UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Synthetic Biology for Microbial Biotechnology

2627-1-F0803Q083

Aims

The educational objective of the course is to introduce the student to the topics and provide the general principles of synthetic biology, as well as a series of basic methodological tools that can be applied in order to redesign and produce (Synthetic Biology) biological systems (e.g. genetic circuits based on DNA or RNA) already present in nature or to design and manufacture biological components and systems that do not yet exist, for biotechnological applications in the field of industrial microbiology and in particular of *Biomanufacturing*.

The **predominant practical part** , which will take place in the laboratory (IT lab and molecular biology lab) aims at generating at least one system deriving from the application of synthetic biology tools.
Furthermore, the students will be introduced to the planning of experiments, management and use of laboratory instruments and analysis of the results obtained during the lab work.

Knowledge and understanding
On completion of the course, the student should be able to:

- account for central methods and tools in synthetic biology;
- plan and carry out basic experiments in synthetic biology using a safe and scientifically based way of working;
- in writing and orally present and explain the planned and completed experiments and methods of the course.

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

Autonomy of judgement.
The student must be able to process what he/she has learned and be able to recognise the processes and

problems in which synthetic biology methodologies can accelerate, enable and enhance microbial bioprocesses. This is possible thanks to the extensive practical part in which, alongside theoretical knowledge, experiments also help to acquire practical skills.

Communication skills.
At the end of the teaching the student will be able to express himself appropriately in the description of the topics dealt with, in the definition of the relevant terminology, with properties of language and confidence in exposition.

Learning ability
At the end of the teaching the student will be able to consult the literature on the topics dealt with and will be able to analyse, apply, integrate and connect the knowledge acquired with what will be learnt in subjects related to the production of chemical products of commodity interest in the biotechnology industry.

Contents

The basic principles of Synthetic Biology are: (i) the use of standardised and well characterised building blocks, (ii) the hierarchical design of nature-inspired, artificial genetic circuits and proteins in silico, and (iii) the use of chemically synthesized DNA sequences not found in nature.
During lectures the students will learn the basic technologies to build genetically modified microorganism(s) and how to design and analyze synthetic biology systems for bioproductions.
During the practical laboratory experience, the students will design with informatics tools the genetic material and the genetic modifications that will be introduced in a selected GRAS microorganism during the wet-lab sessions. In addition, the novel functions of the generated microorganism(s) will be analysed by setting up cultures in flasks and/or controlled bioreactors, which will be followed by the most suitable analytical techniques to describe quantitatively and qualitatively the results obtained, and allow a critical and comparative analysis.

Detailed program

Lessons in class
About Synthetic Biology and its application in the field of Biomanufacturing with microorganisms
Quick review of relevant cellular processes
DNA Assembly, genome editing and whole genome engineering (modular cloning and CRISPR-Cas)
Parts and composition I: What are parts and how do they connect?
Parts and Composition II: Gene expression and regulation, Toggle Switch, Oscillators
RNA Devices
Biological synthesis of novel compunds: "*new to biochemistry*"
Practical lessons
Design of engineering systems for GRAS yeasts using bioinformatics tools and Golden Gate as modular cloning system;
Construction of engineered bacterial and of yeast strains, those with the CRISPR-Cas based precision editing;
Primary testing of the resulting transformants;
Production processes on engineered strains;
Data analysis *in intinere* and at completion: discussion, comparison, hypotheses for redesign

Prerequisites

Basic knowledge in molecular biology, genetics and industrial microbiology.

Teaching form

The course will be largely practical.

In particular, the course will consist of **14 hours of frontal lessons** in which the fundamental concepts and tools of synthetic biology will be introduced and explained and of **40 hours of practical activity** in the laboratory in which some tools of synthetic biology will be applied and the results will be analyzed on microbial cultures.
The 14 lesson hours are delivered in 7 two-hour lessons consisting of:

- a part in delivery mode (delivery didactics, DE, 10 hours) focused on the presentation-illustration of contents, concepts, scientific principles
- a part in interactive mode (interactive didactics, DI, 4 hours), which provides supplementary didactic interventions of exchanges with trainees, preliminary and preparatory explanations for experimental exercises aimed at familiarising the trainees with the computer tools subsequently used.
- The slides are produced in English, the course is delivered in English on request.

The 40 laboratory hours are carried out in interactive mode (interactive teaching, DI), which envisages a continuous exchange among peers and with the teacher of reference and any tutors. The interactive mode is intended both as a practical guide in the execution of the experimental procedures, and as requests for in-depth studies and questions from the lecturer that allow the student to reflect on the implications of the experiments being carried out and on future plans. This work is preparatory to the acquisition of skills, which are then verified in the final examination.
Attendance at laboratory hours is compulsory.

Textbook and teaching resource

Lecture slides and recordings of lectures (the slides also contain links to background articles, which are accessible to students either because they are open access publications or because they are included in the academic certificate);
Protocols for the experiments to be carried out in the laboratory;
Supporting material such as articles and in-depth reviews, to be used both for study and examination preparation.

Semester

First semester

Assessment method

The proactive and responsible participation in the laboratory sessions is rquired to achieve a positive assessment.
Students are required to write a written report consisting of the design and analysis of a new biological system planned on the basis of what was acquired in the lectures and in the laboratory, and hypothetically realised and

analysed qualitatively and quantitatively. This activity is to be considered preferably as a group work, which will be handed in to the lecturers one week before the examination, and will be presented and assessed during an oral examination session in which there will also be questions for clarification and in-depth study. Each member of the group will present one part of the work, as agreed in the group, but in-depth questions may be asked of each group member on any part of the project. Each member of the group will still be asked questions, so that an individual judgement can be made.

Office hours

By appointment

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION