

ESF Exploratory Workshop on

# Valuing Biofilm Services: The Beauty and the Beast

Scientific Report



Lunz am See, Austria, 19 - 22 September 2007

**Convened by:  
Tom Battin<sup>①</sup>**

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*Co-sponsored by*

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## 1. Executive summary

22 participants from Europe, Canada and Australia met from 19<sup>th</sup> to 22<sup>nd</sup> of September 2007 at the Interuniversity Centre for Aquatic Ecosystem Research, WasserCluster Lunz, to discuss the role of microbial biofilms – both beneficial and detrimental – in various systems.

Biofilms are matrix-enclosed microbial communities and are the dominant form of microbial life in most natural, engineered systems and within humans. Environmental biofilms sustain most Earth processes including the global carbon cycle and associated green house gas emissions. In engineered systems, biofilms drive, for instance, water treatment processes but can also cause major economic loss through biofouling, biodeterioration and biocorrosion. Within medicine, biofilms are of utmost significance where they are responsible for many antibiotic-tolerant persistent infections (e.g., periodontitis, endocarditis, pneumonia and infected medical devices). Biofilms also constitute sinks and sources of pathogens in food and water industry.

The last three decades of biofilm research have resulted in major advances, which have revealed the diverse nature of biofilms as being both central and essential to earth system services, as well as their detrimental roles in industrial and medical environments. This is exemplified by an exponential increase in scientific output over the last five years. However, these efforts have been mostly fragmented and largely lacking cohesion. As a result, biofilm research has evolved across many scientific disciplines (e.g. microbiology, infection biology, ecology, biotechnology, bioengineering, ecotoxicology) and fields (environment, industry, medicine). The consequence has been an increasing disconnect of scientific interests and communication between the scientific sub-disciplines. This lack of cohesion prevents the scientific community from advancing as quickly and effectively as it could otherwise to develop new strategies for biofilm control (medical, environmental, industrial).

The participants of the Exploratory Workshop agreed that future biofilm research should be integrative to create conceptual and technological synergies. This goal should be achieved by an ESF “*Research Networking Programme*” (RNP) as the major follow-up activity of the Exploratory Workshop. The participants suggested the following points to be included in future networking:

- Identification, development and dissemination of innovative analytical techniques to advance biofilm research to the next level.
- Integration of ecological and evolutionary theory for the understanding of biofilm biodiversity and functionality.
- Integration of systems biology (from transcriptomics to proteomics) into biofilm research.

- Development of computational and validation of tools for biological, chemical and physical processes in biofilms.
- Interdisciplinary training of a new generation of biofilm researchers.

These joint efforts will lead to the exploitation of new understanding of biofilms for the development of novel biofilm control strategies in medical, environmental and industrial settings.

## **2. Scientific content of the event**

### **2.1. Talks**

After a welcome by the convenor Tom Battin, an overview of the objectives and funding possibilities provided by the ESF was given. The first day of the meeting was devoted to an overview of biofilm research in various systems and fields. It started with a retrospective and the development of biofilm research by Maurice Lock; this talk nicely outlined how biofilm research started in natural ecosystems to become deeply embedded in medical and industrial microbiology. Scott Rice, who replaced Staffan Kjelleberg, introduced the participants into genetic regulation of biofilm formation and dispersal, and also highlighted recent findings on extracellular DNA in biofilms. Next, Thomas Neu showed the overwhelming diversity of extracellular polymeric substances (EPS) and suggested a systematic approach to the various functions and structures of EPS. Piet Lens gave a good introduction of biofilm applications in reactor and process technology. After lunch, Mark van Loosdrecht developed this topic into more in-depth insights into process technology and scaling issues in biotechnology. Wim Admiraal opened the floor for natural biofilms then, showing the relevance of phototrophic communities for large river ecosystems, for instance. As a logical next step, Thomas Schwartz highlighted the role of biofilms as potential reservoirs for pathogens in drinking water systems.

These two sessions were then followed by a plenary discussion that emphasized both the diversity of biofilm research and the need of communication between and within the various disciplines involved.

The second day started with a session on modelling and bioengineering in biofilm research. First, Christian Picioreanu gave a brilliant overview on modelling approaches to phototrophic systems and nitrogen cycling (as part of the PHOBIA project) and to microbial fuel cells. William Sloan represented the COMIX (EuroDIVERSITY CRP) approach to biofilms as microbial landscapes emerging from neutral ecology. In an engineering approach, Harald Horn presented new techniques to better understand the effect of fluid dynamics on biofilm structure. Next, Carsten Matz presented new findings on protozoan grazing, general and chemical defense mechanisms in biofilms. Gideon Wolfaardt described biofilms as cell nurseries and highlighted the role of biofilm dynamics in carbon dynamics.

After lunch, Annette Moter gave an excellent introduction into medical biofilm research and opened the floor for the *in vivo* versus *in vitro* biofilm research discussion. Jeremy Webb then presented new insights into the genetic regulations and physiology of biofilm dispersal, and related to the previous talk, revisited knowledge of biofilm formation and cystic fibrosis.

After these infection-related talks, David Paterson presented biofilms as ecosystem engineers that significantly contribute to sediment cohesion and stability in lowland rivers and estuaries. Helena Guasch then revealed the relevance of environmental biofilms for freshwater ecotoxicology. Finally, Holger Daims present novel techniques that may be of relevance for biofilm research.

## **2.2. Discussion**

There were brief ad hoc discussions after each talk, an extended afternoon discussion after the sessions, and a final morning discussion on Saturday.

Major topics emerging from the discussion included:

1. Evolutionary and ecological approaches to biofilm research to properly understand biotic and abiotic interactions, and consequences for the (eco)systems. What can we learn from complex environmental systems and what can be learned from model biofilm systems?
2. *In vivo* versus *in vitro* approaches to biofilm research, which may be particularly relevant to medical microbiology.
3. Computational sciences to advance process understanding.

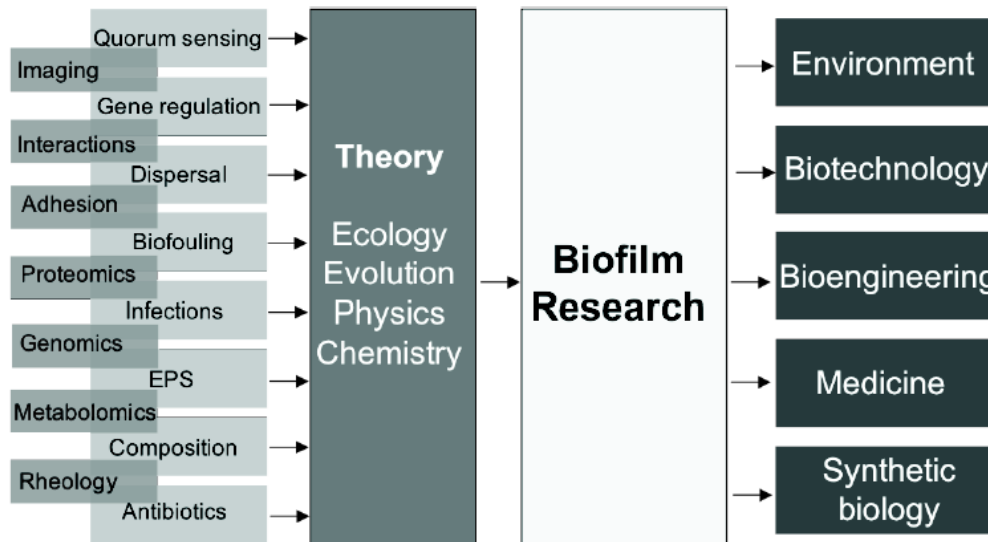
## **3. Assessment of results and future directions**

Participants greatly welcomed the event, some forged new collaborations during the workshop, and all agreed upon a large-scale follow-up activity.

The discussions immediately after the respective sessions focused on technical aspects presented in the talk. But the participants rapidly recognized the need to move beyond disciplinary topics, which then became the major focus of the Saturday morning discussion. The common sense was that a follow-up activity would be required to de-fragment biofilm research in Europe. The European community is particularly well suited for this effort, since it includes excellence in most disciplines related to biofilm research; this includes, for instance, genetic regulation, structure-function coupling, confocal microscopy and EPS chemistry, molecular biology, computational microbiology, ecology, evolution, biotechnology and bioengineering. Numerous scientists of that community have already cooperative links, which, however, do not operate under a formal umbrella.

Therefore, the participants spent the Saturday morning writing a white paper, which served then as the basis to develop a proposal for a 5-year Research Networking Programme

“European Biofilm Network”. The participants also discussed strategies to combine the Standing Committees for Life, Earth and Environmental Sciences (LESC), Medical Sciences (EMRC) and Physical and Engineering Sciences (PESC) to cover the through diversity of European biofilm research. Furthermore, participants discussed possibilities to increase the awareness of biofilm research in the various national councils.



**Integration of biofilm research across disciplines and fields, and solidly rooted in theory.**

The proposal was submitted within 4 weeks after the workshop. The goal of the *European Biofilm Network* is to integrate biofilm research in Europe and to serve as an interface for researchers from other continents. Ultimately, this would help Europe develop leadership in this rapidly developing field. More than 40 researchers from Europe supported the proposal, which proposes a number of interdisciplinary workshops ranging from transcriptomics and proteomics to evolutionary ecology, and the in vivo versus in vitro debate, for instance. It also includes the inter-lab exchange of graduate students to train a new interdisciplinary generation of biofilm researchers. Finally, the European Biofilm Network is also supposed to organize the Biofilm-IV and Biofilm-V conferences in Europe.

#### 4. Conclusion

The Exploratory Workshop provided a unique platform for European, Canadian and Australian scientists from various fields and disciplines to screen the vast field of biofilm research. It allowed the participants to integrate existing expertise and to use the generated synergies to outline future collaborations through an ESF *Research Networking Programme*. Finally, Philippe Hunter, a UK scientific writer, wrote an article on the Exploratory Workshop that was published on the ESF website and that was extremely well received by the international community.

## **5. Statistical information participants**

20 participants invited, 1 convenor

### **Gender repartition:**

2 females

19 males

### **Repartition by country:**

<b>Country</b>	<b>Participants</b>
Australia:	1
Austria:	5 (including convenor)
Canada:	1
Germany:	5
Spain:	1
The Netherlands:	4
United Kingdom:	4



14.00-14.25	<b>Thomas Neu:</b> The biofilm matrix - extracellular polymeric substances of different chemistry and functions
14:25-14:50	<b>Jeremy Webb:</b> Seed dispersal in biofilms and its medical relevance
14:50-15:15	<b>David Paterson:</b> Comparative assessment of biofilm properties across a salinity gradient
15:15-15:45	<i>Coffee break</i>
15:45-16:10	<b>Helena Guasch:</b> Natural biofilms as indicators of toxicants in fluvial ecosystems
16:10-16:35	<b>Holger Daims:</b> Structure-function analysis of microbial biofilms
16:35-17:15	<b>Andrea Hoffmann:</b> Seventh Framework Programme
17:30-19:00	<b>Discussion groups (The Beast, The Beauty Mix)</b>
19:30-	<i>Dinner (Restaurant SeeTerrasse)</i>

## **Saturday 22 September 2007**

08:00	Breakfast
09:00-12:00	<b>Reports, plenary discussion, wrap-up, European perspectives</b>
12:30-13:00	<i>Lunch</i>
13:00	<i>Departure</i>



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