UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nanobiotechnology Methods

2627-2-F0902D018

Aims

The course provides the theoretical and practical foundations of the main nanometer-scale manipulation and characterization techniques used in the study of biological systems at the single-molecule level. By the end of the course, students will be able to understand the physical principles, instrumental operation, and main applications of different methodologies, including Atomic Force Microscopy (AFM), Magnetic Tweezers, and Optical Tweezers.
Knowledge and understanding – By the end of the Nanobiotechnology Methods course, students will be able to understand the physicochemical principles underlying the main techniques for the characterization of nanobiomaterials at the single-molecule level.
Applying knowledge and understanding – By the end of the course, students will be able to use the acquired knowledge to assess and understand the potential of techniques for the characterization of biological systems at the single-molecule level.
Autonomy of judgment – By the end of the course, students will be able to critically evaluate the usefulness and reliability of techniques for the characterization of nanobiomaterials at the single-molecule level.
Communication skills – By the end of the course, students will have acquired appropriate scientific terminology and will be able to clearly and accurately present the topics covered.
Learning skills – By the end of the course, students will be able to understand and critically evaluate the scientific literature related to techniques for the characterization of biological systems at the single-molecule level.

Contents

To understand the operating principles of the most important techniques and the most widely used biophysical analysis instruments employed to study the properties of biological systems at the single-molecule level.

Detailed program

1. Introduction to single-molecule nanomanipulation. Concept of force at the nanometer scale. Force regimes in biological systems.
2. Non-optical microscopy techniques: AFM (Atomic Force Microscopy). Operating principles of AFM. Cantilever, tip, and deflection detection systems. Imaging modes: Contact mode, Tapping mode, Non-contact mode. Imaging of biological surfaces, nanostructured materials, DNA, and proteins. Force measurements and force–distance curves on single DNA and protein molecules. Force spectroscopy on cells. Applications: study of proteins and membranes, nanomechanical characterization of cells, nanomechanical unfolding of DNA and proteins.
3. Other non-optical microscopy techniques: Electron microscopy – SEM (Scanning Electron Microscopy), TEM (Transmission Electron Microscopy).
4. Nanomanipulation techniques: Magnetic Tweezers (MT). Physical principles. Generation and control of magnetic fields. Magnetic beads. Applications: study of single DNA and protein molecules. Measurement of stretching and torsional forces. Nanomechanical denaturation of DNA and proteins. Nanomechanical unfolding of proteins.
5. Nanomanipulation techniques: Optical Tweezers (OT). Principles of optical trapping. Gradient and scattering forces. Experimental setup. Force calibration. Applications: manipulation of single molecules, study of molecular motors, cellular nanomechanics.
6. Comparison between MT and OT. Force ranges. Precision. Advantages and limitations.
7. Light scattering. Static Light Scattering (SLS). Dynamic Light Scattering (DLS). Z-potential.
8. Other analytical techniques relevant to nanobiotechnology: Raman spectroscopy, SERS (Surface-Enhanced Raman Spectroscopy), SPR (Surface Plasmon Resonance), ITC (Isothermal Titration Calorimetry) and DSC (Differential Scanning Calorimetry), FTIR (Fourier Transform Infrared Spectroscopy).

Prerequisites

Basic knowledge in chemistry, biochemistry and molecular biology

Teaching form

Lectures.
All lectures are conducted in person in a traditional format.
24 lectures of 2 hours each are conducted in person in a traditional format.

Textbook and teaching resource

Material and bibliographic references supplied by the professor.

Semester

First semester

Assessment method

ORAL EXAM ON THE TOPICS COVERED IN LECTURES: Oral examination, questions about the topics afforded during the lessons.
No mid-term tests are scheduled.

Office hours

By telephone appointment (02 6448 8209 or 02 6448 8215) or by email (francesco.mantegazza@unimib.it or domenico.salerno@unimib.it).

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING