduring the Collapse of Idealism” is to review the critical concept of personalism by Jēkabs Osis and to conduct a theoretical analysis of sources, in comparison to works of philosophers Gottfried Wilhelm Leibniz (1646-1716) and Rudolf Hermann Lotze (1817-1881). Another aim is to explore further the reception of concepts of the Tartu personalism school into the history of ideas, and to reveal this school as part of the late German idealism.



5. Examination of a Set of Challenges to the Economy and Society of Latvia in International Context and Instruments for Developing a Smart Economy and Society.

Collective monograph “The Strength of Latvia for the Long-term Development”, 2022, pp. 480.

Research institutions involved: the Latvian Academy of Sciences, the University of Latvia, Latvia University of Life Sciences and Technologies, Riga Stradiņš University etc., in Latvian and English. Editor-in-chief: LAS full member Baiba Rivža, director of project “Challenges for the Latvian State and Society and the Solutions in International Context” (Interframe-LV; 2018-2022) implemented under the national research programme “Latvian Heritage and Future Challenges for the Sustainability of the State”; editor-in-charge: Ausma Mukāne.

The monograph contains the problems of Latvia’s smart economy and society development identified as a result of the research under Interframe-LV project in an international context and the tools recommended by scientists and experts for the changes to be made. Research areas include: technological and social innovations; digitalization of companies; society’s digital competence; bioeconomy and circular economy; aging and stratification of society and the necessary improvements of the pension system, the leveling of regional stratification, the contribution of professional education to the reduction of inequality; risk management in business in the context of values and social security, etc. A broad insight into the implementation of sustainability policy in the world and in Europe is provided in the context of the adjustments caused by the Covid-19 pandemic and the latest policies for the synergy of recovery and sustainability, the financial resources available to member states for introducing changes.

APPLIED SCIENCE

6. Development of chromogenic materials for smart windows and zero energy buildings.

LAS full member Juris Purāns, *Dr.phys.* Ilze Aulika, *Dr.phys.* Boriss Poļakovs, *Dr.phys.* Mārtiņš Zubkins, *Dr.habil.phys.* Smagul Karazhanov (Department for Solar Energy Materials and Technologies, Institute for Energy Technology, Norway). Institute of Solid State Physics, University of Latvia.

New single and multi-layered transition metal oxide (TMO) thin films of ReO_3 , $\text{ReO}_3\text{-WO}_3$, ReO_3/WO_3 , $\text{WO}_3/\text{Cu}/\text{WO}_3$, Zn-Ir-O and rare-earth metal oxy-hydrides (REHO) YHO were developed and fabricated by advanced Reactive High Power Impulse Magnetron Sputtering (R-HiPIMS) technique and industrially scalable roll-to-roll (R2R) technology for applications in Smart Windows (SW). Thin films of rare-earth metal oxy-hydrides (REHO) are a new class of inorganic mixed-anion materials and a prominent photochromic effect and a light-induced resistivity change at room temperature and ambient pressure is demonstrated. Moreover, a superconducting filament effect in Y-O-H and in yttrium hydrides is demonstrated.

The research resulted in:

- Successful implementation of the ERDF-075 HiPIMS and LAS FARP Nr. lzp-2020/2-0291 projects;
- Development of new TMO thin films with electrochromic and photochromic properties;



- A new structures and properties for electrochromic ReO_3 - WO_3 and photochromic YHO thin films were demonstrated;
- HiPIMS and R2R technology development with the high flexibility in the Re-to-W ratio in the resulting material, allowing high Re content (>50%) at moderate temperatures and without the use of high pressure;
- 14 papers published in high impact factor journals;
- Application for patents relevant to flexible coated PET substrates using R2R;
- ERA-Chair Horizon Europe project “Smart windows for zero energy buildings” (SWEB) with the funding of 2.4 MEur for 5 years (2023-2028).

7. Innovative amphoteric decoupled water electrolysis – a simple concept to split water and produce H₂ with high efficiency in a cheap and safe way.

Dr.phys. Mārtiņš Vanags, *Mg.sc.ing.* Guntis Kuļikovskis, *Mg.chem.* Juris Kostjukovs, *Mg.sc.* Laimons Jēkabsons, LAS corresponding member Anatolijs Šarakovskis, *Dr.phys.* Krišjānis Šmits, *Mg.phys.* Līga Bikše, LAS full member Andris Šutka. Institute of Materials and Surface Engineering, Riga Technical University, Faculty of Chemistry, University of Latvia, Institute of Solid State Physics, University of Latvia.

Renewable energy stations are characterized by variable loads and operational interruptions. Traditional grid transmission systems are not designed to transmit intermittent power. Water electrolysis for hydrogen (H₂) production has great advantages in energy management and efficient use of renewable energy. Membrane electrolysis equipment used so far has several disadvantages, namely limited water splitting efficiency, high cost and low durability. This innovative amphoteric decoupled water electrolysis is a simple concept to split water and produce H₂ with high efficiency in a cheap and safe way, without the use of membranes or other auxiliary devices. The method will make possible the widespread implementation of electrolysis in the production of H₂.

8. A unique solution in industrial robotics – smart robot with advanced vision, sensing, and human gesture understanding capabilities.

LAS full member Modris Greitāns, *Mg.sc.ing.* Jānis Ārents, *Mg.sc.comp.* Pēteris Račinskis. Institute of Electronics and Computer Science, in collaboration with Bjorn Debaillie (IMEC, Beļģija), Pawel Kostka (Dresden University of Technology, Germany) un Bernd Lesser (Virtual Vehicle Research GmbH, Austria).

As the leading partner, EDI scientists, along with their colleagues from Belgium, Germany, and Austria, have completed the implementation of the Horizon2020 project “Artificial Intelligence for Industrial Digitalization (AI4DI)” and have created a unique industrial robotics solution that can perceive and interpret the surrounding environment and interact with objects and people in it. The robot, with the help of a 3D camera and embedded artificial intelligence (AI) algorithms, is able to classify and locate various, arbitrarily placed objects to make decisions about manipulating them. A dedicated framework for AI training and validation has been developed to easily create synthetic twins of physical objects and generate large-variety training datasets. A special “artificial skin” on the robot allows it to sense touches, and using a 60 GHz radar, it can pick up commands given by human gestures. The goal of the research is to increase the use of smart industrial robots in dynamic conditions, to provide intuitive collaboration between robots and humans, in order to promote the digitization of the industry.



9. The development of resistance-busting antibiotic combination against multidrug-resistant pathogens.

LAS full member Edgars Liepiņš, *Dr.chem.* Pavels Donets, *Dr.chem.* Kirils Šubins, *Dr.chem.* Dmitrijs Lubriks, *Dr.chem.* Andrejs G. Barans, *Dr.pharm.* Jānis Kūka, *Dr.chem.* Solveiga Grīnberga, *Dr.chem.* Marina Martjuga, *Mg.sc.* Mārtiņš Priede, LAS full member Edgars Sūna. Latvian Institute of Organic Synthesis.

Within a highly collaborative European research program, scientists from the Latvian Institute of Organic Synthesis (LIOS) have discovered a new potential treatment that has the ability to reverse antibiotic resistance in bacteria that cause severe conditions such as sepsis, pneumonia, and urinary tract infections. The treatment approach capitalizes on the combination of well-known antibiotics such as carbapenems with adjuvants, special drug molecules that suppress bacterial resistance to antimicrobials.

Carbapenems, such as meropenem, are a group of ‘last-resort’ antibiotics used to treat serious, multi-drug resistant infections when other antibiotics have failed. Some bacteria have found a way to survive treatment with carbapenems, by producing enzymes called metallo-beta-lactamases (MBLs) that break down the carbapenem antibiotics, stopping them from working. An extensive study, conducted by researchers from the Ineos Oxford Institute (IOI) for Antimicrobial Research at the University of Oxford, LIOS and a number of European scientific institutions, has led to the development of a new class of adjuvants, called indole carboxylates, that can block MBL resistance enzymes leaving the antibiotic free to attack and kill MBL-producing superbugs. The potential new drugs in combination with meropenem were found to be five times more potent at treating severe bacterial infections than meropenem alone, and at lower dose. Importantly, these potential drugs show only mild side effects in animal models.

10. Study on pituitary neuroendocrine tumors: towards the discovery of new biological markers.

Mg.biol. Helvijs Niedra, *Dr.biol.* Raitis Pečulis, *Mg.biol.* Rihards Saksis, *Mg.biol.* Ilona Mandrika, *Dr.biol.* Kaspars Megnis, *Mg.biol.* Ramona Petrovska, Helēna Daiga Litvina, Oļesja Rogoza, *Dr.* Inga Balcere, *Dr.med.* Ilze Konrāde, *Dr.* Mihails Romanovs, *Dr.* Līva Šteina, *Dr.* Jānis Stukčēns, *Dr.* Austra Breikša, *Dr.* Jurijs Nazarovs, *Dr.med.* Jeļizaveta Sokolovska, *Dr.* Rasa Liutkeviciene, *Dr.* Alvita Vilkeviciute, LAS full member Valdis Pīrāgs, LAS full member Jānis Kloviņš, *Dr.biol.* Vita Rovīte. Latvian Biomedical Research and Study Centre, Rīga Stradiņš University, University of Latvia, Riga East Clinical University Hospital, Pauls Stradiņš Clinical University Hospital, Lithuanian University of Health Sciences.

A group of scientists in Latvian Biomedical Research and Study Centre led by *Dr.biol.* Vita Rovīte are conducting study on pituitary neuroendocrine tumors. The aim of the study is to discover novel bio-markers that could be applied in clinical practice, and develop novel model systems for the study of these tumors *in-vitro*. In collaboration with the Pauls Stradiņš Clinical University Hospital, Riga East Clinical University Hospital, and Lithuanian University of Health Sciences the researchers have recruited more than 500 pituitary neuroendocrine tumor patients within the study. Currently the researchers have published studies regarding the research of circulating nucleic acids in plasma of pituitary neuroendocrine tumor patients, and studies regarding the transcriptomic and genomic changes within tumor tissues and cell culture model systems.



Pituitary neuroendocrine tumors (PitNETs) are intracranial benign tumors with high incidence within the population (17%). However clinically relevant pituitary tumors are diagnosed for one out of 1000 individuals. Clinically relevant pituitary adenomas are divided into two categories: hormonally active and hormonally inactive. The most common symptoms of these tumors are mass effects and hormonal changes which can greatly impact the quality of life for the patient and increase the risk of mortality. Currently the diagnostics of malignant tumors are closely intertwined with the analysis of various molecular markers in order to adapt the most effective treatment strategy for each patient. This analysis has not yet been adapted within diagnostics of PitNETs. The discover of novel molecular markers could significantly improve the diagnostics and prognostics of PitNETs.

11. Studies on *Ribes* plants, *Cecidophyopsis* mites and Blackcurrant Reversion virus for sustainable resistance breeding and cultivation of *Ribes*.

Institute of Horticulture: PhD Inga Moročko-Bičevska, *Dr.agr.* Arturs Stalažs, LAS corresponding member Gunārs Lācis, *Dr.agr.* Valda Laugale, *Mg.agr.* Kristīne Drevinska, *Mg.biol.* Neda Zuļģe, *Mg.biol.* Katrīna Kārklīņa, *Mg.biol.* Toms Bartulsons, BSc. Māris Jundzis, LAS corresponding member Līga Lepse, *Dr.biol.* Sarmīte Strautiņa. Latvian Biomedical Research and Study Centre: *Dr.biol.* Ina Baļķe, MSc. Ieva Kalnciema, MSc. Gunta Reseviča, MSc. Ņikita Zrelovs, MSc. Ivars Silamiķelis.

The cultivation of *Ribes* plants is seriously affected by bud mites (*Cecidophyopsis*) and blackcurrant reversion virus (BRV). The project (Nr. 1.1.1.1/18/A/026) gained new knowledge on *Cecidophyopsis* species, their genetic diversity and role in BRV transmission, and the host resistance to *Cecidophyopsis* using high throughput sequencing. The research methodologies were improved (*Cecidophyopsis* species diagnostic methods, RNA extraction method for sequencing, germplasm evaluation methodologies), the local *Ribes* germplasm was evaluated, and the core collection was supplemented with virus-free, most valuable local genotypes. Under the influence of the knowledge created, a state-supported blackcurrant breeding program has been renewed. The knowledge created in the research provides the information base for sustainable *Ribes* resistance breeding and cultivation, meanwhile promoting a knowledge-based bioeconomy.

12. Research on heterogeneous populations of self-pollinating cereals: agronomic performance, changes due to growing environment, creation and improvement possibilities.

Institute of Agricultural Resources and Economics: *Dr.agr.* Linda Legzdiņa, *Dr.agr.* Māra Bleidere, PhD Indra Ločmele, *Mg.agr.* Vija Strazdiņa, *Mg.geogr.* Dace Piliksere, *Mg.agr.* Valentīna Fetere, *Dr.biol.* Ieva Mežaka, *Mg.biol.* Elīna Sokolova. Latvian State Forest Research Institute “Silava”: LAS corresponding member Dainis Edgars Ruņģis, *Dr.silv.* Vilnis Šķipars.

Plant diversity play significant role in organic farming, that's why barley and wheat populations are being investigated as an alternative to homogeneous varieties. They have several advantages, including ability to adapt to particular growing environment, provide better and more stable yields etc. Creation of composite cross populations in Latvia was initiated, and testing of performance for traits essential in organic farming was performed. Evaluation of growing environment and duration effect on population diversity and research on population improvement methods is being continued. Latvia participated in EC temporary experiment on population marketing with spring barley population 'Mirga', providing bases for the currently introduced regulations on organic heterogeneous material. Populations were tested on 6 organic farms. Results were summarized in 24 conference presentations and 16 publications and PhD thesis on it was defended.