RESEARCH CONFERENCES/ OBSERVER REPORT

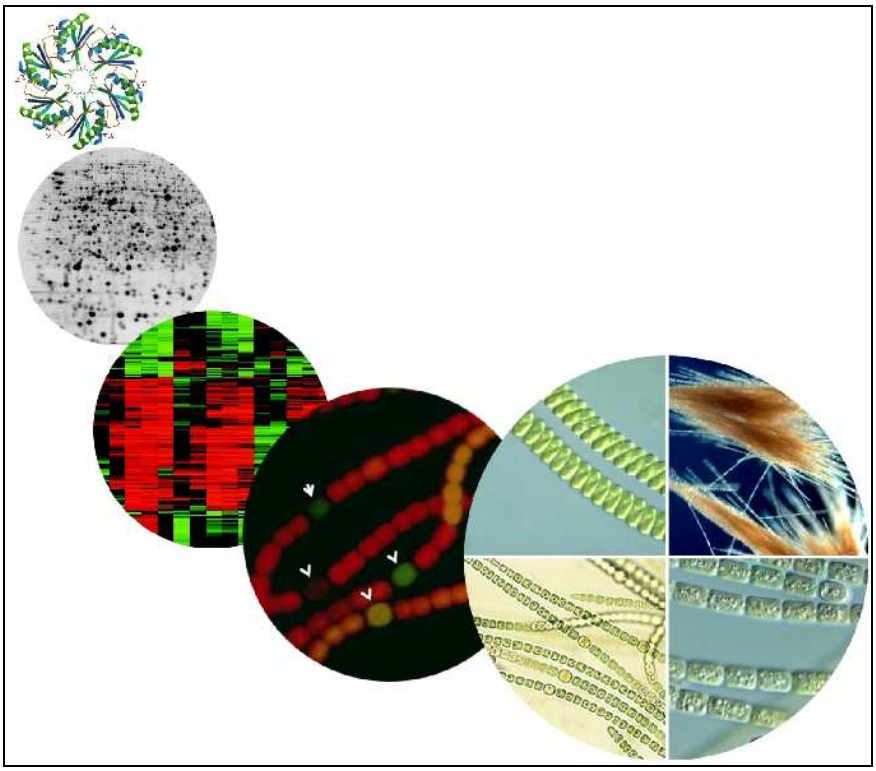
Molecular Bioenergetics of Cyanobacteria 2011: From Cell to Community

Hotel Eden Roc, Sant Feliu de Guixols (Costa Brava) • Spain
10-15 April 2011

Chair : Cheng-Cai Zhang, Université d'Aix-Marseille II and CNRS, FR
Co-Chairs: Elke Dittmann, University of Potsdam, DE
Conrad Mullineaux, Queen Mary University of London, UK

EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

EMBO European Molecular Biology Organization



Observer notes by Hans C.P. Matthijs

A. Looking back at the conference series as a whole and its established esteem

Cyanobacteria conquered their nowadays outstanding place in the world of science relatively late. Several reasons for the late start apply. Earlier, in depth analysis of mechanistic questions in photosynthesis rather used chloroplasts from plants or green algae. For adding evolutionary perspective green and purple sulfur bacteria were used as single photosystem models. Additionally, agriculture and agrochemical interests fully relied on plants as research vehicles.

What is in a name? Till the turning point in 1978, cyanobacteria were known as blue-green algae and via those systematics were just another type of algae with typical accessory pigments. The efforts of a group of inspired microbiologists with advanced vision gave lead to a huge transformation. The blue-green algae were renamed cyanobacteria and were moved from the plant kingdom and botanical code to the realm of prokaryotes and the bacterial classification code. In this new microbial world, cyanobacteria all at once were the only specimens with the capacity to evolve oxygen, propelling new and outspoken interests in cyanobacteria. Referring to the highly versatile metabolic traits an often cited epigram of thirty years ago was: "Cyanobacteria can do it all".

The amazingly versatile properties of cyanobacteria comprised plant like photosynthesis, a fully developed respiratory chain, nitrogen fixation, and even cell differentiation was among the highly surprising traits of these 'primitive' prokaryotes. In that era the heydays of bioenergetics research and the emerging molecular biology gave rise to a focus on the 'Molecular Bioenergetics of Cyanobacteria'.

The godfather of the conference series Prof. dr. G. Peschek of Vienna, Austria suggested to ESF to invest in this new and fast developing field, from which a series of two highly ranked research conferences emerged, held in Gmunden Austria and Obernai France respectively[1,2]. In those conferences the traditional bioenergetic topics photosynthesis and respiration merged with issues on nitrogen fixation, phylogeny, algal culture and in particular diurnal rhythms and associated clock and signal transduction, another highly surprising property of cyanobacteria.

Soon after, proof for genetic accessibility (also including very practical 'natural transformation') further strengthened interests in cyanobacteria and made adopt cyanobacteria as model system for evolutionary traits and for higher plant photosynthesis. It was no surprise that a cyanobacterium became the third bacterium ever with a completely sequenced and annotated genome very early in 1996 already. This brand new development, made possible directed mutagenesis, further increasing research opportunities.

Emerging modern genomics polished a follow up request for continued support to ESF which was granted and resulted in research conferences number three and four in the series held in Maratea, Italy and San Feliu, Spain respectively[3,4]. These conferences were high quality events with top experts of fame from around the globe in which the first exciting results of next generation crystallography and transcriptomics and databases were presented. Fully resolved photosynthetic reaction centers, were realized thanks to another useful trait of cyanobacteria, thermophily. With contributions on rapidly developing transcriptomics and proteomics, and early application of the newly established metabolomics technology, cyanobacteria were again at the forefront of original developments.

Understanding genome organization from two angles, 1) acquiring knowledge of each and every transcript in its life science context of metabolic networks, and 2) the role of transcripts in (eco)system's biology, which introduced a societal context into the plans that were ventilated to ESF with the request to support continuation of a highly successful series of research conferences on the Molecular Bionergetics of Cyanobacteria. With EMBO as additional sponsor a new set of 2 conferences was allotted, both took place in San Feliu, Spain [5,6].

These events hosted pure science at top level, tackling issues like cell differentiation, membrane biogenesis, applying non-invasive technology, using natural pigments as reporters. Renewed interest in the functionality of the multiple bioenergetic pathways and their integration in metabolic networks thanks to the fruits of the omics revolution. By having contributions from the USA in the conference, the interest in nitrogen fixation and cell differentiation was sparked. This was a nice bridge to a few early presentations on alternative energy projects such as hydrogen production with cyanobacteria. This increased awareness for societal needs, highlighting also the negative aspects of cyanobacteria such as cyanotoxin formation.

In retrospect, the ESF research conferences have greatly supported cyanobacteriology in Europe. At the start it was hard to predict that the field would evolve so rapidly and with so much success. Support for the high-level meeting series has been of utmost importance; the money spend has gained strong international visibility for EU research. As a training experience with optimal opportunities for young scientists the ESF meetings are possibly unrivaled. The ESF conference has over the years attracted the best scientists not only from Europe, but also from the rest of the world and was at all occasions applauded for its novelty, originality and timeliness.

Prospects for cyanobacteria in a fast moving world-economy are wonderful. Sunlight is the eternal energy source that can be harnessed by oxygenic phototrophs (cyanobacteria) to help balance climate change directly. Cyanobacteria have played a major role for over 2 billion years already; their success to thrive in changing natural environments, is living proof for their sturdiness and makes predict 1) applications in biotechnology to be a next station on the research venue, using the accumulated knowledge as a great support; 2) needs for knowledge on nuisance prevention; 3) optimal use of natural properties that are great fro science development such as anti-sense RNA and synthetic biology.

The conferences have established contacts between scientists of around the world, and it may even be regarded that front running efforts as the ongoing complete sequence analysis of not less than 50 cyanobacteria is a direct result of contacts between scientists from the EU with their homologs from in particular the US and also Japan.

[1]The first ESF research conference on Molecular Bioenergetics of Cyanobacteria took place in Gmunden Austria in 1999 (chair Guenter Peschek). The conference highlighted aspects of biological energy conservation with top experts in that field with a background different from cyanobacteria contributing to a high level exchange on 'Photosynthesis and respiration'. It paved the way for cyanobacteria to become research vehicles of importance on their own and contributed a lot to relate EU cyanobacteriologists.

[2] The second ESF meeting was in 2001 in Obernai, France (Chairs Etienne and Jean Houmard, co-chair Imre Vass). It highlighted 'in silico' data mining from at that time fashionable gene cloning and sequencing efforts in search for phylogenetic relations. The discovery of huge populations of new cyanobacteria in the oceans ('Prochlorococcus') contributed to shaping biodiversity and global issues.
[3] The third ESF meeting was in 2003 in Maretea, Italy, it focused on 'Light perception and light energy utilization' (chair, Imre Vass; co-chair, Hans Matthijs), it highlighted the mechanism of the biological clock, regulators of C and N metabolism, and early transcriptomics. In this meeting the microbiology of cyanobacteria was discussed at high level.
[4] The fourth ESF meeting was in 2005: 'Genomics, proteomics and structure for functional understanding' (chair, Hans Matthijs; co-chair, Eva-Mari Aro), highlighted atomic structures of crystallised reaction centers, introduced many participants to state of the art proteomics, and extended to implementation of databases like Cyanobase in daily research, including an offer from Japan to send questions on protein-protein interaction for comparison to data in a newly started Y2H database.
[5] The fifth ESF_EMBO meeting was held in 2008 in San Feliu, Spain: 'Towards systems biology level of understanding' (chair: Eva-Mari Aro; co-chairs, Cheng-Cai Zhang and Elke Dittmann). While systems biology in the life sciences is mostly connected to metabolic network analysis in a single cell, the prevalence of cyanobacteria, their widely different biodiversity, and occurrence in many different environments added attention for the ecosystems biology, and interplay of signaling the environment and tuning of metabolism.
[6] The sixth ESF_EMBO sponsored research conference in the Molecular Bioenergetics of Cyanobacteria series was in 2011 also in San Feliu. 'From Cell to Community' (chair : Cheng-Cai Zhang, co-chairs: Elke Dittmann and Conrad Mullineaux). A short characterization is that the focus was quite broad, with a topic 'adaptation to the environment' marking a trend of diversification. This conference will be reviewed in some detail below. The observations were gathered by participant Hans Matthijs during the 6th ESF research conference in the series on the Molecular Bioenergetics of Cyanobacteria, held in Hotel Eden Roc, Sant Feliu de Guixols (Costa Brava) • Spain 10-15 April 2011

B. Observer notes Molecular Bioenergetics of Cyanobacteria 2011

Science. The conference had more diverse topics than at earlier occasions. The title of the oral presentation section covered the contents correctly. The actual status of using multiple approaches to tackle scientific problems is an evident reason for increased diversity.
Some of the sessions were a bit crowded. The stories presented by Martin Hagemann, Susan and Jim Golden, Diana Kirilovsky, Lu Liu, Claudia Steglich, Annegret Wilde and Wolfgang Hess were state of the art and seen as highlights of the conference by the observer. Otherwise, almost all talks were very well presented and contributed to the excellent appreciation of the conference as a whole.

"Stress" and Metabolism" is an up to date topic which was well represented in 3 invited presentations that addressed actual interests like photorespiration (which for many years was a process thought to be absent from cyanobacteria), photooxidative stress and the role cyanotoxins in ecosystems, the latter was continued in the short presentations where the

potential protection against photooxidative stress provided by cyanotoxins was highlighted. These were all purely scientific topics, with good applicability in biotechnology and environmental care issues. The session was properly balanced and had a lively discussion.
Cyanobacteria seen as multi cellular organisms. This provoking title not only addresses cell differentiation but also provides great new detail on how differentiated cells cooperate to the benefit of the organism as a whole. The session was packed with 4 invited speakers and 4 short talks, the contents were pure science, and highlighted the advanced position that cyanobacteria take in the realm of bacteria.
The circadian clock and cell biology. This session was in number of contributors well balanced, with 3 invited talks and 3 short talks. Cyanobacteria have a unique feature among prokaryotes, a circadian clock allowing cells to modulate the entire activities on the basis of a daily light/dark rhythm. This issue was discussed and included timing of cell division, mechanism of cell division, membrane function and signaling of light.
How relevant is laboratory-based photosynthesis research to the real world? This session also included three invited talks and three short talks. Light usage was discussed, in particular how excess light was channeled via the OCP, its binding to the cyanobacterial light harvesting antenna (phycobilisome) and prospects that like in chloroplasts fluorescence may find second use ('state transition'). Other aspects of photooxidative stress such as the D1 cycle were discussed in top level presentations.
Adaptation to the environment. This session included 3 invited talks and 4 short talks, and was experienced by the observer as quite long because of its diversity. Several topics were united under the session title, these included aspects of direct endosymbiosis, as in Azolla, where the actual key to symbiosis was highlighted, the cyanobacterium starts losing genes and cannot do without the host, whereas the host cannot do without the nitrogen fixation of the endosymbiont cyanobacterium. Environment induced responses were also shown for cyanobacterial mats. Great again in the conference was to see how well the Prochlococcus research has developed, from brand new at the 2001 conference, it is now a leading topic for interrogation of conditional gene expression by anti-sense non-coding RNA, only 10 years later.
Systems biology and integrated approaches. The new field status follows nicely from just 2 invited talks and 5 short talks. The real trends still have to lined out, but it was good to hear that the promise made by US colleagues in the 2008 conference to sequence as many as 50 new cyanobacteria has actually been followed up. Soon the sequence information will be available for the community. Understanding metabolic networks and controls is progressing nicely, even including three D structure resolution of compounds involved such as NtcA.

The round table session on new techniques was interesting, it showed the potential that coloured components naturally present in cyanobacteria can have in non-invasive approach technology.

Program, sessions and attendance. A total of 6 regular sessions with 3 long and 4 short oral presentations on average, 2 round table sessions and 2 poster sessions were part of the program. There were no plenary poster discussions or short oral presentation opportunities for young starters. There was no excursion either. There was a nice conference dinner.

The program was a bit packed, no use was made of the possibility to have a round table at night to save daytime for being outside for smaller discussions between participants and possibly one

presentation less per session. One of the goals of a high-level research conference is to allow researchers to exchange ideas through contact and discussions. In this regard, the ESF research conference format is a really outstanding venue, also this one fulfilled the expectations, it provided the real conference setting as it should be, one appreciates talks, poses sharp questions, both questions and answers were usually in a friendly way, the atmosphere was excellent. At this conference an experiment was done, by allowing a flexible period of time in each session under the control of the experienced session chairs and by having attentive microphone runners. The discussions were plentiful and at the cutting edge of world class science, and there was no need for stopping before most questions were posed and answered. Such an organization only works well if all in the audience can stay present permanently, from own experience I discovered the disadvantage that the start or end of a talk could also be several minutes shifted from announced in the programme. The advantage was possibly bigger: despite, an extensive range of questions from the audience, not only from established scientists that were eager to interact lively, but also from young starters in the field, there was no time pressure, one felt at ease to dare pose a question. The experiment has all in all not been noticed by the general participant and as such must be positively evaluated.

I observed almost no flaw in the presence during the days of the conference, eye-bowling I estimated that from 100% on day I (the hall looked nearly completely filled) well over 80 % of the participants remained present during all sessions, including the official poster visiting time-spans. This is a high number and indicates that sessions were all attractive and were felt not to be missed by the great majority of the participants. The strong interaction, and long period of discussion following each talk is truly outstanding and indicates a highly successful program.

I was also impressed by the round table sessions, these were well prepared by the organizers, without creating another one way oral session, it really inspired to think at the spot. My impression was that cyanobacteriology is indeed very active, fastly progressing and creative enough for ongoing success. The forward-looking discussion session at the end of the conference highlighted European research on cyanobacteria, proposed future directions for European research on the use of cyanobacteria for bioenergy generation, synthetic biology, environmental protection and possibly identification of useful drugs for pharmaceutical industry.

Participants. Due to natural disasters in Japan, the current edition of the conference lacked the earlier highly appreciated colleagues from there, but this was more then compensated by having an impressive number of US based participants (and not only the ones invited) and a growing number of EU colleagues that earlier felt no affinity to bioenergetics and now join because the conference has such a great appeal. I met many enthusiastic young PhD students and postdocs. Possibly due to the collective absence of our Japanese colleagues, the total number of actual participants (110) was lower than the maximum number of 131 accepted abstracts. Actually, the conference size should not grow much larger, 100 or slightly over is a correct number of the venue. The mix of older and younger scientists, and also regarding gender was well balanced and reflected properly that cyanobacteria are not only great for science but also contribute to equal opportunities for all.

I observed that discussions at the posters continued till long after 'the free time' hour had started. The Poster sessions were heavily visited and gave rise to ongoing discussions, that

continued during meals and breaks.
Here, I'm a bit critical about the venue, poster display space was fairly limited, this forced the organizers to have 2 poster sessions, which I judge unfavourable for this type of conference. It puts pressure on seeing it now or never and as such limits free exchange between participants at ease. I may also remember well that posters could not be visited at other than conference hours, I tried once but found the hall locked.

Venue. The hotel and its staff were wonderful, first day reception, including the visit to the ESF desk with our punctual and well informed ESF host Jean Kelly for congress materials was well organized and processing was fast and efficient. I have been asking around, all present were content about rooms and meals. Due to the early moment in the season maintenance works in the garden and pools made the nearby surroundings slightly less inviting than at earlier visits, I have not seen people sitting down and discuss in the early afternoon sun after lunch. I also noticed that night time activities were a bit less entertaining than before, gathering together over a beer at the outside coffee place near to the conference hall and poster display was missed by me. However, the day time breaks at that same place were excellent.
Projection and sound. This was not good, I have changed place often to watch and listen from different positions. Projection in front was from some places partly obstructed by a beam in the ceiling, projection with a second projector at the back on a screen halfway the hall suffered from lack of sharpness at the screen, and a mismatch of screen position and the actually projected slide, by which a part of the slide was not visible. The technical state or battery functions of microphones and pointers were not optimal.

Talking with participants. It appeared that the conference may not have offered completely satisfying opportunities for young participants to exchange with the older and more experienced participants. The latter possibly should have been stimulated by the organizers to mix with younger participants more than has been the case, in particular during the conference dinner I observed lack of mixing and also that same nationalities grouped together. Being asked about your thesis or postdoctoral work or exchanging otherwise with someone you only know from literature is a good experience that I do remember myself as essential for my later career. Well after these minor points, it is good to end with the conference being praised by quite a number of attendees as a great meeting, where one learned a lot and made many contacts with colleagues one did not before. I heard say that this had been a highly successful scientific meeting and the best one, one had participated in.

Future. The highly valued ESF research conferences (recently co-sponsored by EMBO) on the Molecular Bioenergetics of Cyanobacteria have greatly contributed to a strong EU wide research effort with cyanobacteria with important spin-offs in science and society. The great progress since the first conference is amazing. So much has already been discovered, but much still waits for further study. Hot topics of the nearby future are 1) biofuel generation using sunlight as its driving force, with cyanobacteria as highly favourable biological devices; 2) timely preparation for increasing climate change. Using cyanobacteria as a common value several science disciplines including evolutionary biology, environmental microbiology, biochemistry and biophysics, bioinformatics, cellular biology and synthetic biology will fruitfully interact in a warmly welcomed next ESF supported conference as recently proposed by Prof. Elke Dittmann.