INTRODUCTION TO DYNAMICAL MODELS IN BIOLOGY

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Department of Biotechnology and Bioengineering
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PRE-REQUISITES : Must have studied Mathematics at 10+2 level. Have studied graduate-level Biochemistry and Molecular Biology. Knowledge of Computer Programming will be helpful but not a necessity

INTENDED AUDIENCE : Students of Biotechnology, Biology, Mathematical Biology, and allied subjects.

INDUSTRY SUPPORT : Bio-pharma industries use cellular level as well organism level mathematical models. This course would help to initiate biologists to such modeling.

COURSE OUTLINE :

Mathematical modeling has become integral part of different fields of biology, from ecology to cell biology. This course is intended to 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.

ABOUT INSTRUCTOR :

Dr. Biplab Bose is an Associate Professor in the Department of Biosciences and Bioengineering at IIT Guwahati. He has developed and taught courses on data analysis, systems biology, and bioinformatics. He is interested in understating the design principles of molecular networks, applications of dynamical systems theory and statistical physics in biology. He has also developed software like FlowPy, CorNetMap, and DEBay.

COURSE PLAN :

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