UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Structural Biotechnology

2627-1-F0803Q080

Aims

The course aims to deepen the structural characteristics of biological macromolecules (proteins and nucleic acids), to present the main biophysical methodologies adopted for their investigation, and to introduce some applications in different biotechnological fields. Particular emphasis will be placed on the integration of structural information obtainable with the different approaches, and on the functional implications that these properties have in systems with different levels of complexity.

Knowledge and understanding skills
At the end of the course, the student will know the main techniques used for the structural study of macromolecules, the principles on which they are based and the information they can provide on the systems being studied. He will also be able to identify the structural determinants underlying particular biological functions and interpret the effects deriving from their alteration (mutations, interactions with ligands, environmental effects, etc.).

Ability to apply knowledge and understanding
At the end of the course, the student will be able to interpret the experimental results deriving from the methodologies addressed during the course, obtaining structural information on the macromolecules under analysis and functional implications deriving from these results. He will also be able to evaluate the consequences of these properties in various application fields (medical / pathological, drug design & delivery, protein engineering for industrial purposes, etc.).

Making judgments
At the end of the course, the student will be able to choose the most suitable methodological approaches to determine and modify specific structural properties of macromolecules, and to integrate results deriving from multiple techniques to obtain more complete information. He will also be able to critically judge the results presented in scientific publications on these topics. These skills will be acquired by guided practical tutorials during the lessons.

Communication skills
At the end of the course, the student will be able to expose the structural properties of macromolecules with

suitable terminology, as well as to communicate the concepts learned on investigation methodologies with appropriate scientific language, and to report the content of scientific articles. He will also be able to discuss in an effective and in-depth way complex issues related to the topics covered, even in application areas other than those addressed in the course.

Learning skills
At the end of the course, the student will have the knowledge and tools necessary to be able to autonomously extend the notions acquired during the course to the treatment of problems similar to those faced, such as the use of more advanced strategies for structural investigation or their application in more complex contexts (*e.g.* structural "omics" techniques).

Contents

- Structural features of biological macromolecules
- Experimental methods for the determination of a structural model
- Dynamic properties of biological macromolecules
- Macromolecular interactions and non-covalent complexes
- Outline of integrated structural biology methods
- Applications in industrial biotechnology

Detailed program

- *Elements of structural biology*. Structural levels and motifs of macromolecules, domains. Structural databases and classifications.
- *Methods for high-resolution determination of the three-dimensional structure*. X-ray crystallography: diffraction theory, data acquisition, phase problem, model construction and validation. Cryo-electron microscopy: electron-biosample interaction, vitrification, radiation damage, single-particle analysis, tomography. NMR spectroscopy: theoretical aspects, 1D, 2D and 3D spectra for the resolution of protein structures, solid state NMR.
- *Low-resolution experimental methods*. Small-angle scattering of X-rays (SAXS) and neutrons (SANS). Conformational properties by native mass spectrometry and ion mobility. Covalent labeling methods (cross-linking) for the determination of the structural model.
- *Dynamic properties of macromolecules*. Heterogeneous conformational ensembles, interconversion between states. Examples of dynamic systems (molecular motors, intrinsically disordered proteins, etc.) and methodological approaches for their investigation.
- *Macromolecular complexes*. Protein-protein, protein-DNA and protein-ligand interactions. Examples of non-covalent complexes (membrane receptors, ribosomes, etc.) and methodological approaches for their investigation.
- *Computational methods and integrated structural biology*. Molecular dynamics, docking, homology modeling and de novo prediction. Integration strategies of data from distinct methodologies for the structural characterization of macromolecules.
- *Biotechnological applications*. Structural determinants of pathologies, misfolding diseases, amyloid aggregation. Epitope mapping, antibody conjugation, rational design and drug delivery. Biosensors, immobilization and engineering of enzymes, use of macromolecules in bioprocesses and biomaterials (etc.).

Prerequisites

Background. The fundamental notions of a basic biochemistry course.
Prerequisites. None.

Teaching form

21 lectures (2h) in the classroom, composed by:

a) a section (around 50%) focused on the presentation of contents, concepts and principles (didattica erogativa, DE), supported by the use of electronic slides.
b) a section (around 50%) focused on trainees interventions, case studies analysis and supervised execution of tutorials and quiz (didattica interattiva, DI), supported by the use of softwares and web servers.

Didactic activities are conveyed by means of face-to-face lectures.

Teaching language: Italian.

Textbook and teaching resource

Slides. Available on the teaching e-learning platform.
Records. Available on the teaching e-learning platform.
Tutorials. Available on the teaching e-learning platform.
Scientific articles. Available on the teaching e-learning platform.
Any specific textbooks (or parts of them) will be recommended for the different topics covered.

Semester

Second semester.

Assessment method

The exam is an oral interview of 20-30 minutes, which consists in the discussion of the topics covered in class and can include the comment of experimental results presented by the lecturer. The evaluation will cover both the level of knowledge of the topics and the ability to analyze and comment on specific results.

Office hours

Contact: on demand by email request to the lecturer.

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING