

# ADVANCED COURSE Bioprocess Design

16 - 20 September 2024

Henk Noorman  
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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 VLAG Graduate School.

## 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  
Wageningen University & Research  
Wageningen, the Netherlands

René Wijffels  
Bioprocess Engineering  
Wageningen University & Research  
Wageningen, the Netherlands

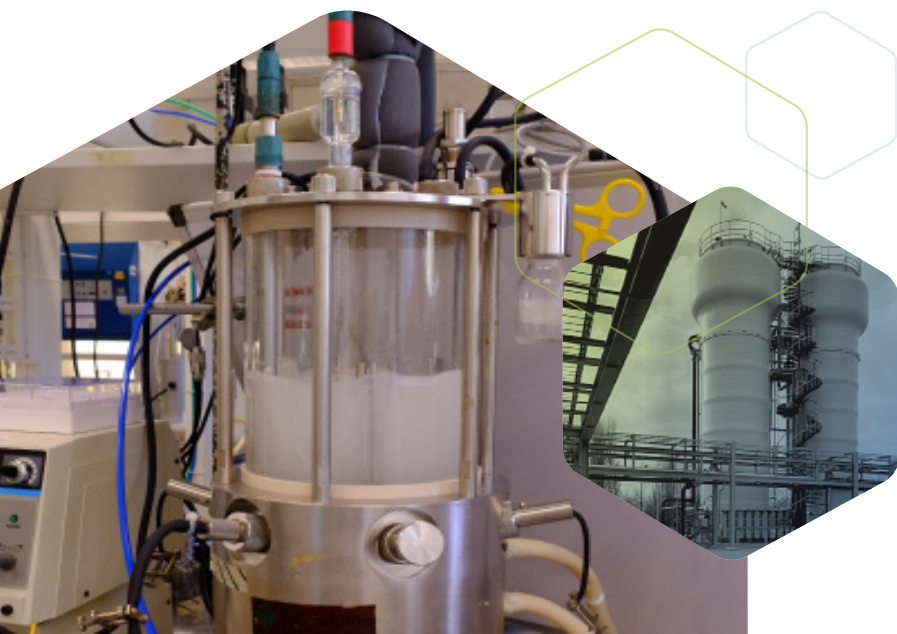
Liang Wu  
DSM-Firmenich  
Delft, the Netherlands

Mark Bisschops  
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 16 SEPTEMBER 2024

- Theme: Processes: DSP, pretreatment  
Micro-organisms: rates and process reaction
- 08:45** Registration
- 09:00** Introduction  
*Cindy Gerhardt*
- 09:25** 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** Precision fermentation  
*Mark Bisschops*
- 18:35** Biotech Campus Delft tour (optional)
- 19:00** Social drink and buffet

## TUESDAY 17 SEPTEMBER 2024

- Theme: Fermentors: design of transport
- 09:00** Brief introduction to scale effects and gas-liquid flow  
*Henk Noorman*
- 09:30** Mixing  
*Henk Noorman*
- 10:30** Gas transport  
*Henk Noorman*
- 11:30** A Game of Balances  
*Sef Heijnen*
- 12:00** Lunch
- 13:00** Exercise: Design of in- and outflows  
*Sef Heijnen and Henk Noorman*
- 14:30** Exercise: Transport processes  
*Sef Heijnen and Henk Noorman*
- 15:45** Exercise: Mixing and gradients  
*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 18 SEPTEMBER 2024

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

## THURSDAY 19 SEPTEMBER 2024

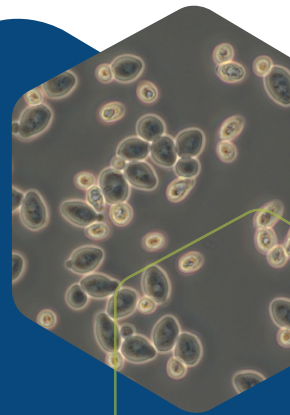
- Theme: Case study
- 09:00** Part 2: Quantification of in- and outputs (rates, composition) and fermentor broth mass
- 10:45** Multilevel engineering of microbial ethyl acetate production  
*Ruud Weusthuis*
- 11:45** Part 2: Reporting results
- 12:15** Lunch
- 13:30** C1 fermentation feedstocks  
*Liang 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 20 SEPTEMBER 2024

- Theme: Case study
- 09:00** Scale-up/scale-down: characteristic times and gradients  
*Sef Heijnen*
- 10:00** 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
- 15:30** Keynote Lecture  
Lessons from the industry: developing scalable bioprocesses  
*Noelia Gudino*
- 16:15** Geno prize
- 16:30** Closure & certification

### 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 26 August 2024. Applicants will be handled in order of the date of receipt.

## COURSE FEE

€ 2.500 in case of registration before 8 July 2024 or  
€ 2.750 in case of registration after this date. In the event of cancellation before 22 July 2024, 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

Jenifer Baptiste, BA

Course coordination

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Advanced  
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