Engineering Tripos Part IIB, 4G1: Mathematical biology of the cell, 2019-20

Module Leader

Dr Thierry Savin [1]

Lecturers

Dr T Savin, Dr T O'Leary [2]

Timing and Structure

Michaelmas term. 16 lectures (including 2 examples classes). Assessment: Coursework 100%

Aims

The aims of the course are to:

- introduce to sub cellular processes and the role of thermal fluctuations
- shift from the classical biology approach to a more physical description
- illustrate mathematical/computing approaches to study regulatory networks and biomolecular dynamics
- provide background knowledge on stochastic processes

Content

The course covers topics in stochastic processes and statistical mechanics with application to examples from biology. No background in biology is assumed.

Introduction (Savin)

- Cells are a very well organized machinery
- But molecular processes are subject to fluctuations, i.e. stochasticity
- How is it possible?

Mathematical formalism (Savin)

- Probabilities & Random Variables
- Stochastic Processes
- Master Equation, Fokker-Plank Equation

Regulation of gene expression (O'Leary)

- Gene expression analysis
- Stochastic gene expression
- Stochastic simulations

Cell structural organization (Savin)

- Biomolecules (DNA, cytoskeleton)
- Statistical physics for biology
- Polymer mechanics

- Transport processes in cells

Coursework

Coursework	Format	Due date & marks
Coursework activity #1: Analysis of noise in prokaryotic gene expression Cells often express genes in low copy numbers, leading to substantial variability in protein. In this coursework you will build a simple model of gene expression, analyse it mathematically and simulate a stochastic version of the model. Learning objective: • understand how to estimate fluctuation size in a stochastic system and limitations of analytic estimates; • be able to implement stochastic simulations; • interpret biological data and predictions that simulations yield.	Individual report Anonymously marked	Posted Fri we Due Fri week 30/60
Coursework activity #2: Modelling DNA's mechanical response The mechanical properties of DNA and other biological filaments are important factors for cell functions. In this coursework you will simulate a DNA molecule using a bead-spring chain model undergoing thermal fluctuations, and compare your results with the theory and existing experimental data. Learning objective: • understand models and Brownian dynamics of biological polymer; • code and carry out the simulations; statistically analyse the data; • interpret the simulations output in comparison with theory and experimental data.	Individual report Anonymously marked	Posted Fri w Due Fri two w 30/60

Booklists

Please see the **Booklist for Group G Courses** [3] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [4].

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