UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Biophysics Laboratory

2627-3-E3001Q063

Aims

1. Knowledge and understanding.
The student will acquire both basic and applied knowledge related to:
-absorption and fluorescence spectroscopy for the study of biomolecules and fluorophores,
-optical techniques for analyzing protein secondary structure and folding/unfolding processes (CD, IR, fluorescence),
-interactions between proteins and ligands through fluorescence measurements,
-quasi-elastic light scattering for analyzing the size and aggregation state of proteins and nanoparticles,
-photothermal effects of metallic nanoparticles and thermal imaging,
-acquisition of biological images using confocal and widefield (transmitted light) fluorescence microscopy,
-fundamentals of image and data analysis using artificial intelligence (AI) tools,
-fundamentals of geometric optics.

2. Applying knowledge and understanding.
At the end of the course, the student will be able to:
-use spectroscopic and optical instruments to analyze biological systems,
-apply experimental protocols to study protein structures and determine nanoparticle size/aggregation,
-carry out experiments with lasers and thermal cameras to investigate the photothermal effects of nanoparticles,
-use confocal and transmitted light microscopy to acquire and interpret images of cells and tissues,
-apply basic AI techniques for image processing and experimental data analysis.

3. Making judgements.
The student will develop:
-critical skills in analyzing spectroscopic and microscopic data,
-autonomy in evaluating the reliability of experimental results,
-awareness of the limitations and potential of the employed techniques,
-the ability to select the most appropriate method depending on the biomolecule or sample under study.

4. Communication skills.

The student will be able to:
-present experimental results clearly and accurately,
-describe setups and techniques using appropriate technical terminology,
-write reports on laboratory experiments.

5. Learning skills.
The student will acquire:
-methodological tools to independently learn new biophysical techniques,
-the ability to consult scientific articles, experimental protocols, and analysis software,
-skills useful for pursuing laboratory activities, an experimental thesis, or advanced courses in biophysics, nanotechnology, or biomedical imaging.

Contents

Absorbance, Fluorescence, Dynamic Light Scattering, Microscopy, Nanoparticles, Geometric Optics, Artificial Intelligence methods for data and image analysis

Detailed program

The 8 CFU comprises 2 CFU of data and image analysis through artificial intelligence-based methods. The remaining 6 CFU are related to the Laboratory lessons.
Before the Laboratory, introductory lessons about the different instruments and spectroscopy/microscopy techniques will be illustrated together with data analysis methods.

The main topics are reported in the following:

Absorbance and fluorescence spectroscopy of biomolecules and fluorophores.
Evaluation of the secondary structure of proteins and study of the folding-unfolding processes through optical techniques (UV-Vis absorption, fluorescence).
Study of biomolecules-small ligands interactions through fluorescence techniques.
Estimate of the proteins dimension and the aggregation state of gold nanoparticles by means of quasi-elastic light scattering.
Hyperthermic effect induced on metallic nanoparticles by an infrared laser and its measurement through a thermal camera.
Fluorescence confocal microscopy applied to image acquisition of cells and biological tissues: image analysis, measurement of the optical resolution of the system.
Development and characterization of an optical system
Data and image analysis through artificial intelligence-based methods (2 CFU)

Prerequisites

knowledge of classical electromagnetism, optics, elements of biophysics

Teaching form

Interactive lessons, in Italian, related to:

- Laboratory in which each group of students will perform the experiments described in the program section (6 CFU)
- Exercises related to data and image analysis by means of artificial intelligence-based algorithms (2 CFU)

Textbook and teaching resource

Textbooks:

Cantor and Schimmel "Biophysical Chemistry"

Robert Pecora, Bruce J. Berne, "Dynamic Light Scattering"

Joseph R Lakowicz, "Principles of fluorescence spectroscopy"

Slides provided on the e-learning site

Semester

Second semester

Assessment method

ORAL EXAM related to the laboratory reports. The Laboratory report comprises both the theroretical introduction and the description of the developed experiments with the related data analysis. Individual or group reports can be presented for exam evaluation.

The final grade will be determined based on the evaluation of the written report, the knowledge of the various topics covered, the analysis of experimental data, and the student's conduct throughout the laboratory course. These components will be weighted equally to determine the final grade, expressed on a 30-point scale.
Additionally, the following will be assessed:

- the use of appropriate technical terminology
- the ability to present concepts in a clear, logical, and coherent manner
- the command of scientific language

Office hours

Usually the teacher is always available for reception, however the presence is guaranteed only if previously arranged, either in classroom or by e-mail.

Sustainable Development Goals

QUALITY EDUCATION | GENDER EQUALITY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | REDUCED INEQUALITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION | PARTNERSHIPS FOR THE GOALS