

# MS202-15 Cellular Decision Making

**26/27**

**Department**

Warwick Medical School

**Level**

Undergraduate Level 2

**Module leader**

Timothy Saunders

**Credit value**

15

**Module duration**

10 weeks

**Assessment**

100% coursework

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

This module focuses on how complex biological systems can make decisions. For example, the body must respond to changes in the local environment quickly and reliably. The approach taken here is to use mathematical modelling to understand how networks and feedback can generate precise responses, such as switching and pulse generation. Relatedly, we will develop the students ability to perform estimation and quick calculations relevant to biological systems.

The module will be compulsory for second year Integrated Natural Science (INS) students. The module builds on the ethos of INS, with a clear emphasis on solving problems by drawing freely from the methods and mindsets of more than one discipline. The module will be open to SLS students who want to expand their quantitative and mathematical skills. No prerequisites are required, though students without knowledge of calculus will need to do some prescribed pre-module reading and exercises.

### Module aims

The module will focus primarily on mathematical methods to analyse data, and model interactions and spatial patterns. The students will be equipped to extract quantitative information from images, derive network information and mathematical models to describe multidimensional patterns and complex multi-species interactions. The module provides an important view on understanding

biological systems that is quite distinct from most other approaches covered in UG modules in SLS and WMS.

## 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.

Block 1: Numbers in biology – learning to estimate  
Back-of-envelope calculations  
Scales in biology  
Number patterns in biology

Block 2: Law of mass action and application to simple gene networks  
Michaelis-Menten simple derivation  
Thresholds for generating gene response  
Concept of steady-state  
Non-dimensionalisation

Block 3: Generating simple circuits with genes  
Simple gene network – feedforward  
Positive feedback switch  
Effects of noise on switching

Block 4: Timing in gene networks  
Multiple thresholds for generating timing sequence  
Pulse generation  
Basic intro to generating biological oscillators

Block 5: Interpretation of spatial information by gene networks  
Morphogen gradients and positional information  
Interpreting morphogens through gene networks

Project: Extracting and analysing quantitative imaging data  
Students given imaging data, e.g. butterfly wing images. In groups of around four, implement segmentation via available software packages, e.g. ilastik. Generate figures from quantitative data. Individually write short reports on imaging data, emphasising statistical analysis.

## Learning outcomes

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

- Utilise software packages for analysing imaging data (written report)
- Understand fundamental concepts underlying biological networks, including feedback, hysteresis, and robustness
- Comprehend concepts underlying networks and their representation
- Apply model fitting approaches to experimental data (written report)
- Apply statistical knowledge to estimate uncertainties in analysis (written report)
- Apply statistical techniques to a variety of biological data

- Generate and interpret graphs of biological data

## Indicative reading list

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

## Interdisciplinary

Utilises concepts from mathematics, physics and computer science to tackle problems related to biology.

## Subject specific skills

Knowledge of key methods in network analysis, simple dynamic modelling, data handling and analysis. Knowledge of approaches to model linear and multidimensional gradients resulting in cellular decision making and robust pattern formation. Knowledge how to use tools to extract quantitative data from images and analyse the data.

## Transferable skills

Students will be able to demonstrate integrated thinking across the Sciences. They will learn to work as a team to tackle a problem. They will learn how to structure a longer project over 10 weeks.

## Study

### Teaching split

Provider	Weighting
Warwick Medical School	60%
Life Sciences	40%

### Study time

Type	Required
Lectures	5 sessions of 1 hour (3%)
Project supervision	5 sessions of 1 hour (3%)
Practical classes	10 sessions of 2 hours (13%)
Private study	95 hours (63%)
Assessment	25 hours (17%)
Total	150 hours

## Private study description

Reviewing lecture material prior to practical classes.

Reading literature, particularly Systems Biology by U Alon.

Going through practical class material afterwards to embed learning and to cover any questions missed.

Working on project in groups initially and then individually to prepare data for the report.

Preparation for in-class test

## Costs

No further costs have been identified for this module.

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## Assessment

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

### Assessment group A1

	Weighting	Study time	Eligible for self-certification
<b>Assessment component</b>			
Quantitative approaches to biological imaging data	50%	15 hours	Yes (extension)
Students given imaging data, e.g. butterfly wing images			
In groups of four, implement segmentation via available software packages, e.g. ilastik			
Generate figures from quantitative data			
Individually write short reports on imaging data, emphasising statistical analysis			
Each member of the group can use the group's shared data to generate figures. However, each figure must be their own with separate analysis. Where shared data is used, clear attribution must be provided.			
All reports will be checked with Turnitin. As part of the classes focused on the report writing, we will discuss how to attribute work, and what is acceptable. Plagiarism, including self-plagiarism, is discussed.			
Each report is marked independently, with no specific mark given for group work. Students are frequently reminded to highlight any issues with group dynamics early in the process of the work. Learning to handle any group frictions is an important "soft skill" developed as part of the work. If a student is unable to submit to the original deadline, then a sample data set will be provided for their reporting writing for resubmission. In the case of a failed submission, the student will have the option to reuse their original dataset or be provided with a sample data set.			

**Weighting****Study time****Eligible for self-certification**

Reassessment component is the same

Assessment component

Mathematical approaches to understanding biological networks

50%

10 hours

No

The 90 minute in-class test will take place at the beginning of term two. It will consist of short maths problems related to understanding biological networks.

Reassessment component is the same

**Feedback on assessment**

Students will receive homework problems based on past papers prior to the in-class test. Worked solutions will be provided where appropriate. The project will have 5 1-hour classes available where students can come for feedback on their progress.

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**Availability****Pre-requisites**

Students without calculus knowledge should do precourse reading as prescribed by the lecturer

**Courses**

This module is Core for:

- Year 2 of UMDA-CF10 Undergraduate Integrated Natural Sciences (MSci)

This module is Optional for:

- Year 2 of UBSA-C700 Undergraduate Biochemistry
- ULFA-C1A2 Undergraduate Biochemistry (MBio)
  - Year 2 of C1A2 Biochemistry
  - Year 2 of C700 Biochemistry
- Year 2 of ULFA-C702 Undergraduate Biochemistry (with Placement Year)
- Year 2 of ULFA-C1A6 Undergraduate Biochemistry with Industrial Placement (MBio)
- Year 2 of UBSA-3 Undergraduate Biological Sciences

- Year 2 of ULFA-C1A1 Undergraduate Biological Sciences (MBio)
- Year 2 of ULFA-C113 Undergraduate Biological Sciences (with Placement Year)
- Year 2 of ULFA-C1A5 Undergraduate Biological Sciences with Industrial Placement (MBio)
- Year 2 of UBSA-C1B9 Undergraduate Biomedical Science
- ULFA-C1A3 Undergraduate Biomedical Science (MBio)
  - Year 2 of C1A3 Biomedical Science
  - Year 2 of C1B9 Biomedical Science
- Year 2 of ULFA-C1A7 Undergraduate Biomedical Science with Industrial Placement (MBio)
- Year 2 of ULFA-CB18 Undergraduate Biomedical Science with Placement Year