UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Systems Biochemistry

2526-1-F0803Q069

Aims

Tackling the study of the cell as a complex system, whose understanding requires a multidisciplinary approach in which biochemistry and cellular and molecular biology techniques are integrated by bio-informatics and computational simulation of mathematical models.

This approach allows to address the fundamental biological processes in integrated terms, providing the researcher with tools, not only to test the acquired knowledge with quantitative rigor, but also to modify the behavior of the cellular systems under study, for example for:

(i)identify, develop and engineer microorganisms capable of carrying out innovative and eco-friendly biotechnological biotransformations;

(ii) develop in silico replicas of single individuals (Digital Twins) and identify the most suitable personalized drug treatment for each single patient

The course allows to integrate and put in the appropriate biotechnological context, many of the concepts illustrated in the bioinformatics courses offered in the master's degree in Industrial Biotechnology

1. Knowledge and understanding. At the end of the course the student must know the possibilities offered by the integration of computational an experimental technologies (including post-genomic approaches) both in the context of basic research and in their application in diagnostic and therapeutic fields or in innovative biotechnological biotransformations.

2. Applying knowledge and understanding. At the end of the course the student must be able to apply the knowledge acquired in point 1 to scientific, methodological and application problems different from those explicitly dealt with in class

3. Making judgment. The student must be able to rework the principles and methodologies learned, firstly to consult the literature so as to update his/her skills before they become obsolete and secondly to identify the privileged

areas of use. The student will have an immediate and direct way to apply the concepts learned to case studies and oral scientific articles that he/she will have to present to the other students in the form of a Journal Club, as discussed in greater detail in the chapter on the teaching method
4. Communication skills. At the end of the course the student will be able to express himself appropriately in Italian (for students of Italian mother tongue) and English (for all students) in the description of the topics addressed with proper language.

5. Learning skills At the end of the course the student will be able to analyze, apply, integrate and connect the knowledge acquired –in the lectures and subsequently gained through the consultation of the literature - with what he/she has learned in related teachings, in order to solve scientific problems both in basic and applied biochemistry.

Contents

The functionality of (macro) biological molecules will be analyzed in the context of the interaction between molecules. Some cellular regulatory circuits (for instance transcriptional and metabolic networks, growth and cell cycle) will be examined in order to highlight some key characteristics of cellular regulatory circuits, in cognitive and applicative terms. Most topics will be analyzed through multidisciplinary analysis of specific case studies. One or more of the case studies will also be anlyzed in the course Analisi Qualitativa e Quantitativa dei Sistemi Biologici with a complementary computational, modeling, bioformatic and systemic perspective

Detailed program

The program will be agreed upon and can be partially modified according to the students' interests.
I. Systems Biology; Introduction and basic concepts
The concept of system: emerging properties
Top-down and bottom-up approaches to computational reconstruction od biological system
Biological networks and their properties (Robustness, fragility, essentiality)

II. Systems metabolomics as a paradigm and interpretative key of cell behaviors

III. The concept of module: modular reconstruction and interconnection of mathematical models with different resolution to comprehensively and integratively reconstruct all functions of a cell

IV. Disassemble and reconstruct inter-cellular complexity: scRNASeq and quantitative high processivity image analysis

V. Biotransformations, circular economy and green economy also in the context of sustainable and circular production chains

VI. Multifactorial diseases: advanced cellular models and Digital Twins

Prerequisites

The course is based on concepts and methodologies exposed in the basic Biochemistry and Molecular Biology courses. In particular, knowledge of the basic elements of prokaryotic and eukaryotic cell biochemistry

(metabolism, signal transduction and cell cycle) and enzymology is required. Some basic statistical knowledge is appreciated

Teaching form

21 2-hour lessons consisting of:

- one part (6-8 lessons) in delivery mode (delivery teaching, DE) focused on the presentation-illustration of contents, concepts, scientific principles
- the remaining part - maximum 15 lessons - in interactive mode (interactive teaching, DI), which includes:
    - Interactive discussion of scientific articles by the students;
    - presentation of scientific articles in a manner similar to the presentation of data at a scientific congress (oral report = journal Club or Poster);
        - 1 CFU (7 hours of lessons) carried out in interactive mode in co-presence with the teacher of Analisi Qualitativa e Quantitativa di Sistemi Biologici (Prof. Pasquale Palumbo) and with Prof. Damiani to deal with a case study together. This educational approach will allow the presentation and examination of biological pathways, functions and systems from complementary points of view, seen with the eye of the biologist and the computational modeller.
- All activities are conveyed by means of face-to-face lectures

Language: Italian, can be changed to English upon request of foreign students

Textbook and teaching resource

Basic concepts of System Biology are presentyed in :
Lilia Alberghina: Per Comprendere la Complessità Biologica – Licosia Editore
Original research, review articles and book chapters will be suggested in class
Video recordings of each lesson, slides and papers discussed in the classroom will be provided

Semester

Second semester

Assessment method

There are no exams in itinere; The exam is oral and will verify the acquisition of the basic concepts of systems

biology and their application, with particular attention to the integration of computational and experimental tools, also through in-depth discussion of specific articles chosen in agreement with the students before the exam

Office hours

By telephone or e-mail appointment

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | RESPONSIBLE CONSUMPTION AND PRODUCTION