PH5016 – Biophotonics

Credits: 15.0
Number of Lectures: 28
Semester: 1
Lecturer: Dr Carlos Penedo-Esteiro, Prof Kishan Dholakia, et al
Academic Year: 2018-19

Overview
The union of photonics and biotechnology presents some of the most exciting scientific and commercial prospects for the 21st century. Largely due to advances in microscopy and the invention of the laser in the 1960s, photonics has touched all aspects of our lives, ranging from home entertainment to optical telecommunications and data storage. Biophotonics is the fusion of photonics and biology that deals with the interaction between light and biological matter. Light is one of the primary tools in biology, and increasingly sophisticated optical instrumentation is used in biological detection and analysis as well as medical treatment.

Aims & Objectives
The module will expose students to the exciting opportunities offered by applying photonics methods and technology to biomedical analysis and detection from the single molecule level right through to tissue. A rudimentary biological background will be provided where needed. Topics include imaging including basic imaging and microscopy, super-resolution methods, fluorescence microscopy and assays, including time-resolved applications, optical tweezers for force measurements, cell and DNA manipulation, Optical Coherence Tomography, Raman Spectroscopy and Optogenetics. Some consideration for the requirements for in vivo / clinical applications of Biophotonic techniques is also discussed.

Learning Outcomes
The key learning outcome is an appreciation for the wide range of photonics technologies that have important roles in the biomedical applications. The students will therefore gain appreciation of the following:

- Basic biological and biochemical concepts, such as the structure and function of cells, proteins and DNA.
- Methods to investigate biological structures with spatial resolutions from angstroms to millimetres and with temporal resolutions from nanoseconds to seconds and beyond.
- The nature of the interaction between biological materials (cells, tissue etc.) with light, such as scattering, absorption, fluorescence and Raman.
- Optical instrumentation used in biomedical practice, especially for imaging.
- Advanced light-based techniques such as single-molecule fluorescence, super-resolution methods, light-sheet microscopy, OCT and Raman Spectroscopy to provide multi-modal information.
- Operation of biomedical detection systems such as assays and their detection limits.
- Advanced optical techniques for mechanical manipulation of proteins and DNA such as optical tweezers and the added functionality and information provided by these methods.
- An introduction to optogenetics and how to use light to control biological response, mostly in neurons.

Students will also gain transferable skills by developing some of the material themselves via critical study of research papers and materials, presentations and group work.

Synopsis
Imaging at different temporal and spatial scales from molecules to cells including optical coherence tomography, confocal and multiphoton imaging, and imaging beyond the diffraction limit. Overview of Microscopy and relevance for biological inspection. Basics of Cell and Molecular Biology, structure and function of biological structures and samples. Optical scattering, absorption and properties of fluorescent labels including small fluorophores, fluorescence proteins and quantum dots and their use in biological assays and biomedical sensing. New generation imaging methods including super-resolution techniques, light sheet microscopy and single-molecule technologies. Single-

**Pre-requisites**

PH3081 or PH3082 or (MT2506 and MT2507), and (PH4034 or PH4035). The course assumes a basic understanding of lasers and optics, as provided in PH4034 (Laser Physics I).

**Anti-requisites**

none

**Assessment**

2 Hour Examination = 80%, Coursework = 20% (presentation on research topic related to lectures =12.5%, News & Views style article = 7.5%)

**Additional information on continuous assessment etc.**

Please note that the definitive comments on continuous assessment will be communicated within the module. This section is intended to give an indication of the likely breakdown and timing of the continuous assessment.

**Recommended Books**

Please view University online record:

http://resourcelists.st-andrews.ac.uk/modules/ph5016.html

**General Information**

Please also read the general information in the School's honours handbook.