UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Systems Biochemistry

2122-1-F0802Q069

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

1. Knowledge and understanding. At the end of the course the student must know: the main post-genomic analysis techniques; the basic concepts of mathematical simulation of complex biological systems; the possibilities offered by the above-mentioned experimental and computational technologies - and their systemic integration - 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 re-elaborate the principles and methodologies learned, firstly to analysis of the literature, in order to update his / her skills before they become obsolete, and secondly to identify the privileged areas of use.

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 course aims to illustrate some aspects related to the study, analysis, modeling and reconstruction in silico of complex biological systems. The functionality of (macro) biological molecules will be analyzed in the context of the interaction between molecules. Some cellular regulatory circuits will be examined in order to highlight some key characteristics of cellular regulatory circuits, such as robustness and the role that their in silico reconstruction can have in cognitive and applicative terms.

Detailed program

I. Systems Biology; Introduction and basic concepts (2 lessons).

The concept of system: emerging properties

The concept of module

Top-down and bottom-up approaches to computational reconstruction od biological system

Biological networks and their properties (Robustness, fragility, essentiality)

II. Mathematical models of biological systems for non-experts (2 lessons)

how can mathematical modeling help understanding the logic of life?

III. Systems metabolomics as a paradigm and interpretative key of cell behaviors (3 lessons)

IV. Whole cell modeling (3 lessons): modular reconstruction and interconnection of mathematical models with different resolution to comprehensively and integratively reconstruct all functions of a cell

V. Disassemble and reconstruct inter-cellular complexity: scRNASeq and quantitative high processivity image analysis with (3 lessons)

VI. Biotransformations, circular economy and green economy (5 lessons)

VII. Connecting biological reality and the virtual world: Digital Twins and advanced wearable sensors (3 lessons)

The number of lessons for each topic is indicative and could be modulated according to the interests of the

students

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

Lectures, classroom demonstrations of software for analysis of construction of mathematical models, Journal club and in-depth interactive analysis of selected scientific papewrs

Textbook and teaching resource

Original research, review articles and book chapters will be suggested in class and uploaded in the e-learning platform of the course

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 e-mail appointment