UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Biotechnological Processes and Biorefineries

**2526-3-E0201Q079**

## Aims

Microbial processes constitutes one of the key elements in the occurring turnabout from linear to circular economy, and more precisely they are of pivotal importance in all the aspects of Circular Bioeconomy. This is mainly due to the increasing knowledge and awareness of the role of microorganisms on our living planet: they are responsible of the dynamic balance between organic and inorganic state of the chemical elements essential for life, and the products of one microbial transformation become the potential substrates for other processes. This principle, together with the awareness that the overshoot day (that is the day in which an entire year's worth of natural resources is consumed) is anticipating every year since 1972, converges in the willing to develop microbial processes that can be viable, economically competitive and sustainable. The course aims to provide students with the basic knowledge necessary to understand the key elements of a microbial process, giving them the possibility to develop a critical and personal view fundamental for being actor of the occurring industrial transition.

Knowledge and understanding
The student will gain knowledge and the principles of bio-based processes, biorefinery, different generations, key steps of a bioprocess together with prs and cons and criticisms

Applying knowledge and understanding
The student will be able to apply the acquired knowledge to evaluate when and how to develop a bioprocess. The teaching activity, especially in its DI mode, as well as the open discussions are preparatory to this learning.

Making judgements
The student will be able to process the acquired knowledge towards the application of bioprocesses in industrially relevant conditions.

Communication skills
Use of an appropriate scientific/chemical vocabulary and ability in oral reports

Learning skills
Skills in literature reading and understanding, skills in the elaboration of interconnections among the

course-related knowledge and other subjects related to industrial bio-based microbial processes and biorefineries.

## Contents

The course shed lights on the basic knowledge necessary to understand the different fields of application of Industrial biotechnology. This implies to deeper investigate concepts as bioprospecting but at the same time to increase the competence in the knowledge of the infrastructures of an industrial (bio)process, from upstream to downstream, including the description of industrial media and substrates. In this logic, one of the key enabling technology of this groundbreaking field is the biorefinery, where residual biomasses not interfering with the food supply chain are valorized into a diverse array of products. This concept will be presented and several examples of ancient and modern processes related (directly or indirectly) to this approach will be examined. The students will learn which are the feedstoks used in industrial bioprocesses as well as which are the steps of the downstream processes and starting from that we will go through a series of bioprocesses that are more complex and technologically advanced, and more and more pose ethical issues as well as offer solutions to the increasing demands for goods and services.
The following topics will be addressed:
1. Biotechnological processes.
2. The concept of Biorefinery.
3. Feedstocks and substrates.
4. Downstream processes.
5. Production of microbial biomass.
6. Production of biofuels.
7. Food and beverages.
8. Single Cell protein & Precision Fermentation.
9. Production of chemical platforms.
10. Enzymes and microbial conversions.
11. Waste water treatment and biogas production.
12. Screening.
13. Life cycle assessment.

## Detailed program

1. Biotechnological processes. Brief historical overview on the concepts of biotechnology, and how they apply to ancient and modern productions. Overview of the different stages of a bioprocess.
2. The concept of Biorefinery. Depiction of principles, implications, technologies and connection with the territory. The different generations of biomasses will be also presented.
3. Feedstocks and substrates. Which are the substrates mainly used in industrial bioprocesses? Which can be considered for the future? Pros, cons and economical evaluation.
4. Downstream processes. Principles for separation and purification of the products of interest, starting from the moment in which the upstream process is over. Instruments and techniques
5. Production of microbial biomass. Bakers' yeast. Single cell proteins. Depiction of the processes of production, from the preparation of the media to the formulation of the selling product
6. Production of biofuels. Explanation of the different classes (ethanol, butanol, biodiesel, etc) and generations (first, second, third) of biofuels that can be produced by microbial fermentation and depiction of running processes.
7. Food and beverages. Importance of microbial fermentations in the field, and examples of fundamental processes. Case study: beer production.
8. Single cell protein & Precision fermentation. Case study & sustainability.
9. Production of chemical platforms.
10. Enzymes and microbial conversions. How enzymes can be produced and how their development is pivotal for

many different industrial bioprocesses, as for semisynthetic antibiotics
11. Waste water treatment and biogas production. Explanation of principles, techniques and possible filed for improvement
12. Screening. General principles and case studies that can exemplify the potential of screening protocols to unveil biodiversity
13. Life cycle assessment. Principles and examples

## Prerequisites

Background: basic knowledge in general, organic and biochemistry, and 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

Lessons will be held in presence, through the projection of slides, videos, shared exercises, issues discussed in working groups.
In particular, the course will be composed of 42 hours of face-to-face lessons delivered in 21 lessons of 2 hours consisting of

- a part (approximately 2/3 of the lectures, 28 hours) in delivery mode (delivery teaching, DE) focused on the presentation-illustration of contents, concepts, scientific principles, but within which there are never lacking moments of interactive teaching determined by extemporaneous questions addressed to the trainees or by requests for clarifications. In particular, the lecturer tends to encourage questions that may allow the creation of interdisciplinary insights.
- a part in interactive mode (interactive teaching, DI, approximately 1/3 of the lessons, 14 hours), involving
  a) 1 flipped class exercise based on the central concept of the course, the biorefinery. The exercise will be fully explained in the classroom, does not involve in-depth study but an understanding of the contants of the lectures given and group work in which the presentation of a case study must be limited to a predetermined number of slides and given time, answering guided questions. A chair is identified from among the trainees, who keeps time for the presentations and moderates the questions that the rest of the trainees are invited to ask. The case studies, suitably corrected if necessary, are also made available among the course material. This exercise is very important for the acquisition of competence, which is then verified in the final examination.
  b) At least one lecture will be carried out with the participation of an external guest lecturer, working in a biotechnology company, in most cases in person. This allows the trainees to verify the need in the area for people capable of working in the field of biotechnological innovation and, if necessary, to ask questions regarding their future professional profile.

The course is taught in Italian.

## Textbook and teaching resource

Learning material (slides of the lessons, suggested websites and recommended publications) is available at the e-learning web page of the course, together with recorded lessons

Recommended textbooks:
- Biotecnologie Microbiche (Donadio, Marino Casa Editrice AMBROSIANA)
- Microbiologia Industriale (Manzoni, Casa Editrice AMBROSIANA)
- Industrial Microbiology: An Introduction (Waites, Morgan, Rockey, Higton, Blackwell Science)
- Biorefineries: Industrial Processes and Products (Kamm, Gruber, Kamm Casa Editrice: Wiley-VCH)
- Encyclopedia of Bioprocess Technology (Flickinger, Drew Casa Editrice: Wiley Interscience)
- Brock – Biologia dei Microrganismi (Madigan, Martinko, Stahl, Clark – Casa Editrice PEARSON)

## Semester

First semester

## Assessment method

The knowledge acquired will be tested by means of an oral examination. During the test, the student will have to present a scientific article chosen from a group of articles suggested as an extension of the lectures given, presenting it in the context of the research and illustrating the objectives and main findings. Some results will be taken as a starting point for further study. Following this, more specific questions, requiring concise but comprehensive answers, complete the examination.

## Office hours

Contact: on demand, upon request by mail to lecturer or inperson, before or after the lesson.

## Sustainable Development Goals

ZERO HUNGER | CLEAN WATER AND SANITATION | AFFORDABLE AND CLEAN ENERGY | DECENT WORK AND ECONOMIC GROWTH | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION | PARTNERSHIPS FOR THE GOALS