Master's degree in Molecular Biology of Cancer
Course syllabus – Bioinformatics: application to molecular oncology

Basic course information

Course:	Bioinformatics: application to molecular oncology			
Type:	Compulsory			
ECTS credits:	6			
Semester:	1º			
Involved departments:	Biochemistry and Molecular Biology			
Course coordinator:	Dr. Gabriel Piedrafita Fernández	Biochemistry and Molecular Biology, School of Chemical Science, UCM	gpiedraf@ucm.es	91394 4265 / 4872
Lecturers:	Dra. Marina Mendiburu-Eliçabe Garganta. Depto. Estadística e Investigación Operativa. F. Farmacia, UCM. mmendibu@ucm.es Dr. Raúl Fernández Pérez. Depto. Bioquímica y Biología Molecular. F. Veterinaria, UCM raufer14@ucm.es DR. Álvaro Gutiérrez Uzquiza. Depto. Bioquímica y Biología Molecular. F. Farmacia. UCM. alguuz@ucm.es			

Specific course information

Course description:	The following contents will be covered in this course: • Management of information from (public or private) tumor databases to study gene expression, mutations and genetic alterations, as well as associated survival. • Usage of molecular data analysis (on DNA, mRNA, protein, etc) from high throughput sequencing techniques and tumor databases. • Genotype-phenotype association analyses. • Molecular modeling software (for predicting mutation-induced changes on protein structure/function, etc).
Requirements:	None
Recommendations:	None

Learning outcomes

Knowledge and content	• To understand the basic molecular and cellular mechanisms whose deregulation leads to the development of cancer, 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 affect tumor progression. • To understand the main genetic and environmental risk factors that predispose to the development of cancer, as well as the principal molecular mechanisms responsible for the effects of these factors. • To understand the similarities and differences at the molecular level among the main types of solid and hematological tumors, as well as their impact on disease progression, diagnosis, and treatment. • To understand the main types of antitumor treatments, with special attention to the use of advanced radiotherapy techniques, cellular therapy, immunotherapy, nanoencapsulation, and targeted therapies. • To understand the main methods of cancer diagnosis, both general and tumor-specific, with particular emphasis on molecular diagnostic methods that enable the identification of specific genetic alterations, as well as the use of early detection techniques such as liquid biopsy. • To understand the foundations for the design of clinical trials in oncology, including statistical analysis, their different phases, and the main bureaucratic procedures required for their submission, approval, and monitoring. • To understand the main stages involved in the process that, starting from basic research

	and preclinical models, allows for the intellectual protection, validation, and, where appropriate, use and commercialization of new biomarkers useful in cancer diagnosis or prognosis; new chemical, biological, or physical agents; or new pharmaceutical formulations with antitumor activity or that alleviate symptoms in oncology patients.
Skills and abilities	• Ability to understand and apply concepts, tools, and methodologies in oncology research, enabling the development of an integrative view of advances in scientific research in this field. • Ability to analyze and understand a scientific paper, from the initial hypothesis and objectives through the preliminary approach to the conclusions obtained. • Ability to present, in a written report or scientific paper in English, research results in the field of molecular biology of cancer clearly and unambiguously. • Ability to communicate the conclusions derived from scientific work clearly and unambiguously to both specialized and non-specialized audiences: to function, understand, and convey knowledge, scientific results, and strategies in English. • Ability to understand the principles that guide the selection or design of appropriate antitumor therapies for each type and stage of cancer and for each patient. • Ability to work with some of the main databases related to molecular oncology, as well as to perform specific analyses using these data and interpret the results obtained.
Competencies	• To understand the molecular, cellular, and pathophysiological bases of cancer, enabling continued study in the field of molecular biology of cancer in an autonomous or self-directed manner. • To design experimental approaches to analyze the molecular, cellular, or pathophysiological mechanisms involved in the development and progression of cancer, as well as to evaluate the effectiveness of new diagnostic methods or new 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 the submission of patents as well as clinical trials in the field of oncology. • To apply the principles of the scientific method, understanding its value and limitations, and incorporating the ethical principles that govern professional practice. • To develop appropriate skills for communicating and disseminating professional activity, both among specialists and to the broader non-specialist public. • To be able, based on the knowledge acquired in the field of molecular biology of cancer, to evaluate and select appropriate scientific information in order to formulate judgments and interpretations from limited information. • To understand and recognize the need for continuous training and ongoing study in the field of oncology for the performance of professional activities. • To develop the ability to work collaboratively in homogeneous or multidisciplinary teams, with shared responsibilities.

Objectives

1 Familiarization with tumor online databases and main data formats.
2 Learning fundamentals of programming: development of scripts for exploratory and statistical analysis of qunantitative data in molecular oncology.
3 Application of genomics analysis techniques and methods for mutation studies, differential expression and annotation.
4 Exposure to novel tumor bioinformatics analysis techniques.
5 Development of critical thinking to interpret and discuss results from bioinformatics analyses and understand their limitations and biases.

Methodology

Description:	The teaching activity will follow a mixed methodology, combining individual and

collaborative learning. On-site activities will involve theory lectures, presentations or seminars and tutorials in computer classroom.

In **theoretical classes** the student will learn through lectures given by the professorship and, to some extent, external invited lecturers with expertise on different topics in the field of the subject. In all these sessions, the speaker will introduce the course content, explaining theoretical concepts and the fundamentals of bioinformatics analysis, so that the student gains a handy overview of the subject. As each lesson begins, its main contents and objectives will be explained. At the end of the lesson, new proposals could be put forward to link concepts with content from the rest of the course or with other subjects. Teaching material (in the form of slides, videos, apps, etc.) will be provided through Campus Virtual to assist students' learning.

In **presentations or seminars** the students will receive computational practices in the computer classroom and they will present research work related with the course content. Presentation/seminar classes are aimed at applying acquired knowledge to practical analysis of bioinformatics analysis as well as discussing methodologies and research papers to be presented to classmates and discussed with them and the professorship. This type of seminars could involve students' visits or "field work" experience in research groups or other institutions of interests according to Master's objectives.

Tutorials will deepen in certain aspects of the program to aid learning.
Assessment: Oral or written exams to assess learning results.
Autonomous work: Individual student's work, including studying, exercise resolution, practical task elaboration and report making, individually or in collaboration with others, is key in the learning process. Individual work includes too documentation, bibliography reading and preparation for the exam.

Distribution of teaching activities

	Hours	% in-person attendance
Theoretical classes:	24	100
Presentations and/or seminars:	17	100
Tutorials:	5	100
Assessment:	2	100
In-person work:	48	100
Independent work:	102	0
Total:	150	

Assessment

Applicable criteria:

The scoring system considers: (a) a final exam (50% of the final mark of the course); (b) continuous assessment, given by on-site classroom work, activities and questionnaires/deliveries, practices and other complementary learning activities (30% of the final mark), and (c) presentation and discussion of research work (20% of final mark). Students are expected to participate, actively and responsibly, in at least 70% of on-site learning activities. Marks will be based on 0 to 10 scoring system, according to RD 1125/2003 guidelines.

Semester organization

Course will be taught in the first semester.

Syllabus

Theoretical Curriculum:

- Introduction. Biological databases and data formats.
- Fundamentals of bioinformatics programming.
- Exploratory and statistical analysis of quantitative data in molecular oncology

	through R programming. • Introduction to genomics analysis techniques. • Mutation and genomic variant analysis. • Transcriptomics analysis and differential expression. • Functional annotation techniques. • Novel bioinformatics techniques in molecular oncology.
Practical sessions:	• Practices on biological database search and data formats. • Practices on basic programming and quantitative data management in Unix and R. • Practices on statistical analysis of quantitative data in R. • Practices on mutational analysis from DNA-seq data. • Practices on differential expression analysis from RNA-seq data. • Practices on functional enrichment and motif analysis. • Presentations on novel bioinformatics tools and analyses.
Bibliography:	• Introduction to Bioinformatics with R: A Practical Guide for Biologists. Autor: Edward Curry. 1st Edition. Chapman & Hall/CRC Computational Biology Series. ISBN 9781138495715 • Bioinformatics: A Practical Handbook of Next Generation Sequencing and Its Applications. Edited By: Lloyd Low and Martti Tammi. Editorial: WSPC. ISBN 9789813144743