Indian Institute of Science

Centre for BioSystems Science and Engineering

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BE 216 (JAN) 3:0 Dynamical Systems Biology

This course provides in-depth understanding of the underlying dynamics of biological systems through introducing students to the theory and applications of modeling biological systems at multiple scales – molecular, cellular, and population levels. Topics covered include systematic approaches to model building, decoding the dynamical traits of biochemical reactions and networks through modeling them via differential equations, estimating parameters and performing robustness/sensitivity analysis, and understanding the origins of cell-to-cell variability and modeling it through stochastic simulations. Also, the emergence and implications of multistability, oscillations, cellular adaptation will be discussed via case studies in cell differentiation, developmental biology, cellular reprogramming, and mathematical modeling of many hallmarks of cancer such as cell cycle, angiogenesis, drug resistance, and metastasis.

Instructor: Mohit Kumar Jolly

References

1. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Press (2006)

2. Markus Covert, Fundamentals of Systems Biology: From Synthetic Circuits to Whole-Cell Models, CRC Press (2015)

3. E Klipp, W Liebermesiter, C Wierling, A Kowald, H Lehrach, R Herwig. Systems Biology: A Textbook, John Wiley & Sons (2011)

Pre-requisites

Basic grasp of calculus, algebra, and some programming experience in MATLAB, C, Python, or Mathematica is recommended. Basic introduction to biology also required at an under-graduate level (or the drive to self-educate).

Additional information

This course is open to doctoral and master's students from all disciplines. Undergraduate students with sufficient background can approach the instructor.

Course objectives

By the end of the course students will be able to:

1. Formulate relevant mathematical models for various biological systems, and simulate them
2. Appreciate how systems-level properties emerge from nonlinear dynamics of biochemical networks
3. Understand the design principles of various biochemical networks, and use mathematical models to predict their dynamical behavior