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CONFERENCE REPORT

The 12th International Conference on "Photosynthesis and Hydrogen Energy Research for Sustainability 2024": in honour of John Allen, Eva-Mari Aro, İbrahim Dinçer, Kazunari Domen, Elizabeth Gantt, and Andrey Rubin

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Abstract

The 12th International Conference "Photosynthesis and Hydrogen Energy Research for Sustainability 2024" was organised in honour of John Allen, Eva-Mari Aro, İbrahim Dinçer, Kazunari Domen, Elizabeth Gantt, and Andrey Rubin, by Bahçeşehir University in Istanbul from 13 to 19 October 2024. The International Society of Photosynthesis Research (ISPR) and the International Association for Hydrogen Energy (IAHE) supported the event. In the brief report, we provide a summary of the conference, the scientific contributions of honoured scientists, and a brief content of individual sessions. We specifically focused on the participation of young researchers, their presentations and awards.

Keywords: artificial photosynthesis; hydrogen production; international conference; natural photosynthesis.

Highlights

- Natural and artificial photosynthesis towards sustainability solutions
- Hydrogen production research focused on biological and catalytic systems
- Photosynthesis and Hydrogen Energy Research for Sustainability – 2024

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Abbreviations: CBP – chlorophyll-binding protein; ELIP – early-light-induced protein; ISPR – International Society for Photosynthesis Research, LED – light-emitting diode; LHCI – Photosystem I-light harvesting complex I; OCP – orange carotenoid protein; ROS – reactive oxygen species; SMALP – styrene maleic acid lipid particle; XFEL – X-ray free-electron laser.

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Introduction

The global energy and food supply faces unprecedented challenges related to climate change, resource depletion, and increasing global energy and food demand. As the world population continues to grow and industrialize, the pressure on existing food and energy systems has become increasingly unsustainable, necessitating innovative approaches to energy production and consumption (D'Odorico *et al.* 2018). Nature provides a profound blueprint for sustainable energy production through photosynthesis, a process that has evolved over billions of years (Blankenship 2010). The fundamental principle underlying photosynthetic energy conversion involves capturing solar radiation and transforming it into chemical bonds. Photosynthetic organisms convert solar energy into chemical energy with remarkable efficiency, offering critical insights for developing renewable energy technologies (Janssen *et al.* 2014). To cope with climate change, it is necessary to examine new strategies to improve plant photosynthesis by targeting both intrinsic photosynthetic limitations and external environmental factors (Hussain *et al.* 2021). Photosynthetic research is extremely complex, addressing, for example, the structure and function of Photosystems I and II (Nelson and Yocum 2006) or the cytochrome b_6f complex (Baniulis *et al.* 2008), the regulatory network of photosynthesis (Foyer *et al.* 2012) or photoinhibition and repair mechanisms (Li *et al.* 2018). By mimicking natural processes, scientists are developing advanced technologies that could revolutionise energy production. Artificial photosynthetic systems aim to replicate the water-splitting mechanism found in plants, potentially generating hydrogen and oxygen through solar-driven reactions (Hou *et al.* 2023). Hydrogen production represents a critical pathway in transitioning toward sustainable energy systems. Unlike fossil fuels, hydrogen can be produced through renewable processes and offers a clean energy alternative with zero direct carbon emissions (Dincer and Acar 2018).

The 12th International Photosynthesis Conference on Hydrogen Energy Research and Sustainability 2024 was organised in honour of John Allen (UK), Eva-Mari Aro (Finland), İbrahim Dinçer (Canada), Kazunari Domen (Japan), Elizabeth Gantt (USA), and Andrey Rubin (Russia), at Bahçeşehir University South Campus, Istanbul from 13 to 19 October 2024. The conference represented a comprehensive forum for exploring multidisciplinary research domains encompassing photosynthesis and hydrogen energy. The scientific program provided an extensive overview of research methodologies and findings, from molecular interactions to global ecological implications related to the photosynthetic process. Participants presented and discussed their research results, covering areas from fundamental structural and mechanistic studies, up to applied aspects of crop research and artificial photosynthesis. The event facilitated extensive networking amongst researchers specialising in photosynthesis and hydrogen energy generation from diverse geographical locations worldwide. The interdisciplinary meeting provided an invaluable platform for students, postdoctoral scholars, and established scientists to enhance their expertise, broaden their professional networks, cultivate novel opportunities, and forge collaborative research partnerships. In total, scientists from twenty-four countries attended the event (Australia, Azerbaijan, Canada, China, Czech Republic, Estonia, Finland, France, Germany, Hungary, India, Iran, Israel, Italy, Japan, Kazakhstan, New Zealand, Poland, Russia, Slovakia, Sweden, Turkey, USA, and UK). Altogether, 152 authors contributed to the conference, of which more than 50 were speakers presenting their work as lectures.

The conference continues the tradition of bringing together researchers from the photosynthesis research domain, starting from the first meeting held in Canada (2004), and later conferences in Russia (2006, 2014, 2016, and 2019), Azerbaijan (2011, 2013, and 2018), Greece (2015), India (2017), and Turkey (2023), as presented in several reports (Allakhverdiev *et al.* 2011, 2013, 2014, 2015, 2019; Tsygankov *et al.* 2017, Borisova-Mubarakshina *et al.* 2020, Subramanyam *et al.* 2024).

We are pleased to present the profiles of exceptional distinguished personalities whose remarkable achievements and contributions were commemorated at the scientific event, highlighting their accomplishments and the recognition they have received.

John F. Allen

University College London, UK

John F. Allen (Fig. 1) obtained his PhD from King's College London in 1975. In 1973, he discovered that superoxide is the initial product of photosynthetic reduction of oxygen in chloroplasts. In 1975, he demonstrated that ferredoxin reduces oxygen to superoxide, and subsequently to peroxide (Allen and Hall 1973). In 1980, while working as a postdoc at Warwick University and the University of Illinois, Allen found that light-dependent phosphorylation of the major chloroplast light-harvesting protein occurs through protein kinase activation by the reduced form of plastoquinone. This discovery explained state transitions – how absorbed excitation energy is redistributed between

Fig. 1. John F. Allen. Photo courtesy of John F. Allen, UK.

Photosystem I and Photosystem II – and opened a new field of his research (Allen *et al.* 1981). During his academic career at the universities of Oxford, Leeds, Oslo, Lund, and Queen Mary University of London, Allen made several key contributions to understanding photosynthesis. His research focused on redox control of chloroplast transcription (Allen and Pfannschmidt 2000), the role of redox processes in organelle genome function (Allen 2015), and the origin and evolution of oxygenic photosynthesis (Dagan *et al.* 2013). In recognition of his scientific achievements, Allen was elected a Fellow of the Linnean Society of London in 2009. His work has been instrumental in advancing our understanding of the molecular mechanisms underlying photosynthetic processes.

Eva-Mari Aro

University of Turku, Finland

Eva-Mari Aro (Fig. 2) obtained her PhD from the University of Turku in Finland, focusing on the molecular components of thylakoid membranes and chloroplast ultrastructure in bryophytes (Aro *et al.* 1987). In 1987, she became a tenured associate professor at the University of Turku, and in 1998, she was appointed full professor. Aro's research primarily concentrated on Photosystem II photoinhibition and repair (Aro *et al.* 1993). Her most significant contributions include the detailed characterisation of protein components in PSII complexes. She discovered and described key proteins involved in PSII repair, elucidating the molecular interactions and pathways responsible for removing damaged PSII complexes and assembling new functional ones (Aro *et al.* 2005). Her research group also contributed to new knowledge related to the regulation of light harvesting and redox signalling in chloroplasts (Rintamäki *et al.* 2000) and the molecular basis of photoprotection under fluctuating light (Tikkanen *et al.* 2010, Suorsa *et al.* 2012). Aro's impact extends beyond her research findings. She has mentored numerous PhD students and cultivated extensive international collaborations, profoundly influencing the global photosynthesis research community. Her work has significantly advanced our understanding of photoprotection mechanisms and the adaptive capabilities of photosynthetic systems. She was honoured as an Academician of Science in 2017 and Commander First Class of the Order of the Lion of Finland in 2019. She was elected a member of the Finnish Academy of Science and Letters in 2002 and the Finnish Technical Sciences Academy in 2012. In 2018, Aro was elected as a Foreign Associate of the US National Academy of Sciences (NAS), and in 2023 she was awarded a Foreign Fellowship of the Royal Society (LDN).

İbrahim Dinçer

Ontario Tech University, Oshawa, Canada

İbrahim Dinçer (Fig. 3) is a distinguished professor of mechanical engineering at Ontario Tech University in Canada, widely recognised as a leading scientist in clean energy research, particularly in hydrogen technologies and

Fig. 2. Eva-Mari Aro. Photo courtesy of Eva-Mari Aro, Finland.

Fig. 3. İbrahim Dinçer. Photo courtesy of İbrahim Dinçer, Canada.

sustainable energy systems. Throughout his distinguished career, Dinçer has significantly contributed to hydrogen research, focusing on thermodynamic analysis, energy efficiency, and sustainable energy technologies. In his work, he systematically analysed various hydrogen production techniques, emphasising the importance of renewable energy integration and environmental sustainability (Dincer and Acar 2015). Dinçer's research has been particularly noteworthy in exploring innovative hydrogen production strategies, such as thermochemical water-splitting cycles (Safari and Dincer 2020). Another significant contribution came through his extensive studies on energy and exergy analyses of hydrogen systems (Dincer 2002). His commitment to sustainable development is also evident in his work on hybrid renewable energy systems. Beyond research publications, Dinçer has been shaping the global discourse on clean energy through numerous books and international conference presentations. His group has developed various novel technologies for

commercialisation. He is an active member of international scientific organisations and societies and serves as editor-in-chief, associate editor, regional editor, and editorial board member of various prestigious international journals. Dr. Dinçer currently serves as President of the Hydrogen Technologies Association in Turkey and Chair of the Energy Working Group at the Turkish Academy of Sciences. Dr. Dinçer is a recipient of several research, teaching and service awards, including the Premier's Research Excellence Award in Ontario, Canada.

Kazunari Domen

Shinshu University and The University of Tokyo, Japan

Kazunari Domen (Fig. 4) is a highly renowned chemist specialising in heterogeneous catalysis and materials science. He received a PhD (1982) in chemistry from the University of Tokyo, after which he joined the Chemical Resources Laboratory at the Tokyo Institute of Technology. Later, he worked as a Special Contract Professor at Shinshu University (since 2017) and as a Professor at the University of Tokyo (since 2019). Kazunari Domen is interested in heterogeneous catalysis, especially in photocatalysts for water splitting. He has been developing photocatalysts with a very high quantum efficiency (Takata *et al.* 2020), visible light-responsive photocatalysts, Z-scheme photocatalysts, semiconductor photocatalysts, and some others (Maeda and Domen 2010, Hisatomi and Domen 2019). He also developed a pilot-scale solar hydrogen production system with a 100 m^2 light-receiving area and hydrogen-separation system (Nishiyama *et al.* 2021). His major research areas are physical chemistry, heterogeneous catalysis, and surface chemistry. He also worked on infrared spectroscopy of adsorbed species on heterogeneous catalysts and sum-frequency generation (SFG) spectroscopy of adsorbed species. Domen also developed various solid acid catalysts and microporous materials. He obtained several awards, such as the Catalysis Society of Japan Award (2007), The Chemical Society of Japan Award (2011, 2019), the Advance of Catalysis Award of the Asia-Pacific Association of Catalysis Societies (2022), the EIC Horizon Prize for “Fuel from the Sun: Artificial Photosynthesis” (2022), Heinz Heinemann Award of IACS (International Association of Catalysis Societies, 2024). In 2024, he was recognised as a Clarivate Citation Laureate in Chemistry.

Fig. 4. Kazunari Domen. Photo courtesy of Kazunari Domen, Japan.

Fig. 5. Elisabeth Gantt. Photo courtesy of Elisabeth Gantt, USA.

Elisabeth Gantt

University of Maryland, USA

Elisabeth Gantt (Fig. 5) received her PhD degree at Northwestern University, Evanston, Illinois, in 1963 and she worked as a biologist at the Smithsonian Institution (1966–1988) and Professor at the University of Maryland (1988–2007), recently as Distinguished Professor Emerita. She is best known for her work on the discovery and structural elucidation of phycobilisomes (Gantt *et al.* 1979, Gantt 1981), which revealed mechanisms associated with photosynthetic adaptations. Her work contributed to advancing our understanding of photosynthetic processes and pigment–protein complexes, providing important insights into the organisation of light-harvesting complexes and their role in photosynthetic energy transfer (Gantt and Lipschultz 1973, Mustardy *et al.* 1992). She paid special attention to carotenoid biosynthesis (Cunningham and Gantt 1998, 2001). Much of the work was carried out while she was still at the Smithsonian Institution but followed up at the University of Maryland. She has also been active in many other ways, serving numerous plant and algal societies, organising meetings and serving as an officer in recruiting new members. She also participated as a lecturer in high school science classes and trained some high school students during summer vacation breaks. As a professor of plant biology at the University of Maryland, she was recognised as a very effective teacher and honoured with a College of Life Sciences Service Award.

Andrey B. Rubin

Faculty of Biology, Moscow State University, Moscow, Russia

Andrey B. Rubin (Fig. 6), Professor of Biophysics at Moscow State University, has made significant contributions to the field of the biophysical aspects of photosynthesis, especially by developing theoretical models and experimental approaches to understand the complex processes involved in light energy conversion by plants and other photosynthetic organisms. He received his PhD in 1963 at Moscow State University and since 1976 he has been Professor and the Head of the Department of Biophysics at the Moscow State University.

In his research, he is concerned with the biophysics of photosynthesis, modelling and thermodynamics of complex systems, and cellular mechanisms of regulation at the molecular level (Antal and Rubin 2008, Rubin and Riznichenko 2009, Belyaeva *et al.* 2016). Qualitative stochastic models of the conformational mobility of proteins have been developed. The concept applied in these models is a step forward toward understanding the structural dynamic organisation of membrane proteins and links between the intramolecular dynamics and biological function of membrane proteins. His research also concerns applied aspects of biophysics in ecology and biotechnology, the development of biophysical methods of water quality evaluation and the detection of plant resistance to different injuring factors (high and low temperatures, fungal and viral diseases, chemical pollution, *etc*.).

He is an Academician of the Russian Academy of Sciences (2022), Chairman of the National Committee of Russian Biophysicists, Head of the Scientific Council on Biophysics of the Russian Academy of Sciences, member of the RAS Council on Space Biology and Biological Membranes, Laureate of the MV Prize Lomonosov for pedagogical activities of the teachers at Moscow University for 2018, Laureate of the K.A. Timiryazev Prize 2016, Distinguished Professor of Moscow State University (2001), Honoured Worker of the Higher School of the Russian Federation (1997), Laureate of the A.A. Krasnovsky Prize in the field of photochemistry and photosynthesis (1996), Laureate of the Lomonosov Prize of Moscow State University (1992), Laureate of the State Prize (1988). He is the author or co-author of more than 900 papers and 46 books.

Fig. 6. Andrey B. Rubin. Photo courtesy of Andrey B. Rubin, Russia.

Conference overview

The conference started with an opening ceremony in which the participants were greeted by the representatives of the host university and faculty, after which the conference was remotely opened by Julian J. Eaton-Rye, secretary of the International Society for Photosynthesis Research (ISPR) and the Chairman of the conference, as well as by the co-chairman Barry Bruce (USA), coordinator of the conference, Suleyman I. Allakhverdiev, and member of Advisory Board of the conference – Győző Garab from Hungary. He also opened the Plenary Section of the conference (*see* some of the speakers in Fig. 7).

The session began with Kazunari Domen of Shinshu University, Japan, who presented his work on the large-scale application of photocatalytic water splitting for green hydrogen production (Hisatomi and Domen 2019, Takata *et al.* 2020). His group has developed and tested a 100-m² system demonstrating the practical feasibility of this approach and is now focused on improving efficiency and expanding the scope to include other fuel production pathways such as methane and ammonia synthesis (Nishiyama *et al.* 2021).

The next plenary speaker, Andrey B. Rubin of Moscow State University, Russia, addressed fundamental challenges in understanding primary photosynthesis. He argued against the oversimplification of cellular processes using traditional models based on concentration, mass action, and simple reaction kinetics. Instead, he emphasised the need for more sophisticated models accounting for the inherent heterogeneity and stochasticity within the cellular environment to accurately depict electron transfer mechanisms (Riznichenko *et al.* 2022).

John F. Allen of University College London, UK, then presented his research on the evolutionary origins and functional significance of organellar genomes in chloroplasts and mitochondria (Allen 1993). His work proposed the “CoRR” hypothesis (Allen 2003), arguing that the retention of a significant portion of the organellar genome is not simply a remnant of endosymbiosis, but a crucial adaptation to maintain tight, responsive regulation of gene expression in the face of fluctuating environmental conditions. This localised regulation ensures efficient coupling of gene expression to metabolic demands (Allen 2015).

The afternoon session of the first day started with the fourth plenary presentation. İbrahim Dinçer of Ontario Tech University, Canada, broadened the perspective to encompass innovative energy systems for a sustainable future. He reviewed various technological approaches to achieving this goal, including renewable energy sources,

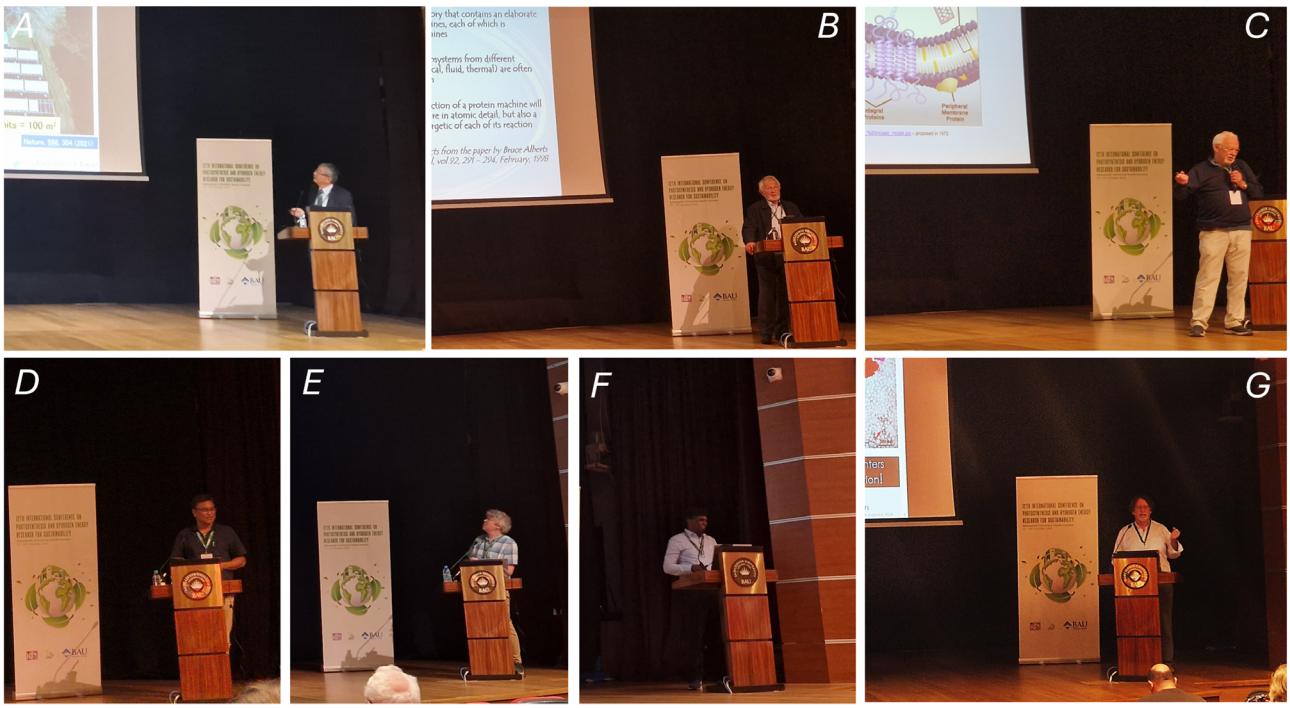

Fig. 7. Photos of several speakers during the conference. (*A*) Kazunari Domen; (*B*) Andrey B. Rubin; (*C*) Győző Garab; (*D*) Arjun Tiwari; (*E*) Jan Kern; (*F*) Rajagopal Subramanyam; (*G*) Barry Bruce. Photos by Marek Živčák.

alternative fuels, and energy storage technologies. His analysis emphasised the importance of a holistic, multi-faceted approach that considers economic, environmental, and societal factors for achieving true sustainability (Dincer and Acar 2015, Dincer and Acar 2018).

The last plenary talk was presented by Arjun Tiwari, from the University of Turku, Finland, representing the group of Eva-Mari Aro; Dr. Tiwari discussed the critical role of PSI photoinhibition under high-light conditions and the subsequent recovery processes in higher plants. His research reveals the complex interplay of electron transport pathways (linear and cyclic) and their role in managing reactive oxygen species generation. The findings emphasise the dynamic regulation of photosynthetic electron flow to maintain efficiency and protect against photooxidative damage.

The afternoon session of the conference continued with invited lectures on diverse aspects of photosynthesis, ranging from the biophysical properties of thylakoid membranes to the structural dynamics of photosynthetic proteins and the challenges of artificial photosynthesis. The session began with Győző Garab from Hungary, who presented research on the role of non-bilayer lipid phases in plant thylakoid membranes. His work suggests that the integrity of protein networks, maintained by these non-bilayer lipids, is crucial for efficient photophosphorylation, rather than solely the impermeability of the bilayer itself. This challenges the conventional understanding of energy conversion in biological membranes. Following Garab's presentation, Jan Kern from the Lawrence Berkeley National Laboratory, USA, discussed the use of femtosecond X-ray pulses from X-ray free-electron lasers (XFELs) to study the structural dynamics of photosynthetic proteins at room temperature. His group obtained high-resolution structures and spectroscopic data for various stages of the water oxidation reaction in PSII, shedding light on the mechanism of this crucial process and providing kinetic information about manganese redox changes. The session continued with Seiji Akimoto of Kobe University, Japan, who investigated the responses of light-harvesting and energy-transfer processes in cyanobacteria grown under different coloured LEDs. His findings revealed that the formation of PSI–PSII megacomplexes in *Synechococcus* varies depending on the light quality, highlighting the adaptive mechanisms of cyanobacteria to diverse light environments. Next, Yuu Hirose from Toyohashi University of Technology, Japan, presented his work on the photosensing mechanism of chromatic acclimation in cyanobacteria. His research, using X-ray crystallography and NMR, revealed the structural basis of the unique green/red light sensing mechanism in the RcaE protein, showing how changes in the bilin chromophore structure regulate light absorption. The final presentation was by Deniz Uner from Middle East Technical University, Turkey, who addressed the challenges of artificial photosynthesis, emphasising the critical role of oxygen management. His research suggests that the CO_2 reduction reaction in dark conditions can be effectively facilitated with hydrogen, highlighting the parallels and challenges between natural and artificial photosynthetic oxygen production.

The sessions of the first day were closed by the Award Ceremony (Fig. 8), and the conference continued with non-formal discussions during the evening social event organised by the host university.

Fig. 8. The coordinator of the conference, Suleyman I. Allakhverdiev, is pictured introducing the Honourary Persons of the conference. Photo by Marek Živčák.

The morning session of Day 2 began with Cheryl Kerfeld from Michigan State University, who eloquently described bacterial microcompartments, specifically carboxysomes, as sophisticated, modular biological organelles perfect for spatially confined chemical reactions. Her work underscored both the fundamental understanding of these structures and their potential for engineering novel catalytic systems. Next, Yusuke Matsuda from Kwansei Gakuin University in Japan delved into the intricate machinery of CO_2 assimilation in marine diatoms. His research illuminated the crucial role of the pyrenoid and its associated pyrenoid-penetrating thylakoids, emphasising the function of lumenal carbonic anhydrases and the identification of bicarbonate transporters as key players in efficient CO_2 utilisation. Following this, Yuichiro Kashiyama from Fukui University of Technology, Japan, presented a captivating study on kleptoplasts – transient organelles acquired from algae – in the euglenozoan *Rapaza viridis*. His work demonstrated the successful integration of horizontally transferred genes encoding Rubisco and related proteins into the kleptoplast's photosynthetic apparatus, showcasing the organism's remarkable adaptability. The focus then shifted to structural biology with Xiaochun Qin from the University of Jinan, China, who revealed the high-resolution structure of the PSI-light-harvesting complex I (LHCI) from *Fittonia albivenis*. This plant's unique adaptation to low-light environments, characterised by strongly red-shifted fluorescence, was directly linked to specific amino acid sequences within the LHCI complex, providing a structural basis for understanding far-red light absorption. Guangye Han from the Chinese Academy of Sciences then presented his research on the intricate architecture of PSII assembly. His work showcased the stepwise assembly process of the PSII core complex and highlighted the diverse supramolecular organisation of light-harvesting complexes across various photosynthetic organisms. This comparative study deepened our understanding of the adaptability of photosynthetic systems. Alessandro Agostini from the University of Padova, Italy, further explored light harvesting, focusing specifically on the mechanisms behind red-shifted chlorophyll absorption in algae. Using opto-magnetic spectroscopies, he identified specific chlorophyll *a* clusters within the light-harvesting complexes responsible for this adaptation to low-light environments, revealing subtle yet significant structural differences between species. Finally, Keisuke Kawakami from the RIKEN Center, Japan, concluded the session with a high-resolution structural analysis of PSII interacting with chlorophyll-binding proteins (CBPs) from *Acaryochloris marina*. His 2.4-Å resolution structure provided unprecedented detail on the interaction between PSII and CBPs, including the arrangement of chlorophyll *d* and associated water molecules, offering significant insights into the workings of this unique far-red light-harvesting system.

The afternoon session of Day 2 at the conference featured presentations on various aspects of hydrogen production and utilisation. Min Yu, from Foshan University, China, explored the role of hydrogen-rich water in enhancing salt tolerance in rice seedlings. His research demonstrated that hydrogen-rich water significantly mitigated the negative effects of salt stress on rice growth and photosynthesis by improving antioxidant capacity and ion balance. Bekzhan D. Kossalbayev, representing Satbayev University in Almaty, Kazakhstan, presented a two-stage cultivation method for enhancing hydrogen production efficiency using immobilised cyanobacteria. This approach combined carbohydrate accumulation under nitrogen-limited conditions with hydrogen production in an anaerobic environment, resulting in a sustained increase in hydrogen yield compared to non-immobilized cells. Fatemeh Khosravitar from the University of Gothenburg, Sweden, described a straightforward single-phase protocol for initiating and sustaining algal hydrogen production. This innovative method eliminated the need for a preliminary

dark incubation period, significantly simplifying the process and achieving sustained hydrogen production. Tatsuya Tomo, from Tokyo University of Science, Japan, investigated the protective effects of hydrogen against light-induced oxidative stress in *Synechocystis* sp. PCC 6803. His findings showed that hydrogen water significantly suppressed chlorophyll degradation and ROS generation under high-light conditions. Can Erkey, of Koç University, Turkey, provided an overview of the current status and research needs for proton exchange membrane electrolysers in green hydrogen production. He highlighted the ongoing efforts to reduce costs and improve efficiency by developing non-platinum group metals catalysts and optimising the electrolyser design. Finally, Dmitry Dunikov, from the Russian Academy of Sciences, Moscow, discussed the use of metal hydrides for hydrogen storage, purification, and compression. The work focused on developing efficient methods for extracting and purifying hydrogen from low-concentration mixtures using metal hydrides, thus creating a clean and sustainable hydrogen source. The session as a whole illustrated the significant advancements in various areas of hydrogen research, from fundamental biological approaches to the engineering of advanced energy technologies. After the talks, the poster session was organised.

The Day 3 of the conference was devoted to cultural tours, poster reading, and non-formal discussions. The fourth day morning session brought seven invited lectures. First, Yusuke Tsukatani from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) delved into the 3.5-billion-year co-evolution of photosynthesis and bacteria, identifying the Last Phototroph Common Ancestor (LPCA) and tracing the evolutionary pathways of photosynthetic ability through vertical and horizontal gene transfer, demonstrating the acquisition of photosynthesis prior to the LPCA. Next, Kentaro Ifuku of Kyoto University, Japan, presented research on the evolution and function of the light-harvesting complex in red-lineage algae. Their work integrated molecular phylogenetic analyses with structural models to classify LHCs into distinct subfamilies and explore their functional roles, specifically focusing on diatoms, crucial to marine primary production. Toru Kondo from the National Institute for Basic Biology, Japan, shifted the focus to the flexible and heterogeneous regulation of photosynthetic light harvesting. Using single-molecule spectroscopy, their team investigated the dynamic and heterogeneous conformational variations in light-harvesting complexes and their impact on the efficiency of photoelectric conversion. The session continued with Keisuke Saito from the University of Tokyo, Japan, who explored the role of the protein matrix in superexchange electron transfer during charge separation in PSII. Through quantum mechanical/molecular mechanical approaches, he demonstrated that superexchange, mediated by a tryptophan residue, is the primary mechanism driving electron transfer in the PSII protein matrix. Daisuke Takagi of Setsunan University, Japan, presented research on the oxygen sensitivity of PSI photoinhibition in land plants. His findings showed that land plants activate protective mechanisms against PSI photoinhibition depending on the growth light environment, highlighting their resilience to oxidative stress. Following this, Barry D. Bruce from the University of Tennessee, USA, discussed the advancement of protein isolation methods for studying PSI, introducing the styrene-maleic acid-lipid particle (SMALP) method to extract PSI while preserving its lipid environment and showing its potential for enhancing our understanding of photosynthetic proteins in their native context. The session concluded with Francesco Francia from the University of Bologna, Italy, who investigated the effect of trehalose, a disaccharide, on electron transfer reactions within the cytochrome bc_1 complex of photosynthetic bacteria. His work showed that trehalose slows down several key electrogenic reactions, potentially influencing the complex's functionality. The session provided a comprehensive overview of current advancements in understanding the intricacies of photosynthesis, from its deep evolutionary history to the sophisticated mechanisms underlying light harvesting and electron transfer.

The afternoon session of Day 4 at the conference focused mostly on acclimation and adaptation strategies of photosynthetic organisms under various stress conditions. The session began with Marek Živčák from the Slovak University of Agriculture in Nitra, Slovakia, who investigated the acclimation of photosynthetic processes in wheat leaves to high temperatures. His research demonstrated the capacity of wheat genotypes to acclimate to heat stress through the regulation of electron transport and PSI protection, identifying significant genotypic variability in heat stress responses. Following this, Rajagopal Subramanyam from the University of Hyderabad, India, presented his work on the acclimation strategies and photosystem remodelling in *Dunaliella salina* under long-term hypersaline conditions. His findings suggested a possible remodelling of the photosynthetic apparatus and an efficient retrograde signalling mechanism in response to high salinity, highlighted by the upregulation of the tetrapyrrole biosynthesis pathway. Next, Ryouichi Tanaka from Hokkaido University in Sapporo, Japan, discussed sustained thermal dissipation mechanisms in overwintering evergreen leaves. Their team investigated the role of early-light-induced proteins (ELIPs) in the significant decrease in PSII activity during winter, demonstrating the importance of ELIPs in protecting photosystems against cold-induced damage. The session continued with Agepati S. Raghavendra from the University of Hyderabad, India, who explored the inverse relationship between photorespiration and ROS contents in *Arabidopsis* leaves under oxidative stress. Their research demonstrated that restricted photorespiration leads to increased ROS contents and oxidative stress, emphasising the role of photorespiration in mitigating oxidative damage. Shailendra Pratap Singh from Banaras Hindu University, India, then presented on chromatic acclimation and photosynthetic fitness in cyanobacteria. Their work focused on *Fremyella diplosiphon*, illustrating how this organism alters its pigment composition and cellular morphology in response to varying light conditions to optimise light harvesting and photosynthetic efficiency. The session concluded

with Jörg Pieper from the University of Tartu, Estonia, who presented the applicability of the method of neutron scattering to investigate the protein dynamics in the case of the orange carotenoid protein (OCP) in cyanobacteria. The session showcased a diversity of approaches and findings, highlighting the remarkable adaptability of photosynthetic organisms to a wide range of environmental challenges.

As an integral part of the conference, the posters of young researchers were assessed by the Poster Session Chairs, including Jan Kern (Germany), Ryouichi Tanaka (Japan), Alessandro Agostini (Italy) Gert Schansker (Germany), Marek Živčák (Slovakia), and Shailendra Pratap Singh (India). The young researchers very actively presented their posters and the committee selected six posters that were awarded by "Best Poster Award". In addition, two young researchers presenting lectures were selected by the conference chairs and received the Young Scientist awards. All winners of the research awards are shown in Fig. 9 and listed in the Fig. 9 caption. The fourth day finished with the social event (Gala Dinner) organised by the host university.

The morning session of Day 5 featured six presentations on various aspects of photosynthetic processes. Mohammad Mahdi Najafpour, from the Institute for Advanced Studies in Basic Sciences (IASBS) in Zanjan, Iran, explored the role of manganese compounds in facilitating water oxidation in artificial photosynthetic systems. His research

Fig. 9. Winners of the young researcher awards (*A*) and their group photo with conference chairs and speakers (*B*). (*A*) *From the left*: Arjun Tiwari (Finland), Yuho Ohashi (Japan), Shriya Sharma (India), Tancredi Bin (Italy), Midori Nakamura (Japan), Aida Shomali (Slovakia), Parveen Akhtar (Hungary), Alessandro Agostini (Italy). (*B*) *From the left*: Gert Schansker (Germany), Francesco Francia (Italy), Győző Garab (Hungary), Suleyman Allakhverdiev (Russia/Turkey), Arjun Tiwari (Finland), Yuho Ohashi (Japan), Shriya Sharma (India), Tancredi Bin (Italy), Midori Nakamura (Japan), Barry Bruce (USA), Aida Shomali (Slovakia), Parveen Akhtar (Hungary), Alessandro Agostini (Italy), Cheryl Kerfeld (USA), Tatsuya Tomo (Japan).

demonstrated the transformation of various manganese compounds into active manganese-oxide-based catalysts during the water oxidation reaction. Next, Alexander N. Tikhonov, representing Moscow State University, Russia, delved into the regulation of intersystem electron transport in plant chloroplasts. His work investigated this process in shade-tolerant and light-loving plant species, revealing how acclimation to varying light conditions influences the chloroplast electron transport chain and the expression of key proteins involved. Iftach Yacoby, from Tel Aviv University, Israel, presented a novel approach to harnessing microalgae for sustainable biofuel production. His research focused on engineering microalgae to continuously produce hydrogen, overcoming the limitations of naturally occurring temporary hydrogen production. Gert Schansker, of *Heinz Walz GmbH* in Germany, discussed using light curves and fluorescence measurements to probe the photosynthetic electron transport chain. His presentation detailed how these techniques can provide valuable insights into the dynamics of electron flow and the regulation of photosynthesis. Arvi Freiberg, from the University of Tartu, Estonia, offered a current understanding of colour-tuning in bacterial photosynthesis. His research used a disordered exciton model to explain the spectral tuning observed in photosynthetic purple bacteria, highlighting the combined effects of exciton shifts and site energy shifts. Finally, Petar H. Lambrev, of the Biological Research Centre in Szeged, Hungary, presented findings on inter-subunit energy transfer in photosynthetic supercomplexes using two-dimensional electronic spectroscopy. This research investigated the dynamics of excitation energy transfer in various supercomplexes from different organisms, revealing diverse strategies for efficient light harvesting and photoprotection. The study also suggested a universal cross-species blueprint for light harvesting that could inform the design of artificial energy-converting systems.

The conference's last (afternoon) session opened Irada Huseynova from the Institute of Molecular Biology & Biotechnologies in Baku, Azerbaijan. Her research focused on the impact of drought stress on water-soluble sugars and phospho*enol*pyruvate carboxylase in wheat, identifying drought-tolerant genotypes with stable sugar contents and regulated enzyme activity, paving the way for developing more resilient wheat varieties. Following this, Rahul Kumar from the University of Hyderabad, India, presented the work on cryo-milled nano-diammonium phosphate fertiliser. The research demonstrated that this novel fertiliser significantly enhanced plant growth and photosynthetic efficiency in rice and tomatoes compared to conventional fertilisers, primarily due to improved phosphorus bioavailability.

Next, Rupal Singh Tomar from the Centre for Scientific and Applied Research in Indore, India, discussed the use of silicon nanoparticles to enhance the growth and bioremediation capabilities of *Chlorella vulgaris*. The study showed that silicon nanoparticles mitigated the toxic effects of pyrene, a polycyclic aromatic hydrocarbon, while simultaneously improving photosynthetic efficiency and boosting pyrene biodegradation by the algae. Yogesh Mishra from Banaras Hindu University, Varanasi, India, then presented the research on how the LexA protein regulates *Anabaena* sp. PCC 7120's tolerance to cadmium stress. The results demonstrated that LexA regulates the expression of photosynthetic genes, optimising the photosynthetic electron transport chain's redox balance under stress.

Mohammad Yusuf Zamal, also from the University of Hyderabad, India, followed with a presentation on the stability of the photosynthetic apparatus, transcriptome, and metabolome of *Rhodobacter alkali* tolerant strain JA916T under alkaline conditions and high light. The research showed that this bacterium maintains stable photosynthetic functions even under stress, demonstrating resilience to alkaline conditions and high-light exposure. Nuria Koteyeva from the Komarov Botanical Institute in St. Petersburg, Russia, then presented her findings on the biochemical and structural diversification of C_4 photosynthesis in the tribe Zoysieae. Her study revealed the evolutionary history of C_4 photosynthesis subtypes within the group, linking the distribution of these subtypes to habitat conditions. Talha Kuru from Selcuk University, Konya, Turkey, continued the session by presenting the research on photocatalytic hydrogen evolution using specific photocatalysts. Yigit Osman Akyildiz, also from Selcuk University, Turkey, explored the size-dependent electrocatalytic hydrogen evolution by micro- and nanoparticles. Their study revealed that nano-sized particles demonstrated superior electrocatalytic activity for hydrogen evolution due to increased surface area and active sites. The session concluded with a presentation by Suleyman I. Allakhverdiev from the K.A. Timiryazev Institute of Plant Physiology in Moscow, Russia. His research investigated the impact of exogenous glycerol as a carbon source on hydrogen production by various cyanobacteria. The results showed that glycerol significantly enhanced hydrogen production in certain cyanobacteria, with *Dolichospermum* sp. exhibiting the most remarkable increase.

The poster session at the conference showcased a diverse range of research in photosynthesis and related fields. A total of 26 posters were presented in the conference poster session, representing different topics of photosynthetic research presented predominantly by young researchers. Their presentations covered diverse topics, from cutting-edge advancements in hydrogen production to innovative approaches in photosynthetic adaptation mechanisms. To summarise the award-winning posters, Parveen Akhtar from the Biological Research Centre in Szeged, Hungary, explored the efficiency of light harvesting by fucoxanthin–chlorophyll proteins in PSI of the diatom *Thalassiosira pseudonana* using time-resolved optical spectroscopy. The findings demonstrated remarkably fast energy transfer, making this system a potential model for efficient light harvesting. Aida Shomali from the Department of Plant Physiology, Slovak University of Agriculture, explored the signalling role of far-red light in regulating photosynthetic electron transfer and carbon fixation in tomatoes. Mutants lacking phytochrome A revealed distinct responses to high light and supplemental far-red light, clarifying the role of this specific

phytochrome in high-light acclimation. Midori Nakamura, from the Division of Applied Life Sciences, Graduate School of Agriculture, Kyoto University, investigated the role of a light-harvesting protein in *Chaetoceros gracilis*' adaptation to specific light and CO_2 conditions. Her work highlights how fucoxanthin–chlorophyll *a*/*c* binding proteins can be remodelled in response to environmental changes, providing a significant advantage for survival. Tancredi Bin from the University of Bologna presented *Rhodobacter capsulatus* as a model to study green chemical interactions with native membranes. The findings demonstrated the ability of specific ionic liquids to affect membrane potential, indicating potential applications in green chemistry research. Shriya Sharma, from the Department of Plant Sciences, School of Life Sciences, University of Hyderabad, presented transcriptomic data on cyclic electron transport mutants in *Chlamydomonas reinhardtii* under high-light stress. Her results revealed differential expression of key photosynthetic genes in response to high light, furthering our understanding of light-stress responses. Yuho Ohashi, from the Department of Applied Engineering, Graduate School of Engineering, Fukui University of Technology, investigated the nitrate assimilation pathway in the kleptoplastic organism *Rapaza viridis*. The study identified genes responsible for nitrate transport and reduction, thereby contributing to understanding nutrient acquisition in unique kleptoplastic systems. In summary, the poster session provided a wide-ranging overview of current photosynthetic research, with a strong emphasis on the adaptation of photosynthetic organisms to environmental stresses and the underlying molecular mechanisms that govern these processes.

References

Allakhverdiev S.I., Huseynova I.M., Govindjee: International conference on "Photosynthesis Research for Sustainability-2011", July 24–30, 2011, Baku, Azerbaijan. – Photosynth. Res. **110**: 205-212, 2011.

Allakhverdiev S.I., Huseynova I.M., Govindjee: International conference on "Photosynthesis research for sustainability-2013: in honor of Jalal A. Aliyev", held during June 5–9, 2013, Baku, Azerbaijan. – Photosynth. Res. **118**: 297-307, 2013.

Allakhverdiev S.I., Subramanyam R., Tomo T.: International conference on "Photosynthesis and Hydrogen Energy Research for Sustainability-2017". – Photosynth. Res. **139**: 1-8, 2019.

Allakhverdiev S.I., Tomo T., Govindjee: International conference on "Photosynthesis research for sustainability-2014: in honor of Vladimir A. Shuvalov", held on June 2–7, 2014, in Pushchino, Russia. – Photosynth. Res. **122**: 337-347, 2014.

Allakhverdiev S.I., Tomo T., Stamatakis K., Govindjee: International conference on "Photosynthesis research for sustainability-2015: in honor of George C. Papageorgiou", September 21–26, 2015, Crete, Greece. – Photosynth. Res. **130**: 1-10, 2015.

Allen J.F.: Control of gene-expression by redox potential and the requirement for chloroplast and mitochondrial genomes. – J. Theor. Biol. **165**: 609-631, 1993.

Allen J.F.: The function of genomes in bioenergetic organelles. – Philos. T. Roy. Soc. B **358**: 19-37, 2003.

Allen J.F.: Why chloroplasts and mitochondria retain their own genomes and genetic systems: Colocation for redox regulation of gene expression. – PNAS **112**: 10231-10238, 2015.

Allen J.F., Bennett J., Steinback K.E., Arntzen C.J.: Chloroplast protein phosphorylation couples plastoquinone redox state to distribution of excitation energy between photosystems. – Nature **291**: 25-29, 1981.

Allen J.F., Hall D.O.: Superoxide reduction as a mechanism of ascorbate-stimulated oxygen uptake by isolated chloroplasts. – Biochem. Bioph. Res. Co. **52**: 856-862, 1973.

Allen J.F., Pfannschmidt T.: Balancing the two photosystems: photosynthetic electron transfer governs transcription of reaction centre genes in chloroplasts. – Philos. T. Roy. Soc. B **355**: 1351-1359, 2000.

Antal T., Rubin A.: *In vivo* analysis of chlorophyll *a* fluorescence induction. – Photosynth. Res. **96**: 217-226, 2008.

Aro E.-M., Somersalo S., Karunen P.: Membrane lipids in *Ceratodon purpureus* protonemata grown at high and low temperatures. – Physiol. Plantarum **69**: 65-72, 1987.

Aro E.-M., Suorsa M., Rokka A. *et al.*: Dynamics of photosystem II: a proteomic approach to thylakoid protein complexes. – J. Exp. Bot. **56**: 347-356, 2005.

Aro E.-M., Virgin I., Andersson B.: Photoinhibition of Photosystem II. Inactivation, protein damage and turnover. – BBA-Bioenergetics **1143**: 113-134, 1993.

Baniulis D., Yamashita E., Zhang H. *et al.*: Structure–function of the cytochrome b_6f complex. – Photochem. Photobiol. **84**: 1349-1358, 2008.

Belyaeva N.E., Bulychev A.A., Riznichenko G.Y., Rubin A.B.: Thylakoid membrane model of the Chl *a* fluorescence transient and P700 induction kinetics in plant leaves. – Photosynth. Res. **130**: 491-515, 2016.

Blankenship R.E.: Early evolution of photosynthesis. – Plant Physiol. **154**: 434-438, 2010.

Borisova-Mubarakshina M.M., Tsygankov A.A., Tomo T. *et al.*: International conference on "Photosynthesis and Hydrogen Energy Research for Sustainability-2019": in honor of Tingyun Kuang, Anthony Larkum, Cesare Marchetti, and Kimiyuki Satoh. – Photosynth. Res. **146**: 5-15, 2020.

Cunningham F.X., Gantt E.: Genes and enzymes of carotenoid biosynthesis in plants. – Annu. Rev. Plant Physiol. Plant Mol. Biol. **49**: 557-583, 1998.

Cunningham F.X., Gantt E.: One ring or two? Determination of ring number in carotenoids by lycopene ε-cyclases. – PNAS **98**: 2905-2910, 2001.

Dagan T., Roettger M., Stucken K. *et al.*: Genomes of stigonematalean cyanobacteria (subsection V) and the evolution of oxygenic photosynthesis from prokaryotes to plastids. – Genome Biol. Evol. **5**: 31-44, 2013.

Dincer I.: Technical, environmental and exergetic aspects of hydrogen energy systems. – Int. J. Hydrogen Energ. **27**: 265-285, 2002.

Dincer I., Acar C.: Review and evaluation of hydrogen production methods for better sustainability. – Int. J. Hydrogen Energ. **40**: 11094-11111, 2015.

Dincer I., Acar C.: Smart energy solutions with hydrogen options. – Int. J. Hydrogen Energ. **43**: 8579-8599, 2018.

D'Odorico P., Davis K.F., Rosa L. *et al.*: The global food-energy-water nexus. – Rev. Geophys. **56**: 456-531, 2018.

Foyer C.H., Neukermans J., Queval G. *et al.*: Photosynthetic control of electron transport and the regulation of gene expression. – J. Exp. Bot. **63**: 1637-1661, 2012.

Gantt E.: Phycobilisomes. – Annu. Rev. Plant Physiol. **32**: 327-347, 1981.

Gantt E., Lipschultz C.A.: Energy transfer in phycobilisomes from phycoerythrin to allophycocyanin. – BBA-Bioenergetics

292: 858-861, 1973.
Gantt E., Lipschultz C.A., Grabowski J., Zimmerman B.K.: Phycobilisomes from blue-green and red algae: isolation criteria and dissociation characteristics. – Plant Physiol. **63**: 615-620, 1979.
Hisatomi T., Domen K.: Reaction systems for solar hydrogen production via water splitting with particulate semiconductor photocatalysts. – Nat. Catal. **2**: 387-399, 2019.
Hou H.J.M., Najafpour M.M., Allakhverdiev S.I., Govindjee G.: Editorial: Current challenges in photosynthesis: From natural to artificial, volume II. – Front. Plant Sci. **13**: 1113693, 2023.
Hussain S., Ulhassan Z., Brestic M. *et al.*: Photosynthesis research under climate change. – Photosynth. Res. **150**: 5-19, 2021.
Janssen P.J.D., Lambreva M.D., Plumeré N. *et al.*: Photosynthesis at the forefront of a sustainable life. – Front. Chem. **2**: 36, 2014.
Li L., Aro E.-M., Millar A.H.: Mechanisms of photodamage and protein turnover in photoinhibition. – Trends Plant Sci. **23**: 667-676, 2018.
Maeda K., Domen K.: Photocatalytic water splitting: recent progress and future challenges. – J. Phys. Chem. Lett. **1**: 2655-2661, 2010.
Mustardy L., Cunningham F.X., Gantt E.: Photosynthetic membrane topography: quantitative in situ localization of photosystems I and II. – PNAS **89**: 10021-10025, 1992.
Nelson N., Yocum C.F.: Structure and function of photosystems I and II. – Annu. Rev. Plant Biol. **57**: 521-565, 2006.
Nishiyama H., Yamada T., Nakabayashi M. *et al.*: Photocatalytic solar hydrogen production from water on a 100-m^2 scale. – Nature **598**: 304-307, 2021.
Rintamäki E., Martinsuo P., Pursiheimo S., Aro E.-M.: Cooperative regulation of light-harvesting complex II phosphorylation *via* the plastoquinol and ferredoxin-thioredoxin system in chloroplasts. – PNAS **97**: 11644-11649, 2000.
Riznichenko G.Y., Antal T.K., Belyaeva N.E. *et al.*: Molecular, Brownian, kinetic and stochastic models of the processes in photosynthetic membrane of green plants and microalgae. – Biophys. Rev. **14**: 985-1004, 2022.
Rubin A., Riznichenko G.: Modeling of the primary processes in a photosynthetic membrane. – In: Laisk A., Nedbal L., Govindjee (ed.): Photosynthesis in silico. Advances in Photosynthesis and Respiration. Vol. 29. Pp.151-176. Springer, Dordrecht 2009.
Safari F., Dincer I.: A review and comparative evaluation of thermochemical water splitting cycles for hydrogen production. – Energ. Convers. Manage. **205**: 112182, 2020.
Subramanyam R., Tomo T., Eaton-Rye J.J. *et al.*: International conference on "Photosynthesis and Hydrogen Energy Research for Sustainability-2023": in honor of Robert Blankenship, Győző Garab, Michael Grätzel, Norman Hüner and Gunnar Öquist. – Photosynth. Res. **161**: 141-150, 2024.
Suorsa M., Järvi S., Grieco M. *et al.*: PROTON GRADIENT REGULATION5 is essential for proper acclimation of photosystem I to naturally and artificially fluctuating light conditions. – Plant Cell **24**: 2934-2948, 2012.
Takata T., Jiang J.Z., Sakata Y. *et al.*: Photocatalytic water splitting with a quantum efficiency of almost unity. – Nature **581**: 411-414, 2020.
Tikkanen M., Grieco M., Kangasjärvi S., Aro E.-M.: Thylakoid protein phosphorylation in higher plant chloroplasts optimizes electron transfer under fluctuating light. – Plant Physiol. **152**: 723-735, 2010.
Tsygankov A.A., Allakhverdiev S.I., Tomo T. *et al.*: International conference on "Photosynthesis Research for Sustainability-2016". – Photosynth. Res. **131**: 227-236, 2017.