Università degli Studi di L'Aquila - Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica

Course catalogue

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Programme of Course "Systems biology"

- Code: I0549
- Type of course unit: Compulsory (Master Degree in Mathematical Engineering curriculum Comune)
- Level of course unit: Postgraduate Degrees
- Semester: 1

Number of ects credits: (Master Degree in Mathematical Engineering) 6 (workload 150 hours)

Teachers: Pasquale Palumbo (pasquale.palumbo@iasi.cnr.it)

1	**Course objectives**	Systems biology is an emerging research area, which aims to provide mathematical models helping to understand the dynamic interactions occurring within and between cells. This course gives the mathematical tools to model and analyze gene transcription networks as well as signal transduction and metabolic networks: most important network motifs are investigated and data-based identification algorithms are also provided.
2	**Course content and learning outcomes (dublin descriptors)**	Topics of the module include: • Transcription networks. The rules of transcription: promoters and transcriptor factors, activators and repressors. Graph properties of a transcription network: in/out degree distribution, clustering coeffcients and modularity, scale-free distributions and hubs. ODE approach: modeling the clearance and production rate, Hill functions and logic input functions, dynamics of gene regulation. Network motifs emerging by comparison to randomized networks: negative/positive autoregulation, coherent/incoherent Feed-Forward Loops (FFL), Single-Input-Modules (SIM), Multi-Output Feed-Forward Loops (MO-FFL), bi-fan, diamonds, Dense-Overlapping-Regulons (DOR). Possible functions of network motifs in transcription networks: speed up of the response time, increase robustness, produce oscillations, introduce sign-sensitive delays, generate pulses or temporal programs of expression. Biological examples from the E. Coli: the arabinose system, the lactose system, the galactose system; temporal programs and assembly steps of the flagella motor. • Mathematical tools to identify gene networks. State observers for linear and nonlinear systems. The Ackerman formula. Asymptotic observers: the Luenberger observer. Applications to gene transcription networks: a case study on the FFL. • Growth and cell cycle models. Models of the cell growth: the case of eukaryotic cells. Cell cycle models: balanced exponential growth. Modelling the cell cycle of the budding yeast Saccharomyces cerevisiae: asymmetrical division. Age and protein distribution functions for daughter and parent cells.
3	**Course prerequisites**	
4	**Teaching methodsand language**	Lectures **Language**: English **Reference textbooks** • Uri Alon, ***An introduction to systems biology: design principles of biological circuits***. Chapman & Hall/CRC, Taylor & Francis Group. 2007.
5	**Assessment methods**	A case study on a scientific paper + Oral exams