

Workshop  
Physics of immunity: complexity approach  
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The Workshop proved to be a vibrant forum for reporting the recent successes and discussing new perspectives and open problems in mathematical, physical and computational approaches to immunological processes. The cohort of scientists in Theoretical and Experimental Immunology at the Workshop addressed the following topics: (i) lymphocyte population dynamics and T cell receptor diversity, (ii) model selection, experimentally-based and multi-scale modelling in Immunology, (iii) immune responses against viruses, (iv) humoral immune response and affinity maturation, (v) T cell receptor signalling and T cell activation and (vi) clinical and medical Immunology. Talks spurred hot discussions, manifesting keen interest from the participants. A unique feature of this Workshop was that, despite it being centred on mathematical, physical and computational methodologies, it counted with the participation of world-renowned experimental immunologists, who themselves make use of mathematical approaches. One of them, Andreas Radbruch, director of the German Arthritis Research Centre in Berlin, held the Colloquium lecture. He could not better convey the spirit of the Workshop having focussed in his Colloquium talk on bringing together the modelling and experimentation approaches towards understanding principles of immunity.

The following key participants and their respective presentations deserve special note:

**Antonio Freitas** – Role of quorum-sensing mechanisms in lymphocyte homeostasis.

**Robin Callard** – T cell homeostasis in health and disease.

**Phil Hodgkin** – An evolutionary theory to bind together our molecular, cellular and systems based understanding of the immune response.

**Rob de Boer** – How to properly estimate cellular turnover rates from in vivo labelling data?

**Grégoire Altan-Bonnet** – Differential suppression of effector T cells by regulatory T cells derives from a highly-dynamic IL-2 tug-of-war.

**Ken Duffy** – How many distinct heritable factors are required to explain correlation structures in proliferating lymphocytes?

**Ruy Ribeiro** – How fast are virions cleared from the body?

**Steven Kleinstein** – Unravelling antiviral regulatory networks using systems biology.

**Deborah Dunn-Walters** – B cell repertoire changes in ageing.

**Arup Chakraborty** – How T cells see antigen: from statistical mechanics to human disease.

**Benedita Rocha** – The complexity of gene expression during CD8 activation in immune responses.

**Ria Baumgraß** – Quantitative single cell analysis of transcription factor expression and activation to discover limiting factors for Th cell activation.

**Dagmar Iber** – Activation by trans auto-activation allows binding discrimination at high receptor occupancy.

Scientific newcomers had the opportunity to present a poster in a poster session held on Monday. Additionally, several young PIs and newcomers to the field were invited to present a talk. A special presentation on career advice was offered to students, post-docs, and young PIs.

With over 70 participants from all over the world, this Workshop was a huge success. Out of 23 participants who filled in a feedback form, 13 marked the Workshop as “excellent”, 9 as “very good” and 1 as “good”. 11 responders expressed an interest in a 1-3 month Seminar as a follow-up to the Workshop.

The Workshop will certainly boost the visibility of the field of Theoretical Immunology within the immunology (both experimental and theoretical) community, both because of the seminal immunological questions which were discussed and the influential immunologists who took part. During the discussions, several topics were identified as the most daunting for future research:

- One of the greatest challenges in Immunology is to understand immunological processes at the single cell level, as pointed out by Dr. Altan-Bonnet in his talk during the Workshop. In order to do that, there is a need to bring together theoretical and experimental immunology approaches that can provide single cell resolution and move away from population approaches.
- A second challenge is to measure the diversity of the T and B cell receptor for antigen, as discussed by Dr. Venturi and Dr. Dunn-Walters in their respective talks. In order to do that, there is a need to bring together mathematical and statistical approaches that, combined with the sequencing data, provide accurate measurements of both human and mice T cell and B cell receptor diversity. This work has implications on the development of vaccines and adoptive cell immune therapies.

- A third challenge is to understand the specific mechanisms that regulate gene expression during immune responses and cellular differentiation, as discussed by a number of speakers during the Workshop (Dr. Rocha, Dr. Höfer and Dr. Carneiro). There is a need to develop new mathematical and physical models that can truly integrate processes at the different levels of complexity (population, cellular, molecular and genetic).

We conclude by saying that the atmosphere of the Max Planck Institute helped to trigger new research collaborations between the participants. This meeting has been a booster to the field of theoretical immunology and definitely has set the standard of how research should be done in this relatively novel field of research.