Master's degree in Molecular Biology of Cancer
Course syllabus – Molecular Bases for Cancer Diagnosis and Molecular Pathology Techniques

Basic course information

Course:	Molecular Bases for Cancer Diagnosis and Molecular Pathology Techniques			
Type:	Compulsory			
ECTS credits:	6			
Semester:	1º			
Involved departments:	Biochemistry and Molecular Biology			
Course coordinator:	Dr. María Hernández Sánchez	Biochemistry and Molecular Biology (Pharmacy, UCM)	marher36@ucm.es	+34 913941853
Lecturers:	Dr. María Linares Gómez. Dpt. Biochemistry and Molecular Biology (Pharmacy School, UCM). mlinares@ucm.es Dr. M Jesús Fernández-Aceñero. Dpt. Legal Medicine, Psychiatry and Pathology, Faculty of Medicine, Complutense University of Madrid (UCM), mferna39@ucm.es Dr. Aurelio Hernández Laín. Dpt. Legal Medicine, Psychiatry and Pathology, Faculty of Medicine, Complutense University of Madrid (UCM), aurelioh@ucm.es			

Specific course information

Course description:	In this course, the main techniques used for cancer diagnosis at the clinical level will be studied. Specifically, the following topics will be addressed: • Molecular pathology and cytogenetic techniques. • High-throughput analysis methodologies for genetic diagnosis, including NGS sequencing of exomes/genomes and gene panels; gene expression analysis, including spatial transcriptomics and the study of microRNAs and non-coding RNAs; and techniques for the analysis of epigenetic modifications. • The use of liquid biopsy as a non-invasive technique for the detection of molecular alterations, with emphasis on its application in clinical diagnosis. • Regulations related to the handling of patient-derived samples, including the organization and operation of biobanks. • Diagnostic interpretation and personalized medicine.
Requirements:	None
Recommendations:	None

Learning outcomes

Knowledge and content	• To understand the basic molecular and cellular mechanisms whose dysregulation leads to cancer development, with particular emphasis on oncogenic mechanisms and tumor suppressor pathways. • To understand the molecular and cellular mechanisms involved in the reciprocal interactions between the tumor and the tumor microenvironment, and how these interactions influence tumor progression. • To understand the main genetic and environmental risk factors that predispose to cancer development, as well as the key molecular mechanisms underlying the effects of these factors. • To become familiar with cancer research techniques, including both classical approaches and the most innovative strategies, and to understand their advantages and limitations. • To understand the molecular similarities and differences among the major types of solid and hematological tumors, and their impact on disease progression, diagnosis, and treatment. • To understand the main types of anticancer treatments, with special attention to advanced radiotherapy techniques, cell therapy, immunotherapy, nanoencapsulation, and targeted therapies. • To understand the main diagnostic methods in cancer, both general and tumor-specific, with particular emphasis on molecular diagnostic approaches that enable the identification of specific genetic alterations, as well as the use of early detection techniques based on liquid biopsy. • To understand the key stages involved in the process that, starting from basic research and preclinical models, enables the intellectual protection, validation, and, where appropriate, the clinical application and commercialization of new biomarkers for cancer diagnosis or prognosis, new chemical, biological, or physical agents, or new pharmaceutical formulations with antitumor activity or aimed at alleviating symptoms in oncology patients.

Skills and abilities	• Ability to understand and apply concepts, tools, and methodologies in cancer research, enabling the development of an integrative perspective on advances in scientific research in this field. • Ability to analyze and critically understand a scientific paper, from the initial hypothesis and objectives through the experimental approach to the conclusions obtained. • Ability to clearly and unambiguously present the results of scientific research in the field of molecular cancer biology in written scientific reports or dissertations in English. • Ability to communicate the conclusions of scientific studies clearly and unambiguously to both specialized and non-specialized audiences, including the ability to understand, convey, and discuss knowledge, scientific results, and strategies in English. • Ability to appropriately use and apply the most recent techniques for the analysis of the mechanisms underlying tumor development and progression, as well as to study the mechanisms of action of anticancer treatments in cultured cells, tissues, or whole organisms. • Ability, based on the knowledge acquired, to develop principles for the selection or design of appropriate personalized anticancer therapies for each cancer type and stage (patient-specific). • Ability to understand and, where appropriate, manage the legislative, social, healthcare, and ethical implications of basic, translational, and clinical research in oncology. • Ability for autonomous learning and critical analysis, enabling continuous professional development in a self-directed manner.
Competencies	• To understand the molecular, cellular, and pathophysiological bases of cancer, enabling students to continue studying in the field of molecular cancer biology in an autonomous and self-directed manner. • To design experimental approaches to analyze the molecular, cellular, or pathophysiological mechanisms involved in cancer development and progression, as well as to evaluate the effectiveness of new diagnostic methods or novel therapeutic approaches. • To interpret results derived from the application of diagnostic methods or from reports generated by oncology professionals for the diagnosis and classification of cancer. • To evaluate the social and ethical responsibilities and the environmental risks associated with professional practice. • To prepare basic documents in the appropriate format to support patent applications and clinical trial proposals in the field of oncology. • To apply the principles of the scientific method, understanding both its value and its limitations, and incorporating the ethical principles that govern professional practice. • To develop appropriate communication and dissemination skills related to professional activity, both among specialists and within the broader non-specialist society. • To be able, based on the knowledge acquired in the field of molecular cancer biology, to assess and select appropriate scientific information to formulate judgments and interpretations from limited data. • To understand and recognize the need for continuous training and lifelong learning in the field of oncology for professional practice.

Objectives

General Objective

To provide students with advanced and up-to-date knowledge of the molecular bases of cancer and the main molecular pathology techniques applied to diagnosis, prognosis, and treatment, to enable them to interpret and integrate molecular findings into clinical practice.

Specific Objectives

• To understand molecular pathology and cytogenetic techniques (immunohistochemistry, FISH, karyotyping, etc.), and to assess their usefulness in oncological diagnosis and biomarker identification.

• To become familiar with omics-based techniques used in the molecular diagnosis of cancer, including NGS platforms, transcriptomics, epigenetics, and proteomics, as well as their clinical applications in the analysis of molecular alterations.

• To integrate molecular findings into clinical diagnosis and personalized medicine for the preparation of molecular diagnostic reports and the resolution of clinical cases.

• To analyze the applications of liquid biopsy in diagnosis, monitoring of minimal residual disease, and therapeutic follow-up.

• To recognize the importance of biobanks and the proper handling of clinical samples, taking into account quality and traceability requirements and current national and European legislation.

• To explore future perspectives in molecular pathology, including applications of artificial intelligence.

• To foster critical thinking and scientific discussion in collaborative environments.

• To develop an active and participatory attitude, as well as teamwork skills, within the learning process.

Methodology

Description:	The teaching will be delivered through lectures, seminars, tutorials, and the completion of individual or group assignments. The lectures are intended to provide students with the essential

knowledge for each topic. The course will include invited speakers who are specialists in some of the techniques covered in the subject.
Student participation will be encouraged through seminars and tutorials. These sessions of presentations and seminars aim to apply the knowledge acquired through the discussion of scientific research papers or the resolution of clinical cases.
Students will have access to individual or small-group tutorials, aimed at exploring specific aspects of the syllabus in greater depth to facilitate learning.
A written examination will be conducted to assess learning outcomes. In addition, seminar presentations and active participation throughout the course will be considered.

Distribution of teaching activities

	Hours	% in-person attendance
Theoretical classes:	14	100
Presentations and/or seminars:	6	100
Tutorials:	2	100
Assessment:	2	100
In-person work:	24	100
Independent work:	51	0
Total:	75	

Assessment

Applicable criteria:

Student assessment combines: (a) a final examination (60% of the overall course grade) and (b) continuous assessment, defined as (b.1) in-class presentation and discussion of research papers (30% of the overall course grade), and (b.2) student work and participation in classes and other complementary learning activities (10% of the overall course grade).
Students are required to participate actively and responsibly in at least 70% of the face-to-face learning activities.
Grades will be based on an absolute scoring system from 0 to 10, in accordance with the grading scale established in Royal Decree 1125/2003.

Semester organization

The course will be taught in the first semester.

Syllabus

Theoretical Curriculum:

Module 1: Molecular Pathology and Cytogenetic Techniques in Oncology
1.1 Introduction to Molecular Pathology in Clinical Oncology
1.2 Immunohistochemistry, Hybridization Techniques, and Cytogenetics

Module 2: Molecular Analysis for Genetic Diagnosis in Oncology
2.1 Classical Molecular Techniques in Clinical Routine
2.2 Next-Generation Sequencing (NGS)
2.3 Transcriptomic and Epigenetic Techniques

Module 3: Diagnostic Integration and Personalized Medicine in Oncology
3.1 The Molecular Report in Clinical Pathology: Integration of Molecular, Histopathological, and Clinical Data
3.2 Precision Medicine and Therapeutic Decision-Making Based on Biomarkers

Module 4: Liquid Biopsy in Oncology
4.1 Biological Principles of Liquid Biopsy: ctDNA, CTCs, and Extracellular Vesicles. Technologies and Platforms for Liquid Biopsy
4.2 Clinical Applications of Liquid Biopsy in Oncology

Module 5: Biobanks and Handling of Clinical Samples in Oncology
5.1 Biobanks: Organization, Operation, and Quality Management of Human Biological Samples

Module 6: Emerging Trends in Molecular Pathology of Cancer
6.1. Other Omics Techniques (Proteomics, Metagenomics, etc.)
6.2. Artificial Intelligence and Digital Pathology Applied to Molecular Diagnosis.

Practical sessions:	- Clinical case resolution - Discussion of new techniques in molecular pathology and precision oncology - Collaborative thematic workshops on real clinical cases
Bibliography:	*- González de Buitrago, JM y Medina Jiménez, JM: Patología molecular, Editorial McGraw-Hill Interamericana, Madrid, 2001.* *- González Saster, F y Guinovart, JJ: Patología Molecular, Masson, Barcelona, 2003.* *- Shukla, Sharma P, Misra S. Molecular Diagnostics in Cancer Patients. Springer-Verlag, New York, NY, 2019* *- Sánchez Pozo A, Girón González MD, Landeira D, López Onieva L, Heras S, Salto González R, Patología molecular. 2022* *- Coleman W.B. & Tsongalis G.J. "Molecular Pathology: The Molecular Basis of Human Disease" Ed. Elsevier Science & Technology (2nd Ed., 2017).* *- Coleman, W.B. y Tsongalis, G.J.: "Essential concepts in Molecular Pathology", Academic Press, 2010.* *- Buckingham L. Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications. F.A. Davis Company (3rd Ed., 2019).* *- Weinberg R. "The Biology of cancer" Ed. Garland Science (2ª Edición 2014).*