ADVANCED STEM CELL BIOLOGY (AB000002)

1. language

English

2. course contents

Coordinator: Prof. Wanda Lattanzi

Year Course: 1st

Semester: 1st

CFU/UFC: 8

Modules and lecturers:

- GENOME EDITING AND STEM CELL REPROGRAMMING (AB000025) - 3 CFU - SSD BIO/11 - Prof. Angela Gallo/ Prof. Silvestro Conticello
- MECHANOBIOLOGY AND SIGNAL TRANSDUCTION (AB000027) - 2 CFU - SSD BIO/13 - Prof. Wanda Lattanzi / Prof. Pedro Morouco
- OMIC PROFILING OF STEM CELLS (AB000028) - 3 CFU - SSD BIO/10 - Prof. Matteo Bordi /Prof. Claudia Desiderio

3. bibliography

Didactic materials, including scientific articles, multimedia files and appropriate telematic sources, will be provided to students to complete, elaborate and update the contents discussed during lectures. Powerpoint files will be made available upon request.

4. learning objectives

This course aims to strengthen the specialized and multidisciplinary knowledge of stem cell properties, characterized through the current approaches and scientific advances that have revolutionized the field. The course will explore the state-of-the-art technologies and most recent advancements, including genome editing for stem cell engineering, high throughput omic profiling for improved stem cell characterization, and mechanobiology, a novel interdisciplinary field of science where concepts of mechanics, biology, and engineering are combined to understand the different cellular processes through which stem cells can sense and respond to changes in their surrounding environment.

The learning objective will enable the students:

To obtain a thorough knowledge of stem cell biology provided by the most recent approaches applied in this field such as gene reprogramming through gene editing, mechanobiology, and the various OMICS sciences (**Knowledge and understanding)**.

To interpret and understand how the use of new technologies is applicable to stem cells not only for their functional, morphological, and genetic characterization, but also to study the molecular mechanisms underlying pathophysiological processes, carry out pharmacological screening, and finally to improve cellular therapeutic potential (**Applying**

knowledge and understanding).

To integrate the specific knowledge and skills acquired to evaluate and identify the most appropriate approaches in order to exploit the potential of stem cells in the medical field (**Making judgements**).

To gain the needed know-how to communicate clearly and unambiguously, using technical language correctly, in order to appropriately disseminate the scientific content relating to the most recent developments in the field of stem cell biology, to specialist and non-specialist interlocutors (**Communication skills**).

To be able to demonstrate a good capacity of self-assessment, to update and expand his/her knowledge through scientific articles and online platforms (NCBI, ATCC, Human cell atlas etc.), and scientific meetings (**Learning skills**).

5. PREREQUISITES

Knowledge of basic and applied subjects – including cellular and molecular biology, chemistry, biochemistry, physics, genetics - is required and necessary for understanding the subjects covered.

6. teaching methods

The teaching methodology is mostly based on face-to-face frontal lectures providing both the basic elements of the various disciplines and application perspectives, and integrates interactive modes of active learning, such as: problem-based learning, self-learning, simulations, and hands-on practical activities on use cases.

The adopted teaching methods allow students to pursue the learning objectives:

Knowledge and understanding – all the topics listed in the program will be treated during frontal lectures and carefully explained with tutorials and exhaustive explanations, in order to provide the students with the appropriate knowledge and learning methods.

Applied knowledge and understanding – the interactive teaching methods, including “case study”, practical examples and laboratory practice exercises, will allow students to learn the applicative potential of the treated topics.

Making judgements – the active learning modalities will enable students to independently formulate ideas and use critical reasoning.

Communication skills – the active learning modalities will stimulate active and constant interaction with the instructors, towards the progressive development of focused communication skills for the presentation of treated topics through a correct scientific language.

Learning skills – additional material (i.e. scientific articles and appropriate telematics sources) will support students in their individual and autonomous study.

7. other informations

Selected contents and materials for study, along with course’s updates and important communications for students, will be provided by the instructors both by direct emails and through the Blackboard platform. The students are required to constantly check their icatt mailboxes and

the Blackboard contents, to keep up with relevant information and updates.

The instructors are available, by appointment, for further clarifications and discussions regarding the learning modules' topics and any possible related issue. Please DO NOT refer to instructors for seeking technical assistance on class attendance or exam registration as they could not help with these issues, which are rather to be checked with the administrative offices.

To arrange an appointment, please contact the Instructors by email:

Prof. Wanda Lattanzi wanda.lattanzi@unicatt.it

Prof. Pedro Gil Frade Morouço pedro.morouco@ipleiria.pt

Prof. Angela Gallo angela.gallo@opbg.net

Prof. Silvestro Conticello silvestro.conticello@cnr.it

Prof. Matteo Bordi mabo@cancer.dk

Prof. Claudia Desiderio claudia.desiderio@cnr.it

NOTE ON STUDENTS' RESPONSIBILITY

The responsibility for learning falls increasingly on students, as they advance through the course; hence, ultimately, the commitment and the dedication to learn must come from them.

As members of the Università Cattolica S. Cuore learning community, students are expected to respect the intellectual property of course instructors. All course materials presented to students are the copyrighted property of the course instructors and are subject to the following conditions of use:

1) Students may not record nor reproduce lectures or any other classroom activities, unless differently specified by the instructor; however, they may use the recordings for their own course-related purposes only.

2) Students may not reproduce and/or post any course material provided by the instructors online or distribute them without the advance written permission of the course instructor and, if applicable, of any students whose voice or image is included in the recordings.

3) Any students violating the conditions described above may face academic disciplinary sanctions. As members of a learning community, students are expected to respect the time and efforts of their fellow classmates. Therefore, the use of social media and other electronic distractions that can disrupt the concentration of other students in the classroom is NOT allowed.

NOTE ON ACADEMIC INTEGRITY AND CHEATING POLICY

The principles of truth and honesty are fundamental to the educational process and the academic integrity of the University. All students have a right to expect fair and honest evaluation of their work. CHEATING UNDERMINES THIS EXPECTATION AND WILL NOT BE TOLERATED.

Students must avoid the following misconduct behaviors that are considered as cheating:

DO NOT exchange ID badges to collect presence among classmates who cannot attend a lecture.

DO NOT share answers of quizzes during exams.

Any student found by the instructors to be cheating will receive a failing grade for the exam or other graded work, and will be reported to the Course's Coordinator and Instructors' Committee. The instructors may, at their discretion, decide to give a failing grade for the course in severe cases of academic dishonesty.

8. methods for verifying learning and for evaluation

The achievement of learning objectives will be assessed through interim evaluations on selected modules and a final exam.

The final exam serves as the formal evaluation session to assign a grade, is performed using the "assignment" tool of the BlackBoard platform through the Respondus Lockdown Browser, and is composed of a written test, based on 36 multiple-choice quizzes covering the different modules divided as follows:

- GENOME EDITING AND STEM CELL REPROGRAMMING - 12 quizzes (passing score threshold= 7)

- MECHANOBIOLOGY AND SIGNAL TRANSDUCTION - 12 quizzes (passing score threshold= 7)

- OMIC PROFILING OF STEM CELLS - 12 quizzes (passing score threshold= 7)

For each quiz a single correct answer is possible. Each correct answer corresponds to a score= 1, wrong/no answer correspond to score= 0. The scores are calculated automatically by the Blacboard system. To pass the exam the student needs to pass each module, according to the specified score threshold, meaning an overall minimum score of 21 out of 36. The final grade will correspond to the score achieved in the quiz.

- 21/36= 18
- 22/36= 19
- 23/36= 20
- 24/36= 21
- 25/36= 22
- 26/36= 23
- 27/36= 24
- 28/36= 25
- 29/36= 26
- 30/36= 27
- 31/36= 28
- 32/36= 29

- 33/36= 30
- 34/36= 30
- 35/36= 30 with honors
- 36/36=30 with honors

The objective of the evaluation system is to verify:

the knowledge and understanding of stem cell properties and on the related advanced technologies applied in their characterization (**Knowledge and understanding)**.

the ability to connect theoretical concepts and practical problems regarding the different aspects discussed during the course (Applied knowledge and understanding);

the ability to integrate the subjects treated in the different modules of the course (Personal judgement);

the development of communication skills for the presentation of treated topics through a correct scientific language (Communication skills);

the ability to autonomously delve into problems and scientific issues raised in the field of advancements in stem cells research and applications (Learning ability).

9. program

< GENOME EDITING AND STEM CELL REPROGRAMMING >

-Introduction:

General info, loxP system, and gene manipulation

General info on cell reprogramming, Yamanaka factors and iPS

-DNA editing

CRISPR/Cas9 system

-Transcriptional editing

CRISPRa and CRISPRi

-Epigenetic editing

-RNA editing

CRISPR/Cas13

ADAR-mediated editing and alternative new technologies

< MECHANOBIOLOGY AND SIGNAL TRANSDUCTION >

- Introduction and key concepts of mechanobiology.

- Cellular structures involved in mechanosensing and mechanotransduction: focal adhesions, cytoskeleton, primary cilium, nucleoskeleton and nuclear mechanotransduction.

- Mechanotransduction in the maintenance of cell and tissue homeostasis.

- How the cell transduces mechanic stimuli: membrane ion channels and signalling receptors; signal transduction pathways and downstream gene expression activated by mechanical stimuli.

- Biomechanics and mechanobiology of force transduction

- Mechanobiology of bone, cartilage, and tendon tissues

- Bioreactors for tissue engineering and mechanotransduction: load optimization, methods, analysis

- Current knowledge and further research opportunities in mechanobiology

< OMIC PROFILING OF STEM CELLS>

- Introduction to Omics

- Overview of omic technologies (genomics, transcriptomics, proteomics, metabolomics, epigenomics)
- Data integration and systems biology

- Genomic Profiling of Stem Cells

- Genome sequencing and assembly
- Transcriptome profiling (RNA-seq, microarrays)
- Analysis of genomic data (differential expression, pathway analysis)

- Proteomic Profiling of Stem Cells

- Analytical strategies and workflow
- Mass spectrometry-based proteomics (approaches, protein identification, de novo sequencing, PTMs characterization)
- Proteomic data elaboration and gene ontology analysis

- Epigenomic Profiling of Stem Cells

- Chromatin structure and modification
- DNA methylation and hydroxymethylation
- Histone modification and nucleosome positioning
- Analysis of epigenomic data (peak calling, differential methylation)

- Metabolomic Profiling of Stem Cells

- Metabolic pathways and flux analysis
- Metabolite profiling and identification
- Analysis of metabolomic data (pathway analysis, metabolic modeling)

- Single-cell Omics of Stem Cells

- Single-cell isolation and preparation
- Single-cell genomics, transcriptomics, and proteomics
- Single-cell RNA sequencing (scRNA-seq) technology and data analysis
- Analysis of single-cell omic data (clustering, trajectory inference, cell type identification)

- Applications of Omic Profiling in Stem Cell Research

- Stem cell differentiation and development
- Stem cell reprogramming and pluripotency
- Disease modeling and drug discovery

- Future Directions and Challenges in Omic Profiling of Stem Cells

- Emerging technologies and platforms
- Data sharing and standardization