Introduction to Dynamical Models in Biology

About the course:

Mathematical modeling has become an integral part of different fields of biology, from ecology to cell biology. This course will introduce students of biology to elementary mathematical concepts and tools for dynamical models. The course will focus on modeling using ordinary differential equations (ODEs). We will start with basic mathematical concepts of ODE-based models and then connect those with experimental biology. Mathematical models will be on cellular and molecular processes in biology, like cell signaling, and transcriptional networks. Students will learn basics of analytical techniques, graphical techniques, and numerical simulation.

Course Layout

Week 1
L1: Introduction to mathematical modeling in biology
L2: How to start modeling?
L3: Basic concepts of modeling using ODEs: Modeling the spread of infectious disease
L4: Basic concepts of modeling using ODEs: Modeling population growth
L5: Numerical solution of ODE-based models - I
L6: Numerical solution of ODE-based models - II
Week 2
L1: Simulating ODE-based models: Introduction to JSim
L2: Simulating ODE-based models: Examples of simulation in JSim
L3: Steady state and stability analysis: Understanding steady state
L4: Steady state and stability analysis: Stability of steady states
L5: Phase plane analysis - I
L6: Phase plane analysis - II
Week 3
L1: Concepts of bifurcation
L2: Bifurcation in Biological systems
L3: Modeling molecular processes in cell
L4: Modeling molecular processes-I: Ligand-receptor binding
L5: Modeling molecular processes-II: Enzymatic reaction
L6: Modeling molecular processes-III: Transcription and translation
Week 4
L1: Modeling a signal transduction circuit: Negative feedback
L2: Modeling a signal transduction circuit: Positive feedback
L3: Modeling a signal transduction circuit: Incoherent feedforward
L4: Modeling transcriptional circuits – I
L5: Modeling transcriptional circuits - II
L6: Online resources for mathematical modeling in biology