

MD991-10 Physical Biology of the Cell

26/27

Department

Warwick Medical School

Level

Taught Postgraduate Level

Module leader

Darius Koester

Credit value

10

Module duration

10 weeks

Assessment

100% coursework

Study location

University of Warwick main campus, Coventry

Description

Introductory description

This module offers a unique physical science perspective on cellular biology, exploring the fundamental physical principles that govern biomolecular behaviour, dynamic cellular processes, cellular structure, and signaling events. It is designed to equip postgraduate students with the intellectual tools necessary for a research career at the intersection of biology and physics. Throughout the course, students will learn to estimate sizes, speeds, and energy requirements of various biological processes, as well as build simple, explicit models to analyze experimental cell biology data. In addition, the module emphasises problem-solving and collaborative group work, preparing students for the interdisciplinary challenges of modern scientific research.

[Module web page](#)

Module aims

1. To provide a physical science perspective on cellular biology. The module explores the basic physical concepts underlying the behaviour of biomolecules, dynamic cell processes, cellular structure and signalling events.
2. To equip postgraduate students with the intellectual tools necessary for a research career at

the interface of biology and physics. Students will learn how to estimate sizes, speed and energy requirements for a variety of biological processes and build simple explicit models to fit experimental data from cell biology experiments.

3. To provide students with opportunities to problem solve, and to work in groups.

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.

1. Fermi problems

Estimation of quantities, such as molecule numbers, densities, forces, velocities etc and how to put different entities into relation to each other.

2. Scales and sizes

Concentrations, sizes and partitioning of biomolecules, mass and energy budget to build the cell: counting molecules, Poisson distribution, time: conformational changes, cell cycle, diurnal clocks.

3. Moving inside the cell

Brownian motion, diffusion, on/off rates, thermal fluctuations, beating the diffusion speed limit by active transport, and ratchet models.

4. Structures inside the cell

DNA and cytoskeletal filaments: mechanical properties, bending, buckling, twisting, beam theory.

5. Motor proteins

Discussion of motor proteins and other molecular machineries.

6. Biological electricity

Ion permeability and pumping by the membranes, ion channels, action potential, Nernst equation, Hodgkin-Huxley model. Electrostatics in water. Electrostatic intermolecular forces in cytoplasm.

7. Cell division

Pushing and pulling by microtubules, oscillation of kinetochores, time series analysis, actin ring constriction.

8. Biological membranes

Physics of lipid membranes, membrane tension, bending rigidity, mobility of proteins in membranes.

9. Mechanosensing and tissue formation

Stiffness of tissues, extracellular substrate deformation (traction force), forces between cells, control of cell division by density and forces, catch-bonds in focal adhesions, molecular motors.

10. Topological and biophysical understanding of cell packing mechanisms of pattern formation in tissues, Turing dynamics, reaction-diffusion networks in 1D and 2D

Learning outcomes

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

- 1. Apply fundamental analytical and technical skills to investigate the physical biology of the cell.
- 2. Analyse and quantify physical biological properties and behaviours of living systems.
- 3. Formulate scientific questions by harnessing the core concepts of physical biology.
- 4. Design and articulate experimental approaches that effectively address scientific questions.

Indicative reading list

[Reading lists can be found in Talis](#)

Interdisciplinary

This module combines Physics, Chemistry and Biology and displays elements of these disciplines that are important to understand living organisms, organism development and disease.

Subject specific skills

Sound understanding of subject
Critically evaluate
Reflection

Transferable skills

Numeracy
Thinking and problem solving
Written communication
Oral communication
Teamwork
Organisation & time management
Use of tools and technology
Independence and initiative
Adaptability/Flexibility

Study

Study time

Type	Required
Seminars	20 sessions of 1 hour (20%)
Practical classes	10 sessions of 1 hour (10%)
Private study	30 hours (30%)
Assessment	40 hours (40%)
Total	100 hours

Private study description

50 hours self-directed study- Reading material in preparation for next session; solving assessed coursework

problems. Students will be advised to dedicate 50% of their time towards the assessed coursework, 30% of their time

to prepare the formative assignments and 20% of their time to prepare for the seminars.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group A2

	Weighting	Study time	Eligible for self-certification
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Assessment component

Mid-module coursework	50%	20 hours	Yes (extension)
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Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars during the first part of the module.

Each of the 2 problem-solving assignments will have the same weighting in the assessed coursework final mark.

A module pass mark will be awarded if a weighted average mark of 50% or higher is achieved across all assessed components (i.e.; 2 coursework)

Weighting

Study time

Eligible for self-certification

Reassessment: If the aggregated grade across the 2 coursework is less than 50%, students will resit the problem-sets that were failed.

Reassessment component is the same

Assessment component

End of module coursework 50% 20 hours Yes (extension)

Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars during the second part of the module.

Each of the 2 problem-solving assignments will have the same weighting in the assessed coursework final mark.

A module pass mark will be awarded if a weighted average mark of 50% or higher is achieved across all assessed components (i.e.; 2 coursework)

Reassessment: If the aggregated grade across the 2 coursework is less than 50%, students will resit the problem-sets that were failed.

Reassessment component is the same

Feedback on assessment

Marks and individualized feedback will be moderated by the Module Lead, in line with WMS assessment criteria (including submission for plagiarism). Feedback will be available to students throughout the module. Both coursework will be marked by Module Lead and moderated by an academic. Any student failing any assessed component will be offered an appointment with the module lead for face-to-face feedback.

Availability

Courses

This module is Core for:

- Year 1 of TMDA-B91Z Postgraduate Taught Interdisciplinary Biomedical Research

This module is Optional for:

- Year 4 of UMDA-CF10 Undergraduate Integrated Natural Sciences (MSci)