

ADVANCED COURSE Bioprocess Design

30 October - 3 November 2023

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AIM OF THE COURSE

With recent advances in molecular biology and a growing biomass availability for use as industrial feedstock, the bio-based economy is getting a wider range of inputs. Scaling up the bio(techno)logy innovations and implementation in large-scale factories or biorefineries clearly is a present bottleneck: industries are struggling to get the bio-opportunities to the market.

Teachers from universities and companies have joined forces and will present a program that in depth addresses industrial fermentation processes, and is flanked by overviews on upstream and downstream processing. The focus of the course is on design of innovative microbial fermentations, for bio-products such as amino acids and monomers for bio-plastics, complemented with examples of marine and mammalian processes, for micro-algae products and bio-pharmaceuticals. A substantial part (ca. 40% of the time) will be dedicated to a case study, executed in teams of 4-6 participants, on the design of a bioprocess for the production of a chemical (1,4-butanediol). In

this case, basic theory on thermodynamics, microbial stoichiometry and kinetics, transport phenomena and scale up/down will be extensively applied and integrated. The team with the best design performance wins the Genomatica Bioprocess Design prize. There are several guest lecturers from leading universities and industries in the bioprocess field, providing latest insights in technology innovations, non-conventional feedstocks and new bio-product categories, complemented with views from the industrial practice. The Advanced Course Bioprocess Design is cooperatively organised by BioTech Delft and graduate school VLAG.

COURSE DESCRIPTION

This one-week course is intensive and has long days. To ensure active participation by those attending, a combination of theoretical (lectures) and practical (exercises, case study) work is offered. Some online preparatory materials will be given to ensure all have the same basic knowledge.

LECTURES

The core lectures are mainly scheduled in the mornings and will focus on the following themes:

- Rates, thermodynamics and metabolism of micro organisms
- Transport processes in bioreactors
- Fermentation processes and their scale up features

In the early evenings, invited lectures are scheduled on e.g. examples of successful bioprocesses, downstream processing, upstream processing, novel feedstocks and economic aspects of bioprocessing.

EXERCISES AND CASE STUDY

For a better understanding of the lectures, the theory is applied in exercises on the Monday and Tuesday afternoons. From Wednesday on, the practical work continues in a 2.5 day case study on a real-life bioprocess design question where all theory will be needed. The course will be given in English.

WHO SHOULD ATTEND?

The course is primarily aimed at academic and industrial specialists (MSc, PhD or equivalent experience) who seek for refreshing and broadening their knowhow and practical insight in Bioprocess Design, to enable progress towards the biobased economy. A background in e.g. (bio)chemical engineering, microbiology or biochemistry and a basic working knowledge of the other disciplines is expected.

COURSE LEADER

Henk Noorman
DSM-Firmenich
Delft University of Technology
Delft, the Netherlands

COURSE BOARD

Sef Heijnen
Cell Systems Engineering,
Delft University of Technology
Department of Biotechnology
Delft, the Netherlands

Ruud Weusthuis
Bioprocess Engineering
Wageningen University & Research
Wageningen, the Netherlands

COURSE COORDINATION

Yvonne van Gameren
Jenifer Baptiste
BioTech Delft, Delft University of
Technology
Department of Biotechnology
Delft, the Netherlands

GUEST LECTURERS

Cindy Gerhardt
Planet B.io

Michel Eppink
Byondis BV
Nijmegen, the Netherlands and
Bioprocess Engineering
Wageningen University & Research
Wageningen, the Netherlands

Noelia Gudino
Genomatica Inc.
San Diego, CA, USA

Dirk Martens
Bioprocess Engineering
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Wageningen, the Netherlands

René Wijffels
Bioprocess Engineering
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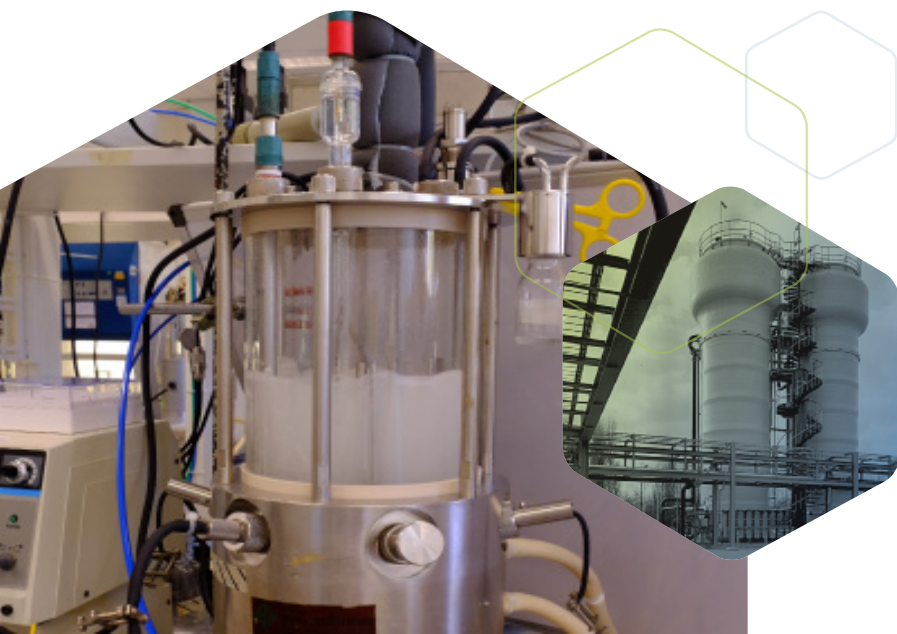
Liang Wu
DSM-Firmenich
Delft, the Netherlands

Mirjam Kabel
Wageningen University & Research
Wageningen, the Netherlands

Kirsten Steinbusch
CTO, DAB.bio
Delft, the Netherlands

CASE STUDY

Amit Deshmukh
DSM-Firmenich
Delft, the Netherlands



PROGRAM

MONDAY 30 OCTOBER 2023

- Theme: Processes: DSP, pretreatment
Micro-organisms: rates and process reaction
- 08:45** Registration
- 09:00** Introduction
Cindy Gerhardt
- 09:30** Course introduction
Henk Noorman
- 09:45** Downstream Processing
Michel Eppink
- 11:00** The process reaction for bioprocess design: a thermodynamic approach
Sef Heijnen
- 12:30** Lunch
- 13:30** Exercise: obtaining the process reaction
- 17:30** Enzyme-driven lignocellulose conversion and consequences for process design
Mirjam Kabel
- 18:35** Biotech Campus Delft tour (optional)
- 19:00** Social drink and buffet

TUESDAY 31 OCTOBER 2023

- Theme: Fermentors: design of transport
- 09:00** Gas transport
Henk Noorman
- 09:45** Heat transport
Henk Noorman
- 10:30** Mixing
Henk Noorman
- 11:30** A Game of Balances
Sef Heijnen
- 12:00** Group picture & Lunch
- 13:00** Exercise: Transport in fermentation
Sef Heijnen and Henk Noorman
- 14:30** Exercise: Transport processes
Sef Heijnen and Henk Noorman
- 16:00** Exercise: Mixing
Sef Heijnen and Henk Noorman
- 17:45** Industry lessons: fermentation with ISPR based on Liquid-Liquid extraction, novel opportunities with new reactor design
Kirsten Steinbusch
- 19:00** End of day

WEDNESDAY 1 NOVEMBER 2023

- Theme: Scale-up of fermentation processes, case study
- 09:00** Industrial microbial fermentation
Henk Noorman
- 09:45** Algal processes
Rene Wijffels
- 10:45** Introduction to the case study
Sef Heijnen, Henk Noorman and Amit Deshmukh
- 11:15** Metabolic design: example and exercise I
Ruud Weusthuis
- 12:30** Lunch
- 13:30** Animal Cell Cultivation for Production of Biopharmaceuticals
Dirk Martens
- 14:15** Metabolic design: example and exercise I
Ruud Weusthuis
- 16:00** Part 1: of the case study
- 17:15** Part 1: reporting results
- 17:30** Scale-up/scale-down approach
Henk Noorman
- 18:30** Evaluation

THURSDAY 2 NOVEMBER 2023

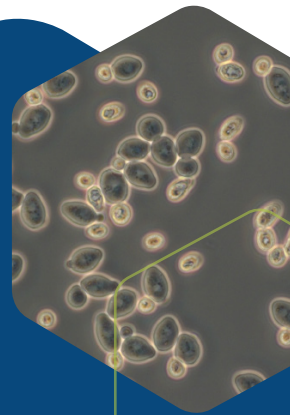
- Theme: Case study
- 09:00** Part 2: Quantification of in- and outputs (rates, composition) and fermentor broth mass
- 10:45** Multilevel engineering of microbial ethyl acetate production
Ruud Weusthuis
- 11:45** Lunch
- 13:00** Part 2: Reporting results
- 13:30** C1 fermentation feedstocks
Liang Wu
- 14:45** Part 3 of the case study
Vessel geometry and quantification of transport processes inside the fermentor
- 17:15** Part 3: Reporting results
- 19:00** Course dinner

FRIDAY 3 NOVEMBER 2023

- Theme: Case study
- 09:00** Scale-up/scale-down: characteristic times and gradients
Sef Heijnen
- 09:45** Part 4 of the case study
Full scale conditions and scale-up/scale-down
- 11:30** *Monascus ruber* as cell factory for lactic acid production at low pH
Ruud Weusthuis
- 12:30** Lunch
- 13:30** Final presentations by the design teams
Genomatica design prize
- 15:15** Keynote Lecture
Lessons from the industry: developing scalable bioprocesses
Noelia Gudino
- 16:30** Evaluation and Farewell drink

LOCATION

The course will be held at
DSM Biotechnology Center
Part of Biotech Campus Delft
Alexander Fleminglaan 1
2613 AX Delft
The Netherlands
<http://www.biotechcampusdelft.nl>



COURSE REGISTRATION

Please register via the website to attend the course. Deadline for application is 1 October 2023. Applicants will be handled in order of the date of receipt.

COURSE FEE

€ 2.500 in case of registration before 21 August 2023 or € 2.750 in case of registration after this date. In the event of cancellation before 4 September 2023, a full refund will be granted. After this date, a 25% fee charge can be made. To facilitate enrolment of young PhD-students from universities, a limited number of fellowships is available. The course fee with fellowship is € 1.250. To apply, please include a copy of your registration as a PhD-student from your university.

The fee includes course materials, lunches, the buffet on Monday and the course dinner on Thursday. The fee does not cover other meals and lodging.

When the number of participants is too low to have a fruitful course, BioTech Delft will cancel the event no later than six weeks before the start of the course. The course fee will be reimbursed within three weeks after cancellation.

In case a speaker will not be able to present his/her lecture due to unforeseen circumstances, BioTech Delft will arrange an equivalent replacement.

Hotel accommodation can be arranged at your request.

Preparatory materials will be accessible a month before the start of the course, and after receipt of the course fee.

The complete course book will be supplied at the start of the course.



BioTech Delft organises biotechnology education at postgraduate level. BioTech Delft closely cooperates with the department of Biotechnology of Delft University of Technology. Since its foundation, in 1987, BioTech Delft has very successfully organised various types of postdoctoral education.

Currently BioTech Delft offers Advanced Courses given each year, covering the multidisciplinary spectrum of biotechnology. The courses have a long track-record dating back to 1988.

- *Microbial Physiology and Fermentation Technology (1988)*
- *Downstream Processing (1989)*
- *Biocatalysis and Protein Engineering (1999)*
- *Environmental Biotechnology (1993)*
- *Bioprocess Design (2014)*
- *Modelling and Computation for Microorganisms in Bioprocesses (2018)*
- *Integrated Multi-Omics approaches for Improvement of Industrial Microbes (2020)*

FURTHER INFORMATION

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Course coordination

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Advanced
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