Advanced mathematical modelling in biology

MATH5565

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• 15 credits
• Taught Semester
• Level 4
• Year running 2008/09
• Pre-requisites: MATH2360 or MATH2370 or MATH3501

• Key topics assumed: Elementary dynamical systems theory, vector calculus and linear PDEs.

• Programmes of study: Mathematics BSc and MMath, Mathematical Studies, Joint Honours (Science), Mathematical Engineering and Theoretical Physics.

• Aims: Introduce some areas of the biological and medical sciences in which mathematics has a significant contribution to make. Present different modelling approaches to understand a wide variety of biological phenomena.

• Objectives: By the end of this module, students should be able to:
  a) model, with understanding, a selected group of biological phenomena,
  b) model certain biological phenomena described by ordinary differential equations,
  c) model certain biological phenomena described by discrete time Markov chains,
  d) model certain biological phenomena described by continuous time Markov chains,
  e) model certain biological phenomena described by partial differential equations,
  f) model special (advanced) topics in mathematical biology such as
     1. T cell repertoire diversity maintenance with and without continuous thymic output,
     2. T cell receptor clustering and multivalent ligands,
     3. first passage times for T cell-dendritic cell interactions in the lymph node,
     4. stochastic dynamics of molecular motors.


• Methods of teaching: Lectures: 26 hours, Tutorials: 0 hours and Examples classes: 7 hours. Monitoring of progress: regular example sheets.

• Form of assessment: 3 hour examination at end of semester (100%).

• Detailed Syllabus:
Ordinary differential equations in biology:
- birth and death populations
- chemostat: bacterial growth
- epidemics

Molecular reactions:
- chemical reactions
- inhibitors
- enzymes

Revision of probability and introduction to random variables:
- basic probability
- discrete random variables
- continuous random variables
- generating functions

Discrete time Markov chains:
- definition
- stationary distribution
- birth and death processes
- extinction

Continuous time Markov chains:
- definition
- stationary distribution
- birth and death processes
- extinction
- quasi-stationary distribution

Partial differential equations in biology:
- introduction
- diffusion
- tumour modelling

Advanced topics in mathematical biology:
- T cell homeostasis
- T cell receptor clustering
- multivalent ligands
- stochastic dynamics of molecular motors

Suggested books:
Informal description:

All the major developments in the physical sciences are underpinned by mathematics, both as (i) a framework (structure or language) for the concise statement of the laws of nature and as (ii) a tool for developing an understanding of new phenomena by modelling analysis. The introduction of mathematics to the biological and the medical sciences is still at an early stage, but it is becoming increasingly important in many areas. This module aims to introduce the student to some areas of mathematical biology that give rise to exciting new developments and to some of the current challenges for mathematical biology.
Details:
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Schedule: three lectures every week, for eleven weeks (from 29/09 to 12/12).
Tuesday 12:00–13:00 RSLT 14
Wednesday 11:00–12:00 RSLT 14
Friday 11:00–12:00 RSLT 05

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