Mathematical modelling in biology

MATH3565

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- 15 credits
- Taught Semester
- Level 3
- 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.
- Outline Syllabus: Modelling biological phenomena from several areas of biology and medicine. Ordinary differential equations in biology: population growth and molecular reactions. Revision of probability and introduction to random variables. Discrete time Markov chains: extinction. Continuous time Markov chains: birth and death processes and extinction (revisited). Reaction-diffusion mechanisms and phase plane analysis.
- 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

Continous time Markov chains:

> definition
> stationary distribution
> birth and death processes
> extinction
> quasi-stationary distribution

Partial differential equations in biology:

> introduction
> diffusion
> tumour modelling

- Suggested books:
  - Bruce Alberts et al., Molecular biology of the cell (4th ed.), Garland Science, 2002.
  - Linda J.S. Allen, An Introduction to mathematical biology, Pearson/Prentice Hall, 2007.
  - Linda J.S. Allen, An introduction to stochastic processes with applications to biology, Pearson Education, 2003.
  - N.F. Britton, Essential mathematical biology, Springer, 2003.
  - N.F. Britton, Reaction-Diffusion Equations and their Application to Biology, Academic Press, 1986.
  - David Chandler, Introduction to Modern Statistical Mechanics, OUP, Oxford, 1987.
  - L. Edelstein-Keshet, Mathematical Models in Biology, McGraw-Hill, 1987.
  - P. Grindrod, Patterns and Waves: the theory and applications of reaction-diffusion, Oxford Clarendon Press, 1991.
  - D.S.Jones and B.D.Sleeman, Differential Equations and Mathematical Biology, CRC Press, 2003.
  - Samuel Karlin and Howard M. Taylor, A first course in stochastic processes, Academic Press, 1975.
  - Samuel Karlin and Howard M. Taylor, A second course in stochastic processes , Academic Press, 1981.
  - J. Keener and J. Sneyd, Mathematical Physiology, Springer, 1998.
  - J.D. Murray, Mathematical Biology, Springer-Verlag, 1989.
  - P. Nelson, Biological Physics, WH Freeman, New York, 2004.
  - Howard M. Taylor and Samuel Karlin, An introduction to stochastic modelling Academic Press, 1998.
  - James D. Watson, Molecular biology of the gene (5th ed.), Pearson, 2004.
- 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.

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

Pre-requisite: MATH2360 or MATH2370 or MATH3501

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