RESEARCH CONFERENCES

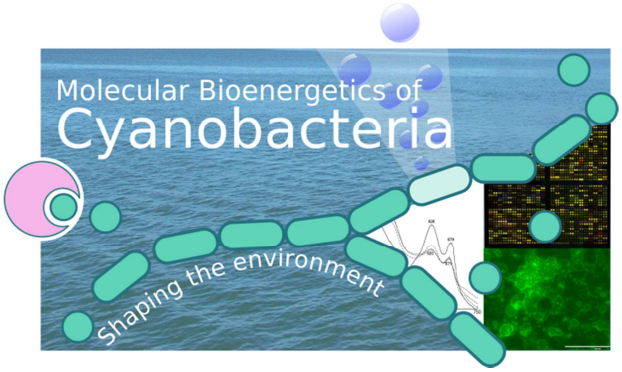
ESF-EMBO Symposium

Molecular Bioenergetics Of Cyanobacteria: Shaping The Environment

15-20 April 2013
Polonia Castle in Pultusk, Poland

Chaired Prof. Elke Dittmann, University of Potsdam, DE

Co-Chaired by Prof. Conrad Mullineaux, Queen Mary, University of London, UK and Prof. Jens Appel, University of Kiel, DE



http://www.esf.org/conferences/13409

Highlights & Scientific Report

30.05.2013

Conference Highlights

Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)

The conference series “Molecular Bioenergetics of Cyanobacteria” looks back at a fifteen year tradition. During that time it has significantly strengthened the research on photosynthesis and related bioenergetic processes in Europe and strongly influenced the introduction of genomics, proteomics, systems biology and cellular biology in the research field. With each of the research schemes, new interdisciplinary aspects were added that have broadened the perspectives of both established scientists and young researchers in the research area. The conference “Shaping the environment” was the last one of its kind and could benefit from a kind of evolutionary process. In fact, the scope of the conference was discussed in the forward looking discussion of the last conference and strongly influenced by round table discussions in 2011. The conference was approaching the “environmental” aspect from three different, though not completely independent perspectives. It was starting with an evolutionary perspective that shed light on the role of cyanobacteria and photosynthesis on shaping the earth biogeochemical history. The invited speaker Paul Falkowski gave a very inspiring talk integrating both earth geophysics aspects and the biochemistry of bioenergetic complexes. He was first time attending the conference. A second highlight in this part of the conference was the talk given by Cheryl Kerfeld on the CYANOGEBA initiative. The group has initiated a large sequencing project aimed to cover all phylogenetically important groups of cyanobacteria. As the result, they provide a very comprehensive view on the diversity and evolution of traits in cyanobacteria that are related to bioenergetic processes. A large part of the conference was then focusing on the present role of cyanobacteria on our earth. This included the impact of cyanobacteria on present biogeochemical cycles, new frontiers in photosynthesis research as well as research on adaptation and differentiation of cyanobacterial cells. Among the highlights were the talk given by Jonathan Zehr on the role of symbiotic cyanobacterial consortia on nitrogen cycles in the oceans and the talk given by Eva-Mari Aro on bioenergetic adaptation mechanisms of cyanobacteria under high light stress. A third part of the conference was devoted to the emerging field of metabolic engineering and synthetic biology of cyanobacteria. Klaas Hellingwerf gave a nice overview over the topic and highlighted possibilities and limitations in the field. Several young researchers contributed to this topic demonstrating the attractiveness of the subject especially for early career scientists. A highlight of the conference that was central for all types of current research on cyanobacteria was the talk given by Yasukazu Nakamura on CYANOBASE, the most important genomic and literature database on cyanobacteria. With the growing amount of data, organization into user-friendly databases becomes more and more important. CYANOBASE is already a benchmark database. Within the following round table discussion the scientific community had the possibility to influence the future expansion of the database. The atmosphere was generally very fruitful, especially during the two poster sessions that were well attended by all scientists. Poster presentations, in general, had high quality standards. The five day conference offered enough time for stimulating discussions during breaks. A cultural highlight was the half-day trip to Warsaw and the visit to the Royal castle.

x I hereby authorize ESF – and the conference partners to use the information contained in the above section on ‘Conference Highlights’ in their communication on the scheme.

Scientific Report

Executive Summary

(2 pages max)

The conference on Molecular Bioenergetics of Cyanobacteria: Shaping the Environment in 2013 was attended by 100 applicants and 17 invited speakers/chairs. Two further invited speakers have cancelled their attendance due to medical or family problems just before the conference. Among the applicants 52% were female and 55% were in the age group below 36. Most of the applicant's abstracts were considered as outstanding or very good. A considerable number of applicants had never attended the conference before. Though most scientists came from various European countries (fifteen different nationalities), further scientists came from US, India, Singapur or Japan. With approximately 120 participants the conference had an ideal size considering the scientific content and the individual presentation time for each oral or poster presenter.

The conference was organized into ten different sessions covering independent scientific aspects. The overall scope of the conference was highly interdisciplinary and included evolutionary, biophysics, biochemical, environmental as well as synthetic biology subtopics. Specifically, the sessions were focusing on I Cyanobacteria and the evolution of the biosphere II The cyanobacterial pan-genome: a blueprint for diversification and adaptation; III Global impact of cyanobacteria on biogeochemical cycles; IV Biogenesis and maintenance of the photosynthetic apparatus; V) Regulatory control in cyanobacteria; VI Data bases and systems biology; VII and VIII) Shaping and Differentiating a Cyanobacterial Cell VIII and IX Secondary Metabolites and Biofuels and X) Metabolic Adaptation and Stress Response. Apart from the fourteen presentations given by invited speakers 24 applicants were selected for short talks. Criteria for the selection of the talks were the scientific quality and the focus on the selected conference topics. Eight of the selected speakers were early stage researchers and have never given talks at this conference series before. The talks, in general, had a high quality. Session leaders took care about the discussions that were lively and included questions from both established scientists and young researchers. Two round table discussions were organized that covered database issues and a forward looking discussion. Paola Campus from ESF gave a stimulating overview about present and future activities of the ESF. As the other scientific sessions, round table discussions were well attended.

Poster sessions took place on two consecutive days. The 67 posters were divided into two halfs (1-33, 34-67). There was sufficient time for the discussion on each poster. However, the participants would have preferred to show their posters for the entire time to facilitate more informal discussions during coffee breaks.

The computer equipment and media needed for presentations were well organized by the local organizers as well as snacks and drinks during coffee breaks. The conference organizer of the ESF, Allegra Roccato was always available during breaks and solved many issues raised during conference, e.g. changes in the program; reimburse questions or questions related to the poster session.

The budget of the conference was divided as follows: 65 % were spent for conference fees and travel costs of speakers and chairs and 45% were spend for reduced conference fees and travel support of early stage researchers. European invited speakers were granted with full conference fees but did not receive a travel support; the four speakers from overseas received a full conference fee plus a 400 Euro travel contribution. From the young researchers, 19 received a 400 Euro reduced conference grant and 35 received a travel support (usually 200 Euros). The selection criteria were the quality of the application and the age of the applicants. PhD students from the group of the chair were not selected to save some money for researchers from overseas.

Participants were appreciating the half day break during the conference. A majority was attending the trip to Warsaw and the visit to the Royal Castle. From the excursion, people got considerably more insights into Polish history before, during and after World War II.

Scientific Content of the Conference

(1 page min.)

- *Summary of the conference sessions focusing on the scientific highlights*

The conference on Molecular Bioenergetics of Cyanobacteria:Shaping the Environment" had three main scopes. It first started with an evolutionary perspective in the session: I Cyanobacteria and the evolution of the biosphere. Paul Falkowski gave an inspiring talk covering both geophysical aspects and the evolution of bioenergetic complexes. He made clear how much cyanobacteria have contributed to the evolution of both the atmosphere and the geosphere. The talk was followed by a presentation given by Cheryl Kerfeld. The group from Berkeley University and the Joint Genome Institute had initiated a 50 genome sequencing project together with the Pasteur Institute. As the genome data were released just before the conference the talk gave a number of unprecedented new insights into specific traits of the cyanobacterial phylum. There is no doubt that the genome initiative will strongly influence the cyanobacterial research field in the next few years. The session was then shifting towards more specific traits. Martin Hagemann gave a comprehensive overview about salt adaptation strategies in cyanobacteria. In particular, he was showing gaps of knowledge and identified future questions in this important field of research. Patricia Sanchez-Barracaldo followed up on Paul Falkowskis talk and talked more specifically about the neoproterozoic origin for marine nitrogen-fixing cyanobacteria. Another speaker in the session, Jose-Manuel Garcia-Fernandez reported further details about the unexpected finding that marine Prochlorococcus strains that are supposed to be strictly autotroph, can take up glucose at nanomolar concentrations.

The second session: The cyanobacterial pan-genome:a blue-print for diversification and adaptation started with an RNA perspective. Wolfgang Hess provided fascinating new insights into the role of regulatory RNAs with a special emphasis on RNAs interfering with bioenergetic processes. Annegret Wilde followed with a talk covering an aspect of the regulatory control in cyanobacteria. She presented compelling data on the role of the second messenger cyclic di-GMP on phototactic mobility of the model strain Synechocystis PCC6803.

Session III covered the "Global impact of cyanobacteria on biogeochemical cycles". Jonathan Zehr gave an inspiring talk about microbial interactions with nitrogen-fixing oceanic cyanobacteria. He is a pioneer in the analysis of non-cultivable marine cyanobacteria and showed how modern techniques can help elucidate biogeochemical cycles *in situ*. Debbie Lindell followed with a very interesting talk on cyanophages. Phages, in general, play an enormous role for the population dynamics of cyanobacteria in different ecosystems. Debbie Lindell gave new insights how the phages also drive cyanobacterial genome diversification. Ondrey Prasil contributed a talk on biophysical aspects governing regulation of light harvesting in *Acaryochloris marina*. One of the most fascinating talks was given by Hans Matthijs who has reported about new methodologies to manage toxic cyanobacterial blooms. The lively talk provided some insights into harmful aspects of cyanobacteria.

Session IV was focusing on "Biogenesis and maintenance of the photosynthetic apparatus". Eva-Mari Aro reported about new findings related to flavodiiron proteins that play different types of photoprotective roles in cyanobacteria. Photoprotection was also the topic of the talks given by Diana Kirilovski and Fedor Kuzminov.Both were talking about the central role of the orange carotinoide protein OCP, though from different perspectives. A central question in understanding the efficiency and dynamics of photosystems is how these multi-component complexes are assembled together and which factors are driving these dynamics. Both Josef Komenda and Birgit Rengstl were addressing these issues in their talks on photosystem II. Whereas Josef Komenda gave a comprehensive overview over the topic, Birgit Rengstl was focusing on specific aspects.

Session V was a compilation of talks related to the regulatory control of cyanobacteria. Asuncion Contreras was talking about new insights into one of the best studied two component systems in cyanobacteria: the

NblS/RpaB system. Next, Taina Tyystjärvi was reporting about very basic mechanism of transcription: the role of the omega subunit of the RNA polymerase in cyanobacteria. Robert Burnap introduced another central aspect of the cyanobacterial autotrophic lifestyle: the carbon concentrating mechanism (CCM). Specifically, he talked about the role of the LysR type transcriptional regulator in cyanobacterial CCM.
Session VI was devoted to the topics databases and systems biology. Yasukazu Nakamura gave a very fascinating talk about the integrated features of Cyanobase, the most important genomics and literature database for cyanobacterial research. He also gave positive prospects for the future. The considerable costs related to the maintenance and further development of the database are covered for the next few years. Matthias Futschik introduced the newly developed meta-analysis database for transcriptomics data that will likely save a lot of time for scientists intending to get a fast overview about the data in the future. Finally, Ilka Axmann talked about non-standard circadian clocks and unexpected findings concerning the oscillation of gene expression in the model strains *Synechocystis* PCC 6803. The session was followed by a round table discussion about the future of databases that offered the possibilities for scientists to give their user comments and recommendations for further development.
Sessions VII and VIII were focusing on cell biology aspects. As some cyanobacteria show advanced cellular differentiation the topic is important even beyond the cyanobacterial research field. Enrique Flores gave a comprehensive overview about the important work of his group on cell-cell communication between vegetative cells and heterocysts. Karl Forchhammer followed up on this topic and presented high resolution pictures of a *Nostoc* septal cell wall showing a nanopore array of membrane complexes implicated in intercellular communication. Enrico Schleiff was concentrating on the outer membrane function of cyanobacteria and presented data on microscopic investigations combined with high throughput mutagenesis. Dirk Schneider was talking about a topic that is mysterious for some time not only in cyanobacteria, but also in chloroplasts: the role of the VIPP1 protein. The question remains. How is VIPP1 influencing thylakoid membrane biogenesis?.Vicente Rubio, finally, used only one slide to demonstrate the multiple facets of the interaction of the central nitrogen regulator in cyanobacteria, NtcA and its intimate interaction partners PII and PipX. He also showed how structural biology can contribute to the understanding of cellular physiology.
Sessions IX and XI were devoted to applied aspects and products of cyanobacteria. Session IX started with two presentations on secondary metabolites. Cyanobacteria are more and more recognized as prolific source of bioactive metabolites and have attracted the attention of pharmaceutical industries. Kaarina Sivonen gave a talk on new methodologies in the genome area to identify new bioactive compounds and their application on cyanobacteria. Muriel Gugger presented data on a large dataset of cyanobacteria and provided evolutionary implications underlying the mosaic-like distributions of secondary metabolites in cyanobacteria. Klaas Hellingwerf gave then a critical overview over the field of metabolic engineering towards different types of biofuels. Cyanobacteria are considered for the production of ethanol, hydrogen and biodiesel type of compounds. This talk was a stimulating introduction for the following talks given by Paul Hudson and Matthew Melnicki that were both focusing on methodological aspect of biofuel engineering and cyanobacterial cultivation. One of the highlight in session XI was the talk on the electrogenic activity of cyanobacteria given by Ilia Baskakov. Embedded between these two biofuel sessions was a session on metabolic adaptation and stress response. Corinne Cassier Chauvat reported a global analysis on the role of glutathione and related compounds in cyanobacteria that could become a benchmark for stress research on cyanobacteria. The session also included talks given by two early stage researchers: Gustav Sandh and Joanna Sacharz. Both have used cell biology techniques to assess the spatial localization of complexes and processes activated under stress or nutrient starvation. One of the most critical molecules formed under stress is singlet oxygen, however, the analytics remains challenging. Imre Vass reported on new techniques for the detection that will inspire research on bioenergetic complexes in the future.

- *Assessment of the results and their potential impact on future research or applications*

Forward Look

(1 page min.)

- *Assessment of the results*

- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

The conference brought scientists from different research disciplines together and allowed for a dissemination of data and an exchange of different scientific cultures. This will certainly influence the future research directions in this field; strengthen existing collaborations as well as help establishing new links between scientists. The latter is particularly true for young researchers. Many of them are looking for Postdoc positions and still have to decide about their future research direction. The conference gave a very good overview about the different disciplines related to research on cyanobacteria and advanced scientists mixed up with early stage researchers during the conference.
One of the topics that have to be solved in the future is the question how the vast amount of data coming from genomics and other high-throughput studies will be handled, e.g. organized and disseminated in the future. The introductory talk on this topic given by Yazukasu Nakamura revealed not only the possibilities in this direction, but also the considerable costs associated with the establishment and maintenance of a desired database. The questions that were therefore discussed were 1) If we expand databases in the future, how shall we focus? 2) Are there possibilities to use community efforts to update databases, e.g. for a better annotation of genome data? 3) Are workshops/conferences a good occasion for genome annotation? 4) Can we use wikis for the exchange of data? In addition to these operational questions we discussed about the necessary quality of data. One of the major questions for the future is if not only completely finished genomes, but also high quality draft genomes can be included in CYANOBASE. The issue was controversially discussed. Cheryl Kerfeld as representative for the Joint Genome Institute explained that many genomes will not be closed in the future. This can be taken as a strong argument to also include unfinished genomes in the future. Yaz Nakamura was open for this question but also argued that we likely have to give up about other data then (e.g. expression data) to avoid capacity overload of the database.
Another question raised during the forward looking discussion was whether it makes sense to establish a web-based platform for cyanobacterial research. As an example, the co-chair of the conference, Jens Appel, presented the WormBase that contains information related to C. elegans and other nematodes. The page provides information on species, resources (e.g. a list of laboratories) and specific tools. It further has a new platform and a discussion forum used e.g. for the discussion of technical problems. In general, this was discussed as a very positive example. But scientists did not see a direct possibility to cover the costs. We also discussed whether we should have an online book with review chapters on cyanobacteria in contrast to a printed book. People were very open for an online initiative but future editors of such a book have to negotiate with publishers.
Concerning future directions of cyanobacterial research, there is an ongoing debate about the true relevance of biofuel research on cyanobacteria for future applications. Although there might be limitations for final applications, scientists in general appreciate the efforts in this field that also have an impact on fundamental research on cyanobacteria. Another trend that was discussed was the foreseen advancement of microscopic and biophysical techniques that will likely influence cyanobacterial research in the next few years. There is the general agreement that we would like to proceed with this conference series.

- Is there a need for a foresight-type initiative?

As the conference was part of a series that always included forward looking discussions and enough space for informal discussions there is currently no need for an additional foresight-type initiative.

Business Meeting Outcomes

- *Election of the Organising Committee of the next conference*
- *Identified Topics*
- *Next Steps*

Conrad Mullineaux from Queen Mary University, London, agreed to serve as a chair of the next conference. He is an expert for cellular biology and biophysics and will push these aspects forward for the next conference scheme. He will apply for financial support of the ESF for a conference in 2015. Jens Appel as an expert for biofuel research and Ilka Axmann as an expert for systems biology of cyanobacteria were selected as possible vice chairs. The future directions as identified

in the forward looking discussion will be cellular biology and biophysics of bioenergetic complexes, synthetic biology towards biofuels and systems biology of cyanobacteria.

There was also a great interest in the exhibition of the company Photosystems Instruments (PSI) from Czech Republic. The company has a very close connection to scientists working in the field and used the advice of many colleagues to develop instruments for cyanobacterial fermentation and analysis.

Atmosphere and Infrastructure

▪ *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

The Pultusk Castle is a very nice venue that combines a romantic and traditional side with a modern conference room with enough space for participants. In general, hotel people were friendly and helpful. The meals were traditional, but really good. The conference organizer from ESF, Allegra Roccato was a great help and solved all problems emerging during the conference, e.g. due to the cancellations or special requests of participants. The trip to Warsaw was a great success thanks to the special efforts of Allegra Roccate (and the nice weather). The poster sessions were in romantic scenery that allowed the combination of poster presentations with more informal discussions with drinks. The poster location, however, could only be used for two days and not the entire conference time. This was discussed as a disadvantage as that lowered the impact and discussion time for posters. The hotel nightclub that was open for three nights offered further possibilities to connect. Despite the overall positive response from participants, there were also a few negative comments. The internet connections were fragile in large parts of the hotel and some participants were accommodated in a youth hostel like house next to the castle. People were complaining about the significantly lower quality of these rooms for the same price. There were only few single rooms available beside rooms for chairs and invited speakers. This was a problem was some of the older colleagues that are not used to share rooms. I know about at least one cancellation that related to this aspect. Taken together, the Pultusk Castle is a very good venue, the conference room in particular is well suited and well equipped. The ideal conference size that can be accommodated is probably 80 scientists rather than 120. Posters should be presented directly in the conference room.

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