



LATVIAN ACADEMY OF SCIENCES ACHIEVEMENTS IN SCIENCE 2020

THEORETICAL SCIENCE

I Deep understanding and prediction of advanced materials for extreme radiation conditions

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The industrial progress of 21st century could greatly benefit from development and exploitation of fusion reactors producing environmentally clean friendly electrical energy. One of the key problems there is need in new advanced materials able to operate under extreme conditions (high temperatures and intensive neutron radiation). Search for such optical and dielectric materials is an essential part of Eurofusion-Latvia association activities. In the series of joint studies of the Institute of Solid State Physics at the University of Latvia and Institute of Physics at the University of Tartu, radiation damage of perspective functional materials was studied under neutron and heavy ion irradiation. The optical and dielectric, as well as vibrational and magnetic properties of radiation defects in numerous oxide crystals, nanomaterials and ceramics were carefully studied and compared. Based on this study, new theoretical methods able to evaluate and predict advanced materials functionality and radiation damage evolution under extreme reactor conditions were developed.

II Random walk-based benchmarking of single-electron circuits

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Miniaturization in digital electronics has reached the ultimate physical limit, that of individual electrons. Single-electron circuits are already used in quantum standards of electrical currents and prototypes of quantum computers. However, these devices are governed by the laws of quantum mechanics which possess fundamental uncertainty, thus imposing intrinsic limits on the fidelity of such devices. To address this issue, Latvian and German researchers have identified and experimentally validated the statistical laws that describe the rare but inevitable errors in accounting of individual quantum particles. The proposed methodology provides a rigorous mathematical foundation for the validation of the precision of quantum standards for electrical quantities and opens new paths for development of integrated quantum circuits.

III New direction for the development of anti-cancer drugs

PhD A. Pustenko, Bc. A. Balašova, Dr.chem. A. Grandāne, PhD R. Žalubovskis. Latvian Institute of Organic Synthesis.

The construction of special molecules that bind to specific enzymes – carbonic anhydrases in cancer cells and thus cause the death of malignant cells – is a new direction in the discovery of the next generation of anti-cancer drugs. However, the enzymes of this group are also involved in the function of normal cells, therefore it is necessary to affect only the targets in the cancer cells.



In the study compounds that specifically inhibit carbonic anhydrases in breast and lung cancer cells without affecting healthy cells and thus the body's function as a whole were discovered. They provide the starting point for the development of new anti-cancer drugs.

IV The promise of extracellular vesicles for preventing Parkinson's disease

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Parkinson's disease (PD) is characterized by progressive loss of dopaminergic (DA) neurons and deficits in motor and cognitive functions. Up to now, no effective therapy for PD exists. In this study, a novel pharmacotherapy directed towards protecting cellular survival in the early stages of PD, prior to neurodegeneration and irreversible psychomotor impairments was chosen. To this end, intranasal administration of extracellular vesicles (EVs) in experimental PD model animals was performed. It was discovered that EVs exert neuroprotection in the PD model animal brain: EVs preserved the number of living DA neurons, enhanced memory processes and ameliorated motor impairments. These effects remained for several days after the end EVs administration. Therefore, these data hold a promise for the development of novel pharmacologic approaches and the translation of these approaches to halt PD.

V The study on the genome of the SARS-CoV-2 virus in Latvia

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Latvian Biomedical Research and Study Centre, Riga Stradiņš University, University of Latvia, Disease Prevention and Control Centre, Laboratory of the Latvian Centre of Infectious Diseases at Riga East Clinical University Hospital, E. Gulbis Laboratory Ltd., Central Laboratory Ltd.

Since April 2020, researchers at Latvian Biomedical Research and Study Centre in cooperation with other organisations are carrying out the study on the genome of the SARS-CoV-2 virus that provides important information on the diversity and variability of the virus. In total, 368 different virus mutations have been detected in Latvia, with average virus genome mutation rate being from one to 22 mutations per sample compared to the genome of Wuhan virus. Data so far have shown that a specific virus mutation (D614G) in protein S (Spike), which is associated with increased infectiveness, is common in at least 97% of infections in Latvia. Results from the sequencing of the SARS-CoV-2 genome reveals that viruses found in Latvia are similar to viruses identified elsewhere in Europe, but the results of the phylogenetic analysis indicate that the virus has been transferred to Latvia several times and most likely even from different continents. An analysis of the acquired virus genomes enables tracking of infections and epidemiological surveillance in Latvia.

VI Unique scientific reference material on the formation of the cultural space of the Baltic peoples since the 13th century has been compiled and systematized

Saulvedis Cimermanis. Tautas celtniecība Latvijas ainavā. [Vernacular Architecture in the Latvian Landscape.] Rīga: Zinātne Publishers, 2020, pp. 688. ISBN 978-9934-599-00-2.



This unique material has been collected and systematized over several decades, and based on the data gathered on ethnographic expeditions organized by the Latvian Academy of Sciences, researches in the Latvian State Historical Archives, in the available archives and libraries of Estonia, Sweden, Russia and other, as well as on individually organized trips to Latvia's regions. Following the studies by the prominent Latvian scientists Augusts Bīlenšteins and Pauls Kundziņš, this is the next most important and academically comprehensive scientific reference material on the formation of the Baltic nations' cultural space since the 13th century. Academician Saulvedis Cimermanis' research "Vernacular Architecture in the Latvian Landscape" is an encyclopedic work in Latvian ethnocultural scene, as it provides an in-deep information about the everyday culture of the Latvian ethnos and its detailed history throughout the period under study. The visual material that include many hundreds of photographs, drawings, survey drawings, and iconographic material found in historical sources as well as several hundred bibliographical items, make this extensive work inimitable. This study of a single author is an achievement worth of a work of a whole research institute and deserves an utmost admiration.

VII Groundbreaking analysis of décor in Riga Art Nouveau architecture

Silvija Grosa. Dekors Rīgas jūgendstila perioda arhitektūrā. [Décor in Riga Art Nouveau Architecture.] Rīga: Neputns, 2019, pp. 592. ISBN 9789934565809. Art Academy of Latvia.

The ambitious monograph by *Dr.art.* Silvija Grosa, Professor and Head of Art History and Theory Department at the Art Academy of Latvia, is a fundamental opus resulting from many years of research and dealing with a visually impressive but difficult to study phenomenon that enriches and enhances the aesthetic bearing of Riga's famous Art Nouveau buildings. The work encompasses not only the analysis of architectural décor during different stylistic phases of the Art Nouveau epoch so significant in Latvia but also a comprehensive history of late 19th to early 20th century workshops of architectural sculpture and decorative painting, utilising information from very fragmentary sources. Education and international migration of masters, relationships among architects, artists, craftsmen and commissioners, stylistic and iconographic sources of décor, both foreign and local in their origin, are other aspects are explored in the study. The publication contains 906 images and an extensive English summary.

VIII The heritage of music life and creativity revealed in a comprehensive study of the Northern Renaissance in Latvia

Ilze Šarkovska-Liepiņa. Latvijas mūzika renesansē: priekšvēstneši, briedums, konteksti. [Latvian Music in Renaissance: heralds, maturity, contexts.] Rīga: LU LFMI Publishing House, 2020, pp. 247. Institute of Literature, Folklore and Art, University of Latvia.

The book by *Dr.art.* Ilze Šarkovska-Liepiņa continues the series of monographs entitled "Latvian Music History from the Beginning to the 21st Century". The current study is dedicated to the heritage of Renaissance music in Latvia, covering the period from the 15th century to the beginning of the 17th century. The publication looks at music life and creativity in the Baltic region countries, especially Germany. The study examines the manifestations of the Northern Renaissance in music, analyzes the song creation initiated by the Reformation, provides an insight into the composers' contribution to the most popular genres of the time (mass, motet, passion, polyphonic song), as well as musical life and music impact on society.



APPLIED SCIENCE

XI A multispectral imaging method with record-high spectral selectivity developed and approbated

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Human eye can distinguish colours but cannot detect images within narrow pre-selected spectral bands. Such so-called spectral images are obtained by means of digital cameras using narrowband spectral filters or spectrally specific illumination. Multispectral imaging (acquisition of image set of an object taken within different spectral bands) allows contactless detailed characterization of optical and content properties of the object; applications span from satellite monitoring of Earth vegetation to colour pigment analysis for artwork expertise. Two main advantages of the new method: at least 100x increased spectral selectivity and 10x shorter acquisition time of the spectral image set, if compared with parameters of the known systems of multispectral imaging. It was achieved using object illumination simultaneously with several laser spectral lines and collecting the spectral image set by a single snapshot, with subsequent extraction of the spectral line images from the whole image data set. To validate the method, five prototype devices of different designs have been assembled and efficiently applied for diagnostics of skin malformations and identification of counterfeit banknotes and documents. 9 inventions have been registered and 17 research papers published on the method and its applications.

X History of fruit growing in Latvia – a comprehensive guide into past and present revealed in a book “I am learning fruit growing”

Māra Skrīvele. Es mācos augļkopību. [I am learning fruit growing.] Rīga: Latvijas Mediji, 2020, pp 416. ISBN: 9789934158322. Institute of Horticulture.

Scientist and practitioner of fruit growing, initiator of the renewal of commercial fruit growing in Latvia, *Dr. agr. Māra Skrīvele* has collected information about the development of the fruit growing industry in Latvia, analyzed it from the viewpoint of today's know-how by using her own professional experience that lasts for already 60 years. A comprehensive study like this has been carried out for the first time in Latvia. *Māra Skrīvele* has tracked the establishment and development of commercial gardens, participated in studies carried out by fruit growing companies *LatHort* and *Pūre DIS*, got acquainted with the trends of fruit growing in other countries, assessed the experience of our forefathers and made it understandable for a wide audience. The core principles of agrotechnics and selection of cultivars, which makes it possible to gain high quality fruit yields, are explained in a science-based, easy to follow language.

XI Innovative solutions to improve the durability of wood

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A detailed study of thermal modification (TM) of alder, aspen, ash and birch has been performed in order to promote the competitiveness of wood in the market of building materials, ensuring a predictable service life, protecting from the effects of environmental degrading factors and expanding the possibilities of use. The modification parameters have been optimized, the service



properties of TM wood and composite materials have been determined and the changes in the wood at the macro-, micro- and sub-micro level in the TM process have been studied. The possibility of obtaining wood with predictable durability by combining two wood protection technologies – impregnation and TM has been evaluated for the dominant species in Latvia – pine and birch. The double treatment reduces the amount of biocides necessary to be absorbed and improves the physical properties and bio-durability of the material. The optimal modification sequence has been assessed, the technological parameters have been optimized. For compiling life cycle inventory of pine and birch grown in Latvia, an original approach has been developed, the environmental impacts of the obtained product during the life cycle has been analysed.