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|  | Cardiff University logo |
| **Systems Biology** |  |  |
| Systems biology is an exciting new area of science where complex behaviour in natural systems (e.g. protein folding, bacterial quorum sensing, fish shoaling, evolution of disease resistance in plants) are understood to involve the complex interactions of the simpler component parts of the system. Importantly, it is founded on the understanding that these outcomes are not a simple sum of the different parts but have ‘emergent properties’ that may not be easily predictable and occur because of the interactions between many individual parts. At its core the new discipline aims to understand biological systems more fully by making use of both experimental data and computational methods. Experimental data is analysed and then used to build *in silico* “models” that in turn are used to produce new hypotheses to be tested experimentally, then in turn providing further data that is then used to improve and enhance the models in a repeated cycle. Systems biology can work with data and models at different scales, from individual molecules through to whole organisms and ecosystems. The systems approach therefore involves borrowing concepts and tools from mathematics, statistics and computer science and applying these to biological problems. It is important to appreciate that whilst the biological systems may be complex, the underlying maths used to understand them and predict their behaviour is straightforward, and such concepts allow us to gain a much deeper understanding of the complexity of biology. This module explores systems biology principles and approaches and equips students with background knowledge that will enable them to explore and understand all biology from a systems perspective. Students will also gain useful skills in working across discipline boundaries.  The module aims to address the concepts and approaches of systems biology and show how a global holistic view of biological systems and processes can lead to a better understanding of the function of system components. It will show how biological systems can be represented at different levels of abstraction, drawing examples from different scales in biology from metabolic and gene control networks to the dynamics of populations. It will cover a range of computational modelling approaches and demonstrate how models may be used to represent processes at a systems level and generate testable biological hypotheses.  | Module Code: BI3157 |  |
| External Subject Code |  |
| Number of Credits: 30 |  |
| Level: 6 |  |
| Module Leader Dr Joanne Lello |  |
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| **On successful completion of the module a student will be able to:**1. Discuss the concepts and approaches of systems biology, and how they are distinguished from traditional approaches.
2. Integrate experimental data with computational technologies and model resources to answer biological questions.
3. Combine software/approaches to represent biological systems at different levels.
4. Evaluate and analyse large-scale data sets in order to reconstruct the underlying biological control networks.
5. Critically assess, design and select an appropriate modelling strategy for different biological situations.
6. Identify and integrate suitable systems approaches with modelling to develop effective systems biology experiments.

Analyse and represent biological systems using standard systems biology language |
| **How the module will be delivered**The module will be delivered by a mixture of lecture sessions, workshops/tutorials and online learning activities. A major part of the delivery of the curriculum content will be through directed study focused around published research papers. Discussion of contemporary research methods and means of interpreting results will also be a focal point of teaching sessions. Assessments will reinforce the curriculum content and relate it to scientific practical work and literature. Directed study and self-directed learning will supplement formal teaching sessions. Students are encouraged to ask/email questions to the lecturer to gain further understanding of the topics covered. Students also have access to innovative teaching material via Learning Central, for self-directed learning to aid their understanding and revision of topics.Student feedback is solicited at several points and, when possible, acted upon immediately to improve teaching/module delivery. |
| **Skills that will be practised and developed**This module will develop key transferrable academic skills of note-taking, reading scientific papers, detailed discussion of complex concepts, and problem-solving. The module will develop scientific written and/or communication skills, as well as reinforcing skills in statistical analysis (introduced in year 2) and the application of published experimental data to determining scientific conclusions. Students will be supported in the interpretation and analysis of research papers and reviews. Literature searching (such as use of PubMed, Scopus or similar databases) and the use of curation databases (such as EndNote) for supporting writing and referencing will be developed as part of the module. Digital literacy skills and the use of subject-specific analytical software will be developed.In addition to subject-specific application of knowledge and understanding, on completion of the module a student will be able to:*Scientific skills and competencies:* 1. Present experimental data in an appropriate and rigorous format.
2. Apply relevant examples, discuss experimental evidence, and refer to appropriate technology and methods of analysis, when demonstrating that the above learning outcomes have been met.
3. Apply appropriate quantitative methods for data analysis and interpretation.
4. Evaluate appropriate methodologies in scientific problem-solving and experimental design.
5. Critically appraise experimental data, reported findings and interpretations.
6. Apply appropriate bioinformatic approaches to data analysis where appropriate.
7. Apply the use of software packages for scientific analyses.
8. Formulate models from baseline.

 *Transferable Skills:*1. Obtain relevant peer-reviewed information from original primary sources.2. Conduct independent study to add depth of understanding to a topic.3. Work in small groups to develop team-working and communication skills.4. Integrate concepts and make connections between subject areas and areas of learning.5. Apply knowledge and understanding to solving scientific problems and planning experimental approaches.6. Communicate science with clarity, fluency and organisation.7. Write using correct grammar, punctuation and spelling, and adhering to scientific convention.In addition to subject-specific skills, teaching on the module also emphasises the development of transferable skills that further enhance employability. |
| **Syllabus content**The module provides coverage of the interlinked topics of systems biology and modelling approaches to provide students with an understanding of how quantitative experimental methods and simple mathematical analysis can help us understand and predict biological systems and processes, which are inherently complex. Mathematical and computational techniques and approaches will be covered throughout the course, to the level required to understand current research papers in systems biology. To develop higher level skills and build deep learning, the course will place an emphasis on problem-based learning. Taking a lead from other successful courses, we will make use of the flipped classroom. As the course involves mathematical and computational skills, the sessions will chiefly be built around workshops where the learners will explore the key syllabus elements. Students will be facilitated by academic staff in developing these new skills gaining both the confidence and capacity to analyse systems problems and build models to describe their behaviour. The specific topics to be covered within the course are; systems thinking, emergent properties, networks, scaling, d) co-ordination, dealing with non-linearity, adaptive / evolving systems.***Underpinning skills***With the overarching goal to draw biological insights for problems spanning different scales, we will be employing methods and introduce a new way of thinking, which will employ computational techniques and mathematics, and therefore, we will provide dedicated sessions throughout the course to help develop student confidence and skills in this area. Importantly computational skills with be taught through clear biological examples, spanning the range of research conducted in the different Research Divisions of the School of Biosciences (https://www.cardiff.ac.uk/biosciences/research/divisions). ***Systems biology***:Students will be introduced to: a) the concept of systems thinking including the iterative experiment - model prediction cycle; b) how to describe components of systems and how to link them (through, e.g. differential equations, Agent-based models, network models); c) an understanding of how we can use large scale datasets to reconstruct underlying biological systems, using examples from a wide range of biological disciplines; d) how to parameterise models from data and how to estimate unknown parameters; e) how to make predictions using well formulated biological assumptions; f) how to compare predictions to empirical data; g) how to derive new hypothesis and tackle them. Concepts of equilibrium, dynamic and stochastic processes in biology will be discussed. **Essential Reading and Resource List**A list of useful textbooks will be provided in the Reading Lists Tab on Learning Central. Students are encouraged to identify their own additional reading from the research literature. Additional resources such as short videos and web links will be provided via the Learning Materials Tab on Learning Central**Background Reading and Resource List**Indicative reading lists of research papers and/or reviews will be provided for individual teaching sessions. |
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