Mini-project #2 with Mario Nicodemi

Statistical Mechanics of Biological Systems:
the mystery of homologous pairing

Abstract

This project focuses on applications of **Statistical Mechanics/Complex Systems** methods (analytical/computational) to understand a very important problem in current Biology, the mechanisms of **homologous chromosome pairing** at Meiosis.

Project description

Scientific Background and Interest

Meiosis is the specialised cell division necessary in sexual reproduction. During meiosis, in a crucial step, homologous chromosomes must identify each other and pair, disruptions being related to serious diseases (e.g., fertility problems, birth defects, cancer). Yet, this process remains perhaps one of the most mysterious of Meiosis. Recent results on model organisms such as *C. elegans* and *Drosophila* have given new key information on pairing mechanisms. In *C. elegans*, for instance, homologs colocalization depends on special recognition regions at their ends (telomeric regions), known as "pairing centers" (PCs). And special DNA binding proteins, HIM/ZIM, localize to their corresponding PC and mediate their pairing.

Objective of the project

Crucial, currently unanswered, questions are on how these elements can generate recognition and colocalisation, and if they are sufficient to that task. The likelihood of random contacts of recognition elements is negligible, so the "Maxwell's demon" responsible for homology sensing and colocalization remains elusive. Models of Statistical Mechanics have been recently introduced to explain the early stages of pairing, incorporating only the minimal physical elements revealed by experiments, i.e., DNA pairing sequences and molecules binding them. This project aims to investigate those quantitative models via analytical or computational methods. After assimilation of the biological background, the project should focus, in particular, on understanding the dynamics of pairing and the effects of deletion/insertion on the DNA sequences involved, and depletion in the concentration of molecular mediators. These results could open the way to interpret a number of currently puzzling experiments.

Prospects

This miniproject is very well suited to become a full PhD project. Yet, it only requires familiarity with some basic concepts from Biology and typical Complex Systems models. It permits to enter in contact with current researches in Quantitative Biology and with the hot market of jobs related to applications of quantitative methods to biologically related problems. Finally, it's a good source of opportunities for further interactions with other Dept.s and Centers (e.g., Bio, Math, Medical School, MOAC, Sys.Bio., etc...) within Warwick University and elsewhere.

To have a flavour: S.L. Page, R. Scott Hawley R., Chromosome Choreography: The Meiotic Ballet. **Science** *301*, 785 (2003). **Nature Phys. News&Views** April 2007.