

Gordon research conference on the dynamics and regulation of photosynthesis: from the origin of bio-catalysis to innovative solar conversion

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Abstract We provide here a news report on the 2015 Gordon Research Conference “*Dynamics and regulation of photosynthesis: from the origin of biocatalysis to innovative solar conversion.*” It was held at Bentley University, Waltham, MA, USA, June 28–July 3, 2015, and offered a mix of traditional and emerging areas that highlighted new directions and methods of analyses. A major innovation was short (1 min) poster highlights that added an exciting dynamic to the interactions. Following the end of the formal sessions, three young scientists (Andrian Gutu, of Harvard University, USA; Alizée Malnoë, of University of California, Berkeley, USA; and Yuval Mazor of Tel Aviv University, Israel) were recognized for their research; they

also each received a recent volume of “*Advances in photosynthesis and respiration including bioenergy and related processes*” from Govindjee. We also provide at the end a brief report on the Gordon Research Seminar that preceded the conference.

Keywords Petra Fromme · Arthur Grossman · Andrian Gutu · Alizée Malnoë · Yuval Mazor · Fabrice Rappaport

Introduction

The 2015 Gordon Research Conference (GRC) on photosynthesis was held from June 28 to July 3, 2015, at Bentley University, Waltham, Massachusetts, USA. For a brief history of this conference, see <http://www.grc.org/conferences.aspx?id=0000207>. The 2015 Conference was chaired by Fabrice Rappaport (Institut de Biologie Physico–Chimique, Centre National Recherche Scientifique (CNRS), Paris France); and the Vice Chair was Arthur Grossman (Carnegie Institution for Science, Stanford, California, USA), who will chair the 2017 conference. Petra Fromme, of Arizona State University, Tempe, Arizona, USA, was elected to be the next Vice Chair (see Fig. 1 for photographs of Rappaport, Grossman, and Fromme, with others). All are welcome to watch for the announcement of the 2017 Conference in Science magazine and apply in advance.

The 2015 conference had an emphasis on “the dynamics and regulation of photosynthesis: from the origin of biocatalysis to innovative solar conversion”. This conference was quite international just as was the 2014 conference. There were 180 (10 more than in 2014) registered participants from 21 (just one more than in 2014) countries: Australia (7); Belgium (1); Canada (4); China (2); Finland (2); France (12); Germany (18); Hungary (1); Israel (3);

This manuscript was prepared mainly to recognize young investigators in the field of photosynthesis research; it was read, edited and approved for publication in *Photosynthesis Research* by William Adams and Barbara Demmig-Adams; Barbara, one of the Associate Editors of *Photosynthesis Research*, wrote: “I have read this paper; it looks great.” Further, Gregory Scholes, a reviewer, said: “I have read over the paper and it is suitable for publication: It’s terrific that you have these meetings documented like this.”

Electronic supplementary material The online version of this article (doi:[10.1007/s11120-015-0187-9](https://doi.org/10.1007/s11120-015-0187-9)) contains supplementary material, which is available to authorized users.

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Fig. 1 *Top left* Fabrice Rappaport (Chair); *top right* Arthur Grossman (Vice Chair). *Second row, left* Rappaport and Grossman standing together; *second row, right* Petra Fromme (elected to be the next Vice Chair), together with Govindjee, celebrating her victory with watermelon. *Bottom row* An informal evening celebration with (from left)

Petra Fromme, Arthur Grossman, Devaki Bhaya, Alizee Malnoë, Fabrice Rappaport, Francis-Andre Wollman, Govindjee, and Sabeeha Merchant. Photos were provided by Gennady Ananyev, Govindjee, and Siddhartha Dutta

Italy (4); Japan (7); New Zealand (1); Norway (3); Poland (4); Sweden (9); Switzerland (1); Taiwan (1); The Czech Republic (3); The Netherlands (7); UK (16) and USA (79).

Figure 2 shows a group photograph of most of the participants provided by the Gordon Research Conference.

Discussion leaders and speakers

Reflecting the interdisciplinary nature of photosynthesis research, a diverse group of international speakers presented a variety of scientific approaches to investigate



Fig. 2 A group photograph of most of the participants at the 2015 Gordon Research Conference on photosynthesis, held at Bentley University, Waltham, Mass, USA (Chair: Fabrice Rappaport; Vice Chair: Arthur Grossman), June 28–July 3, 2015. **Row 1** (left to right) Jay McCarren, Sahr Khan, Mikhail Askerka, David Vinyard, Sebastian Szewczyk, Wojciech Giera, Melania Kujawa, Jiyong Li, Jun Liu, Marjaana Suorsa, Otilia Cheregi, Han Bao, Pasqual Liauw, Nicoletta Liguori, Pengqi Xu, Alizée Malnoé, Fabrice Rappaport, Arthur Grossman, Douglas Campbell, Amanda Cockshutt, Julian Eaton-Rye, Govindjee, Gennady Ananyev, Vasily Kurashov, Marcia Ortega Ramos, Rafael Saer, César Cruz, Samuel Barnett, Roberto Bassi, Vicki Moore, Peter Dahlberg, Benjamin Bailleul, Pierre Cardol, and Anna Armstrong. **Row 2** (left to right) Yuval Mazor (slightly up front), William Rutherford (with white hat), Philipp Gäbelein, Michelle Leuenberger, Charles Dismukes, Ru Zhang, Na'ama Segal, Fatima Foflonker, Shai Saroussi, Sari Jarvi, Arren Bar-Even, Gal Wittenberg, Marc Nowaczyk, Gabor Bernat, Jonathan Meuser, Petar Lambrev, Dmitry Shevela, Anders Hagfeldt, Nicholas Fisher, Johannes Messinger, Tomas Morosinotto, Toshiharu Shikanai, Giovanni Finazzi, Gunvor Rokke, Bjorn Lundin, Jian-Ren Shen, Mei Li, Diana Kirilovsky, Petra Fromme, Peter Neofotis and Hristena Staleva. **Row 3** (left to right) Richard Debus, Sujith Puthiya Veetil, Robert Burnap, R. David Britt, Hideya Fukuzawa, Ryutarō Tokutsu, Martin Hohmann-Mariott, Rhiannon Evans, Siddhartha Dutta, Han-Yi Fu, David Tiede, Jianping Yu, Aaron Kaplan, Harvey Jian-Min Hou, Joerg Nickelsen, Olivier Vallon, Stenbjorn Styring, Long Vo, Dennis Nuernberg, Esther Sundermann, Falciatore Angela, Ronald Pace, Hiroki Makita, Devaki Bhaya, John Sonewald, Alix Boulouis, Dimitri Tolleter, and Craig MacGregor–Catwin. **Row 4** (left to right) Jeremy Hall, Paul Oyala, Matthew Sheridan, Benjamin Sherman, Andrea Fantuzzi, Jacob Lamb, Benjamin Engel, Nicholas Cox, Holger Dau, Colin Gates, Wolfgang Nitschke (in red shirt), Klaus Apel, Theodor Agapie (in blue shirt), Miwa Sugtara, Chris Baker, Jeffrey Cruz (with grey cap), Deserah Strand (with sun glasses), Stephen Herbert, Terry Bricker, Hsiu-An Chu, Ioannis Dikaos, Dipali Singh, Peter Jahns (in green shirt), Alberta Pinnola, Anne-Marie Carey, and P. Leslie Dutton. **Row 5** (left to right) Martin Jonikas (blue shirt), David Savage, Ke Yang, Steven Ball, Keisuke Inomura, Alistair Laos, Anthony Larkum, Sven DeCausermaecker, Michael Schorsch, Guy Hanke, Geoffrey Davis (in green shirt), Wojciech Nawrocki, Tomas Polivka, Vittal Yachandra, Setsuko Wakao (slightly up front and in red dress), Kevin Redding (in dark glasses), Ann Magnuson, Janina Steinbeck, Laura Mosebach, James Allen (in dark glasses), Kailash Adhikari, Antonella Succuro, Anna Matuszynska, Gary Moore (with black beard), Doug Bruce (in red shirt), and David Kramer. **Row 6** (left to right) Manajit Hayer-Hartl, Sabeeha Merchant (in green dress), Fikret Mamedov (grey shirt), Serguei Vassiliev (dark glasses), Volha Chukhutsina, Sara Massey, Tanai Cardona, Herbert van Amerongen (blue shirt), Roberta Croce, Doran Bennett, Michal Gwizdala, Michael Gruber, William Wood, Jennifer Yarnold, Maxwell Ware, Raimund Fromme, Krzysztof Gibasiewicz, and Ana Moore. Copyright: Gordon Research Conference; reproduced with permission



Fig. 3 Portrait of some of the participants. *Top row* Anthony (Tony) Larkum; Leslie P. Dutton; and Francis-Andre Wollman, all pondering the larger issues being raised. *Middle row* Alix Boulouis and Guy T.

Hanke. *Bottom row* Benjamin Engel, Kevin Redding; and Jonathan Meuser. Photos provided by Gennady Ananyev

photosynthesis for the benefit of mankind. Speakers and discussion leaders included (in alphabetical order; poster awardees selected to speak are *italicized*): Thodor Agapie; Kapil Amarnath; Falcior Angela; Klaus Apel; Steven Ball; Arren Bar-Even; Roberto Bassi; Doran Bennett; Devaki Bhaya; Alix Boulouis; Robert Burnap; Pierre Cardol; Roberta Croce; Holgar Dau; Leslie Dutton; Benjamin Engel; Rhiannon Evans; Petra Fromme; Arthur Grossman; Marilyn Gunner; *Andrian Gutu*; Anders Hagfelt; Guy Hanke; Manajit Hayer-Hartl; Matt Johnson;

Aaron Kaplan; Cheryl Kerfeld; David Kramer; Anthony Larkum; Mei Li; *Alizee Malnoe*; *Yuval Mazor*; Sabeeha Merchant; Ana Moore; Joerg Nickelsen; Wolfgang Nitschke; Jennifer Ogilvie; Kevin Redding; Alfred Rutherford; David Savage; Jian-Ren Shen; Toshiharu Shikanai; Miwa Suguira; Setsuko Wakao; and Francis-Andre Wollman.

Figure 3 shows portraits of some of the participants taken by Gennady Ananyev, photographs in Figs. 4 and 5 reflect lighter moments at the conference, whereas Fig. 6



Fig. 4 Lighter moments at the conference, #1. *Top left* Manajit Hayer-Hartl, Arthur Grossman, Devaki Bhaya and Sabeeha Merchant, reminding us all that there is more to life than photosynthesis; *top right* David Kramer (in the *middle*) reminding us to begin planning for the next conference. *Bottom left* Nicoletta Liguori (2nd from *left*)

reminding us that coffee is good for you—after all it is a product of photosynthesis; *bottom right* Govindjee (3rd from the *left*) reminding us that the future belongs to the young, as long as they hold the hand of a more senior investigator. Photos provided by Govindjee and other participants

shows candid moments at the group photo shoot (see Fig. 2).

Topics of the talks and the posters

The general and broad topic of this Gordon Research Conference was, as already stated above, on the dynamics and regulation of photosynthesis. The individual sessions focused on different areas and some session areas were quite similar to the 2014 conference and included: Evolution of photosynthesis; Functional and cellular integration; Light harvesting: structure, function and regulation; Reactive oxygen species; Water oxidation leading not only to oxygen, but to hydrogen production; Photosynthetic membranes, structure and dynamics; Photosynthetic electron transfer and its regulation; Primary charge separation in natural photosynthesis as well as in artificial systems; Photosynthetic carbon and nitrogen metabolism; and Biodiversity of photosynthesis.

High-resolution X-ray crystal structures of reaction centers are being exploited to couple structural with functional information while new insights are also being gained

about the orange carotenoid protein and quenching associated with the phycobilisomes of cyanobacteria. Atomic force microscopy is being used to map the arrangement of Photosystem II and the cytochrome *b₆f* complex in grana membranes, while new 3D imaging technologies are being used to capture the *in vivo* architecture of the photosynthetic apparatus. There are also increased efforts to map alternative electron flow pathways and the roles of the NDH complex in those pathways, the relationship of electron flow pathways to the proton motive force (pmf), singlet oxygen signaling, insights that can be gained by studying photosynthesis in non-model organisms that grow in extreme environments, and even the use of some of the most advanced synthetic biology strategies to improve photosynthetic CO₂ fixation.

Poster presenters

There were more than 130 poster presenters (similar to 2014) on the topics listed above, with about 64 posters on the first 2 days and about 66 on the second 2 days. A major innovation this year was that about half of the poster



Fig. 5 Lighter moments at the conference, #2. *Top row (Left (L) to right (R))* Gennady Ananyev getting ready to take photos; Dmitry (Dima) Shevela posing in a serious mode (we made sure that the poster cannot be read); Johannes Messinger (in *blue shirt*) listening attentively to Hsiu-An Chu, but looks a bit puzzled. *Second row (left panel; L to R)* David (Dave) Tiede, Marilyn Gunner, Leslie (Les) Dutton, and Dan

E. Robertson, a tightly knit interactive group; (*right panel; L to R*) Peter Jahns, Devaki Bhaya, Stephen (Steve) Herbert, and Toshiharu Shikanai, a more free flowing group. *Third row (left panel; L to R)* Antonella Succuro, Kailash Adhikari and Aaron Kaplan; (*right panel; L to R*) David (Dave) R. Britt, Jianping Yu, and Terry M. Bricker. Photographs provided by Gennady Ananyev, Govindjee and Les Dutton

presenters were given 1 min to highlight their posters using just one slide each. The presenters lined up on the side of the auditorium and proceeded in rapid succession to convey the highlights of their work. A practice session was held beforehand to make sure that the process went smoothly. This approach, matching the research, the face of the researcher and the poster number, facilitated greater interactions over the course of the conference, and particularly at the posters and during the evening receptions. Overall, it was a surprisingly successful and wonderful addition to the conference, facilitating discussions—in the true spirit of the Gordon Research Conferences. Even those who had reser-

vations about this unorthodox approach were quickly won over by the quality and enthusiasm of the presenters.

Recognition of young scientists

The posters from three young scientists (names and poster titles given below), from among many that were excellent, were selected as those that were most exceptional. Govindjee presented to each of the three, different recent books from the Springer series (Series Editors: Govindjee and Thomas D. Sharkey) "Advances in Photosynthesis and



Fig. 6 Candid moments at the group photo shoot. A part of the group having fun just waiting to be called to line up properly for the big group photo (see Fig. 2). *Top row left* Gennady Ananyev (with Cannon camera strap), who took many great photographs for this and previous conferences, and told us about the joys of taking pictures; *top row right* Roberto Bassi (with *sun glasses*) said relaxation is the key to good science. *Second row left* Johannes Messinger (in *blue shirt*) was grinning to tell us “Don’t take life too seriously”; *second row right* Gabor Bernat (in *black shirt*) was smiling a bit—telling us “Now, I really

love to work with the beautiful green alga *Chlamydomonas*”. *Third row left* Dave Britt (wearing a hat) was saying “There is nothing more beautiful than the OEC, except maybe the hydrogenase”; *third row right* Ron Pace (with *dark glasses*) was wondering why it is so hot in the “winters”; is n’t it June? *Fourth row left* Giovanni Finazzi (in *red shirt*) was saying “Come to France and see what we really do there? *Fourth row right* Martin Hohmann-Marriott (wearing *open blue shirt*) used the time to advertise his book (volume 39 in *Advances in Photosynthesis and Respiration*). Photos and comments by Govindjee

Respiration Including Bioenergy and other Related Processes.” (<http://www.springer.com/series/5599?>). Figure 7 shows a photograph of the selected three: Andrian Gutu, Alizée Malnoë and Yuval Mazor with others.

- **Andrian Gutu** (of Harvard University, Cambridge, MA, USA; lab of Erin K. O’Shea) for his work on “In situ localization of *psaA* and *psbA* mRNA in cyanobacteria implicates the edges of thylakoid sectors as



Fig. 7 Top Photograph of the 2015 poster awardees with others. Left to right Arthur Grossman; Yuval Mazor; Alizée Malnoë; Govindjee; Andrian Gutu; and Fabrice Rappaport. Bottom Govindjee signing the book before giving it to Alizée; also shown is Andrian waiting for his turn. Photographs provided by Gennady Ananyev

biogenetic areas for PSI and PSII” in the area of *photosynthetic electron transfer and regulation*.

- **Alizée Malnoë** (of University of California, Berkeley, CA, USA; lab of Krishna K. Niyogi) for her work on “A chloroplastic lipocalin is required for SOQ1-related quenching in *Arabidopsis thaliana*” in the area of *light harvesting structure, function and regulation*.
- **Yuval Mazor** (of Tel Aviv University, Tel Aviv, Israel; lab of Nathan Nelson) for his work on “High-resolution structures of plant and cyanobacterial Photosystem I” in the area of *photosynthetic membranes—structure and dynamics*.

We present here a brief write-up on each of our three awardees:

Andrian Gutu received his PhD at Indiana University, Bloomington in 2010 with David Kehoe studying the regulation of phycobilisome composition in chromatically acclimating cyanobacteria. He discovered that complementary chromatic acclimation is integrated with the sulfur limitation response through the expression of a *trans*-acting non-coding RNA. He also found a new role for an alternative translation initiation factor in post-

transcriptional regulation of phycoerythrin gene expression. As a postdoctoral fellow in Erin O’Shea’s laboratory at Harvard University, he studied the signal transduction pathways that link the cyanobacterial Kai clock to circadian gene expression. He discovered the molecular function and signals controlling the activity of CikA, a regulator of circadian gene expression. Recently, he has started working on thylakoid biogenesis in cyanobacteria. His award-winning poster showed that the regions of high thylakoid curvature are likely devoted to translation of core photosystem proteins.

Alizée Malnoë’s first encounter with photosynthesis research was in Gilles Peltier’s lab at CEA (Commissariat à l’énergie atomique et aux énergies alternatives), Cadarache, France, where she worked with Laurent Cournac on the NDA2 complex of *Chlamydomonas reinhardtii*. She did her Master’s research in Ben Hankamer’s lab at the University of Queensland, Brisbane, Australia, where she studied *Chlamydomonas* under sulfur deprivation for biohydrogen production. She received her PhD in Biology from Paris-Sud XI University in 2011 under the supervision of Catherine de Vitry and Fabrice Rappaport in the laboratory of Francis-André Wollman (Laboratoire de Physiologie Membranaire et Moléculaire du Chloroplaste, at the Institut de Biologie Physico-Chimique (IBPC), Paris, France) studying the assembly and function of cytochrome *b₆f* in *Chlamydomonas*. They found that the FtsH protease is required for cytochrome *b₆f* turnover and discovered that photosynthetic growth is possible with a broken Q-cycle. Since 2012, she has been in Krishna (Kris) Niyogi’s lab at the University of California, Berkeley, USA, for her postdoctoral work where she has undertaken a mutagenesis screen in *A. thaliana* to understand a slowly reversible type of quenching regulated by the SOQ1 protein and found that the chloroplastic lipocalin is required for this quenching.

Yuval Mazor is a research associate in Nathan Nelson’s research group at Tel Aviv University in Tel Aviv, Israel. They have recently completed the structure of Photosystem I (PSI) from higher plants at 2.8 Å resolution. Yuval’s MSc and PhD studies were on DNA repair and epigenetic inheritance mechanisms in *Saccharomyces cerevisiae* with Martin Kupiec and the late Anat Krauskopf in Tel Aviv University. Coming from this very different background, he started working for Nathan, in a temporary job, in 2010, before moving on to do his post-doctoral studies. After being exposed to the type of biochemistry that goes on during the light reactions in oxygenic photosynthesis as well as other



Fig. 8 Walking and talking participants. *Top row left* Vittal Yachandra and Johannes Messinger; *top row middle* David Vinyard, Mikhail Askerka and Sahr Khan; *top row right* Charles (Chuck) Dismukes and Ronald (Ron) Pace. *Middle row left* Jian-Ren Shen (on the left) is, obviously, not paying attention to what Ron Pace is trying to tell him; *middle row right* 3-D printout of a chromatophore being shown, rather

enthusiastically, by Peter Dahlberg (in the center), to Marc M. Nowaczyk (on right) and an unidentified participant (on the left). *Bottom row* A group of five participants really having fun just being photographed. Photos provided by Gennady Ananyev and by Govindjee

challenges taken on by Nathan's group, Yuval decided to stay and engross himself completely in the fascinating area of PSI structure. His aim is to realize the possibility of combining structural with functional studies of large photosynthetic reaction centers.

To give the readers a sense of the wonderful ambiance that was present at the conference, we show here a collection of photographs of the participants. These include relaxed moments at the conference (Fig. 8), as well as at a soccer (football) game organized by Nicoletta Laguirri, who



Fig. 9 *Top* A scene from the soccer game. *Bottom* Time for celebration. *Left to right* Anna Matuszynska, Kailash Adhikari, Ioannis Dikaios, Dipali Singh, Antonella Succurro, Roberto Bassi, Angela Falciatore, Aaron Kaplan, William (Bill) Rutherford, and

Giovanni Finazzi. The *top* photo was taken by Pengqi Xu, and provided to us by Jeremy Hall; the *bottom* photo was taken by Alberta Pinnola, and provided to us by Anna Matuszynska

was recognized last year for her extraordinary poster (see Fig. 9, top; also see additional scenes of the game in the Supplementary Material). The spirit of celebration of everything that is good: knowledge gained, collaborations secured, and the great camaraderie established is obvious in Fig. 9 (bottom).

We end this presentation by a brief mention of an important set of seminars that preceded our conference.

Gordon Research Seminar

Preceding our conference, the Gordon Research Seminar (GRS) for graduate students and postdocs was held on June 27–28, 2015 (chaired by Alizée Malnoë; see Fig. 7). The focus was on “*Beyond steady-state photosynthesis: Emerging model organisms and technologies*”. Sabeeha

Merchant, and Petra Fromme (see Fig. 1) attended as senior mentors with almost sixty junior participants (24 postdocs and 35 graduate students). This year a new format for the GRS was tested in which time was given for general discussion at the end of each session. This was a great success as it led to lively debate and extensive participation among the attendees. Shai Saroussi (Carnegie Institution for Science, Stanford, California, USA) and Gal Wittenberg (Max Planck Institute for Molecular Plant Physiology, Potsdam-Golm, Germany) were elected to be the next chairs of the 2017 Gordon Research Seminar. Speakers and Discussion leaders at the 2015 Gordon Research Seminar included (in alphabetical order): Otilia Cheregi; Volha Chukhutsina; Petra Fromme; Wojciech Giera; Michael Gruber; Sahr Khan; Alistair Laos; Alizée Malnoë; Anna Matuszynska; Sabeeha Merchant; Wojciech Nawrocki; Alberta Pinnola; Deserah Strand; Esther Sundermann;

David Vinyard; Gal Wittenberg; Pengqi Xu; Jennifer Yarnold; and Makio Yokono.

Concluding remarks

The 2015 Gordon Research Conference on Photosynthesis provided established and emerging researchers an opportunity to present and appreciate the latest developments in our field. It also highlighted how some of the latest technologies and the use of non-model systems are providing the field with new insights into the structure and function of the photosynthetic apparatus. Indeed, it was one of the best conferences we have attended on photosynthesis. Likewise, it was a congenial environment for socializing with colleagues, both old and new, and for starting new collaborations. Perspectives on previous Photosynthesis Gordon Research Conferences can be found in Govindjee et al. (2007), Govindjee (2009), Govindjee et al. (2011), Moore et al. (2012) and Rappaport et al. (2015).

Acknowledgments We end this News Report by expressing our appreciation to all the attendees of the 2015 Conference for contributing to discussions on various aspects of photosynthesis and advancing the frontiers of science. We thank Fabrice Rappaport for chairing the 2015 Conference. For the description of the Awardees, we are grateful to the awardees themselves: Andrian Gutu, Alizée Malnoë and Yuval Mazor, who provided us with information on their

academic activities. We thank Gennady Ananyev, Jeremy Hall and Pengqi Xu, and several others for offering us many excellent photographs, as well as the Gordon Research Conference for allowing us the use of the of the 2015 group photograph. Special thanks go to Gennady Ananyev for the most and the best photographs. Govindjee thanks Ineke Ravesloot (Springer, Dordrecht, the Netherlands) for mailing the books awarded to Andrian, Alizée and Yuval, and Arthur Grossman for bringing the books to the Conference site. We are highly thankful to Fabrice Rappaport for his help in recognizing participants in the photographs shown here. Lastly, Rajni Govindjee helped us in producing the collages of some of the photos shown here.

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