Modelling and Simulation in Systems and Synthetic Biology

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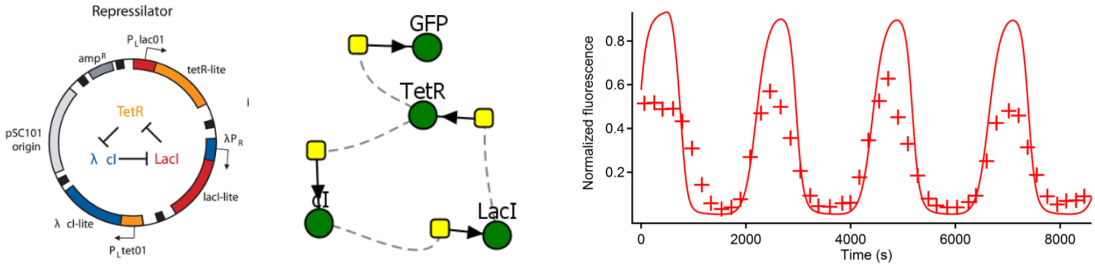
Systems biology consists in the mathematical study, the computational modelling and numerical simulations of complex biological systems[1]. The goal of this workshop is to provide a first approach on this topic. The workshop is divided in three parts.

The first part is a theoretical introduction on the modelling of biological systems. This includes a brief reminder on ordinary differential equations (ODE), basics of numerical methods for the solution of systems of ODEs, an introduction to the formalisms and the models used in systems biology and the analytical resolution of a simple biological system, *i.e.* the synthesis of a protein with a constitutive promoter).

In the second part focus is put on the computational modelling and the simulation of more complex biological systems. An open-source software, VCell[2], is used for this purpose. Two synthetic gene regulatory networks (GRN) are model in this part: the famous *Repressilator* of Elowitz[3] and a biological exclusive OR (XOR) gate designed by Ausländer et al[4]. For these exercises, you need to analyze the system described in the related papers, capture it on VCell (biological parameters and model equations are given) and simulate it.

In the third part, the problem is tackled upside down, with an approach close to synthetic biology. Another artificial GRN designed by Basu et al.[5] is studied. It achieves a band-pass response depending on the concentration of a hormone. In this case, the VCell model of the system is given and your goal is to tune the parameters (transcription rate and transcription factor affinity) in order to fit with an expected response defined *a priori*.



Elowitz's repressilator[3] , associated VCell model and simulation results

[1] Uri Alon, "An Introduction to Systems Biology: Design Principles of Biological Circuits", ed. Chapman & Hall, 2006. ISBN: 978-1584886426.
[2] VCell website. http://www.nrcam.uchc.edu/index.html. Click on Run VCell to download it.
[3] Michael Elowitz and Stanislas Leiber, "A Synthetic Oscillatory Network to Transcriptional Regulators", Nature 406, pp. 335-8, 2000.
[4] Simon Ausländer et al., « Programmable single-cell mammalian biocomputers », Nature 487, pp. 123-8, 2012.
[5] Subhayu Basu et al, « A Synthetic Multicellular System for Programmed Pattern Formation", Nature 434, pp. 1130-4. 2005.