PX3A8-15 Physics of Life and Medicine

22/23

Department
Physics
Level
Undergraduate Level 3
Module leader
Matthew Turner
Credit value
15
Module duration
10 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Living systems use energy to process information, to stay alive and to reproduce. We explain how the processes involved are consequences of the laws of electricity, mechanics and thermodynamics that you studied in the first two years. Physics and physical measurement techniques are also central to diagnostics and used in many therapies. We will concentrate on: magnetic resonance imaging, nuclear medicine, radiotherapy, ultrasound, and X-ray imaging and tomography.

Module web page

Module aims

To cover the physics of life and medicine. The module should show how studying the underlying physical principles helps understand living systems at different levels of complexity - molecular, cellular, up to the organ and system levels. The module should also describe some of the techniques developed by physicists to treat patients.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

What is life? Stability and synchronization in complex and open interacting systems. Entropy and information; DNA as an information storage system.

Fundamental rate processes: Boltzmann equation. Molecular diffusion and Brownian motion. Ion channel dynamics.

Cellular structure and function: passive and active transport across a cell membrane. Membrane potential: Nernst-Planck and Goldman equations. Oscillatory dynamics of membrane potential. Action potential: Hodgkin-Huxley equations. Integrate and fire model and functioning of the brain as an information-processing system.

Mechanical and electrical properties of the heart. Functioning of the cardiovascular system as a system that provides energy and matter to cells. Oscillations and turbulence in blood flow. Interactions between cardiovascular oscillations and brain waves.

An introduction to some of the applications of physics in medicine. Five major topics: Magnetic resonance imaging; Nuclear medicine; Radiotherapy; Ultrasound in medicine; X-ray imaging and tomography

Learning outcomes

By the end of the module, students should be able to:

- Explain the characteristics of the thermodynamically open systems relevant to life
- Explain the functioning of a cell, how cells make ensembles (tissues and organs), and how they interact with other parts of the system
- Apply knowledge of physics and mathematics to describe how information is transmitted and processed in living systems
- Explain the physical principles underlying the five areas of the application of physics to medicine covered in the module
- Discuss the advantages and drawbacks of each of these therapeutic or investigative techniques

Indicative reading list

R Glaser, Biophysics, Springer, 2005.
P Nelson, Biological Physics: Energy, Information, Life, 2008.
S. Webb (Ed), The Physics of Medical Imaging, Hilger B.H. Brown et. al., Medical Physics and Biomedical Engineering IOPP; G. Steele, Basic Clinical Radiobiology, Arnold; Bomford et. al., Walter and Miller's textbook of radiotherapy, Churchill.

View reading list on Talis Aspire

Interdisciplinary

The field illustrates beautifully the importance of interdisciplinarity in science. Medicine uses anything it can to understand and treat illness. It has imported many techniques and therapies from physics (radiology, radiotherapy, MRI, acoustics) as well as from other disciplines. Progress on understanding activities, such as the signal-processing taking place in our bodies, the non-

equilibrium dynamics of cells and brain activity, has only been possible because scientists from different backgrounds have worked together.

Subject specific skills

Knowledge of physics relevant to living systems and medicine. Skills in modelling, reasoning, thinking.

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Private study	120 hours (80%)
Total	150 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for exam, practising on past exam papers

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B

	Weighting	Study time
In-person Examination Answer three questions	100%	

	Weighting	Study time

- Answerbook Pink (12 page)
- Students may use a calculator

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX3A8

Availability

Courses

This module is Option list A for:

- UPXA-F300 Undergraduate Physics (BSc)
  - Year 3 of F300 Physics
  - Year 3 of F300 Physics
  - Year 3 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
  - Year 3 of F300 Physics
  - Year 3 of F303 Physics (MPhys)
- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
  - Year 3 of F3F5 Physics with Astrophysics
  - Year 3 of F3F5 Physics with Astrophysics
- Year 3 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)

This module is Option list B for:

- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 3 of GF13 Mathematics and Physics
  - Year 3 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)