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CONFERENCE REPORT

Twenty years of the International Conferences on Photosynthesis and Hydrogen Energy Research for Sustainability

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Abstract

The International Conference on "Photosynthesis and Hydrogen Energy Research" was inaugurated in 2004 in Trois Rivières, Canada, as "Photosynthesis and Post-Genomics Era". It was conceived by its founders, Suleyman I. Allakhverdiev (Russia), Vyacheslav (Slava) Klimov (Russia), Robert Carpentier (Canada), and Prasanna Mohanty (India) to be an alternating conference to the bigger International Congress on Photosynthesis, which was then held every three years. The name was changed to the International Conference on Photosynthesis (ICP) in 2011. In 2013, "Hydrogen Production" was added, and then finally the current name, "International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability", was used in 2015. The conferences over the last twenty years have been held in three continents – North America, Europe, and Asia – and have been very successful in attracting participants with the latest ideas in photosynthesis, hydrogen production, and energy sustainability. Here we describe all 12 conferences, with details of the major events of each conference.
Major points of the conference were: (*1*) Recent advances in the understanding of the basic mechanisms of water splitting (photosystem II) and the reactions around photosystem I in photosynthetic organisms. (*2*) The role of hydrogen production in photosynthesis. (*3*) The role of innovations in photosynthesis and hydrogen production in the development of global sustainability.

Keywords: artificial photosynthesis; biotechnology; energy sustainability; global climate change; hydrogen production.

Introduction: the genesis of the conference

The origin of the current conference, now celebrating its twentieth year, can be traced back to the 12th International Congress on Photosynthesis Research held in 2001, in Brisbane, Australia. Interestingly, this congress took place just one week before the tragic events of 11 September and the subsequent collapse of the Twin Towers in New York, USA. Had the timing been slightly different, this pivotal gathering might never have occurred.

During the 2001 congress, at the dinner hosted for the delegates, one of us (Suleyman Allakhverdiev – from

Highlights

- Suleyman Allakhverdiev, Robert Carpentier, Slava Klimov, and Prasanna Mohanty initiated the first International Conference on Photosynthesis, which was held twenty-one years ago
- We have held 12 meetings, with a key highlight being the understanding of how photosynthesis converts solar energy, particularly through water splitting, which releases oxygen into the atmosphere
- An emerging focus has also been on the role of photosynthetic processes in hydrogen production, compared to other solar energy-based methods

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Russia) met with Vyacheslav (Slava) Klimov (Russia), Robert Carpentier (Canada), and Prasanna Mohanty (India) [for Klimov, *see* Allakhverdiev *et al*. (2018); and for Mohanty, *see* Tiwari *et al*. (2014)]. It was during this informal discussion that the idea of establishing an alternative venue dedicated to photosynthesis research emerged – one that would alternate with the main Photosynthesis Congress. Robert Carpentier, who was organizing the upcoming Photosynthesis Congress, expressed keen interest in helping to develop this new initiative. He suggested hosting the conference at his university, Université du Québec à Trois-Rivières, in Canada, and thus, the seed was planted for what would become the first International Conference on Photosynthesis and Hydrogen Energy Research in 2004 (Allakhverdiev *et al.* 2014, Tiwari *et al.* 2014).

The vision was to initiate a series of conferences that would specifically celebrate the ground-breaking achievements of distinguished scientists and their students in the field of photosynthesis. At that time, Suleyman Allahkverdiev, having been involved with Robert Carpentier's laboratory in Trois-Rivières, had recently moved to work with Professor Norio Murata (Japan). It was a natural decision to honor Norio Murata's immense contributions during the inaugural event. Subsequently, it was agreed that Professor James (Jim) Barber [UK; *see e.g*., Govindjee (2021)] would serve as the chair for the future conference(s). Additionally, the International Society of Photosynthesis Research (ISPR), with support from the International Association for Hydrogen Energy (IAHE), pledged to endorse these gatherings. The first five conferences, held under various titles, laid the foundation for the series. In 2013, it was decided to incorporate "Hydrogen Production" into the conference's official title, reflecting the expanding scope of research and innovation within the conference.

The inaugural conference of this series was officially titled "Photosynthesis and Post-Genomics Era," and held in 2004 in Trois-Rivières, Quebec, Canada. A highlight of this event was that the conference gave the Honor Award to Professor Norio Murata (*see* Fig. 1) with the inscription: "*Professor Murata's major distinction lies in his recognition as one of Japan's most highly cited scientists in Plant and Animal Sciences. He has played a pivotal role in the global dissemination of research through extensive collaborations with scientists worldwide. The International Satellite Meeting held in his honor was not only a celebration of his remarkable achievements but also an acknowledgment of his influence on the entire international scientific community.*"

Fig. 1. The official presentation of the Honor Award, in 2004, to Prof. Norio Murata (*in the middle*) by officials of the Trois-Rivières University, Quebec, Canada.

The Second International Conference on the Structure and Functions of Photosystems, held in Pushchino, Russia, 2006

The 2nd International Conference on the Structure and Functions of Photosystems was held in Pushchino, Russia, in 2006, in honor of the renowned Professor James (Jim) Barber, a distinguished scientist in photosynthesis research. This conference brought together a diverse group of over 300 delegates from more than 36 countries worldwide, reflecting the global interest and importance of understanding the structure and function of the two Photosystems (I and II).

This event served as a significant platform for presenting the latest advancements, exchanging ideas, and fostering collaborations among researchers specializing in photosynthesis, biochemistry, biophysics, and related disciplines. This conference was highly successful, with numerous keynote speeches, oral presentations, and poster sessions that highlighted innovative research and emerging trends in the field around the world.

Following this conference, most of the papers presented were compiled and published in a special issue of "Biochimica Biophysica Acta" [Volume 1767, 2007; *see* Allakhverdiev *et al.* (2007)]. This issue provides a comprehensive overview of the state-of-the-art research on the photosystems, summarizing key findings and discussions from the conference. Overall, the conference not only celebrated the contributions of Jim Barber but also significantly advanced understanding of the molecular structure and function of the two photosystems, paving the way for future research and significant discoveries in photosynthesis [*see e.g*., Ferreira *et al*. (2004)].

The 2006 conference covered broad areas of photosynthesis, beginning with the inaugural address by Professor James (Jim) Barber during his fruitful career (*see* Fig. 2). This conference was aimed both at reviewing the present status of these areas of photosynthesis research and at discussing the future directions, fostering a collaborative environment for exchanging ideas and insights. Further, this conference also provided a great opportunity to celebrate Professor Barber's retirement in August 2007, marking the culmination of a distinguished and impactful career. Professor Barber was a renowned scientist whose work has significantly advanced our understanding of oxygenic photosynthesis. His papers (more than 300) in refereed journals, along with numerous reviews, book chapters, and authoritative books, are a true reflection of his enormous scientific contribution and enthusiasm for photosynthesis [*see e.g*., Govindjee *et al.* (2021)].

Fig. 2. Professor James Barber (*left*) sharing a joke with one of us (Tony Larkum) at the Pushchino conference in 2006.

Fig. 3. The main building of the Azerbaijan National Academy of Sciences, in Baku, Azerbaijan, where the 2011 conference was held.

The Third International Conference on Photosynthesis was held at Baku, Azerbaijan, in July 2011

Over 280 delegates attended this conference from 41 countries, reflecting, as in earlier conferences, a truly international gathering of experts in the field. Fig. 3 shows the main building where this conference was held. Work presented at the conference was subsequently published in a prominent scientific journal (Allakhverdiev 2012a,b; Allakhverdiev *et al.* 2012). These publications showcased the latest advances in understanding natural photosynthesis mechanisms and explored innovative approaches to artificial photosynthesis systems, aiming to contribute to sustainable energy solutions worldwide.

One of us (Suleyman Allakhverdiev) organized this 2011 conference in Baku, Azerbaijan, a country renowned for its rich cultural heritage and strategic importance in energy production. The involvement of Suleyman Allakhverdiev (who hails from Azerbaijan) and of Jalal Aliyev (who lived in Azerbaijan at that time) underscored the significance of fostering international scientific collaboration within Azerbaijan (for contributions of Jalal Aliyev, *see* below for the fourth conference). In addition to the scientific sessions at this conference, a series of vibrant local events and traditional dances provided the attendees with a real taste of the Azerbaijani culture and hospitality.

Highlights of the social program included several memorable excursions designed to showcase the beauty and historical significance of the region. One of the key highlights was a visit to Baku's Old City, known as Icheri Sheher, an ancient area with evidence of human settlement dating back to the Paleolithic period. This UNESCO World Heritage site features historic mosques, caravanserais, and the iconic Maiden Tower, offering a glimpse into the city's storied past. Another excursion took the delegates to the Pink Lake, renowned for its striking hue caused by natural mineral deposits, and a visit to the historic site of the First Oil Well, which marked the beginning of Azerbaijan's long-standing oil industry. The tour also included the Bibiheybat Mosque, a significant religious and architectural landmark. *En route*, participants passed through the picturesque Candy Cane Mountains, famous for their colorful striped formations, and Altiagaj National Park, a protected area rich in diverse flora and fauna.

The Fourth International Conference on Photosynthesis was also held at Baku, Azerbaijan, in June 2013

This conference was also a significant gathering of experts in the field. The conference honored Jalal A. Aliyev for his outstanding contributions to photosynthesis research.

The year 2013 marked a milestone as the theme of the conference was introduced, in full and in appropriate terminology, for the first time: “Photosynthesis research for sustainability: Keys to produce clean energy”. The 2013 conference also provided a valuable platform for presenting the latest advances, fostering collaborations, and discussing innovative approaches toward sustainable energy solutions and provided a springboard for the next conference to include hydrogen production as a focus (*see* Fig. 4 for photographs of key speakers).

Comprehensive summaries of this conference can be found in Allakhverdiev *et al.* (2013a,b), Allakhverdiev *et al.* (2014), and Allakhverdiev and Shen (2014).

The Fifth International Conference on Photosynthesis and Hydrogen Production; Pushchino, Russia, September 2014

The Fifth International Conference, held in Pushchino, Russia, was a significant gathering that brought together leading scientists and researchers from around the world to discuss the latest advances in the fields of not only photosynthesis but of all aspects of hydrogen generation, emphasizing both fundamental understanding and potential technological applications.

Fig. 4. Some of the speakers at the opening ceremony of the fourth International Conference. *Top*, *left to right*: John Walker (Nobel Prize in Chemistry 1997, UK), Hiroshi Nishihara (Japan), Bruce Osborne (Co-chair of conference, and President of Federation of European Societies of Plant Biology – FESPB, UK), and P. Leslie (Les) Dutton (USA). *Bottom*, *left to right*: Norio Murata (Japan), Eva-Mari Aro (Finland), Akif Alizadeh (President of Azerbaijan National Academy of Sciences), and Ahliman Amiraslanov (Academician Secretary of the Department of Biological and Medical Sciences, Azerbaijan National Academy of Sciences).

This conference was organized in honor of Vladimir A. Shuvalov, a renowned scientist from the Biological Research Center of the Russian Academy of Sciences in Pushchino, whose pioneering work has profoundly influenced the study of photosynthetic processes. Shuvalov's contributions have laid the groundwork for many contemporary investigations into the intricate mechanisms of photosynthesis, making this conference a fitting tribute to his scientific legacy.

Over 150 delegates participated in this conference, representing 21 countries across multiple continents. The gathering fostered rich discussions and exchanges on a broad array of topics related to photosynthesis, with a particular focus on the structure and function of photosynthetic complexes at the molecular level. This emphasis provided a deeper understanding of how light energy is captured and converted into chemical energy in various organisms.

A highlight of the 2014 conference was Govindjee's keynote presentation titled “Primary Photochemistry of Photosynthesis: A Perspective in Honor of Vladimir (Vlad) A. Shuvalov”. Govindjee, who reviewed the recent profound discoveries on the early events in photosynthetic reaction centers, going all the way back to the work of Jim Barber's laboratory in the early 2000s, and paying tribute to Shuvalov's influential research. Fig. 5 shows Govindjee and Shuvalov discussing research at coffee time after Govindjee's address.

Chronologically, notable contributions of Vlad Shuvalov include:

i) from 1976: In bacterial reaction centers (bRC), bacteriopheophytin (BPheo) was identified as an electron acceptor that precedes the ubiquinone electron acceptor, Q_A, shedding light on the sequential electron transfer processes.

ii) from 1978: Studies revealed that within the bacterial reaction center, bacteriochlorophyll (BChl) acts as the primary electron acceptor before BPheo, providing insight into the electron transfer chain's dynamics.

iii) from 2008 through 2021: In PSII reaction centers, Shuvalov's research indicated that a D1 chlorophyll molecule can serve as an alternate electron acceptor to pheophytin (Pheo), specifically highlighting the role of P680-ChlD1 in this process.

Fig. 5. Govindjee Govindjee (*on the left*) and Vlad Shuvalov at the conference in 2014.

iv) from 2010 through 2021: In PSI, it was demonstrated that a chlorophyll molecule (Ao) undergoes reduction within an astonishingly fast time – 100 femtoseconds, elucidating the ultrafast electron transfer events fundamental to photosynthesis.

v) from 2012 through 2021: In bacterial reaction centers, primary charge separation was observed to occur within femtoseconds (120–180 fs) in the excited P870, providing critical understanding of the initial energy conversion steps.

Sadly, Vlad Shuvalov, whose great achievements are listed above, passed away in 2021 [*see* Vasilieva *et al.* (2022)].

The success of this conference was largely due to the meticulous organization by Jim Barber, whose efforts ensured a stimulating scientific environment as well as memorable social functions. In addition to the key lectures, the attendees enjoyed cultural excursions, including visits to Moscow and the Kremlin, fostering not only academic collaboration but also intercultural exchange.

In summary, the Fifth International Conference on Photosynthesis and Hydrogen Production, held in 2014, served as a landmark event, advancing the collective understanding of photosynthetic mechanisms and inspiring future research in renewable energy sources.

The Sixth International Conference on Photosynthesis and Hydrogen Production, with the main focus on Photosynthesis Research for Sustainability, was held in Crete, Greece, in 2015

This conference was held in honor of George Papageorgiou, of the National Centre for Scientific Research, Demokritos, Athens, Greece. Papageorgiou was a highly esteemed scientist, regarded as an international authority on the regulation of photosynthesis, and in the use of chlorophyll *a* (Chl *a*) fluorescence as a noninvasive tool to measure various photosynthetic reactions. His pioneering work has significantly advanced our understanding of how plants and algae harness solar energy, and his contributions continue to influence research in plant biology and renewable energy technologies [*see e.g.*, Papageorgiou *et al*. (2007)].

The organizers of this 2015 conference were Kostas Stamatakis, Suleyman Allakhverdiev, Győző Garab, and Govindjee Govindjee. Their collective efforts brought together leading experts from around the world, fostering collaboration and innovation in photosynthesis research. Fig. 6 shows George C. Papageorgiou with Kostas Stamatakis at this 2015 conference. Sadly, George passed away in 2020; *see e.g.*, Tsimilli-Michael (2021).

A total of 150 delegates attended this conference, representing 20 different countries, reflecting the global importance and interest in the topics discussed. The diverse attendees included university professors, research scientists, graduate students, and industry specialists, all dedicated to exploring the latest advancements in photosynthetic processes and their applications.

This conference had as its major theme: utilizing solar energy *via* photosynthesis and hydrogen production for global sustainability. This new focus underscored the urgent need to harness natural processes for renewable energy solutions that could help address climate change and reduce dependence on fossil fuels. The discussions highlighted cutting-edge research on bio-inspired systems, artificial photosynthesis, and bioenergy production.

In addition to the primary theme, the conference covered a wide range of other topics, including genetic engineering of photosynthetic organisms, stress tolerance mechanisms, advancements in chlorophyll fluorescence techniques, and the ecological significance of photosynthesis under various environments. As at earlier conferences, workshops and poster sessions provided platforms for early-career researchers to present their findings and engage with seasoned experts.

The 2015 conference not only celebrated scientific excellence but also emphasized the importance of interdisciplinary approaches in tackling global energy challenges. The insights gained during the conference are expected to contribute significantly to future research and technological developments in sustainable energy production.

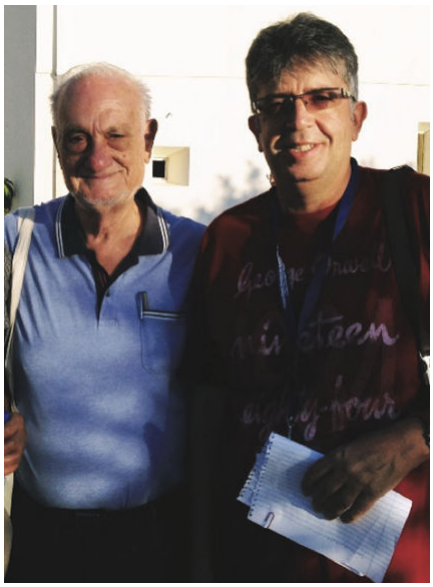

Fig. 6. George Papageorgiou, *left*, the honored scientist from Greece at the 6th conference in 2015, alongside Kostas Stamatakis, *right*, a close colleague (*see* Stamatakis *et al*. 2016).

Fig. 7. Nathan Nelson (*left*) from Israel, one of the two honored scientists in 2016, and T. Nejat Veziroglu (*right*) from Turkey/USA, the other honored scientist, giving his lecture at the seventh conference.

The Seventh International Conference on Photosynthesis and Hydrogen Production held at Pushchino, Russia, June 2016

Once again, this gathering brought together leading scientists, researchers, and industry experts from around the world to exchange knowledge, discuss recent advancements, and foster collaborations in the fields of photosynthesis and sustainable hydrogen production. This 2016 conference was held in honor of two distinguished scientists who have made significant contributions to science: Nathan Nelson from Israel and T. Nejat Veziroglu from Turkey/USA (*see* Fig. 7). Their pioneering research and leadership have greatly influenced their respective

fields and continue to inspire new generations of scientists.

A comprehensive summary of this 2016 conference was published in "Photosynthesis Research", *see* Tsygankov *et al.* (2017). This detailed report highlights the key presentations, breakthroughs, and discussions that took place during that conference.

Govindjee delivered the conference address dedicated to Nathan Nelson, acknowledging his status as a world-leading scientist renowned for his detailed and insightful studies of the fine structure of biological molecules, especially PSI. Nelson's work encompassed vital components such as V-ATPases, neurotransmitter transporters – particularly GABA transporters – and three of the four major proteins involved in photosynthesis: the cytochrome *bf* complex, ATP synthase, and Photosystem I. His most notable contribution has been the development of the first high-resolution model of Photosystem I, a milestone that has significantly advanced the understanding of the photosynthetic process.

Additionally, Govindjee provided a thoughtful address on T. Nejat Veziroglu, a pioneer in hydrogen energy research, who founded the "International Journal of Hydrogen Energy". During his distinguished career, Veziroglu has published more than 300 papers, advancing the scientific community's understanding of hydrogen production and utilization, which is vital for future sustainable energy solutions.

This 2016 conference also featured a distinguished address by Ada Yonath, the 2009 Nobel Laureate in Chemistry, renowned for her groundbreaking work on the structure of the ribosome. Her presentation provided insights into the molecular mechanisms of protein synthesis, emphasizing the importance of structural biology in understanding fundamental biological processes.

Fig. 8. *Left to right*: Agepati S. Raghavendra (India), William A. Cramer (USA), and Govindjee Govindjee (USA) at the 2017 conference in Hyderabad, India.

In recognition of outstanding contributions, the conference awarded numerous student prizes. In the field of Photosynthesis, awards went to Kaichiro Endo (Japan), Marina Kozuleva (Russia), Pini Marcu (Israel), Sonal Mathur (India), Gergely Nagy (Switzerland), Eva Pšidová (Slovakia), Margarita Rodionova (Russia), Lyubov Surova (Russia), Yoshifumi Ueno (Japan), and Arjun Tiwari (Finland). These young scientists have demonstrated exceptional research and promise for future advancements.

In the area of Hydrogen Production, awards were given to Azat Abdullatypov (Russia), Vinzenz Baryo Kaiser (Israel), Oren Ben-Zvi (Israel), and Zinaida Eltsova (Russia). Their innovative work has contributed significantly to the development of efficient and sustainable hydrogen generation technologies.

The Eighth International Conference on Photosynthesis and Hydrogen Production; Hyderabad, India, October/November 2017

The conference was held in the School of Life Sciences, University of Hyderabad, Hyderabad, India. It brought together leading academics, researchers, and industry experts from around the globe to exchange knowledge, to share innovative ideas, and to discuss recent advancements in photosynthesis and hydrogen production. This 8th conference also served as a vital platform for fostering collaboration across disciplines, promoting sustainable energy solutions, and exploring new technologies to harness solar energy efficiently.

The main organizers of this 8th conference were Rajagopal Subramanyam and Venkataramana Chintalapati from the University of Hyderabad, with invaluable assistance from Suleyman Allakhverdiev (Russia) and Tatsuya Tomo (Japan). The success of the conference was also made possible through the dedicated efforts of a large number of local organizing committee members and experts from various institutions, who ensured smooth logistical arrangements and a vibrant academic environment.

This 2017 conference was held in honor of three distinguished scientists: (*1*) Agepati S. Raghavendra (India), (*2*) William A. Cramer (USA), and (*3*) Govindjee Govindjee (USA). The groundbreaking research and contributions of these three eminent scientists (*see* Fig. 8 for a photograph) have significantly advanced our understanding of photosynthesis and related bioenergetic processes; their work continues to inspire new generations of researchers and drive innovation in sustainable energy technologies. The conference also celebrated the innovative career of Vyacheslav (Slava) Klimov, who died in 2017, and who participated in many of the previous conferences (*see e.g.*, Allakhverdiev *et al.* 2018).

As with the two preceding conferences, the overarching theme was sustainability – focusing on how advances in

photosynthesis and hydrogen production can contribute to a cleaner, greener future and a more sustainable world. Discussions at this conference ranged from fundamental biochemical mechanisms to the development of practical applications, such as biohydrogen production, artificial photosynthesis systems, and renewable energy strategies. The event also highlighted ongoing challenges, emerging trends, and future directions for research in these critical fields, emphasizing the importance of interdisciplinary approaches and international collaboration. A report on this conference is available in a paper by Allakhverdiev *et al.* (2019).

The Ninth International Conference on Photosynthesis and Hydrogen Production took place in Baku, Azerbaijan, in December 2018

This conference was dedicated to the memory of Professor Jalal L. Aliyev, a pioneering figure in plant biochemistry and photosynthesis research, who passed away in 2016. His contributions had already been recognized in the fourth conference (*see* above), and his legacy continues to inspire new generations of researchers. A heartfelt tribute to Professor Aliyev was included in the conference proceedings, referencing the article by Huseynova *et al.* (2016) in "Photosynthesis Research". In addition, Professor Aliyev's former students established the International Aliyev Award and Gold Medal to recognize his outstanding achievements in photosynthesis research. On this special occasion, they organized a dedicated conference session in Baku, inviting distinguished scientists and scholars from around the world. The event also featured the participation of Professor Julian Eaton-Rye, the Secretary of the International Society for Photosynthesis Research (ISPR), who delivered an opening address emphasizing the importance of continued innovation and international collaboration in this vital field.

The local organizing committee, in collaboration with the ISPR office, carefully selected the recipients of the prestigious awards. After extensive deliberation, they chose Professor Jian-Ren Shen from Japan, renowned for his groundbreaking work on the molecular mechanisms of photosynthesis and renewable energy applications. The award ceremony was a highlight of the conference, celebrating Professor Shen's significant contributions to science and his dedication to advancing sustainable energy solutions (*see* Fig. 9).

Overall, the conference not only honored the legacy of Professor Aliyev but also fostered a vibrant exchange of ideas and research that will undoubtedly influence the future trajectory of photosynthesis and hydrogen energy technologies worldwide.

The Tenth International Conference on Photosynthesis and Hydrogen Production, held in Saint Petersburg, Russia, in September 2019

This conference marked a significant milestone in the ongoing global efforts to advance sustainable energy solutions; it again brought together leading scientists, researchers, and industry experts from around the world to share recent developments, innovative research, and collaborative strategies in the fields of photosynthesis, hydrogen energy, and sustainability.

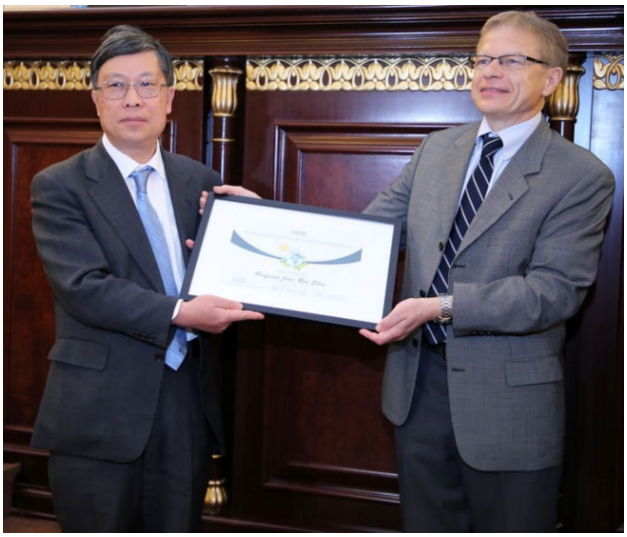

Fig. 9. Prof. Jian-Rian Shen (*on the left*) receiving the first Jalal Aliyev award from Julian Eaton-Rye (Secretary of ISPR) at the 9th International Conference, in 2018.

Fig. 10. Julian Eaton-Rye (*on the right*) presenting a Distinguished Science award to Cesare Marchetti in 2019.

This tenth conference was held in honor of four distinguished scientists who have made outstanding contributions to the field: (*1*) Tingyun Kuang (China); (*2*) Anthony (Tony) Larkum (Australia); (*3*) Cesare Marchetti (Italy); and (*4*) Kimiyuki Satoh (Japan); *see* Fig. 10 for a photograph of Cesare Marchetti with Julian Eaton-Rye. The opening day of the conference was largely given over to lectures on their ground-breaking research. Additionally, medals were awarded to recognize their exceptional contributions to the field. In a special belated gesture, the conference also honored Nathan

Nelson (Israel) and Nejat Veziroglu (USA), esteemed scientists from the 2016 International Conference, who were presented with their awards during this event, after missing the opportunity earlier.

Over 200 delegates participated in this 2019 conference, representing more than 22 countries across Asia, Europe, North America, and beyond. The diverse international attendance underscored the global importance of hydrogen as a clean energy carrier and the collaborative spirit necessary to address the challenges of climate change and energy security.

The significance of this conference was further highlighted through a detailed review published in 2019 in the "International Journal of Hydrogen Energy" (Borisova-Mubarakshina *et al*. 2019). This comprehensive review summarizes key presentations and the emerging trends that were discussed throughout the tenth conference.

Throughout the conference, a broad spectrum of topics related to hydrogen production was explored. These included:

• Energy for a Future Hydrogen Economy: Strategies for integrating hydrogen into existing energy infrastructures.
• Combatting Climate Change: The role of hydrogen in reducing greenhouse gas emissions.
• Biological Hydrogen Production: Advances in harnessing biological systems, such as algae and bacteria, for sustainable hydrogen generation.
• Hydrogenases: Enzymes that catalyze hydrogen production, with discussions on their mechanisms and potential applications.
• Reduction Catalysts: Development of catalysts to improve efficiency in hydrogen evolution reactions.
• Reduction of Carbon Dioxide: Innovative approaches to convert CO_2 into useful fuels and chemicals using hydrogen.
• Artificial Photosynthesis for Hydrogen Energy: Mimicking natural photosynthesis to produce hydrogen using sunlight.
• Nanotechnology in Fuel Cells: Enhancing performance and durability of fuel cells through nanomaterials.
• Nanomaterials for Hydrogen Production: Novel nanostructures designed to improve catalytic activity.
• Hydrogen Energy Education and Emerging Techniques: Promoting awareness and exploring new methodologies for hydrogen research.

A notable aspect of this conference was its emphasis on nurturing the next generation of scientists. Special awards and prizes for the best presentations were conferred upon promising young researchers, including Zahra Abdi, Daisuke Takagi, Eugene Maksimov, Valeria Dmitrieva, Sasan Aliniaeifard, Jack Forsman, and Kseniya Nikerova.

In summary, just as the earlier conferences, the Tenth International Conference on Photosynthesis and Hydrogen Production served as a vital platform for disseminating cutting-edge research, fostering international cooperation, and inspiring future advancements in sustainable hydrogen energy. This 2019 event reinforced the collective commitment of the global scientific community to address pressing environmental challenges through innovative science and technology.

Away from the floor of the conference, highlights were: visits to the Botanic Gardens and a visit to the Grand Peterhof Palace, both in St. Petersburg. In addition, there was a wonderful dinner in one of the most favorite restaurants, White Night, in the city, with a live band.

The Eleventh International Conference on Photosynthesis and Hydrogen Production; Istanbul, Türkiye (Turkey) in July 2023

This conference honored the following eminent scientists in the field: Robert (Bob) Blankenship (USA), Győző Garab (Hungary), Michael Graetzel (Switzerland), Norman (Norm) Huner (Canada), and Gunnar Öquist (Sweden). These distinguished individuals have made significant contributions to advancing our understanding of photosynthesis, bioenergy, and related disciplines, and their participation highlighted the global importance of the event.

This 11th conference was held at BAU – Bahçeşehir University on the northern outskirts of Istanbul. The venue provided a vibrant and inspiring setting, fostering a collaborative environment for scientists, researchers, and students alike. The picturesque surroundings and state-of-the-art facilities facilitated engaging discussions and networking opportunities that enriched the overall conference experience.

A summary of this conference was published in "Photosynthesis Research" in 2010: *see* Subramanyam *et al.* (2024). This comprehensive report highlights the key presentations, breakthroughs, and thematic sessions, underscoring the conference's contribution to the field's ongoing development. Further insights and detailed analyses of this 11th conference have also been published in "Photosynthetica" in 2024 by Kossalbayev *et al.* (2024); this publication has provided an extensive overview of the scientific discussions, emerging trends, and future directions identified during the 11th conference.

A total of 151 delegates attended this conference, representing 32 countries from Europe, Asia, the Americas, and beyond. The diverse international participation underscored the global relevance of the research topics discussed and fostered a rich exchange of ideas across cultural and scientific boundaries.

Once again, the conference served as a vital platform for the dissemination of knowledge and the fostering of collaborations in the fields of photosynthesis, hydrogen energy, and global sustainability. It provided an excellent opportunity for the participants to engage in meaningful dialogues about the previous achievements, the current challenges, and the prospects. The scientific program was particularly exciting, covering a wide spectrum from the molecular mechanisms and bioengineering to the global energy strategies. This conference, in Istanbul, also emphasized cutting-edge developments in artificial photosynthesis, nanobiotechnology, and sustainable energy solutions, reflecting the innovative spirit of the field. Again, as at earlier conferences, this wonderful event successfully reinforced the importance of interdisciplinary approaches in addressing the world's

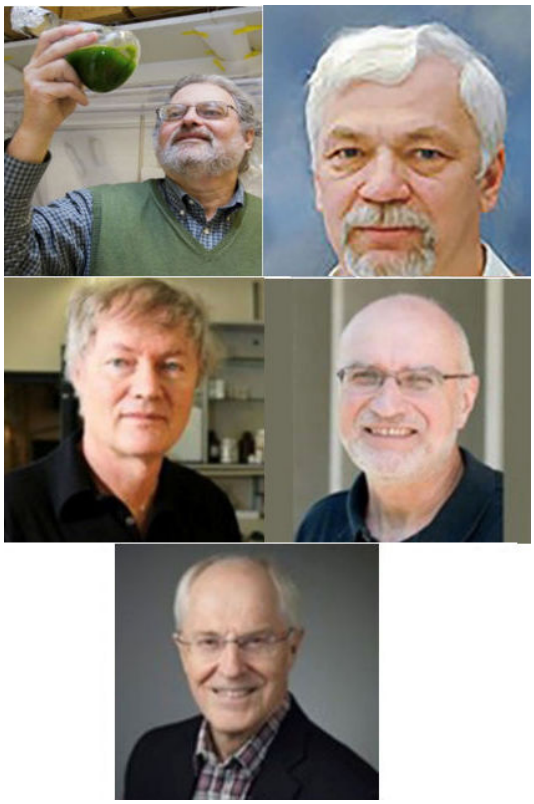

Fig. 11. The honoured delegates at the conference in 2023. *Top*, *left to right*: Robert (Bob) Blankenship and Győző Garab. *Middle*: Michael Grätzel and Norm Hüner. *Bottom*: Gunner Öquist.

energy needs and environmental concerns, inspiring new research initiatives and strengthening existing partnerships across the globe.

Fig. 11 shows photographs of those delegates who were honored in 2023 in Istanbul, Türkiye (Turkey).

The Twelfth International Conference on Photosynthesis and Hydrogen Production: For Sustainability, held in Istanbul, Türkiye (Turkey) in October 2024

This conference was also held at BAU, Bahçeşehir University (for information, *see* above); it continued to serve as a vital platform for the exchange of ideas, breakthroughs, and innovative research in the fields of photosynthesis and hydrogen production, both of which are critical in advancing sustainable energy solutions worldwide.

This 12th conference honored the following eminent scientists (*see* Fig. 12 for their photographs) who have made significant contributions to the field:

- John Allen (UK), recognized for his pioneering work in the molecular biology of photosynthesis.
- Eva-Mari Aro (Finland), renowned for her research on the molecular biology of photosynthesis.
- Ibrahim Dincer (Canada), a leading figure in sustainable energy systems.
- Kazumari Domen (Japan), celebrated for his advancements in artificial photocatalysis.
- Elisabeth Gantt (USA), distinguished for her work on red algae and their phycobilisomes.
- Andrey Rubin (Russia), noted for his research in mechanisms of photosynthetic processes.

The twelfth conference was attended by 152 delegates, representing 24 countries across the globe, reflecting the truly international nature of this event. The diverse participation fostered rich discussions and facilitated collaborations aimed at addressing some of the most pressing challenges in energy sustainability. The conference successfully highlighted recent developments in both fundamental research and applied technologies related to photosynthesis, with a focus on harnessing these processes to promote the growth of the hydrogen economy.

Fig. 12. Scientists honored by the conference in 2024. *Top*, *left to right*: John Allen (UK), Eva-Mari Aro (Finland), and Ibrahim Dincer (Canada). *Bottom*: Kazumari Domen (Japan), Elisabeth Gantt (USA), and Andrey Rubin (Russia).

Throughout the conference, participants attended a variety of keynote lectures, technical sessions, and poster presentations that covered cutting-edge topics such as artificial photosynthesis, biohybrid systems, renewable hydrogen production methods, and integration of these technologies into existing energy infrastructures. This conference, like the earlier ones, provided a platform for young scientists and students, offering them opportunities for networking, mentorship, and recognition through dedicated student prizes, which fostered the next generation of researchers in this vital field.

In addition to the scientific program, the conference featured a lively social component designed to promote cultural exchange and relaxation. Participants enjoyed a wonderful tour on the Bosphorus, taking in the stunning views of Istanbul's historic skyline, the Bosphorus Bridge, and the vibrant city life that exemplifies the rich cultural heritage of Turkey. These social activities helped build lasting connections among the attendees and enriched the overall conference experience.

This Twelfth International Conference on Photosynthesis and Hydrogen Production reaffirmed the scientific community's commitment to advancing sustainable energy research and fostering international collaboration. With ongoing innovations and a dedicated community of scientists, the future of clean energy solutions appears promising, and these conferences are expected to continue to serve as a pivotal platform in driving that progress forward.

The Thirteenth International Conference on Photosynthesis and Hydrogen Energy Research for Sustainability

This conference will be held in Italy from 17–20 May 2026 and will honor the contributions of the following esteemed researchers: Frano Barbir (Croatia), Juan Carlos Bolcich (Argentina), Richard Cogdell (UK), and Wolfgang Lubitz (Germany). For further details, *see* the webpage at: https://phrs-conference.com/ and https://phrs.entrat.eu/.

Summary

The first conference, titled "Photosynthesis and Post-Genomics Era," was held in 2004 in Trois-Rivières, Quebec, Canada. Since then, eleven additional conferences have taken place, with the most recent being the "Conference on Photosynthesis and Hydrogen Energy Research for Sustainability." This new title reflects a shift from solely focusing on natural photosynthesis to also exploring artificial photosynthesis for hydrogen production and energy sustainability in the coming years, along with efforts to enhance crop productivity through engineering photosynthesis.

These conferences have effectively addressed a crucial gap by providing a platform for regular, smaller-scale meetings focused on these topics. Held at research centres worldwide – primarily in North America, Europe, and Asia, they have gained significant popularity and continued support through funding from the International Society for Photosynthesis Research (ISPR) and the International Association for Hydrogen Energy (IAHE). Several prominent journals, including the "International Journal of Hydrogen Energy", "Photosynthesis Research", and "Photosynthetica", have published special issues dedicated to these conferences [*see* Govindjee *et al.* (2002), Govindjee and Yoo (2007)].

Fig. 13. A photograph of Suleyman Allahakhverdiev (*on the right*) with Johanna Harnois, the wife of Robert Carpentier, who organized the conference at Trois-Rivières in Canada, 2004. Photo by Robert Carpentier.

We have made significant progress in understanding the molecular mechanisms of photosynthesis and hydrogen production, along with advancing the broader goal of harnessing solar energy sustainably through photosynthesis in bacteria, eukaryotic algae, and land plants. These efforts are crucial in combating climate change. Many conference organizers over the years have been especially grateful to one of us (Suleyman Allakhverdiev) for organizing many conferences and giving a guiding hand to all of them.

We end this paper with a 2004 photograph (Fig. 13) of one of us (Suleyman Allahkhverdiev).

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