SYSTEMS BIOLOGY FOR HEALTH AND DISEASE - 2024/5

Module code: BMS3112

Module Overview

Systems Biology is widely accepted as a major future direction of biological research. The ethos of Systems Biology is to generate, analyse, and integrate multiple data sets for understanding and modelling a biological system. We want to know the components (molecules) of the system, how they work/interact together, and, ideally, have some quantitation: the abundance of a particular component and/or the rates of action/interaction. Due to technological advances within molecular biology, we are now able to obtain quantitative information about molecules within a biological system on both small and large scales.

The purpose of this module is to introduce students to the basic concepts of Systems Biology for health and disease. The module includes subjects relevant to prokaryotic and eukaryotic systems and is thus suitable for all bioscience students. Learning methods include: lectures, seminars, computer practical sessions, article discussion, workshops, and research and problem solving during both lectures and computer-based investigations.

Module provider

School of Biosciences

Module Leader

BARBERIS Matteo (Biosciences)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 6

Module cap (Maximum number of students): N/A

Overall student workload

Workshop Hours: 16

Independent Learning Hours: 31

Lecture Hours: 33

Seminar Hours: 18

Tutorial Hours: 14

Practical/Performance Hours: 22

Guided Learning: 5

Captured Content: 11

Module Availability

Semester 1

Prerequisites / Co-requisites

MOLECULAR BIOLOGY AND GENETICS: FROM GENES TO BIOLOGICAL FUNCTION (Module code: BMS2036)

Module content

Indicative content includes:

Founding ‘good research practice’ concepts (BARBERIS)

- An introduction to, and concepts of Systems Biology in health and disease
- How to design a Systems Biology experiment
- Research proposal “surgery” sessions where students can discuss their proposal with peers and academics

Mathematical Modelling (BARBERIS)

- Founding concepts in mathematical modelling of dynamic systems
- Building mathematical models and analysis of model parameters
- Conducting simulations of cellular processes in health and disease using specialised software
- Computer practical sessions where software for modelling analyses will be presented
- Research seminars will discuss examples of mathematical modelling in scientific research

Modelling complex biological systems (BARBERIS)

- Building a complex biological network
- Integrating mathematical modelling with experimental data
- Modelling cell cycle control: experimental background and model building
- In silico model predictions and experimental validation

- Modelling genome scale metabolic networks
- Flux Balance Analysis: stoichiometric coefficients and stoichiometric matrix
- Fluxes, biomass, and optimization criteria
- Research seminars where mathematical modelling research and applications in Systems Biology in health will be presented and discussed

Modelling diseases (BARBERIS)

- Mathematical equations used in discrete and continuous disease modelling
- Modelling cancer: biological background and modelling pipeline
- Spheroid models and signalling pathway models
- Integrating mathematical modelling with experimental data in cancer development
- Modelling the immune system: biological background and model pipeline
- Infection models and immune response models
- Integrating mathematical modelling with experimental data in inflammatory disease
- Research seminars where mathematical modelling research and applications in Systems Biology in disease will be presented and discussed

Bioinformatic analyses (LAING)

- Concepts of –omics and network biology in understanding human health and disease
- –omics data (genomics, transcriptomics, proteomics, interactomics, metabolomics, meta–omics): data generation, processing and analysis
- Core dataset, statistical analysis, and concepts in biological annotation
- Molecular interaction networks: reconstruction from data/computational approaches and basic concepts of network analysis
- Data integration – why one '–ome' is not enough, and biological interpretation
- Research seminars where Bioinformatics research and applications in Systems Biology will be presented and discussed

Assessment pattern

Assessment type	Unit of assessment	Weighting
Oral exam or presentation	ORAL POSTER PRESENTATION: CRITICAL ANALYSIS OF A SYSTEMS BIOLOGY JOURNAL ARTICLE	30
Coursework	RESEARCH GRANT PROPOSAL: DESIGN A NOVEL SYSTEMS BIOLOGY RESEARCH PROJECT	70

Alternative Assessment

N/A

Assessment Strategy

The **assessment strategy** is designed to provide students with the opportunity to demonstrate

- Ability to understand and accurately report the outputs of mathematical and metabolic models and bioinformatic analysis
- Ability to select the most appropriate methods for answering their own independent research question(s)
- Awareness of cutting-edge research in Systems Biology

Discussions between students in a workshop, led by academics in seminar sessions, will further demonstrate breath of the field and its role in contemporary Life Sciences.

The grant proposal assessment is key to providing students with the opportunity of demonstrating their ability to formulate independent research ideas involving application of Systems Biology approaches.

Thus, the summative assessment for this module consists of:

- An oral poster presentation on the critical analysis of a recent scientific article involving the application and analysis of a Systems Biology approach, combining (any of) Bioinformatics, –omics analysis, and mathematical and metabolic modelling. The analysis will demonstrate the understanding of advantages and limitations of those approaches, and how they can be used to understand and gain further knowledge of cellular phenomena. Depending on the number of students enrolled for the module, it is expected that each article will be shared by groups of 2 students. Reports to be submitted two weeks before the end of the module.

- Coursework on an original Systems Biology idea as a grant proposal (submitted at the end of the module).

Formative assessment

Dedicated tutorials will provide examples of formative assessment on poster presentations and research grant proposal, as well as the evaluation criteria will be presented and discussed in detail.

Feedback

The students will receive formative feedback from their peers and the Module Leader during the workshops. The feedback received

will directly support the development of a research grant proposal. Extensive feedback will be provided on research grant proposals during the scheduled "surgery" workshop session, before submission.

Module aims

- To introduce the field of Systems Biology and the key topics within it
- To provide examples of how experimental and computational approaches may be integrated to address behaviours of complex biological systems
- To provide practical understanding of computer simulations of living systems, computational analysis of experimental data, and interpretation of results
- To increase awareness of the information that can be gained from the application of high-throughput "-omics" technologies employed to measure parameters at a systems level, and exploitation of this data using bioinformatic and/or modelling techniques
- To increase awareness of current research within the field of Systems Biology

Learning outcomes

		Attributes Developed
001	Understand the basic quantitative techniques used within the field of Systems Biology	KPT
002	Analyse high-throughput data sets using current available software/web-tools	CP
003	Use key bioinformatic tools for interpreting your results	CPT
004	Use software tools for computer simulations of molecular interaction networks	CPT
005	Integrate diverse data sets to understand organisms at a systems level	CPT
006	Present your ideas in a concise and cohesive style of a research grant proposal	KCPT
007	Present your ideas in an oral poster presentation	PT
008	Design a Systems Biology experiment	KCPT
009	Critically review the literature	KCPT

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The learning and teaching strategy is designed to:

Provide students with an understanding and awareness of Systems Biology approaches, to enable their independent and creative application for answering research hypotheses and global challenges. We will provide basic skills of mathematical modelling and computational data analysis. Assessment is focussed on the critical evaluation of a scientific journal article and the ability to

discuss and formulate independent research ideas.

The learning and teaching methods include:

- Lectures, including online lectures
- Tutorials on module content and assessments
- Research seminars on designing experiments
- Computer practical sessions plus online resources
- Journal article critical review workshop
- Research proposal “surgery” workshop
- Presentation of original Systems Biology ideas in the form of research grant proposal

Indicated Lecture Hours (which may also include seminars, tutorials, workshops and other contact time) are approximate and may include in-class tests where one or more of these are an assessment on the module. In-class tests are scheduled/organised separately to taught content and will be published on to student personal timetables, where they apply to taken modules, as soon as they are finalised by central administration. This will usually be after the initial publication of the teaching timetable for the relevant semester.

Reading list

https://readinglists.surrey.ac.uk
Upon accessing the reading list, please search for the module using the module code: BMS3112

Other information

This module may be not available to ERASMUS and other international exchange students. Please check with the International Engagement Office email: ieo.incoming@surrey.ac.uk

Five pillars are embedded within the module, as described as follows:

1) Resourcefulness & resilience
Students work in groups of two individuals to produce a scientific poster within a theme of Systems Biology. The posters are based on scientific articles chosen by the module lead, who is assisting the students regarding how to present the content. Furthermore, students work individually to produce a grant proposal developing their own research idea, where computational and experimental aspects are integrated with the guidance of the module lead. The students will conduct the research themselves, and the module lead assists them in the formulation of the research question and in how to integrate computational and experimental aspects. The students discuss their posters and their research with each other and with the module lead, and they seek advice from the module lead. These efforts help students to exhibit commitment, resourcefulness, and resilience.

2) Global & cultural capabilities
Students choose a pre-selected topic within the scientific area of their interest, and they are required to work in groups of two individuals to decide on the strategies to present – in an oral poster presentation – the topic, which sources are better suitable to support the line of thoughts they have, which scientific reasoning they would use to present a Systems Biology research. The students will produce their poster and present it together. These efforts help students to exhibit cultural capabilities.

3) Sustainability
The module content is largely based on the use and application of mathematical modelling techniques, which can be used to predict definite biological behaviours that may be tested in dedicated experimental settings. This path helps the students seeing the sustainable approach of the scientific research, to perform only the experiments to test the model prediction and not any (often

unnecessary) experiment. Furthermore, for example, some of the research ideas develop on model organisms useful for cleaning the environment, and the students are encouraged to consider sustainability within the development of their own idea for the research grant proposal. These efforts directly contribute to sustainability of scientific research.

4) Digital capabilities
Students perform their own research which is primarily digitally based. They produce a poster using PowerPoint and present it digitally. Furthermore, the module covers the use of mathematical software (Matlab, Copasi, Optflux) to address and solve biological dynamical and steady state systems. These efforts help the students to acquire digital capabilities.

5) Employability
The Systems Biology field provide the students with the ability to integrate knowledge of computational and experimental approaches that they may use in their future research - whether in the academic setting or in the industry setting. The students are exposed to multiple ways the computational and experimental approaches are integrated together to address and solve a range of biological questions (i.e. the Systems Biology circle). The scientific research they are exposed helps to acquire a breath of the scientific vision that may serve when choosing their future career, thus increasing their employability.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
Biochemistry BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Biological Sciences (Animal Biology and Ecology) BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Biological Sciences (Cellular and Molecular Sciences) BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Biological Sciences (Infection and Immunity) BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Biological Sciences BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Biomedical Science BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Biomedical Science MSci (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module
Microbiology BSc (Hons)	1	Optional	A weighted aggregate mark of 40% is required to pass the module