UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Metabolic Engineering and Bioprocesses of New Generation

2627-1-F0803Q058

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 (mentioning only those in synthetic biology, which are the subject of a dedicated course), for obtaining advanced cell factories 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, 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. This ability will be acquired thanks to the alternation of DE and DI during the course.

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

PART 1: METODOLOGIES
Pathway Design
Strain development and evolution

PART 2: APPLICATIONS AND EXAMPLES
The second part contains insightful descriptions of the practical applications of metabolic engineering, including specific examples that shed light on the topics within.

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 next-generation bioprocesses according to the iterative cycle of Design-Build-Test-Learn. The course therefore lends itself well to linking up with various other teachings from which methodologies and notions can be drawn.
In particular, the following topics will be explored:

1. Difference between genetic engineering and metabolic engineering; relationship between metabolic engineering, synthetic and systems biology; process stress: robustness and tolerance;
2. Development of recombinant microorganisms for the production of primary and secondary metabolites: general concepts and *case studies*;
3. Examples of Biomanufacturing 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 UN 2030 agenda

Prerequisites

Knowledge of biochemistry, industrial microbiology, molecular and genetic biology, bioreactoristic techniques and technologies.

Teaching form

The course will consist of 42 hours of face-to-face lectures delivered in 21 2-hour lessons consisting of:

- a part (about 2/3 of the lessons, about 28 hours) in delivery mode (delivery didactics, DE) focused on the presentation-illustration of contents, concepts, scientific principles
- a part in interactive mode (interactive didactics, DI, about 1/3 of the lessons, about 14 hours), which includes integrative didactic exchanges with students, aimed at familiarising with the concepts used in the reference works. DI lectures will be interspersed with DE lectures: with the concepts exposed, the trainees will be asked to make working hypotheses, and once the hypotheses have been clarified, experimental results will be shown and together they will be examined, in order to understand the results obtained and the implications.
  This continuous exchange is preparatory to the acquisition of skills, which is then verified in the final examination.
  At least one lecture will be given with the participation of an external guest, a leading figure in metabolic engineering, if possible in presence or alternatively with the guest connected remotely.
- The slides are produced in English, the course can be delivered in English on request.

Textbook and teaching resource

Lecture slides and recordings of lectures.
Supporting material such as articles and in-depth reviews, to be used both for study and examination preparation.

Semester

Second semester

Assessment method

The assessment of the knowledge learned will be carried out at the end of the course by an oral exam, but in case you need to reason about certain concepts by making diagrams, pen and paper will be available;
It will start from one of the examples illustrated and examined in interactive and participative mode in the classroom (remember to study the reference articles of the examples examined): the article will be of the candidate's choice;
Links to the methodology part (first part of the course) will be asked;
You will be asked, using the skills acquired, to propose approaches to investigate topics relating to metabolic engineering in the context of advanced biotechnological processes

In conclusion, the final exam consists of a single oral exam at the end of the course, with a score between 18-30 / 30 cum laude, which comprises the discussion of various topics covered in the course, with an emphasis also on the connections between concepts and processes, such as to arrive at a critical evaluation..
The final score will be between 18/30 and 30/30 cum laude, based on the overall assessment considering the following criteria:
(1) knowledge and understanding;
(2) ability to connect different concepts;
(3) autonomy of analysis and judgment;
(4) ability to correctly use scientific language

Office hours

Contact: by appointment, by e-mail to the lecturer, or in person, in class.

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION | PARTNERSHIPS FOR THE GOALS