Engineering Tripos Part IIB, 4G2: Biosensors, 2024-25

Module Leader

Prof G Malliaras [1]

Timing and Structure

Michaelmas term. Lectures and coursework. Assessment: 100% coursework.

Aims

The aims of the course are to:

- To provide an introduction to the field of bioelectronics
- To highlight the application of bioelectronic devices in the medical and consumer sectors

Objectives

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

- Extend principles of engineering to the development of bioelectronic devices.
- Understand the principles of signal transduction between biology and electronics.
- Appreciate the basic configuration and distinction among bioelectronic devices.
- Demonstrate appreciation for the technical limits of performance.
- Make design and selection decisions in response to measurement and actuation problems amenable to the use of bioelectronic devices.
- Be able to evaluate novel trends in the field.

Content

One of the most important scientific and technological frontiers of our time is the interfacing of electronics with living systems. This endeavour promises to help gain a better understanding of biological phenomena and deliver new tools for diagnosis and treatment of pathologies including epilepsy and Parkinson’s disease. The aim of this course is to provide an introduction to the field of bioelectronics. The course will link science and engineering concepts to the principles, technologies, and applications of bioelectronics. The fundamentals of electrophysiology and electrochemistry will be applied to implantable and cutaneous bioelectronic devices and to in vitro systems to explain the principles of operation. Examples from current scientific literature will be analysed.

COURSE CONTENT

1. Introduction

Drivers for bioelectronics
What is bioelectronics?
Organisation of the module

Part I: Fundamentals

2. Elements of anatomy and function

The nervous system
The neuron
Neural circuits
Other systems of interest

3. Signal transduction across the biotic/abiotic interface

Types of electrodes
Electrochemical impedance
Electrochemical reactions
Neural recording and stimulation
Transistors as transducers
Complete systems

Part II: Technology

4. Implantable devices

Cardiac pacemaker
Auditory and visual prostheses
CNS and PNS implants
Implantable sensors and drug delivery systems
The foreign body response

5. Cutaneous devices

Recording devices for brain, heart, muscle
Stimulation devices for brain, heart, muscle
Wearable electronics and electronic skins

6. In vitro devices

Electrochemical biosensors
In vitro electrophysiology
Impedance biosensors
Body-on-a-chip

Part III: Translation and ethics

7. Translation

From the drawing board to patients at scale
Device discovery
Preclinical research and prototyping
Pathway to approval
Regulatory review
Post-market monitoring

8. Ethics

Medical ethics
When a device becomes part of you

What happens to the data?
Animal research

Further notes

The course will be interdispersed with discussions highlighting the state-of-the art in the field.

Coursework

The coursework will be assessed on two marked assignments. The first assignment will involve a demonstration of glucose sensor technology. The second assignment will involve an illustration of the principles of electrophysiology applied to bioelectronic devices.

Coursework	Format	Due date & marks
[Coursework activity #1 : Cutaneous electrophysiology] Learning objectives: • To introduce students to sensors employed for the measurement of electrophysiology. • To explore different recording configurations. • To quantitatively analyse measurements conducted using cutaneous electrodes. • To extend the principles to the design of a sensor for the measurement of biopotentials.	Individual Report anonymously marked	Typically wee [30/60]
[Coursework activity #2 : Mock design of a bioelectronic system] Learning objectives: • To give stduents a holistic view of bioelectronic system design. • To explore different stimulation protocols used in neuromodulation. • To explore different materials involved in the design of electrodes. • To understand the process of translation.	Individual Report anonymously marked	Typically wee [30/60]

Booklists

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [3] standard:

Toggle display of UK-SPEC areas.

General Learning Outcomes

Graduates with the exemplifying qualifications, irrespective of registration category or qualification level, must satisfy the following criteria:

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Links
[1] mailto:gm603@cam.ac.uk
[2] https://teaching24-25.eng.cam.ac.uk/content/form-conduct-examinations
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