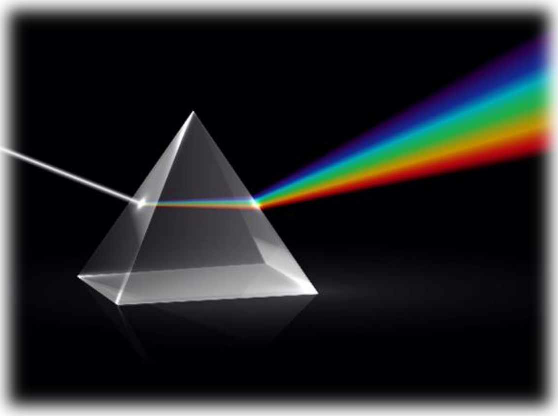
LIGHT for LIFE Seminar Series 2024

LIGHT-BASED PROCESSES AND TECHNOLOGIES FOR SUSTAINABLE FUTURE



Bulgarian Academy of Sciences, Sofia, Bulgaria,

Acad. G Bonchev Str. Bl. 21, floor 2, 16.05.2024, 9.50 – 16.00 h

Organizers:

- ➢ Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences
- ➢ Institute of Plant Physiology and Genetics, Bulgarian Academy of Sciences

Main topics:

- ➢ Light and living systems
- ➢ Light as a physical phenomenon

https://biomed.bas.bg/en/light-for-life-2024/

Program Committee:

- Prof. Sashka Krumova, IBPhBME-BAS
- Prof. Anelia Dobrikova, IBPhBME-BAS
- Prof. Emilia Apostolova, IBPhBME-BAS
- Prof. Violeta Velikova, IPPG-BAS
- Assoc. Prof. Kiril Mishev, IPPG-BAS

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- Web design: Assoc. Prof. Vassia Atanassova, IBPhBME-BAS
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Invited speakers:

Assoc. Prof. Stoyno Stoynov – Institute of Molecular Biology "Rumen Tsanev", Bulgarian Academy of Sciences, Sofia, Bulgaria
https://dnarepair.bas.bg/index.php/stoynov/

Velislav Stoyanov & Georgi Bojinov – High School of Mathematics and Science "Acad. Sergey Korolyov", Blagoevgrad, Bulgaria

Prof. Alexander Ivanov – Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Sofia, Bulgaria; Department of Biology, University of Western Ontario, London, Ontario, Canada
https://biomed.bas.bg/en/alexander-ivanov/

Prof. Petar Lambrev – HUN-REN Biological Research Centre, Szeged, Hungary
https://www.researchgate.net/profile/Petar-Lambrev; http://cv.brc.hu/nb_lape_en.pdf

Assoc. Prof. Krasimir Velinov – Bulgarian National Committee on Illumination (BNCI), Sofia, Bulgaria
https://bnci.eu/index_EN.htm

Assoc. Prof. Violeta Madjarova – Institute of Optical Materials and Technologies "Acad. Jordan Malinowski", Bulgarian Academy of Sciences, Sofia, Bulgaria
https://www.researchgate.net/profile/Violeta-Madjarova

Assoc. Prof. Nikolay Tzvetkov – Institute of Molecular Biology "Rumen Tsanev", Bulgarian Academy of Sciences, Sofia, Bulgaria
https://www.researchgate.net/profile/Nikolay-Tzvetkov-2

Christian Naydenov – "Thomas Jefferson" Secondary High English School, Sofia, Bulgaria

Scientific program

9.50 – 10.00	Opening	
10.00 – 12.00	*Session I: Light and living systems*	
10.00 – 10.30	Image Life, Discover the Future	*Stoyno Stoynov*
10.30 – 11.00	Bioluminescent Processes – from Organisms to Practical and Medical Applications	*Velislav Stoyanov, Georgi Bojinov, Ljubomira Petkasheva, Milena Slavkova*
11.00 – 11.30	Light Harvesting in Photosynthesis Observed on Femtosecond Timescales	*Petar H. Lambrev, Parveen Akhtar, Hoanh Long Nguyen, Thanh Nhut Do, Howe-Siang Tan*
11.30 – 12.00	Photosynthetic Advantages for Survival and Dominance of Evergreen Conifers in the Boreal Forest	*Alexander Ivanov*
12.00 – 13.00	Lunch break	
13.00 – 15.00	*Session II: Light as a physical phenomenon*	
13.00 – 13.30	Growing Plants under Artificial Light	*Krasimir Velinov, Svetlana Velinova*
13.30 – 14.00	Introduction to Optical Coherence Tomography and Its Applications in Biology and Medicine	*Violeta Madjarova*
14.00 – 14.30	Photoinduced Electron Transfer (PET) Processes and Their Use in Photo- and Supramolecular Chemistry	*Nikolay Tzvetkov*
14.30 – 15.00	Infrared Changes of Human Antebrachium during Physical Activity: an Experimental Model Proposal	*Christian Naydenov*
15.00 – 16.00	Reception	

Image Life, Discover the Future

Stoyno Stoynov

Institute of Molecular Biology "Acad. Roumen Tsanev", Bulgarian Academy of Sciences, Sofia, Bulgaria

Over three centuries following van Leeuwenhoek's unprecedented observations of the microworld, microscopy has become a pillar of cellular and molecular biology. It is in the past three decades that we have seen technical advances in microscopy usher in new methodologies, which made possible a boom in novel discoveries regarding how cells, tissues, and organisms function. One seminal advance was the possibility to label a protein of interest with a fluorescent protein (e.g. GFP), which allowed scientists to follow its localization, dynamics, and interactions. Nowadays, this can be done on the single-molecule level. Further, advanced microscopy techniques now allow us to overcome the diffraction limit of light, providing us with a view at an angstrom spatial resolution and temporal resolution of milliseconds. Herein, we will touch on the novel advances in light microscopy and their applications in the life sciences.

Bioluminescent Processes – from Organisms to Practical and Medical Applications

Velislav Stoyanov, Georgi Bojinov, Ljubomira Petkasheva, Milena Slavkova

High School of Mathematics and Science "Acad. Sergey Korolyov", Blagoevgrad, Bulgaria

The project presents a detailed analysis of bioluminescence – a phenomenon in nature where certain organisms exhibit the ability to emit light. It discusses the mechanisms behind this process, including the chemical reactions and photoproteins, with luciferin being the primary actor in these reactions. The diversity of organisms utilizing bioluminescence is emphasized, encompassing both marine and terrestrial life forms. Applications of bioluminescence in medicine, ecology, and technology are also examined. The project concludes with a summary of the potential of bioluminescence for future scientific research and technological innovations.

Light Harvesting in Photosynthesis Observed on Femtosecond Timescales

Petar H. Lambrev[1], Parveen Akhtar[1], Hoanh Long Nguyen[2], Thanh Nhut Do[2], Howe-Siang Tan[2]

[1]HUN-REN Biological Research Centre, Szeged, Hungary
[2]School of Chemistry, Chemical Engineering and Biotechnology, Nanyang Technological University, Singapore

Photosynthetic organisms – plants, algae, and cyanobacteria – convert sunlight to chemical energy that is used to fixate carbon dioxide into biomass. Light is captured by the pigment-protein complexes of the thylakoid membranes – the photosystems I and II and various light-harvesting complexes (LHCs) associated with them. After absorbing a photon, the electronically excited pigments (chlorophylls and carotenoids) transfer its energy to other neighbouring pigments in a highly tuned and coordinated network encompassing hundreds of interconnected pigments. Ultimately the light-harvesting system is designed to deliver the excitation energy to the photosystem reaction centre, where it is stored in a photochemical reaction. The entire process can last only a few picoseconds (10-12 s) and elementary steps of energy transfer can be much faster – occurring on femtosecond timescales. Understanding the mechanisms and dynamics of energy and electron transfer has been a challenge in photosynthesis research for several decades. Recently, a number of breakthroughs have been made, thanks to advances in ultrafast optical spectroscopy, structural biology, and quantum theory of optical spectra. With the combination of two-dimensional electronic spectroscopy (2DES) and structure-based theoretical modelling, we have been able to map key steps in the light-harvesting processes in photosystem I and II and move closer to a complete experimentally verified kinetic model of the photosynthetic unit. This knowledge is indispensable for the future design of hybrid and artificial light-harvesting systems.

Photosynthetic Advantages for Survival and Dominance of Evergreen Conifers in the Boreal Forest

Alexander G. Ivanov[1,2]

[1]Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Sofia, Bulgaria
[2]Department of Biology, University of Western Ontario, London, Ontario, Canada

Evergreen conifers in boreal forests can survive extremely cold (freezing) temperatures during long dark winter and fully recover during summer. Unlike deciduous plants, boreal conifers retain their green needles (leaves) over the winter by maintaining their chlorophyll. They face the toughest challenge in February-March when sub-zero temperatures coincide with high solar radiation. To maintain a balance between the harvested and the utilised light energy, evergreen conifers deploy various mechanisms, often in parallel. These involve: 1. spill-over-mediated PSI-dependent excess energy quenching as a major component of sustained non-photochemical quenching; 2. up-regulation of the PSI-dependent cyclic electron flow and 3. up-regulation of alternative electron pathways with plastid terminal oxidase (PTOX) and flavodiiron (Flv) proteins identified as effective safety valves for excess electrons. An evolutionary and ecological perspective was used in integrating these mechanisms in all-inclusive photosynthetic alterations, which may contribute to new understanding of conifers winter survival, acclimation and dominance in the boreal forests.

Growing Plants under Artificial Light

Krasimir Velinov, Svetlana Velinova

Bulgarian National Committee on Illumination (BNCI), Sofia, Bulgaria

Is it profitable to grow plants in artificial light? Is it possible to grow plants in Antarctica? And on Mars? Is there industrial cultivation of vegetables under artificial light in Bulgaria? What should be the design of grow luminaires? Are tomatoes grown under such conditions tasty? For the conditions of Bulgaria, what is appropriate – growing vegetables, young plants or seeds? What about algae and their specific spectral requirements? What is the rate of their biomass production? How much energy is needed and where will we get it from?

This presentation attempts to answer these questions.

Introduction to Optical Coherence Tomography and Its Applications in Biology and Medicine

Violeta Madjarova

Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia, Bulgaria

Optical coherence tomography (OCT) is based on the interference in white light where the backscattered light from different positions within the studies object can be measured. The scanning in x-y plane allows for creating tomographic images in a similar manner to ultrasound echography, however with considerably better resolution in the range of 1-40 μm. Due to OCT's capacity to obtain tissue images, similar to histological in a nondestructive, non-ionizing, non-contact manner, the method was proposed in the early nineties of 20th century as a diagnostic method. Its high special resolution compared to ultrasound tomography and MRI established OCT as an early diagnostics tool in ophthalmology, gastroenterology, dermatology, dental medicine, as well as a research method in developmental biology, and many other fields. In this work different types of OCT systems will be presented: time-domain OCT; spectral domain OCT and swept source OCT. The latest development in OCT field will be presented, in particular OCT in developmental biology of plants.

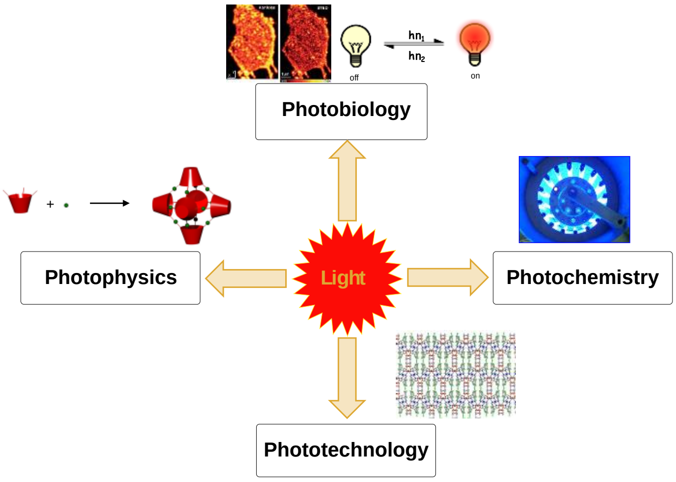
Photoinduced Electron Transfer (PET) Processes and Their Use in Photo- and Supramolecular Chemistry

Nikolay Tzvetkov

Department of Biochemical Pharmacology and Drug Design, Institute of Molecular Biology,
Bulgarian Academy of Sciences, Sofia, Bulgaria

Are the reactive oxygen species (ROS) “good” or “bad” and how useful they could be? The answer of this controversial question will be given in the LIGHT of the photoinduced electron transfer (PET) as a basic chemical process with diverse applications in photochemistry and supramolecular chemistry. Herein, a short overview of the photochemical reactions and their early use in the mid and late 20th century for synthesis of complex structures throughout the most advanced research and potential applications of PET reactions at the beginning of the 21st century will be presented.

During the last two decades of the 20th century, PET became successfully established in organic synthesis. Radical ions can easily be generated by an oxidative (radical cation ROS) or a reductive (radical anion ROS) single-electron transfer (SET) from neutral molecules. In photochemistry, such in situ generated ROS (via oxidative or reductive PET) play a key role for intramolecular cascade-domino-cyclization reactions leading to the formation of specifically condensed natural scaffolds, including polyquinanes (reductive PET: linear, angular, bridged triquinanes), steroids (oxidative PET), and many others. Most of these naturally occurred structures are tricyclic sesquiterpenes, found in plant, marine and microbial sources. Due to the complexity of unusual structural formation, the photochemical reactions, in which ROS are actively involved, belong to the so called “green” type of organic synthesis. In recent years, the intramolecular PET processes have attracted an increased interest due to the photophysical properties of supramolecular chemical systems like calix[4]arenes, resorc[4]arenes, fullerenes, and others. Some of these chemical structures and their application as photoswitches in photobiology will be shown and discussed.



Infrared Changes of Human Antebrachium during Physical Activity: an Experimental Model Proposal

Christian Naydenov

"Thomas Jefferson" Secondary High English School, Sofia, Bulgaria

INTRODUCTION: Light is an electromagnetic radiation which is visible to the naked eye only within the wavelengths of 0.4 μm and 0.7 μm. On the other hand, the human body emanates infrared illumination (3-20 μm), which can be detected by precise thermal sensors.

AIM: To establish an experimental model capable of detecting the infrared changes of the human antebrachium during physical activity.

MATERIAL AND METHODS: A healthy female volunteer, 51 years of age, BMI of 23.8, without a history of regular physical activity was asked to repetitively curl her fingers against pressure for 1 minute. Her antebrachium was measured before and immediately after the exercise by using an infrared camera - LWIR, 0.62 mRad IFOV, 0.06°C NETD.

RESULTS: We found a slight increase in the mean temperature of the skin overlying the antebrachial muscles immediately after the physical activity (Δt 0.026 °C). However, the difference between the maximal temperatures detected in a point was much greater (Δt 1.293 °C).

CONCLUSION: The physical activity of antebrachium results in a detectable increase of the skin temperature over the muscles. Additional number of participants is needed to confirm this initial observation.