

INTENSIVE PROGRAMME ON MATHEMATICAL MODELS IN LIFE SCIENCES (A)

Prof. Pasquale Palumbo

Laurea Magistralis Degree in Mathematical Engineering (3 CFU)

University of Aquila – Academic Year 2010/2011

This course deals with relevant aspects concerning developmental and protein-protein interaction networks, aiming to detail the basic features of signaling at the molecular level. Bottom-up and top-down approaches are treated in order to provide mathematical models, as well as an outline on the chemical master equations.

Detailed program.

- **Developmental networks** [1]. Double feedback networks and interlocked FFLs. Main differences with sensory networks.
- **Signaling networks** [1,2]. Protein-protein interaction networks. Elements of chemical kinetics: phosphorylation. Two-color networks: negative feedback and repressilator. Examples from biology: E. Coli chemotaxis: fine-tuned and robust models. Bottom-up model: the G1/S transition in the budding yeast.
- **Kinetic proofreading** [1]. Kinetic proofreading: the cases of translation and of the immune system.
- **Optimal circuit design** [1]. Benefit and cost functions, the role of the environment. Examples on FFLs and positive/negative regulation. The Savageau demand rule.
- **Master chemical equations** [3]. Master chemical equations: from the general case to the one-step Poisson process: steady-state solutions and simulations.

References:

- [1] U. Alon, *An introduction to systems biology: design principles of biological circuits*, Chapman & Hall/CRC, Taylor & Francis Group, 2007
- [2] M. Barberis, E. Klipp, M. Vanoni, L. Alberghina, “Cell Size at S Phase Initiation: An Emergent Property of the G1/S Network”, *PLoS, Computational Biology*, Vol.3, Issue 4, pp.649–666, 2007.
- [3] N.G. Van Kampen, *Stochastic processes in physics and chemistry*, Elsevier Science & Technology Books, 2007