Engineering Tripos Part IIB, 4G8: Engineering Living Systems, 2026-27

Leader

Dr S Bakshi

Lecturers

Prof G Micklem, Dr S Bakshi, Dr L Di Michele (CEB) and Dr J Molloy (Biochem)

Timing and Structure

Lent term 14 lectures. 100% exan

Aims

The aims of the course are to:

- introduce the technologies that enable large-scale engineering of living systems.
- Examine the engineering constraints that limit synthetic biological systems.
- Develop an understanding of how design, mesurement, optimisation, and scale influence biological engineering.
- Expose students to industrial, infrastructural, and governance considerations in bioengineering.
- Equip engineers to collaborate productively across biology, biotechnology, and industry

Objectives

As specific objectives, by the end of the course students should be able to:

- understand the capabilities and limitations of modern genome sequencing and genome engineering technologies
- evaluate which genome engineering or evolutionary strategy is appropriate for a given engineering goal
- design synthetic genetic circuits while accounting for resource limitations, burden, evolution, and host-circuit interactions
- analyse the impact of stochasticity and noise on engineered biological systems
- propose experimental strategies to characterise and measure circuit performance at single-cell and population levels
- understand the principles of design-build-test-learn (DBTL) optimisation in biological systems
- appreciate the challenges of scaling engineered systems from laboratory to industrial bioprocessing
- understand the role of automation, open technologies, and infrastructure in engineering biology
- recognise biosafety, dual-use, and governance considerations in bioengineering

Content

The course is structured around the technological foundations and engineering challenges of Lectures 1-5: Writing, Editing, and Rewriting Genomes (GM)synthetic biology.

Lectures 1-5: Writing, Editing, and Rewriting Genomes (GM)

- Genome sequencing technologies and biological information

- Sequence alignment, assembly, and annotation
- CRISPR-based genome editing
- Prime editing and base editing
- Off-target detection technologies
- Genome-scale engineering

Lectures 6-10: Engineering Genetic Circuits Under Constraints (SB)

- From gene editing to synthetic genetic circuits
- Abstraction hierarchies in biological engineering
- Host-circuit interactions and resource competition
- Fitness costs, burden-driven feedback, and growth coupling
- Experimental characterisation: sequencing-based assays, imaging, microfluidics, and machine-learning approaches
- Design-Build-Test-Learn pipelines and optimisation strategies

Lectures 13-14: Cell-free and Artificial Cells (LDM)

- Cell-free circuit engineering and optimisation
- Artificial cells and engineering biology
- Cell-free phage engineering and infection on artificial cells

Lectures 13-14: Bioprocessing and Scale (LDM)

- Bioreactor design and scale-up principles
- Metabolic load and stability at scale
- Translating engineered circuits to manufacturing environments

Examination Guidelines

Please refer to Form & conduct of the examinations [1].

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Links
[1] https://teaching26-27.eng.cam.ac.uk/content/form-conduct-examinations