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**BASIC SCIENCES  
SUSTAINABLE DEVELOPMENT  
BELGRADE 2022**



**International Year of Basic Sciences for Sustainable Development**

**World Conference on Basic Sciences and Sustainable Development**

► **September 19–22, 2022**

► **Belgrade, Serbia**



# BASIC SCIENCES SUSTAINABLE DEVELOPMENT BELGRADE 2022

Following the initiative of the International Union of Pure and Applied Physics (IUPAP), the General Conference of UNESCO proposed in November 2019 to proclaim the year 2022 as the International Year of Basic Sciences for Sustainable Development (IYBSSD 2022). The proposal was based on the facts that since 2005 six international years of basic sciences have been organized and that in September 2015 the United Nations General Assembly endorsed the resolution *Transforming Our World: The 2030 Agenda for Sustainable Development*, which included 17 Sustainable Development Goals, most of which are clearly connected to basic sciences. In December 2021, the United Nations General Assembly approved the proposal. The total number of organizations that participate in the organization of this series of events is 50. In addition, 112 science academies, learned societies, and scientific associations support the organization of IYBSSD.



The main aim of IYBSSD 2022 is to mobilize national, regional, and global scientific institutions to clearly demonstrate to the public and especially to political and business leaders worldwide how basic sciences are helping us to establish an inclusive, balanced, and sustainable development of the planet. The main message of the series of events is that basic research is the important initial link in the chain of research and development that can, only as a whole, make nature and society sustainable.

The initial event within IYBSSD 2022 was held on July 8, 2022 at the UNESCO Headquarters, in Paris, France, while the final event will take place at the European Organization for Nuclear Research (CERN), in Geneva, Switzerland, in the beginning of October 2023. One of the main events within the series of events was the World Conference on Basic Sciences and Sustainable Development, held on September 19–22, 2022 in Belgrade, Serbia. The proposal was given by the World Academy of Art and Science and it was accepted by the Steering Committee of IYBSSD.

The agenda of the Conference contained the following:

- **Special Session**
- **Introductory Session**
- **Section 1:** Importance of Basic Sciences for Sustainable Development
- **Section 2:** Advanced Basic Research in Mathematics and Physics
- **Section 3:** Advanced Basic Research in Chemistry and Biology
- **Section 4:** Advanced Multiple Disciplinary Basic Research
- **Section 5:** Connections of Basic Sciences with Other Sciences, Innovation, and Engineering
- **Section 6:** Contributions of Basic Sciences to Medicine, Healthcare, and Water and Food Security
- **Section 7:** Connections of Basic Sciences with Energy Technologies, Climate Action, and Protection of the Environment
- **Section 8:** Contributions of Basic Research to Advanced Education
- **Poster Section:** For Women in Science
- **Concluding Session**

The Special Session was devoted to the latest report to The Club of Rome, *Limits and Beyond*. Sections 1–8 included two sessions each consisting of 67 talks. The Poster Section included three sessions. The authors of the posters were nine young scientists awarded within the *For Women in Science* National Program in Serbia, established by the company L'Oréal Balkan, the Commission of Serbia for Cooperation with UNESCO, and the Ministry of Education, Science and Technological Development of Serbia.

Besides, two exhibitions went on during the Conference, prepared by Matica Srpska, the oldest Serbian cultural and scientific institution—on its past and present activities, and by the company L'Oréal Balkan, on the Sustainable Development Program of L'Oréal Group, the world's largest cosmetics company—*L'Oréal for the Future*. In addition, the Conference included a concert on September 21, 2022 in the National Museum in Belgrade.

### “Limits and Beyond”: The presentations and discussion

– Carlos Álvarez Pereira



The Conference had an inspiring prologue with the Special Session, in the evening of September 19, in the cozy ambiance of the Club of the Serbian Academy of Sciences and Arts. The topic was the latest report to the Club of Rome, *Limits and Beyond*, published on the occasion of the 50<sup>th</sup> anniversary of the first report to the Club, *The Limits to Growth*. Both co-editors of *Limits and Beyond*, Ugo Bardi, Professor of the University of Florence, and Carlos Álvarez Pereira, Vice-President of the Club of Rome, intervened in the session as well as Nebojša Nešković, President of the Serbian Chapter of the Club of Rome and the main organizer of the Conference.

The co-editors explained that the book is a collective work of 21 contributors to give a broad perspective of the thinking and action inspired by *The Limits to Growth* in the five decades since its publication. It starts with what that seminal work was saying (and not saying), how it was received and not sufficiently discussed in scientific terms, and how it has been interpreted since 1972, with the contributions by Ugo Bardi and two of the original authors, Dennis Meadows and

Jorgen Randers. Then, an exploration is made of what has happened during the 50 years in the light of the scenarios proposed by *The Limits to Growth*. Several of the contributors emphasize the limitations of the dominant economic thinking as an obstacle to our capacity to address the socio-ecological challenges of humanity.

An important section of the book is devoted to perspectives of the future through a variety of different lenses, from futures studies to feminist thinking and several approaches from Asian backgrounds, among others. The final section addresses how humanity has been unable to learn, in spite of evidence that our course leads, with growing probability, to the collapse of civilizations, of which current fractures of all kinds are just anticipatory signals. The last chapter by Carlos Álvarez Pereira is significantly titled “Learning what we already know”.

The presentation of the book and the additional remarks by Nebojša Nešković on the role of science and its global-local nature sparked a lively discussion among the participants. The capacity of science to nurture positive responses to the challenges of humanity was in particular questioned, depending on how its role is framed, as a perfect prologue to the discussions that took place in the Conference the following days.

### “Limits and Beyond”: How to make the right choices for the future

– Ugo Bardi



The first report to the Club of Rome, *The Limits to Growth*, was published in 1972. Few books published during the 20<sup>th</sup> century had such a remarkable impact on human views of the world and on humankind’s future.

The basic message of the book was that growth could not continue to go on forever on a finite planet. The scenarios developed in the study indicated that, if we continued to run the economy on the basis of pure individual profits, the world’s economy could collapse during the first two decades of the 21<sup>st</sup> century.

Today, a new book re-examines the whole story of *The Limits to Growth* and its relevance for our present and our future. It is titled *Limits and Beyond*, a multi-author book that includes contributions from 21 authors, including two of the original authors of *The Limits to Growth*. It is edited by Ugo Bardi and Carlos Álvarez Pereira.

*Limits and Beyond* tells the story of how the original *Limits to Growth* story was created, then misunderstood and demonized, and how, at present, it is re-emerging as a fundamental element in our understanding the mechanisms of the economy and the interaction of humankind with the ecosystem. Most people tend to interpret the world’s problems on the basis of single factors, such as overpopulation, climate change, peak oil, inequality, or others. All these are relevant factors but none of them is the only problem. But the computer model at the basis of the *Limits to Growth* study could generate scenarios for the future on the basis of the available data, without being swayed by ideology or personal biases taking into account all the parameters.

The difficulties that *The Limits to Growth* saw in store for humankind’s future are appearing right now in front of us. So, we are facing difficult times, but we can probably avoid collapse if we make the right choices: avoiding the overexploitation of natural resources, using clean technology, reducing inequality, and adopting similar ways to take care of the planet.

## Going beyond limits in basic sciences

– Nebojša Nešković

Motivated by the recent appearance of *Limits and Beyond*, a report to The Club of Rome, I was talking about three limitations in establishing and practicing basic sciences that exist today throughout the world and should be overcome. They are related to the social responsibility for basic research, to national and global approaches to science and technology, and to small countries and Big Science.



The conclusions of my talk were the following:

- The social responsibility for creating, maintaining, actualizing and enhancing basic research in a country lies primarily with its scientific community, individually and collectively.
- The necessary basis for advancement and excellence in science and technology in a country is a dialectical unity of the national and global approaches to these fields.
- One of the proper ways to ensure the integration of science of a small country with global science is to establish and foster Big Science in the country.

The limitations that make the realization of these three conclusions in a country hard are in the minds of its scientists, engineers, and politicians. My opinion is that this problem should be taken as a challenge in preparing and carrying out the plan of looking for and reaching the road of inclusive, balanced and sustainable development of the country, *i.e.*, as a challenge to go beyond these limits.



## Introductory Session

### Welcome address – Vladimir Kostić



The initial part of the address was: “Faced with an array of issues, including the problems of science, we are witnessing an ever-increasing acceleration, which does not allow for stepping aside and a more serious break for reflection and understanding

of what is happening to us—to put it simply, we are shifted to the time of instant attitudes and flash decisions. This is one of the reasons why the Serbian Academy of Sciences and Arts, an institution a little over 180 years old, expresses satisfaction with the fact that it is a co-organizer of the meeting entitled the World Conference on Basic Sciences and Sustainable Development, which we perceive as an opportunity to participate in an attempt to, albeit briefly, draw a line and establish current balances in the face of an uncertain future.”

The address also included the following thoughts: “Please, forgive me, since I am an older man, for a certain conservatism and sentimentality, but I do not like the question of the cynical philosopher who says that ‘everyone is allowed, if he wants to study the Hittite language, black holes, the differences between St. Cyprian and St. Augustine in the interpretation of the sacrament of baptism, or Japanese Zen gardens, but why should the taxpayer pay for it?’ If such utilitarianism prevailed, would it, as some predict, mean the downfall of the university and to a considerable extent civilization itself? It is a witty statement, despite the fact that the university and scientific institutions

serve to transmit and improve all the technical abilities on which the life of civilization depends, that they are also ‘the institutionalized form of that special human biological property—curiosity, as a spontaneous reflex, the ability to know the world for the sake of knowing.’ Eisenberg does not hide his conviction that the government and industry should consciously provide funding for the production of ‘knowledge for the sake of knowledge’ and thus, even more cynically, points to the ‘benefit of useless knowledge.’”

The final part of the address was: “As for our meeting, some titles among all these great topics and some key words make me especially happy: Scientific research as promoter of intercultural dialogue and peace (although I am aware that this is not the case, especially not today!), How to make wise use of science to promote biodiversity conservation and ecological civilization, Science and education for peace and sustainable future (but also for a perspective on our survival), ... Why? Well, because it seems to me that the authentic responsibility of thinking people can be seen behind such titles, just as it seems to me that behind the sustainable peeking through is our fear that we have brought both this planet and our own civilization to a point close to the point of no return. It seems that, contrary to Habermas’ statement, science will have to think after all. In this sense, I wish you a successful work as the host, but, considering that you are in the city where civilizations met in the most literal sense, I also hope you will use the time for mutual communications and meetings. Believe me, it is difficult to find a better place!”



## Opening address – Marijana Dukić Mijatović

The initial part of the address was: “On behalf of the Government of the Republic of Serbia and its Ministry of Education, Science and Technological Development, I am pleased to welcome you all in Belgrade, Serbia. It is my great pleasure to open the World Conference on Basic Sciences and Sustainable Development and to greet you in the name of the First Deputy Prime Minister and the Minister of Education, Science and Technological Development of Serbia, Mr. Branko Ružić. We are glad to have the opportunity to host this important conference in Belgrade as one of the main events in the International Year of Basic Sciences for Sustainable Development and to see you all in person after the long period of COVID-19 pandemic.”

The central part of the address was devoted to the steps the Government and the Ministry have undertaken in reforming the science and research system in Serbia with the aim to improve its excellence and relevance for the economic development of the country. The passing of the Law on Science Fund, in December 2018, and the Law on Science and Research, in July 2019, were two crucial initial steps in the reform. Also, the new Law on Innovation Activity was passed, in December 2021. Besides, the Government adopted the Strategy of Scientific and Technological Development, for the period 2020–2025, the Strategy of Smart Specialization, for the period 2020–2027, and the Strategy for the Development of Start-Up Ecosystems, for the period 2021–2025. Special attention was paid to the network of science and technology parks that

has been created in Serbia, in Belgrade, Novi Sad, Čačak, and Niš, which allow companies from Serbia and abroad to connect and collaborate with each other and with research institutes and universities in Serbia, and to the initiative to construct the BIO4 Campus, in Belgrade, as a new European biomedicine, biotechnology, bioinformatics, and biodiversity hub.

The participation of Serbia in the realization of the research, innovation and development programs of the European Union was especially emphasized as well as its full memberships in the European Organization for Nuclear Research (CERN), in Geneva, Switzerland, and its associate membership in the Joint Institute for Nuclear Research (JINR), Dubna, Russia.

The final part of the address was: “Finally, I wish you a successful work at the Conference. I am sure that the conclusions of the Conference will assist in finding some of the answers to the key questions of sustainable development.

Also, I would like to draw your attention to the Poster Section. The authors of the posters are nine young scientists awarded within the ‘For Women in Science’ National Program in Serbia, established by the company L’Oréal Balkan, the Commission of Serbia for Cooperation with UNESCO, and the Ministry of Education, Science and Technological Development of Serbia.”



## Inaugural address – Michel Spiro



On December 2, 2021, under the initiative of the International Union of Pure and Applied Physics (IUPAP), the United Nations General Assembly proclaimed the year 2022 as the International Year of Basic Sciences for Sustainable Development, under the auspices of UNESCO. Due to the late proclamation, the Opening Ceremony took place in UNESCO Headquarters in Paris on July 8, 2022, and the Closing Ceremony is expected to be held one year later at CERN on October 6, 2023. During this International Year, we expect thousands of events worldwide. This event the World Conference on Basic Sciences and Sustainable Development in Belgrade (Serbia) from September 19<sup>th</sup> to September 23<sup>rd</sup> is one of the few Flagship Events of this International Year.

Basic sciences are curiosity- and inquiry-driven. They are not always and everywhere considered as they deserve, in the discussions concerning the societal, environmental, and economic development. Yet, curiosity-driven sciences construct the pool of knowledge that future generations will use to face their problems.

Examples are:

- Vaccines and treatments against COVID-19 are full of basic biology (DNA, RNA, etc.)
- The WEB was born at CERN from the needs of fundamental science

- Google research engine comes from a brilliant mathematical idea
- Artificial intelligence relies on statistical methods
- Cellular phones are full of Quantum Mechanics: transistors, integrated circuits...
- GPS relies on Einstein's Theory of Relativity and on quantum atomic clocks
- The Genome Project has opened the way to gene therapies
- PET scan and MRI are based on antimatter physics and fundamental atomic magnetism
- Generation and storage of renewable energy depends on advances in physics, chemistry, and materials science
- Reduction in pollution and green chemistry rely on basic advances in chemistry

Basic Sciences are the foundations of education and the sources of discoveries which turn into applications: they can then serve inclusive sustainable development (improving global equity and well-being together with a healthy and lively planet). All together (education, discoveries, applications, and inclusive sustainable development) can boost collaborative and open Basic Sciences. This is the virtuous circle that we want to promote during the International Year of Basic Sciences for Sustainable Development and after. To achieve this goal, we shall need everyone - teachers, scientists, the private sector, decision-makers (private and public), and society at large to share this vision and act accordingly.

## Basic sciences for the service of humanity – Amal Kasry



UNESCO is the only United Nations Agency with a mandate in science, which contributes to its mission to build peace in societies. The Natural Science Sector at UNESCO has a distinct role that no other bilateral or multilateral development partner can match in generating relevant data and knowledge products, providing expert advice and convening power. This is ensured via generating normative knowledge and policies through UNESCO's intergovernmental and international programmes, UNESCO's category 2 Centres (which are Centres of excellence), and UNESCO Chairs, as well as through global networks of the International Centre of

Theoretical Physics (ICTP) and the World Academy of Sciences (TWAS).

In this talk, the focus was on how the Natural Science sector is addressing challenges such as climate change, natural disasters, biodiversity loss, and water crisis, and how solutions are determined through global science, technology and innovation governance and through developing STI policies. The talk also focussed on UNESCO's Natural Sciences' contribution to the Sustainable Development Goals (SDGs) through different programmes and activities.

This talk was delivered on behalf of Ezra Clark, Acting Director, Division of Science Policy and Basic Science (PBS), Natural Sciences Sector (SC), United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris, France.

## Basic science for human security – Garry Jacobs

Science came of age in the mid-20<sup>th</sup> century with the advent of antibiotics, television and of course nuclear weapons. In the aftermath of World War II, numerous scientists and intellectuals, who had witnessed the potential of humankind to destroy itself, began to explore the idea of an international, non-governmental body that could address the major concerns of humanity.

The First International Conference on Science and Human Welfare was held in Washington DC., 1956, calling for establishment of the World Academy of Art & Science. WAAS was founded in 1960 as a call to science to come out of its ivory tower, turn to address the problems of the real world, take responsibility for the consequences of scientific knowledge and technology, and assume a large, active role in shaping decision-making to ensure a peaceful, safe world for all.

The primary objective of WAAS is to influence decision-makers in all fields—government, research, business and finance—to address the pressing challenges that confront humanity today with greater urgency and sincerity.

Today humanity confronts unprecedented threats to human security in all fields. The COVID-19 pandemic, the current war in Ukraine and the fast-approaching calamity of climate change all pose threats to the full range of human security needs—personal safety and

peaceful communities, food and healthcare, economic welfare, a safe environment, political freedoms and human rights.

Humanity needs a new security paradigm that places human beings at the center. To address these threats the Academy has just entered into collaboration with the UN on a global campaign to promote human security for all human beings.

Human Security is a comprehensive umbrella encompassing all dimensions of human security—community, food, health, economic, environment, personal, political—including the biosphere, since human security depends on the security of all beings and life on the planet. It approaches all these dimensions as inseparable, interlinked and interdependent aspects which can only be effectively addressed in relation to one another.

The Basic Sciences have a very important role to play in addressing all these dimensions. This conference is part of a larger project co-organized with UNESCO and other partners to mobilize the enormous capabilities of the basic sciences to promote research on measures that can advance human security and sustainability for all humanity in a wide range of different fields.





## SESSION 1.1



**From left to right:** Garry Jacobs (moderator), Carlos Álvarez Pereira, Amal Kasry, Maria da Graça Carvalho & Nebojša Nešković

### Learning what we already know: On the 50<sup>th</sup> anniversary of “The Limits to Growth” – Carlos Álvarez Pereira

The seminal report to The Club of Rome “The Limits to Growth” was published in 1972 and it had a huge editorial success. Millions of copies were sold, the book influenced public agendas and created a wide debate which is still ongoing. But overall, humanity did not find its pathway(s) towards equitable human wellbeing within a healthy biosphere, rather the contrary. We are now at a more critical moment than 50 years ago, with a multiplicity of emergencies converging into a suicidal path. In a new report to The Club of Rome, “Limits and Beyond”, we suggest that the deep reconfiguration of societal patterns required for desirable futures can emerge from the present state of emergency. But positive emergence cannot be planned, nor is it guaranteed. At the very least, it calls for allowing ourselves to explore a wider space of possibilities.

Could we liberate our processes of learning from the incumbent mental frameworks which keep us imagining the “solutions” with the same lenses that created the “problems” in the first place?

We propose to question how research, innovation and learning processes are currently framed. This is the core intention of “The Fifth Element” program recently



launched by The Club of Rome. It is an invitation to change upside down the existing model of knowledge creation in order to respond to the challenges humanity faces today, which the disciplinary structures of conventional academia are unable to address. Rather than targeting supposedly universal solutions in a top-down manner, this approach bets on a multiplicity of pathways towards wellbeing in the biosphere, in which cultural and geographic contexts, traditional ecological knowledge, relational wisdom, and the best of modern science are woven together. As the name of the program suggests, the process intends to create patterns of learning inspired by how Life works.



### VIGNETTES FROM IYBSSD 2022

The World Conference on Basic Sciences and Sustainable Development was one of the few Flagship Events of the International Year of Basic Sciences for Sustainable Development.

## Strengthening basic sciences: Towards sustainable societies – Amal Kasry

Sustainable Development Goals (SDGs) are the means to achieving the United Nations Agenda 2030, adopted in September 2015, through focus on poverty reduction, infrastructure development, education, achieving gender equality and empowering all women and girls, etc., among other critical social, economic and environmental areas. Almost all 17 of these goals are anchored in science and technology.

It is extremely important to understand the link between physics, chemistry, mathematics and biology, and applications such as energy and health as well as new emerging technologies. It is even more important for scientists to recognize the links between these applications, technologies and sustainable development.

During the past two decades, nanotechnology, for example, has risen, not only as a hot research topic but as a tool that can influence future technologies and solutions. By definition, nanotechnology is the area of science and engineering where materials on the nanoscale (1–100 nm) are utilised in the design and production of devices that can be implemented in several applications such as energy, health, etc. Therefore, these areas of research that are affecting



our daily lives are being taken to a new perception and possibilities for great advancement, which will lead to even more sustainability.

This talk focussed on some examples of basic science disciplines with their applications and showed their importance for the sustainability of societies. Examples included the link between basic sciences and energy, nanotechnology and health.

It also discussed some of the programmes and activities that are currently undertaken at UNESCO to strengthen and promote basic sciences and their potential impact on different societies.

## The role of research and technological development in the energy transition: The European Union example – Maria da Graça Carvalho

The lecture described the most relevant EU policies, programmes and initiatives focused on research and innovation as the cornerstone of the green and digital transition plans. The EU has set important goals to reach in the next 30 years, both to achieve climate neutrality in line with the Paris Agreement and to accompany the digital transformation of society and the economy. This talk started with a brief overview of the European policies to ensure an effective and inclusive green transition (namely the Green Deal, the Climate Law and the Fit455 Package). The second part focussed on the role of clean and affordable technologies to reach the targets set for 2030 and 2050, and explored the centrality of Horizon Europe instruments to support the industrial decarbonisation and the reduction of the societal carbon footprint, with particular reference to the European Institute of Innovation and Technology and the Joint Undertakings. The final part of the talk was dedicated to the integration of the industrial policy into the innovation plans of the Union. It briefly described the main initiatives that the Union is adopting in this area, notably the New Industrial Strategy and the efforts to integrate the knowledge triangle across the European single market (in particular through the renewed plans to enhance the European Research, Education and Innovation Area).



**INTERNATIONAL YEAR OF BASIC SCIENCES FOR SUSTAINABLE DEVELOPMENT**

The International Year of Basic Sciences for Sustainable Development, celebrated in 2022, recognizes that basic sciences are vital to attain sustainable development and to improve the quality of life for people all over the world. The Year is being organized by UNESCO, in collaboration with its global partners, from July 2022 to October 2023.

## New TESLA Project: Research, Development and Education for the Fourth Industrial Revolution – Nebojša Nešković

The TESLA Accelerator Installation, in the Vinča Institute of Nuclear Sciences, is a large user infrastructure for production, acceleration and use of ion beams in science, technology, medicine, and education. Its construction began in December 1989. TESLA has two parts—the low energy and high energy parts. The low energy part, called FAMA, is used for research and development in materials science. It was commissioned in May 1998 and is currently in the phase of upgrading. The high energy part of TESLA, named the VINCY Facility, should be used for: radiation research and development in biology, chemistry and physics; research and development in physics of thin crystals; neutron research and development with a small inherently safe fission nuclear reactor; research, development and experimental production of radiopharmaceuticals for diagnostics and therapy; proton therapy of eye tumors. It is in the phase of waiting for the decision of the Government of Serbia on the completion of the construction.

A successful carrying out of the programs of use of TESLA will bring concrete contributions to realization of the Fourth Industrial Revolution (4IR) in Serbia. These contributions are connected to: materials technology, energy technology, particle beam (PB) technology, virtual reality (VR) technology, and artificial intelligence (AI) technology, which drive 4IR. In addition, a concrete contribution to realization



Small cyclotron complex within FAMA (M3), currently under commissioning

of 4IR in Serbia is expected through the designing, fabrication and utilization of the control and safety systems of the machines and experimental channels within TESLA in accordance with the principles and achievements of AI technology.

In addition, the completion of construction and use of TESLA should enable long-term fruitful cooperation in science, technology, medicine and education in Southeastern Europe, contributing to its sustainable development, and, hence, additionally support economic and political stabilization of the region, and its true and permanent integration into Europe and the rest of the world.

This presentation was co-authored by Roman Balvanović and Zoran Jovanović, Vinča Institute of Nuclear Sciences, University of Belgrade, Serbia.



## SESSION 1.2



**From left to right: Ugo Bardi (moderator), Nebojša Nakićenović, Ioan Fazey, Luiz Oosterbeek & Dragan Đuričin**

### Transformative science and science transformation for sustainability

– **Nebojša Nakićenović**

Humanity is facing formidable challenges from war and food insecurity to the pandemic and ever-increasing pressure on the Earth systems including climate change. With the adoption of the United Nations 2030 Agenda with its 17 Sustainable Development Goals and the Paris Climate Agreement back in 2015, there appeared a resolve to achieve the aspirational and ambitious vision of a safe and just future for all. Almost seven years have passed, and a lot has been achieved but not nearly enough, given the Herculean task ahead. An important example is climate change. To achieve the Paris Agreement goals, greenhouse gas emissions need to be halved every decade and approach net zero by the middle of the century, in less than three decades. But the global emissions are still increasing at an unprecedented rate.

Transformation toward a sustainable future for all is still possible but the world is still going in the other direction. These challenges cannot be resolved in isolation or in academic “silos”. Evidence is accumulating that this can only be achieved through a systemic and holistic approach and is no longer possible through incremental, detached, and partial solutions. As Garry Brewer once said, the world has problems while universities (movements as well as the private sector) have departments. We argue that



nothing short of a new integrated, systemic, and holistic science is required to achieve the needed grand transformation —a new transformative science.

Science itself needs to be transformed along with education and learning in general to rise to this challenge. Disciplines will surely continue to be needed in the future as the pillars to support the new, let us call it “horizontal” and transformative science for the people and the planet. The new European Bauhaus initiative that is rooted in the European Green Deal calls for a sustainable, inclusive and beautiful future. There is a huge portfolio of what needs to be done and hopefully a transformative science can help answer the key question of how.

### SCIENCE FOR SUSTAINABLE DEVELOPMENT



“In these adverse times in the world, with wars, pandemics, famine, etc., science is the sole and crucial way to achieve sustainable development in the world.”

## The transformation of science for the future of humanity and life on Earth: A challenge for the basic sciences – Ioan Fazey

Formalised knowledge systems, including universities and research institutes, are important for contemporary societies and have brought phenomenal benefits. They are, however, also seriously failing humanity when their impact is measured against the level of progress being made in stimulating the societal changes needed to address issues like climate change and global inequality. At the heart of the challenge is an urgent need for a new form of second order science, where researchers operate as if from within the systems they seek to understand and intervene. This is different to the dominant first order approach, that assumes the best way to intervene is to first understand the world by standing from the outside looking in. A shift to second order science is necessary to accelerate learning and develop wisdom about and how to steward transformational change. The shift to second order science is somewhat inevitable as the limits of current modes of science for transcending the problems that have been created by it increasingly become apparent. This then raises critical questions for the basic sciences about how they also need to evolve so they can be effective in accelerating sustainable development and ensuring longevity of human life and many other species on our planet.



## Basic sciences and wicked problems: Towards an integrated understanding – Luiz Oosterbeek

The 21<sup>st</sup> century is becoming the stage for a growing disconnection between individuals' agency and institutional responses. This includes a dimension of mistrust with several expressions, from disruptive social processes to anti-science and post-truth phenomena, with severe consequences for facing the global challenges that humans face today.

An attempt to divert the attention of research towards short-term problems, enhancing the relevant contributions of science, has been a dominant strategy in the most recent years, namely fostering the integrated approaches of STEM and STEAM. These proved their efficiency, for instance, in the context of the pandemic, leading not only to vaccines but, overall, to coping health strategies. However, the pandemic is, itself, an example of some interesting and contradictory phenomena, which also highlight the limitations of such a short-term problem-solving approach.

While problems remain fundamental for contemporary societies, the main disputes relate to longer-term dilemmas, which do not find "solutions" but "options", rooted in "values" and "priorities". The challenges imposed on humans, from health to climate or inequality, become integrated with those longer-term dilemmas, such as how to manage ageing, borders, or knowledge construction.

The scale of problems is the reign of techniques and technology, and of the illusion of unique solutions for



all. The scale of dilemmas is one that allows us to build new values and, namely, a notion of Humanity, as an identity which goes beyond the biological dimension of Humankind and allows us to build convergence through diversity. How medicine is understood in Western Europe or in Southeast Asia is an example of this. This longer-time dimension is the reign of basic or fundamental sciences, which include mathematics/philosophy, earth sciences/history, life sciences/anthropology, etc. The divide between humanities and science, which finds ground in techniques, becomes impossible in basic sciences.

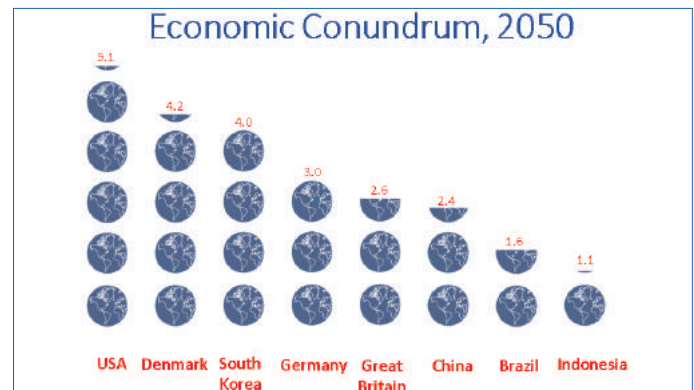
Revisiting the centrality of basic sciences, beyond restricted compromises that do not fully encapsulate their integrity (as with STEM), is a fundamental priority for restoring the credibility of science/*Wissenschaft* at large.

## New economics rules and Big Science

– Dragan Đurićin

The theoretical foundations of neoliberal (or orthodox) growth model and economic policy platform stems from two assumptions, the linearity of economic system and the pattern matching behavior of economic players. Unfortunately, the linear model of growth has largely ignored the key principles of physical system and biosphere like reversibility and evolution. Anthropogenic climate crisis, microbe mutations, and geopolitics as the new macroeconomic variables have sublimated the negative consequences of neoliberal economic theory's fault lines and mainly contributed to economic free fall.

Not only to thrive, but to survive, the economy needs multiple and radical changes, or paradigm change. The emerging paradigm in Economics must also be in harmony with nature. Over the last four decades, four leading trends have had a major impact on the paradigm change in Economics: the rise of Behavioral Economics, fall of Market Fundamentalism, technological change under the impact of Industry 4.0, and growing awareness of global commons. People are not necessarily rational and consistent, not selfish by definition, and without a symmetric risk-reward relationship. Moreover, well-being is not the first derivative of egoism. When universal connectivity is the new free good, the economy becomes a highly nonlinear system. So, the explanatory power of heuristics, trials-and-errors and feedback loops



is greater than targeting (for example, inflation targeting) based on optimization modelling. As a legacy of Industry 4.0, nonlinear systems dominate in natural sciences and engineering.

Modern economics concepts like stakeholder capitalism, circular (and regenerative) model of growth, heterodox economic policy platform, structural policies, automatic macroeconomic stabilizers, “net-zero” vision of new industrialization and impact investments financed by sustainability budget, and “green” instruments (including green quantitative easing) could be considered as manifestations of the double paradigm change in economics, both macro and micro. Sustainable and inclusive economy, both towards people and nature, is a prerequisite for Big Science to prosper.



## SESSION 2.1



*From left to right: Stevo Todorčević (moderator), W. Hugh Woodin, Vladimir Kekelidze & François Légaré*

### Beyond the infinite – W. Hugh Woodin

The modern mathematical story of infinity began in the period 1879–84 with a series of papers by Cantor that defined the fundamental framework of the subject. Within 40 years, the key ZFC axioms for Set Theory were in place and the stage was set for the detailed development of transfinite mathematics, or so it seemed. However, in a completely unexpected development, Cohen showed in 1963 that even the most basic problem of Set Theory, that of Cantor's Continuum Hypothesis, was not solvable on the basis of the ZFC axioms. Now, nearly 60 years since Cohen's work, we see a vast development of Cohen's method and the realization that the occurrence of unsolvable problems is ubiquitous in Set Theory. This arguably challenges the very conception of Cantor on which Set Theory is based.

Thus, a fundamental dilemma has emerged. On the one hand, the discovery, also over the last 60 years, of a rich hierarchy of axioms of infinity seems to argue that

#### The future

If the Ultimate- $L$  Conjectures are true:

- ▶ Then the axiom  $V = \text{Ultimate-}L$  is arguably the key missing axiom for  $V$ .

If the Ultimate- $L$  Conjectures are false:

- ▶ Then the program to understand  $V$  by generalizing the success in understanding  $V_{\omega+1}$  and the projective sets fails.

However this story concludes, I am absolutely confident of one thing:

- ▶ **It will be beautiful.**

Cantor's conception is fundamentally sound. But on the other hand, the developments of Cohen's method over this same period seem to strongly suggest there can be no preferred extension of the ZFC axioms to a system of axioms that can escape the ramifications of Cohen's method.

But this dilemma was itself based on a misconception and recent discoveries now strongly suggest there is a resolution.

### NICA Project – Vladimir Kekelidze

NICA (Nuclotron-based Ion Collider facility) is an international research complex, which is being implemented at the Joint Institute for Nuclear Research (JINR), in Dubna. The main tasks of this complex are the study of hot and dense baryonic matter in the energy region of maximum baryon density, as well as the study of the nucleon spin structure and polarization phenomena. The NICA complex includes a chain of accelerators that provide beams of various ions from protons to gold, including polarized protons and deuterons, for both fixed-target and collider experiments. The available energy range is up to  $\sqrt{s} = 11$  AGeV for heavy ion collisions and up to  $\sqrt{s} = 27$  GeV for polarized proton collisions in the collider. Two collaborations, the Multipurpose Detector (MPD) and the Spin Physics Detector (SPD), are preparing collider experiments to study heavy ion collisions and nucleon spin structure, respectively. Fixed-target experiments using the detector Baryonic Matter at Nuclotron (BM@N) have already begun to study short-range correlations in nuclei and explore dense baryonic matter. Opportunities for various applied research will also be available.



## Ultrafast science and technology at the Advanced Laser Light Source

– François Légaré

The Advanced Laser Light Source (ALLS) facility, based at INRS-EMT, has been serving academic, government, and industrial users since 2005. In 2019, to further expand the user base, ALLS has joined the LaserNetUS network. With 0.75 petawatts of peak power, ALLS is home to the most powerful laser in Canada. This is complemented by a series of laser and secondary sources that cover the spectral range from THz to X-ray, as well as high-energy particle beams. While synchrotrons provide photons of high-brightness across a wide range of wavelengths, high-power lasers offer high-intensity ultrafast pulses to access femtosecond ( $1 \text{ fs} = 0.000\,000\,000\,000\,001$  second) temporal resolution. The first part of the talk presented the unique capabilities offered by the facility as well as some of the scientific highlights that have been realized over the years by the users. In addition, it presented recent results showing how high-power lasers enable interdisciplinary research activities impacting other fields including advanced manufacturing and life science. The second part of the talk discussed specific aspects of the research program that includes the generation of high-energy ultrashort light pulses with pulse duration of few optical cycles<sup>1</sup>, of high-field mid-infrared laser pulses to probe material properties using high harmonic spectroscopy<sup>2</sup>, and of high flux X-ray pulses for time-resolved spectroscopy with a focus on probing ultrafast magnetization dynamics.<sup>3</sup>



1) R. Safaei *et al.*, *High-energy multidimensional solitary states in hollow core fiber*, *Nature Phot.* 14, 733–739 (2020).

2) M. R. Bionta *et al.*, *Tracking ultrafast solid-state dynamics using high harmonic spectroscopy*, *Phys. Rev. Res.* 3, 023250 (2021).

3) G. Fan *et al.*, *Ultrafast magnetic scattering on ferrimagnets enabled by a bright Yb-based soft X-ray source*, *Optica* 9, 399–407 (2022).



### AIMS OF THE INTERNATIONAL YEAR OF BASIC SCIENCES FOR SUSTAINABLE DEVELOPMENT (IYBSSD 2022)

- Mobilization of national, regional, and global scientific institutions to clearly demonstrate to the public and especially to leading politicians and business persons worldwide how basic research contributes to inclusive, balanced, and sustainable development of the planet.
- Connecting national, regional, and global research institutions with the objective to intensify their mutual communication and collaboration.
- Directing national scientific institutions to the joint preparation of proposals of the strategies of basic research and the corresponding investment plans for governments of their countries.





SESSION 2.2



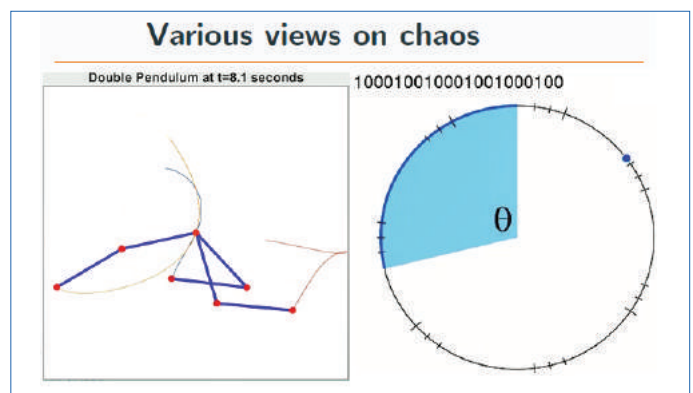
From left to right: Luc Bergé (moderator), Eli Glasner, Zhiyu Sun, Luka Č. Popović & Michael Benedikt

Various views on chaos – Eli Glasner

Small differences in initial conditions, such as those due to errors in measurements or due to rounding errors in numerical computation, can yield widely diverging outcomes for such (*i.e.*, chaotic) dynamical systems, rendering long-term prediction of their behavior impossible in general. This can happen even though these systems are deterministic, meaning that their future behavior follows a unique evolution and is fully determined by their initial conditions, with no random elements involved.

“Sensitive dependence on initial conditions”, “Devaney chaos”, “Li-Yorke chaos”, “positive entropy”, “positive Lyapunov exponents”—these are some of the mathematical notions which were introduced by mathematicians in an attempt to catch the mathematical essence of chaotic behaviour.

The talk briefly reviewed some of these ideas and then described a relatively new notion which can be called “tameness”. It represents the opposite kind of



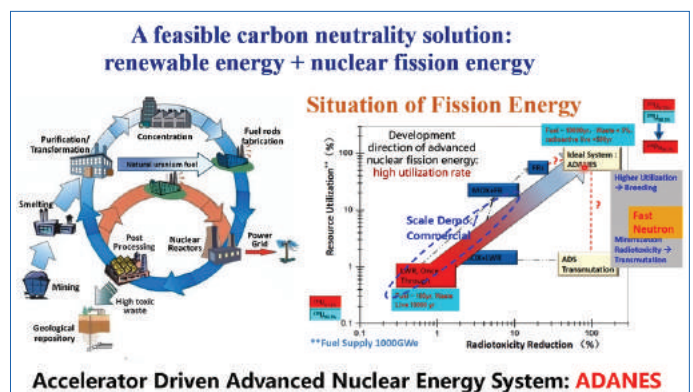
behaviour (so that chaotic systems can be viewed as not-tame or wild). It applies to a large yet manageable class of dynamical systems.

In particular, it turns out that minimal tame systems have a rather simple and easily understood structure. (Minimal systems form in some sense the building blocks of the general dynamical system).

China’s next generation high intensity ion beam accelerator facility and its research programs – Zhiyu Sun

The next generation high intensity ion beam accelerator facility of China is considered and planned to be constructed at the Nuclear Research Center in Huizhou. In addition to exploring some important fundamental and frontier scientific issues in the field of nuclear physics, the facility will play an important role in the applications of nuclear technology, such as nuclear energy and nuclear waste transmutation research.

The whole project will be divided into three phases. The construction work of phase one has already started, which includes two national major science and technology infrastructures, the High Intensity Accelerator Facility (HIAF) and the China initial Accelerator Driven System (CiADS). This talk gave a

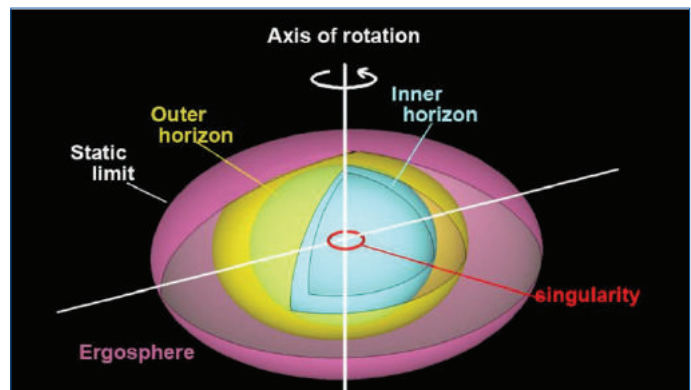


brief report on the overall planning of the project, the research work expected to be carried out, and the current construction progress.

## Supermassive black holes and the activity of galaxies – Luka Č. Popović

It is widely accepted that all massive galaxies host supermassive black holes (SMBHs), ranging in mass from fewer than one million solar masses to many billions of solar masses. The masses of SMBHs have a significant influence on the structure of their host galaxies, *e.g.*, they are known to correlate with the bulge properties of the host galaxies. Understanding the relationship between host galaxies and their central SMBHs is very important for understanding the evolution of galaxies and the universe in general. Therefore, the investigation of SMBHs is a very important task in astrophysics today.

An SMBH cannot be directly observed, but in the phase of accretion of material to the central SMBH (in the form of an accretion disc), it is possible to estimate the basic SMBH parameters. In this so-called active phase of the SMBH, an enormous amount of energy is emitted from the galactic center, which is present



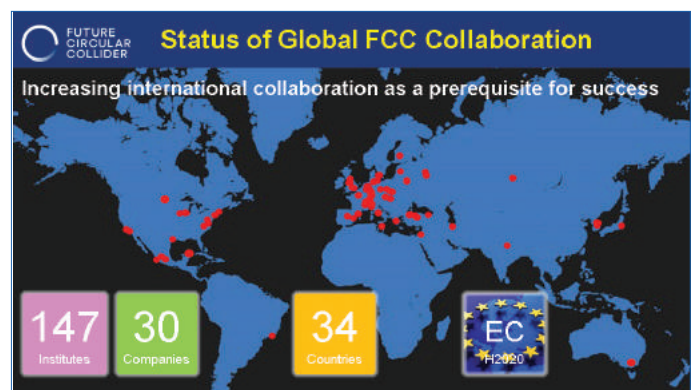
in a galaxy phase, the so-called active galactic nuclei (AGNs).

This talk gave an overview of black holes in general, the role of SMBHs in galaxy evolution and activity, and recent observations of SMBH shadows in the center of our galaxy and AGN M87.

## Future Circular Colliders: Planning a research infrastructure for the 21<sup>st</sup> century – Michael Benedikt

The Future Circular Collider (FCC) program, proposed at CERN, consists of a luminosity-frontier electron-positron collider (FCC-ee) as the first stage, followed by an energy-frontier hadron collider (FCC-hh) as the second stage, and promises the most far-reaching physics program for the post-LHC era. The FCC-ee is a precision instrument to study the Z, W, Higgs, and top particles, and offers unprecedented sensitivity to signs of new physics. Most of the FCC-ee infrastructure can later be reused for the subsequent hadron collider, the FCC-hh. The FCC-hh provides proton-proton collisions at a centre-of-mass energy of 100 TeV and can directly produce new particles with masses of up to several tens of TeV.

The 2020 Update of the European Strategy for Particle Physics requested a feasibility study of the FCCs and related infrastructure to be established as a global endeavor and completed on the timescale of the next Strategy Update, by 2026. A key challenge when preparing the construction of a new 90 km circumference tunnel for a future collider is the optimization of layout and implementation, by balancing scientific excellence with territorial and environmental constraints and geological conditions



and risks. Developing cutting-edge technologies for the sustainable construction and operation of the future research infrastructure also offers numerous opportunities for training the next generation of scientists and experts in the different areas covered by the FCC study. In parallel, a socio-economic impact study explores ways to maximise the impact of this facility. The presentation summarized the status of implementation and infrastructure studies, the conceptual designs of the FCC-ee and FCC-hh, covering the machine concepts, the R&D for key technologies, the socio-economic studies, and a possible implementation schedule.

### BASIC SCIENCES ARE THE SINE QUA NON FOR SUSTAINABLE DEVELOPMENT



IYBSSD 2022 focuses on the links between basic sciences and the Sustainable Development Goals. It offers a unique opportunity to convince all stakeholders of the importance of the basic sciences in ensuring a balanced, sustainable and inclusive development of the planet.

## SESSION 3.1



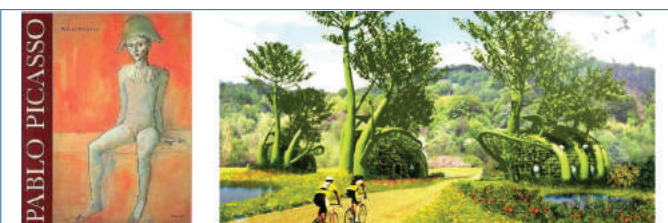
**From left to right: Igor Pašti (moderator), Roman Jerala, Jan H. J. Hoeijmakers, Huimin Zhao & Aleksandr Bugay**

## Synthetic biology for engineering proteins and cellular circuits

– Roman Jerala

Life is based on highly complex and dynamic networks of molecular structures, which however only sampled a small fraction of possibilities. Principles of synthetic biology can be used to engineer biological and biomimetic systems in order to achieve new interesting properties and also to understand the function of natural systems. Science has now reached the stage where we can construct new protein folds, introduce new mechanisms of regulation and design signal processing in cells, which is needed to modulate cellular response.

Modularity can be applied to rationally design new types of protein folds, based on coiled-coil (CC) building modules that can fold into new types of assemblies, and to use well-understood CC modules to design protein folding pathway that enable multiple use of the same module within the designed protein chain. Introduction of CC forming peptides can introduce allosteric regulation of diverse proteins. CC modules also enable multiplexing of cellular localization within mammalian cells, tunable enhancement of transcriptional regulation, proteolysis- and CC-based logic gates that can respond within minutes and



**Others have seen what is and asked why.  
I have seen what could be and asked why not.**

regulation of various natural proteins. The results presented in this talk demonstrate that synthetic biology tools enable new insight into the biological systems and diverse biotechnological and therapeutic applications.

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2. A. Ljubetič *et al.*, *Nat. Biotechnol.* 35, 1094 (2017).
3. T. Lebar *et al.*, *Nat. Chem. Biol.* (2018).
4. T. Fink *et al.*, *Nat. Chem. Biol.* (2019).
5. T. Lebar *et al.*, *Nat. Chem. Biol.* (2020).

## INVESTING FOR SUSTAINABILITY



Roman Jerala

“I was pleased to hear that Serbia is planning to invest 200 million euros for BIOFOR which I think is definitely a good sign for the future.”

## DNA repair: The contribution of basic sciences to understand the process of ageing and promote healthy ageing – Jan H. J. Hoeijmakers

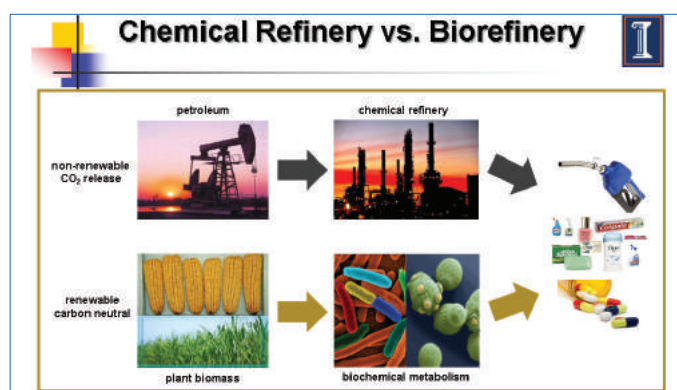
Aging appears remarkably plastic: *e.g.*, suppressing insulin signalling extends lifespan in numerous species. However, virtually all premature aging syndromes are linked with genome instability. We have generated mouse models which strikingly mimic human DNA-repair-deficiency syndromes and display wide-spread accelerated aging. For instance, *Ercc1<sup>Δ/-</sup>* mice, carrying multiple repair defects, show multi-morbidity, limiting lifespan to 4–6 months. Simultaneously, they exhibit an anti-aging “survival response”, which suppresses growth and enhances maintenance, resembling the longevity response induced by dietary restriction (DR) as an attempt to delay the accelerated aging. Interestingly, subjecting these progeroid mutants to actual (30%) DR tripled lifespan and drastically retarded accelerated aging, most notably neurodegeneration, preserving 50% more neurons and maintaining full motoric function. The DR response in these mice resembled the response in wild type animals including reduced insulin signaling and reduced DNA damage load, explaining why DNA repair mutants overrespond to DR. Interestingly, *Ercc1<sup>Δ/-</sup>* liver gene expression profiles showed gradual decline of expression preferentially of long genes, consistent with genome-wide accumulation of stochastic, transcription-blocking lesions, which affect long genes more than short ones. This phenomenon was also discovered in normal aging of post-mitotic tissues. DR largely prevented transcription stress,



indicating that DR prolongs genome function. This talk presented phenotypes of conditional DNA repair models targeting aging to selected organs, striking parallels with Alzheimer's disease, and the first remarkable results translating these concepts from mice to progeroid children. The findings identify DNA damage as main cause of aging, establish repair-deficient mice as powerful models for interventions to promote healthy aging, reveal untapped potential for reducing endogenous damage and transcription stress in neurodegeneration, explain the molecular anti-aging mechanism of DR and the aging component of proteinopathies based on transcription stress, and promote counterintuitive DR-like interventions for progeroid syndromes, preventing neurodegenerative diseases and ischemia reperfusion damage in surgery and for improving chemotherapy outcome.

## Directed evolution of enzymes and microorganisms for sustainable development – Huimin Zhao

Directed evolution mimics the Darwinian evolution in the test tube, consisting of iterative rounds of diversity generation followed by screening/selection. This simple yet powerful algorithm has been widely used for engineering of biological systems including enzymes, pathways, and genomes. This talk gave a historical account of the directed evolution field and highlighted a few of the accomplishments in the development and application of directed evolution tools for engineering proteins, pathways, and genomes with novel or improved functions. Examples included but were not limited to staggered extension process (STEP) *in vitro* recombination, targeted site saturation mutagenesis, *in vitro* co-evolution, and development of a NAD(P)H cofactor regeneration method. In addition, it discussed the work in extending directed evolution to the design and engineering of biochemical pathways and whole genomes. Specifically, it introduced three genome evolution strategies including RNA interference assisted genome evolution (RAGE), multi-functional genome-wide CRISPR (MAGIC) system, and CRISPR-Cas9 and homology-directed-repair-assisted genome-scale engineering (CHAnGE) for rapid engineering of *Saccharomyces cerevisiae* for production of chemicals and fuels. Finally, it highlighted a few recent examples in combining directed evolution with artificial intelligence/machine learning and laboratory automation to accelerate the design and engineering of biological systems for sustainable development.



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## Radiation and human brain: Problems on Earth and in deep space

– Aleksandr Bugay

In the past decades, much progress has been made to understand the mechanisms of central nervous system (CNS) functional disorders connected with different neurodegenerative diseases like multiple sclerosis, and Huntington's, Parkinson's, and Alzheimer's diseases. However, there have been no advances in understanding the basis of radiation-induced cognitive disorders. Prior to 1970, the human brain was thought to be highly radioresistant and radiotherapy became one of the common tools for brain tumor treatment. Now, brain tumor patients survive long enough after irradiation to experience radiation-induced functional deficits, including progressive impairments in memory, attention, and executive function. Moreover, it was recently found that high charge and high energy ions of the Galactic Cosmic Rays would make a great contribution to the health risk to astronauts during manned deep space missions. It has been shown that heavy charged particle exposure of laboratory animals even at much lower doses than those used in radiotherapy leads to heavier violation of mental and motor functions. Therefore, there is a critical need to investigate the mechanisms responsible for harmful effects of radiation in various brain regions as well as their integration at relevant doses and radiation types.



### SESSION 3.2

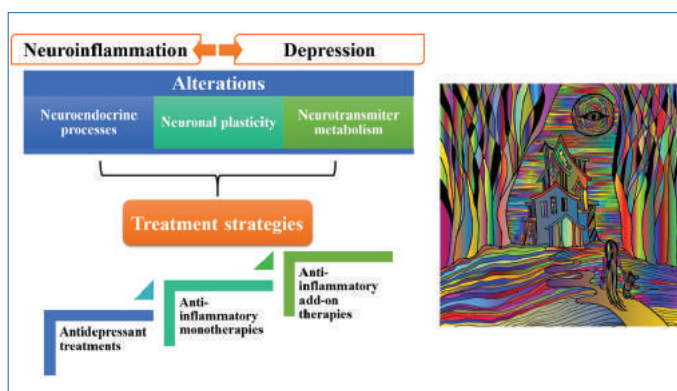


*From left to right: Jelena Radulović (moderator), Miroslav Adžić, Tijana Rajh, Richard B. Hoover & Tatjana N. Parac-Vogt*

## Therapeutic strategies against inflammation-associated depression

– Miroslav Adžić

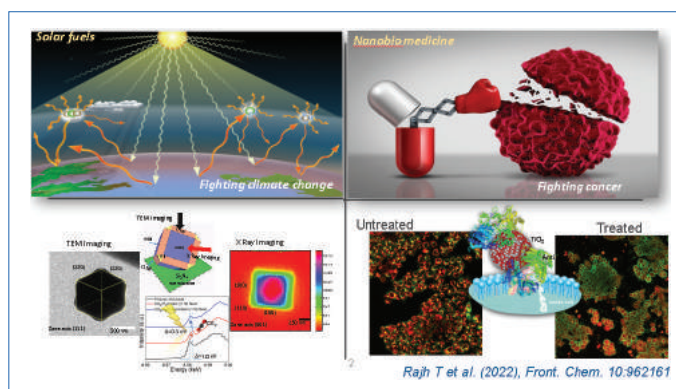
The most widely prescribed types of antidepressant (AD) drugs target and facilitate the action of monoamine neurotransmission. However, nearly 50% of patients do not respond to the treatment. Therefore, there is an urgent need to develop novel therapeutic strategies in the treatment of depression, one of the most common mental health conditions worldwide. Mounting evidence demonstrates enhanced systemic levels of inflammatory mediators in depression, indicating that inflammation plays a role in the etiology and course of mood disorders. Indeed, pro-inflammatory cytokines induce a behavioral state of conservation-withdrawal resembling human depression, characterized by negative mood, fatigue, anhedonia, psychomotor retardation, loss of appetite, and cognitive deficits. Besides that, neuroinflammation contributes to non-responsiveness to current AD therapies. While response to conventional AD medications is associated with a decrease in inflammatory biomarkers, the resistance to the treatment is accompanied by unchanged or even increased levels of inflammation mediators. In accordance with that, the utility and shortcomings of pharmacologic AD treatment strategies focused on inflammatory pathways, applied alone or as an adjuvant component to current AD therapies, were discussed.



## Manipulating nanoparticle reactivity through surface chemistry

– Tijana Rajh

Bioinspired artificial photosynthesis has resulted in efficient solutions for many areas of science and technology spanning from solar cells to medicine. Owing to rapid development of synthesis and nanofabrication methods, we are able to engineer advanced materials at atomic and molecular levels and assemble them into functional devices. This talk described facet engineering of Copper(I) oxide ( $\text{Cu}_2\text{O}$ ) nanoparticles for selective and efficient photoconversion of  $\text{CO}_2$  into methanol. A catalyst with selective active sites was designed to target  $\text{CO}_2$  molecules and facilitate their adsorption and reduction.  $\text{Cu}_2\text{O}$  was chosen because it absorbs light at frequencies covering most of the solar spectrum, its unique electronic properties, and the abundance of its components, copper and oxygen. The activity of these sites was unraveled using operando multimodal correlated characterization of a single particle, *in situ* activity measurements as well as density functional theory (DFT) calculations. Second, the talk described integration of metal oxide ( $\text{TiO}_2$ ) nanoparticles with soft and biological materials that results in one of promising types of hybrids for advancing medical technologies. Manipulation of the  $\text{TiO}_2$  nanoparticle surface was found to alter the way nanoparticles



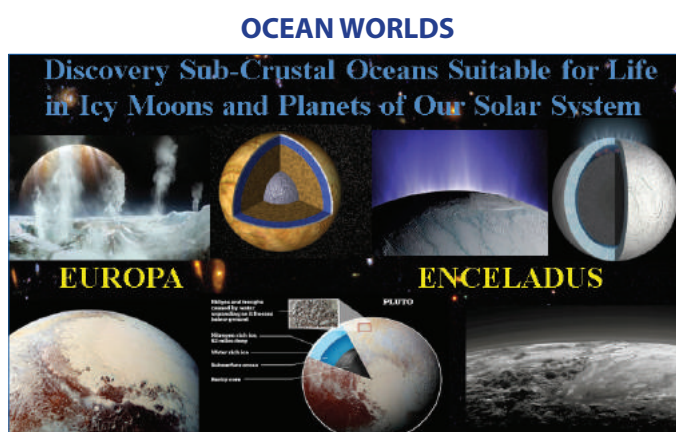
interact with light, enhance their chemical reactivity, and improve their optical properties in the visible region. These ligands were used as “leads” that bridge the electronic properties of semiconductors to electroactive biomolecules. Monoclonal anti-EGFR antibodies (C225) have been utilized for targeting nanoparticles to the epithelial colon cancer cells. Photoinduced charge separation was then employed to create reactive oxygen species and induce apoptosis in the tumor cells. “Cold light” or bioluminescence, the same property exhibited by fireflies, was also used to develop “lightfree” localized therapy that is activated only in the cancers, leaving the healthy cells intact.

## Meteorites, comets, rogue planets and the distribution of biosphere

– Richard B. Hoover

*Is life restricted to planet Earth or more widely distributed throughout the Universe?* This is the fundamental question of Astrobiology. Ecosystems in ancient permafrost, polar ice caps, deep sea vents, and deep crustal rocks have expanded knowledge of Earth’s biosphere. The recent Scanning Electron Microscopy discoveries of diatoms, cyanobacteria, and other microfossils in the Orgueil C11 (1864), Murchison CM2 (1969), and other carbonaceous meteorites provide evidence directly relevant to this question. Energy Dispersive X-ray Spectroscopy spot data and 2D X-ray maps show N typically <0.5% atomic and anomalous C/O, C/S ratios, indicating that the recognizable meteoritic biological remains are ancient. Independent researchers have found carbonaceous meteorites to contain many life-critical biomolecules. Nucleobases Guanine, Adenine, and Uracil are detected; but Thymine and Cytosine are absent, and only 10 of the 20 proteinogenic amino acids (some racemic but others with *L*-excess) are present. The missing amino acids and nucleobases provide absolute proof the meteorites were not contaminated by living microbes after arrival. Therefore, life is not restricted to planet Earth.

This presentation described the novel “Wet Panspermia” mechanism for the transfer of intact biospheres across interstellar and possibly intergalactic distances. It is based on the physical properties of water and Neutron Activation Analysis measurements of Heat Producing Elements ( $^{40}\text{K}$ ,  $^{238}\text{U}$ , and  $^{232}\text{Th}$ ) in meteorites. The detection of diatoms and cyanobacteria in meteorites, Vostok ice cores and deep crustal rocks, the presence of low-density boulders and *L*-amino acids on asteroids Ryugu & Bennu and comet 67P/C-G, oceans beneath crusts of icy moons, and the discovery of rogue planets and the interstellar comets 2I Borisov and Oumuamua provide support for this hypothesis.



## Chemical tools for designing artificial enzymes

– Tatjana N. Parac-Vogt

Effective catalysts for the controlled transformation of large and complex biomolecules are rare and challenging to develop. In particular, selective hydrolysis of proteins by non-enzymatic catalysis is difficult to achieve, yet it is crucial for many modern applications in biotechnology and proteomics.

In recent years, the conceptually new way of selectively cleaving proteins has been discovered by combining the enzyme-like molecular recognition ability of a water-soluble polyoxometalate (POM) scaffolds with the hydrolytic activity of a strong Lewis acid metal cation imbedded into the POM structure [Fig. 1(a)]

[1]<sup>1</sup>. In this approach, the POM acts as a ligand for the Zr(IV) or Hf(IV) ion, and due to its three-dimensional shape and negative charge, it also induces the selectivity that is necessary for a controlled fragmentation of the polypeptide backbone. A selective cleavage that occurs predominantly at Asp-X peptide bonds, located

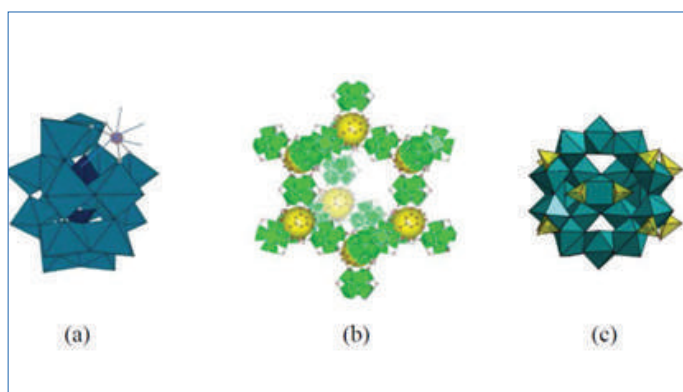


Figure 1. Structures of:

(a) Zr-POM, (b) {Zr<sub>6</sub>O<sub>8</sub>}-based MOF-808, and (c) Hf<sub>18</sub> cluster

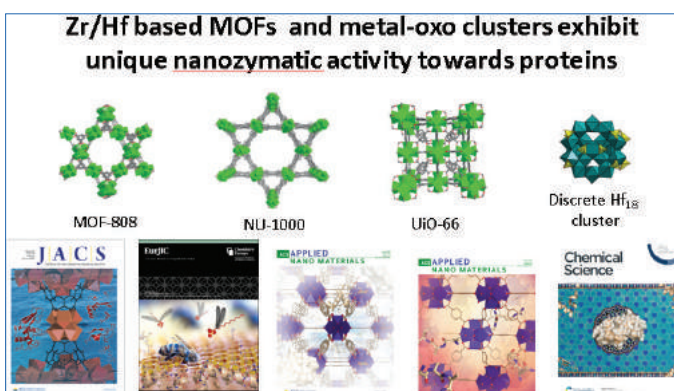
pH<sup>[2,3]</sup>. The potential of metal-oxo clusters as nanozymes for protein hydrolysis has been further demonstrated on the example of discrete (Hf<sub>18</sub>O<sub>10</sub>(OH)<sub>26</sub>(SO<sub>4</sub>)<sub>13</sub>(H<sub>2</sub>O)<sub>33</sub>) cluster [Hf<sub>18</sub>, Fig. 1(c)], which showed excellent activity and selectivity in the hydrolysis of horse heart myoglobin, cleaving peptide bonds only at six solvent accessible Asp residues among 154 amino acids present in the protein sequence.<sup>4</sup>

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4) J. Moons, F. de Azambuja, J. Mihailović, K. Kozma, K. Smiljanić, M. Amiri, T. Čirković-Veličković, M. Nyman, and T. N. Parac-Vogt, *Angew. Chem. Int. Ed.* 132, 9179 (2020).



at positive patches that can accommodate the POM ligand, has been demonstrated in a range of different proteins differing in three-dimensional structure, size, and charge. More recently, we have shown that {Zr<sub>6</sub>O<sub>8</sub>}-based metal-organic frameworks (MOFs) act as very effective heterogeneous catalysts for the hydrolysis of the peptide bond.<sup>2,3</sup> The catalytic activity of MOFs [Fig. 1(b)] was shown to be excellent through a broad pH range, resulting in the rate constants which are more than 4 orders of magnitude faster compared to the uncatalyzed reaction. The activity of MOFs has been also demonstrated towards hen egg white lysozyme (HEWL) protein and horse heart myoglobin, which were selectively fragmented under physiological

### BRINGING SCIENTISTS ACROSS BASIC SCIENCES TOGETHER



More than 60 scientists from across the world discussed the importance of basic sciences for sustainable development, advanced basic studies in mathematics, physics, chemistry and biology, links between basic and other sciences, innovation, engineering, energy technologies, climate action and environmental protection, as well as contributions of basic sciences to medicine, health, water and food security and advanced education.

## SESSION 4.1

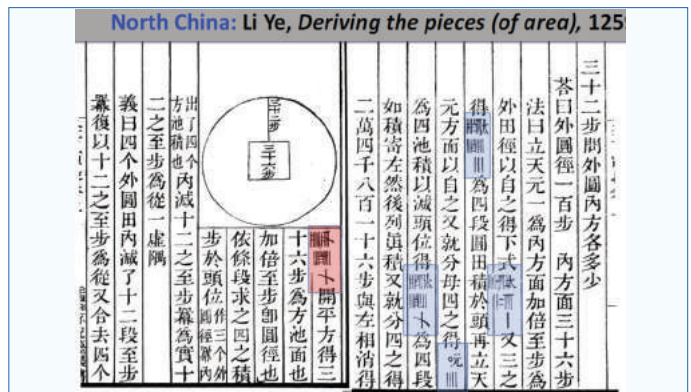


**From left to right: Michel Spiro (moderator), Karine Chemla, Alexander Karpov, Jüri Engelbrecht & Maurizio Bona**

### Forgetting the results of advanced knowledge: A historical perspective

– **Karine Chemla**

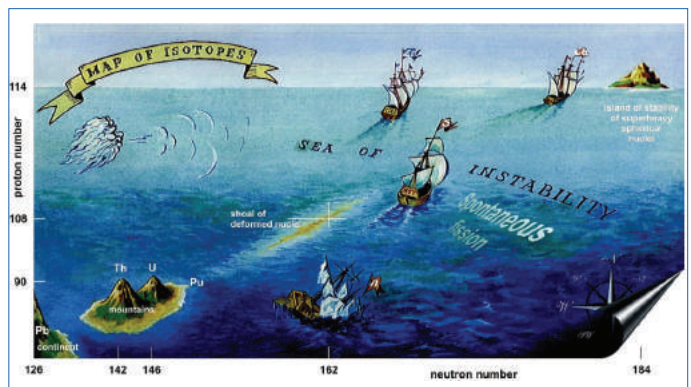
Studies in the history of science have highlighted several moments in history during which the results of the most advanced knowledge were forgotten. Episodes of this kind were often discussed separately, and in the context of a partial analysis, forgetting—often perceived in terms of “decline”—was attributed to *ad hoc* causes. This talk outlined several cases of this kind. It showed how analyses focusing on a single case were conducted and the problems that they raise. Especially, they often identify causes that, when confronted with other cases, look unconvincing. The talk then suggested how deepening our historical reflection globally on episodes of this kind might equip us with the means to better support a smoother development of science.



### Island of stability in the periodic table of chemical elements

– **Alexander Karpov**

The journey to the borders of the world of atoms and nuclei began about 80 years ago and continues to this day. During this time, 24 artificial elements not found on Earth have been synthesized, and they found their places in the periodic table of chemical elements. The heaviest element known today, with atomic number 118, was discovered at the Joint Institute for Nuclear Research and named “oganeson”, after Professor Yuri Oganessian.



The increased stability of superheavy elements is due to the existence of the “island of stability”—a hypothetical region on the nuclear chart predicted by theorists 55 years ago in the region of proton number 114 and neutron number 184. Confirmation of the existence of the island of stability of superheavy elements was one of the most important results of the JINR experiments.

Today, the earlier discovered superheavy elements have become available for a detailed study of their properties, thanks to the creation of new accelerator complexes, such as the Superheavy Element Factory, in Dubna. The synthesis of new and even heavier elements, and the related search for the limits of existence of chemical elements remain an urgent task for the world’s leading laboratories.

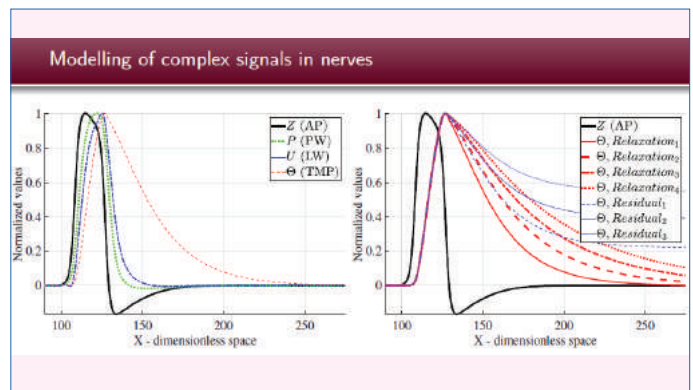


## Modelling of complex signals in nerves – Jüri Engelbrecht

The propagation of signals in nerves is a fundamental physical process needed for understanding cognitive processes and mental phenomena. It involves not only electrical signals (action potential, ion currents) but also mechanical disturbances in nerve fibres and temperature changes. The modelling of dynamic processes in continua (leaving aside particle physics, astrophysics, *etc.*, where relativity of motion is of importance) is based on the conservation of momentum, which is usually known as Newton's Second Law. The thermodynamical effects are modelled by Fourier's law (heat flux is related to temperature gradient) and Joule's law (heat is related to electric current). Traditional models of nerve signals pay more attention to physiology, which helps to explain biological phenomena. In order to explain all the phenomena in nerves, a broader view must be elaborated. According to general principles of complex systems, the first step of the bottom-up modelling needs identifying all the basic elements (basic physical processes) and their interactions with each other (couplings), so that many components are united in order to generate a whole: an ensemble of waves. A possible mathematical model following these ideas is derived. The governing equations for the components of the ensemble correspond either to the modified classical ones for describing the action potentials or are derived from the laws of physics resulting in a consistent system. The interaction of the components of the ensemble is realized by coupling forces. The numerical simulation has shown that the model can grasp the measured effects. The mathematical model generated by the authors<sup>1</sup> is an attempt aiming to couple all the measurable effects of the signal propagation in nerves into a system and demonstrates the importance of basic sciences in developing plausible models. This is an interdisciplinary approach at the interface of physiology, physics, and mathematics but it can be said that physics shapes signals in nerves.

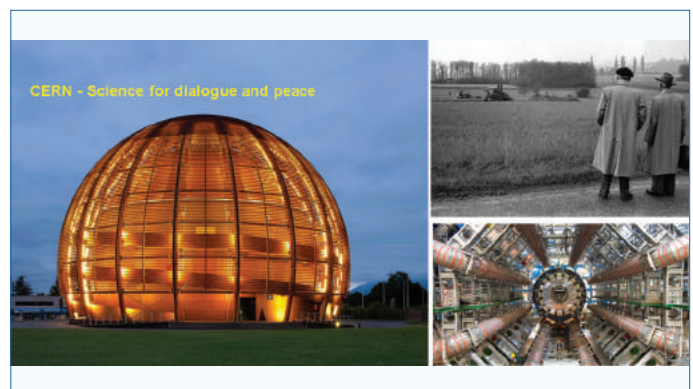
This presentation was co-authored by Kert Tamm and Tanel Peets, Department of Cybernetics, School of Science, Tallinn University of Technology, Estonia.

<sup>1</sup> J. Engelbrecht, K. Tamm, and T. Peets, *Modelling of Complex Signals in Nerves* (Springer, Cham, 2021).



## CERN, SESAME and SEEIIST: Scientific research as promoter of intercultural dialogue and peace – Maurizio Bona

In the aftermath of World War II, a group of far-sighted scientists, politicians, diplomats and intellectuals advanced the idea to set up a scientific international organization whose mandate was to encompass the promotion of co-operation without frontiers in the field of elementary particle physics. Thanks to its Convention—which clearly states that its activities must have no concern with work for military requirements and that all its scientific results must be made publicly available—CERN was a privileged place where researchers from all over the world met and worked together, learning how to transform cultural differences into enriching reasons to co-operate to reach common objectives. At the beginning of the new century, the “CERN model” was exported outside Europe and served as the model for the establishment of SESAME. This scientific international organization, whose Convention is largely based on that of CERN, has proven that scientific and human co-operation is possible in the Middle East among researchers coming from countries of a region in which diplomatic relations between neighbors are not always ideal. A further attempt of showing the exportability of the CERN model is presently underway with the SEEIIST initiative, whose aim is to foster scientific and political collaboration among countries in the West Balkan area. This presentation gave an overview of the elements that allow CERN and SESAME, and that hopefully will allow SEEIIST to contribute to intercultural dialogue and peace. The speaker also presented the results of some reflections on the past and present trends in science diplomacy, underlining its potential as well as its practical limitations in the present complex international situation.



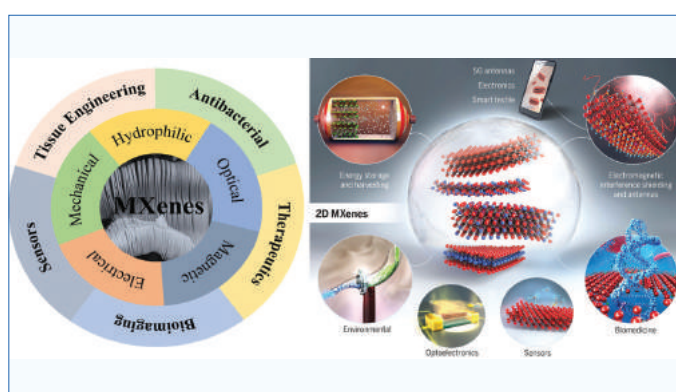
## SESSION 4.2



*From left to right: Aleksander Zidanšek (moderator), Yuri Gogotsi, László Forró, Ivan Gutman & Carlo Rizzuto*

## Synthesis and modification of inorganic nanomaterials for sustainable development – Yuri Gogotsi

We live in the world of materials. Materials defined the progress of humanity, as people moved from the Stone Age to the Bronze Age and then to the Iron Age. Receiving access to new materials enabled new tools and technologies. We entered the Silicon Age more than half-a-century ago and, as a result, electronics and computer technologies greatly accelerated technical progress, changing our life. What is next? Probably the Nanomaterials Age. The era of assembly of new materials, structures and devices from nanoscale building blocks providing any imaginable, but impossible in conventional materials, combinations of properties and functions. Assembly from nanoparticles will allow integration of electronics, energy harvesting and storage, creating self-powered internet of things and wearable internet. It may also minimize waste during products manufacturing. 2D materials, like graphene, dozens of which are available nowadays and thousands more expected soon, provide very attractive building blocks, because they can easily assemble and self-assemble into dense structures, just like bricks in the wall.



There are currently many insulating and semiconducting 2D materials available, which can be used as single sheets in devices, or as building blocks. 2D transition metal carbides and nitrides (MXenes) have been expanding rapidly since their discovery at Drexel University in 2011. They added metallically conductive 2D building blocks to the available materials list. About 50 different MXenes have been synthesized, and the structure and properties of numerous other MXenes have been predicted using DFT calculations. Moreover, the availability of solid solutions on M (transition metal) and X (carbon or nitrogen) sites, control of surface terminations, and the discovery of ordered double-M MXenes offer the potential for synthesis of dozens of new materials. This presentation described the discovery of MXenes, and their synthesis and assembly into films and 3D structures. Their properties and applications in energy storage, optoelectronics, plasmonics, electromagnetic interference shielding, antennas, electrocatalysis, medicine, sensors, water purification/desalination and other fields were discussed.

## How to do scientific research with responsibility? – László Forró

Harvesting, storing, and transmitting energy and information are some of the most pressing needs that we face, and they require new and better performing materials. On the way to finding the appropriate system which has the highest performance, it is important to evaluate all the risks, the health hazards that lead to new technology, to a new prototype. Scientists must address these issues as well. This complex program is illustrated in the case of the novel photovoltaic perovskite  $\text{CH}_3\text{NH}_3\text{PbI}_3$ , which is the star compound in the last decade, showing an exceptionally high light to electricity conversion efficiency of 26%.



## What is mathematical chemistry? – Ivan Gutman

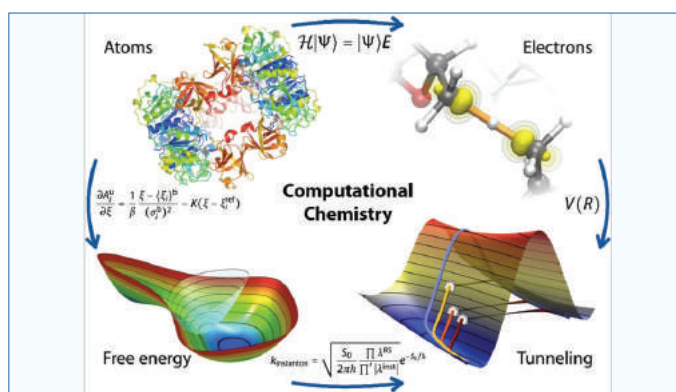
Mathematical Chemistry is a branch of science in which mathematics is used in connection with chemical phenomena. Its roots go back to the 18<sup>th</sup> century and even earlier.

Usually, mathematical models are constructed, aimed at describing and rationalizing chemical facts, relying on laws and methods of physics. For this, the standard inventory of mathematics (mainly of analysis and algebra) is used.

However, the interaction between chemistry and mathematics may also go in the “opposite” direction:

new mathematical concepts may emerge from chemical considerations. A characteristic example for this is “graph energy”, based on the chemical concept of “total  $\pi$ - electron energy”. Nowadays, graph energy is a popular topic of mathematical investigations, and the subject of around 100 mathematical papers annually.

Some basic facts from the long history of Mathematical Chemistry were presented, illustrated by a few recent examples. Then, details on graph energy and its surprisingly versatile applications (far beyond chemistry and mathematics) were outlined.



## Multi-disciplinary and multi-probe research in materials sciences: The approach of CERIC-ERIC – Carlo Rizzuto

Basic and applied research in Materials and Biomaterials Sciences requires a highly integrated multidisciplinary approach and the most advanced research is based on analytical facilities allowing the use of different complementary probes and detection methods, only very seldom available in a single laboratory.

The costs of the facilities which allow high sensitivity measurements may be too high for a single institution or even for a larger country, and the approach to some of these facilities has been to build them within international collaborations, like the European Synchrotron Radiation Facility (ESRF, Grenoble), or the neutron spectroscopy facilities like the Institut Laue-Langevin (ILL, Grenoble) and the European Spallation Source (ESS, Lund). But even these large laboratories do not offer to their users the access to other complementary techniques based on, *e.g.*, ions, electrons or nuclear spin resonance.

Moreover, also due to historical and financial reasons, the Central and Eastern European countries (and some of the other smaller European countries) lack the possibility to acquire the access to the whole spectrum of needed Materials Sciences facilities.

Taking the opportunity of a new legal approach allowed by the European integration, the ERIC legal framework, a number of countries have been able to overcome these limitations by integrating into a single



research entity and to offer to external users as a single laboratory their medium or large facilities, while investing in them to ensure their full competitiveness at the world level, supported by international evaluation and coordination to use different national and international funding sources effectively.

The Central European Research Infrastructure Consortium integrates the research developed within the top Materials and Biomaterials facilities for the analysis and synthesis with nanoscience approach in eight countries. This allows external and internal researchers to perform multitechnique and multiprobe research based on photons, electrons, neutrons and ions.

The talk gave details on the techniques, users, and internal research which is now underway within CERIC-ERIC.

## SESSION 5.1



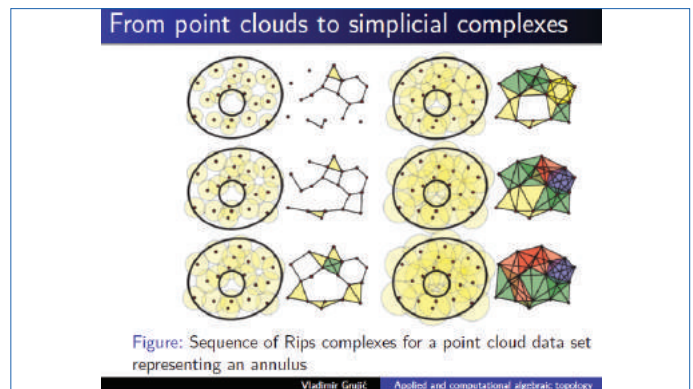
**From left to right: Jüri Engelbrecht (moderator), Vladimir Grujić, Cándid Reig & Frederica Darema**

### Applied and computational algebraic topology – Vladimir Grujić

Algebraic Topology is a core mathematical discipline which, together with other basic mathematical disciplines, has played a central role in shaping the development of mathematics in the last 100 years.

One of the central paradigms of Algebraic Topology is the emphasis and focus on methods for extracting information from incomplete data, often in the presence of noise, which are robust and to a large extent resistant to deformation and perturbation. Applied and Computational Algebraic Topology (ACAT) is a young, emerging mathematical discipline emphasizing and studying problems of algebraic topology relevant to diverse applications in engineering and applied sciences (including computer science, machine learning, neuroscience, etc.). Its growing number of research themes comprise topological data analysis, topological robotics, stochastic topology, topology of sensor networks, topological methods in combinatorics and discrete mathematics, and many others.

ACAT serves as a very good example illustrating fruitful, sustained interaction of a basic mathematical field with applied sciences. An overview of the historical genesis of this interaction was provided, emphasizing two characteristic features:



1. The importance for applications of fundamental mathematical concepts and theories (such as homology theory and Morse theory), which were originally developed for applications within mathematics and mathematical physics.

2. The revolutionary growth of experimental data in the sciences and the availability of unprecedented computing power as a challenge and inspiration for contemporary mathematics.

Rade Živaljević, Mathematical Institute, Serbian Academy of Sciences and Arts, Belgrade, Serbia, was the co-author of this presentation.

### IYBSSD 2022: A KEY MOMENT



The basic sciences are at the heart of sustainable development. They have been instrumental in fighting the COVID-19 pandemic.

They are instrumental in all areas of our lives.

The International Year of Basic Sciences for Sustainable Development is a key moment of mobilization for the common good.

## Giant magnetoresistance (GMR): Science matters – Cándid Reig

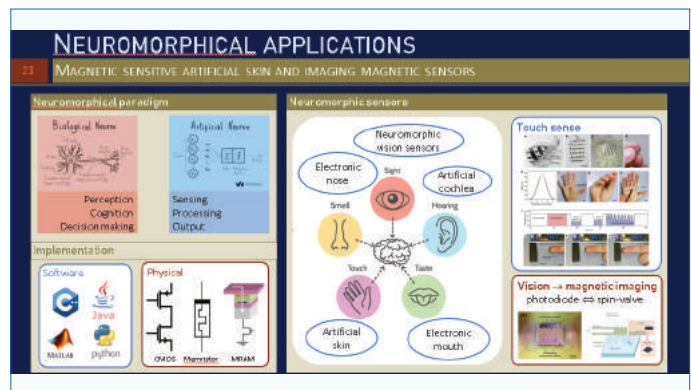
Science is expected to give us answers for understanding the surrounding world, but also to provide mankind with the basic knowledge on technological tools for allowing our plentiful development as a society.

The Giant Magnetoresistance (GMR) is one of the more recent and paradigmatic examples of this close relationship between science and technology. In fact, the fundamental physics supporting this phenomenon was described in 1989, and the first commercial device (a sensor) based on this principle was commercialised in 1994.

The transcendence of this discovery was stated in 2007, when Grünberg and Fert, fathers of GMR, were awarded the Nobel Prize in Physics. Such a rapid evolution has a clear parallel to the case of the transistor, which is considered one of the most important discoveries of the twentieth century.

GMR is a quantum mechanical effect observed in nanometric multilayers composed of alternating ferromagnetic and non-magnetic conductive layers.

In these structures, the electrical resistance changes significantly with the application of a magnetic field, at room temperature. By making use of standard microelectronics fabrication processes, such structures can be engineered as functional two-terminal electronic devices, which can be used as magnetic field sensors.



The first usage of GMR devices was as readers in the heads of magnetic hard disks. Rapidly, their inherent properties regarding sensitivity and easy design opened them to a range of application in many fields including conventional magnetometry (electronic compasses), different industrial applications (non-destructive eddy current testing or electrical current monitoring) or biotechnology. Nowadays, almost any smartphone or car is equipped with several GMR sensors measuring orientation, position or electric currents.

This talk was dedicated to draw the overall scope of the GMR phenomenon as a paradigmatic example of a rapid transit from basic science to developed applications. From the definition of the concepts to the analysis of several selected cases of success, the different topics related to this novel technology were described.

## InfoSymbiotics/DDDAS for systems-analytics and autonomic capabilities

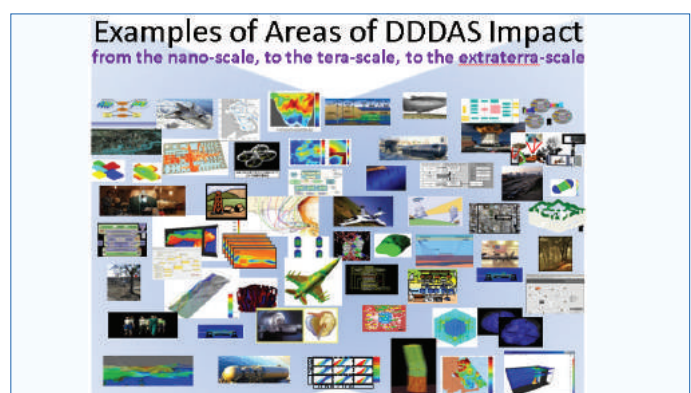
– Frederica Darema

Systems of today and those foreseen in the future, be they natural, engineered, or societal, provide unprecedented opportunities for new capabilities, but they also present concomitant increased levels of complexity and heterogeneity.

The ensuing “systems-of-systems” and their also complex subsystems call for advanced methods of analysis and management.

We need methods not only to design, but also to manage and optimize the systems’ operational functions under varying and dynamic conditions, their evolution, fault tolerance, and interoperability with other systems, and throughout the systems’ lifecycle. *Ad hoc* methods are no longer sufficient. We need systems-analytics, not only data-analytics.

The talk discussed the DDDAS paradigm, and how it has been used to support advanced methods



for systems-analytics and autonomic capabilities, in a wide range of areas, from smart cities infrastructures (transportation systems, energy grids, communications networks) to environmental events (wildfires, hurricanes, tornadoes), medical and societal applications, and more.

## SESSION 5.2



*From left to right: Roman Balvanović (moderator), Ian Freestone, Akio Matsumoto & Veljko Milutinović*

## Contribution of basic sciences to the investigation of archaeological materials – Ian Freestone

Archaeology is the study of the material past, so that the analysis of the materials left by past societies is central to its practice. This presentation focused upon the contributions of analysis to our understanding of inorganic materials, which are those most commonly preserved. Basic sciences contribute to archaeological understanding in a number of areas including:

- **Chronology/dating** – carbon-14 dating and other direct methods such as luminescence are the best known, but other changes such as the use of different pigments or recipes can also provide useful information.
- **Classification** – we need to be able to compare artefacts from widely different locations, in different museums under different jurisdictions, and usually they cannot be moved.
- **Trade and Connectivity** – the material frequently holds evidence of the location of its manufacture and if we can identify this, we can reconstruct contacts and trading relationships between early peoples.
- **Production Technology & Technological Change** – inform us about skills, knowledge and knowledge transfer and exchange, as well as indirectly about social issues such as identity.



- **Deterioration and Conservation** – each artefact is a unique record which is removed from the environment in which it has been preserved for centuries or millennia. Understanding its deterioration can help us preserve it for future generations.

Investigations are constrained by the need to minimise damage to the archaeological object and there is an increasing trend towards non-destructive analysis using state-of-the-art methods, sometimes underpinned by invasive but more robust approaches.

Case studies drawn from a range of materials including metals, glass and ceramics were used to illustrate these points.



“At a time when humanity must invent new ways of producing, travelling and heating, we know we need the basic sciences and the potential they possess. More than ever, we must allow the basic sciences to expand in all directions in order to explore, investigate and experiment. For this capacity to imagine, innovate and discover will determine whether we are able to rise to the major challenges of our time.”

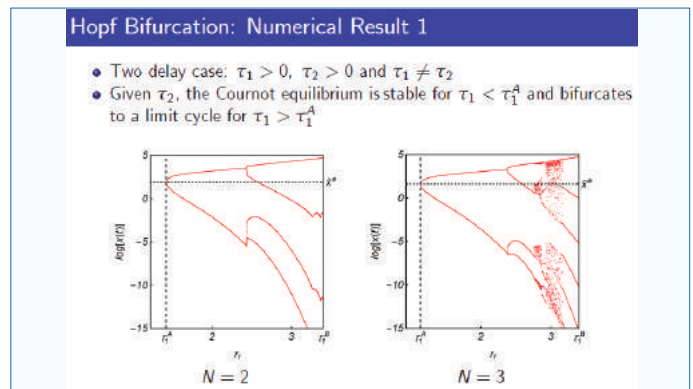
**– Audrey Azoulay**  
Director-General of UNESCO

## Do the time delays matter? Traditional Cournot model revisited

– Akio Matsumoto

Microeconomics mainly considers how the economic agents make their optimal decisions and how the markets evolve. According to theories on oligopoly markets that are applicable to analyze actual behavior in the real economy, the firms make their optimal decisions based on those of the competitors. It is well-known that such information may not be instantaneous because time delays are inherent in economic phenomena. In particular, data collection about the competitors needs time, and then finding optimal decisions and implementing those are additional reasons why the firms use delayed information on the actions of the competitors and also on their own decision variables.

However, in the existing literature, not much has yet been revealed with respect to the circumstances under which the delays affect optimal decisions and exhibit complex non-linear dynamics. This talk aimed to shed light on what effects the delays can generate on static and dynamic behavior. To this end, a brief summary of the delay oligopoly theory was provided first, and then different models of Cournot duopoly with different delays were built in a continuous-time framework. With the help of the recent development of mathematical methods for multiple delays, three particular models were examined, in which the equilibrium is locally asymptotically stable without delays.



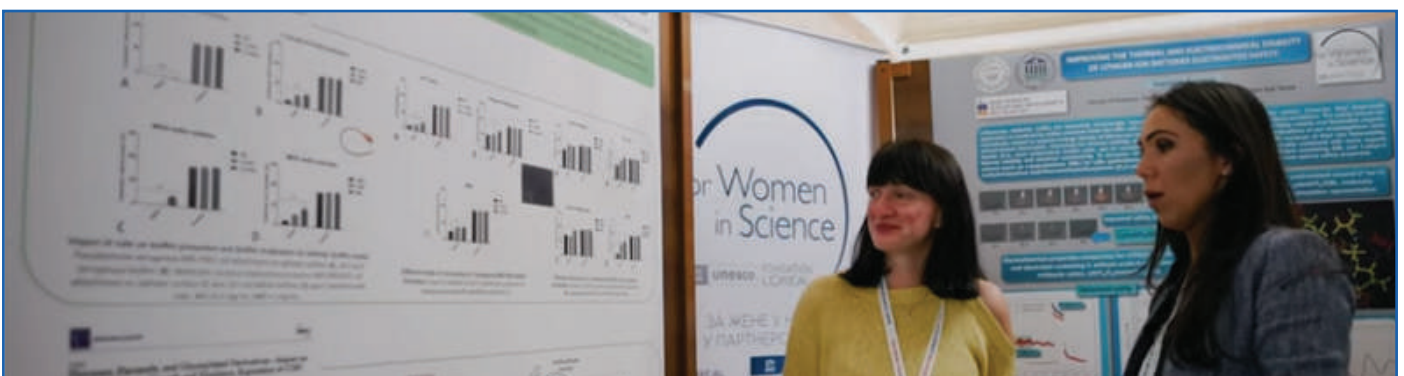
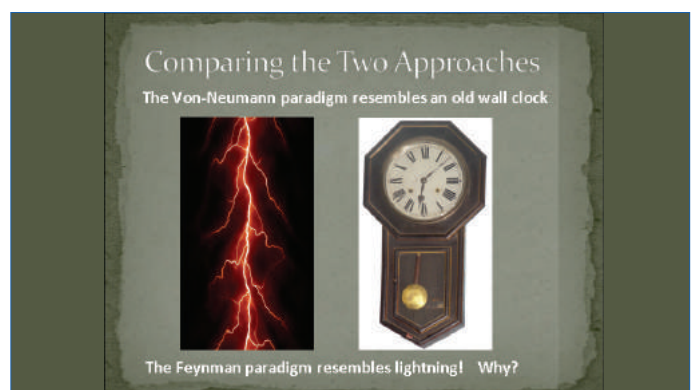
In the first model, both information and implementation delays are assumed and it is shown that the delays have the dual roles of destabilizing and stabilizing the equilibrium involving chaotic behavior with larger values of the delays.

In the second model, only information delays are assumed on the competitors' outputs, and it is verified that the delays do not affect the stability of the equilibrium.

In the third model, only implementation delays are assumed, which can destabilize the otherwise stable equilibrium. In addition to the theoretical developments, numerical studies illustrate and verify the theoretical findings.

## The ultimate SuperComputer-on-a-Chip for big data and machine learning – Veljko Milutinović

The future Supercomputers on a chip, according to many research efforts, should include a small number of multi-cores (e.g., 4), a large number of many-cores (e.g., 4000), a fixed systolic array for the most frequent algorithms of the targeted application (e.g., Machine Learning), and a reconfigurable DataFlow engine for a large plethora of less frequent algorithms (e.g., General Artificial Intelligence). The crucial part is the DataFlow engine, and it has to be carefully tuned to both the targeted applications and the implementation technology, which was the focus of this presentation.



# Contributions of Basic Sciences to Medicine, Healthcare, and Water and Food Security

## SESSION 6.1



*From left to right: Goran Milašinović (moderator), Isaac P. Witz, Jelena Radulović & Junguo Liu*

### Cancer is sustained by its microenvironment – Isaac P. Witz

The seventies of the last century witnessed a dramatic conceptual shift in cancer research. The cancer-centric view (*i.e.*, the formation of cancer and its progression towards metastasis is caused exclusively by alterations in genes that control essential cell functions) dominated the thinking of cancer researchers and oncologists. This viewpoint was replaced by the notion that the cancerous tissue is an ecosystem (termed Tumor Microenvironment – TME) in which both cancer cells as well as non-cancerous cells alike collaborate and play pivotal roles in the fate of incipient cancer cells and their progression to metastasis. It was increasingly realized that mutations in oncogenes or suppressor genes, although essential for malignancy initiation, are not the exclusive determinants of oncogenesis and cancer progression. They certainly do not provide a satisfactory mechanism behind tumor progression towards metastasis, being the major killer of cancer patients.

TME is composed of a heterogeneous assortment of cancer cells as well as of resident or recruited non-cancerous, host-derived cells. The interactions of cancer cells with non-cancerous cells in their immediate environment form a dynamic and complex interaction arena which reciprocally regulates the phenotypes of the interaction partners and the progression of the cancer cells towards metastasis. These interactions may lead to three alternative consequences: the cancer cells may perish, enter into a state of dormancy or progress to overt metastasis.

The cancer-TME cross-talk either drives tumor progression or blocks it

The balance between these opposing effects determine the state of malignancy

Progression

Regression

Dormancy



The TME field has propagated to become a major cancer-research field: almost 30,000 studies dealing with various aspects of TME were published during the 3-year period 2019–2021; TME has become a major discussion point in cancer-research meetings and major organizations such as the EU or the NIH invest large sums of money in the TME research.

At the scientific, translation level, TME has developed into a very extensive research topic and many clinical trials all over the world endeavor to harness TME for cancer therapy. This is being achieved by strengthening and boosting TME-mediated anti-cancer activities or, alternatively, by antagonizing pro-cancer ones.

The recent success of cancer immunotherapy is an impressive manifestation of the remarkable advancements in employing TME-targeting in the clinic.

#### THEMES OF IYBSSD 2022

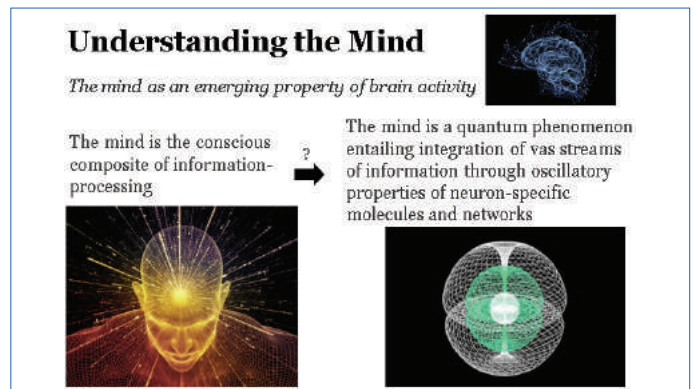
- Science as a global public good.
- Innovation and economic development.
- Education and human development.
- Connecting the links of the chain of research and development.
- Enhancing basic research in weakly developed countries.
- Strengthening the presence and visibility of women in research and development.
- Basic sciences as sources of international dialogue and peace.
- Global challenges, the Sustainable Development Goals (SDGs), and basic research.



## Advancing mental health through basic science

– Jelena Radulović

With an estimated 450 million people suffering from psychiatric disorders worldwide, the understanding of the neurobiology of psychological phenomena, mechanisms leading to psychiatric illnesses, and principles of their treatment have become a top medical and societal priority. Whereas remarkable technological advances and molecular/genetic discoveries have boosted treatment of diseases across all areas of medicine, psychiatric diseases have remained largely incurable. This presentation discussed ongoing scientific efforts to translate animal biobehavioral research to human psychology and psychopathology, focusing not only on challenges, but also on the promise of new discoveries in neuroscience. Individual topics included an analysis of rodent models in the framework of human research domain

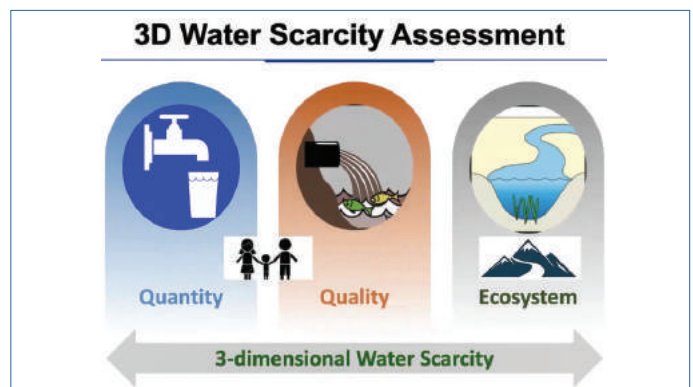


criteria, an overview of systemic and neuron-specific preclinical manipulations with imminent translational impact, and the use of computational approaches as a gateway to personalized medicine.

## Water security and its linkage to sustainable development

– Junguo Liu

According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), released in February 2022, risks from various aspects of water insecurity have emerged as a significant global challenge. Water also features prominently in the Sustainable Development Goals (SDGs) and plays a central role in various systems transitions needed for climate-resilient development. This talk showed that intensification of the hydrological cycle due to human-induced climate change is affecting physical aspects of water security, thereby exacerbating existing water-related vulnerabilities caused by other socioeconomic factors. Water scarcity is one important aspect of water insecurity. About 4 billion people on Earth are estimated to experience severe water scarcity for at least one month per year. The talk also showed that there is a need to apply the three-dimensional water scarcity assessment framework that integrates water quantity, quality and environmental flow requirements to gain a more complete picture of water scarcity. Limiting global warming to 1.5°C would minimize the increase in risks in various water use sectors and keep adaptation effective. Therefore, minimizing the risks



to water security from climate change will require a full-systems view that considers the direct impacts of mitigation measures on water resources and their indirect effect via limiting climate change. The talk concluded that water security can serve as a shining star to guide policymakers through the overwhelming task of achieving the UN 2030 Agenda for Sustainable Development. Hence, immediate interventions are called for to act rapidly towards achieving water security, SDGs and climate-resilient development worldwide.



### HOLISTIC SOLUTION FOR IMPROVING THE GLOBAL SITUATION

“The only way to improve the situation in the world and treatment of mental disease is to better understand our own brain and our own mental state.”

SESSION 6.2

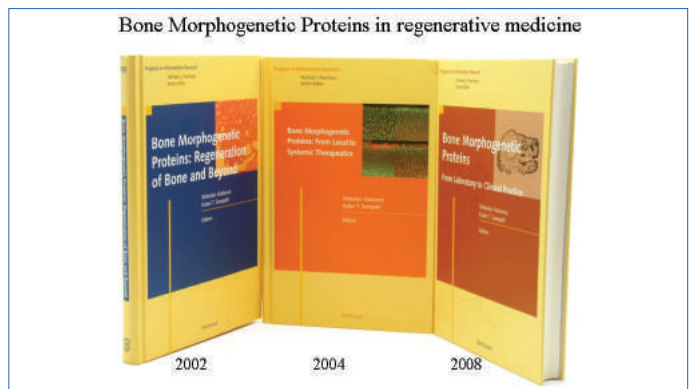


*From left to right: Thomas Reuter (moderator), Slobodan Vukičević, Jules Beekwilder & Nir Ohad*

**First ever global biological drug from discovery to marketing in academic environment – Slobodan Vukičević**

A novel autologous bone graft substitute (ABGS) implant has been developed composed of recombinant human BMP6 (rhBMP6) delivered in autologous blood coagulum (ABC). ABGS contains low doses of BMP6 as compared to BMP2 (InFuse®) and BMP7 (Ossigraft®) and is free of animal sourced collagen, not causing inflammation and immune responses. Safety and efficacy preclinical studies using rabbit ulna segmental defect model and posterolateral lumbar spine fusion models in rabbits and sheep have been conducted. ABGS was examined alone and in combination with allograft or synthetic ceramics as compression resistance matrix (CRM) in spine fusion models. ABGS induced a robust bone formation resulting in restoration of segmental defects and complete ectopic bone fusion with adjacent transverse processes at bilateral lumbar spine sites.

The safety and efficacy of ABGS was tested in Phase I/II randomized, double blind, placebo-controlled trials in patients with a distal radius fracture (DRF) and high tibial osteotomy (HTO). ABGS was formulated to render a flexible and injectable implant. In the DRF study, three groups of patients were enrolled: standard of care, ABC alone and ABGS (ABC + rhBMP6). The HTO trial was conducted in 20 patients treated with 10 ml ABC containing placebo or 1 mg



of rhBMP6. Evaluation of ABGS with allograft is in progress following recruitment of 143 patients with degenerative disc disease to a randomized Phase II posterolateral lumbar interbody fusion (PLIF) study. Phase III trials will include patients with weight bearing long bone non-unions and transforaminal lumbar interbody fusion (TLIF) in patients with degenerative disc disease.

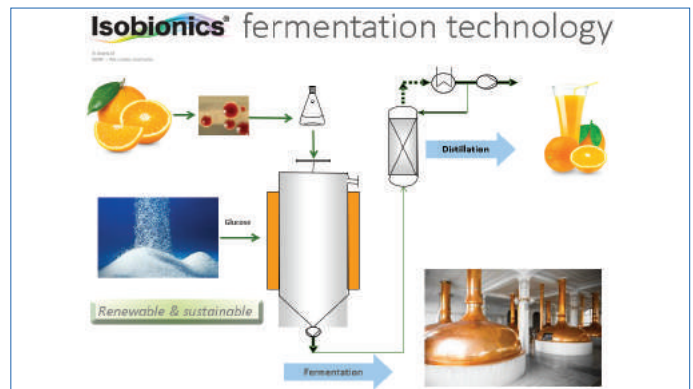
The discovery is protected by patents till 2043 and has been funded by FP7 HEALTH, HORIZON 2020, Angel investor, via milestones from technology transfer to China (Macao and Hong Kong) and is the first ever novel drug for global use developed and tested within a consortium of academic institutions.



## Biotechnology for producing essential oils and beyond

– Jules Beekwilder

Essential oils play an important role in today's economy, for flavouring, fragrance, therapeutic, nutrition and cosmetics applications. These oils are often extracted from plant waste materials, such as orange waste from the juice industry and pine trunks. Also, materials are obtained from dedicated plant cultivation, such as cornmint, lavender and patchouli. In some cases, the oils are sourced from species with a more complex lifecycle, which are difficult to cultivate. Examples of those include the Asian sandalwood tree (*Santalum album*), native to India, and the candeia tree (*Eremanthus erythropappus*), native to Brasil. Both of these represent tree species, which need more than 15 years before they can be harvested, and face extinction due to illegal cutting in the wild. In such cases, their main essential oil ingredients, which are often sesquiterpenes, can also be produced by microbial fermentation. Such biotechnology derived



materials are produced sustainably, without the use of pesticides, and have a much smaller ecological footprint. As fermentation technology is advancing, replacing lower-value ingredients currently produced from petrochemistry with sustainable biotechnological products is becoming reality.

## The role of academia in promoting sustainable food security: Lessons from the Manna Center at TAU – Nir Ohad

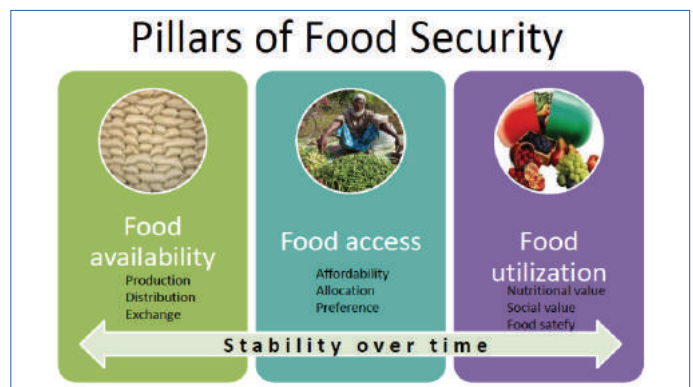
With over 7 billion mouths to feed globally, ensuring a secure supply of food is a burgeoning and critical challenge for scientists and policymakers alike.

The Manna Center Program for Food Safety and Security (MCPFSS), at the Tel Aviv University (TAU), provides the infrastructure and seed funding taking part in meeting this challenge, to cope with these issues.

MCPFSS connects researchers from diverse academic disciplines to promote innovative research, forges ties with professionals and academics around the world, and prepares the next generation of scientists and policymakers to guide global food security issues.

MCPFSS operates in three complementary spheres of activity:

- **Teaching**, preparing the next generation of scientists and policymakers to guide global food security issues.
- **Research**, building an interdisciplinary research platform to develop knowledge for ensuring a



more food-secure world through ground-breaking, innovative practical solutions and data-based policy.

- **Outreach**, forging local and international partnerships between professionals and academics to raise awareness and address food security.

Examples from the three pillars of activities and their outcome were presented during the presentation.



### PRESS COVERAGE IN CorD MAGAZINE

Serbia's monthly English language news magazine covers the World Conference on Basic Sciences and Sustainable Development.

## SESSION 7.1



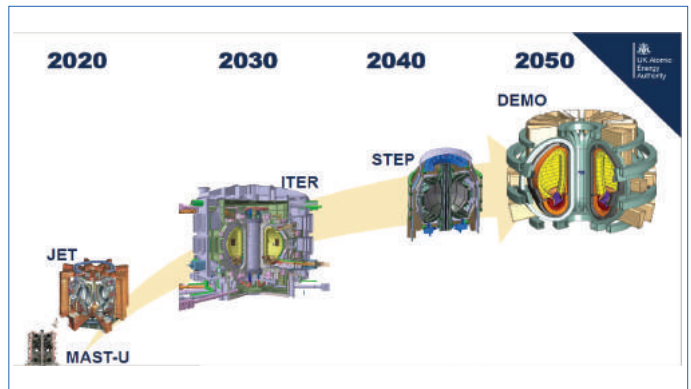
**From left to right: Nebojša Nakićenović (moderator), Dragoslav Ćirić, Ugo Bardi, Marina Frontasyeva & Jinfeng Zhou**

### Fusion energy: From JET via ITER to DEMO – Dragoslav Ćirić

Fusion has the potential to provide a sustainable and inexhaustible source of energy for future generations. It is based on the fusion of hydrogen isotopes (deuterium and tritium) at extremely high temperatures, *i.e.*, the process that powers the Sun and other stars. Among several pathways to fusion, the most developed approach is based on the heating of deuterium-tritium plasma confined inside the toroidal vacuum chamber by strong magnetic fields—this type of device is known as tokamak.

Among more than hundred devices built so far, the largest and most successful operational tokamak is the Joint European Torus (JET). It was designed, constructed, and operated as the joint undertaking of the countries of the European Union. JET was built with the aim to achieve scientific breakeven, *i.e.*, to produce fusion power in excess of plasma heating power (fusion energy gain factor of  $Q \geq 1$ ). JET did not achieve this goal, but it holds records in achieved fusion power of 16 MW ( $Q = 0.67$ ) and fusion energy of 59 MJ ( $Q = 0.33$ ).

Scientific breakeven is expected to be reached and exceeded by ITER (International Thermonuclear Experimental Reactor), which is under construction in southern France. ITER is a much larger device, which should achieve up to 500 MW of fusion power and



fusion energy gain factor of up to  $Q = 10$ . The ITER project is a joint endeavour of the European Union, the USA, Russia, Japan, China, South Korea, and India. It is expected to achieve first plasma in the mid-2020s, with deuterium-tritium operation planned for the mid-2030s.

In addition to accomplishing scientific goals and demonstrating steady-state nuclear fusion, the ITER project will develop and validate technologies and processes required for DEMO (DEMONstration Power Plant), which is intended to demonstrate electrical power production from nuclear fusion. The European DEMO concept is aimed at steady state fusion power of 2,000 MW ( $Q = 25$ ) and should become operational in the 2050s.



## A 100% renewable society: Is it possible?

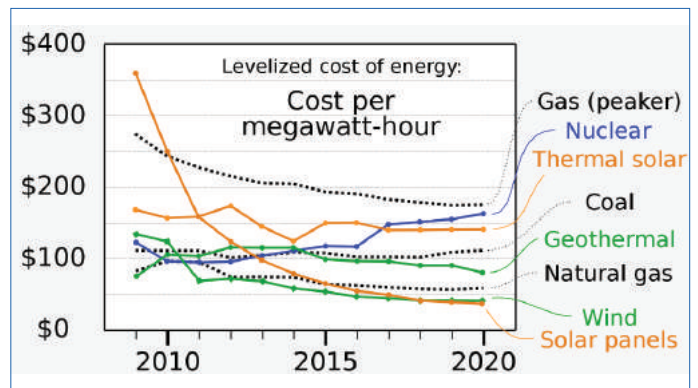
– Ugo Bardi

The transition to renewable energy is a much-discussed subject nowadays. It may be argued that the main renewable technologies, photovoltaics and wind, are sufficiently advanced today to be a suitable replacement for fossil fuels. In particular, the most recent data indicate that the energy return in energy invested (EROI) for renewables is superior to that of traditional technologies such as fossil fuels and nuclear fission. This higher EROI is reflected in lower prices, at present outcompeting all the alternatives. Renewables also do not need large amounts of rare minerals, nor do they create persistent pollution or pose security problems.

The question remains whether it is possible to go through the transition in times fast enough to avoid both the 1.5°C increase in temperature set by the 2015 Paris treaty, and the depletion of the remaining fossil fuel resources. The human tendency of fighting for what is left, rather than sharing it, is especially worrisome in this respect.

To understand the kind of trajectory that the global economy will be following in the coming years, we need to use models. This subject was already quantitatively modelled in 1972 by the study titled *The Limits to Growth* sponsored by the Club of Rome. The study found that the most probable trajectory of the world's economy was to collapse because of combined factors of depletion and pollution. Nevertheless, the study did not include the role of renewables, at that time not sufficiently advanced to be a practical alternative to fossils.

By the second decade of the 21<sup>st</sup> century, it was possible to use modelling techniques similar to those used in 1972, but including the increasingly efficient renewable technologies. The results of several different

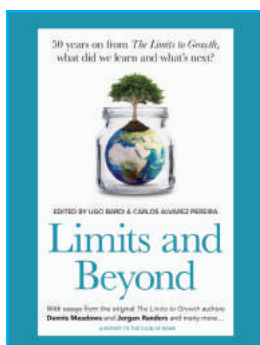


models show that the transition is now possible in times of the order of 20-50 years, without passing the limits of emission established by the Paris treaty. To obtain this result, however, considerable investments will be needed. Unfortunately, the decision makers are apparently much more interested in investing in hardware for war.

At present, the models indicate that it will not be possible to avoid a significant contraction of the world's economy during the coming decades. That does not mean that there will be no transition, but that it will be slower. In time, the system will be able to grow again and reach levels of supply comparable to the current ones. Note that, in any case, renewable energy tends to self-limit because of the limited available space for collecting sunlight or wind. It means that a renewable-based economy will not go in overshoot but will tend to stabilize over the years.

The models do not rule out the complete collapse of the world's economy and the return to a purely agricultural system with a drastic population reduction. But this dire possibility can be avoided by supporting renewable energy to the maximum possible level, starting now.

### “LIMITS AND BEYOND” – 50 YEARS FROM “THE LIMITS TO GROWTH”: WHAT DID WE LEARN AND WHAT’S NEXT?



The Club of Rome publication that was the focus of the Special Session reaches back half a century to when the report *The Limits to Growth* shook the world into realising that we live on a finite planet, brings it sharply up to date, and looks clear-eyed into the future. The Club of Rome is a platform of diverse thought leaders who identify holistic solutions to complex global issues and promote policy initiatives and action to enable humanity to emerge from multiple planetary emergencies. The organisation has prioritised five key areas of impact: Emerging New Civilisations; Planetary Emergency; Reframing Economics; Rethinking Finance; and Youth Leadership and Intergenerational Dialogues.

# Monitoring long-term and large-scale deposition of air pollutants based on moss analysis in the framework of the UNECE ICP Vegetation

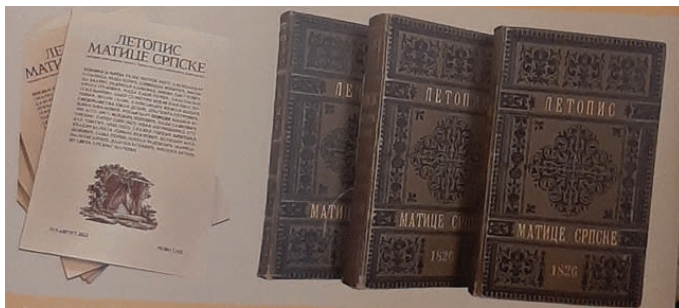
– Marina Frontasyeva

A brief historical review was given on the development and milestones of the moss biomonitoring technique used to study atmospheric deposition of trace elements, nitrogen, persistent organic pollutants (POPs) and radionuclides of technogenic and natural origin in Europe, as well as cosmic dust. The relevance of these studies to the UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP) was shown. Examples of the long-term activity of the ICP Vegetation (International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops), established in 1987, were given to illustrate the tendencies in behavior on a large scale of air pollutants such as heavy metals, nitrogen and persistent organic pollutants. In agreement with the long-term strategy of the LRTAP Convention to enhance participation and improve air quality in Eastern Europe, the Caucasus, Central Asia, and South Eastern Europe, efforts to extend the moss survey to former republics of the USSR such as Armenia, Azerbaijan, Georgia, Moldova,



Kazakhstan, and Uzbekistan were successfully undertaken. Around 15 teams were formed in Russia to cover moss sampling in Northern and Central Russia, Western Siberia, and the Far East of Russia (Kamchatka and Sakhalin). To date, 42 countries expressed their desire to participate in the 2020-2021-2022 moss survey. Analytical methods and approaches to data interpretation were reviewed.

## ON MATICA SRPSKA



MATICA SRPSKA CHRONICLE AND INITIAL LITERARY EDITIONS

At the turn of the 19<sup>th</sup> century, the time when the national consciousness and the movement to free Serbia from the centuries of the Ottoman occupation were gaining power, Serbian intellectuals in the Habsburg Monarchy accepted the cultural and organizational norms and values that were spreading in Europe under the influence of the enlightening ideas. In 1826, Matica Srpska was founded. Its members strived for the presentation of the Serbian culture to the world and, at the same time, for the enlightenment of the people. The goal was to join the trends of contemporary Europe as well as to maintain the national identity thereat.

Matica Srpska, located in Novi Sad, Serbia, treasures the memories of its honorees, benefactors, and associates, but has also been the guardian of the collective memory of other significant Serbian individuals for almost two centuries now. Several dozen projects are worked on in the seven scientific departments of Matica Srpska. Some of these are of crucial importance for the creation of the Serbian people: the Serbian Biographic Dictionary, with 28,000 biographies, and the Serbian Encyclopedia, which contains information about numerous individuals, institutions, and events.



Mihajlo Pupin



Nikola Tesla



Milutin Milanković

The documents that give testimonies about the lives and works of the most esteemed Serbs are conserved and processed in the Manuscript Department. Nine scientific journals are published by Matica Srpska. Among other things, the information about the writers, scientists, and others who made a mark on the Serbian history can be found in them, including Mihajlo Pupin (1854–1935), Nikola Tesla, (1856–1943), and Milutin Milanković (1879–1958), three world

famous Serbian engineers and scientists. The Library of Matica Srpska has more than 4,000,000 publications, including many with biographical data about prominent individuals. Numerous portraits are exhibited in the Gallery of Matica Srpska. Its experts care for dozens of others that are not included in the permanent exhibition. Matica Srpska has unofficially become a Serbian Pantheon of a kind.

## How to make wise use of science to promote biodiversity conservation and ecological civilization – Jinfeng Zhou

The industrial civilization, increasingly driven by basic sciences and various applied disciplines, has a huge impact on ecosystems.

Sustainable aviation fuel and electric aircraft can reduce carbon emissions and play an important role in tackling climate change. Research on substitutes for plant raw materials can reduce the usage of wild animal organs in traditional Chinese medicine. The development of an oral rabies vaccine has helped to reduce hostility to wildlife that are considered to be bacteria carriers and there have been recent reports of new radar technology that, when added to wind power facilities, could significantly reduce damage to birds.

But if new technologies are not restricted and regulated, their negative impact on the environment will also be enormous. Wind and solar energy could reduce carbon emissions, but its construction and operation often cause harm to wildlife. If the development of AI does not involve bioethical considerations, algorithmic and design errors will occur. Many pseudoecological projects, with the banner of “protecting nature” and scientific environmental impact assessment (EIA) under the industrial civilization system, destroy wilderness by building manmade parks. Collecting and artificially raising marine animals in the name of popular science increase illegal hunting and accelerate biodiversity loss. Large-scale hydropower stations cause migratory aquatic species to lose their pathway to reproduce. Overusing pesticides could increase crop yield but kills a lot of wild animals.



We need to mainstream biodiversity conservation and promote the synergies between biodiversity conservation and addressing climate change. Biodiversity mainstreaming can be perfectly achieved through practicing Community Conservation Area (CCAfa), Human-based Solution (HbS), and Biodiversity Conservation in Our Neighborhood (BCON). And Nature-based solutions are suggested in Ecological Restoration, and all ecological repair projects should be based on 3 Axioms of Pollution Control: non-proliferation, non-hazardous, and full publicity and transparency, in line with the four Principles of Ecological Restoration: Resource-saving principle, Nature-based principle, Moderate principle, and Holistic principle, combined with ecological restoration capabilities to maximize repair of damaged ecosystems.

We need to make wise use of science to promote ecological civilization and let science play a positive role in the new era.



## SESSION 7.2



*From left to right: Ian Fazey (moderator), Slobodan B. Marković, Anastassia Makarieva & Tanja Čirković Veličković*

## Milanković and future climate change

– **Slobodan B. Marković**

We are witnessing a developing interest worldwide in the phenomenon of climate change, within both a notable portion of the scientific community and the public at large. This widespread interest in climate change implies the existence of a wide range of circulating perspectives on this problematic phenomenon, from underestimating its potential consequences to interpretations excessively catastrophic in nature. Such an unprecedented global interest in understanding the mechanisms of climate dynamics is an understandable reaction, given the modern civilization being undeniably dependent on climate stability and predictability.

Viewed from the perspective of long-term Cenozoic climate change, we are living in the last warm phase (interglacial) of the Quaternary Ice Age, which is still far cooler than the Paleocene-Eocene climate maximum. Many contemporary scientists have argued that an increase in greenhouse gas emissions released into the Earth's atmosphere will cause significant global warming. This study analyzes the variability of the Earth's climate over the last 65.5 million years, with a focus on greenhouse gases. It offers a possible basis for a more comprehensive critical assessment of contemporary attempts to foresee future climate change variability. The Quaternary Ice period started around 2.5 million years ago and has been characterized by extreme climatic variations related to cold glacial and warm interglacial phases. The widely



known Serbian scientist Milutin Milanković crucially influenced modern paleo-climatic research with his theory that Quaternary Ice Age climatic fluctuations are caused by variations in the Earth's orbit around the Sun. The overriding belief among the scientific and broader community is that humans are starting to have the dominant effect on climate, and that there is a danger of a "superinterglacial" period that would last much longer than Milanković's cycles predicted. It is symptomatic that the fear of anthropogenically caused global warming is widely used in politics and other social undertakings that are only loosely connected to scientific climate research. Unfortunately, mankind still lacks an adequate replacement for the economically justified usage of fossil fuels, which brings to the fore the inevitable civilizational search for new, efficient and financially favorable energy sources.





## Basic science to clarify the climate-regulating function of the world's pristine forests: Water is the key – Anastassia Makarieva

In several global climate models of the latest generation, the contribution of cloud changes to projected global warming exceeds the carbon contribution and, together with the Earth's darkening due to decreasing snow cover, accounts for a major part of global warming. This suggests that, even in the absence of CO<sub>2</sub> emissions, a considerable global climate change could be triggered by any process that would significantly perturb the Earth's cloud cover and, more generally, the vertical and horizontal global flow of water vapor.

One such process can be easily identified: it is the destruction, in the recent century, of pristine vegetation, mostly forests, over a major part of land area. How these changes matter for climate cannot be reliably quantified by modern global climate models because of systematic deficiencies in their representation of the regional water cycles as well as due to the fact that the forest impact on moisture transport and cloud cover began to be actively investigated only very recently. The implication is that the role of natural ecosystem preservation and recovery in the mitigation of global and regional climate change can be dangerously underestimated, while certain CO<sub>2</sub>-related measures



can be inadequate for climate mitigation or, if they cause extra pressure on pristine ecosystems, even aggravate the situation.

Basic theoretical research in climate physics and ecology acquires a particular significance in this context. Theoretical research has less inertia than numerical modeling in the modern highly sophisticated GCMs and has the potential to quantitatively outline new principles to guide our way out of the current predicament. Here, water vapor dynamics as controlled by pristine forests should be a major research focus.

## ON L'ORÉAL



The exhibition of L'Oréal Group, the world leader in cosmetics industry, *L'Oréal for the Future*, presented the company's sustainability commitments for 2030, as an example of how the business sector can transform to serve sustainable development. It is no longer enough for companies to reduce their environmental impact with objectives that are "self-set", so



at L'Oréal, the commitment is to ensure that the activities are respectful of the so-called "planetary boundaries" (what the planet can withstand), as defined by environmental science. In the context of growing environmental and social challenges, L'Oréal has been accelerating its transformation in order to reconcile the needs with the preservation of a resource-limited planet and reinforcing its commitments to both sustainability and inclusion.

The exhibition first guided the visitors through the company's sustainability history since 1979 to the present moment. The second part of the exhibition was focused on the *L'Oréal for the Future* principles and sustainable commitments of the Group for 2030, that embody the view as to what the company's vision, purpose, and responsibilities should be to meet the challenges facing the world.

The Poster Section included three sessions. The authors of the posters were nine young scientists awarded within *For Women in Science* National Program in Serbia. This program has been established in Serbia in 2010 by L'Oréal Balkan, the Commission of Serbia for Cooperation with UNESCO, and the Ministry of Education, Science and Technological Development of Serbia. The goal of the international program L'Oréal-UNESCO *For Women in Science* is to support outstanding women researchers around the world, who contribute to the progress of science and society with their dedication, achievements, and vision.

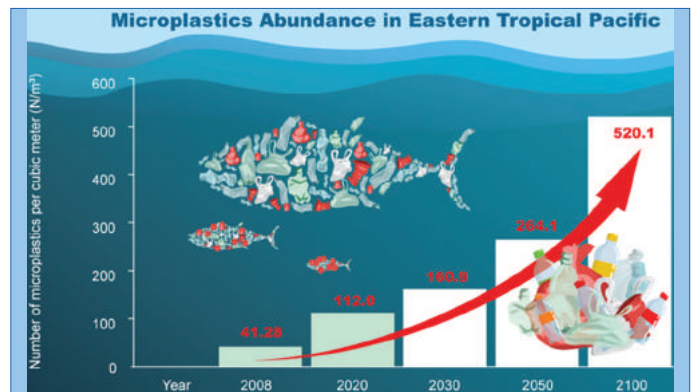
For eleven years now, the best young women scientists have been awarded in Serbia within this initiative, a form of support to their further professional development and an incentive to continue to pursue science in Serbia.

## Micro- and nanoplastics in food and environment

– Tanja Ćirković Veličković

It is hard to imagine our life without plastics. Plastics are also exceptionally durable and hence can persist in the environment. In the environment, the plastics can slowly degrade into smaller particles, called microplastics, of all shapes, chemical compositions, and sizes. The degradation of plastics will eventually result in formation of microparticles, currently defined as plastic materials with various morphologies in the range of 0.1–5,000  $\mu\text{m}$ . Primary microplastics are already microscopic in size from the point of manufacture. Common examples are microbeads that act as exfoliating agents in cleansers, facial scrubs and other cosmetic products, and virgin pellets that are used as raw materials in the production of plastic goods. Micro- and nanoplastics are manufactured for different commercial purposes and can unintentionally be released into the environment and contribute to the growing plastics pollution.

Estimates suggest that 5.25 trillion plastic particles currently circulate in ocean surface waters. The presence of plastic particles in various environments also pose a threat to food security, food safety, and human health. Unfortunately, solid data on the prevalence of microplastic particles in the environment are still limited due to the analytical and technical challenges of extraction, characterization, and quantification from complex environmental matrices. Microplastics found in the diet can be derived from food additives (salt, sugar), drinking water, and microplastics incorporated into the food chain (in particular shellfish) or released from plastic packaging during food processing. Interestingly, the highest reported concentration of microplastics comes not from the food chain, but rather from the processing of foods in plastics.



Reusable plastic bottles have also been identified as a source of microplastics which could be generated through cleaning and refilling. In fact, infant exposure to microplastics is higher than was previously recognized due to the prevalence of polypropylene-based products used in formula preparation, and highlights an urgent need to assess whether exposure to microplastics at these levels poses a risk to infant health.

Apart from their physical presence as environmental pollutants, concerns have been raised regarding binding other components to microplastics, in which case, an interplay of contaminants can result in the outcomes that are not easy to predict. For instance, there is a substantial lack of knowledge on binding allergenic proteins to microplastics and influence on the development of allergy and processes relevant for allergen degradation and presentation to the immune system (*i.e.*, digestibility and bioavailability). The aim is to understand the effect of micro- and nanoplastics combined with potentially harmful environmental contaminants and allergens adhering to their surfaces and finding their way into the human body.



## SESSION 8.1



**From Left to Right: Janani Ramanathan (moderator), Anjum Halai, Sascha Marc Schmeling, Pu Chen & Susan G. Clark**

### Inclusive & quality mathematics education for all: Lessons from the CANP Project of ICMI – Anjum Halai

Creating networks and reaching out to the critical mass in mathematics education community is a potent strategy to maximize the impact of reform in mathematics education. The Capacity and Network Project (CANP) is a step in this direction.<sup>1</sup> A key purpose of CANP is to create networks in low- and middle-income countries to enhance mathematics education at all levels. It aims to develop the educational capacity of those responsible for mathematics teachers, and create sustained and effective regional networks of teachers, mathematics educators and mathematicians, also linking them to international support.



To date, ICMI has supported five CANPs each with the common purpose of advancing mathematics education but differing in its approach and methodology. The community of mathematicians and mathematics educators across the five CANPs is a significant resource because working at the grassroots level they provide insights into key issues and challenges in supporting mathematics education. An important feature of CANP is that it brings together mathematicians and mathematics educators to enable teachers to upgrade their mathematics knowledge and for mathematicians to better understand the changed nature of mathematics for teaching. Through building on local networks and sharing cross-national regional experiences, the CANP community aims to deepen and broaden the understanding of lessons learnt in the process of promoting inclusive and quality mathematics education.

1) CANP is supported by the International Commission of Mathematical Instruction (ICMI), the International Mathematical Union (IMU), UNESCO and the International Council of Scientific Unions (ICSU) as well as by regional governments and institutions.

### NEED FOR A NEW PARADIGM



“A key message from this conference is that the world is facing unprecedented global challenges that can only be addressed by shifting our concept of security to focus on people. Human security represents the common denominator linking people to all these multidimensional threats. A global commitment to enhancing security is the means for effectively addressing them.”

## Science and education for peace and sustainable future

– Sascha Marc Schmeling

The European Organization for Nuclear Research (CERN) is one of the oldest intergovernmental organisations in Europe. In June 1953, the final draft of the CERN Convention was agreed upon and signed by twelve Member States. It laid out the ways Member States would contribute to, as well as the early indications of CERN's ethos and organisation — from adopting a policy of open access to its commitment to diversity. Today's headline "Science for Peace" was already visible and sketched then as well as the pillars of modern science and research, which can also be re-found in the current "Sustainable Development Goals" of the UN. CERN's mission included fundamental research in nuclear physics as well as dissemination of research results, international peaceful collaboration, and education of scientists of tomorrow.

In the last nearly 70 years, CERN has pursued this tradition with all its partners in Europe and beyond, helping to lay the foundations of a science-aware society, getting scientists and engineers to work



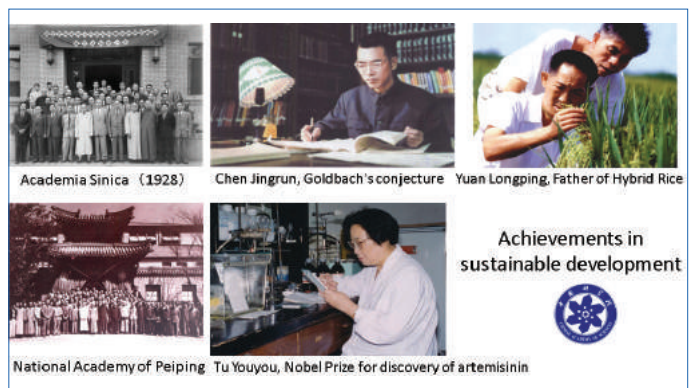
together peacefully, and by that promoting the Nature of Science.

This presentation highlighted how CERN has fulfilled its mission, described current involvement in education and research, drew connections to the UN's Sustainable Development Goals, and gave an outlook of the future of science education on an international scale.

## The importance of basic science talent cultivation to sustainable development: A historical perspective – Pu Chen

During the early period of the People's Republic of China, China was in extreme shortage of talent in the basic sciences for nation-building and scientific research. China took many measures to rapidly enlarge the talent pool by attracting overseas students to return, selecting students to study abroad, and cultivating talents independently. In the aspect of independent talent cultivation, institutions and departments were adjusted to change discipline structure and geographical distribution of higher education. That led to a rapid increase in the talent quantity for science and engineering, including basic scientific research.

In order to cultivate high-level talents for basic scientific research, the Chinese Academy of Sciences established a postgraduate system and trained a number of scientific research talents. Most of them



became the backbone of basic science in China. These measures immediately met China's demand for talents in basic scientific research, whose work made valuable contributions to the sustainable development of the nation and regions.



## Integrating basic science and advanced education in our challenging times – Susan G. Clark

Achieving “a better and more sustainable future for all people and the world by 2030” and “living in harmony with nature by 2050” is a formidable task that demands much from us. Foremost, it demands practical heuristics (integrative problem-solving approaches). Yet we show an incapacity to cope intelligently with environmental and social problems—a “curious twist.”

The challenges we face pose existential, evolutionary, ecological, social, and political hurdles. Current social responses focus on markets, technology, and policy reform. For individuals, locating one’s self realistically in the flow of events is essential! We need to use basic science and advanced education, strategically and practically. Basic science rests on the assumption that what we see around us or what is known and what we want to know about the world is a gap that we long to know and close. Basic science tells about reality, truth as a kind of timelessness (also a timely pursuit). We are making progress to be sure.

Education is about transformation and development and, these in turn, are about the acquisition and reorganization of skills. In any basic or applied effort, we start with two beginnings, each of which has its own kind of authority: observations (induction) cannot be denied, and fundamentals (deduction) must be fitted. These can be fitted together using a



practical heuristic approach that gives us explanatory notions, abstractions, thought-symbols, perspectives, perceptions, and attitudes (abduction) of theoretical and practice use. This talk focussed on a heuristic abduction that permits integration. That allows the appropriate combination of knowledge from many different specialties as a means to shed new light on an actual problem. The talk featured a model advanced course and offered other educational examples. Our goals cannot be realized without finding common interests amongst people who have an interest in resources used at question. Securing the public good requires pragmatic heuristics, and basic science, applied sciences, education, and advanced education can all help us meet goals.

### SESSION 8.2



**From left to right:** Jüri Engelbrecht (moderator), Christophe Ritzenthaler, John D. Bradley & Aleksander Zidanšek

## Cooperation in mathematics with developing countries: Successes and challenges – Christophe Ritzenthaler

Through concrete examples of actions, this talk illustrated some successes but also the challenges faced when cooperating in education at research level with developing countries.

Promoting Research in Mathematics in Developing Countries

Mathematics is everywhere...

COVID-19

GLOBAL TEMPERATURES

CIMPA  
Centre International de Mathématiques Pures et Appliquées

Source: NASA/Goddard Institute for Space Studies

## Basic sciences in education for sustainable development

– John D. Bradley

Many scientists have a deep interest in education. Their motives include transmitting their hard-earned knowledge and understanding to attract new recruits, gain public support, and contribute to general improvement in public education. School science teachers share some of these motives for teaching. To an increasing extent, school curricula have included science-technology-society themes both to motivate learning and increase the wider relevance to future citizens of what is learned. A special sub-set of these activities has been directed at “science education for development”, which is a contribution to developing less-developed countries through wider access to science education.

On a global scale, UNESCO has been amongst the most active in this endeavour. The experiences in one such UNESCO project (Global Microscience Project) inform suggestions to be made here for the future. Global climate change adds urgency to these activities.



Science education now needs to address sustainable development. Basic scientists need to guide, inform and inspire science teachers in their task of preparing future citizens. A special focus should be upon those who prepare new science teachers: these teachers can be equipped to help older colleagues understand the new challenges and the need for systems-thinking.

## Systematic competence development for sustainability

– Aleksander Zidanšek

The contemporary world provides many opportunities and also many challenges that threaten the survival of human civilisation. We live in critical times when the future of humanity depends on our ability to take advantage of opportunities. Therefore, it is important to systematically develop competences among the youth as well as in the lifelong learning processes.

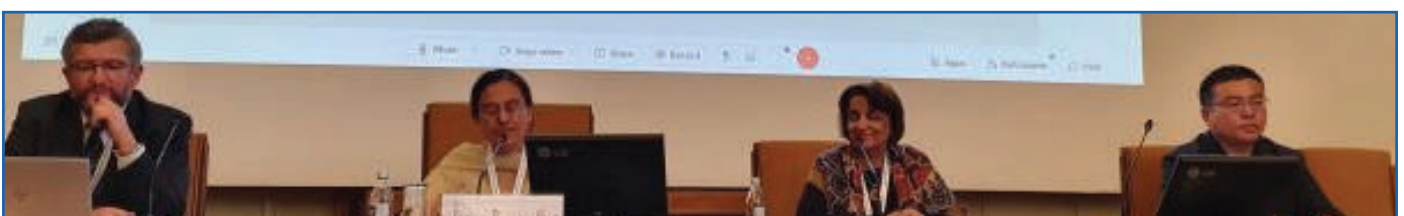
The development of the science, technology, engineering, and mathematics (STEM) competences is most useful for the future development of science, which will in the long-term contribute the most to sustainability. It is however also important to develop soft-skill competences like creativity, critical thinking, solving problems, teamwork, solving conflicts, etc. These soft skills contribute both to better relations between people and also to the development of science.

Creativity is a typical competence which has contributed a lot to knowledge. Einstein's theory of relativity is the most famous example of this contribution, and there are many other examples that have improved our quality of life significantly, in particular since the 1900s.



In this contribution, a systematic approach to the monitoring and development of competences with the help of an expert system was presented. This approach provides the strongest opportunities in the development of the future generations of scientists.

In addition to the development of each particular competence, it is even more important to develop the competences of self-motivation and curiosity because curious and motivated future scientists are the best guarantee for survival and thriving of humanity in the future sustainable knowledge society.



# Poster Section: For Women in Science

## Genetic diversity is crucial for species conservation and management

– Nevena Veličković



A hidden planetary crisis has long been neglected, but it is as serious as the disappearance of species and degradation of habitats. Genetic diversity, which reflects the variation in DNA within species and populations and is the key to their capacity to adapt in times of change, is being lost at an alarming rate. The loss of genetic diversity can affect resiliency in the face of environmental change and result in the loss of important services provided to society. **Once gone, genetic diversity can take millennia to return.**

Developments are making large-scale monitoring of this hidden and neglected level of biodiversity possible, including innovative policy and legislation, growing collaborations and capacity building efforts, and databases that store and make publicly available exponentially increasing genetic data.

The genetic diversity conservation community embraces the FAIR principles (data should be findable, accessible, interoperable, and reusable), which means that data collected for basic research can be reused for conservation and vice versa. Collaborations and increased capacity are helping to improve knowledge in understudied geographic regions.

### GENETIC DIVERSITY IS CRUCIAL FOR SPECIES CONSERVATION AND MANAGEMENT

Nevena Veličković  
Laureate of the L'Oréal-UNESCO For Women in Science Award in Serbia

A hidden planetary crisis has long been neglected, but it is as serious as the disappearance of species and degradation of habitats. Genetic diversity, which reflects the variation in DNA within species and populations and is the key to their capacity to adapt in times of change, is being lost at an alarming rate. The loss of genetic diversity can affect resiliency in the face of environmental change and result in the loss of important services provided to society. **Once gone, genetic diversity can take millennia to return.**

**URGENT, EXPLICIT, AND COMMITTED CONSIDERATION AND FUNCTIONING GENE FLOW IN SPECIES IS NEEDED. MONITORING GENETIC DIVERSITY CAN HELP TO DETECT VULNERABILITIES.**

**Research and monitoring programs**

Collect non-genetic data: Collect environmental, demographic and geographic data for monitoring to support.

Design an adaptive monitoring strategy to assess genetic diversity: Sampling of biological material can be integrated into field surveys (e.g. citizen science) whenever the likelihood is high to measure genetic diversity over space and time, and also capacity to collect, store and analyze such data.

Store genetic data: Upload genetic datasets with associated metadata for public access.

Analysis: Analyze genetic data with a geneticist network (e.g. GBI, G2G, G2G+G, G2G+G+G) to identify key genetic diversity.

Other genetic data: Link existing data for conservation to complete the picture, inform strategy and adapt future plans.

**Synthesis**

Assess genetic diversity: Compare genetic diversity across species, regions, and time to identify key genetic diversity.

Assess: Assess genetic diversity across species, regions, and time to identify key genetic diversity.

Monitor: Monitor genetic diversity across species, regions, and time to identify key genetic diversity.

Policy: Use information on genetic diversity to inform policy and legislation.

Monitoring: Monitor genetic diversity across species, regions, and time to identify key genetic diversity.

**Aggregates and build capacity**

Assess: Assess genetic diversity across species, regions, and time to identify key genetic diversity.

Monitor: Monitor genetic diversity across species, regions, and time to identify key genetic diversity.

Policy: Use information on genetic diversity to inform policy and legislation.

Monitoring: Monitor genetic diversity across species, regions, and time to identify key genetic diversity.

**GENOMES**

The genetic diversity conservation community embraces the FAIR principles (data should be findable, accessible, interoperable, and reusable), which means that data collected for basic research can be reused for conservation and vice versa. Collaborations and increased capacity are helping to improve knowledge in understudied geographic regions.



## A simple and low cost tetra-primer ARMS-PCR method for detection of triazole-resistant *Aspergillus fumigatus* – Aleksandra Barać



**Background:** Invasive aspergillosis (IA) is a life-threatening fungal infection with high morbidity and mortality in immunocompromised individuals. When the early diagnosis is done, the first-line therapy with voriconazole is initiated promptly, while the itraconazole is mainly used in low-income, developing countries. The emergence of azole resistance became a serious problem worldwide and it is shown that infection with azole-resistant strains is associated with a higher rate of treatment failure, in some countries up to 90%. Acquired resistance in *Aspergillus fumigatus* may be developed by long-term azole therapy and exposure of the fungi to the azole fungicides, widely used in agriculture. Recent studies suggest that mutations in the *cyp51* gene, particularly TR34/L98H, are responsible for azole resistance. Therefore, the development of new methods for the rapid detection of triazole-resistance associated point mutations is crucially important for the improvement of aspergillosis management, and consequent decreased mortality and morbidity rates.

**Methodology:** The aim was to evaluate a simple and low-cost tetra-primer amplification refractory mutation system ARMS-PCR technique for detection of TR34/L98H mutations in the *cyp51A* gene of azole-resistant *A. fumigatus*. The tetra-primer ARMS-PCR assay optimized by four primers in one reaction consists of external primers for detection of tandem repeats in the promoter region and internal primers for detection of a point mutation in codon 98 (L98H) in the *cyp51A* gene of azole-resistant *A. fumigatus*. The specificity of TR34/L98H mutation detection was assessed by testing 36 clinical and environmental *A. fumigatus* strains.

**Results:** The tetra-primer ARMS-PCR assay from *A. fumigatus*, containing wild-type sequence (T allele) and L98H mutation at *cyp51A* (A allele), yielded two DNA fragments of 908 bp and 740 bp and two of 942 bp and 212 bp, respectively. None of the *A. fumigatus* isolates without the TR34/L98H mutation yielded false-positive results. The ARMS-PCR assay was 100% concordant with DNA sequencing results. Results confirmed that prevalence and screening of the TR34/L98H mutation in the *cyp51A* gene in *A. fumigatus* isolates may be determined by simple method in resource-poor settings.

**Conclusion:** Novel, inexpensive, rapid and simple ARMS-PCR assay by using tetra-primers is suggested as a reliable method for rapid detection of the TR34/L98H mutation in the *A. fumigatus* *cyp51A* gene in low-resource settings. The project contributed to strengthening national resources and national expertise in the diagnosis and treatment of invasive fungal infections as well as in promoting science at the national level.

**A simple and low cost tetra-primer ARMS-PCR method for detection of triazole-resistant *Aspergillus fumigatus***

Dr Sci. Med. Aleksandra Barać, Clinic for Infectious and Tropical Diseases, University Clinical Center of Serbia, Belgrade

*The world needs Science, and Science needs Women!*

**Background**

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**Methodology**



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References:  
 1. Stone JJ et al. (2018) Clinical implications of globally emerging azole resistance in *Aspergillus fumigatus*. *Philo Trans R Soc B* 373(1796):20180460.  
 2. J. J. de Hoog et al. (2019) Triazole resistance in *Aspergillus fumigatus*: recent insights and challenges for patient management. *Clin Microbiol Infect* 20(2):178-186.  
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# Application of artificial intelligence algorithms in biomedical image processing – Tijana Šušteršič



Artificial intelligence (AI) has the ability to detect hidden patterns in a dataset and is widely used in clinical diagnosis, treatment and prediction of disease developments. In numerous research studies of application of AI in the medical field, the primary focus is on sustainability and feasibility to incorporate various computer techniques of AI into modeling of medical information.

For these purposes, medical images from magnetic resonance imaging (MRI), computed tomography (CT) or ultrasound imaging are most often used as data.

The standard medical procedure, which uses a manual annotation of the region of interest by an expert doctor, has shown great variability and poor reproducibility. The originality of the proposed research lies in the use of deep learning, as a branch of AI, in the automation of the process of analysis of medical image processing, shortening the time for diagnosis as well as ensuring high accuracy and repeatability of results.

When it comes to pattern recognition in medical images, then Deep Convolutional Neural Networks (DCNN) are most commonly used. With a sufficiently large set of data, DCNN can learn to automatically extract relevant characteristics from training samples for a given task by iteratively adjusting its weighting coefficients. This study presented some of the main findings of application of AI in medicine:

- stratification of patients with carotid artery disease by analyzing clinical and personalized data, plaque and cerebral image processing and novel biomarkers (<https://taxinomis-project.eu/>);
- processing of ultrasound and CT images for early detection of cardiomyopathy (<https://silicofcm.eu/>);
- early detection of COVID-19 disease by classifying the clinical picture based on X-rays and convolutional neural networks and feeding it into personalized AI model for COVID-19 prediction in patients (<http://www.covidai.kg.ac.rs/>);
- segmentation and diagnosis of levels and sides of disc herniation based on MRI images, using U-net, AlexNet, ResNet5 and VGG16.

World Conference on Basic Sciences and Sustainable Development  
September 20–22, 2022, Belgrade, Serbia

## APPLICATION OF ARTIFICIAL INTELLIGENCE ALGORITHMS IN BIOMEDICAL IMAGE PROCESSING

Tijana Šušteršič<sup>1,2</sup>  
E-mail: [tijana@kg.ac.rs](mailto:tijana@kg.ac.rs)  
<sup>1</sup> Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia  
<sup>2</sup> Bioengineering Research and Development Center (BioIRC), Kragujevac, Serbia

Artificial intelligence has the ability to detect hidden patterns in a dataset and is widely used in clinical diagnosis, treatment and prediction of disease development. In numerous research studies of application of artificial intelligence in medical field, the primary focus is on sustainability and feasibility to incorporate various computer techniques of artificial intelligence into modeling of medical information. For these purposes, medical images from magnetic resonance imaging (MRI), computed tomography (CT) or ultrasound are most often used as data. The standard medical procedure, which uses a manual annotation of the region of interest by an expert doctor, has shown great variability and poor reproducibility. The originality of the proposed research lies in the use of deep learning, as a branch of artificial intelligence, in the automation of the process of analysis of medical image processing, shortening the time for diagnosis, as well as ensuring high accuracy and repeatability of results. When it comes to pattern recognition in medical images, then deep convolutional neural networks (DCNN) are most commonly used. With a sufficiently large set of data, DCNN can learn to automatically extract relevant characteristics from training samples for a given task by iteratively adjusting its weighting coefficients.

### STRATIFICATION OF PATIENTS WITH CAROTID ARTERY DISEASE

The automatic carotid artery (lumen and wall) segmentation has been done using SegNet and U-Net based deep convolutional networks. Image segmentation was performed to detect four classes in images - background, fibrous, calcified and lipid atherosclerotic plaque components. After segmentation, 3D model reconstruction was performed, mesh was created, and model was analyzed using Finite Element Method (FEM).

**H2020 EU TAXINOMISIS** - A multidisciplinary approach for the stratification of patients with carotid artery disease, <https://taxinomis-project.eu/>, January 2018 - December 2022.

### ULTRASOUND IMAGES PROCESSING FOR DETECTION OF CARDIOMYOPATHY

Proposed methodology included implementation of U-net neural network for LV segmentation in apical view and extraction of Left Ventricular Length, 2D - LV<sub>l</sub> [cm].

For M modal view analysis, template matching and edge detection were used, after which interventricular Septum Thickness, M-mode - IVS [cm], LV Internal Dimension, M-mode - LVID [cm], Left Ventricular Posterior Wall Thickness, M-mode - LVPW [cm].

**H2020-EU project, SILICOFCM** - In Silico trials for drug tracing the effects of sarcomeric protein mutations leading to familial cardiomyopathy <https://silicofcm.eu/> June 2018 - February 2022.

### PERSONALIZED MODEL FOR EARLY DETECTION OF COVID-19 DISEASE

Developed model uses machine learning methods to mine heterogeneous patient data to assess the disease progression of the patient infected with COVID-19 in the next couple of days. This tool works with the following data: demographic data, clinical image, blood test data, imaging data. The result of the model is prediction of the category risk of mortality. Additionally, developed patient specific lung models will focus on the spread of virus-laden to many regions of the lungs from the initial site of infection.

**CEI project COVIDAI** - Use Of Regressive Artificial Intelligence (AI) And Machine Learning (ML) Methods in Modelling Of Covid-19 Spread, <http://www.covidai.kg.ac.rs/>, July 2020 - December 2022.

### SEGMENTATION AND CLASSIFICATION OF DISCUS HERNIA

The proposed methodology consisted of four steps: 1) Segmentation of region of interest (ROI) - U-net convolutional neural network is used to extract the disc area in axial and sagittal view MRI images, 2) Bounding box cropping - contour recognition and creating bounding boxes around the segmented area to reduce the search area for the CNN during classification, 3) ROI Enhancement - improvement of the contrast of the ROI, 4) Data augmentation - increasing the number of images for training and validation.

5) Classification - the image is classified into adequate classes (healthy, bulge, central, right or left herniation for axial view and healthy, L4/L5, L5/S1 level of herniation on sagittal view).

**Acknowledgment:** This research is funded by Serbian Ministry of Education, Science, and Technological Development [451-03-66/2012-14/2020/07 (Faculty of Engineering, University of Kragujevac)]. This research is also supported by the projects that has received funding from the European Union's Horizon 2020 research and innovation programmes under grant agreements No. 751320 (TAXINOMISIS), No. 777204 (SILICOFCM) and No. 952603 (SGABLU). This research was also supported by the CEI project "Use of Regressive Artificial Intelligence (AI) and Machine Learning (ML) Methods in Modeling of COVID-19 spread - COVIDAI" [Grant Nr. 306-K019-20]. T. Šušteršič also acknowledges the support from L'ORéal-UNESCO "For Women in Science" National Fellowship program Serbia (2021 Fellows).



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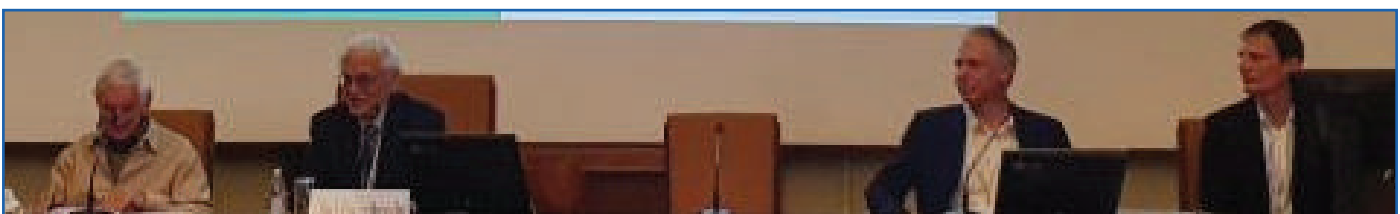
## Sport-related differences in QT dispersion and echocardiographic parameters in male athletes – Emilija Stojanović



This study aimed to compare QT dispersion (QTd) and echocardiographic parameters in male athletes competing across different sports and a control population. A total of 173 subjects voluntarily participated in this study, including long-distance runners (n = 12), volleyball athletes (n = 14), footballers (n = 39), powerlifters (n = 26), bodybuilders (n = 39), and sedentary controls (n = 43). QTd structural and functional cardiac parameters were measured. One-way analyses of variance (ANOVA) with Bonferoni post-hoc tests and partial eta squared ( $\eta_p^2$ ) were used to identify significant differences and quantify the effect sizes between groups for all outcome measures, respectively. ANOVA revealed significant moderate-strong differences ( $p < 0.001$ ,  $\eta_p^2 = 0.52-0.71$ ) in corrected QTd, intraventricular septal wall thickness (ISWT), posterior wall thickness (PWT), relative wall thickness (RWT) and LV (left ventricular) index between groups. Powerlifters and bodybuilders displayed significantly ( $p < 0.001$ ) higher corrected QTd, ISWT, PWT and RWT compared to other athlete groups and controls. While all athlete groups exhibited a significantly higher LV index ( $p < 0.05$ ) compared to controls, only long-distance runners, volleyball athletes, and footballers displayed a significantly ( $p < 0.001$ ) lower corrected QTd compared to controls. Long-distance runners (58% and 33%), volleyball athletes (50% and 50%), and footballers (56% and 41%) displayed mostly normal geometric pattern or eccentric LV hypertrophy (LVH). In contrast, powerlifters (58%) and bodybuilders (54%) displayed mostly concentric LVH. Although significant disparities ( $p < 0.05$ ) were observed in functional echocardiographic parameters across groups, effect size analyses revealed that the differences were minimal ( $\eta_p^2 = 0.09-0.22$ ) in magnitude. Advanced LVH, predominantly concentric in nature, appears to be accompanied with increased QTd in powerlifters and bodybuilders. On the other hand, runners, volleyball athletes, and footballers displayed LVH toward the upper threshold of the normal reference range accompanied by a shorter QTd compared to other groups.



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# Natural waveguides on *Hoplia argentea* elytra


– Danica Pavlović



Advanced optical and photonic structures, such as microlenses, photonic crystals and diffraction gratings, have been found on many insect species, enabling their survival in a hostile environment. This study reported on *Hoplia argentea* scarab beetle, whose non-iridescent yellow-green coloration is achieved by the scales with internal Bragg reflector and the external surface covered with a dense arrangement of fiber-like protrusions.

Light, which is guided, diffracted and selectively absorbed outside the green part of the spectrum, produces a dull, yellow-green appearance, making the insect unnoticeable on the background of green foliage, its natural habitat. If exposed to water, the insect quickly turns brown-red, making him unnoticeable on the wet soil. The structures have been analyzed using electron and optical microscopy and a finite element method devised revealing that the fine fiber-like surface structures preclude the iridescence of internal Bragg grating. As a result, the insect color is constant irrespective of the illumination and observation directions. In spite of the dense surface structure, the insect is not superhydrophobic, but rather hydrophilic, enabling a fast color change in wet conditions.


This poster was co-authored by Branislav Salatić, Svetlana Savić-Šević, and Dejan Pantelić, Institute of Physics, Belgrade, Serbia, and Nikola Vesović and Srećko Ćurčić, Faculty of Biology, University of Belgrade, Serbia.



## Natural waveguides on *Hoplia argentea* elytra

D. Pavlović<sup>1</sup>, B. Salatić<sup>1</sup>, S. Savić-Šević<sup>1</sup>, N. Vesović<sup>2</sup> and D. Pantelić<sup>1</sup>

<sup>1</sup>Institute of Physics, University of Belgrade, Serbia  
<sup>2</sup>University of Belgrade - Faculty of Biology



Light waveguides are structures with a role in receiving and channeling light and filtering certain wavelengths of the electromagnetic spectrum. That's how it comes to light capturing and local reinforcement of its intensity, which can be further utilized for various purposes (e.g. conducting light to pigments in the eye, forming structural coloration, etc.). Based on their geometric structure waveguides can be planar or linear (banded or fibrous).

Microstructures with a waveguide role have been studied a lot in the living world. Structures with a function of optical waveguides have also been discovered in insects. They can be found on antennae, in complex eyes, on wing scales and other parts of the body, and can work as integral part of light or IR receptors, thermoregulatory systems, or can play an important role in the formation of structural coloration.

Here we present cuticular structures on beetle elytra (Insecta: Coleoptera) that produce structural coloration thanks to morphology and function of light waveguides. *Hoplia argentea* from family Rutelidae was used as a model organism. We found out that individuals of this species possess linear type of waveguides on its front hardened wings, which are responsible for the production of structurally green coloration.

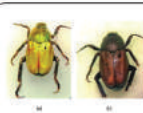


Fig. 1. *Hoplia argentea*. The two species (red elytra and black elytra).

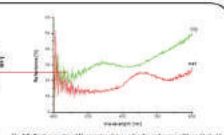


Fig. 2. Distribution spectra of *H. argentea* elytra under dry and wet conditions. Under dry conditions, the spectra show a peak at approximately 550 nm, which shifts to a longer wavelength (around 600 nm) when the elytra are wet.

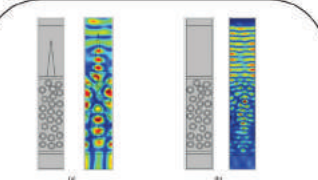


Fig. 3. Schematic of *H. argentea* wing scales and distribution of radiation. (a) Model of scale with hairs (left) and radiative distribution (right) which is introduced from the structure through the hairs (red arrow); (b) Model of hairless scale (left) and uniform distribution of radiation (right) and loss structures of radiation inside the scale.

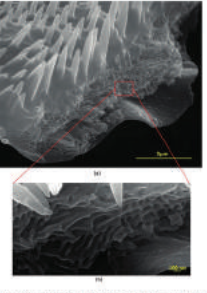


Fig. 4. SEM micrographs of the *H. argentea* scales and its fiber structures at different scales with numerous networks of interconnected tubular fibers by lateral ridges at higher magnification.

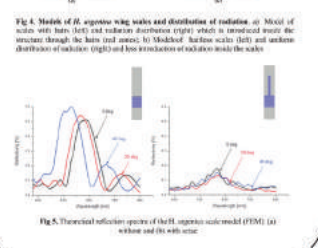


Fig. 5. Theoretical reflection spectra of the *H. argentea* scales model (FEM) (a) without and (b) with scale.

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**Acknowledgments**

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# Antibiotic exposure at the site of infection: Role of microdialysis in treatment optimization – Ana Tomas Petrović



The outcome of antibiotic treatment depends on several complex interactions between the infectious agent, antimicrobial drug, and host defense mechanisms, and the treatment outcome shows high variability of the dose-response relationship. Antibiotics can exert their therapeutic action only with adequate penetration at the infection site. Multiple factors, such as rate of protein binding, drug liposolubility, and organ blood flow all influence the ability of antibiotics to penetrate into target tissues. Microdialysis ( $\mu$ D) is an *in vivo* sampling technique that has been successfully applied to measure the distribution of antibiotics in the interstitial fluid of various tissue sites both in animal studies and clinical setting.  $\mu$ D enables continuous *in vivo* sampling and provides direct measurement of unbound concentration-time profile of antibacterials in the interstitial fluid. Our experience with  $\mu$ D shows that this method is suitable for sampling not only antibiotics but also substances that can potentiate antibacterial activity of conventional drugs.

Multiple advantages such as excellent replicability, high temporal resolution, continual and prolonged sampling time, and simple preparation of samples for analysis make  $\mu$ D superior to standard PK sampling methods. However, highly sensitive quantification methods are necessary because of small sample volumes. Clinical  $\mu$ D studies demonstrated that tissue concentrations for certain antibiotics and clinical conditions may be suboptimal despite adequate plasma levels. Standard tissue concentration measures based on tissue homogenates offer only values for total drug concentration (intracellular and extracellular) while for the majority of infections the interstitial free concentrations are relevant. Integration of  $\mu$ D-derived tissue pharmacokinetics with pharmacodynamic data offers crucial information for correlating exposure with antibacterial effect.

## Antibiotic exposure at the site of infection: Role of microdialysis in treatment optimization



For Women in Science

**Ana Tomas Petrović MD PhD**

Department of Pharmacology, Toxicology, and Clinical Pharmacology  
Faculty of Medicine, University of Novi Sad, Serbia



**Abstract**

The outcome of antibiotic treatment depends on several complex interactions between the infectious agent, antimicrobial drug, and host defense mechanisms, and the treatment outcome shows high variability of the dose-response relationship. Antibiotics can exert their therapeutic action only with adequate penetration at the infection site. Multiple factors, such as rate of protein binding, drug liposolubility, and organ blood flow all influence the ability of antibiotics to penetrate into target tissues. Microdialysis ( $\mu$ D) is an *in vivo* sampling technique that has been successfully applied to measure the distribution of antibiotics in the interstitial fluid of various tissue sites both in animal studies and clinical setting.  $\mu$ D enables continuous *in vivo* sampling and provides direct measurement of unbound concentration-time profile of antibacterials in the interstitial fluid. Our experience with  $\mu$ D shows that this method is suitable for sampling not only antibiotics but also substances that can potentiate antibacterial activity of conventional drugs. Multiple advantages such as excellent replicability, high temporal resolution, continual and prolonged sampling time, and simple preparation of samples for analysis make  $\mu$ D superior to standard PK sampling methods. However, highly sensitive quantification methods are necessary because of small sample volumes. Clinical  $\mu$ D studies demonstrated that tissue concentrations for certain antibiotics and clinical conditions may be suboptimal despite adequate plasma levels. Standard tissue concentration measures based on tissue homogenates offer only values for total drug concentration (intracellular and extracellular) while for the majority of infections the interstitial free concentrations are relevant. Integration of  $\mu$ D-derived tissue pharmacokinetics with pharmacodynamic data offers crucial information for correlating exposure with antibacterial effect.

**Pharmacokinetics/Pharmacodynamics (PK/PD)**



**Determining PK**

Therapeutic drug monitoring for antibacterials - Maximize effectiveness and minimize toxicity. Personalize dosing to attain antimicrobial exposures associated with a high probability of therapeutic success.

Application: PK has not been clearly studied (e.g. critically ill, significant comorbidities, elderly and extremes of body size), life-threatening infections, Decreased susceptibility of pathogens

Drug levels measured in blood (plasma) - Issue - what are antibiotic levels at the site of infection?

**Describing PD**

Identify bacteria - determine susceptibility- determine MIC - time-kill curves

**Microdialysis**

Microdialysis probe

placed in tissue (skin, subcutaneous fat, muscle, lung, brain)

Continuous sampling

Free unbound concentrations



Microdialysis principle

**Microdialysis applications**



**Our experience**

Placement of probe requires time & care

Large number of samples - equivalent to standard PK sampling - requires sample preparation prior to quantification

Difficult to place and to maintain

Quantification of ultrafiltrate requires prior to tissue homogenate

Small sample volumes

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**Antibiotic levels: blood or infection site?**



## Green solvents for sustainable processes

– Jelena Vladić

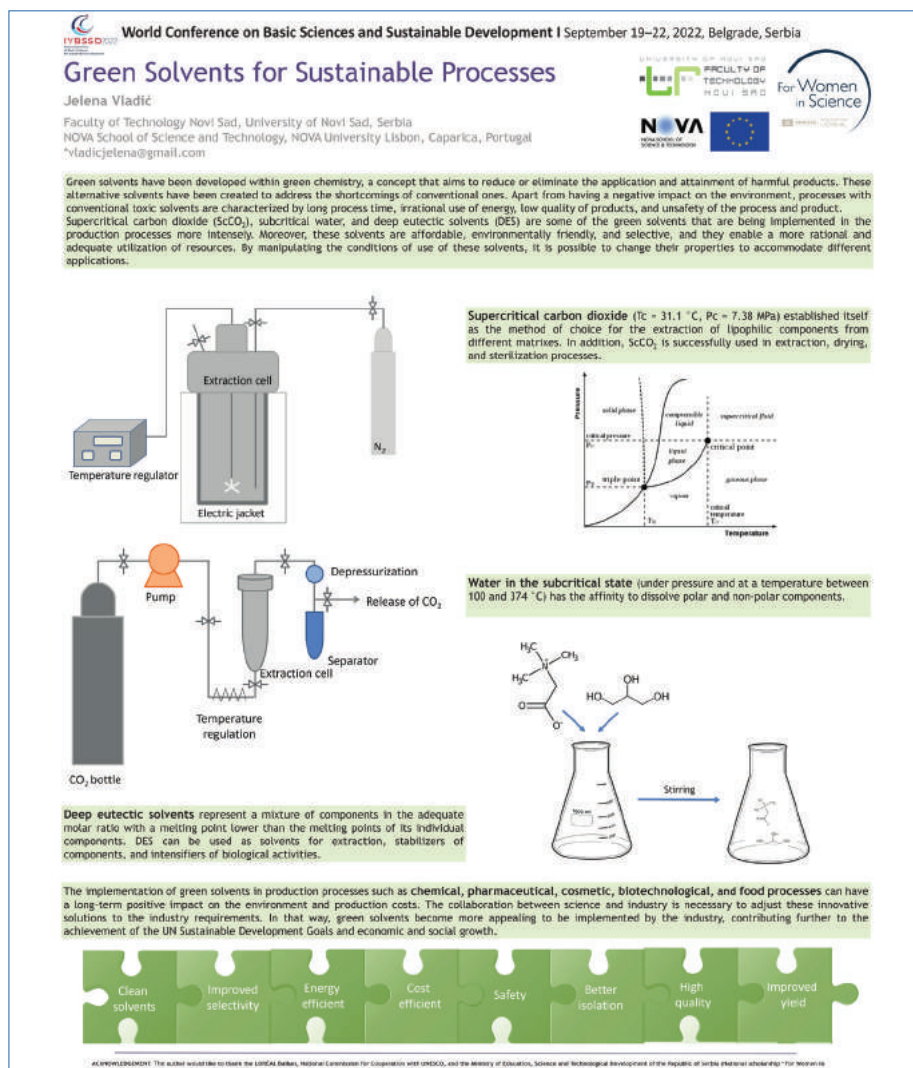


Green solvents have been developed within green chemistry, a concept that aims to reduce or eliminate the application and attainment of harmful products. These alternative solvents have been created to address the shortcomings of conventional ones. Apart from having a negative impact on the environment, processes with conventional toxic solvents are characterized by long process time, irrational use of energy, low quality of products, and unsafety of the process and product.

Supercritical carbon dioxide ( $\text{ScCO}_2$ ), subcritical water, and deep eutectic solvents (DESs) are some of the green solvents that are being implemented in the production processes more intensely. Moreover, these solvents are affordable, environmentally friendly, and selective, and they enable a more rational and adequate utilization of resources. By manipulating the conditions of use of these solvents, it is possible to change their properties to accommodate different applications.

Supercritical carbon dioxide ( $T_c = 31.1^\circ\text{C}$ ,  $P_c = 7.38\text{ MPa}$ ) established itself as the method of choice for the extraction of lipophilic components from different matrixes. In addition,  $\text{ScCO}_2$  is successfully used in drying and sterilization processes. Water in the subcritical state (under pressure and at a temperature between 100 and 374  $^\circ\text{C}$ ) has the affinity to dissolve polar and non-polar components. Deep eutectic solvents represent a mixture of components in the adequate molar ratio with a melting point lower than the melting points of its individual components. DESs can be used as stabilizers of components and intensifiers of biological activities.

The implementation of green solvents in production processes such as chemical, pharmaceutical, cosmetic, biotechnological, and food processes can have a long-term positive impact on the environment and production costs. The collaboration between science and industry is necessary to adjust these innovative solutions to the industry requirements. In that way, green solvents become more appealing to be implemented by the industry, contributing further to the achievement of the UN Sustainable Development Goals and economic and social growth.

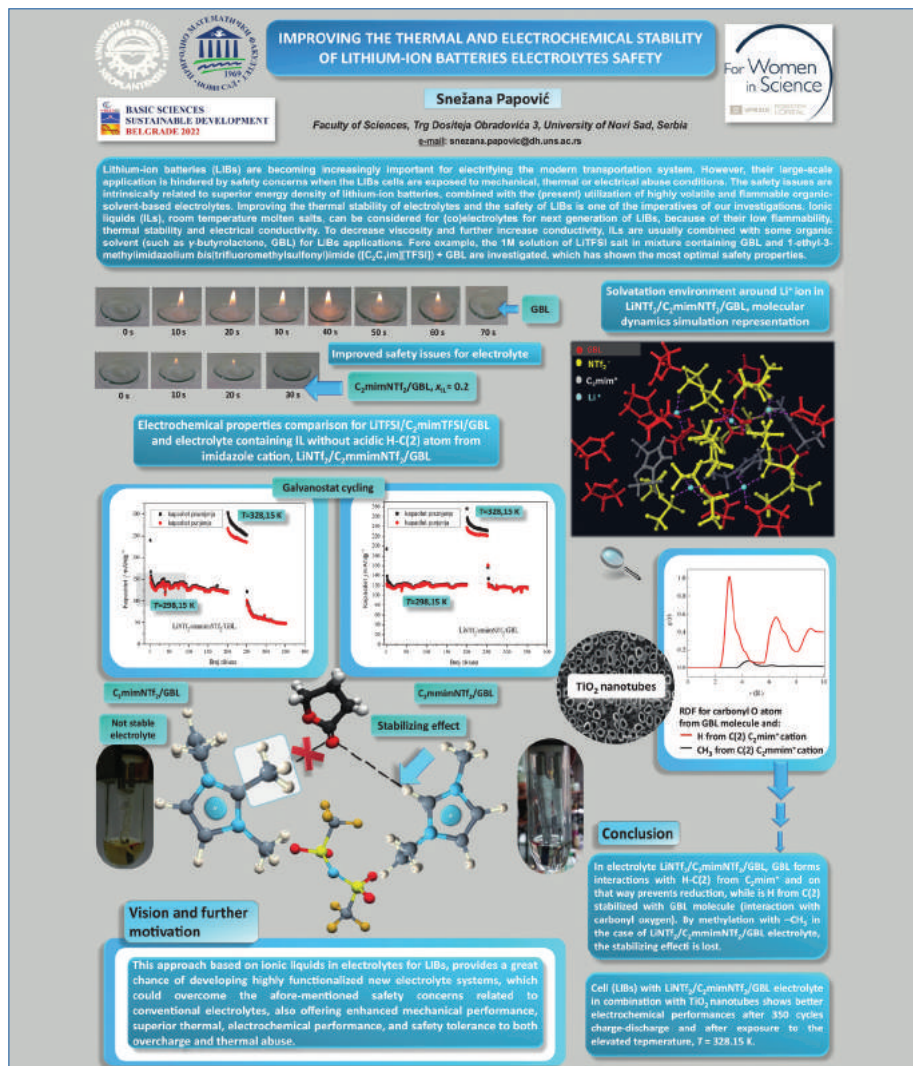


# Improving the thermal and electrochemical stability of lithium-ion battery electrolytes safety – Snežana Papović



Lithium-ion batteries (LIBs) are becoming increasingly important for electrifying the modern transportation system and, thus, hold the promise to enable sustainable mobility in the future. However, their large-scale application is hindered by severe safety concerns when the cells are exposed to mechanical, thermal, or electrical abuse conditions. These safety issues are intrinsically related to their superior energy density combined with the (present) utilization of highly volatile and flammable organic-solvent-based electrolytes. Improving the thermal stability of electrolytes and the safety of LIBs is one of the imperatives of our investigations.

The challenges, which have so far prevented the widespread replacement of organic carbonate-based electrolytes, will also be mentioned. Starting from rather “facile” electrolyte modifications by (partially) replacing the organic solvent or lithium salt and/or the addition of functional electrolyte additives, conceptually new electrolyte systems including ionic liquids (ILs) are considered. Ionic liquid/organic solvent mixtures are investigated as potential optimal electrolytes for LIBs that can combine low flammability, good thermal stability, and high electrical conductivity. That approach provides a great chance of developing highly functionalized new electrolyte systems, which may overcome the afore-mentioned safety concerns related to conventional electrolytes, also offering enhanced mechanical performance, superior thermal, electrochemical performance, and safety tolerance to both overcharge and thermal abuse.



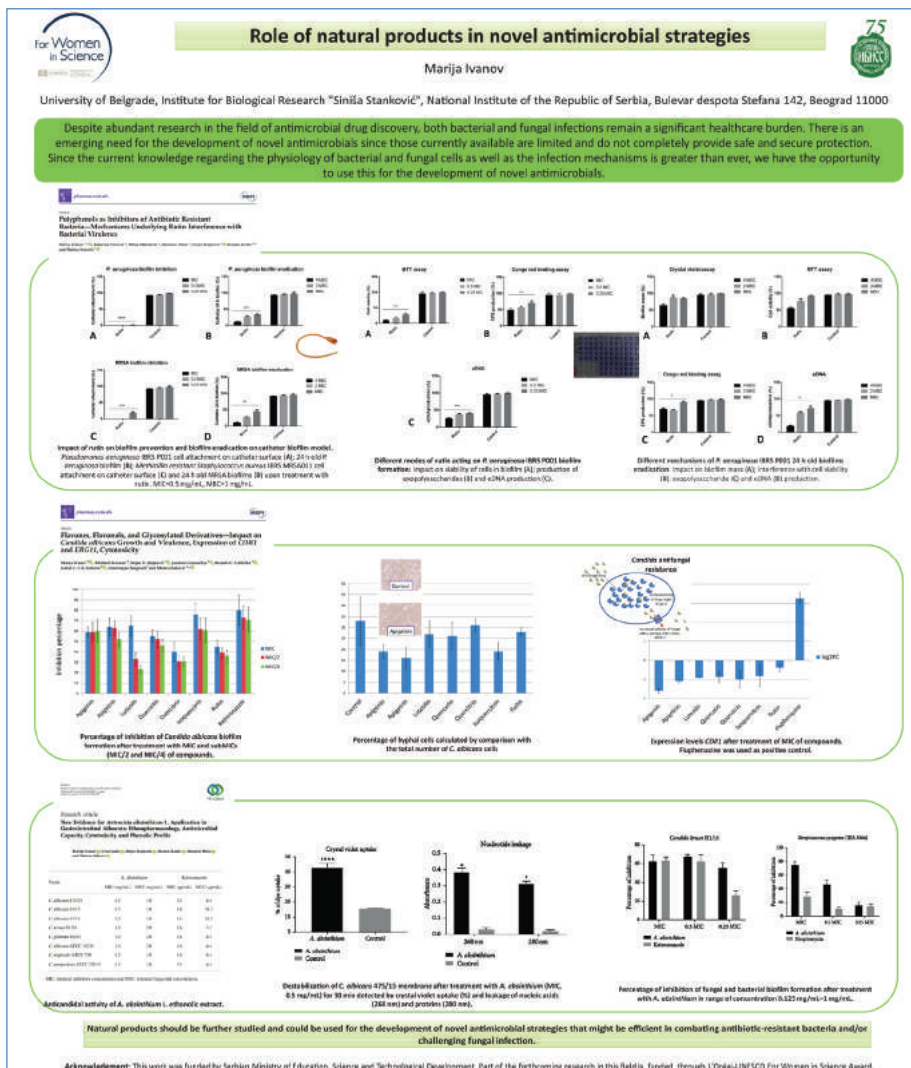
# Role of natural products in novel antimicrobial strategies

– Marija Ivanov



Despite abundant research in the field of antimicrobial drug discovery, both bacterial and fungal infections remain a significant healthcare burden. There is an emerging need for the development of novel antimicrobials since those currently available are limited and do not completely provide safe and secure protection. Since the current knowledge regarding the physiology of bacterial and fungal cells as well as the infection mechanisms is greater than ever, we have the opportunity to use this for the development of novel antimicrobials. The antimicrobial strategies studied nowadays include interference with antimicrobial resistance, interference with virulence factors, such as biofilms and hyphae, etc. One of the well-known natural products class are polyphenols, the molecules best known for their antioxidant activity. However, besides antioxidant activity, these plant bioactive compounds have shown a range of antimicrobial properties. It was observed that rutin, for instance, could reduce bacterial and fungal ability to group into biofilms. Likewise, in the biofilms formed by antibiotic resistant bacteria application rutin has reduced both bacterial viability and their ability to produce exopolysaccharides and extracellular DNA, the main components of biofilm matrix both linked to antibiotic resistance. Rutin also reduces the antibiotic resistant microorganism ability to adhere to skin keratinocytes. Additionally, this polyphenol, along with others from the flavonoid class, could be involved in the novel antifungal strategies as it reduces the range of virulence and resistance traits in the *Candida albicans*.

Natural products, including rutin, should be further studied and could be used for the development of novel antimicrobial strategies that might be efficient in combating antibiotic-resistant bacteria and/or challenging fungal infection.



## Concluding Session

### Personal remarks

#### – Michel Spiro

- Basic Sciences were advertised in their beauty and advancements.
- Sustainable Development was discussed as an urgent transformative need for the society.
- The links between the diverse Basic Sciences disciplines were advertised, especially through the birth of Interdisciplinary Basic Sustainability Sciences and co-constructed knowledge.
- This was a flagship event of the International Year of Basic Sciences for Sustainable Development gathering people with very different profiles, coming from all over the world!
- Curiosity-driven sciences re-enchant our world and make it worth to be sustainable. Scientific knowledge, technology and innovation shape our lives, our imagination, our hopes, our fears. But beyond, it is a common universal heritage.
- Global challenges (from components to system approach, from local to global approach, from short term to long-term approach, involving the society at large) are a unique opportunity to build a better world: improve well-being beyond just consuming, target global equity and a lively and healthy planet. Following further the current international mobilization, laws and treaties should be enacted towards these goals, based on a dialog between all stakeholders, including scientists.
- Business as usual is no more an option. Every scientist through his/her institution, especially when supported by public funds, and even if his research is curiosity and inquiry driven, must try to best connect to the society and should have in mind how his or her activity and findings could impact the world (responsibility), and might be of interest for contributing to make it better and not worse. However, scientists must be given the necessary funding and freedom and the right to collaborate with the other scientists in their field to conduct their research (science for peace) and be listened to at all levels of decision making and inspire that way the decision makers and the society at large. It is a balancing act to ensure societies trust their scientists and the knowledge they provide.
- Sustainability Sciences education of young people, which is multidisciplinary and integrative should be implemented in addition to the standard STEM education.
- Sustainability Sciences must be multi-disciplinary, integrative, collaborative, co-constructed and open. They could benefit for their organisation from models of organisation in Big Sciences and from the IPCC and IPBES model of interaction between scientists and decision makers. Circular economy fuelled by decarbonated energy could be the application target of Sustainable Sciences, with a lot of innovations and new practices needed.
- A decade of actions might be necessary to implement all that!
- This conference was a great event thanks to the World Academy of Arts and Sciences, The Club of Roma, the Serbian Academy of Sciences and Arts, the speakers, the audience, the organization and support and last but not least, the conductor Nebojša Nešković!!!



### MESSAGES OF THE INTERNATIONAL YEAR OF BASIC SCIENCES FOR SUSTAINABLE DEVELOPMENT

- Education in basic sciences at all levels develops curiosity, courage, creativity, and persistence in pupils, and thus considerably contributes to a proper development of their personalities and their forming as independent and responsible citizens.
- Involvement in basic research should be made possible to everyone who wants and can perform it, independently of his or her origin and social status.
- Results of basic research should be available to all those interested in them around the world.
- Basic research represents the initial link in the chain of research and development, which can only as a whole make nature and society sustainable.



## Concluding remarks

– **Nebojša Nešković**

The International Year of Basic Sciences for Sustainable Development (IYBSSD 2022) was initiated by the International Union of Pure and Applied Physics, whose President Michel Spiro is also the President of the Steering Committee of IYBSSD. The World Conference on Basic Sciences and Sustainable Development was initiated by the World Academy of Art and Science, whose President and Chief Executive Officer is Garry Jacobs. The organizers of the Conference were: UNESCO, the World Academy, the Serbian Academy of Sciences and Arts, the Club of Rome, the Ministry of Education, Science and Technological Development of Serbia, the World University Consortium, the Vinča Institute of Nuclear Sciences, and the Serbian Association of Economists. The hosting institution of the Conference was the Serbian Academy, whose President is Vladimir Kostić.

The program of the Conference was created by its Program Committee, whose Co-Chairs were Carlos Álvarez Pereira, Vice-President of the Club of Rome, Vladimir Kostić, President of the Serbian Academy, and myself. The dominant part of the job was done by Stevo Todorčević and Tanja Ćirković Veličković, from the Serbian Academy, Miroslav Adžić, from the Vinča Institute, Goran Milašinović, President of the Commission of Serbia for Cooperation with UNESCO, Luka Popović, from the Astronomical Observatory of Belgrade, and myself. The program of the Conference comprised 67 talks in 19 sessions and nine posters in three sessions. Besides, it included two exhibitions, by Matica Srpska and the company L'Oreal Balkan.

The Conference was organized by its Organizing Committee, whose Co-Chairs were Marijana Dukić Mijatović, the State Secretary in the Ministry, and Aleksandar Vlahović, President of the Association of Economists. The dominant contribution to the

organization was given by Marijana Dukić Mijatović and Aleksandar Jović, from the Ministry, Luc Allemand, Secretary General of the Steering Committee of IYBSSD 2022, Vladimir Kostić, President of the Serbian Academy, and myself.



The important contributions to the organization of the Conference were given by the Technical Team, from the Vinča Institute led by Sonja Jovanović, the team from the Belgrade Travel Agency led by Bojana Stanarčević, and the team from the public relations agency Represent Communications led by Tamara Ivanković. The financial resources for the organization of the Conference were provided dominantly by the Ministry, and also by the World Academy, the Serbian Academy, the company L'Oreal Balkan, and Jeff Ubois and Smiljana Antonijević.

I express my sincere gratitude to all the institutions and especially the individuals mentioned here for their concrete, valuable and significant efforts and contributions to the organization of the Conference. Our joint work was an honor and pleasure for me.

Finally, on behalf of the organizers of the Conference, I express my deepest gratitude to all the speakers and moderators at the event for their exceptional contributions to its program. I hope our joint effort and the results accomplished will be a clear message to political and business leaders worldwide that basic sciences represent the important initial link in the chain of research and development, without which life on the planet cannot be made inclusive, balanced and sustainable.



“How will the government of a country make an appropriate strategy of basic research and the corresponding investment plan? It can do that only on the basis of the proposals made by the scientific community of the country, *i.e.*, by its independent scientific institutes and such institutes within its universities and industry. This means that the social responsibility for creating, maintaining, actualizing and enhancing basic research lies primarily with the scientific community, individually and collectively, *i.e.*, with those who have committed themselves to the exploration of the unknown.”

– **Nebojša Nešković**



## List of participants

1. **Miroslav Adžić**, Department of Molecular Biology and Endocrinology, Vinča Institute of Nuclear Sciences, University of Belgrade, Serbia
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4. **Ugo Bardi**, The Club of Rome
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41. **Akio Matsumoto**, Faculty of Economics, Chuo University, Tokyo, Japan

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74. **W. Hugh Woodin**, Harvard University, Cambridge, MA, USA
75. **Huimin Zhao**, University of Illinois at Urbana-Champaign, IL, USA
76. **Jinfeng Zhou**, Secretary General, China Biodiversity Conservation and Green Development Foundation, Beijing, China
77. **Aleksander Zidanšek**, Jožef Stefan International Postgraduate School & Jožef Stefan Institute, Ljubljana, Slovenia; Faculty of Natural Sciences and Mathematics, University of Maribor, Slovenia; World Academy of Art and Science; The Club of Rome; President, Slovenian Association for The Club of Rome

## Opening Address

– Marijana Dukić Mijatović



On behalf of the Government of the Republic of Serbia and its Ministry of Education, Science and Technological Development, I am pleased to welcome you all once again in Belgrade, Serbia. It is my great honor to open this concert, as a special

part of the World Conference on Basic Sciences and Sustainable Development. We are glad that Serbia and its scientists have been recognized as a significant part of the world research and academic community in the field of basic sciences and given the opportunity to host this important conference in Belgrade as one of the main events within the International Year of Basic Sciences for Sustainable Development.

We are aware that progress is not possible without continuous access to new scientific knowledge and opportunities for collaboration with scientists and innovators around the world. For the scientific community of Serbia, this is an extraordinary opportunity to hear from the eminent experts in the field of basic sciences and sustainable development about the latest achievements of their research. In addition, the Conference will help Serbian researchers

to establish new collaborations with the colleagues from the best world scientific institutes and universities, and thus expand their international cooperation.

I am sure that you will have a successful work at the Conference and a pleasant stay in Belgrade. Tonight, we just want to add an artistic contribution to your stay in Belgrade by this small musical program, to be performed by eminent Serbian artists.

Music is both an art and a science, and music and science are closely related. Both use mathematical principles and logic, blended with creative thinking and inspiration to arrive at conclusions that are both enlightening and inspirational. It could be said that Science is the music of the intellect, and Music is the science of the heart. A music composition is basically a mathematical exercise. It is the interaction of sounds, tempo and pitch that creates music, just as the interaction of known facts and knowledge coupled with imagination, conjecture and inspiration produces new scientific discoveries. Both Science and Music use 'formulas' and 'theories' to solve problems, and to explore the intangible mysteries of life.

There are a number of scientific theories that try to explain music, but tonight, I am suggesting that you forget theories and formulas and just enjoy the music.





## Program

A concert at the Atrium of the National Museum in Belgrade was part of the World Conference on Basic Sciences and Sustainable Development. The concert was opened by Marijana Dukić Mijatović, and featured vocal and instrumental performances by three groups of specially chosen eminent Serbian artists—the Trmčić sisters, Bora Dugić and his group, and the Belgrade Chamber Choir conducted by Vladimir Marković.

Trmčić Sisters, Biljana and Ivana, perform primarily traditional Serbian songs. They have made a number of archive recordings of such songs for Radio Belgrade. They sang two of those pieces written by unknown authors: Hey, Kom Mountain and Three Girls Had a Chat.

Bora Dugić, the king of Serbian flute, has traveled the whole world with his instruments. This artist produces the flutes he plays by himself and performs mainly his compositions. He has released numerous CDs and given a very large number of concerts. He and his group performed five pieces: Go Down, Go Down (Bright Sun), written by Aleksandar Sarijevski, then his compositions Grasshopper, Elégie de Minuit and An Ordinary Balkan Day, and finally Skylark (Ciocârlia), written by Angheluș Dinicu. The first piece was played without an interruption of musical phrase to take breath.

The Belgrade Chamber Choir was founded more than 25 years ago. It performs dominantly spiritual music and music of European heritage. The Choir, with conductor Vladimir Marković, has represented Serbia in numerous European musical festivals. It played four pieces: We Praise Thee, composed by Zoran Mulić, Great Doxology, written by Apostol Nikolaev-Strumski, Locus Iste, composed by Anton Bruckner, and Royal Litany, written by an unknown author. The first song is part of the first and only existing liturgy in the Roma language.

The musical program was a perfect complement to the scientific discussions that comprised the Conference.



## Organizing institutions

### United Nations Educational, Scientific & Cultural Organization (UNESCO)



UNESCO seeks to build peace through international cooperation in education, sciences and culture. UNESCO's programmes contribute to the achievement of the Sustainable Development Goals defined in the 2030 Agenda, adopted by the UN General Assembly in 2015. UNESCO develops educational tools to help people live as global citizens free of hate and intolerance. UNESCO works to ensure that every child and every citizen has access to quality education. By promoting cultural heritage and the equal dignity of all cultures, UNESCO strengthens the bonds between nations. UNESCO fosters scientific programmes and policies as platforms for development and cooperation. UNESCO stands up for freedom of expression, as a fundamental right and a key condition for democracy and development. As a laboratory of ideas, UNESCO helps countries to adopt international standards and manages programmes that foster the free flow of ideas and the exchange of knowledge.

### World Academy of Art and Science (WAAS)



The World Academy of Art & Science was founded in 1960 by eminent intellectuals including Albert Einstein, Robert Oppenheimer, father of the Manhattan Project, Bertrand Russell, Joseph Needham, co-founder of UNESCO, Lord Boyd Orr, first Director General of FAO, Brock Chisholm, first Director General of WHO, and many others. The Academy serves as a forum for reflective scientists, artists, and scholars dedicated to addressing the pressing challenges confronting humanity today independent of political boundaries or limits, whether spiritual or physical—a forum where these problems can be discussed objectively, scientifically, globally, and free from vested interests or regional attachments to arrive at solutions that affirm universal human rights and serve the common good of all humanity. WAAS is founded on faith in the power of original and creative ideas—real ideas with effective power—to change the world.

### Serbian Academy of Sciences and Arts (SASA)



The Serbian Academy of Sciences and Arts (SASA) is the highest scientific and artistic institution in the Republic of Serbia, which, within the scope of its tasks, mission and objectives, develops and stimulates science, organizes and promotes fundamental and applied scientific research, and stimulates and promotes artistic activities. SASA is engaged in the production of works of national interest, such as Srpska enciklopedija (Serbian Encyclopedia), Rečnik Srpske akademije nauka i umetnosti (Dictionary of the Serbian Academy of Sciences and Arts), a national atlas and encyclopedias covering the fields of sciences and arts, as well as critical editions of the most important scholarly and literary works in the Serbian language, valuable works of music and the most important legal monuments. The publishing activities of the Academy are aimed at producing permanent and non-permanent publications in the fields of science, culture and art, sold to or exchanged with the organizations and institutions at home and abroad with which SASA has strong ties, particularly with international associations of national and state academies. In accordance with an agreement between the Republic of Serbia and Republika Srpska there is very strong cooperation with the Academy of Sciences and Arts of Republika Srpska.



## The Club of Rome (CoR)



The Club of Rome is a platform of diverse thought leaders who identify holistic solutions to complex global issues and promote policy initiatives and action to enable humanity to emerge from multiple planetary emergencies. The organisation has prioritised five key areas of impact: Emerging New Civilisations; Planetary Emergency; Reframing Economics; Rethinking Finance; and Youth Leadership and Intergenerational Dialogues. The Club of Rome was created to address the multiple crises facing humanity and the planet. Drawing on the unique, collective know-how of its 100 members—notable scientists, economists, business leaders and former politicians—it seeks to define comprehensive solutions to the complex, interconnected challenges of our world. As a network of thought leaders from a rich diversity of expertise, its members are committed to facilitating the difficult conversations and the bold actions required to confront the planetary emergency facing humanity and our common home. Its goal is to actively advocate for paradigm and systems shifts which will enable society to emerge from our current crises, by promoting a new way of being human, within a more resilient biosphere.

## Ministry of Education, Science & Technological Development of Serbia (MESTDS)

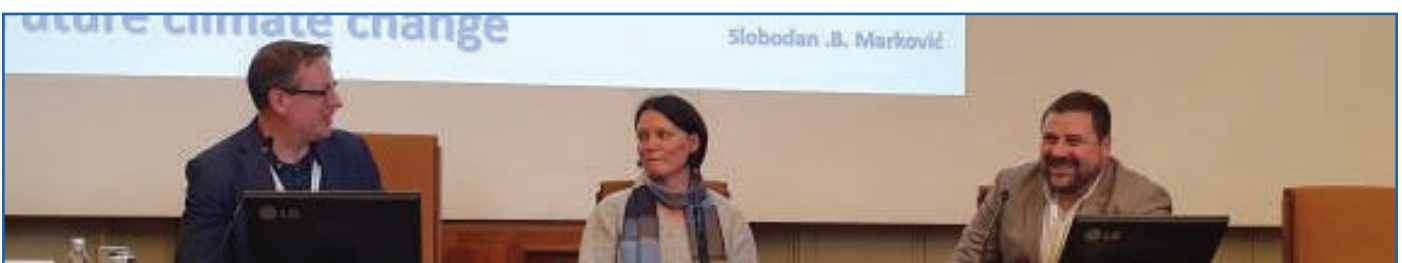


The Ministry of Education, Science and Technological Development carries out public administration activities related to: the system, development and promotion of scientific and research activities for the purposes of scientific, technological and economic development; defining and implementing the policies and strategies of scientific and technological development; defining and implementing the programmes of scientific, technological and development research; training scientific research staff; defining and implementing innovation policies; fostering techno-entrepreneurship and the transfer of know-how to the economy; developing and improving the innovation system in the Republic of Serbia; developing the scientific and research information system and scientific and IT infrastructure; defining the policies and strategy for building the information society; preparing laws, other regulations, standards and measures in the field of e-business; investigating the application of IT and the internet; providing IT services; developing and improving the academic computer network; coordinating the preparation of strategic and development documents at the national level; research in the field of nuclear energy; ensuring the safety of nuclear facilities; producing and disposing of radioactive materials, except in nuclear power plants, as well as other activities stipulated by the law.

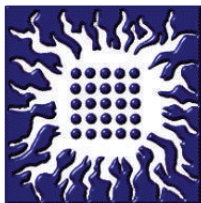
## World University Consortium (WUC)



The mission of World University Consortium is to evolve and promote development of accessible, affordable, quality higher education worldwide based on a human-centered approach that shifts the emphasis from specialized expertise to contextualized knowledge within a trans-disciplinary conceptual framework reflecting the complexity and integration of the real world, from teaching mastery of a field of knowledge to learning that enhances the capacity of students to think and discover knowledge for themselves, from theoretical mastery to acquisition of knowledge, skills and values relevant to each individual's personal development and career—an educational system better suited to develop the full potentials of social personality and individuality for productive engagement, social welfare and psychological well-being.



## Vinča Institute of Nuclear Sciences (VINS), Belgrade, Serbia



**Vinča Institute  
of Nuclear Sciences**

The Vinča Institute of Nuclear Sciences is a nuclear physics research institution near Belgrade, Serbia. Since its founding, the institute has also conducted research in the fields of physics, chemistry, and biology. The scholarly institute is part of the University of Belgrade. The Institute is regarded as Serbia's leading scientific institute in fundamental and applied research, owing to its size, scientific productivity, international reputation in research, and the quality of its scientific personnel and research facilities. It is unique in the multidisciplinary nature of its scientific capacities, with a unique infrastructure for the most ambitious research projects of strategic significance for the Republic of Serbia. The result of these

activities has made a direct contribution to the national economic development encompassing the major areas of health, defense, industry, and education. Vinča Institute has been actively involved in the conducting of basic, postgraduate and doctoral studies. The scientific staff of the Institute actively participates in the process of knowledge exchange in science-education model in Serbia. With extensive international scientific cooperation, the Vinča Institute promotes good will, strengthens the political image of the Republic of Serbia, and helps civil society and private business through projects that bear tangible results.

## Serbian Association of Economists (SAE)



Serbian Association of Economists (SAE) is a non-party and non-profit association of Serbian economists founded in 1947 with the aim of pursuing goals in the field of advancement of economic science and practice in Serbia. Since its foundation, SAE has been headed by the most prominent academics, economic practitioners and highest representatives of state administration and regulatory bodies. Today, SAE has successful cooperation with the Association of Economists of Vojvodina, as well as with associations of economists in Belgrade, Niš, Kraljevo, Kragujevac and Pirot, and gathers around 50 most notable enterprises, banks, other financial intermediaries and regulatory bodies. The operation of SAE is managed by its Presidency. It comprises 43 renowned economists working in the field of economy,

business consulting and at universities and regulatory bodies. The main activities of SAE are the following:

- organizing scientific assemblies, counseling meetings, seminars, round tables and thematic gatherings;
- publishing activity within the *Ekonomika Preduzeća* journal;
- knowledge transfer through education and training;
- cooperation with higher education institutions, regulatory and government bodies;
- cooperation with related organizations in the country and abroad.





## Conference Committees and Teams

### Program Committee

**Co-Chairs:**

Nebojša Nešković	Vladimir Kostić	Carlos Álvarez Pereira
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**Members:**

Shamila Nair-Bedouelle	Goran Milašinović	Michel Spiro	Luc Bergé
Garry Jacobs	Isaac P. Witz	Aleksander Zidanšek	Tanja Čirković Veličković
Stevo Todorčević	Ugo Bardi	Kristín Vala Ragnarsdóttir	Jinfeng Zhou
Aleksandar Baucal	Alberto Zucconi	Miroslav Adžić	Jasna Atanasijević

### Organizing Committee

**Co-Chairs:**

Marijana Dukić Mijatović	Aleksandar Vlahović
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**Members:**

Peggy Oti-Boateng	Antonia Jutronić	Luc Allemand
Stuart Palmer	Nebojša Nešković	Vladimir Kostić
Carlos Álvarez Pereira	Alberto Zucconi	Snežana Pajović

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*Marija Grujić*



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*Jelena Rmuš*



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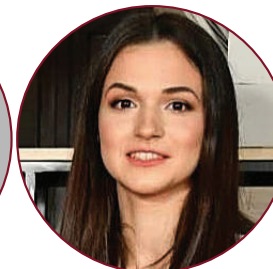
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