



The  
University  
Of  
Sheffield.

Chemical &  
Process  
Engineering.

## M.Sc. Biological & Bioprocess Engineering

### Course Guide

#### Course Description

M.Sc. in Biological and Bioprocess Engineering is a taught Masters programme, offered by the Department of Chemical and Process Engineering. The programme is designed to provide:

- (i) multidisciplinary training in the emergent discipline of biological engineering and
- (ii) training in industrial bioprocessing.

**The objectives** of the course include the following:

- (a) Provision of access to interdisciplinary Master's degree to students from a range of academic backgrounds
- (b) Preparation of students for a professional career in bioindustry or advanced bioengineering research sectors.
- (c) Development of professional interpersonal skills.
- (d) Encouragement of students to think for themselves and work effectively on their own initiative.
- (e) Provision of experience of extensive research projects.
- (f) Development of individual ability to make technical decisions.
- (g) Provision of a broad knowledge base to gain deep understanding and practical experience of biological and bioprocess engineering.

Biological engineering is a branch of engineering where the core engineering design principles of measurement, modelling and manufacture are now being applied to complex biological systems, underpinning a new "systems biology". The fundamental challenge is to utilise and integrate fundamental genomic-level information to explain and predict the behaviour of complex biological systems. Applications include healthcare, environmental and lifescience problems. Bioprocessing is a crucial part of the biotechnology/biopharmaceutical sector, with application areas including cell therapies, tissue engineering, gene therapy and novel manufacturing approaches for proteins and biopharmaceuticals.

The Department of Chemical and Process Engineering at Sheffield houses a unique bio-engineering centre with world-class capabilities. The establishment of a world-class research centre (ChELSI) at the department that specialises in research at the interface of chemical engineering and life sciences provides a core team of inherently multidisciplinary academic staff with primary research interests and expertise in biosystems engineering and bioprocessing. The Master's programme harnesses this knowledgebase to provide a uniquely multidisciplinary learning experience relevant to the emerging discipline of biological

engineering and careers in industrial bioprocessing. Whilst based in the Department of Chemical Engineering, the programme also incorporates highly complementary teaching modules provided by a range of Sheffield's world-class departments, including Molecular Biology and Biotechnology, Engineering Materials and Physics.

## Course structure

The course is designed to provide specialisation to both engineering and bioscience graduates, through the introduction of a complementary conversion module in the first semester, before the specialist modules. For taught modules, formal lectures are the principal means of imparting knowledge, and understanding is gained through a combination of tutorials, example classes and coursework assignments. Detailed practical knowledge and understanding is gained through an extensive laboratory-based research project assessed via a dissertation and oral presentation. The programme provides a number of opportunities for personal development, including the interaction with leading bio-industrialists working in the field during invited seminars and workshop sessions.

### Semester 1

The semester begins with a conversion module to introduce complementing knowledge to the graduates. For bioscience graduates, this is **Principles of Biochemical Engineering (CPE6006)**, which is designed to introduce core concepts of biochemical engineering to science graduates with little or no direct training in biochemical engineering, and includes concepts of material and energy balances, heat and mass transfer; fluid dynamics and reaction engineering. For engineering graduates, this is **Principles of Biomolecular Sciences (MBB603)**, conducted by the Department of Molecular Biology and Biotechnology, which is designed to introduce graduate engineers with little or no direct training in biological science to core concepts of biomolecular structure and function, cell biology, metabolism and systems biology.

Two other modules, then introduce the graduates to research methods in biochemical engineering, and advanced aspects of biosystems engineering and computational biology. The module on **Research Methods in Biochemical Engineering (CPE6002)** enables the graduate to gain an appreciation of the philosophical objectives of research in biochemical engineering and understand the basis of (a) why research is conducted (theory building and hypothesis formation), (b) how research is conducted and results analysed, and (c) how research is presented. The second module on **Biosystems Engineering and Computational Biology (CPE6005)** is designed to provide students with the knowledge and tools necessary to understand analyse and design biological systems for human benefit. In particular, the course will teach aspects of reconstruction of biochemical networks and their mathematical representation and analysis. This will then be used to allow for formulation of metabolic engineering and/or synthetic biology strategies. This unit aims to introduce core concepts of computational/systems biology and its application towards engineering of biological systems.

### Semester 2

The second semester has one compulsory taught module in bioprocess engineering and three electives to choose from four modules on advanced topics offered by specialist departments of the University. The compulsory module (**Biopharmaceutical Bioprocessing – CPE6004**) aims to provide students with an awareness of bioproduct manufacturing technology, especially with respect to biopharmaceutical bioprocessing. Generic examples of cell engineering, metabolic engineering, upstream and downstream unit operations and other

related topics such as biopharmaceutical formulation, bioproduct analysis and systems engineering will be covered with reference to particular products and processes. The unit will be run as small group teaching with additional seminars and case histories provided by invited expert speakers from industry. It is intended that the group will visit an industrial biopharmaceutical manufacturing site.

The four specialist modules from which to choose three electives are:

1) **Microfluidics (CPE6007)**, conducted by the Department of Chemical & Process Engineering, where the graduate student will gain an understanding of the range of processes that can be conducted in microfluidic devices and learn the fundamental physicochemical hydrodynamics necessary to analyse and design microfluidic devices. Microfluidics is an emerging arena coupling several disciplines that has already delivered devices with unparalleled levels of microdispersions, microemulsions, cell disruption, liposomes and injectibles. The technology covers applications in chemical processing, food manufacturing and additives, pharmaceutical production and research, biotechnology and cosmetics.

2) **Stem cell Biology (BMS6056)**, conducted by the Department of Biomedical Sciences, which will provide the graduate student with an in-depth account of stem cell biology and its application to regenerative medicine. Special reference will be made to the molecular and genetic control of cell fate specification and differentiation. The module is designed with due consideration to existing and potential clinical use of stem cells and their derivatives, and of the ethical issues that these raise. As this is a rapidly developing field, strong emphasis will be placed on understanding the current controversies in the literature.

3) **Bionanomaterials (MAT6730)**, conducted by the Department of Materials Engineering, introduces basic concepts of cell and molecular biology, before looking at examples of how biomolecules can be used for designing nano-structures, and the use of these nano-structures in biological and medical applications. Students will gain comprehension of the principles of bionanotechnology and an understanding of applications of natural materials in nanotechnology and of nanomaterials in biology and medicine.

4) **Tissue Engineering Approaches to Failure in Living Systems (MAT407)**, conducted by the Department of Materials Engineering, explores tissue and biomedical engineering approaches to address disease, failure and old age in the human system. A theme throughout the module considers common forms of pathology or injury to tissues and current therapeutic approaches and then uses this as a basis to explore the tissue and biomedical approaches.

The taught modules are followed by a compulsory laboratory based **Research Project (CPE6011)**, which aims to introduce the graduate student to practical experience of research in a chosen area of biological and bioprocess engineering. The projects will be chosen by the student in an area related to the research activities at the Department of Chemical & Process Engineering, and will be supervised by one or more members of academic and research staff. There will be an emphasis in the module on both oral presentation and written report. Project and laboratories encourage the students to develop the ability to make technical decisions. Sufficient time is allowed throughout the course for students to develop ability to work effectively on their own initiative. It will be required to submit a dissertation at the end of the project, that will be assessed.

For those graduates with an inclination to do research, it is possible to use the Masters course as the first year of a 4 year focused PhD in the field of Biological & Bioprocess Engineering. This is called a "New Route PhD". For 2008-09 there are 3 fully funded "New Route PhD"

places available for suitably qualified students (funded by BBSRC that will cover course fees and a stipend for 4 years).

### Schematic of course structure

