For more detailed information, please refer to the PhD program page on Unistudium

Course	Module	Lecturer	Class time (h)	Credit Units	Year of PhD Course	Course delivery period	Final exam	*Curriculum*
Bioinformatics	Introduction to data analysis and data formats	Gianluigi Cardinali	12	2	I	February 2024	Yes	AC
	Introduction to basic programmming in biotechnologies		6	1		TBD		
Photonics	Femtobiology	Benedetta Carlotti	12	2	I	March 2024	Yes	C-BB
	Two-photon absorption for bio-applications	Alessio Cesaretti	6	1		September 2024		
Safety in biotechnology lab	Safety in biotechnology	Assunta Marrocchi	12	2	I	November 2023	Yes	AC
	Bioprocesses		6	1		June 2024		
Advanced informatics	Advanced databasing and programming in biotechnology	Vincent Robert	18	3	II	TBD	Yes	AC
Advanced medical biotechnology	Transcriptomics data mining theory	Giuseppe Nocentini	6	1	II	June 2024	Yes	C-MB
	Transcriptomics data mining practice	Luigi Cari	6	1		TBD		
	Cancer immunotherapy	Stefano Bruscoli & Efisio Puxeddu	6	1		June 2024		
	Introduction to biomarkers	Lorena Urbanelli	6	1		May 2024		
Writing EU research projects	Writing EU research projects	Sara Alimenti	6	1	II	TBD	Yes	AC
Bioessay in biotechnologies	Bioessay in biotechnologies	Laura Corte	6	1	II	September 2024	Yes	AC
Gene editing	Medical gene editing	Stefano Bruscoli	6	1	III	TBD	Yes	C-MB/C-MIB
	Plant gene Editing	Francesco Paolocci	6	1		TBD		
	Machine learning applied to gene editing	Francesco Morena	12	2		May 2024		
Food and environmental biotechnology	Functional foods	Florentina Matei	6	1	III	June 2024	Yes	C-MIB

Introduction to robotics and AI-based surgery	Introduction to robotics and AI-based surgery	Fabio Rondelli	6	1	III	TBD	Yes	C-MB
Ethics of the scientific research	Scientific and technological foundation	Gianluigi Cardinali	6	1		TBD	Yes	AC
	Ethical foundations	Marco Moschini	6	1		TBD		
HT data generation	HT data generation	Jacopo Lucci	6	1	III	TBD	Yes	AC

Legenda

AC = tutti i curricula / all curricula

C-BB = curriculum Biomateriali e Biodispositivi / curriculum on Biomaterials and Biodevices

C-MB = curriculum Biotecnologie Mediche / curriculum on Medical Biotechnologies

C-MIB = curriculum Biotecnologie Molecolari e Industriali / curriculum on Molecular and Industrial Biotechnologies

COURSES

BIOINFORMATICS

Lecturer: Gianluigi Cardinali

The course consists of two modules taught one after the other. In the first module, "Data and Formats," various types of data are discussed from mathematical, computational, and biological perspectives. Advanced data formats used in metagenomics are also explained and illustrated. This is followed by the treatment of data storage structures: vector, matrix, tensor, array. From various types of matrices or tensors, the discussion moves to various types of distances for continuous, categorical, DNA/RNA/Proteins, and classified data. Lastly, some forms of data representation with dimensionality reduction algorithms such as PCoA are presented.
The second part of the course deals with the basic mechanisms of programming (conditional testing, loops, indexing, etc.) to automate the main analyses carried out in the biotechnological field. Throughout the course, students work on their own PCs in the R environment, ideal for illustrating various aspects of data and their structures, as well as teaching the basics of programming. Learning assessment occurs through the proposal of problems that must be solved using the algorithms and procedures studied in R.

PHOTONICS

Lecturers: Benedetta Carlotti, Alessio Cesaretti

FEMTOBIOLOGY

Femtosecond Lasers. LASERs. Femtosecond lasers are necessary to track events over time at the molecular level. How to generate femtosecond laser pulses. How to tune their wavelength. Fluorescence Up Conversion. Fluorescence. Time-resolved fluorescence spectroscopy. Fluorescence up-conversion: single wavelength and broad-band detection. Fluorescence polarization and anisotropy. Femtobiology. Ultrafast dynamics in nucleic acids and proteins: hydration of biomolecules; photoinduced electron transfer processes; Forster resonance energy transfer processes.

TWO-PHOTON ABSORPTION FOR BIO-APPLICATIONS

Two-photon absorption (TPA) is a nonlinear optical phenomenon in which two photons of half the energy are used to excite small organic molecules, typically in the near-infrared, as opposed to the common UV-Vis radiation used in conventional single-photon excitation. The TPA process can be exploited to develop new non-invasive bio-imaging technologies, allowing for higher spatial resolution and optical sectioning in the sample at various depths. The TPA phenomenon can be utilized in photodynamic therapy through the selective excitation of specific compounds. When high cross-sections of TPA are coupled with significant production of triplet states, these molecules, once excited, can lead to the formation of ROS and thus selective death of tumor cells. Examples of the use of TPA in both bio-imaging and photodynamic therapy are discussed. At the end of the course, a final test will be administered with some questions on LibreEol.

SAFETY IN BIOTECHNOLOGY LAB

Lecturer: Assunta Marrocchi

SAFETY IN BIOTECHNOLOGY. The course aims to inform about the risks associated with the use of chemical substances, biological agents, and physical agents in biotechnological research laboratories: (1) Hazard, risk, prevention, protection, risk perception and assessment, risk management, and communication concepts.
(2) Main regulatory references. (3) Chemical risk: Definition of hazardous chemical agents; hazard classes; the concept of exposure to chemical agents: the threshold limit value (TLV); routes of absorption of chemical agents and parameters influencing absorption; chemical risk assessment, prevention, and protection measures.
(4) Biological risk: Definition of biological agent, microorganism, cell culture; classification of biological agents; Physical risk assessment: Definition of physical agent; relevant physical agents in biotechnological laboratories; in-depth analysis of artificial optical radiation; health and safety effects of exposure to artificial optical radiation.

At the end of the course, a final test will be administered with some questions on LibreEol.

BIOPROCESSES. The course aims to provide basic knowledge related to bioprocesses in the biotechnological industry; more specifically, the main fermentation and enzymatic processes will be discussed. Additionally, an overview of the impact of industrial biotechnologies, a panorama of products from the biotechnological industry (biofuels and bioenergy, chemicals, new materials, etc.), and a brief mention of the key role of industrial biotechnologies in the context of environmental sustainability will be provided. Guidance will be given regarding relevant websites in this field and suggestions for further scientific readings.

The course will involve frontal lectures, requiring active participation from doctoral students. To assess learning outcomes, at the end of the training period, a evaluation test will be administered to the doctoral students, consisting of closed and/or open-ended questions, on the LibreEol platform.

ADVANCED BIOINFORMATICS

Lecturer: Vincent Robert

The course is based on the use of advanced databases employed in biotechnology and leverages all the concepts taught in the Bioinformatics I course. In fact, the two courses are designed and modified in collaboration by the two instructors. The course introduces database management systems, mainly using the VB.net language and partly Python, with the aim of showing the differences and similarities between two different languages, both widely used in professional applications (VB.net) and in script and pipeline construction (Python). The main programming mechanisms are presented and explored. The use of libraries in standalone programming (VB.net) or scripting (Python) is then illustrated. The explanation moves on to systems for subjecting database data to major statistical and/or, in the case of DNA, phylogenetic treatments. Students will conduct a personal project, partly in class and partly as work to be done outside of class hours. The course assessment is based on the results of the assigned project.

ADVANCED MEDICAL BIOTECHNOLOGY

Lecturers: Giuseppe Nocentini, Luigi Cari, Stefano Bruscoli, Efisio Puxeddu, Lorena Urbanelli

TRANSCRIPTOMICS DATA MINING

Prognosis and personalized treatment of patients with solid tumors; infiltration of the tumor microenvironment by cells of the immune system; organization of the 'public repositories' Array Express and GEO; information obtainable through the freely accessible software 'Gepia'; information obtainable through the paid software 'GeneVestigator'.

CANCER IMMUNOTHERAPY

First Part - Introduction to immunotherapy for cancer treatment; concepts of immunotherapy and chemotherapy; main approaches of oncological immunotherapy. Second Part - Description of tumor cells' 'immuno-escape' and immune checkpoints; insights into thyroid immuno-oncology; synthesis of results from clinical studies of immunotherapy in thyroid cancer; ongoing clinical studies of immunotherapy in thyroid cancer; data on immunoprofiling of thyroid carcinoma; advanced immunophenotypes of thyroid carcinoma (ATC and PDTC); Role of the beta-catenin pathway in the development of a PDTC subtype.

INTRODUCTION TO BIOMARKERS

Introduction to the concept of biomarkers; descriptive characteristics of a biomarker and main types (diagnostic, monitoring, pharmacodynamic, predictive, prognostic, susceptibility or risk, safety). Overview of pipelines for biomarker discovery; biomarkers and liquid biopsy. At the end of the course, a final test will be administered with some questions on LibreEol.

WRITING EU RESEARCH PROJECT

Lecturer: Sara Alimenti

European funding represents more than ever an opportunity for researchers, who through these channels can benefit from resources to finance activities, build and consolidate networks, and engage in pathways to valorize research results and maximize impacts. In this perspective, researchers require skills that enable them to

identify funding opportunities, develop successful proposals, and manage funded projects most effectively. The training activity proposes an approach to European funding structured as follows:

- Understanding the main European research funding programs;
- Planning scouting and analysis activities for funding to identify measures most suitable for research needs;
- The lifecycle of the research project: the pre-award phase; managing funded projects; results valorization processes; impact maximization;
- Organizing networking activities with institutions, research entities, organizations, and the business world;
- Managing relationships with administrative and scientific-professional figures involved in research design and management.

BIOASSAYS IN BIOTECHNOLOGIES

Lecturer: Laura Corte

Introduction to the concept of biosensing as a tool for microbiological-genetic biomonitoring. Types of biosensing and biological sensors. Comparison between biosensing and biosensors. Main biosensing applications in medical, pharmaceutical, agri-food, and environmental fields. At the end of the course, a final test will be administered with some questions on LibreEol.

GENE EDITING

Lecturers: Stefano Bruscoli, Francesco Paolocci, Francesco Morena

GENE EDITING

First Part - Basic principles of molecular biology; Genetic editing of somatic and germ cells; Basic mechanism of CRISPR/Cas9 genetic engineering technology; CRISPR/Cas9 strategies for genetically modifying animal experimental models; New applications of CRISPR/Cas9 technique; Limitations and flaws of CRISPR/Cas9 technique: 'off-target' events and mosaicism; Practical applications examples in clinics: treatment of genetic diseases, infectious diseases, tumor pathologies, potential treatments in patients with HIV; Ethical aspects.

Second Part - Gene editing in plants: Application for studying basic mechanisms, for genetic improvement of plants of agricultural interest, and as a tool for neo-domestication; Issues related to the acceptance by civil society of plant organisms derived from 'new breeding technologies' (NBT).

MACHINE LEARNING APPLIED TO GENE EDITING

The course aims to provide knowledge on the functioning of Gene Editing through CRISPR-Cas9 and its potentials. It will address the potentials and critical aspects of this technique, and how genomic editing could be made more precise through artificial intelligence (Machine Learning). The course will enable students to acquire knowledge on current genomic engineering techniques, particularly the CRISPR-Cas9 system and its variants, and understand their potentials for biomedical and biotechnological applications. Additionally, through guided analysis of crucial experiments, students will acquire the basic skills necessary to address and apply genomic engineering techniques through CRISPR-Cas9 to experimental studies. At the end of the course, a final test will be administered with some questions on LibreEol.

FOOD AND ENVIRONMENTAL BIOTECHNOLOGY

Lecturer: Florentina Matei

FUNCTIONAL FOODS

Introduction to the principles of nutrition and nutrients. Probiotic, prebiotic, and symbiotic foods. Specific fermentations for probiotic enrichment. Functional foods. Products aimed at specific groups of the population with particular nutritional needs (FSG): Regulation EU 609/2013. ADAP. At the end of the course, a final test will be administered with some questions on LibreEol.

INTRODUCTION TO ROBOTIC AND AI-BASED SURGERY

Lecturer: Fabio Rondelli

The aim of the course is to assess the new technological frontiers in the medical and surgical fields, particularly focusing on the mini-invasive robotic approach. As extensively demonstrated in international scientific literature, the robotic mini-invasive approach, when compared to purely laparoscopic surgical approach, results in a lower conversion rate in most complex oncological interventions. This naturally leads to lower intraoperative blood loss, reduced post-operative hospital stay, lower rates of surgical wall complications, and consequently, significant cost savings.

For medical biotechnology doctoral students, a 7-hour course is proposed, held in a single day and divided into theoretical and practical parts. The theoretical portion involves outlining current guidelines for the use of robots in abdominal visceral surgery, accompanied by a description and explanation of the latest devices on the market (Alpi-tube, Tri-Staple Sutures...). This is accompanied by a brief discussion of some cases with pre-op image reconstruction (CT and MRI), following the current concept of 'tailored surgery.'

The practical part allows participants to personally perform robotic movements in the operating room; each student can carry out simple gestures on the simulator, in 3D vision, to test firsthand the real precision and freedom of movement of the latest generation robot. At the end of the course, a final test will be administered with some questions.