UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Fermentations and Microbial Bioprocesses

2526-3-E0201Q060

Aims

Expected outcomes defined according to the Dublin Descriptors

Knowledge and understanding
At the end of the course, the student is expected to have:

- Learned the different techniques and process technologies in the field of fermentation processes, giving great emphasis to the conditions necessary for the development of a process that can be carried out on an industrial scale.
- Learned the methods of quantitative analysis of a fermentation process
- Learned the basics of designing a fermentation process
- Learned the correlation between the physiological and metabolic characteristics of microorganisms and the requirements of an industrial fermentation process.

Applying knowledge and understanding
At the end of the course the student will be able to:

- Characterize a fermentation process from a quantitative point of view and will be able to define which data are necessary to allow an appropriate and complete evaluation of a process
- Outline the design of a fermentation process based on the physiological and metabolic characteristics of microorganisms and on the requirements of an industrial fermentation process.
- Analyze, apply and integrate the knowledge acquired with what will be learned in other courses related to the production of products in the biotechnology industry.

Making judgments
At the end of the course the student is expected to be able to:

- evaluate the essential requirements for the implementation of a fermentation process
- define the quantitative parameters that are necessary to obtain from the analysis of a fermentation process,

to evaluate the performance of the process.

These skills will be made possible thanks to the support of theoretical lessons with practical exercises carried out independently in the presence of the teacher. These exercises are designed to encourage a critical analysis of the results and of the ways of applying the theoretical notions learned.

Communication skills
At the end of the course, the student is expected to be able to communicate the notions learned with proper language and to rigorously describe the characteristics of a fermentation process.
This ability will be encouraged by the teacher during the theoretical lessons, promoting the intervention of the students.

Learning skills
At the end of the course, the student will be able to read and understand appropriately scientific literature in which microbial fermentation processes are described and quantitatively analyzed.
This ability will be promoted during the theoretical lessons in which some case studies are described thanks to the support of scientific literature.

Contents

The course will focus on the following topics:

- Fundamental requirements for the implementation of an industrial scale fermentation process
- Crucial elements for planning a production process
- Practical bioreactor technology and schemes of bioreactors for biological processes
- Elements and methods of control of bioreactors
- Kinetics of microbial growth and production
- Different fermentation modes (e.g., Batch, Continuous cultures and Fed-Batch)
- Quantitative analysis of processes: productivity, yields and mass balances
- Case Studies: examples of industrial fermentation processes (including problem solving cases)

Detailed program

- Fundamental requirements for the implementation of an industrial-scale fermentation process
  Production media, fermentation methods, waste treatment, process productivity
- Crucial elements for planning a production process
  Definition of the "dead times" of a production process and their consideration in the process planning phase
- Elements of bioreactoristics and schemes of bioreactors for biological processes
  Types of bioreactor: bubble column, air lift, stirred tank.
  Focus on stirred tanks: different types of stirrers; oxygen transfer rate (OTR);
- Elements and methods of control of bioreactors
  Definition of measured, determined and calculated parameters
  Probes for process monitoring
  Methods and modes of process control
- Kinetics of growth and microbial production
  Definition and quantitative analysis of lag phase, exponential phase and stationary phase
  Specific growth rate
  Monod's law and relationship with the fermentation process
- Different fermentation modes (e.g, Batch, Continuous cultures and Fed-Batch)

Definition of the different fermentation modes
Analysis of the differences between the different fermentation modes
Application of the different fermentation modes

- Quantitative analysis of processes: productivity, yields and mass balances
  The different types of processes (batch, continuous culture, fed-batch) are quantitatively characterized by:
  - Calculation of productivity
  - Calculation of yields
  - Mass balances (including degree od reduction balance)
- Case Studies: examples of industrial fermentation processes (including * problem solving * cases)
  Some case studies highlighting the correlation between the physiological / metabolic features of a microorganism and the process characteristics will be presented (e.g. production of citric acid, production of lysine)

Prerequisites

- Background: Basics of biochemistry and Industrial Microbiology.
- Specific prerequisites: Industrial Microbiology.
- General prerequisites: Students can take the exams of the third year after having passed all the exams of the first year of the course.

Teaching form

The teaching activities will be in the form of **frontal lessons** in person, for a total of **56 hours** (28 lessons of 2 hours each).

Kessons will be delivered with different modes, in particular:

- 42 to 44 hours of lectures will be carried out in delivery mode (Delivery Teaching) focused on the presentation-illustration of contents, concepts and scientific principles.
- 10 hours will be dedicated to practical exercises. Exercises will take place in interactive mode (Interactive Teaching) in the classroom, where students can work in group or alone in the presence of the teacher that can guide and support the students. A collective general discussion is always included.
- 6 to 8 hours of teaching will involve external teachers (experts active in the Academy or in Industy) who will carry out thematic lessons on specific topics relevant to the teaching contents. The responsible teacher will be actively present during these lectures.

Teaching is held in Italian and the support material for the lessons (slides and reference and in-depth material) will be predominantly in English.

Lectures will be recorded and made available to the students via the e-learning page of the course.

Textbook and teaching resource

Learning material will be available at the e-learning web page of the course.

The **main reference book** is:

Bioprocess Engineering Principles
Pauline M. Doran
Academic Press Limited
ISBN: 0-12-388461-6

Other reference books used as reference for specific lectures are:

1. Biochemical Engineering
A Textbook for Engineers, Chemists and Biologists
Second, Completely Revised and Enlarged Edition
2015 Wiley-VCH Verlag GmbH & Co.
KGaA, Boschstr. 12, 69469 Weinheim, Germany
Print ISBN: 978-3-527**-33804-7; ePDF ISBN: 978-3-527-68499-1; ePub ISBN: 978-3-527-68501-1

2. Bioreaction Engineering
Principles
John Villadsen, Jens Nielsen, Gunnar Lidèn
Third Edition
Springer New York Dordrecht Heidelberg London
ISBN 978-1-4419-9687-9 e-ISBN 978-1-4419-9688-6
DOI 10.1007/978-1-4419-9688-6

3. Practical fermentation Technology
Edited by Brian McNeil and Linda M. Harvey
2008 John Wiley & Sons, Ltd.
ISBN: 978-0-470-01434-9

Semester

Second semester

Assessment method

The learning will be assessed through the mode: Written test + optional oral test.

In particular, the written test consists of calculation exercises for the analysis of fermentation processes and open questions in which you are asked to explain some of the notions exposed and explained during the lessons.
Usually, the test consists of 2 exercises and 2 open questions
The maximum score that can be obtained from each answer is explained in the text of the written test.

The student who obtained a grade of at least 16/30 in the written test may request to take the oral test.

Office hours

On demand

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION