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ORIGINAL ARTICLE

International conference on "Photosynthesis and Hydrogen Energy Research for Sustainability-2019": in honor of Tingyun Kuang, Anthony Larkum, Cesare Marchetti, and Kimiyuki Satoh

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Abstract

The 10th International Conference on «Photosynthesis and Hydrogen Energy Research for Sustainability-2019» was held in honor of Tingyun Kuang (China), Anthony Larkum (Australia), Cesare Marchetti (Italy), and Kimiyuki Satoh (Japan), in St. Petersburg (Russia) during June 23–28, 2019. The official conference organizers from the Russian side were from the Institute of Basic Biological Problems of the Russian Academy of Sciences (IBBP RAS), Russian Society for Photobiology (RSP), and the Komarov Botanical Institute of the Russian Academy of Sciences ([K]BIN RAS). This conference was organized with the help of Monomax Company, a member of the International Congress Convention Association (ICCA), and was supported by the Ministry of Education and Science of the Russian Federation. Here, we provide a brief description of the conference, its scientific program, as well as a brief introduction and key contributions of the four honored scientists. Further, we emphasize the recognition given, at this conference, to several outstanding young researchers, from around the World, for their research in the area of our conference. A special feature of this paper is the inclusion of photographs provided by one of us (Tatsuya Tomo). Lastly, we urge the readers to watch for information on the next 11th conference on "Photosynthesis and Hydrogen Energy Research for Sustainability-2021," to be held in Bulgaria in 2021.

Keywords Tingyun Kuang · Anthony Larkum · Cesare Marchetti · Kimiyuki Satoh · Photosynthesis Research · Hydrogen Energy Research · Sustainability

Introduction

In oxygenic photosynthesis, light energy is used to convert water and CO_2 to oxygen and food; the process involves oxidation of water (with release of oxygen) and reduction of CO_2 (with the formation of carbohydrates): for details, see Blankenship (2014) and Shevela et al. (2019). About 3.5 billion years ago, ancient cyanobacteria started to

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Govindjee Govindjee—In the past, Govindjee has used one name only.

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change the anaerobic atmosphere of our Earth, making it suitable for the development of diverse living organisms (see, e.g., Shevela et al. 2013; Cardona 2019, Cardona and Rutherford 2019). Solar energy was used by these organisms leading to the accumulation of fossil fuels, which is being used at an alarming high rate by the current industrial society (see, e.g., Hou et al. 2014) Thus, new directions are needed to fulfill our future needs.

The burning of fossil fuels and subsequent environmental consequences are among the most urgent problems to be solved. One of the promising ways to meet future energy demands in a sustainable manner is the artificial generation of energy by mimicking natural photosynthesis. Indeed, with the help of a wide range of modern methods and techniques of biochemistry, biophysics, molecular biology, and both theoretical and experimental chemistry, it has become possible to investigate the structure and function of photosynthetic complexes, as well as the mechanisms of numerous photosynthetic reactions (cf. Blankenship 2014; Shevela et al. 2019). Modern approaches have made possible the determination of the molecular structures of not only Photosystem (PS) I and II, but even the light-harvesting antenna complexes (see, e.g., Ben-Shem et al. 2003; Ferreira et al. 2004; Liu et al. 2004; Umena et al. 2001; Wang et al. 2013, 2019; Qin et al. 2015; Wei et al. 2016; Suga et al. 2017; Pi et al. 2018, 2019; Young et al. 2016; Yu et al. 2018) and cytochrome *b6/f* complex (Kurisu et al., 2003). These molecular details are complimenting the previously discovered mechanisms of light-induced water oxidation leading to NADP reduction, and are expected to aid in the design of biomimetic approaches for supplying clean energy. However, we still lack molecular understanding of the photochemical reactions and the photosynthetic apparatus of a large variety of photosynthetic organisms.

The 10th International Conference «Photosynthesis and Hydrogen Energy Research for Sustainability-2019», held in St. Petersburg, Russia, honored the pioneering research of *Tingyun Kuang* (China), *Anthony Larkum* (Australia), *Cesare Marchetti* (Italy), and *Kimiyuki Satoh* (Japan). It was attended by scientists from all over the world working in the area of photosynthesis and related topics. This conference was preceded by several held earlier in Canada (2004); Russia (2006 and 2014); Azerbaijan (2011, 2013, 2018); Greece (2015); and India (2017); for details, see Allakhverdiev et al. (2012, 2013, 2014, 2015, 2019) and Tsygankov et al. (2017). Those honored at earlier conferences, listed alphabetically, included (Late) *Jalal Aliyev* (Azerbaijan); *James (Jim) Barber* (UK); *William (Bill) C. Cramer* (USA); *Govindjee*, now Govindjee Govindjee (USA); *Norio Murata* (Japan); *Nathan Nelson* (Israel); *George C. Papageorgiou* (Greece); *Agepati S. Raghavendra* (India); *Vladimir (Vlad) A. Shuvalov* (Russia), and *Turhan Nejat Veziroğlu* (USA).

The 10th conference in the series (https://icprs.ru/) was held during June 23–28, 2019 in Saint Petersburg, one of the world's most northern city, with a population of over one million people. It was a great occasion for discussion of the past, the present, and the future research on photosynthesis and hydrogen energy, from the molecular to the global level, providing an exciting scientific program, which covered the entire breadth and depth of research in photosynthesis and on hydrogen energy, from the fundamental and the applied aspects of research all the way to artificial photosynthesis and nanobiotechnology. Our conference was held at the Beloselsky-Belozersky Palace at the intersection of the Fontanka River and Nevsky Prospekt in Saint Petersburg, Russia. Figure 1 shows a photograph of this palace, and a few more from the opening ceremony (see below).

The first day of the conference

Our conference started on June 23, with a welcome speech by one of us, Anatoly Tsygankov, Chairman of the Conference, and the Acting Director of the Institute of Basic Biological Problems of the Russian Academy of Sciences (IBBP RAS). This was followed by a welcome, also by one of us, Julian Eaton-Rye (Secretary of the International Society of Photosynthesis Research, ISPR), and then welcome address by Dmitry Geltman (Director of the Komarov Botanical Institute of the Russian Academy of Sciences ([K] BIN RAS)), by Suleyman Allakhverdiev (Coordinator of the conference, also an author of this article), and finally by Maria Borisova-Mubarakshina (first author of this article) & Olga Voitsekhovskaja (both being co-chairs of our conference).

June 23 was dedicated to those being honored at the conference. First, Jian-Ren Shen introduced Kimiyuki Satoh, who then delivered his plenary lecture "Sixty years since the death of Robert Emerson: History of uncovering the chemical entities," which provided the basis for his own great findings. The next plenary lecture "Photosynthesis Research in Tingyun Kuang's Laboratory" was given by Guangye Han. Then, Govindjee (one of the authors) not only introduced Cesare Marchetti, but gave Marchetti's plenary lecture "Self-sinking capsules, a final solution to radioactive disposal." This was followed by Julian Eaton-Rye introducing Anthony Larkum, which was followed by Larkum giving his plenary lecture "Stromatolites old and new." These introductions and the four plenary lectures were followed by Tatsuya Tomo (also an author), Suleyman Allakhverdiev, and Julian Eaton-Rye giving the wonderful "Outstanding Achievement Award" plaques as well as certificates on behalf of ISPR to the four honored persons "for their significant contributions

Fig. 1 Opening ceremony of the 10th International Conference «Photosynthesis and Hydrogen Energy Research for Sustainability-2019» **a** The Beloselsky-Belozersky Palace (from https://petersburg24.ru/eng/place/dvorecz-beloselskih-belozerskih). **b** Suleyman Allakhverdiev giving welcome speech. **c** Left to right: Julian Eaton-Rye, Dmitry Geltman, Kimiyuki Satoh, Anthony Larkum, Cesare Marchetti, Anatoly A. Tsygankov and Olga Voitsekhovskaja. **d** Standing (left to right): Maria Borisova-Mubarakshina and Anatoly Tsygankov; sitting (left to right): Suleyman Allakhverdiev and Julian Eaton-Rye discussing organizational matters. **e** Left to right: Rajagopal Subramanyam, Nathan Nelson and Govindjee Govindjee, participants of the conference. Photographs (**b**–**e**) were provided by Tatsuya Tomo

in science." These award plaques were also given to Nathan Nelson and T. Nejat Veziroglu, the two honored scientists of the 7th International Conference «Photosynthesis and Hydrogen Energy Research for Sustainability-2016». For a parallel News Report that includes photographs from the presentation of award plaques and certificates to the four honored scientists, see Borisova-Mubarakshina et al. (2019).

The end of the first day of the conference was held in a memorable atmosphere. A group photograph was taken at the bottom of the stairs of the Beloselsky-Belozersky palace (see Fig. 2). Then, we all went to the "get together evening" at the BIN RAS. This get together was held in a luxurious setting in the Botanical Garden of St. Petersburg, and was followed by excursions to the Greenhouses of this Garden (Tropical Pathway and Victoria House) (see http://www.saint-petersburg.com/parks/botanical-garden/).

About our honored scientists

Figure 3 shows portraits of the four honored scientists: **a**: Tingyun Kuang, **b:** Anthony Larkum, **c:** Cesare Marchetti, **d:** Kimiyuki Satoh.

Tingyun Kuang (China) (by Jian-Ren Shen and Tatsuya Tomo, based on presentation by Guangye Han)

Tingyun Kuang (Fig. 3a) has dedicated her life, since 1962, to photosynthesis research at the Institute of Botany, the Chinese Academy of Sciences (IBCAS). We present here a brief introduction to her scientific career and achievements; she is one of the great scientists who has made important contributions to photosynthesis research, especially in the field of structure and function of both PS I and PS II chlorophyll–protein super-complexes (also see Lu et al. 2015).

Tingyun Kuang, Professor at the Institute of Botany (Chinese Academy of Sciences), was born in 1934, in Zizhong County, Sichuan Province of China. She graduated from the Department of Soil Agricultural Chemistry, Beijing Agricultural University in 1956, and obtained a PhD degree in Biology from Moscow State University in 1962. After returning back to China, she joined the Institute of Botany. During 1980–1981, she did research as a visiting scholar in Charles J. Arntzen's Laboratory at Michigan State University (East Lansing, MI).

Already in 1995, Kuang was selected as a member of the Chinese Academy of Science. She has served several societies over the years including Botanical Society of China

Fig. 2 A group photograph of the participants and the organizers of the 10th International Conference «Photosynthesis and Hydrogen Energy Research for Sustainability-2019» at the stairs of the Beloselsky-Belozersky palace. In the first row: from right to left: Suleyman Allakhverdiev; Julian Eaton-Rye; Cesare Marchetti; Antony (Tony) Larkum; Govindjee Govindjee; Jian-Ren Shen, and unidentified. On the extreme left in the second row is Maria Borisova-Mubarakshina, and on the extreme right in the third row is Anatoly Tsygankov (holding the conference bag). *Source* Tatsuya Tomo

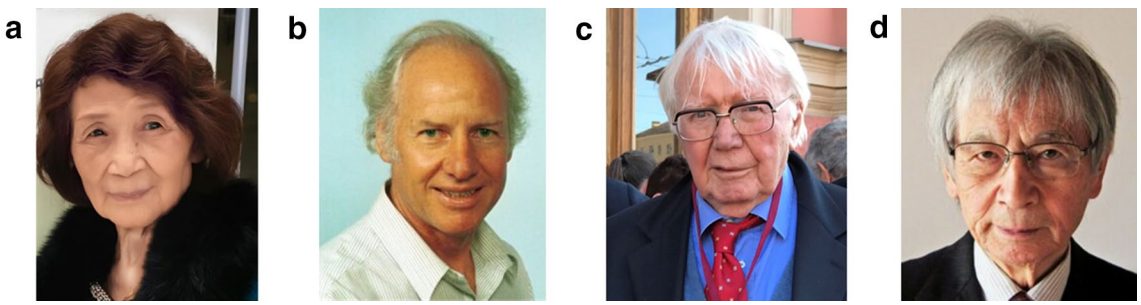

Fig. 3 Photographs of the honored scientists. **a** Tingyun Kuang. **b** Anthony Larkum. **c** Cesare Marchetti. **d** Kimiyuki Satoh. Photographs provided by those who introduced the speakers

(1998–2002; President); International Society of Photosynthesis Research (1998–2004; member of the Executive Committee); Botanical Society of China (2003—present; honorary President); and Plant Physiology Society of China (2000–2004; honorary President). Since 2004, she has been a member of the International Academy of Sciences for Europe and Asia. Further, we note that she, along with other colleagues, had successfully organized the 15th International Congress on Photosynthesis, held in Beijing in 2010.

Kuang has focused her research on the structure and function of photosynthetic membrane protein complexes of various plants and algae. Her major achievements have been in the following areas: (i) Role of manganese in photosynthesis; (ii) Structure and function of thylakoid membranes; (iii) Structure and function of the chlorophyll–protein complex of PS I; and (iv) Structure and function of chlorophyll–protein complex of PS II. For details, see Kuang et al. (1984), Xu et al. (2000), Chen et al. (2008), Wang et al. (2013), and Qin et al. (2015).

A major achievement of Tingyun Kuang and her team, in collaboration with the research group of Wenrui Chang, has been in the analysis of the crystal structure of LHCII, the major light-harvesting complex II from spinach, at 2.72 Å resolution (Liu et al. 2004).

Anthony Larkum (Australia) (by Julian Eaton-Rye)

Anthony (Tony) Larkum was born at the beginning of the Second World War in London (UK). After the war, he benefitted from the reforms to education, which meant that he was able to attend a Public (Private) school, Emanuel, in South London. After completing a BSc degree, in 1961, from the Imperial College (London, UK) studying botany and chemistry, Larkum (Fig. 3b) conducted biochemical research with Henrik Lundegårdh at the University of Uppsala, Sweden for 1 year. Then he continued his postgraduate research at Oxford University (UK), where he received his DPhil degree in 1966 for a thesis that dealt with the *processes of ion uptake in barley roots*. During his postdoctoral fellowship (1966–1968) at the University of Cambridge (UK), he worked in the laboratory of Enid MacRobbie, and studied the ionic status of chloroplasts. There, he investigated the role of compatible solutes in energy transduction in chloroplasts and wrote on *the ionic relations of chloroplasts* in vivo showing that chloroplasts have much higher salt concentration than the surrounding cytoplasm, and that this difference is involved in energy transduction (Larkum 1968). At this time, he was also involved in developing early applications of underwater (Self-Contained Underwater Breathing Apparatus, SCUBA) techniques to plant physiology, particularly the ways by which algae harvest solar energy in situ. In 1968, he worked, as a postdoctoral fellow for a year at the Johnson Foundation with Britton Chance and P. Leslie (Les) Dutton at the University of Pennsylvania (Philadelphia) on *energy transduction in chloroplasts*.

In 1969, Larkum joined the University of Sydney (Sydney, Australia) as a Lecturer in Plant Physiology, becoming Associate Professor of Biology in 1982 and Professor in 1994. Under the aegis of the Australian Academy of Science, he organized in 1990 a *Fenner Environment Conference on Ultraviolent B Radiation Impacts*, held in Canberra, Australia. Further, he chaired the working group that set the guidelines for a proposal to the International Geophysical Biological Program for research on the impact of UV-B on living organisms. We note that later he also chaired the Biology Committee of the Australian Research Council.

From 1996 until 2000, Larkum served as the Deputy Director of the School of Biological Sciences, and then from 2000 until 2004, as the Director of the Biological Informatics and Technology Centre of the University of Sydney. In 2001, he became a professorial fellow and then in 2003, Professor Emeritus at the same university. In 2009, he joined the University of Technology (also in Sydney) as an adjunct professor, where he now works in the C3 Global Change Cluster.

Larkum has served on the editorial board of several journals including *Aquatic Botany*, *Marine Biology*, *Phycologia* and *Trends in Plant* Science. Currently he serves on the editorial board of *Interface of the Royal Society* and *Frontiers in Marine Science*.

Anthony Larkum has published extensively—over 200 research publications. Readers may get a glimpse of his contributions by reading the following papers: Hatcher and Larkum (1983), Larkum and Barrett (1983), Lockhart et al. (1996), Salih et al. (2000), Larkum and Kühl (2005), and Larkum et al. (2018). His current interests are on the cyanobacteria (of stromatolites) with near-infrared-absorbing chlorophylls, and on the mechanisms of mass coral bleaching.

An interesting aspect of Larkum's life is that in addition to all these academic activities, Tony holds the Australian marathon record (for people 50 and above) of 2 h 32 m 36 s in Sydney (1990).

Cesare Marchetti (Italy) (by Govindjee and Jesse Ausubel)

Govindjee, in his talk on Marchetti, gave the following information (see Fig. 3c for a portrait of Marchetti). Cesare Marchetti was born on May 12, 1927, in Lucca, Italy. He was clearly a 92-year-young scientist at our conference. He had been earlier described to be a "thinking, planning and explaining" scientist, but more importantly as a leader in the field of "Hydrogen and Energy." However, topics of interest to Marchetti have been many including (i) Chemical economy and engineering; (ii) Climate change which includes geoengineering and the CO_2 problem; (iii) The capacity of the Earth for the human race; (iv) Society as a learning system as related to discovery, invention and innovation cycles; and (v) Travel behavior of humans as related to anthropological invariants.

Marchetti has been known for his intellectual curiosity of how things work from his early childhood. We have come to know that as a child he would dismantle toys to learn how they worked; his interest in chemistry came very early—when he was still in school. We have learnt that he did "dangerous" chemistry experiments even in his home! After the so-called *Laurea* in Physics at the University of Pisa, he graduated in 1949 from the *Scuola Normale Superiore*, in Pisa, which was a unique institution in Italy, having been founded by Napoleon Bonaparte himself. After this, Marchetti went, on a scholarship, to work at the world-famous Niels Bohr's Institute in Copenhagen, Denmark.

Marchetti's very first real academic research, during 1950–1955, was in Milan at the CISE (*Centro Informazioni*

Studi Esperienze). Here, he was involved in the area of Nuclear Energy and Heavy Water (D_2O) production, needed for the construction of nuclear reactors, operating with uranium. (In addition, in 1950, he had also obtained a consultancy contract, that was to last 20 years, with General Electric in Schenectady and Fairfield (USA) for forecasting and problem solving for the corporate leadership.) During 1956–1958, he worked at the Institute Battelle in Geneva, where he developed a lubricant for mechanical watches to avoid corrosion from liquids. During 1958, he was the director for the research center for designing nuclear reactors at the Agip Nucleare, in Milan. From 1959 to 1973, he was Director of the Materials Division of the Center of *Euratom* at Ispra (north of Milan) and also spent time in The Netherlands. At the beginning of this period (1959–1960), he spent 2 years in Canada as Representative of *Euratom* for the optimization of nuclear reactors.

Since 1974, Marchetti has done research as a Systems Analyst at IIASA (International Institute for Applied System Analysis) in Laxenburg (Austria). Here, he dedicated the first 10 years to the area of Energy, later extending the application of Systems Analysis to the description and forecasting in various areas of technological innovation, on the evolution of economic and social systems, on the dynamics of populations, of transport systems, of historical processes, of war events, of bank systems, and of creativity cycles of musicians, painters, and scientists. This period also included research on the evolution of the limits of knowledge and the dynamics of empires and religions. He has charted the construction of Gothic cathedrals in Europe, mosques, Mozart musical productions, and the length of railways. There is a *Marchetti Constant* saying that, since humanity began, humans travel about 1 h a day for personal purposes. Marchetti observed that all cities till 1800 had a maximum diameter of 5 km with a maximum population of one million people because of time budgets and the dominance of foot travel. Now that cars make possible an average speed of travel of about 40 km/h, cities can grow to have 25 million people!

Cesare Marchetti is an author of more than 200 publications. We list here just a few: Marchetti (1986, 1987); Ausubel and Marchetti (1996); Ausubel et al. (1998). A key research, since the 1960s, has been on 'Self- Sinking Capsules" which could solve the problem of disposal of nuclear waste and thus enable the hydrogen economy, and this was the topic of his talk at our conference.

Kimiyuki Satoh (Japan) (by Jian- Ren Shen and Tatsuya Tomo)

Kimiyuki Satoh served as a professor in the biology department at Okayama University, Japan, since 1982. In 2001, he became a Professor Emeritus at the same university. He has made substantial contributions to the field of primary photosynthesis (*see below*).

Satoh was born in 1935 in Shikoku-island, Japan, and graduated from Okayama University in 1958. He started his photosynthesis research in the laboratory of Hirosi Huzisige at Okayama University, and obtained a PhD degree from the University of Tokyo in 1972 while working at Okayama University. Even before this time, i.e., in 1967, he was appointed as an assistant professor in Plant Physiology in the Faculty of Science, Okayama. While he was on the faculty in Japan, he took time out to do collaborative research in USA. From 1975 to 1977, he worked as a visiting scholar in the laboratory of Warren L. Butler at University of California at San Diego (UCSD); in 1979, he worked as a postdoctoral associate in Philip Thornber's lab at the University of California at Los Angeles (UCLA); and in 1981, he was a Visiting Professor in the research group of Charles (Charlie) J. Arntzen at the Michigan State University.

Satoh has also served several societies including being the Vice President of the International Union of Photobiology (1996–2000), Secretary of the International Society of Photosynthesis Research (2001–2004), and the President of the Japanese Society of Plant Physiologists (2002–2003).

Satoh's major contribution to photosynthesis research is mainly on the biochemical identification and characterization of PS II. He initiated the work on biochemical separation of chlorophyll–protein complexes responsible for each one of the three chlorophyll-fluorescence emission bands (at ~ 685 nm, ~ 695 nm, and ~ 720 nm), observed in chloroplasts at 77 K (Satoh and Butler 1978). In this study, he succeeded in purifying the PS II core complex from spinach and identified the polypeptides as well as their chemical composition. He demonstrated that the PS II core complex contains two polypeptides of apparent molecular masses of about 30 kDa, which eventually were identified as the D1 (herbicide-binding) and D2 proteins (Satoh et al. 1983; this work was carried out in Charlie Arntzen's Lab). One of the remarkable successes in Satoh's research has been the isolation of an O_2-evolving PS II core complex, which was one of the first demonstrations that O_2 evolution could take place *in isolated pigment protein complexes* (Tang and Satoh 1985). Subsequently, Satoh and his research team reported the selective iodination of two tyrosine residues on the D1 and D2 subunits of the PS II complex that may correspond to the species responsible for the EPR signal IIvf (very fast) and IIs (slow) and function as the direct and auxiliary electron donors to the PS II reaction center (P680), respectively (Takahashi et al.1986). These two tyrosine residues were finally identified to correspond to the tyrosines, labeled as Y_Z and Y_D, respectively.

A major achievement of Kimiyuki Satoh is the isolation of a D1–D2-Cytochrome b_{559} complex (Nanba and Satoh 1987) that has indeed provided the unambiguous evidence

for the location of the PS II reaction center P680. Until 1986, the localization of the "special pair" P680 had not been clearly demonstrated, and this finding accelerated the characterization of this special pair and established that the site of primary charge separation in PS II is located in the complex consisting of the D1 and D2 proteins, the proteins that are homologous to the L and M subunits of the purple bacterial reaction center. Thus, Satoh has greatly contributed to our understanding of the phylogenetic and functional relationships between oxygenic and anoxygenic photosynthesis.

Research presentations and more

During the following 3 days of the conference, from June 24–26, 2019, we had two parallel research sessions: (1) *Photosynthesis Research for Sustainability*, which was devoted to studies of the structure, function, and biogenesis of the photosynthetic apparatus, and (2*) Hydrogen Energy Research for Sustainability*, which was devoted to research on both biological hydrogen production and fuel cell production. Both areas included fundamental and applied aspects of research, as well as work in the field of artificial photosynthesis, using nanomaterials and nanotechnology. For the detailed program, see https://icprs.ru/#!/schedule.

Topics of sessions and a partial list of speakers

The scientific program of the 10th International Conference «Photosynthesis and Hydrogen Energy Research for Sustainability-2019» included daily plenary lectures on photosynthesis and hydrogen energy, oral and poster presentations by the conference participants, as well as selected presentations by young scientists. During the Conference, we had several plenary lectures, which were given, in order of their presentation, by Jian-Ren Shen, Mahdi Najafpour, Tatsuya Tomo, Andrey Rubin, Sumanta Kumar Padhi, William Cramer (via Skype), Matthias Rögner, Julian Eaton-Rye, Marc Nowaczyk, Nathan Nelson, Govindjee, Anatoly Tsygankov, Giovanni Venturoli, Dmitry Dunikov, Mats Hansson, and Giuseppe Spazzafumo. Within each day, selected participants presented 16 talks in two parallel sections: eight in the Mirror Hall and eight in the Oak Hall (selected photos of the speakers are shown in Fig. 4).

On June 24, we had the session for the oral presentations by young scientists (listed in alphabetical order): Zahra Abdi, Sasan Aliniaeifard, Valerya Dmitrieva, Jack Forsman, Eugene Maksimov, Kseniya Nikerova, and Daisuke Takagi (for the titles of their presentations see https://icprs.ru/#!/schedule).

Fig. 4 Photographs of selected speakers of the 10th International Conference «Photosynthesis and Hydrogen Energy Research for Sustainability-2019»: **a** Bolatkhan Zayadan. **b** William Cramer (via Skype). **c** Alexey Semenov. **d** Kostas Stamatakis. **e** Mahdi Najafpour. **f** Taras Antal. **g** Matthias Rögner, **h** Olga V. Voitsekhovskaja, **i** Gadi Schuster. **j** Andrey Rubin. **k** Szilvia Toth. **l** Govindjee Govindjee. *Source* Tatsuya Tomo

Fig. 5 Recognition of the young scientists—the winners of the best oral and poster presentations with four of the coauthors (italicized). From left to right: Camilla Rabaganova, Volker Hartmann, Mahya Salmanion, Maxim Kozlov, Martina Beckova, Aleksandr Ashikhmin, Jack Forsman, *Govindjee*, *Julian Eaton-Rye*; Tirupathi Malavath, Zahra Abdi, *Tatsuya Tomo*, *Suleyman Allakhverdiev*, Daisuke Takagi, and Miyuki Tanabe. This photograph was provided by Rie Nagayoshi

Fig. 6 Photographs of young scientists, winners of the best oral and poster presentations, receiving special certificates from Julian Eaton-Rye. **a** Aleksandr Ashikhmin. **b** Camilla Rabaganova. **c** Jack Forsman. **d** Mahya Salmanion. **e** Martina Beckova. **f** Maxim Kozlov, **g** Miyuki Tanabe. **h** Daisuke Takagi. **i** Tirupathi Malavath. **j** Volker Hartmann. **k** Zahra Abdi. *Source* Govindjee's archives

Our conference provided awards/prizes to eleven young researchers chosen from both oral and poster presentations. The awards were presented to those who were judged by a committee to have done outstanding research in one of the fields of photosynthesis, hydrogen energy, plant biology, nanomaterials, and nanotechnology for sustainability (Fig. 5). The winners (listed alphabetically) were Zahra Abdi; Aleksandr Ashikhmin; Martina Beckova; Jack Forsman; Volker Hartmann; Maxim Kozlov; Tirupathi Malavath; Camilla Rabaganova; Mahya Salmanion; Daisuke Takagi, and Miyuki Tanabe (see Fig. 6 for their photographs and Appendix for the titles of their presentations). All the

eleven prizes were courtesy of Agrisera and Springer, the latter provided books from the "Advances in Photosynthesis and Respiration" series (Series editors: Thomas Sharkey and Julian Eaton-Rye; founding editor: Govindjee) and "Hydrogen Energy." These books were signed by Suleyman Allakhverdiev, Tatsuya Tomo, Julian Eaton-Rye, and Govindjee Govindjee, with best wishes for future research of the awardees.

The poster sessions were of great importance to our conference; they were held for 2 days and were crucial to the success of our conference since they were the hub of detailed scientific discussions. They provided a great opportunity for young scientists to interact with other scientists in both the fields of photosynthesis and hydrogen energy. In summary, this meeting provided a wonderful forum for students, postdoctoral fellows, and scientists from different countries to strengthen their knowledge and understanding, widen professional contacts, create new opportunities, and establish new collaborations.

In addition to the scientific program, the participants and the accompanying persons had the opportunity to enjoy the cultural program of the conference: an excursion to Peterhof with a visit to the Grand Palace and Grottoes of the Grand cascade, and the Sightseeing bus tour with a visit to the Peter and Paul fortress.

Supplementary Material provides information on the Banquet as well as a few informal and interesting photographs from the conference. Figure S1 has selected scenes from the wonderful "free time" during the conference, and Figure S2 is of some of our sponsors.

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Appendix

List of the titles of the presentations by young scientists—the winners of oral and poster talks (arranged alphabetically, with the titles of their papers):

- Zahra Abdi (Iran): "Water oxidation by vitamin B12: questions and challenges"
- Aleksandr Ashikhmin (Russia) "Carotenoid-induced formation of LH1 light-harvesting complexes from B820 subunits of sulfur photosynthetic bacterium Ectothiorhodospira haloalkaliphila"
- Martina Beckova (Czech Republic) "Role of specific Photosystem II complexes in the cyanobacterial chlorophyll a biosynthesis"
- Jack Forsman (New Zealand) "Hydrophobic interactions between the D1 and PsbT subunits of Photosystem II stabilize the iron-quinone acceptor complex"
- Volker Hartmann (Germany) "In vitro reconstitution of a Photosystem II- phycobilisome super-complex for enhanced light harvesting in bio-photovoltaics"
- Maxim Kozlov (Russia) "Influence of vibrations of conjugated bonds of lutein on the energy transfer rate in LHCII"
- Tirupathi Malavath (Israel) "Structure of Photosystem I from halotolerant green algae Dunaliella salina"
- Camilla Rabaganova (Russia) "TOR kinase and GORK channels in sensing of cellular potassium levels during induction of autophagy in Arabidopsis and barley"
- Mahya Salmanion (Iran) "Nickel–iron hydroxides: New findings and challenges"
- Daisuke Takagi (Japan) "Phosphorus toxicity decreases both electron sink activity and anti-oxidative activity in rice leaves"
- Miyuki Tanabe (Japan) "Responses of energy-transfer processes in diatoms to fluctuating light."

References

Allakhverdiev SI, Huseynova IM, Govindjee (2012) International conference on ''Photosynthesis research for sustainability-2011'', July 24–30, 2011, Baku, Azerbaijan. Photosynth Res 110:205–212

Allakhverdiev SI, Huseynova IM, Govindjee (2013) International conference on ''Photosynthesis research for sustainability-2013: in honor of Jalal A. Aliyev'', Baku, Azerbaijan. Photosynth Res 118:297–307

Allakhverdiev SI, Tomo T, Govindjee (2014) International conference on ''Photosynthesis research for sustainability-2014: in honor of Vladimir A. Shuvalov'', Pushchino, Russia. Photosynth Res 122:337–347

Allakhverdiev SI, Tomo T, Stamatakis K, Govindjee (2015) International conference on ''Photosynthesis research for sustainability2015: in honor of George C. Papageorgiou'', September 21–26, 2015 Crete, Greece. Photosynth Res 130:1–10

Allakhverdiev SI, Subramanyam R, Tomo T (2019) International Conference on "Photosynthesis and Hydrogen Energy Research for Sustainability-2017". Photosynth Res 139:1–8

Ausubel JH, Marchetti C (1996) Elektron: Electrical systems in retrospect and prospect. Daedalus 125:139–169

Ausubel JH, Marchetti C, Meyer P (1998) Toward green mobility: the evolution of transport. Eur Rev 6:137–156

Ben-Shem A, Frolow F, Nelson N (2003) Crystal structure of plant photosystem I. Nature 426:630–635

Blankenship RE (2014) Molecular mechanisms of photosynthesis, 2nd edn. Wiley, Oxford

Borisova-Mubarakshina MM, Tsygankov AA, Tomo T, Allakhverdiev SI, Eaton-Rye JJ, Govindjee (2019) The 10th international conference on "Photosynthesis and Hydrogen Energy Research for Sustainability": a pictorial report in honor of Tingyun Kuang, Anthony Larkum, Cesare Marchetti and Kimiyuki Satoh. Int J Hydrog Energy, (Submitted)

Cardona LT (2019) Thinking twice about the evolution of photosynthesis. Open Biol. https://doi.org/10.1098/rsob.180246

Cardona LT, Rutherford AW (2019) Evolution of photochemical reaction centres: more twists? Trends Plant Sci. https://doi.org/10.1016/j.tplants.2019.06.016

Chen GY, Niu XD, Chen XB, Li LB, Kuang TY, Li SQ (2008) Characterization of chlorophyll-protein complexes isolated from a siphonous green alga, *Bryopsis corticulans*. Photosynth Res 96:75–81

Ferreira KN, Iverson TM, Maghlaoui K, Barber J, Iwata S (2004) Architecture of the photosynthetic oxygen-evolving center. Science 303:1831–1838

Hatcher BG, Larkum AWD (1983) An experimental analysis of factors controlling the standing crop of the epilithic algal community on a coral reef. J Exp Mar Biol Ecol 69:61–84

Hou HJM, Allakhverdiev SI, Najafpour MM, Govindjee (Eds.) (2014) Current challenges in photosynthesis: from natural to artificial; Frontiers Research Topic; Ebook, Frontiers Media SA; pp 103

Kuang TY, Argyrousi Akoyunoglou JH, Nakatani HY, Watson J, Arntzen CJ (1984) The origin of the long-wavelength fluorescence emission band (77 K) from photosystem I. Arch Biochem Biophys 235:618–627

Kurisu G, Zhang H, Smith JL, Cramer WA (2003) Structure of the cytochrome b6f complex of oxygenic photosynthesis: tuning the cavity. Science 302:1009–1014

Larkum AWD (1968) Ionic relation of chloroplasts in vivo. Nature 218:447–448

Larkum AWD, Barrett J (1983) Light harvesting processes in algae. Adv Bot Res 10:1–219

Larkum AWD, Kühl M (2005) Chlorophyll *d*; the puzzle resolved. Trends Plant Sci 10:355–357

Larkum AWD, Pernice M, Schliep M, Davy P, Szabo M, Raven JA, Lichtenberg M, Elgetti Brodersen K, Ralph PJ (2018) Photosynthesis and metabolism of seagrasses. In: Larkum A, Kendrick G, Ralph P (eds) Seagrasses of Australia. Springer, New York, pp 315–342

Liu ZF, Yan HC, Wang KB, Kuang TY, Zhang JP, Gui LL, An XM, Chang WR (2004) Crystal structure of spinach major light-harvesting complex at 2.72 Å resolution. Nature 428:287–292

Lockhart PJ, Larkum AW, Steel M, Waddell PJ, Penny D (1996) Evolution of chlorophyll and bacteriochlorophyll: the problem of invariant sites in sequence analysis. Proc Nat Acad Sci USA 93:1930–1934

Lu C, Shen J-R, Zhang L (2015) Special issue on regulation of the photosynthetic systems in honor of Tingyun Kuang. Photosynth Res 126:185–188

Marchetti C (1986) Environmental problems and technological opportunities. Technol Forecast Soc Change 30:1–4

Marchetti C (1987) The future of hydrogen: an analysis at world level, with special look at air transport. Int J Hydrog Energy 12:61–71

Nanba O, Satoh K (1987) Isolation of a photosystem II reaction center consisting of D-1 and D-2 polypeptides and cytochrome b-559. Proc Natl Acad Sci USA 84:109–112

Pi X, Tian L, Dai H-E, Qin X, Cheng L, Kuang T, Sui S-F, Shen J-R (2018) Unique organization of photosystem I-light harvesting supercomplex revealed by cryo-EM from a red alga. Proc Natl Acad Sci USA 115:4423–4428

Pi X, Zhao S, Wang W, Liu D, Xu C, Han G, Kuang T, Sui S-F, Shen J-R (2019) The pigment-protein network of a diatom photosystem II-light harvesting antenna supercomplex. Science. https://doi.org/10.1126/science.aax4406

Qin X, Suga M, Kuang T, Shen JR (2015) Structural basis for energy transfer pathways in the plant PSI-LHCI supercomplex. Science 348:989–995

Salih A, Larkum AWD, Cox GC, Kuhl M, Hoegh-Guldberg O (2000) Fluorescent pigments in corals are photoprotective. Nature 408:850–853

Satoh K, Butler WL (1978) Low temperature spectral properties of subchloroplast fractions purified from spinach. Plant Physiol 61:373–379

Satoh K, Nakatani HY, Steinback KE, Watson J, Arntzen CJ (1983) Polypeptide composition of a photosystem II core complex; presence of a herbicide-binding protein. Biochim Biophys Acta 724:142–150

Shevela D, Pishchalinikov R, Eichacker LA, Govindjee (2013) Oxygenic photosynthesis in cyanobacteria. In: Srivastava A et al (eds) Stress biology of cyanobacteria. Taylor & Francis, London, pp 3–40

Shevela D, Bjorn L, Govindjee (2019) Photosynthesis: solar energy for life. World Scientific, Singapore

Suga M, Akita F, Sugahara M et al (2017) Light-induced structural changes and the site of O=O bond formation in PSII caught by XFEL. Nature 543:131–135

Takahashi Y, Takahashi M, Satoh K (1986) Identification of the site of iodide photooxidation in the photosystem II reaction center complex. FEBS Lett 208:347–351

Tang XS, Satoh K (1985) The oxygen-evolving photosystem II core complex. FEBS Lett 179:60–64

Tsygankov AA, Allakhverdiev SI, Tomo T, Govindjee (2017) International conference on "Photosynthesis Research for Sustainability-2016" in honor of Nathan Nelson and Turhan Nejat Veziroglu. Photosynth Res 131:227–236

Umena Y, Kawakami K, Shen JR, Kamiya N (2001) Crystal structure of oxygen-evolving photosystem II at a resolution of 1.9 Å. Nature 473:55–60

Wang WD, Qin XC, Sang M, Chen DQ, Wang KB, Lin RC, Lu CM, Shen JR, Kuang TY (2013) Spectral and functional studies on siphonaxanthin-type light-harvesting complex of photosystem II from *Bryopsis corticulans*. Photosynth Res 117:267–279

Wang W, Yu L-J, Xu C, Tomizaki T, Zhao S, Umena Y, Chen X, Qin X, Xin Y, Suga M, Han G, Kuang T, Shen J-R (2019) Structural basis for blue-green light-harvesting and energy dissipation in diatoms. Science. https://doi.org/10.1126/science.aav0365

Wei X, Su X, Cao P, Liu X, Chang W, Li M, Zhang X, Liu Z (2016) Structural of spinach photosystem II–LHCII supercomplex at 3.2 Å resolution. Nature 534:69–74

Xu CC, Kuang TY, Li LB, Lee CH (2000) D1 protein turnover and carotene synthesis in relation to zeaxanthin epoxidation in rice leaves during recovery from low temperature photoinhibition. Aust J Plant Physiol 27:239–244

Young ID, Ibrahim M, Chatterjee R et al (2016) Structure of photosystem II and substrate binding at room temperature. Nature 540:453–457

Yu L-J, Suga M, Wang-Otomo Z-Y, Shen J-R (2018) Structure of photosynthetic LH1-RC super-complex at 1.9 Å resolution. Nature 556:209–213