

PX398-7.5 Physics of Living Systems

21/22

Department

Physics

Level

Undergraduate Level 3

Module leader

Matthew Turner

Credit value

7.5

Module duration

5 weeks

Assessment

100% exam

Study location

University of Warwick main campus, Coventry

Description

Introductory description

Living systems are complex systems which use energy to process information, to stay alive and to reproduce. They are not in thermodynamic equilibrium but are subject to the laws of thermodynamics. They generate and transmit information as electrical signals both at the level of cells and whole organisms. This module explains how many of the processes involved are consequences of the laws of electricity, mechanics and thermodynamics that you studied in the first two years.

[Module web page](#)

Module aims

To introduce the physics of life, and to show how physical principles help one to understand living systems at different levels of complexity - molecular, via the cellular, to the organ and system levels.

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.

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

Indicative reading list

R Glaser, Biophysics, Springer, 2005.

P Nelson, Biological Physics: Energy, Information, Life, 2008.

[View reading list on Talis Aspire](#)

Interdisciplinary

The module looks at the physiological activity associated with life. Examples include signal-processing, non-equilibrium dynamics and brain activity. Physics has always been, and is increasingly, important to this field. For example, the Hodgkin-Huxley model (1952, Nobel Prize for physiology in 1963) describes the equivalent electrical circuit governing the transmission of electrical signals along neurons. While many of the models of life, and the methods used to solve them, are physical models, the intuition needed to construct the models and to understand their solutions comes from physiology and many other sciences. The field illustrates beautifully the importance of interdisciplinarity in science.

Subject specific skills

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

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	15 sessions of 1 hour (20%)
Private study	60 hours (80%)
Total	75 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

Assessment component	Weighting	Study time	Eligible for self-certification
In-person Examination Answer two questions	100%		No

- Answerbook Green (8 page)
- Students may use a calculator

Reassessment component is the same

Feedback on assessment

Personal tutor, group feedback

[Past exam papers for PX398](#)

Availability

Courses

This module is Option list A for:

- Year 3 of UPXA-F300 Undergraduate Physics (BSc)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)

This module is Option list B for:

- Year 3 of UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
 - Year 3 of GF13 Mathematics and Physics
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)