MD991-10 Physical Biology of the Cell

22/23

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

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

Phillips.,R, Kondev, J., Theriot, J, Garcia, H (2012) “Physical Biology of the Cell”, 2nd edition, pub: Garland
Nelson, P (2014) “Physical Models of Living Systems”, pub: WH Freeman
Milo, R., Phillips, R (2015) “Cell Biology by the Numbers” pub: Garland

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 (29%)
Practical classes	10 sessions of 1 hour (14%)
Private study	40 hours (57%)
Total	70 hours

Private study description

40 hours self-directed study- Reading material in preparation for next session; solving assessed coursework problems and be preparing for the written exam.
Students will be advised to dedicate 50% of their time towards the assessed coursework, 30% of their time to prepare and work for the written exam problem set 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 A

	Weighting	Study time
Coursework (1/5)	12%	4 hours

Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars 1&2. Each of the 5 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.; Coursework and Final Problem Set)

Reassessment: If the aggregated grade across the five regular problem sets is less than 50%, students will resit the problem-sets that were failed. The mark of the re-assessed problem-solving assignment(s) will be capped at 50%.

Coursework (2/5)	12%	4 hours

Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars 3&4. Each of the 5 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.; Coursework and Final Problem Set)

Reassessment: If the aggregated grade across the five regular problem sets is less than 50%, students will resit the problem-sets that were failed. The mark of the re-assessed problem-solving assignment(s) will be capped at 50%.

Coursework (3/5)	12%	4 hours

Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars 5&6. Each of the 5

	Weighting	Study time

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.; Coursework and Final Problem Set)

Reassessment: If the aggregated grade across the five regular problem sets is less than 50%, students will resit the problem-sets that were failed. The mark of the re-assessed problem-solving assignment(s) will be capped at 50%.

Coursework (4/5) 12% 4 hours

Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars 7&8. Each of the 5 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.; Coursework and Final Problem Set)

Reassessment: If the aggregated grade across the five regular problem sets is less than 50%, students will resit the problem-sets that were failed. The mark of the re-assessed problem-solving assignment(s) will be capped at 50%.

Coursework (5/5) 12% 4 hours

Assessed coursework: to assess the student's ability to use analytical skills to solve particular problems in biophysics described in seminars 9&10. Each of the 5 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.; Coursework and Final Problem Set)

Reassessment: If the aggregated grade across the five regular problem sets is less than 50%, students will resit the problem-sets that were failed. The mark of the re-assessed problem-solving assignment(s) will be capped at 50%.

Final Problem set 40% 10 hours

Set of five problems that can be solved using a combination of the taught materials and creative, logical thinking.

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

Reassessment: If the Final Problem set is failed, students will be re-assessed on this component and the mark will be capped at 50%.

Feedback on assessment

The session leads will mark the coursework (problem-solving assignments). 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. The Final Problem set will be doubled marked by Session leads and the Module Lead. Any student failing any assessed component will be offered an appointment with the module lead or a session 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 Option list A for:

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