



# Principles of Fermentation Processes

30 September - 2 October 2024

**MBI** Modular training for the  
bioprocess industries

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study/industrial-training](https://ucl.ac.uk/biochemical-engineering/study/industrial-training)

# MBI Training Programme

## Principles of Fermentation Processes

30 September - 2 October 2024

Welcome to the UCL MBI Principles of Fermentation Processes module.

This module is designed to create a foundation in fermentation processes. The underlying principles of fermentation are introduced through a series of lectures, which are supported by case studies. This module provides the basis for the material presented in later modules on fermentation process design and operation and mammalian stem cell processes. This module is suitable for scientists and engineers who wish to familiarise themselves with fermentation processes and those who wish to build underlying principles into their operational expertise.

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### Module Coverage:

- Modes of fermentation and their application
- Materials balances and fermentation data Interpretation
- Principles of medium development
- Kinetics of growth and evaluation of different expression systems
- Fermentation productivity and yields
- Impact of microbial physiology on fermentation
- Fermentation and mammalian cell culture development

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### Related Modules:

- Rapid Fermentation Process Design
- Design of Experiments for Bioprocess Optimisation
- Mammalian Cell Culture Hands-On (Resilience)
- Microbial Fermentation Hands-On (Resilience)

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### Qualifications:

An assessment is offered for those who wish to build up credits for qualifications and demonstrate their new skills. It is based on the content of the two fermentation modules (Principles of Fermentation Processes and Rapid Fermentation Process Design) and takes the form of a written examination on a date to be confirmed. Successful completion of the assessment will lead to the award of 30

credits that can be counted towards a MSc Bioprocessing.

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### Module Leader

Frank Baganz, UCL

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### Expert Speakers

Darren Nesbeth, UCL

Gary Lye, UCL

Joe Egan, UCL

Stephen Goldrick, UCL

Jonathan Welsh, AstraZeneca

Ronan O'Kennedy, ROK Bioconsulting

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# MBI Training Agenda

**Monday, 30 September 2024**

Design Suite, Bernard Katz Building

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**10.45am**  
**Registration**

**11.00am**  
**Introduction to MBI Training Programme and Module**  
Frank Baganz, UCL and Olivia Festy, UCL

This session will cover the objectives of:

- (i) Lectures
- (ii) Case Studies

**11.30am**  
**Evaluation of Different Expression Systems**  
Darren Nesbeth, UCL

In this lecture we will consider several expression systems for the production of recombinant proteins. Many different expression systems are available to the fermentation scientist, all with distinct advantages and disadvantages. In particular we will discuss mammalian cell, insect cell, fungal cell (*Pichia* and *Aspergillus*) and bacterial cell (*E. coli*) systems. Mechanisms of operation, processing methods, examples and comparisons between these systems will be made and a summary showing the trade-offs between the different systems will highlight the challenges involved in final selection.

**12.15pm**  
**How Upstream Can Help Ease Overall Processing**  
Darren Nesbeth, UCL

This lecture addresses some of the advances in upstream processing in particular cell engineering which has a direct impact on whole bioprocessing and potential cost savings. The lecture will draw on examples from *E. coli* and *Pichia pastoris* studies.

**1.00pm**  
**Lunch and Tour of the Department**

**2.00pm**  
**Fermentation Mass Balancing I**  
Gary Lye, UCL

Balancing of materials which are taken up, consumed and converted by micro-organisms,

forms the basis for design and operation of a fermentation process at all scales. Here, the principles governing mass balancing, such as stoichiometric equations and formulation of elemental balances are given.

**3.00pm**  
**Cell Growth Kinetics I**  
Frank Baganz, UCL

Cells may be grown under different regimes. In this lecture cultivation of cells in batch mode, which is the most widely studied system is examined, and factors affecting growth are reviewed. Different stages of batch growth are described and the kinetics of growth governing each stage are explained, giving delegates one of the essential tools for successful operation of a fermentation.

**4.00pm**

**4.15pm**  
**Fermentation Mass Balancing II**  
Gary Lye, UCL

This lecture continues with the concept of materials balancing, focusing on typical examples and drawing on data available on elemental composition of microorganisms, in order to illustrate the significance of the analysis in design and operation of fermentation processes.

**5.15pm**  
**Cell Growth Kinetics II**  
Frank Baganz, UCL

Other measures of fermentation performance such as yield of biomass, or product on substrate and their relative importance are discussed. Concepts of primary and secondary metabolites in relation to product formation are also reviewed. Exit gas data is a powerful tool in assessing the progress of fermentations. Concepts of oxygen uptake rate (OUR), carbon dioxide evolution rate (CER) and respiratory quotient (RQ) are reviewed, and their significance discussed.

**6.15pm**  
**Close**

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## MBI Training Agenda

**Tuesday, 1 October 2024**

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**9.30am**

**Case Study: Mass Balancing**

[Gary Lye, UCL](#)

This session follows up on the earlier lectures. Delegates work through a fermentation mass balance, results obtained are reviewed performance.

**11.15 am**

**Break**

**11.30pm**

**Introduction to Animal Cell Culture**

[Stephen Goldrick, UCL](#)

This lecture will provide an overview of the historical development of large-scale animal cell culture, and its acceptance for therapeutic and vaccine agent production. It addresses cell biology issues with emphasis on restrictions imposed by the cell itself, medium selection and development, furthermore discussing issues such as mass cultivation and mammalian cells in theory and practice, e.g. reactor type, oxygen transfer, scale-up and instrumentation and control.

**12.30pm**

**Lunch**

**1:30pm**

**Different Modes of Fermentation**

[Frank Baganz, UCL](#)

This lecture continues from day one describing other modes of fermentation such as fed-batch and continuous culture. One focus will be on different ways of operating fed-batch fermentations and industrial applications such as high cell density cultures will be discussed.

**2.30pm**

**Fermenter Productivity and Operating Economics**

[Gary Lye, UCL](#)

This lecture will introduce a framework by which different fermenters, or fermenter operating conditions, can be compared based on maximising the output of product and/or minimising product cost. The benefits of the enhancements achieved by strain and/or process improvements will be illustrated with relevant industrial examples.

**3.30pm**

**Break**

**3.45pm**

**Fermentation Bioreactors - Monitoring and Control**

[Ronan O’Kennedy, ROK Bioconsulting](#)

In this talk we will review bioreactor system components used to achieve bioreactor control and understand key controller attributes that you need to understand and can use to specify bioreactor equipment. We will review how bioreactor control is configured and approaches to optimise control. In addition we will look at attributes of SCADA data acquisition systems and consider aspects of data integrity.

**4.45pm**

**Case Study: Control of Substrate Concentration during Fed-Batch Operation**

[Frank Baganz and Joe Egan, UCL](#)

This case study focuses on designing a feeding strategy for a yeast cultivation using batch phase data and a mathematical model based on Monod kinetics.

**6.15pm**

**Close**

**7.00pm**

**Dinner**

## MBI Training Agenda

**Wednesday, 2 October 2024**

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**9.30am**

**Case Study: Microbial Media Development**

[Gary Lye, UCL](#)

Participants are guided through a case study in which differences between defined and complex

media are highlighted with reference to the areas of application.

**11.00pm**

**Break**

**11.45pm**

**Process Analytical Technology and Bioreactor Systems**

[Jonathan Welsh, AstraZeneca](#)

Process Analytical Technology (PAT) is a toolbox of methods geared to enhance process understanding and control. As we move through the product lifecycle the need shifts from process understanding to control of the critical process parameters. The focus of this lecture will be the PAT solutions we have experience of in our laboratory. There will be a description of soft sensors, spectroscopy-based systems and at-line LC-MS.

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**12.30pm**

**Lunch**

**1.30pm**

**Panel Discussion - Present and Future Fermentation Trends**

To include:

- [Jonathan Welsh, AstraZeneca](#)
- [Ronan O'Kennedy, ROK Bioconsulting](#)
- [Stephen Goldrick, UCL](#)

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**2.30pm**

**Close**

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