**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
Coursework

| Coursework activity #1: Analysis of noise in prokaryotic gene expression |
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| **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: |
| 1. understand how to estimate fluctuation size in a stochastic system and limitations of analytic estimates; |
| 2. be able to implement stochastic simulations; |
| 3. interpret biological data and predictions that simulations yield. |

| 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: |
| 1. understand models and Brownian dynamics of biological polymer; |
| 2. code and carry out the simulations; statistically analyse the data; |
| 3. interpret the simulations output in comparison with theory and experimental data. |

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].