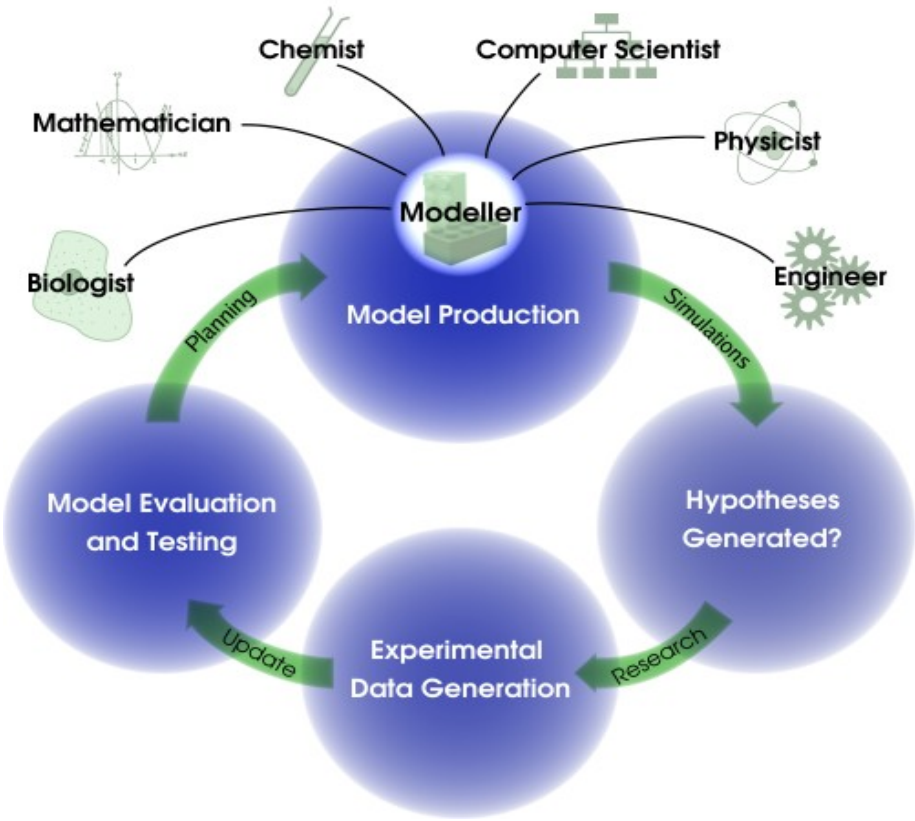
MSc. INTEGRATIVE BIOLOGY



School of Biosciences

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MSc in Integrative Biology

Background

Integrative Biology involves collation of data sets from experiments quantifying biological molecules such as DNA, RNA, proteins, hormones, transporters etc. facilitating development of sophisticated mathematical models. These models are used to simulate and predict behaviour of biological systems and organisms under investigation. Integrative Biology is intrinsically multi-disciplinary and most effective when carried within a group of scientists with many divergent types of expertise.

Computers can now be used to make predictive models of biological systems, ranging in scale from individual biochemical reactions through to virtual cells to tissues, complete organisms and even populations of organisms. This discipline depends on collaboration between the theoretical modellers and laboratory investigators of biological systems, analogous to relationship between theoretical and experimental physicists. Integrative Biology is perceived as a major area of future bioscience research.

This one-year course trains people in the skills necessary to develop models for use in bioscience research. Integrative Biology expertise is increasingly required by all research groups in both academic and industrial sectors, indicating excellent employment prospects for graduates.

This course attracts graduates who have an interest in applying their biological knowledge in a mathematical computing environment. Students are familiar with IT and are therefore more comfortable working with computers than in traditional laboratories. Undergraduate courses described here use models of biological systems to predict experimental responses prior to actual experimentation, then used to confirm or refute model results.

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Integrative Biology is valuable in identifying experiments that are the highest priority and will provide the most critical but missing information, thereby increasing the probability of producing successful discoveries in the laboratory.

Course Structure

Students are required to accumulate 180 credits comprising 120 credits in Part I, provided as taught modules, delivered in the Autumn and Spring semesters and consisting of a mixture of compulsory and optional topics, with a qualifying barrier for progression to the 60-credit Part II Project component completed in association with scientists and submitted for assessment at the end of the final semester.

The programme provides opportunities for students to develop and demonstrate knowledge, understanding and skills in the following areas:

- the mathematical and computational techniques required to produce useful and effective mathematical models of biological systems including spanning the physical scales from chemistry, through molecular and cellular biology, to whole organism anatomy and physiology, and population biology
- the information and informatics resources available to make these models
- the application and understanding of Integrative Biology techniques to a specific research project
- the role of multi-disciplinary work in Integrative Biology
- the application of Integrative Biology in the private sector

Criteria for admission

Candidates will normally hold a second class or higher, Honours Degree in biological science, or allied discipline, providing sufficient background for the course. An A level GCE or equivalent in

Mathematics is also highly recommended. Relevant workplace experience may, in some circumstances, be accepted as qualification for entry to this course

International Students

Applicants whose native language is not English must attain a British Council IELTS average final score of 6.0 with a minimum of 5.0 in each element or a TOEFL paper-based test score of 550 or computer-based test score of 213, with a minimum score of 4 in the Test of Written English, achieved no more than 2 years prior to admission. Students may also apply to undertake a full-time intensive English language and academic preparation course of appropriate length in the Centre for English Language Education.

How to apply

Applications for the Programme are processed at The University of Nottingham, School of Biosciences. Students will register at the university specified in their offer letter. Visiting student status will be provided at the other university.

Application forms are available from:
School of Biosciences,
The University of Nottingham,
Sutton Bonington Campus,
Loughborough, Leics,
LE12 5RD, UK
or by applying online at https://pgapps.nottingham.ac.uk/

Course Director: Professor Charlie Hodgman
Course Manager: Dr. Jim Maas
james.maas@nottingham.ac.uk

Web Page: http://www.mycib.ac.uk/teaching.shtml

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MSc Integrative Biology Modules

Biomolecular Networks (D2DIB1)
The students will gain knowledge and understanding of:

- the mathematical and computational techniques to make useful and effective models of biological systems including and spanning the physical scales from chemistry, through molecular and cellular biology, to whole organism anatomy/physiology and population biology
- the application and understanding of integrative biology techniques to a specific research project, the role of multi-disciplinary work in integrative biology
- the application of integrative biology in the private sector
- the ability to determine the appropriate mathematical or computational techniques to model biological systems/processes of research interest
- the ability to acquire information and process this in order to keep abreast of developments in the relevant subject areas. professional/practical skills
- the ability to; plan, execute and report on a research project, search and retrieve the information needed to build integrative biological models. develop and/or use programming tools to construct and refine computer models of biological systems, and from simulations propose experiments to test hypotheses
- ability to present scientific work and ideas in a range of formats, including essays, dissertations, research papers, research council grant applications, illustrated oral presentations, posters and web pages

Computing and Mathematical Concepts for Integrative Biology (D2DIB2)
This module provides an introduction to:

- computing and mathematical concepts that lie at the heart of Integrative Biology
- binary representation of data, data standards and modelling
- information and knowledge of representation in computational biology
- computer representation of 3D objects and real-time changes in physical systems
- binary operations in single central processor units and multi-tier networked systems
- solving differential equations
- series and numerical methods Linear stability analysis

Literature Review & Project Design in Integrative Biology (D2DIB3)
This module requires students to write a literature review of approximately 3000 words for the research project chosen from a list of topics provided by academic research staff. This information is then used to build a research plan.

Post-Genomic Data and Integrative Biology (D2DIB4)
This module provides an introduction to:

- ways in which post-genomic technology (PGT) data are interpreted through references to known biological pathways in PGT-data analysis tools and with optimisation techniques applied to holistic biomolecular networks
- ways in which biological networks have been inferred from time series and/or genotypic variant PGT data using Bayesian networks, Markov models and genetic programming

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Transferable Skills for Integrative Biology (D2DIB5)
This module covers the full range of soft skills needed by professional scientists and managers in the Integrative Biology arena including:

- written and verbal presentations skills
- the processes of job acquisition and development
- the cultures and drivers in different academic disciplines participating in Integrative Biology
- group management
- business establishment and development, especially with respect to the biomedical and food sectors
- mechanisms for raising funds for research projects

Introduction to Programming (G6DICP)
The students will learn:

- the fundamentals of programming in Java, and be provided with a thorough grounding in procedural logic, flow control, simple data structures, and event driven programming
- to understand and implement complex software specifications
- to develop Java software according to client specifications
- to evaluate the task at hand and utilise the most appropriate programming methodologies

They will gain extensive experience in problem solving, and will learn to interpret technical documentation.

Software Engineering (G6DSWE)
The students will learn:

- Programming, Instruction in Unified Modelling Language for determining system requirements, Documentation and help systems
- Awareness of various software architectures for use in system and network design, understanding and evaluating requirements specifications, working in teams on complex software engineering problems
- Programming utilising software engineering methods, Evaluating software design tools, Identifying usability issues in software design, Solving software design problems
- Working in teams and organising activities using formal techniques (e.g. PERT diagrams) , Writing software manuals, Retrieving information on software design practices

Experimentation & Computing Techniques (D2DC02)
The students will learn:

- Principles of experimental design
- Major approaches to statistical data analysis
- Data Interpretation
- to critically appraise designs and analyses by peers
- Design experiments, Organize, analyse and interpret data, Write reports, Assess evidence, Produce concise reports

Mathematical Medicine and Biology (G13MM2)

- This module forms part of the Nonlinear Mathematics Pathway. It gives students: an introduction to how mathematics can be usefully applied to problems in medicine and in biology
- an introduction to uses of a variety of widely-used techniques of applied mathematics, including model building, solution techniques for ordinary and partial differential equations, and application of fundamental ideas regarding transport processes
- coverage of some advanced topics using nonlinear mathematics.

Coordinated Physiological Functions (D235Z7)

The students will learn:

- anatomy of the hypothalamus and its main connections, how the hypothalamus links physiology and motivational status
- physiological adaptations to physical exercise and their control
- how to recognise and use appropriate theories, concepts and principles from a range of relevant disciplines
- to collect and integrate several lines of evidence and apply them in a balanced manner to support an argument, taking ethical considerations into account where appropriate, apply subject to address familiar and unfamiliar problems
- to critically analyse, synthesise and summarise information drawn from various sources, including published research papers and reports, demonstrate the provisional nature of facts and principles associated with the latest developments within the field of study, design and carry out appropriate tests or experiments to test a hypothesis, carry out experiments to test a hypothesis
- to collect and record data, work safely in the laboratory, communicate clearly and concisely in a written form, work productively as an individual and as part of a team and manage time efficiently

Integrated physiology (D236Z2)

The students will learn:

- of the connections between various branches of biological science, strategies that can be used to manage complex problems and teams
- the ability to apply information from one branch of science to another, to collect and integrate information from different areas or techniques
- the ability to put in place appropriate structures for administration of large and complex research teams
- communicate clearly and concisely in a written form, prepare and present posters and work effectively in a team to present information

Systems neurophysiology (D235Z2)

The students will learn:

- the range of techniques used to investigate the nervous system in vivo, the role of the spinal cord in rhythmic locomotion, the main areas of the brain stem involved in the genesis and control of the respiratory rhythm
- the main factors affecting arterial blood pressure
- how survival depends on the integrated functioning of basic neural systems
- how to recognise and use appropriate theories, concepts and principles from a range of relevant disciplines, collect and integrate several lines of evidence and apply them in a balanced manner to support an argument, taking ethical considerations into account where appropriate, address familiar and unfamiliar problems

- how to critically analyse, synthesise and summarise information drawn from various sources, including published research papers and reports, demonstrate the provisional nature of facts and principles associated with the latest developments within the field of study
- design and carry out appropriate tests or experiments to test a hypothesis, how to collect and record data, work safely and productively as and individual or as part of a team in the laboratory, communicate clearly and concisely in written form

Plant Disease Control (D236P3)
The students will learn:

- an appreciation of the range of organisms which cause plant disease, their transmission, diagnosis and the losses they cause
- the underlying principles and recent development in disease control strategies, collect and integrate several lines of evidence and apply them in a balanced manner to support an argument, apply subject knowledge to solve problems, derive and analyse material from a range of sources
- how to carry out experiments to test a hypothesis, collect and record data, work safely in the laboratory, communicate clearly and concisely in a written form, work productively as an individual and as part of a team and manage time efficiently

Plant Cell Signalling (D2D1P2)
This module aims to provide a basic understanding of gene regulation by endogenous and exogenous factors, plant biotechnology.
Objectives:

- to develop practical skills in the handling of plant cell fractions
- to develop an appreciation of the structure and function of plant cell membranes
- to impart an appreciation of the properties of membrane receptors and the transduction chains activated by them
- to illustrate the range genes induced by signals from other cells and external stimuli and how they differ from other plant genes
- to develop a range of transferable skills.

Crop protection (D2DP01)
The students will learn:

- an appreciation of the diversity and characteristics of organisms that cause losses in crops, the physiology of some events that lead to crop losses
- the value and limitations of control options available to farmers and growers
- to derive, analyse and interpret information from current research and commercial sources, critically evaluate current research in the field of crop protection, search for and retrieve information from a wide range of sources including electronic and print systems
- prepare and present a talk using Powerpoint, communicate clearly and concisely in written, verbal and visual forms
- to critically appraise and present information from a wide range of sources, sse general IT tools, internet and other learning resources to generate concise scientific overviews and to advance own knowledge base