UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Metabolic Engineering and Bioprocesses of New Generation

2122-1-F0802Q058

Aims

The course aims to introduce and develop topics and problems related to microbial biotechnologies: they will be taken into potential or realized industrial applications that are based on the use of microorganisms and will highlight the role of these processes in different sectors of the circular bioeconomy. In particular, the principles and tools of metabolic engineering will be explained, as well as those of synthetic biology, for obtaining advanced cell factories or synthetic communities that can not only lead to the development of bioprocesses, but also to their quantitative control.

Knowledge and understanding
At the end of the course, the student will have to be able to evaluate the basic principles necessary for the development of industrial processes based on recombinant microorganisms. The course therefore aims to provide the tools to study the molecular and metabolic aspects that limit current yields, productions and productivities so that interventions can be planned to develop new generation bioprocesses that lead to a decarbonisation of current productions. It therefore includes the design of microbial strains of industrial interest, the creation of synthetic communities, the development of molecular circuits, biosensors, reprogramming systems, all aimed at improving cell factories. The student will be able to develop comparative analyses of the characteristics of different cell factories for the various advanced productions of the biotechnological industry in different fields such as food, pharmacology and health, in the production of fine chemicals, but also for processes for the protection of environment and energy recovery (Circular Bioeconomy).

Applying knowledge and understanding
At the end of the course the student must be able to apply the acquired knowledge to biosynthetic methodologies for industrial processes. In particular, it will be taught how to apply the iterative principle of DESIGN-BUILD-TEST-LEARN which underlies microbial biotechnology in all its different applications, and which encompasses the many disciplines that contribute to its growing success.

Making judgements

The student must be able to personalise what has been learned and be able to recognize the processes and problems in which the methodologies of industrial microbiology and fermentations can be used.

Communication skills

At the end of the course the student will be able to express himself appropriately in the description of the topics addressed, in the definition of the pertinent terminology, with properties of language and consciousness in exposure.

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

Research related to the development of recombinant microorganisms or synthetic consortia for the production of:

1. Primary metabolites, including alcohols, including biofuels, and organic acids

2. Secondary metabolites, including vitamins, flavors, nutraceuticals

The issues relating to the valorisation of residual biomass will also be examined, according to the concept of biorefinery:

3. Metabolic engineering, cellular rewiring and adaptive laboratory evolution for the development of robust strains

4. Synthetic biology for the use of complex substrates and for the production of complex products

Detailed program

The course aims to provide the tools to be able to study the physiological, molecular and metabolic aspects that limit current yields and productions so that interventions can be planned to develop new generation bioprocesses, according to the iterative cycle of Design-Build-Test -Learn. The course is therefore well suited to connect with various other teachings from which it is possible to draw methodologies and concepts.

In particular, the following topics will be explored:

1. Metabolism, metabolic engineering and synthetic biology (including genome editing applications through classical and derived CRISPR-Cas technologies, artificial metabolosomes, membrane engineering, with focus on transporters, biosensors and riboswitches)

2. Development of recombinant microorganisms and synthetic consortia for the production of primary and secondary metabolites: general concepts and case studies

3. Examples of Biorefineries based on microbial cell factories for the use of second, third and fourth generation biomass, with reference to the concept of sustainability and life cycle assessment, with reference to the strategies

indicated in the Green Deal and outlined in the Sustainable Development Goals of the agenda UN 2030

Prerequisites

Knowledge of biochemistry, industrial microbiology, molecular and genetic biology, bioreactoristic techniques and technologies. Prerequisites: none

Teaching form

Lectures supported by PowerPoint presentations and blackboard insights. The methodological approach involves a reconstruction of the logical process that guided the experimentation and that led to the understanding of the mechanisms underlying the bioprocesses and the progress deriving from direct and reverse metabolic engineering techniques, as well as synthetic biology. The work is carried out by alternating lessons with group work led by the teacher, as well as the consequent exhibitions and dialectics.

Teaching language: 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.

Semester

Second semester

Assessment method

The assessment of the knowledge learned will be carried out by an oral exam at the end of the course. During the exam, the student will have to present one scientific article, among a number that are suggested for each year course, to answer to one open question to articulate giving a complete picture of the requested subject, from general to specific aspects. Finally, few specific questions will be also asked.

Office hours

Contact: on demand, upon request by mail to lecturer or during the lecture.