UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nanomedicine

2627-1-F0902D003

Aims

The course aims to provide an understanding of the techniques, tools, and strategies used for the design, characterization, and validation of nanotechnologies (and nanoparticles) in the medical field, for the therapy, prevention and diagnosis of human diseases. The course is focused on understanding the development process of a (nano)drug, from the laboratory to the clinic.

Knowledge and understanding – At the end of the Nanomedicine course, students will be able to understand and integrate interdisciplinary knowledge relevant to nanobiotechnological research methodologies. They will know and understand the fields of application of nanomedicine.
Applying knowledge and understanding – By the end of the course, students should be able to use the acquired knowledge to understand the potential of nanotechnologies in the medical field.
Making judgements – Upon completion of the course, students will be able to understand the development pathway of a (nano)drug, from the laboratory to clinical application. They will be able to integrate information from different fields (biology, medicine, technology) to understand and interpret nanomedicine.
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 – At the end of the course, students will be able to critically understand and evaluate scientific literature in the field of nanomedicine.

Contents

Fundamentals of nanotechnology and nanomedicine; major classes of nanocarriers and nanomaterials for medical applications; nanoparticle multifunctionalization strategies; applications of nanomedicine in oncology and in neurological and neurodegenerative diseases; pharmacokinetics, biodistribution, and nanotoxicology; advanced techniques for nanoparticle characterization and biological investigation; biomimetic approaches; advanced biomaterials; nanorobotics; and technology transfer and translational aspects of nanomedicine.

Detailed program

Lectures:

- Fundamentals of nanotechnology and nanomedicine: physicochemical principles at the nanoscale, nano–bio interactions, and rational design of nanomaterials for biomedical applications.
- Major classes of nanocarriers and nanomaterials for medical applications (lipid nanoparticles, polymeric and inorganic nanoparticles, biomimetic nanomaterials, extracellular vesicles, and exosomes), including methods for their synthesis, manufacturing, characterization, and quality control.
- Functionalization and multifunctionalization strategies for nanoparticles aimed at active targeting, controlled drug release, multimodal imaging, and theranostic applications.
- Nanomedicine for the delivery of biologics and nucleic acid therapeutics, including mRNA, siRNA, and CRISPR/Cas-based gene-editing systems.
- Applications of nanomedicine in oncology: targeted drug delivery, cancer immunotherapy, combination therapies, and precision medicine approaches.
- Applications of nanomedicine in neurological and neurodegenerative diseases: blood–brain barrier targeting, neuroimaging, and innovative therapeutic strategies.
- Pharmacokinetics, biodistribution, safety, and immunocompatibility of nanoparticles, including protein corona formation, immune interactions, and regulatory considerations.
- Advanced methodologies for studying the biological fate of nanoparticles, including in vivo imaging, multimodal tracking, advanced cellular models, organoids, and organ-on-chip systems.
- Intracellular trafficking, cellular uptake mechanisms, subcellular targeting, and intracellular delivery of drugs and biomacromolecules.
- Biomimetic nanomedicine: cell membrane-coated nanoparticles, extracellular vesicles, exosomes, and bioinspired delivery systems.
- Advanced biomaterials for regenerative medicine and tissue engineering, including smart hydrogels, stimuli-responsive biomaterials, and biofabrication approaches.
- Nanorobotics, microrobotics, and intelligent nanosystems for diagnosis, therapy, and minimally invasive biomedical interventions.
- Artificial intelligence and data-driven approaches for the design, optimization, and translational development of nanomedicines.
- Translational aspects of nanomedicine, including GMP manufacturing, preclinical and clinical evaluation, regulatory pathways, and emerging future perspectives.

Laboratory:

Preparation, functionalization, drug-loading and characterization of lipid-based nanoparticles. Critical discussion of the results from the preclinical point of view. Overview of the instrumentation useful for scientific research in the field of nanotechnology and nanomedicine.

Prerequisites

Basic knowledge of chemistry, biochemistry and biology.

Teaching form

20 h (10 lessons, 2 h each): Frontal Lesson (DE), face-to-face lessons
8 h (4 lessons of 2 h each): Frontal Lesson (DE), online lessons
4 h (2 activities of 2 h each): Interactive Lesson (DI), Exercises, face-to-face lessons
24 h (6 activities of 4 h each): Interactive Lesson (DI), Laboratory, face-to-face lessons

Textbook and teaching resource

Review and articles published in international journals will be indicated during the course.
Materials used during the frontal lessons (slides).
All material will be loaded on e-learning platform.

Suggested text books:

1. Understanding Nanomedicine - An Introductory Textbook By Rob Burgess. ISBN 9789814316385. Jenny Stanford Publishing
2. The Handbook of Nanomedicine (English Edition) 3° Edizione By Kewal K. Jain. ISBN-10 1493983547. Humana Pr Inc

Semester

1st semester

Assessment method

Individual written examination
12 multiple-choice questions (2 marks each) on frontal lesson
1 multiple-choice questions (2 marks) on laboratory activities
1 open question (4 marks) on all the programme of the course
to be completed in 30 minutes.

The exam is positively evaluate with a score of 18/30 or higher. The questions proposed in the written exam will be constructed in such a way as to induce the student to biochemical-bio/nanotechnological reasoning, to understand the units of measurement and to be able to evaluate the skills and competences acquired according to the objectives of the course.

There are no *itinere* tests planned.

Office hours

On appointment writing to: francesca.re1@unimib.it

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING