UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Advanced Cellular Models in Pre-Clinical Research and Personalized Medicine

2627-1-F0803Q082

Aims

The course addresses the challenges associated with the construction and reconstitution of multicellular systems capable of reproducing different aspects of tissue heterogeneity and variability. Understanding these systems requires a multidisciplinary approach in which techniques from biochemistry, cell biology and molecular biology are integrated with advanced methodologies in microfluidics, microscopy, image analysis and spatially resolved omics technologies.
Such an approach enables the integrated study of fundamental biological processes, providing tools both to generate new basic knowledge and to develop in vitro replicas of human tissues and organs, with the aim of identifying personalized pharmacological treatments for individual patients.

The course aims to achieve the five learning objectives described below.

1. Knowledge and understanding
Students will acquire knowledge of the opportunities offered by different advanced cellular models in basic and pre-clinical research, as well as their potential applications in diagnostic and therapeutic settings, particularly in the field of precision medicine.

2. Ability to apply acquired knowledge to new problems
Students will be able to apply the knowledge acquired to scientific, methodological and applied problems that differ from those explicitly addressed during the lectures.

3. Autonomy of judgement
Students will be able to critically re-elaborate the knowledge and methodologies acquired, consult the scientific literature critically and remain up to date on both the topics covered during the course and the main fields of application of advanced cellular models. The development of these skills will be enhanced through journal clubs, in which scientific articles provided by the lecturers will be critically analysed and discussed interactively in class by the students.

4. Communication skills
Students will be able to communicate appropriately in Italian, for native Italian speakers, and in English, for all students, describing the topics covered with appropriate terminology and confidence in oral presentation.

5. Learning skills
Students will be able to analyse, apply, integrate and connect the knowledge acquired with that gained in related courses, in order to address scientific problems in an integrated manner.

Contents

Pre-clinical studies of multifactorial diseases, such as cancer and neurodegenerative disorders, require increasingly complex cellular models that can more effectively recapitulate the features of the disease under investigation compared with conventional cell cultures.
The course will describe and compare the generation of different advanced cellular models and the main analytical technologies used to study them, with particular attention to advanced imaging, single-cell omics technologies and spatially resolved methodologies. The possible role of some of these models in personalized medicine will also be discussed.
Many of the topics will be addressed through the multidisciplinary analysis of specific case studies.

Detailed program

1. Spheroids: three-dimensional cellular aggregates derived from a single cell type, defined as homotypic, or from two or more different cell types, defined as heterotypic.

2. Organoids: structures derived from one or a few cells of a tissue, from embryonic stem cells or from induced pluripotent stem cells, capable of self-organizing in three-dimensional cultures thanks to their self-renewal and differentiation properties.

3. Organ-on-chip systems: systems containing engineered or natural tissues grown within miniaturized microfluidic chips. These devices are designed to mimic aspects of human physiology and allow control of cellular microenvironments while preserving tissue-specific functions.

4. Patient-derived xenografts (PDXs): tumour models in which tissue or tumour cells from a patient are implanted into an immunodeficient or humanized mouse, in order to reconstruct an environment that allows natural tumour growth, tumour monitoring and evaluation of responses to treatments.

5. Main analytical technologies, including quantitative approaches: imaging, morphometric analyses, autofluorescence, Seahorse analysis and specific fluorescent probes.

Prerequisites

There are no formal prerequisites. However, the course is based on concepts and methodologies covered in basic Biochemistry, Molecular Biology and Cell Biology courses.
In particular, knowledge of basic cellular biochemistry, as well as general biology, eukaryotic cells and microscopy, is useful. Basic knowledge of statistics is also useful.

Teaching form

The course consists of 14 lectures of 2 hours each, organized as follows:

- 8-10 lectures in a traditional teaching format, focused on the presentation and explanation of scientific contents, concepts and principles;
- 4-6 interactive sessions, involving the discussion of scientific articles by the students, also through presentations similar to the communication of scientific data at a conference, in the form of an oral presentation, journal club or poster;
- 20 hours of laboratory activities dedicated to the preparation and biochemical and image-based analysis of advanced cellular models, in particular homotypic and heterotypic spheroids, and to their morphometric and biochemical analysis.

The exact balance between traditional frontal teaching and interactive teaching will depend on the number of students enrolled in the course. All activities will take place in person.

Language of instruction: English (upon request by international students).

Textbook and teaching resource

Specialized articles, review articles and/or book chapters will be recommended during the course.
Specific experimental protocols related to the laboratory activities will also be provided.
Video recordings of the frontal lectures will be made available.

Semester

First semester

Assessment method

There are no mid-term assessments.

The exam is oral and will assess the acquisition of the basic concepts related to the development and use of advanced cellular models and their applications.
The exam consists of three parts:

- assessment of the knowledge acquired on advanced cellular models;
- assessment of the knowledge acquired on analytical methodologies;
- assessment of the skills acquired and description of the activities carried out during the laboratory sessions.

The final grade will take into account all the aspects listed above.

Office hours

By appointment via email

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION