UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Protein Biochemistry

2425-1-F0601Q060

Aims

This course aims to deepen concepts related to the relationships between the structure and function of proteins within a pathway that, starting from physiological and evolutionary aspects, considers pathological implications and biotechnological applications of proteins. Some biophysical and biochemical techniques suitable for studying the structure, function and modification of individual proteins or biochemical circuits will be described. By emphasising the need for a multidisciplinary approach, the course aims to offer not only cognitive but also methodological tools useful for the study, control and biotechnological exploitation of complex biological phenomena involving proteins. The general objectives are as follows:

Knowledge and understanding
By the end of the course, students will have acquired knowledge about the mechanisms of protein folding, the relevance of structural flexibility and functional promiscuity, conformational and functional transitions, natural evolution and *directed-evolution* of proteins, conformational transitions often associated with the establishment of protein-protein interactions, under both physiological and pathological conditions. Students will acquire knowledge of some techniques for structural and functional studies of some classes of proteins.

Ability to apply knowledge and understanding
The examples illustrated during the lectures bring out the main mechanisms of (mal)functioning of proteins, associated with their structural peculiarities and interaction with the environment. It is expected that they can be recognised in contexts other than those exemplified and are potentially applied, for example, to design new 'synthetic' proteins. It is expected that students learn to recognise the various contexts in which the techniques outlined in the course are profitably applicable.

Autonomy of judgment
Students will be stimulated to recognise the relationships between protein structure and function and to predict the effects of certain environmental contexts on both these aspects.
Students will be encouraged to personally identify the wealth of connections between the main topics of this course. The identification of complex biological problems and the development of original solutions increasingly requires the use of knowledge from different and complementary disciplinary fields - from cell biology to chemistry

to physics. Grasping relationships between different phenomena (e.g. molecular and biophysical) and exploiting the complementarity of different investigative techniques creates the prerequisites for proposing new visions, developing a critical sense and offering new solutions.
Students will be able to predict the effects of various environmental contexts on proteins, developing a critical and original perspective in interpreting and solving complex biological problems.

Communication skills
By the end of the course, students will have acquired the appropriate vocabulary and linguistic skills to describe the biochemical and molecular phenomena covered in the course.

Learning skills
Students will be able to successfully tackle advanced courses in Protein Science and understand the scientific literature in these disciplinary areas.

Contents

1. Structure of proteins and methods for their study
2. *In-vitro* and *in-vivo* studies on protein folding
3. Protein-protein interactions; separation and phase transition of biomolecules
4. Mechanisms of protein turnover
5. Principles of natural and directed evolution of proteins

Detailed program

1. Structure of proteins and methods for their study.
Structural order and disorder; Structural elements and motifs;
Methods for the structural study of proteins: X-ray crystallography, Electro-cryo microscopy, NMR spectroscopy
How to meeasure protein similarity;
Similarity and divergence in protein structure analysed through case studies.

2. *In-vitro* and *in-vivo* studies on protein folding
Thermodynamic and kinetic aspects of protein folding;
Protein folding theories;
Protein folding *in vivo*;
Importance of translation events on protein folding (codon bias and translation rate);
Biotechnological implications of translation rate control.

3. Protein-protein interactions; separation and phase transition of biomolecules
Methods for studying protein-protein interactions (microcalorimetry; surface plasmon resonance);
Chemical-physical phenomena underlying molecular condensates;
Examples of biological relevance of bio-molecular condensates;
From liquid condensates to solid aggregates: physiological and pathological aspects of phase transition;
Types of protein aggregates;
Amyloid fibrils and prion proteins. Hallmarks of amyloid aggregation;
From propagation mechanisms to diagnostic devices of amyloid pathologies.

4. Mechanisms of protein turnover
Overview of cellular mechanisms of protein turnover;
Protein degradation by the ubiquitin-proteasome system (UPS);

Pharmacological potential of natural UPS mechanisms and dual target degrader drugs. Case studies.

5. Principles of natural and directed evolution of proteins
General concepts of natural evolution and evolvability from the perspective of biotechnological protein design;
Protein evolution rate and fitness landscape;
Role of phenotypic variation and neutral drift in protein evolution;
Various protein engineering approaches and techniques of protein directed evolution.
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Prerequisites

Prerequisiti: Basic knowledge in the fields of Biochemistry and Cellular biology.

Teaching form

The course The course consists of 24 lessons (6 ECTS) delivered in a mixed mode, conventional and interactive. The conventional lecture-based format necessitates in-person attendance, whereas the interactive format encourages active student participation in the analysis and interpretation of recently published scientific papers.

A number of lessons (up to four) will be conducted with guest experts who will deliver seminars illustrating the application of specific techniques for the structural or functional study of proteins.

In response to student requests, new topics or techniques for studying the structure and function of proteins may be introduced.
The number of students in attendance will determine whether group work will be organised to analyse scientific literature.

Textbook and teaching resource

PPT slides and videos published on the Moodle website (http://elearning.unimib.it/).

Articles referred/described in the lessons

Semester

First semester

Assessment method

Oral exam lasting 30-40 minutes, divided into two parts:

First part: Presentation with PowerPoint slides of a scientific article agreed upon with the teacher (duration: 15 minutes), followed by questions related to the article (5-10 minutes).
Evaluation (50% of the final mark) considers the degree of understanding of the article, the ability to clearly explain the scientific problem and the technical approach, and the use of appropriate language.

Second part: Questions on the content of the lectures (at least two of the five thematic blocks) (10-15 minutes).
Evaluation (50% of the final mark) considers the knowledge of specific topics, the ability to identify connections between the lesson content and the seminar topic, the use of appropriate language, and clarity of presentation.

Students who register for the 1st exam call will have the opportunity to present the scientific paper (part 1) in the form of a seminar for the class.

Office hours

On demand, by mail to stefania.brocca@unimib.it

Sustainable Development Goals

QUALITY EDUCATION