

# CS904-15 Computational Biology

**24/25**

**Department**

Computer Science

**Level**

Taught Postgraduate Level

**Module leader**

Till Bretschneider

**Credit value**

15

**Module duration**

10 weeks

**Assessment**

Multiple

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

The module will cover topics on the acquisition of and analysis of large-scale data generated in biomedical sciences, particularly DNA/RNA sequences, live cell microscopy and multi-gigapixel pathology images. Students will be introduced to how these data are acquired, modern machine learning methods to process the data, and computational modelling approaches to help us better understand the complex phenomena underpinning biological processes. The module will be taught following an "algorithmic approach," demonstrating that addressing problems in computational biology requires a diverse range of theoretical concepts and algorithms, making it an exciting and rapidly evolving field for computer scientists. The students will learn using deep learning models for analysis of multi-gigapixel images. Therefore, basic understanding of image processing concepts will be required.

### Module aims

The module is designed to develop student research skills in the broad area of computational biology.

### 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.

- Molecular biology fundamentals;
- Sequence alignments;
- Phylogenetic Trees;
- Dimensionality reduction and clustering;
- Live cell microscopy fundamentals;
- Image based modelling of single cell dynamics;
- Overview of mathematical modelling techniques and their application: Ordinary differential equations, stochastic differential equations, Monte Carlo methods
- Introduction to tissue imaging and computational pathology;
- Whole-slide image (WSI) handling
- WSI processing using machine learning and deep learning algorithms;
- Recognising various kinds of cells in cancerous WSIs;
- Advanced research topics in computational biology;

## **Learning outcomes**

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

- Have an understanding of how tissue slides are imaged with high throughput
- Have a basic grasp of fundamental molecular biology concepts as relevant to this module
- Understand some basic and commonly used algorithms in bioinformatics
- Know algorithms to compute sequence alignments and how these are applied in current research
- Understand basic problems in the processing and analysis of tissue images and some standard solutions to those
- Be able to apply image analysis and machine learning to real-world computational pathology problems
- Understand principles of fluorescence microscopy and image-based modelling of single cell dynamics
- Know how to apply different mathematical techniques for modelling cellular dynamics

## **Indicative reading list**

Zvelebil, M., and Baum, J.O., Understanding Bioinformatics. Garland Science, 2008;

Kremling, A., Systems Biology. CRC Press, 2014;

Pantanowitz, L., and Parwani, A., Digital Pathology. ASCP, 2017;

Alberts, B., et al., Essential cell biology: an introduction to the molecular biology of the cell (5/e). Garland, 2008.

## **Research element**

Students need to develop and implement algorithms to address questions typically asked in current research projects. For example: Perform sequence analysis of homologous genes and construct phylogenetic trees, generate simulation data of gene regulatory networks and perform dimensionality reduction and clustering, develop models for cellular dynamics, analyze digital pathology images taken from real-world data.

## Interdisciplinary

The module will cover a broad range of techniques used in biology, mathematics, and computer science.

## Subject specific skills

By the end of the module, students will have acquired skills in:

- Implementing fundamental bioinformatics algorithms for computing alignments and phylogenetic trees
- Formulating and solving mathematical models of gene regulatory networks
- Applying methods of dimensionality reduction and clustering
- Formulating mathematical models of cellular dynamics
- Handling and processing of whole-slide images (WSI) data
- Recognising various kinds of cells in cancerous WSIs
- Recognising various kinds of regions in WSIs
- Performing survival analysis using features collated from WSIs

## Transferable skills

Technical - Technological competence and staying current with knowledge

Communication - Verbal, listening, writing, technical communication skills, using different medium for communicating

Critical Thinking - Problem-solving, analysis of possible solutions etc

Creativity - Ability to harness creative ideas and turn them into tangible and strategic products/solutions

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## Study

### Study time

Type	Required
Lectures	20 sessions of 1 hour (13%)
Supervised practical classes	10 sessions of 1 hour (7%)
Private study	120 hours (80%)
Total	150 hours

### Private study description

Background reading of research papers, working through additional examples and improving coding skills, revision.

## 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.

Students can register for this module without taking any assessment.

### Assessment group C5

	<b>Weighting</b>	<b>Study time</b>
Assignment 1	16%	
This assignment covers the first section of the module, Bioinformatics. This assessment is eligible for self-certification (extension).		
Assignment 2	17%	
This assignment covers the first section of the module, Mathematical Modelling of Cellular Dynamics. This assessment is eligible for self-certification (extension).		
Assignment 3	17%	
This assignment covers the first section of the module, Computational Pathology. This assessment is eligible for self-certification (extension).		
In-person Examination CS904 examination	50%	

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- Answerbook Pink (12 page)

### Assessment group R2

	<b>Weighting</b>	<b>Study time</b>
In-person Examination - Resit CS904 resit examination. Standard calculator allowed.	100%	

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- Answerbook Pink (12 page)

## Feedback on assessment

Written comments on coursework

[Past exam papers for CS904](#)

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## Availability

### Courses

This module is Core optional for:

- Year 1 of TBSA-C1P9 Postgraduate Taught Systems Biology

This module is Optional for:

- TCSA-G5PD Postgraduate Taught Computer Science
  - Year 1 of G5PD Computer Science
  - Year 1 of G5PD Computer Science
- Year 1 of TMAA-G1PF Postgraduate Taught Mathematics of Systems
- Year 1 of TBSA-C1P9 Postgraduate Taught Systems Biology

This module is Option list A for:

- RMAA-G1PG Postgraduate Research Mathematics of Systems
  - Year 1 of G1PG Mathematics of Systems
  - Year 1 of G1PG Mathematics of Systems
- Year 1 of TMAA-G1PF Postgraduate Taught Mathematics of Systems

This module is Option list B for:

- Year 5 of UCSA-G504 MEng Computer Science (with intercalated year)
- UCSA-G503 Undergraduate Computer Science MEng
  - Year 4 of G503 Computer Science MEng
  - Year 4 of G503 Computer Science MEng