INTERNSHIP PROPOSAL

Laboratory name: LPTMS CNRS identification code: UMR8626
Internship supervisor: FRULEUX, Antoine
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Internship location: Université Paris-Saclay, Orsay
Thesis possibility after internship: YES Funding: No

Using statistical models to unravel the gene interactions behind developmental robustness

Two organisms experiencing different environmental conditions will develop certain traits with a high level of similarity, while some others will be unalike. An open question is the relation between the sensitivity of biological systems to environmental disturbance on the one hand, and the complex interplay between the cellular mechanisms it involves on the other hand. With the tools of statistical physics, we aim at describing how the robustness to environmental condition may result from the organization of the cellular machinery.

The cells' functions derive from multiple interactions between genes, mRNAs, proteins… The complexity of these interactions makes their apprehension and the comprehension of their influence on the cells' functioning difficult. A strategy to bypass this obstacle has then been to simplify these interactions, for example in reducing them to binary interactions between genes. Such approach allowed to identify structures in the organization of interactions, such as scale free interaction networks, where few genes interact with much more others than average. We aim at understanding the possible relations between this organization and the robustness of the biological traits they relate to.

We build models for the development of organisms and their evolution. The organisms' development is the dynamical changes they experience through their lifetime. We model development in accounting for the influence of the environment, cellular mechanisms and their organization. Modeling organisms' evolution consists in describing the passing of one generation of organisms to another. First, in accounting for the likeliness of individuals to be reproduced, given their fitness to environmental conditions. Second, in considering the mutations which induce inter-generational changes in gene interactions. With these models, we account for the influence of environmental conditions on both the dynamics of cells during their lifetime and on the evolution of gene interactions.

The main goal of this internship will be to build a model for the dynamics of a set of organisms. In a lifetime, each individual will have its own dynamics described by ODEs accounting for cellular interactions and the influence of environmental conditions. From a generation to another, a resampling will occur depending on the fitness of organisms to their environment. We will use tools of statistical physics such as Monte Carlo simulations or mean field approaches to solve this model. Doing this, we will be able to characterize the sensitivity of individual organisms to environmental conditions and to relate it to the structure of gene interactions.

The intern will benefit from the expertise of the host team in morphogenesis, statistical and biological physics. The internship may be followed by a PhD.

Condensed Matter Physics: NO Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: YES