UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Introduction To Biophotonic

2627-3-E3001Q068

Aims

The interaction between radiation (UV-VIS) and matter makes it possible to study soft matter, particularly biological systems with varying degrees of complexity."
The course "Elements of Biophotonics" has the purpose to introduce the student to the main spectroscopic techniques for investigating biosystems mainly in the UV-.VIS range of the electromagnetic spectrum.

Knowledge and Understanding
At the end of the course, the students will be familiar with the characteristics of the main biological macromolecules. They will understand the principles behind various investigative techniques, both theoretical and experimental, and will be able to identify the type of information that can be obtained from each technique for applications in the fields of biophysics and nanomedicine.

Applied Knowledge and Understanding
By the end of the course, the student will be able to:

Know the primary structure of proteins and nucleic acids

Decide which spectroscopic technique to use to determine the secondary or tertiary structure of a biological macromolecule

Solve simple problems in the field of biophysics

Independent Judgment
By the end of the course, the student will be able to:

Decide which spectroscopic technique is best suited to address a basic problem in biophysics

From a critical reading of a scientific article, identify the main results and the data collected

Communication Skills
Be able to present a scientific article in depth, using appropriate language and critically selecting the key findings. Discuss topics covered in the course appropriately and critically.

Learning Skills
Be able to apply the knowledge acquired in practical settings (e.g., in a subsequent laboratory course) and potentially in other fields beyond biological soft matter.

Contents

Main features of the biological macromolecules

UV-VIS spectroscopy, out-of-resonance and in resonance mode,

Elements on fluorescence microscopy

Elements of thermodynamics for biological applications

Nanosystems for biomedical applications

Detailed program

The players: proteins, nucleic acids, cells, chromophores, nanomaterials. Structures and interactions.

Spectroscopic Techniques:

Quasi-elastic light scattering and elements of hydrodynamics. Some applications to biomolecules, molecular size characterization and aggregation studies.

Absorption spectroscopy. The Beer-Lambert law. Absorption coefficients. Effects of interaction among chromophores. Characteristic spectra of proteins (alpha helix, beta-sheets, random coils) and DNA. Conformational effects.

Circular dichroism. Principles of CD. Characteristic spectra of proteins (alpha helix, beta-sheets, random coils) and DNA. Conformational effects.

Fluorescence spectroscopy. Spontaneous emission coefficient. Definition of quantum yield, excited state lifetime. Excitation and emission spectra. Dependence from the fluorophore concentration. The intrinsic fluorescence of biomolecules. The most popular fluorescent probes. The class of “Fluorescent Proteins (GFP)”. Mechanisms of fluorescent quenching I: collisional quenching by Stern-Volmer, static quenching and their application to biomolecules. Mechanisms of fluorescent quenching II: the fluorescent energy transfer mechanism via Foerster theory. Applications. Solvent effects of fluorescence: bulk effects, Lippert-Mataga equation.

Elements of optical microscopy, confocal and non-linear excitation. Typical microscope setups. Image acquisition. Applications in biophysics (to cells, small organisms, in vivo applications)

Elements of Thermodynamics: Gibbs and Helmholtz free energy. Chemical potential, mass action law. Energy and binding kinetics. Cooperativity effects. The folding-unfolding process-

Multifunctional nanoparticles for biomedical applications and their interaction with radiation. Targeting mechanisms and cell internalization. Thermal effects in the medical field.

Prerequisites

Knowledge of the physics topics acquired in the courses of the first two years of the Bachelor degree in Physics course.

Teaching form

Traditional lessons ("Didattica erogativa"): Lessons in classroom with slides and blackboard. The slides are available on the e-learning platform, together with selected papers to specific topics.

Textbook and teaching resource

Slides loaded on the elearning platform.
The recorded lessons are available.

Selected papers for further infortmation

Reference textbooks::

1. Webb, Andrew; “Introduction to biomedical imaging”

2. Cantor, Charles R.; Schimmel, Paul R.; "Biophysical chemistry” [Comprende: The conformation of biological macromolecules 1 Techniques for the study of biological structure and function 2 The behavior of biological macromolecules 3]

When needed,new materials is made available and loaded on the e-learning platform.

Semester

I semester

Assessment method

the exam is oral and it will consist in:

1. A brief presentation of a scientific journal article related to the topics covered in the course is required. Articles on a variety of subjects are available on the e-learning platform, although students may also choose

an article independently. As an alternative, students may give a more in-depth presentation on a topic of their choice among those discussed during the course.

2. Open-ended questions on the other topics discussed during the course.

Regarding the grading criteria: Part 1 carries less weight in the final evaluation and is not sufficient on its own to pass the exam. The final grade takes into account the students' ability to personally elaborate on the chosen article, their understanding and use of appropriate language when discussing topics covered in class, and their ability to apply the techniques studied to solve problems in the field of biophysics.

For Erasmus students: it is possible to take the exam in English.

Office hours

By appointment.

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | LIFE ON LAND