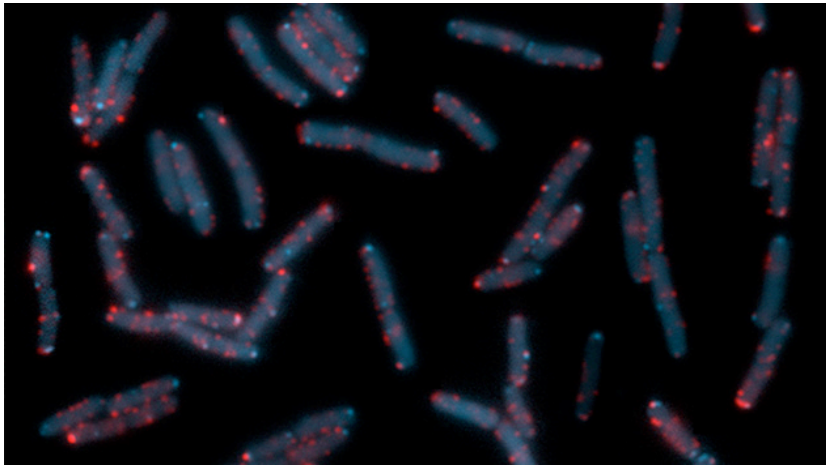




RESEARCH CONFERENCES



ESF-EMBO
Conference

Bacterial Networks – BACNET15

9 – 14 May 2015
Sant Feliu, Spain

Chaired by: Victor Sourjik
Co-chaired by: Julia Vorholt

<http://bacnet15.esf.org/>

Highlights & Scientific Report

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 biannual conference *Bacterial Networks* or shortly *BacNet* has been the most important European meeting in the field of quantitative microbiology for 17 years, focussing on the architecture, function and dynamics of bacterial regulatory networks. Over these years, *BacNet* helped to shape this rapidly developing field in Europe and worldwide, largely contributing to understanding the molecular structure and function of bacteria, their role in pathogenesis and ecology as well as their use in biotechnology. *BacNet15* successfully continued this series, demonstrating how interdisciplinary approaches that combine molecular biology and biochemistry with the latest microscopy developments, whole cell (–omics) approaches and mathematical modelling can advance our knowledge of bacteria and help to formulate new concepts in microbiology. It further showed how current biotechnology and medical microbiology could profit from our understanding of and ability to rationally modify regulatory networks of bacteria.

The keynote lecture (that was introduced for the first time at *BacNet15*) given by Christine Jacobs-Wagner (Yale University) gave an excellent start to the conference, demonstrating impressively how quantitative experiments and computational modelling can be combined to get fundamental insights into bacterial cellular functions. The sessions on ‘Signal transduction and behaviour’ and ‘Stress response and gene regulation’ illustrated progress in our knowledge of bacterial environmental sensing and decision making, showing how bacteria perceive and integrate multiple sensory inputs to control their behaviour. This was further expanded by the session on ‘Global regulatory networks’, which highlighted our increasing understanding of fundamental mechanisms of global control in bacterial metabolism and cell biogenesis. Advances in understanding cell morphogenesis were more extensively covered in the session on ‘Cell shape, polarity and division’, demonstrating the tremendous progress in the quantitative description of how different bacterial cells gain and maintain their morphologies. The session on ‘Small molecule signalling and multicellular behaviour’ demonstrated impressive progress that has been made in the analysis of the structure, function and signal exchange within bacterial communities, particularly such processes as quorum sensing, biofilm formation and the dynamics of bacterial viruses. The meeting further covered the aspects of ‘Network evolution’, from potential evolutionary selected benefits of individuality to bacteria in populations to the evolution of bacteria-virus interactions. Finally, the session on ‘Synthetic biology’ showed the diverse capabilities of bacteria can be rationally modified and used for biotechnological and biosynthetic applications, and how bacteria can be redesigned to harbour artificial genetic elements and novel signalling pathways. Across all of the sessions, the distinguishing feature of *BacNet15* was a combination of talks covering experimental work (with a particular focus on quantitative experimentation) with presentations on computational analysis of bacterial networks. This interdisciplinary format received a very positive feedback from participants and will be continued in future *BacNet* meetings.

In addition to these scientific sessions, *BacNet15* also continued the relatively recently established ‘Science & Society’ session, this time focussing on ‘Visual communication in science’ and providing a critical view on the usage of scientific images in science and also presenting an excellent example of science-inspired art.

x I hereby authorise 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)

BacNet15 had a total of 143 participants (representing the upper limit on the number of participants that could be accommodated on site). Besides the invited speakers, these participants were chosen from over 200 applicants (based on scientific interest and quality of poster abstracts). Almost half (46 %) of the participants were females. The participants representing broadly the European research and also included participants from the USA and Asia.

BacNet15 featured a keynote lecture, 22 invited and 27 short scientific talks (in 7 scientific sessions), and 2 invited talks covering the relation between science and society. 24 of the 50 speakers were female (48 %), and 16 of 50 speakers were young investigators/early stage researchers.

95 posters were presented in three very well attended evening poster sessions. Two prizes were sponsored by ESF and by *Nature Reviews Microbiology*. The best poster prize was awarded to Abdelrahim Zoued (Aix-Marseille Université, France). The best presentation prize for an early career researcher was awarded to Melanie Blokesch (EPFL, Switzerland).

The scientific appeal and importance of *BacNet15* was further emphasized by the interest from the scientific journals. For the entire duration, it was attended by Christina Tobin Kahrström, the current editor-in-chief of *Nature Reviews Microbiology* and future microbiology editor for *Nature*; by Andrew Jermy, current *Nature* editor who is to become the editor-in-chief for *Nature Microbiology*; and by Helene Hodak, the editor of *Journal of Molecular Biology*.

Besides the budget jointly provided by ESF and EMBO, *BacNet15* was also supported by the *Ernst Schering Foundation* (Berlin) that funded the 2 speakers of the *Science & Society* session (with up to € 4.500)

Scientific Content of the Conference

Due to the advances of novel experimental techniques and methods of quantitative analysis, research on the bacterial regulatory networks is currently experiencing a true revival. *BacNet15* focused on a wide coverage of the related topics, from bacterial physiology, stress responses and metabolism to cell biology, behaviour and evolution and ultimately to synthetic biology. The conference covered both advances in the details of understanding of the model systems and on the emerging novel concepts in the regulation of bacterial metabolism and collective behaviour. A number of highlights have emerged from individual sessions at *BacNet15*:

Keynote lecture given by Christine Jacobs-Wagner was an outstanding illustration of how quantitative experiments combined with computational analysis can drive understanding of bacterial cell biology.

Session I: Signal transduction and behaviour

This session presented advances in understanding how bacteria perceive and integrate multiple regulatory stimuli, such as pH and magnesium (Edouardo Groisman), extracellular and intracellular potassium levels (Ulrich Gerland), different organic acids (Tino Krell), temperature and amino acids (Yigal Meir) and even magnetic fields (Stefan Klumpp) and convert them into coordinated responses. It also covered impressive advances in structural understanding of the motility engines used by different bacteria (Judy Armitage and Lotte Sogaard-Andersen).

Session II: Stress response and gene regulation

This session covered the richness of the regulatory mechanisms bacteria use to respond to extracellular stress factors and to control gene expression, from the general stress response mediated by multiple signalling systems in Alphaproteobacteria (Julia Vorholt) to the novel translational regulation dependent on the elongation factor P (Kirsten Jung) to the sporulation program activated via cyclic di-GMP in *Streptomyces* (Natalia Tschowri). The complexity of the bacterial response to exposure to multiple antibiotics has also been addressed (Tobias Bollenbach).

Session III: Small molecule signalling and multicellular behaviour

This session addressed the increasing understanding of regulatory complexity that is observed in bacterial communities. This includes quorum sensing, where multiple signals are exchanged within populations and are regulated on several levels via feedback loops (Ned Wingreen). The importance of quorum sensing in the context of gut colonization was also presented (Karina B. Xavier). Another intensely studied topic is the transition from the planktonic to sessile (biofilm) lifestyle, that is governed by c-di-GMP (Regine Hengge, Urs Jenal).

Session IV: Global regulatory networks

Understanding general principles that govern regulation of bacterial metabolism is a major upcoming challenge to microbiology. A tremendous progress that has been made in this direction in the last few years and was presented in this session (Terence Hwa, Uri Alon, Matthias Heinemann). Many advances have also been made towards global mapping of regulatory networks in model bacterial organisms (Athanasios Typas).

Session V: Cell shape, polarity and division

Quantitative understanding of bacterial cell morphogenesis was one of the main topics of this session, with the approaches ranging from superresolution microscopy (Seamus Holden) to biophysical modelling (KC Huang). The unusual cell division mode of the L-forms of bacteria that lack the cell wall was presented, which provides insights into the possible way of replication of primitive life forms (Jeff Errington). Also exciting new insights into the biogenesis of extracellular structures and their use by bacteria to move or to wage interspecies warfare were introduced (Melanie Blokesch, Gert Bange).

Session VI: Network evolution

Evolutionary interpretation of the structure and function of cellular networks remains a big challenge. Talks in this session demonstrated that evolutionary approach can be used to understand such features as heterogeneity of bacterial populations as evolutionary selected features (Martin Ackermann). Evolutionary analysis further helps to understand specificity of the phage-bacteria interactions and the specificity of the gene transfer (Tal Dagan).

Session VII: Synthetic biology

Talks in this session have shown that synthetic biology of bacteria is coming of age. There is much advance in the construction of replicons / artificial chromosomes for the expression of multiple foreign genes in bacteria (Anke Becker, Torsten Waldminghaus). Bacteria can be efficiently used for the production of novel combinatorial peptide-based antibiotics (Oscar Kuipers). Ultimately, bacterial cell division system can be reconstructed in vitro, bringing us closer to the construction of artificial cell (Martin Loose).

Session VIII: Science & Society: Visual communication in science

This session presented a critical perspective on the use of images in biology (Joachim Schummer) and also illustrated how an artist (Pinar Yoldas) becomes inspired by biology.

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 feedback by the participants of *BacNet15* was overwhelmingly positive. All of them emphasized the broad coverage of the cutting edge research by excellent speakers as the strength of the conference. Nearly all presentations had the outstanding scientific quality, including those given by early career researchers. Overall, the meeting clearly gave an excellent overview of the European microbiology, and particularly of its quantitative aspects.

BacNet conferences have been instrumental and will remain so for the generation and highly successful maintenance of a thriving and well-connected European community of molecular microbiologists, bacterial systems and synthetic biologists. It is also obvious that highly successful and ambitious young researchers, who have done their postdoctoral work in the US, consider their talks at *BacNet* as their points of entry into this European scientific community. By exposing them to the first-class research, the meeting also serves as a much-needed forum for the researchers at their early career stage (PhD students and postdocs). It allows them to develop new ideas and place their research in a more general context, and also establish connections that will help them in the future career.

The very high quality of research presented at *BacNet15* – which was at least on an equal level with that of the best Gordon Research Conferences in the US – probably also reflects the fact that the funding situation, especially for basic research, meanwhile seems better in Europe than in the US. It is also likely that several years after its introduction, funding by the European Research Council (ERC) begins to have an impact on scientific progress and excellence also in molecular microbiology and bacterial systems biology.

With respect to scientific topics, a number of emerging trends could be observed at *BacNet15*. In particular, these were:

(i) The growing importance of the *spatial organisation* of regulatory networks – networks seem to ‘go 3D’ at all levels of resolution. This applies to single cells, in which many of the components of regulatory networks can be found at specific locations such as the poles or the midplane of the cell. Also the determination of cell shape has become an intriguing topic for investigation. Moreover, the spatial structure of cellular communities, i.e. biofilm microanatomy and differentiation into distinct physiological strata and regions, is becoming a hot topic that will also address the question how complex morphological pattern form at the macroscopic level. This trend reflects the introduction of cell biology technology and high-resolution microscopy into molecular microbiology.

(ii) *Evolutionary aspects* are clearly becoming ever more important. On the one hand, this relies on microbial genomics based on the availability of thousands of genome sequences. On the other hand, this is a consequence of the small size and fast growth of microbes, which allows to follow evolution in vitro in real-time. In particular, evolutionary aspects are being studied within the context of biofilms and complex microbial communities in general, with special emphasis on the evolution of communication, cooperativity and mutualism under highly competitive conditions and adaptation to complex environments as e.g. within hosts. High mutation rates and short generation times mean that microorganisms have a unique advantage as models for the evolutionary research, because they are amendable to experimental evolutionary approaches.

(iii) Another trend clearly observable on *BacNet15* is an increasing integration of quantitative experimental microbiology with *mathematical modelling and computational analysis*. While it is already a standard in the analysis of complex networks (systems biology), such interdisciplinary approach is becoming increasingly common in all fields of microbiology. It can also lead to some very useful generalization of biological phenomena, potentially enabling us to derive general laws that govern the

behaviour of bacterial cells and communities.

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

No – what is required is the continuation of the *BacNet* series of conferences as a focus for scientific community building and maintenance and as the most important place for the exchange of knowledge and fostering novel collaborations in European molecular and systems microbiology.

Business Meeting Outcomes

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

The forward-looking session was chaired by Julia Vorholt (as the Vice-Chair of *BacNet15* and future Chair of *BacNet17*). The following topics were discussed or dealt with:

Kirsten Jung (LMU Munich) was elected as a Vice-Chair for *BacNet17*.

The Forward Looking plenary discussion confirmed that *BacNet15* was a full success. The balanced coverage of topics related to understanding of bacterial networks was highly praised by the attendees, and no criticism of the scientific program has been raised during the discussion. It was a clear consensus that the program has very well covered the new developments in the field, from molecular foundations of the cellular processes to the quantitative analysis of the higher-order control of the cellular networks in bacteria to the efforts of designing novel cellular networks. The number and balance of invited and short talks during the conference was just right to ensure a broad coverage of different topics and also to enable both leaders in the field and young scientists to present their work.

The main discussion point was the likely termination of the ESF conference funding. This raised a great disappointment among the participants, and there was a unanimous support for the continuation of this series of conferences. The discussed option was to apply for the full support of the conference from EMBO. There was also a very much welcomed commitment from the Journal of Molecular Biology to co-support the upcoming *BacNet* conference(s). All participants strongly supported the proposal to keep the conference at the same site in San Feliu.

Based on the outcome of this forward-looking session, Julia Vorholt (Chair) and Kirsten Jung (Vice-Chair) will explore the modality of funding and submit a proposal for the *BacNet17* conference.

Atmosphere and Infrastructure

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

During the forward-looking session as well as in a lot of personal feedback during and after the conference, participants expressed their highest enthusiasm about the meeting place. This included the room situation, the excellent food, management and service. Moreover, participants were very satisfied with the highly professional and efficient organisation by ESF and local representatives.

The social atmosphere during the conference was friendly, inclusive for everybody with intensive communication also between established and young researchers and not 'cliquish' at all. Informal networking among the participants was greatly facilitated by the familiar atmosphere in the dining places as well as by the presence of a large and pleasant open bar area right next to the conference/poster room.

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