Master's degree in Molecular Biology of Cancer
Course syllabus – Cancer risk factors and cancer as a hereditary disease

Basic course information

Course:	Cancer risk factors and cancer as a hereditary disease			
Type:	Compulsory			
ECTS credits:	3			
Semester:	1º			
Involved departments:	Biochemistry and Molecular Biology			
Course coordinator:	Dr. Marco Cordani Dr. Monica Musteanu	Department of Biochemistry and Molecular Biology	mcordani@ucm.es; mmustean@ucm.es	91 394 5032 91 394 1788
Lecturers:	Dr. Marco Cordani. Department of Biochemistry and Molecular Biology. Faculty of Biological Sciences. mcordani@ucm.es Dr. Monica Musteanu. Department of Biochemistry and Molecular Biology. Faculty of Pharmacy. mmustean@ucm.es			

Specific course information

Course description:	This course covers content related to genetic and environmental factors that confer predisposition to cancer. Specifically, it will address: • Cancer epidemiology, as well as some of the main environmental risk factors (radiation, viral infections, tobacco, alcohol) associated with the development of different tumour types. • The main metabolic and immunological factors (obesity, chronic inflammation, microbiome alterations, etc.) and their relationship with cancer development. • The main genetic factors that confer cancer predisposition, including examples of the most common hereditary cancer syndromes. • Analysis of the main genes whose genetic alteration is associated with cancer development, including issues in genetic counselling related to the interpretation of pathogenic and non-pathogenic variants in these genes. • Cancer prevention strategies.
Requirements:	None
Recommendations:	None

Learning outcomes

Knowledge and content	• Understand the basic molecular and cellular mechanisms whose dysregulation leads to cancer development, with particular emphasis on oncogenic and tumour-suppressor mechanisms. • Understand the molecular and cellular mechanisms involved in the reciprocal interactions between the tumour and the tumour microenvironment, and how these interactions influence tumour progression. • 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. • Understand the main types of anti-tumour treatments, with particular attention to advanced radiotherapy techniques, cell therapy, immunotherapy, nano-encapsulation, and targeted therapies.
Skills and abilities	• Ability to understand and apply concepts, tools, and methodologies in oncology research, enabling an integrative perspective on advances in this field. • Ability to analyse and interpret a scientific study, from the initial hypothesis and objective through the experimental approach to the conclusions reached. • Ability to present research results in a scientific report or written assignment in English clearly and unambiguously, within the field of molecular cancer biology.

	• Ability to communicate conclusions from scientific work to both specialised and non-specialised audiences clearly and unambiguously; to operate, understand, and convey knowledge, scientific results, and strategies in English. • Ability to understand, and where appropriate address, the legislative, social, health-related, and ethical implications of basic, translational, and clinical research in oncology. • Ability to learn autonomously and to perform critical analyses that support self-directed professional development.
Competencies	• Understand the molecular, cellular, and pathophysiological bases of cancer, enabling continued autonomous/self-directed learning in molecular cancer biology. • Design experimental approaches to investigate the molecular, cellular, or pathophysiological mechanisms involved in cancer development and progression, and to evaluate the efficacy of new diagnostic methods or therapeutic approaches. • Assess the social and ethical responsibilities and the environmental risks associated with professional practice. • Prepare basic documents in the appropriate format to support patent applications and clinical trial submissions in oncology. • Apply the principles of the scientific method, understanding its value and limitations, and incorporating the ethical principles governing professional practice. • Develop effective communication and outreach skills regarding professional activity, both among specialists and towards the broader non-specialist public. • Be able, based on acquired knowledge in molecular cancer biology, to evaluate and select appropriate scientific information to formulate judgements and interpretations from limited information.

Objectives

GENERAL OBJECTIVE

To provide students with a broad and integrated overview of the main cancer risk factors—environmental and occupational, lifestyle-related, and linked to metabolic and immune status, as well as those associated with the microbiome and genetic predisposition—together with the biological mechanisms through which they contribute to carcinogenesis and the key strategies for prevention and early detection.

SPECIFIC OBJECTIVES

- To understand the main epidemiological metrics used in cancer research and to critically assess the quality and scope of available information sources.
- To analyse the contribution of ageing and related processes (cellular senescence, immune changes, and chronic inflammation) to tumour initiation and progression.
- To study environmental, occupational, and lifestyle-related risk factors, and to understand the general mechanisms by which they disrupt cellular homeostasis (DNA damage and repair, oxidative stress, xenobiotic biotransformation).
- To understand the role of oncogenic infections in cancer risk and the main prevention and control measures applicable in public health.
- To understand the relationship between metabolism, immunity, inflammation, and the microbiome in tumour promotion and risk modulation.
- To understand the fundamentals of hereditary cancer predisposition and to recognise the most common syndromes, including concepts such as penetrance, family history, and surveillance.
- To integrate risk information (environmental, clinical–metabolic, and genetic predisposition) to justify prevention/screening strategies and to support the critical interpretation of studies in oncology research and translational settings.

Methodology

Description:	Teaching will follow a blended methodology integrating collaborative learning and individual work. Face-to-face activities are organised into lectures, seminars/presentations, and tutorials.

In the lectures, students will acquire core knowledge through sessions delivered by the teaching staff and, where appropriate, by invited speakers who are specialists in specific aspects of the course. These sessions will present the theoretical concepts and experimental evidence needed to provide a comprehensive overview of the subject.

At the beginning of each topic, its content and main objectives will be outlined. At the end, links may be drawn between the material covered and other topics in the course or other modules within the Master's programme. To support the lectures, appropriate teaching materials (slides, videos, applications, etc.) will be provided through the Virtual Campus.

In seminar/presentation sessions, students will present and discuss research work related to the course content, with particular emphasis on the critical reading of scientific articles. These sessions may combine student-led presentations with seminars delivered by staff members or invited experts, depending on the nature of the topic. After each presentation or seminar, a structured discussion will be held between students and staff to explore methodological and conceptual aspects in greater depth.

Tutorials will allow students to explore specific parts of the syllabus in more detail, address questions, and receive guidance for autonomous work, thereby facilitating the integration of the theoretical and practical components of the course.

Learning outcomes will be assessed through oral and/or written examinations, in which students must demonstrate acquisition and integration of the content covered across the different teaching activities.

Independent student work is an essential part of the learning process and will include individual study, problem-solving, seminar preparation, and the production of assignments and reports, individually or in groups. It also includes reading the bibliography recommended by the teaching staff and preparing for the assessments.

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:

Assessment will combine a final written exam with continuous assessment and the evaluation of student presentations/seminars.

Final written exam (50% of the final grade)
An individual assessment in which the student must integrate and apply the theoretical and practical content of the course. It will include essay-style questions, data interpretation, case resolution and/or multiple-choice questions aimed at assessing understanding of cancer risk factors, their molecular mechanisms, and strategies for prevention and early detection.

Continuous assessment (25% of the final grade)
This component will assess work carried out throughout the course, including active participation in class, completion of exercises or case studies, Virtual Campus activities,

	possible mid-term tests, and the quality of submitted assignments. It is intended to reflect the student's engagement and progressive learning. Presentations and seminars (25% of the final grade) This component includes the preparation, in-class presentation, and discussion of research work or scientific articles related to the course content. Assessment will consider the ability to synthesise information, rigour in critical analysis, clarity of presentation, and the quality of scientific discussion with peers and teaching staff. Students must participate actively and responsibly in at least 70% of the face-to-face teaching activities. Grades will be expressed on a 0–10 scale, in accordance with Royal Decree 1125/2003.
Semester organization	The course will be taught in the first semester.

Syllabus

Theoretical Curriculum:

A. INTRODUCTION AND EPIDEMIOLOGICAL FRAMEWORK

1. Introduction to cancer epidemiology. Basic metrics (incidence, prevalence, mortality, survival), time trends, geographic patterns, and social inequalities in cancer.
2. Data sources and limitations. Main registries and databases (IARC, GLOBOCAN, SEER, EUROCARE), rate standardisation, reporting biases, and comparability issues across populations.
3. Ageing and cancer. Demographic transition and cancer burden; the role of cellular ageing, senescence and SASP, immunosenescence, and clonal haematopoiesis/clonal drift in tumour initiation and progression.

B. ENVIRONMENTAL AND OCCUPATIONAL FACTORS

4. Ionising and UV radiation. Types of radiation, dose–response relationships, latency periods, residential radon, and mechanisms of photocarcinogenesis.
5. Chemical contaminants and xenobiotic metabolism. Exposure to asbestos, PAHs, arsenic, benzene, nitrosamines, fine particulate matter (PM2.5); xenobiotic biotransformation (phase I – CYP450; phase II – conjugation reactions), ROS production/oxidative stress, DNA damage, and repair mechanisms.
6. Oncogenic viral infections. HPV, HBV, HCV, EBV, HHV-8: mechanisms of viral oncogenesis, genomic integration, chronic inflammation, and prevention strategies (vaccination, screening, antivirals).
7. Lifestyle and modifiable exposures. Tobacco and alcohol, diet and physical activity, obesity, night shift work, relevant domestic and occupational exposures, endocrine disruptors, and their contribution to cancer risk.

C. METABOLIC, IMMUNOLOGICAL, AND MICROBIOME FACTORS

8. Obesity and signalling. Insulin/IGF-1–PI3K–AKT–mTOR axes, the role of adipokines and bioactive lipids, target organs, and links to tumour initiation and progression.
9. Chronic inflammation and immune response. NF-κB/STAT3/COX-2 pathways, basic concepts of immunoediting (elimination–equilibrium–escape), and interactions between an inflammatory microenvironment, immune surveillance, and therapeutic responses.
10. Microbiome and other metabolic determinants. Dysbiosis and microbial metabolites, diabetes and insulin resistance, systemic oxidative stress, hormones, and modification of cancer risk across different organs.

D. CANCER GENETICS AND HEREDITARY SYNDROMES

11. Molecular foundations. Gatekeeper and caretaker genes; tumour suppressors and oncogenes; DNA repair pathways (MMR, HR, NER); mutational signatures; the two-hit model, haploinsufficiency, mosaicism, and structural variants.
12. Common hereditary syndromes. Lynch syndrome; BRCA1/2 syndromes (HRD); APC/FAP; Li-Fraumeni (TP53); Cowden/PTEN, among others; inheritance patterns, genotype–phenotype correlations, and general surveillance recommendations.

	13. Moderate-penetrance genes and special scenarios. CHEK2, ATM, PALB2, HOXB13 and other moderate-risk genes; the impact of ancestry and founder mutations, and CMMRD syndrome; regulatory variants and somatic mosaicism with clinical implications. 14. Additional syndromes and syndrome-specific surveillance. MAP (MUTYH) and polymerase-associated syndromes (POLE/POLD1); Peutz–Jeghers (STK11), juvenile polyposis (SMAD4/BMPR1A), serrated polyposis syndrome; hereditary diffuse gastric cancer (CDH1); MEN1/MEN2 (RET), VHL, NF1 and other less frequent syndromes; clinical suspicion criteria and basic screening/referral pathways. 15. Oncogenetics methodologies. NGS panels versus WES/WGS; complementary techniques (MLPA, array-CGH, long-read sequencing); paired tumour–normal samples; ctDNA and epigenetic markers (methylation); basic concepts of quality control and orthogonal validation of findings. **E. PREVENTION AND EARLY DETECTION** 16. Brief clinical implications. General principles of screening and prevention in high-risk individuals; examples of genotype–phenotype–therapy relationships: • Microsatellite-instability tumours and response to immune checkpoint inhibitors. • Homologous recombination deficiency (HRD) tumours and sensitivity to PARP inhibitors.
Practical sessions:	Applied genetic counselling: Interpretation of real genetic test reports (ACMG/AMP criteria), management of variants of uncertain significance (VUS), pedigree construction and interpretation, planning and implementation of cascade testing, and discussion of referral criteria and high-risk screening proposals. Integrated hereditary syndrome cases: Analysis of clinical cases involving syndromes such as Lynch, BRCA1/2, CDH1, POLE/POLD1, among others; design of surveillance strategies based on clinical guidelines, coordination of care across healthcare levels, therapeutic implications (MSI–response to immune checkpoint inhibitors; HRD–sensitivity to PARP inhibitors), and addressing psychosocial aspects within families. Operational foundations of genetic counselling: Development and interpretation of pedigrees; indications for referral to genetics units; informed consent; communication and disclosure of results to patients and relatives; principles of cascade testing. Essential variant interpretation and resources: ACMG/AMP criteria and their practical application; integrating functional evidence versus in silico predictions; variant reclassification over time; use of repositories and databases (ClinVar, LOVD, and others); coordination with genetic counselling professionals.
Bibliography:	Core bibliography - Weinberg, R.A. The Biology of Cancer. 3rd ed., 2023. - Henson, J.W., Resta, R.G. Diagnosis and Management of Hereditary Cancer. Tabular-Based Clinical and Genetic Aspects. Elsevier, 2021. Suggested additional reading - Adami, H.-O., Hunter, D.J., Mucci, L. (eds.). Textbook of Cancer Epidemiology. Oxford University Press. - Dos Santos Silva, I. Cancer Epidemiology: Principles and Methods. IARC. - Eeles, R.A., Berg, C.D., Tobias, J.S. (eds.). Cancer Prevention and Screening: Concepts, Principles and Controversies. Wiley-Blackwell, 2018. - Chung, D.C., et al. Principles of Clinical Cancer Genetics. Springer. Other resources Teaching materials and lecture slides prepared by the teaching staff, available via the Virtual Campus.