

**COURS DOCTORAUX DE L'IMÉRA**  
**Institut d'études avancées d'Aix-Marseille, 2 place Le Verrier, MARSEILLE**

**MODELING THE COMPLEXITY**  
**OF THE ADAPTIVE IMMUNE RESPONSE**  
**8, 9 et 10 décembre 2014, 13h30-16h30**

**Held by Elena Agliari & Adriano Barra**  
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**Cours en anglais ouverts aux doctorants et aux chercheurs.**

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In the last three decades, immunology has succeeded in dissecting the immune system into a number of various cell types, chemical messengers, component genes, signal transducers, receptors, ligands, etc. and, locally, has characterized the processes emerging from the interactions of these components. At present, however, we are still unable to control the system to our satisfaction, quoting Irun Cohen, "now the question is how to turn information into comprehension" [1].

Scope of this short course is to try and frame the main (present and past) paradigms of immunology (i.e. the two signal model, the clonal selection theory) within a coherent and self-consistent statistical mechanical scaffold [2,3,4]. Indeed, since the beginning of the past century statistical mechanics aroused as a discipline to describe systems built by a large number of degrees of freedom: firmly based on probability and information theories, it plays nowadays as the main reference for complexity theory. In fact, it already revealed itself as a key tool for understanding neural networks in the past and it has recently showed its potentiality even in decrypting immunological complexity.

For detailed information, please look at the daily program.

[1] I.R. Cohen, Autoantibody repertoires, natural biomarkers, and system controllers, Trends in Immunology, 34:620 (2013).

[2] G. Parisi, A simple model for the immune network, Proc. Natl. Acad. Sc. 87:429-433 (1990).

[3] E. Agliari, A. Barra, F. Moauro, F. Guerra, A thermodynamic perspective of immune capabilities, J. Theor. Biol. 267:48, (2011).

[4] E. Agliari, A. Annibale, A. Barra, T. Coolen, D. Tantari, Immune networks: Multi-tasking capabilities close to saturation, J. Phys. A 46: 415003 (2013).

## DETAILED PROGRAM

**Lundi 8 décembre 2014, de 13h30 à 16h30**

**A) Agliari (90 mn): Introduction to the (adaptive) immune networks, the B world only.**

Can positive and negative selection during ontogenesis provide information on the network architecture and on its self/non-self discrimination capabilities?

Modelling the B network via graphs. Graph theory tools. Emerging properties for the idiotypic network.

**B) Barra (90 mn): Deepening the (adaptive) immune networks, the B world only.**

Can B cells be looked at as a system of mutually interacting agents? If so, can we detect any systemic features?

Modelling the B network via statistical mechanics. Fundamentals of statistical mechanics. Low-dose tolerance, bell-shape response, etc. recovered.

**Mardi 9 décembre 2014, de 13h30 à 16h30**

**C) Agliari (90 mn): Introduction to the (adaptive) immune networks, including T cell signalling.**

Helper/Suppressor cells provide eliciting/inhibiting signal: the hallmark of complexity. Grasping the concept of complexity in immunology via a toy-model.

**D) Barra (90 mn): Deepening the B-T network. Equivalence between the differential-equation and the statistical mechanic approaches.**

Statistical mechanics unveils the multitasking capabilities (i.e. multiple antigenic defense) of the immune system and the agents which may impair it.

**Mercredi 10 décembre 2014, de 13h30 à 16h30**

**E) Agliari (90 mn): Is the multitasking immune network potentially controllable?**

Graph theory allows estimating different topological regimes for the B-T networks characterised by different degrees of connectivity (and controllability). The percolation transition triggered by the B/T ratio.

**F) Barra (90 mn): A renewal role for the idiotypic network (i.e. Varela theory) on the T signalling (i.e. two-signal model)**

The statistical mechanic allow to address both contributes simultaneously and provides a unifying picture.